Journal of Air Law and Commerce

Volume 87 | Issue 3 Article 2

2022

The Use of Law to Address Space Debris Mitigation and Remediation: Looking Through a Science and Technology Lens

Annie Handmer
University of Sydney

Author(s) ORCID Identifier:

Steven Freeland: https://orcid.org/0000-0002-0287-8509

Steven Freeland
Western Sydney University

Author(s) ORCID Identifier:

Steven Freeland: https://orcid.org/0000-0002-0287-8509

THE USE OF LAW TO ADDRESS SPACE DEBRIS MITIGATION AND REMEDIATION: LOOKING THROUGH A SCIENCE AND TECHNOLOGY LENS

Annie Handmer*
Steven Freeland**

ABSTRACT

Increasingly over the past six decades, space exploration and technology have revolutionized the world we live in. The landscape in outer space has continued to evolve rapidly, presenting new challenges for a much slower moving legal framework as well as for peaceful uses of space more generally. In particular, space debris has emerged as a pressing global threat. In response, states have shifted towards a more informal two-pronged approach to outer space, as reflected by non-binding instruments adopted by the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), along with the development of technologies that aim to provide practical solutions to space debris concerns. Taking into account these strategies, this Article first undertakes a review of various complexities facing the existing regulatory framework regarding the environment of space with a focus on dual-use technologies. The Article then demonstrates how Science and Technology Studies (STS) perspectives may offer frameworks and approaches that allow legal scholars to approach highly networked and entangled questions in ways that offer new paths forward while also facilitating technical legal analysis. By doing this, we hope to emphasize that a more multi-disciplinary perspective regarding the complexities and challenges associated with increasing levels of space activities is both warranted and constructive.

DOI: https://doi.org/10.25172/jalc.87.3.2

* Associate Lecturer, University of Sydney; Research Assistant, Bond University, Australia.

** Emeritus Professor, Western Sydney University; Professorial Fellow, Bond University, Australia.

TABLE OF CONTENTS

I. INTRODUCTION

OVER THE PAST DECADES, space exploration and technology have revolutionized the world we live in. Along with the initial focus on military and scientific developments, the uses of outer space have multiplied as space has become increasingly accessible to a wide range of actors, such that it now plays an essential role in everyday human activities, from agriculture to finance to communications and beyond.[1]

Developments in outer space have also contributed to shaping—and in turn have been shaped by—political conceptions and international relations. Particularly striking is the context in which the first significant breakthroughs in space technology occurred: a climate of fierce competition and near confrontation between the United States and the Soviet Union, giving rise to what became known as the (first) "space race."[2]

---

[1] *See generally*, WORLD ECON. F., SIX WAYS SPACE TECHNOLOGIES BENEFIT LIFE ON EARTH (2020), https://www3.weforum.org/docs/WEF_GFC_Six_ways_space_technologies_2020.pdf [https://perma.cc/GQ7H-HJK5].

[2] *See* Steven Freeland, *What Sort of Space "Race" Should We be Pursuing?*, AUSTL. INST. INT'L AFFS. (Dec. 15, 2021), https://www.internationalaffairs.org.au/austra-

This perception of outer space as a state-dominated competitive arena was at the heart of the 1967 Outer Space Treaty, considered by many as the "constitution" of international space law.[3] This landmark Treaty, which codified various fundamental principles, was followed in relatively quick succession by four more space treaties.[4]

Despite this early regulatory evolution, the landscape in outer space has continued to evolve rapidly, presenting new challenges for a much slower moving legal framework. Notably, space debris has emerged as a pressing global threat, warranting a coordinated response at the international level.[5] Yet, the current binding international framework as set out in these treaties largely appears unequipped to deal with the increasing proliferation of space debris despite widespread acknowledgement of the hazards it creates.[6]

In response, states have shifted towards a more informal (at least from a legal sense) two-pronged approach to outer space, as reflected by non-binding instruments adopted by the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), along with the development of technologies that aim to provide practical solutions to space debris concerns.[7]

---

lianoutlook/what-sort-space-race-should-we-be-pursuing/ [https://perma.cc/7P58-5G39] (discussing the various "space races" that have taken place).

[3] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, *opened for signature* Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty]; *see also* Jill Stuart, *The Outer Space Treaty Has Been Remarkably Successful – but Is It Fit for the Modern Age?*, CONVERSATION (Jan. 27, 2017, 11:59 AM), https://theconversation.com/the-outer-space-treaty-has-been-remarkably-successful-but-is-it-fit-for-the-modern-age-71381 [https://perma.cc/UDD6-D8E5].

[4] *See* Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119 [hereinafter Rescue Agreement]; Convention on International Liability for Damage Caused by Space Objects, *opened for signature* Mar. 29, 1972, 24 U.S.T. 2389, 962 U.N.T.S. 187 [hereinafter Liability Convention]; Convention on Registration of Objects Launched into Outer Space, *adopted* Nov. 12, 1974, 28 U.S.T. 695, 1023 U.N.T.S. 15 [hereinafter Registration Convention]; Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, *adopted* Dec. 5, 1979, 1363 U.N.T.S. 3 [hereinafter Moon Agreement].

[5] Paul B. Larsen, *Solving the Space Debris Crisis*, 83 J. AIR L. & COM. 475, 476–77 (2018).

[6] *See id.* at 477.

[7] *See* Steven Freeland, *For Better or for Worse? The Use of 'Soft Law' Within the International Legal Regulation of Outer Space*, 36 ANNALS AIR & SPACE L. 409, 438–39 (2011).

Taking into account these strategies, this Article focuses on how the international community has responded to the issue of space debris, utilizing elements of a Science and Technology Studies (STS) approach, in order to evaluate the efficacy of the prevailing legal-centric strategy. By doing this, we hope to emphasize that a more multi-disciplinary perspective regarding the complexities and challenges associated with increasing levels of space activities is both warranted and constructive.

Before this examination, however, we will undertake a review of the problems facing the existing regulatory framework regarding the environment of space, in particular those arising from the problem of space debris.

II. THE PROBLEM OF SPACE DEBRIS

Space debris principally comprises those space objects (satellites) that have reached their end of life; various launch stages (for example, rocket bodies and upper stages of launch vehicles); and the remnants of space objects from explosions, conjunctions, or deliberate destruction, as well as other items that are deliberately or accidentally released during a space mission.

While there is as yet no universally accepted or legally binding definition of orbital space debris, COPUOS has developed a definition, incorporating debris both in Earth orbit but also in the process of "de-orbiting," as follows: "[A]ll man-made objects, including fragments and elements thereof, in Earth orbit or reentering the atmosphere, that are non-functional."[8] This definition itself comes from various non-binding instruments developed through COPUOS dealing specifically with space debris mitigation (as discussed in more detail below).[9]

According to estimates by the European Space Agency, as of April 4, 2022, there were in Earth's orbit more than 130 million pieces of debris smaller than 1 centimeter, about 1,000,000 pieces of debris 1–10 centimeters in length, and around 36,500 of pieces larger than 10 centimeters.[10] The total mass of all

---

[8] U.N. Off. for Outer Space Affs., Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space 1 (2010), https://www.unoosa.org/pdf/publications/st_space_49E.pdf [https://perma.cc/7QJZ-4L63].

[9] *See infra* Section III.B.

[10] *Space Debris by the Numbers*, EUR. SPACE AGENCY https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers [https://perma.cc/J78M-LMAC] (Aug. 11, 2022).

space objects—a large proportion of which is in the form of space debris—is greater than 9,900 tons.[11]

Given the orbital velocity of even the smallest piece of debris, any collision with another space object would almost certainly result in damage to, or destruction of, that object and the production of further pieces of debris.[12] This increases the possibility of what has been termed the "Kessler Syndrome,"[13] and ultimately a tragedy of the commons in outer space.[14]

Space debris is a major area for environmental concern, and it clearly also impacts human safety. For example, on March 12, 2009, the three astronauts aboard the International Space Station (ISS), Americans Mike Fincke and Sandra Magnus, and Russian Yury Lonchakov, were forced to evacuate the main station and remain in the ISS escape vehicle for nine minutes, while a piece of debris about thirteen centimeters in length passed by.[15] Had the debris hit and pierced the ISS, it is possible that a fatal loss of air pressure could have ensued. Such contingency measures have been instituted on the ISS on other occasions.[16]

Only one month before the March 2009 ISS incident, an operational American commercial satellite (Iridium 33) and an inactive Russian communications satellite (Cosmos 2251) collided approximately 790 kilometers above the Earth, resulting in the total destruction of both.[17] This was the first time that two intact

---

11 *Id.*

12 DONALD J. KESSLER ET AL., LIMITING FUTURE COLLISION RISK TO SPACECRAFT: AN ASSESSMENT OF NASA'S METEOROID AND ORBITAL DEBRIS PROGRAMS 1 (2011).

13 *See* Mike Wall, *Kessler Syndrome and the Space Debris Problem*, SPACE.COM (Nov. 15, 2021), https://www.space.com/kessler-syndrome-space-debris [https://perma.cc/Y55C-YF5T].

14 *See generally* Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243, 1243–44 (1968) (discussing the tragedy of the commons in the context of mankind overpopulating Earth); *see also* Steven Freeland, *Common Heritage, Not Common Law: How International Law Will Regulate Proposals to Exploit Space Resources*, 35 QUESTIONS INT'L L. 19, 33 (2017) (discussing the implications of the tragedy of the commons for the use of outer space).

15 Maggie Mckee, *Debris Threat Prompts Space Station Crew to Evacuate*, NEW SCIENTIST (Mar. 12, 2009), https://www.newscientist.com/article/dn16755-debris-threat-prompts-space-station-crew-to-evacuate/ [https://perma.cc/5SH8-ZABA].

16 *See, e.g.*, *International Space Station Forced to Swerve to Avoid US Space Junk*, GUARDIAN (Dec. 3, 2021), https://www.theguardian.com/science/2021/dec/03/international-space-station-forced-to-swerve-to-avoid-us-space-junk [https://perma.cc/UB25-HZCF].

17 Brian Weeden, SECURE WORLD FOUND., 2009 IRIDIUM-COSMOS COLLISION FACT SHEET (2010), https://swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf [https://perma.cc/V4CW-UN5Y].

satellites collided, and the incident resulted in approximately 2,000 additional pieces of hazardous debris of four centimeters or more being created, with the potential to cause additional decades-long pollution in space.[18]

Adding to the complexity of the issue, in 2007 and 2008, both China[19] and the United States,[20] respectively, proceeded to deliberately destroy their own satellites in space, thus causing additional space debris from the resultant explosions. More recently, in March 2019, India[21] also kinetically destroyed one of its own satellites, as did Russia[22] in late 2021.

Recent events have led to the United States committing in April 2021 "not to conduct destructive, direct-ascent anti-satellite (ASAT) missile testing," seeking to establish this as "a new international norm for responsible behavior in space."[23] This commitment is part of a growing trend towards defining and committing to non-binding norms intended to reduce collective risk. Indeed, at the time that this article is being written, an Open-Ended Working Group on "reducing space threats through norms, rules and principles of responsible behaviours," which was established by the United Nations General Assembly, was holding its first session in Geneva.[24]

---

18 *Id.*; *see also* Leonard David, *Effects of Worst Satellite Breakups in History Still Felt Today*, SPACE.COM (Jan. 28, 2013), https://www.space.com/19450-space-junk-worst-events-anniversaries.html.

19 Carin Zissis, *China's Anti-Satellite Test*, COUNCIL ON FOREIGN RELS. (Feb. 22, 2007, 10:37 AM), https://www.cfr.org/backgrounder/chinas-anti-satellite-test [https://perma.cc/B4K3-UJEP].

20 Jim Wolf, *U.S. Satellite Shootdown Debris Said Gone from Space*, REUTERS (Feb. 27, 2009), https://www.reuters.com/article/us-space-usa-china-idUSTRE51Q2Q220090227 [https://perma.cc/ZVW2-4HPW].

21 Ashley J. Tellis, *India's ASAT Test: An Incomplete Success*, CARNEGIE ENDOWMENT FOR INT'L PEACE (Apr. 15, 2019), https://carnegieendowment.org/2019/04/15/india-s-asat-test-incomplete-success-pub-78884 [https://perma.cc/J6SX-U2SK].

22 Shannon Bugos, *Russian ASAT Test Creates Massive Debris*, ARMS CONTROL ASS'N (Dec. 2021), https://www.armscontrol.org/act/2021-12/news/russian-asat-test-creates-massive-debris [https://perma.cc/X6JR-CJX2].

23 *FACT SHEET: Vice President Harris Advances National Security Norms in Space*, WHITE HOUSE (Apr. 18, 2022), https://www.whitehouse.gov/briefing-room/statements-releases/2022/04/18/fact-sheet-vice-president-harris-advances-national-security-norms-in-space/ [https://perma.cc/34CE-YQG3].

24 *Open-Ended Working Group on Reducing Space Threats*, U.N. OFF. FOR DISARMAMENT AFFS. (2022), https://meetings.unoda.org/meeting/oewg-space-2022/ [https://perma.cc/8MLL-6F5Z].

III. THE EXISTING LEGAL FRAMEWORK APPLICABLE TO SPACE DEBRIS

A. The Treaty Framework

The Outer Space Treaty focuses primarily on issues of peaceful uses of outer space, regulation of space activities by non-governmental entities, and freedom of exploration and use.[25] At the same time, the legal regime has not prevented the development of military technology capable of being used in outer space.[26] While there are some restrictions, these were specified in relatively general terms and were open to divergent interpretation as to what they did (and did not) prohibit.[27] This is not entirely surprising, since the development of space-related technology was, at least initially, inextricably related to military strength—both in reality and to influence the perception of others.[28] It is no coincidence that, as noted, the first space race "emerged at the height of the Cold War," when both the United States and the USSR strove to flex their respective technological "muscles."[29] The early stages of human space activity coincided with a period of quite considerable tension, with the possibility of large-scale and potentially highly destructive military conflict between the (space) superpowers of the time always lurking in the background.[30]

Despite the possibilities for humankind that it would present, the successful launch of Sputnik 1 in 1957 generated unease in the West, since the technology was similar to that used for ballistic missiles.[31] Within this highly sensitive context, it was crucial that efforts were made by the international community to regulate this new frontier to avoid both a buildup of weapons and armed conflict in space.[32]

---

25 *See* Outer Space Treaty, *supra* note 3, pmbl.

26 *See, e.g.*, Dana J. Johnson, Scott Page & C. Bryan Gabbard, Space: Emerging Options for National Power 5 (1998).

27 *See* Constraints Under International Law on Military Operations in, or in Relation to, Outer Space During Armed Conflicts 2–5 (May 3, 2022) (Int'l Comm. of the Red Cross, Working Paper), https://www.icrc.org/en/document/constraints-under-international-law-military-space-operations.

28 Freeland, *supra* note 2.

29 *See id.*

30 *See id.*

31 *See NATO Update: 1957*, N. Atl. Treaty Org., www.nato.int/docu/update/50-59/1957e.htm [https://perma.cc/9M6D-Z3TC] (Nov. 6, 2001).

32 *See id.*

When it comes to issues regarding the space environment, the only mention of this in the Outer Space Treaty appears in Article IX, which concentrates primarily on the international principles of cooperation and mutual assistance, a duty to give "due regard to the corresponding interests" of other state parties, and the prevention of potentially harmful interference with other states' activities.[33] It also provides inter alia that

> States Parties to the Treaty shall pursue studies of outer space, including the [M]oon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose.[34]

Article IX thus calls upon states to avoid the harmful contamination of outer space (forward contamination) and stresses the necessity to also prevent backward contamination, which results from the introduction of extraterrestrial matter into the Earth's environment.[35]

The semantics of this part of Article IX appear to reveal an anthropocentric focus in relation to backward contamination of the Earth's environment, referring to "adverse changes" as the threshold of harm in contrast to what might be regarded as a narrower concept of "harmful contamination" required for forward contamination of outer space.[36] The relevance and utility of Article IX in addressing the issue of space debris is further reduced by the fact that the Outer Space Treaty does not provide a definition of "harmful contamination," and there is still discussion amongst scholars as to whether or not space debris must be regarded as falling within the scope of "harmful contamination."[37]

Indeed, some authors contend that, because the word "contamination" is used in common parlance with respect to chemical effluents, biological hazards, or radiation, the provisions of Article IX should be construed as referring only to pollution

---

33 Outer Space Treaty, *supra* note 3, art. IX.

34 *Id.*

35 *Id.*

36 *See id.*

37 *See* PETER STUBBE, STATE ACCOUNTABILITY FOR SPACE DEBRIS: A LEGAL STUDY OF RESPONSIBILITY FOR POLLUTING THE SPACE ENVIRONMENT AND LIABILITY FOR DAMAGE CAUSED BY SPACE DEBRIS 155 (2018) (discussing the notion of "harmful contamination" in Article IX of the Outer Space Treaty and its scope regarding space debris).

arising from the release of such contaminants in outer space, thus not encompassing space debris.[38]

The requirement to conduct space activities within the context of "due regard" to the corresponding interests of other spacefaring states[39] (and presumably also those private entities within their jurisdiction and supervision) is an important concept. The so-called due regard principle serves to introduce an objective element into the process of consideration as to whether a particular activity should be contemplated.[40]

The notion of giving due regard to the interests of others, to safety, or to both is also an element in the international treaty framework for air activities[41] and the law of the sea.[42] Its inclusion in Article IX imposes a restriction on unfettered exploration and use of outer space by requiring a due-diligence assessment of the potential impacts a particular activity may have on the activities undertaken by others.[43] While the due regard principle has not been resorted to in any formal legal proceedings, its application would likely be considered on a case-by-case basis and also requires a consideration of what might constitute a "corresponding" interest.[44]

Of the remaining four treaties, only the Liability Convention contains provisions that are relevant in the context of space deb-

---

38 *See, e.g.*, Vishakha Gupta, *Critique of the International Law on Protection of the Outer Space Environment*, 14 ASTROPOLITICS 20, 21 (2016); Jinyuan Su, *Control over Activities Harmful to the Environment*, *in* ROUTLEDGE HANDBOOK OF SPACE LAW 80 (Ram S. Jakhu & Paul Stephen Dempsey eds., 2017).

39 *See* Outer Space Treaty, *supra* note 3, art. IX.

40 *See id.*

41 *See* Convention on International Civil Aviation art. 3(d), Dec. 7, 1994, 15 U.N.T.S. 295 [hereinafter Chicago Convention] ("The contracting States undertake, when issuing regulations for their state aircraft, that they will have due regard for the safety of navigation of civil aircraft.").

42 *See* United Nations Convention on the Law of the Sea art. 87.2, Dec. 10, 1982, S. TREATY DOC. NO. 103-39, 1833 U.N.T.S. 397 [hereinafter UNCLOS] ("These freedoms [of the high seas] shall be exercised by all States with due regard for the interests of other States in their exercise of the freedom of the high seas, and also with due regard for the rights under this Convention with respect to activities in the Area.").

43 *See, e.g.*, Giulia Pavesi, *Legal Consequences of Environmental Pollution in Outer Space*, *in* 13 A FRESH VIEW ON THE OUTER SPACE TREATY 15, 22 (Annette Froehlich ed., 2018), https://elib.dlr.de/132311/1/AFreshView_on_OuterSpaceTreat_2018.pdf [https://perma.cc/8APC-YC3Y].

44 *See* John Goehring, *The Russian ASAT Test Caps a Bad Year for the Due Regard Principle in Space*, JUST SEC. (Jan. 12, 2022) (detailing how the due regard principle is rarely if ever formally invoked by states in the outer space context).

ris.[45] The Liability Convention does not address the issue of space environment and debris as such, but it provides some indications regarding liability for damage caused by space objects, which are defined as "component parts of a space object as well as its launch vehicle and parts thereof" for the purposes of the Convention.[46] It is thus relevant in the event of damage caused by space debris.[47] Of course, in this regard, it is only relevant *after* the event and is not directly a preventative mechanism, apart from any deterrence value that it might have.

One should also note that the Moon Agreement establishes a heightened protection of the space environment and calls for the preservation of its existing balance.[48] With that said, its seemingly broad applicability is limited due to the fact that it has thus far attracted only eighteen ratifications,[49] with none by any nation that might be referred to as a major spacefaring nation.[50] That is not to deny, however, that this instrument is a part of the international space law treaty framework and sets out binding rights and obligations for those eighteen states parties vis-à-vis themselves in accordance with the general principles underlying all treaties.[51]

---

[45] *See* Liability Convention, *supra* note 4, arts. II–III; *see also* Steven Freeland & Annie Handmer, *It's Not How Big Your Laser Is, It's How You Use It: Space Law Is an Important Part of the Fight Against Space Debris*, CONVERSATION (Apr. 14, 2021, 4:08 PM), https://theconversation.com/its-not-how-big-your-laser-is-its-how-you-use-it-space-law-is-an-important-part-of-the-fight-against-space-debris-158790 [https://perma.cc/C8UV-XZRE].

[46] Liability Convention, *supra* note 4, art. I(d).

[47] *See id.*

[48] *See* Moon Agreement, *supra* note 4, art. 7.

[49] The parties to the Moon Agreement as of May 2022 are Armenia, Australia, Austria, Belgium, Chile, Kazakhstan, Kuwait, Lebanon, Mexico, Morocco, the Netherlands, Pakistan, Peru, the Philippines, Saudi Arabia, Turkey, Uruguay, and Venezuela. *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, U.N. TREATY COLLECTION, https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXIV-2&chapter=24&clang=_en (Jan. 9, 2022).

[50] Most people agree that one provision in particular gave rise to reluctance on the part of many spacefaring nations to adhere to the Moon Agreement: Article 11 states that natural resources in outer space are the "common heritage of mankind" and envisages a future regulatory regime for the exploitation of space resources through the rational management of those resources as well as the equitable sharing of benefits derived from them. *See* Moon Agreement, *supra* note 4, art. 11. For a more detailed analysis of the Moon Agreement, see Steven Freeland et al., *The Moon Agreement*, *in* 2 COLOGNE COMMENTARY ON SPACE LAW 325–426 (Stephan Hobe, Bernard Schmidt-Tedd & Kai-Uwe Schrogl eds., 2013).

[51] *See generally* Vienna Convention on the Law of Treaties, May 23, 1969, 1155 U.N.T.S. 331 [hereinafter Vienna Convention] (setting out principles generally applicable to treaties).

However, it is true to assert that none of these binding treaty instruments provide a satisfactory framework to effectively tackle the issue of the creation and multiplication of space debris, and to coordinate actions in this regard.

1. Non-Binding "Legal" Instruments

As noted, space debris and their cascading effects represent one of the greatest challenges for the long-term sustainability of space activities.[52] In light of the growing threat of space debris, and in the absence of any satisfactory binding regulation at the international level to address the issue, experts and state representatives have gathered in various international and regional fora to discuss space debris mitigation and outer space activities in general.[53] This has led to the development of several non-binding instruments, through which states voluntarily accept to comply with certain fundamental rules and standards in order to ensure the continuity of space activities in the future.[54]

Their non-binding terms envisage implementation at the national level via national or agency policies and policymakers in the hope that this might ultimately contribute to the formation of a due-diligence—or indeed, due regard—standard, if international practice becomes sufficiently widespread and representative.[55]

---

[52] *See* discussion *supra* Part II.

[53] *See, e.g.*, Comm. on the Peaceful Uses of Outer Space, Annotated Provisional Agenda of the Legal Subcomm. for Its Sixty-First Session, para. 11, U.N. Doc. A/AC.105/C.2/L.319 (2022), https://www.unoosa.org/res/oosadoc/data/documents/2022/aac_105c_2l/aac_105c_2l_319_0_html/AC105_C2_L319E.pdf [https://perma.cc/KE69-HKNB].

[54] *See, e.g.*, European Code of Conduct for Space Debris Mitigation § 2.1–.2 (June 28, 2004), https://www.unoosa.org/documents/pdf/spacelaw/sd/2004-B5-10.pdf [https://perma.cc/44WJ-6J7V] (Contributions from various European space agencies); *see also* Eur. Space Agency [ESA], *Space Debris Mitigation for Agency Projects* 3 (Mar. 28, 2014), https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjJ6Zu4ncz4AhXiH0QIHVGtBLAQFnoECAYQAQ&url=https%3A%2F%2Fwww.iadc-home.org%2Fdocuments_public%2Ffile_down%2Fid%2F4150&usg=AOvVaw2tIGmo5CJXozERqy_jrH_w [https://perma.cc/CFQ5-PNF9]; Int'l Telecomm. Union [ITU], *Environmental Protection of the Geostationary-Satellite Orbit*, Recommendation ITU-R S.1003-2 (Dec. 2010), https://www.itu.int/dms_pubrec/itu-r/rec/s/R-REC-S.1003-2-201012-I!!PDF-E.pdf. [https://perma.cc/322H-UCWM].

[55] *See* European Code of Conduct for Space Debris Mitigation, *supra* note 54, § 2.1–.2.

The main non-legally binding instruments are the 2002 IADC Space Debris Mitigation Guidelines[56] and the 2007 Space Debris Mitigation Guidelines as adopted by COPUOS and endorsed by the United Nations General Assembly.[57] More recently, in June 2019, COPUOS adopted a number of Long-Term Sustainability Guidelines that will also be relevant to the issue of space debris mitigation.[58]

2. *IADC Space Debris Mitigation Guidelines*

Even before the incidents referred to above, it has been recognized that the continuous generation of additional space debris, whether by accident, decay, or deliberate action, causes an ever-increasing collision hazard for human-made satellites.[59] For this reason, it was decided in 1993 to establish among interested space agencies an Inter-Agency Space Debris Coordination Committee (IADC), which is "an international forum of governmental bodies for the coordination of activities related to the issues of man-made and natural debris in space."[60] According to its terms of reference, "[t]he primary purpose of the IADC is to exchange information on space debris research activities between members, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities and to identify debris mitigation options."[61]

In accordance with its mandate, the IADC discussed ways in which the issue of space debris might be addressed. After several years of discussion and debate, the IADC Space Debris Mitigation Guidelines (IADC Guidelines)[62] "were formally adopted [by consensus] in October 2002 during the Second World Space

---

56 *See* Inter-Agency Space Debris Coordination Comm. [IADC], *IADC Space Debris Mitigation Guidelines*, IADC-02-01 (Sept. 2007), https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf [https://perma.cc/2NBT-QADL].

57 G.A. Res. 62/217, (Dec. 22, 2007).

58 *See* U.N. Off. for Outer Space Affs., Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space (2021), https://www.unoosa.org/res/oosadoc/data/documents/2021/stspace/stspace79_0_html/st_space79E.pdf [https://perma.cc/9A63-5T6J].

59 *See* IADC, *supra* note 56, at 4.

60 *Id.* at 3.

61 IADC, *Terms of Reference*, at 7, IADC-93-01 (Oct. 3, 2018), https://www.iadc-home.org/terms_reference [https://perma.cc/4SNV-QG54].

62 IADC, *supra* note 56.

Congress in Houston, Texas."[63] They describe then-existing practices that had been identified and evaluated for their impact on limiting the generation of space debris in the environment.[64]

B. Space Debris Mitigation Guidelines of COPUOS[65]

The IADC presented its Debris Mitigation Guidelines to the Scientific and Technical Subcommittee (STSC) of COPUOS, which had been considering the issue of space debris since 1994.[66] The STSC established a Working Group to develop a set of guidelines based on the IADC standards, and the IADC Debris Mitigation Guidelines thus served as a baseline for the eventual development of the Space Debris Mitigation Guidelines of COPUOS in 2007.[67]

As noted above, in its Resolution 62/217, the United Nations General Assembly endorsed the Space Debris Mitigation Guidelines as adopted by the STSC and agreed that these voluntary guidelines for the mitigation of space debris reflected the existing practices as developed by a number of national and international organizations.[68]

The Guidelines recognize two broad categories of space debris mitigation measures:

(a) "those that curtail the generation of potentially harmful space debris in the near term . . . the curtailment of the production of mission-related space debris and the avoidance of break-ups," and (b) "those that limit their generation over the longer term . . . end-of-life procedures that remove decommissioned spacecraft and launch vehicle orbital stages from regions populated by operational spacecraft."[69]

The seven Guidelines remain at a generalized level and encourage, on a voluntary basis, actions that would:

> [(a)] Limit debris released during normal operations[;]
>
> [(b)] Minimize the potential for break-ups during operational phases[;]

---

63 Nicholas L. Johnson, *Recent Developments in Space Debris Mitigation Policy and Practices*, NASA, https://ntrs.nasa.gov/citations/20060052514 [https://perma.cc/5DLN-Q72P] (Sept. 7, 2013).

64 IADC, *supra* note 56, at 7–10.

65 U.N. Off. for Outer Space Affs., *supra* note 58.

66 *Id.* at iii–iv.

67 *Id.* at iv.

68 *See* G.A. Res. 62/217, *supra* note 57, paras. 1, 27.

69 U.N. Off. for Outer Space Affs., *supra* note 58, at 1.

[(c)] Limit the probability of accidental collision in orbit[;]

[(d)] Avoid intentional destruction and other harmful activities[;]

[(e)] Minimize potential for post-mission break-ups resulting from stored energy[;]

[(f)] Limit the long-term presence of spacecraft and launch vehicle orbital stages in the Low-Earth Orbit (LEO) region after the end of their mission[; and]

[(g)] Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission.[70]

These Guidelines are broad and non-specific, and although they are becoming more widely accepted,[71] they do not provide comprehensive standards covering all aspects of the space debris question. They do not, for example, address issues such as environmental protection and liability, or the politically charged question of the deliberate destruction of space objects, merely stating that it "should be avoided."[72] This is a particularly contentious matter given the fundamental principle of free use and exploration of outer space, enshrined in Article I of the Outer Space Treaty.[73]

More fundamentally, it can be observed that the guidelines reflect an anthropocentric approach and are still very much structured around ideas of state sovereignty and individualism.[74] They focus on the standards that should be implemented in order to prevent damage to spacecraft and ensure access to outer space in the future, and do not touch upon environmental protection as such.[75] Moreover, despite the global consequences of pollution of the space environment and the potential for individual actions to impact the situation, the guidelines fail to promote a coordinated approach to the issue of space debris. The recommendations are focused on technical standards and are directed to COPUOS member states to implement on a volun-

---

70 *Id.* at 2–4.

71 *See* U.N. Off. for Outer Space Affs., *Compendium of Space Debris Mitigation Standards Adopted by States and International Organizations*, https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html#:~:text=the%20compendium%20of%20space%20debris,Subcommittee%20on%20%22General%20exchange%20of [https://perma.cc/SEH6-UU2V].

72 U.N. Off. for Outer Space Affs., *supra* note 8, at 3.

73 Outer Space Treaty, *supra* note 3, art. I.

74 *See* U.N. Off. for Outer Space Affs., *supra* note 8, at 2.

75 *See id.* at 2–4.

tary basis, and thus relate to situations when they are undertaking space activities "individually."[76]

Research by member states and international organizations in the area of space debris should continue in a spirit of international cooperation to maximize the benefits of space debris mitigation initiatives. This document will be reviewed and may be revised, as warranted, in light of new findings. Mention of cooperation is only made once in the Guidelines, in a rather abstract and vague section regarding "Updates."[77] The global character of the issue of space debris and the interconnectedness of states' actions thus seem to be lacking in COPUOS Space Debris Mitigation Guidelines.

C. Guidelines for the Long-Term Sustainability of Outer Space Activities of COPUOS

During its 62nd session in June 2019, COPUOS adopted the Preamble and 21 Guidelines for the Long-Term Sustainability of Outer Space Activities (Long-Term Sustainability Guidelines).[78] These provide guidance on policy and a regulatory framework for space activities; safety of space operations; international cooperation, capacity-building, and awareness; and scientific and technical research and development.[79]

Among the specific issues addressed by the Long-Term Sustainability Guidelines, the problem of space debris is a major element.[80] Indeed, most of the Long-Term Sustainability Guidelines are relevant to the issue of space debris, with the following Guidelines having specific relevance:

> [(a)] Guideline A.1 [–] Adopt, revise and amend, as necessary, national regulatory frameworks for outer space activities[;]
> [(b)] Guideline A.2 [–] Consider a number of elements when developing, revising or amending, as necessary, national regulatory frameworks for outer space activities[;]
> [(c)] Guideline B.1 [–] Provide updated contact information and share information on space objects and orbital events[;]
> [(d)] Guideline B.2 [–] Improve accuracy of orbital data on space objects and enhance the practice and utility of sharing orbital information on space objects[;]

---

76 *See id.*
77 *See id.* at 4.
78 *See* Comm. on the Peaceful Uses of Outer Space, Rep. of the Sci. & Tech. Subcomm. on its Fifty-Sixth Session, U.N. Doc. A/AC.105/C.1/L.366 (2019).
79 *Id.* at 3.
80 *See id.* at 1.

> [(e)] Guideline B.3 [–] Promote the collection, sharing and dissemination of space debris monitoring information[;]
> [(f)] Guideline B.8 [–] Design and operation of space objects regardless of their physical and operational characteristics[;]
> [(g)] Guideline B.9 [–] Take measures to address risks associated with the uncontrolled reentry of space objects[; and]
> [(h)] Guideline D.2 [–] Investigate and consider new measures to manage the space debris population in the long term.[81]

While the Long-Term Sustainability Guidelines are voluntary and non-binding, the Preamble calls upon states to do the following:

> States . . . should voluntarily take measures, through their own national or other applicable mechanisms, to ensure that the guidelines are implemented to the greatest extent feasible and practicable, in accordance with their respective needs, conditions and capabilities, and with their existing obligations under applicable international law, including the provisions of applicable United Nations treaties and principles on outer space.[82]

It remains to be seen the extent to which these practical suggestions are, indeed, implemented into binding national law. Any national implementation of measures directed towards space debris mitigation and remediation should address the relevant elements of each of the Guidelines referred to above. This is a desirable but ultimately complex task.

That said, amongst other things, we consider that the elements contained in the 2019 Long-Term Sustainability Guidelines may support the development of solutions regarding space debris remediation. Remediation is widely believed to be an essential element in order to properly address the growing population of space debris and thus ensure the long-term sustainability of outer space.[83] This was very clearly emphasized in a 2012 Report of the International Association for the Advancement of Space Safety (IAASS) to COPUOS, when it stated the following:

> These mitigation guidelines focus on the mitigation (or reduction) of the rate at which new pieces of space debris are generated. However, in view of the massive amount of debris already in existence in Earth orbit, growing consensus among experts sug-

---

[81] *Id.* at 5–6, 10–11, 15–16, 20.
[82] *Id.* at 3.
[83] *See, e.g.*, J.-C. LIOU ET AL., STABILITY OF THE FUTURE LEO ENVIRONMENT – AN IADC COMPARATIVE STUDY § 5 (2013), https://conference.sdo.esoc.esa.int/proceedings/sdc6/paper/199/sdc6-paper199.pdf [https://perma.cc/6XG8-C8HC].

gests that an active process for the removal of existing debris from space and for on-orbit servicing of satellites is required, in addition to the mitigation efforts.[84]

Overall, while the regulatory framework established through COPUOS's process relating to issues of the mitigation and remediation of orbital space debris does contain important elements relating to best practice notions, it is neither entirely comprehensive nor binding.[85] Given the various significant issues addressed earlier relating to the problems caused by proliferating space debris, we regard it as useful to also consider other measures that have been developed and will now proceed to consider those through the lens of a STS approach.

IV. A SCIENCE AND TECHNOLOGY STUDIES APPROACH TO DEBRIS-RELATED ISSUES UNDER INTERNATIONAL SPACE LAW

Having briefly canvassed the law and law-related approaches to the problems associated with space debris, we now take a different lens with which to analyze the situation—an STS assessment of the issues. As a preliminary question, one might ask a simple question: what does STS have to do with international space law? The answer to this will, it is hoped, becomes clear by the conclusion of this Article. In the following analysis, we present some concepts in STS and demonstrate how alternate ways of thinking about the relationship between technology and society may lead to new paths forward for intractable legal challenges such as addressing the proliferation of space debris.

There are many different ways of conceptualizing the interface (or, indeed, problematizing the notion of a discernible or fixed interface at all) between technology and social systems.[86] Perhaps the most central tenet of contemporary STS approaches is to recognize that science is always, and has always

---

[84] Ram Jakhu, Chair, IASS Legal & Regul. Comm., Presentation to the 49th Session of the Scientific and Technical Subcommittee, Committee on the Peaceful Uses of Outer Space: Active Debris Removal – An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space 5 (2012), https://www.unoosa.org/pdf/pres/stsc2012/tech-21E.pdf [https://perma.cc/D877-ZD9U] (alteration in original).

[85] *See* Comm. on the Peaceful Uses of Outer Space, *supra* note 78, at 1, 3, 5–21.

[86] *See generally* ULRIKE FELT, HANDBOOK OF SCIENCE AND TECHNOLOGY STUDIES (Sheila Jasanoff, Gerald E. Markle, James C. Petersen & Trevor Pinch eds., 1995) (discussing an overview of common STS methodologies).

been, entangled with political and social forces.[87] This contention causes particular discomfort in the space sector, where Cold War interests consistently insisted that science was both apolitical and amoral as a matter of national policy.[88]

The appeal to reason and method that science promised was a useful tool for diffusing political heat, while also producing knowledge and technology to bolster power.[89] Such an approach also had ethical implications. Scientists, we are led to believe, are capable of seeking out hard facts and knowledge independent of their political *milieu.* Such an approach was politically beneficial; in the same way that it made it easier to overlook the deaths of the enslaved workers that Wernher von Braun oversaw at Dora-Mittelbau concentration camp,[90] on the basis that the knowledge *itself* that he promised, and delivered, to the western world was amoral, it also made it simpler to transmute the destructive V2 rocket into the inspirational Saturn V.[91]

The core space treaties arose from a collective understanding that, even if we could believe that science and technology were amoral and apolitical, their development was not without practical consequence.[92] Indeed, when, in 1967, "diplomats came together during the height of Cold War brinksmanship to conclude the Outer Space Treaty,"[93] they "initiated the most significant principle of law for enhancing the common interest of all in space in order to thwart potential colonization ambitions in space."[94] By declaring that outer space "is not subject to national appropriation" by any means, the Treaty established a

---

87 *See* AUDRA J. WOLFE, FREEDOM'S LABORATORY: THE COLD WAR STRUGGLE FOR THE SOUL OF SCIENCE 2 (2018).

88 *See, e.g.*, David Tyfield, *A Cultural Political Economy of Research and Innovation in an Age of Crisis*, 50 MINERVA 149, 154 (2012).

89 *Id.*

90 *See* MICHAEL J. NEUFELD, VON BRAUN: DREAMER OF SPACE, ENGINEER OF WAR 176 (2007); *Dora-Mittelbau: Overview*, HOLOCAUST ENCYC., U.S. HOLOCAUST MEM'L MUSEUM, https://encyclopedia.ushmm.org/content/en/article/dora-mittelbau-overview.

91 *See generally* NEUFELD, *supra* note 90, at 476–77; ROGER D. LAUNIUS, REACHING FOR THE MOON: A SHORT HISTORY OF THE SPACE RACE 118 (2019) (discussing those aspects of the space race involving Von Braun).

92 *See* Rescue Agreement, *supra* note 4; Liability Convention, *supra* note 4; Registration Convention, *supra* note 4; Moon Agreement, *supra* note 4.

93 Kuan-Wei Chen, Ram S. Jakhu & Steven Freeland, *Space Exploration Should Aim for Peace, Collaboration and Co-operation, Not War and Competition*, CONVERSATION (Oct. 11, 2021, 9:11 AM), https://theconversation.com/space-exploration-should-aim-for-peace-collaboration-and-co-operation-not-war-and-competition-169317 [https://perma.cc/FGZ6-STTJ].

94 *Id.*

governance system that placed mutual understanding and friendly relations ahead of individual gain.[95]

Today, 111 countries are parties to the Outer Space Treaty.[96] They undertake to uphold the "common interest" of all humanity to explore and use outer space for "peaceful purposes."[97] The Treaty affirms that outer space is "free for exploration and use by all States . . . on a basis of equality and in accordance with international law."[98] In undertaking such activities, however, states are, as discussed above, required to do so "with due regard to the corresponding interests" of other states.[99]

In essence politics and pragmatism stepped in, and even though they were protagonists in an all-encompassing diplomatic (and physical) war, the major spacefaring states (supported by the remainder of the international community) negotiated the extent to which each was willing to give up certain freedoms in exchange for the collective management of risk.[100]

While that risk might seem more abstract to us in 2022,[101] it was part of the fabric of the lives of those who wrote the treaties. They had lived through World War II in all of its destruction and loss, and were experiencing a time of immense technological change and excitement.[102] Despite some imperfections, their Treaty, which was predicated on a commitment to the idea that science was apolitical (or, at the very least, civil) contributed to a period of diplomacy, cooperation, (pragmatic) friendship, and advancement in the space sciences.[103] But as politically useful as

---

95 *Id.* (quoting Outer Space Treaty, *supra* note 3, art. II).

96 *Id.*

97 Outer Space Treaty, *supra* note 3, pmbl.

98 *Id.* art. I.

99 *Id.* art. IX.

100 *See generally* ALBERT K. LAI, THE COLD WAR, THE SPACE RACE, AND THE LAW OF OUTER SPACE: SPACE FOR PEACE 86–99 (2021).

101 *But see* Holly Ellyatt, *Russian Forces Invade Ukraine*, CNBC, https://www.cnbc.com/2022/02/24/russian-forces-invade-ukraine.html [https://perma.cc/3BXL-93BZ] (Feb. 24, 2022, 11:38 AM) (noting that this might not be entirely true at the moment since this Article is being written at a very tense geopolitical time with an ongoing war in Ukraine).

102 *See, e.g.*, Kristen D. Burton, *The Scientific and Technological Advances of World War II*, NAT'L WW II MUSEUM, https://www.nationalww2museum.org/war/articles/scientific-and-technological-advances-world-war-ii [https://perma.cc/9PCV-8CFD].

103 *See* LAI, *supra* note 100, at 93, 95–97; Stephen Buono, *Merely a 'Scrap of Paper'? The Outer Space Treaty in Historical Perspective*, 31 DIPLOMACY & STATECRAFT 350, 354 (2020).

the idea of objectivity and amorality of "fact" might be, does the idea still serve a pragmatic purpose?

Social constructivist approaches rose in prevalence in the field of STS during the 1970s, a theoretical and practical rejoinder to realist angles.[104] Realism (very simply, the idea that there is a "real world," and that science describes the truth of that reality in increasingly more accurate ways)[105] did not readily address the social and cultural context within which knowledge was formed, distributed, and situated.[106]

According to scholars employing a social constructivism lens, the production of knowledge is necessarily a socially mediated process.[107] They argue that science does not directly translate objective reality (nature) into objective truth (facts).[108] The production of science is inevitably social—whether it is in the laboratory where a version of nature is produced and interrogated, or through the use of instruments such as telescopes that, rather than being direct mirrors of nature, produce a mediated image that is given meaning and significance through human acts.[109]

Having reframed science as a product of social interactions, STS scholars have spent decades sifting through it to form a more complete understanding of how, precisely, society and technology interact with one another.[110]

The 1980s saw a cluster of approaches to understanding society and its relationship to technology. Historian John Ellis's 1986 book, *The Social History of the Machine Gun*, provides a broad brushstroke overview of the implementation (or lack thereof) of machine gun technologies and the social reasons for their adop-

---

104 SERGIO SISMONDO, AN INTRODUCTION TO SCIENCE AND TECHNOLOGY STUDIES 51–52 (2004).

105 *Id.* at 52.

106 Everett Mendelsohn, *The Social Construction of Scientific Knowledge*, *in* 1 THE SOCIAL PRODUCTION OF SCIENTIFIC KNOWLEDGE 3, 6 (Everett Mendelsohn, Peter Weingart & Richard Whitley eds., 1977).

107 *See* SISMONDO, *supra* note 104, at 55.

108 *See id.*

109 *See id.*; KARIN KNORR-CETINA, THE MANUFACTURE OF KNOWLEDGE: AN ESSAY ON THE CONSTRUCTIVIST AND CONTEXTUAL NATURE OF SCIENCE 4 (1981); *see also* Catherine Wilson, *Instruments and Ideologies: The Social Construction of Knowledge and Its Critics*, 33 AM. PHIL. Q. 167, 171 (1996) (discussing optical instruments in the context of constructing scientific knowledge).

110 *See* SISMONDO, *supra* note 104, at 10; *see also* Annie Handmer, Making a Success of 'Failure': A Science Studies Analysis of PILOT and SERC in the Context of Australian Space Science 15–16, (Sept. 30, 2021) (Ph.D. thesis, University of Sydney), https://ses.library.usyd.edu.au/bitstream/handle/2123/27383/handmer_ag_thesis.pdf?sequence=2&isAllowed=y.

tion and resistance in particular contexts.[111] The book argues that changes in military technology are inseparably intertwined with the social fabric of the cultures within which they were adopted.[112] On Ellis's view, it would be futile to try to understand technology without also understanding how it is actively shaped by social networks, and it would be equally foolish to try to study social networks without reference to the technologies around which they arrange themselves.[113] He writes:

> The history of technology is part and parcel of social history in general. The same is equally true of military history, far too long regarded as a simple matter of tactics and technical differentials. Military history too can only be understood against the wider social background. For as soon as one begins to discuss war and military organisation without due regard to the whole social process, one is in danger of coming to regard it as a constant, an inevitable feature of international behaviour. In other words, if one is unable to regard war as a function of particular forms of social and political organisation and particular stages of historical development, one will not be able to conceive of even the possibility of a world without war.[114]

Two things stand out from Ellis's call to action. The first is the use of the phrase "due regard," which coincidentally also appears in Article IX of the Outer Space Treaty.[115] The phrase has been cast by space law practitioners as the "due regard principle," and it introduces an objective "due diligence" concept that is dependent on the particular circumstances.[116]

In Ellis's use, due regard naturally means something different, but there are nonetheless elements in common that we feel provide analytic value. STS compels us to consider a phenomenon within its context, rather than in abstraction.[117] To do so, it is necessary to understand everything surrounding that phenomenon, from policy to culture to technology to economics (the whole social process), and to examine how these factors intersect with each other as well as with the subject.

---

[111] *See* JOHN ELLIS, THE SOCIAL HISTORY OF THE MACHINE GUN 1–9 (Pantheon Books, Random House & Croom Helm Ltd. 1975).

[112] *Id.* at 9.

[113] *Id.*

[114] *Id.* at 9–10.

[115] *See* Outer Space Treaty, *supra* note 3, art. IX.

[116] *See, e.g.*, Pavesi, *supra* note 43, at 22.

[117] SISMONDO, *supra* note 104, at 55.

Similarly, paying "due regard to the corresponding interests of all other States Parties to the Treaty"[118] in the pursuit of technological ends necessarily prompts a number of inherently social, rather than technological, questions: Who are the other parties? What are their interests? Which of these interests might fall within the qualification of "corresponding?" How much regard is due, and what practical form might it take? In our view, the answer to this last question might also consider what the consequences would be if the other parties perceive that the regard paid to their interests does not meet the benchmark of what they feel is due, and the precedent that action of enforcing their rights might set for future interpretations of Article IX.

Importantly, it is the process of enacting due regard and engaging actively in trying to answer these questions (requiring international cooperation and dialogue) that in itself constitutes a large component of due regard. The due regard principle cannot be solved in isolation by lawyers.

The second aspect that stands out flows directly from this observation. Ellis insists that attention to the social process is essential, not just as a matter of academic interest but from a practical standpoint.[119] Because technology is so inseparable from society, failure to question the inevitability of an outcome facilitates its continuation.[120] This is not quite the same as identifying a linear, one-way chain of causation (the belief that something is inevitable does not on its own guarantee that it will occur), but it does highlight that the relationship society has with technology, and the structures and institutions we form around it, are not influenced by technology alone.

Indeed, social constructivist approaches to technology have historically problematized technological determinism. In 1985, Melvin Kranzberg, a leader in the field of the history of technology, presented his presidential address to the Society for the History of Technology.[121] In it, he argued that adopting a stance of technological determinism (which he defines as the idea that our society is shaped mainly by technology) on the basis that technology has somehow "outrun human control" is a kind of intellectual cliché.[122] The resonances for the space industry,

---

[118] Outer Space Treaty, *supra* note 3, art. IX.

[119] *See* ELLIS, *supra* note 111, at 9–10.

[120] *Id.*

[121] Melvin Kranzberg, TECHNOLOGY AND HISTORY: "Kranzberg's Laws", *in* 27 TECH. & CULTURE 544 (1986).

[122] *Id.* at 545.

with its frequent assertions that technology necessarily outpaces regulation, are clear.

At the same time, failure to regulate and reach agreements on new challenges, given the extent to which terrestrial activities are reliant on satellite infrastructure, presents a uniquely high risk.[123] Such challenges occupy precisely this awkward space because they have to do with emerging technologies and associate emerging social and institutional structures (industry).

In our view, a core strength of our existing principles of international space law is that they do not attempt to restrict technologies: They instead regulate *behaviors* in two important ways. First, they establish norms (abstract), and secondly, they arise out of and sustain particular social structures—in this instance, primarily COPUOS (practical). To effect societal change or influence the use of technology, a technologically deterministic approach requires that we regulate technology itself. We believe that a social constructivist lens, on the other hand, may offer another way through regulation of the social process.

Kranzberg's speech also summarized six principles for technology that are now famous (at least to a certain set of people) as "Kranzberg's Laws."[124] The first of these is probably the most widely known—"technology is neither good nor bad; nor is it neutral."[125] However, his fourth principle is more immediately relevant and reads: "Although technology might be a prime element in many public issues, nontechnical factors take precedence in technology-policy decisions."[126] We suggest that a technologically sensitive analysis of international space law—what Kranzberg might call a "social instrument"[127]—is an essential task if we are to have any way of understanding how the rapidly developing technologies, along with other factors, challenge its core principles.

It is possible to see one example of Kranzberg's fourth law in action in the international law-related efforts to regulate, reduce, and remove space debris as described above. Here, all of the agreed guidelines have tended to focus on reducing the quantity of debris in orbit by proposing standards for preventing

---

123 *See* Ahmad Alsharoa, Emna Zedini & Mohamed-Slim Alouini, *Downlink Resource Allocations of Satellite–Airborne–Terrestrial Networks Integration, in* 123 ADVANCES IN COMPUTERS 1, 8–9 (2021).

124 *Id.* at 545–60 (discussing Kranzberg's six laws).

125 *Id.* at 545.

126 *Id.* at 550.

127 *Id.* at 553.

break-ups, speeding up de-orbit, and avoiding collisions.[128] However, they are also non-binding,[129] and in order to achieve international consensus (a significant achievement), they are consequently hazy on technical details. Precisely how compliance with the guidelines should be achieved by commercial entities at a national level is left for national governments to legislate.

By way of example, in Australia, an application for a Launch Permit under the *Space (Launches and Returns) Act 2018* requires that "an application for the grant of an Australian launch permit must include a strategy for debris mitigation" and that "[t]he strategy must address the matters prescribed by the rules for the purposes of this subsection."[130] The Rules to the Act specify that "[t]he strategy for debris mitigation in the application must be based on an internationally recognised guideline or standard for debris mitigation, and identify the guideline or standard being used."[131] They also state that "[t]he strategy must describe any mitigation measures planned for orbital debris arising from the proposed launch or launches (including from payloads)" and provide an example of how to address the following:

> (a) how debris may be limited during normal operations;
> (b) how the potential for break-ups during operational phases will be minimised;
> (c) how the probability of accidental collision in orbit will be limited;
> (d) how the potential for post-mission break-ups as a result of stored energy will be minimised; and
> (e) how the long-term presence of payloads and launch vehicle orbital stages in the low-earth orbit region or in geosynchronous earth orbit will be limited after the end of the mission.[132]

Precisely how—the technical part of the problem—is left to each applicant to solve in that applicant's own way.

In many ways, this is a useful way of drafting regulation to deal with a rapidly developing technological landscape. Arguably, law should not purport to keep pace with this technological change with respect to space, given that the developments are so rapid and fluid. Today's technology is often quite quickly rendered

[128] IADC, *supra* note 56, at 7–10.
[129] *See id.* at 3, 5.
[130] *Space (Launches and Returns) Act 2018* (Cth) s 34(2)–(3) (Austl.).
[131] *Space (Launches and Returns) (General) Rules 2019* (Cth) r 54(1) (Austl.).
[132] *Id.* r 54(2).

obsolete (or at least insufficient) in tomorrow's world.[133] Therefore, to assert that the legal framework is completely up-to-date in every way is misleading and may even lead to complacency. Conversely, to attempt to provide for every conceivable future development might amount to seeking to regulate for the "unknown," which brings with it another set of inherent risks.[134]

By asking applicants to adhere simply to "an internationally recognised guideline or standard,"[135] the legislation and accompanying regulations remain flexible, automatically updating-without-updating to any international changes in best practice. Likewise, by identifying a non-exhaustive list of issues that might be addressed in the plan, the rules push responsibility for identifying technological solutions onto the applicant, while leaving the methods open for innovation.[136] They also incentivize government and commercial entities alike to engage actively in the formation of international standards, facilitating bottom-up regulatory participation. Nonetheless, they present a non-trivial challenge to applicants in determining and applying best practices and innovations according to their best judgment.

V. DEBRIS REMEDIATION THROUGH ACTIVE DEBRIS REMOVAL

While adherence to mitigation guidelines can reduce the proliferation of debris, the problem of what to do with existing defunct objects in orbit remains. A variety of technological solutions, from robotic arms to adhesives, foam, harpoons, tethers, nets, lassos, tentacles, and high-power lasers, have been mooted (and even funded) to try to remove objects from orbit.[137]

This process is called Active Debris Removal (ADR).[138] At this stage, despite technological progress on concept development and even controlled experimentation and testing, ADR has yet to be successfully demonstrated on a real debris target in or-

---

133 Declan Butler, *Tomorrow's World*, 530 NATURE 398, 399 (2016).

134 *See* Steven Freeland, *International Law and the Exploration and Use of Outer Space*, *in* RISK AND THE REGULATION OF UNCERTAINTY IN INTERNATIONAL LAW 77, 82 (Mónika Ambrus, Rosemary Rayfuse & Wouton Werner eds., 2017).

135 *Space (Launches and Returns) (General) Rules 2019* r 54(1).

136 *See id.*

137 *See* Minghe Shan, Jian Guo & Eberhard Gill, *Review and Comparison of Active Space Debris Capturing and Removal Methods*, 80 PROGRESS AEROSPACE SCIS. 18, 19–22 (2016); Handmer, *supra* note 110, at 104.

138 *See* P.J. Blount, *On-Orbit Servicing and Active Debris Removal: Legal Aspects*, *in* PROMOTING PRODUCTIVE COOPERATION BETWEEN SPACE LAWYERS AND ENGINEERS 179, 179–80 (Anja Nakarada Pecujlic & Matteo Tugnoli eds., 2019).

bit.[139] ADR presents significant technological challenges: Generally, the first step is proximity, then rendezvous, followed by capture and disposal, which may involve the release or the "sacrifice" of the debris-removal vehicle itself.[140] The process is highly complicated however it is approached, and it needs to happen remotely, hundreds or thousands of kilometers away from the surface of the Earth.[141]

But ADR also presents a highly nuanced political challenge that hinders its implementation.[142] Technologies that are capable of achieving the steps involved in ADR are dual-use, meaning that they could be used as easily for hostile purposes as peaceful ones.[143] While many space (and other) technologies fall into this dual-use category, ADR technologies are particularly fraught because the activities they necessarily carry out to remove debris—proximity; rendezvous; grappling; and disposal of an object that may be minimally characterized, unfamiliar, and uncooperative—are identical to the potential steps that, in our view, would likely be involved in the operation of space weaponry.[144]

To date, attempts under international law to identify a difference between ADR and weapons systems at a technological level that can be defined and translated into international regulation have not been successful.[145] Scholars in international law have noted the tension between the way the Outer Space Treaty privi-

---

139 *See* Leonard David, *Space Junk Removal Is Not Going Smoothly*, SCI. AM. (Apr. 14, 2021), https://www.scientificamerican.com/article/space-junk-removal-is-not-going-smoothly/; *see also* Handmer, *supra* note 110, at 73.

140 NASA, STTR 2011 PHASE I SOLICITATION 1 (2011).

141 *See* J.-C. LIOU, ACTIVE DEBRIS REMOVAL – A GRAND ENGINEERING CHALLENGE FOR THE TWENTY-FIRST CENTURY 4 (2011), https://ntrs.nasa.gov/citations/20110011986.

142 *See* JOAN JOHNSON-FREESE, SPACE WARFARE IN THE 21ST CENTURY: ARMING THE HEAVENS 30–31 (2016); *see also* Claude R. Phipps, *A Laser-Optical System to Re-enter or Lower Low Earth Orbit Space Debris*, 93 ACTA ASTRONAUTICA 418, 428 (2014) (discussing the need for international cooperation before a laser-optical system can be used for space debris removal).

143 *See* Handmer, *supra* note 110, at 65; Phipps, *supra* note 142, at 418, 428; Jakub Pra_ák, *Dual-Use Conundrum: Towards the Weaponization of Outer Space?*, 187 ACTA ASTRONAUTICA 397, 397 (2021); Bohumil Doboš & Jakub Pra_ák, *To Clear or to Eliminate? Active Debris Removal Systems as Antisatellite Weapons*, 47 SPACE POL'Y 217, 218 (2019).

144 Pra_ák, *supra* note 143, at 401–02.

145 *See, e.g.*, Anne-Sophie Martin, Opinion, *Forty Years of Negotiations on PAROS: Outcomes and New Challenges*, SPACEWATCH GLOB., https://spacewatch.global/2020/11/spacewatchgl-opinion-forty-years-of-negotiations-on-paros-outcomes-and-new-challenges/ [https://perma.cc/TW4P-UDAT].

leges ideas of "peaceful use" of space and the ubiquity of dual-use technologies,[146] which the Treaty and its associated social structures tries to regulate without doing so explicitly. Some have gone so far as to classify this tension (and a perceived legal gap) as a *lacuna*.[147] The core of the challenge is in drawing clear lines: What is a weapon, and what is not? What is military and what is civil? What makes a space object "debris?" Without clear definitions for all of these terms, regulatory efforts have historically stalled and are difficult to revive.

Two examples of this impasse in action are the Prevention of an Arms Race in Outer Space (PAROS) process,[148] which has to date been unsuccessful in its efforts to define the term "space weapon,"[149] and an attempt by the Space Generation Advisory Council (SGAC) to assess ADR methods against a scorecard that incorporated legal, economic, and policy criteria as well as technical viability.[150] SGAC was unable to identify a viable ADR option, instead falling back on the need to define "space debris" itself, among other things.[151]

Readers might well say, "Of course the issue in both these cases was not the definition of the technology, but a problem of politics." But this is precisely the point; many current legal efforts persist in the belief that if we could only get past the politics, there is some workable definition to be found.[152] At the same time, ADR (and other emerging dual-use space technologies) are indivisibly entangled with social factors—most notably, geopolitics. It is politics, not technology, that makes an ADR sys-

---

146 *See, e.g.*, Christopher Newman, Ralph Dinsley & William Ralston, *Introducing the Law Games: Predicting Legal Liability and Fault in Satellite Operations*, 67 ADVANCES SPACE RSCH. 3785, 3787 (2021).

147 *See, e.g.*, Blount, *supra* note 138, at 180–85.

148 See the numerous United Nations General Assembly (UNGA) Resolutions, beginning with Resolution 36/97C, which has been directed towards the "Prevention of an Arms Race in Outer Space." G.A. Res. 36/97C (Dec. 9, 1981). Most recently, the United Nations General Assembly adopted Resolution 76/230, which called on all states, in particular those with major space capabilities, "[t]o take urgent measures to prevent for all time the placement of weapons in outer space and the threat or use of force in outer space, from space against Earth and from Earth against objects in outer space." G.A. Res. 76/230, art. 3(a) (Dec. 24, 2021).

149 Blount, *supra* note 138, at 182.

150 Matteo Emanuelli, Giulia Frederico, Joshua Loughman, Deva Prasad, Tiffany Chow & Minoo Rathnasbapathy, *Conceptualizing an Economically, Legally, and Politically Viable Active Debris Removal Option*, 104 ACTA ASTRONAUTICA 201–02 (2014).

151 *Id.* at 200.

152 *See* Blount, *supra* note 138, at 182.

tem a weapon. Likewise, it is the result of what is essentially a political process that any regulatory instrument—whether binding or not—is developed through COPUOS, where decisions are made by consensus, thus enabling horse trading and compromise to achieve an end result.[153]

Thus, efforts to strip out politics are, on this view, well-intentioned but at times unlikely to yield useful results. If approaches that seek to divide categories have proven unsatisfactory, STS might be a useful resource for sparking more sympathetic ways of conceptualizing the entanglements of the problem itself, offering new paths towards solutions that incorporate social and political factors as well as technological and legal ones.[154]

VI. DEBRIS REMEDIATION THROUGH RENDEZVOUS AND PROXIMITY OPERATIONS

Already, international efforts are emerging that attempt to update regulatory frameworks to apply in helpful ways to aspects of ADR. One such aspect worthy of examination is an early step in many ADR proposals—Rendezvous and Proximity Operations (RPOs).[155]

The ability to get close to an object in orbit (proximity operation)—defined by The Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) as the "[s]eries of orbital maneuvers executed to place and maintain a spacecraft in the vicinity of another space object on a relative planned path for a specific time duration to accomplish mission objectives"[156]—is an essential step in most activities that have the capacity to improve the sustainability of space activities.[157] On-orbit servicing, for example, involves a diagnostic step that may require imaging or sensing from a proximate location.[158]

Rendezvous (the act of actually making contact with a space object) is of significant value for extending the life of existing

---

[153] Mehak Sarang, Op-Ed, *Thoughts on UN COPUOS*, SPACE GENERATION ADVISORY COUNCIL (Aug. 4, 2019), https://spacegeneration.org/oped-thoughts-on-un-copuos [https://perma.cc/T5F7-XCML].

[154] *See generally* Handmer, *supra* note 110, at 137–38 (discussing a detailed empirical study of ADR technology development through an STS lens).

[155] *See* CONSORTIUM FOR EXECUTION OF RENDEZVOUS AND SERVICING OPERATIONS, GUIDING PRINCIPLES FOR COMMERCIAL RENDEZVOUS AND PROXIMITY OPERATIONS (RPO) AND ON-ORBIT SERVICING (OOS) 1–2 (2021).

[156] *Id.* at 2.

[157] *Id.* at 1–2.

[158] *See id.* at 2.

space assets, whether through servicing, refueling, repair, or attachment of additional modules (for example, thrusters).[159] RPOs can also be used to characterize, move, or remove debris.[160] For commercial entities, the question of "how close is too close?" is a difficult, but important, one to resolve.

One of the core principles placed on states and outlined in Article IX of the Outer Space Treaty is, as noted above, the obligation to undertake space activities "with due regard to the corresponding interests of all other States Parties to the Treaty."[161] The same Treaty provision also requires states to "undertake appropriate international consultations" before they conduct any "activity or experiment" that may "cause potentially harmful interference" with other states' activities.[162] The combination of these principles is notable in that it prompts states not only to curtail their activities but also to engage proactively in international discussions. In resolving the question "how close is too close," Article IX asks states to consider whether potentially harmful interference could arise, and if so, to initiate a consultation process.[163]

In theory, this principle is a failsafe. In practice, it would be extremely rare for a state to initiate a consultation along these lines prior to engaging in a space activity. Moreover, the growing number of commercial entities looking to conduct RPOs as part of their operations (whether they are passing through or intending to lurk closely to another satellite, or perhaps even carrying out ADR)[164] challenges the effective operation of this principle. The obligation to conduct consultations rests with the state, not with the commercial entity.

This is not to say that commercial activities are unregulated—for example, the Rules to the relevant Australian national space law require the owner of any payload (who is an Australian national) seeking a permit to "not operate the payload in a manner that causes Australia to be liable for any damage under the Liability Convention" and to "not operate the payload in a man-

---

159 *See, e.g.*, GODDARD SPACE FLIGHT CTR., NASA, ON-ORBIT SATELLITE SERVICING STUDY PROJECT REPORT 70, 87–88 (2010).

160 *Id.* at 38.

161 *See supra* notes 115–18 and accompanying text; *see also* Outer Space Treaty, *supra* note 3, art. IX.

162 Outer Space Treaty, *supra* note 3, art. IX.

163 *Id.*

164 BRUCE MCCLINTOCK, KATIE FIESTEL, DOUGLAS C. LIGOR & KATHRYN O'CONNOR, RAND CORP., RESPONSIBLE SPACE BEHAVIOR FOR THE NEW SPACE ERA: PRESERVING THE PROVINCE OF HUMANITY 18 (2021).

ner that the owner knows, or ought reasonably to know, will negatively affect the national security of Australia."[165]

Arguably representing proxies for "due regard," these provisions go a long way in our view to strongly encouraging commercial entities to avoid reckless behavior. However, there are some nuances to the wording. Rather than simply asking applicants to demonstrate *how* they will avoid causing damage, Rule 50(1)(j)(iv) asks them to undertake *not to cause* Australia to be liable under an international treaty (the Liability Convention),[166] arguably passing on responsibility from the state (to continually supervise) to the commercial entity itself. In other words, reading the text as written, the implication is that such causation may be assessed in a context of result, not intention.[167]

The consequence involves a series of nested binary conditions that exist in an uncertain future state—should hypothetical damage occur at any time in the future and should Australia be found liable under international law (an international state-to-state legal process), the domestic legal question may then hinge on whether the commercial entity operated the payload in a manner that caused the *liability*, not the damage.[168] Rule 50(1)(j)(v), on the other hand, leaves the specific range of consequences and actions that may "negatively affect . . . national security,"[169] placing a significant burden on applicants to consider not only technological factors but also political issues. A significant degree of professional judgement is required on this point, since the factors that may contribute to a space activity being viewed as a political threat are many and varied. Importantly, answering "how close is too close" with "caus[ing] Australia to be liable" and possibly "negatively affect[ing] the national security of Australia" does not provide useful technological parameters for the people making technical decisions—generally engineers.[170]

The questions raised here will no doubt be resolved if and when this part of the law is tested. The point of this analysis is simply to illustrate the complexities through the example of one domestic regulatory system in the way that it seeks to address the

---

165 *Space (Launches and Returns) (General) Rules 2019* (Cth) r 50(1)(j)(iv)–(v) (Austl.).

166 *Id.* r 50(1)(j)(iv).

167 *See id.*

168 *See id.*

169 *Id.* r 50(1)(j)(v).

170 *Id.* r 50(1)(j)(iv)–(v).

distribution of responsibility. Clearly, it is important to provide clarity for commercial operators to ensure safe and cohesive approaches to emerging and established space activities. This follows from the fact that space in many ways is now playing an important private role.[171] The beginning of the 1990s saw the commercialization of space expand rapidly.[172] Since 1998, the value of the commercial space sector has exceeded that of the government space sector.[173] The global commercial space economy in 2021 totaled approximately $370 billion[174] and is anticipated to grow to between $1–3 trillion by the 2040s.[175]

The commercialization of outer space is highly significant, and a growing array of private space actors seek enabling rules of the space road that would allow them to expand their potential business opportunities with strong government support but minimal government interference.[176] In return, many—but not all—countries develop their sovereign space capabilities through partnering with the private sector and by leveraging the technological advancements of the private sector.[177] The public–private relationship in space for those countries is an essential two-way street.

This requires that complex and sometimes competing elements be considered in the ongoing development of regulatory and governance structures for space at both the international and national levels. The international law principles are based on a notion of shared and common interests in space, even going so far as to require, as noted, that space activities are to be "carried out for the benefit and in the interests of all countries."[178] One overarching theme of this international regime is that countries are responsible for ensuring that all activities that

---

171 *See* Steve Simon, *A Cause for Concern: Developing Regulatory Competitions in NewSpace*, 187 ACTA ASTRONAUTICA 212, 212 (2021).

172 *See* Loring Wirbel, *The Space Industry: Supporting U.S. Supremacy*, INST. FOR POL'Y STUDS. (Oct. 4, 2005), https://ips-dc.org/the_space_industry_supporting_us_supremacy/ [https://perma.cc/DH83-PN44].

173 Freeland, *supra* note 2.

174 Press Release, Euroconsult, Euroconsult Estimates That the Global Space Economy Totaled $370 Billion in 2021 (Jan. 11, 2022), https://www.euroconsult-ec.com/press-release/euroconsult-estimates-that-the-global-space-economy-totaled-370-billion-in-2021/ [https://perma.cc/RX4J-G4XZ].

175 *See* KEITH W. CRANE, EVAN LINCK, BHAVYA LAL & RACHEL Y. WEI, INST. FOR DEF. ANALYSES, MEASURING THE SPACE ECONOMY: ESTIMATING THE VALUE OF ECONOMIC ACTIVITIES IN AND FOR SPACE 33, 35 (2020).

176 *See* Simon, *supra* note 171, at 218.

177 *See id.*; Handmer, *supra* note 110, at 74–76.

178 Outer Space Treaty, *supra* note 3, art. I.

they and their corporate and private citizens undertake in space will adhere to the globally accepted principles of law.[179]

However, one might easily conclude that these foundational principles are not necessarily always squarely in sync with the needs of private commercial actors, who operate around a carefully calibrated risk/reward calculation when determining their investments in space. For companies operating in the space sector, the answers to uncertain questions have real impacts for whether they can secure a permit, get insurance, and receive spectrum allocation, in addition to affecting the cost of their product. Governments therefore need to carefully balance these competing factors when crafting national space regulations. They are bound by the important global principles of international space law, but at the same time, some of those governments will also wish to encourage private and commercial involvement in space, for their own benefit and for the growth of their industry, domestic economy, inward and outward foreign direct investment, and the enhancement of their strategic technological competitiveness.

As our analysis demonstrates, law cannot provide certainty where these and other political, social, and technological questions are so enmeshed. Australia is just one example that illustrates how provisions that seem simple at first glance incorporate a breadth of political considerations that may impact the development, regulation, and operation of technology.

VII. EXAMPLE: APPLYING KRANZBERG'S "LAWS"

On the basis of the prior analysis, we now present three distinct types of solutions to the "uncertainty gap" that arises when non-technical factors take precedence in inherently political decisions about technology.[180] These are the following:

1. The delegation of international obligation to domestic regulatory authorities;
2. The proliferation of non-governmental entities that provide transparency to an otherwise opaque area;
3. The development of industry-led regulatory guidelines.

The first type, the delegation of international obligation to a government-established regulatory body, includes, for example, Australia's launch-permit rules.[181] The relevant regulatory

179 *See id.* arts. VI–VII.

180 *See generally* Kranzberg, *supra* note 121, at 544–60.

181 *See Space (Launches and Returns) (General) Rules 2019* (Cth) pt 3 (Austl.).

agency, the Australian Space Agency, has responsibility for enacting the authorization process, which incorporates aspects of the due regard principle as well as the obligation to carry out authorization and continuing supervision.[182] Another example is the delegation of responsibility for managing spectrum, which in Australia falls to the Australian Communications and Media Authority (ACMA).[183] ACMA liaises with the International Telecommunication Union (ITU) on behalf of commercial entities.[184]

The second type of solution to the "uncertainty gap," the proliferation of non-governmental entities that increase transparency by making space activities public, contributes to the formation of precedent by providing open-source intelligence and reports. Examples include Gunter's Space Page,[185] Jonathan McDowell's General Catalog of Artificial Space Objects and Space Report,[186] and collation products such as Secure World Foundation's Global Counterspace Capabilities Report (published annually)[187] and CSIS's Space Threat Assessment.[188] The latter organizations also facilitate informal international discussions, which progress consensus and provide commercial entities with the opportunity to contribute alongside national representatives.[189]

---

182 AUSTL. SPACE AGENCY, ADVANCING SPACE: AUSTRALIAN CIVIL SPACE STRATEGY 2019 – 2028, at 8 (2019); *see also Space (Launches and Returns) Act 2018* (Cth) (Austl.); *Space (Launches and Returns) (General) Rules 2019*.

183 *See Launch or Communicate with a Small Satellite or CubeSat*, AUSTL. COMMC'NS & MEDIA AUTH., https://www.acma.gov.au/launch-or-communicate-small-satellite-or-cubesat [https://perma.cc/QZ3N-SX8F] (Nov. 6, 2019).

184 *Id.*

185 Gunter D. Krebs, *Gunter's Space Page*, https://space.skyrocket.de/index.html [https://perma.cc/U55H-ES87] (Feb. 7, 2022).

186 Jonathan C. McDowell, *General Catalog of Artificial Space Objects*, https://planet4589.org/space/gcat [https://perma.cc/FH7S-B6Q6] (June 30, 2022); *see also* Jonathan McDowell, *Jonathan's Space Report* (June 27, 2022), https://planet4589.org/jsr.html [https://perma.cc/HQ4V-2DL3] (providing launch information spanning multiple nations).

187 SECURE WORLD FOUND., GLOBAL COUNTERSPACE CAPABILITIES: AN OPEN SOURCE ASSESSMENT (Brian Weeden & Victoria Samson eds., 2022), https://swfound.org/counterspace/ [https://perma.cc/3CXQ-3TXB].

188 TODD HARRISON, KAITLYN JOHNSON, JOE MOYE & MAKENA YOUNG, CTR. FOR STRATEGIC & INT'L STUD., SPACE THREAT ASSESSMENT (2021), https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/210331_Harrison_SpaceThreat Assessment2021.pdf?gVYhCn79enGCOZtcQnA6MLkeKlcwqqks [https://perma.cc/P494-6AXV].

189 *See, e.g.*, Ctr. for Strategic & Int'l Stud., *Space Security: Issues for the New U.S. Administration*, YOUTUBE (Mar. 22, 2017), https://www.youtube.com/watch?v=LFtY2-NKX0E&t=4846s [https://perma.cc/UR83-FNWW].

The third emerging-solution category concerns the rising interest in and development of industry-led regulatory instruments. In the absence of clear specifications from national regulators and the presence of non-specific and non-binding international guidelines, big commercial players have begun working together to define their own answers to questions such as "how close is too close." One such organization is CONFERS,[190] comprising corporate members receiving initial funding from the Defense Advanced Research Projects Agency (DARPA) in the United States. Beginning from the presumption that RPO and On-Orbit Servicing (OOS) activities *will* occur, CONFERS aims to coordinate directly between commercial actors to form accepted norms of behavior and share information.[191] In October 2021, CONFERS released its updated *Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS)*.[192] The set of four non-binding guidelines narrows the bounds within which a commercial actor is supposed to operate,[193] in effect forcing the establishment of best practices by agreement, rather than waiting for precedent.

Given the emerging nature of this category, and the interesting dynamic it adds to the overall space-policy landscape, we have provided further analysis on these guidelines below.

The first principle is "Consensual Operations"—the document specifies, "RPO for on-orbit services with artificial space objects will be conducted via commercial agreements between consenting parties."[194] This principle focuses on behavior rather than technological capability.

The second principle addresses the regulatory uncertainties that currently exist in the nexus between international and domestic law, and thereby between domestic law and commercial entities; the principle states that, in addition to being compliant with domestic laws of the client space object and servicer, "the collaborating parties will conduct their operations in full compliance with the [Outer Space Treaty]."[195]

---

190 For background information about CONFERS, see *What is CONFERS?*, CONSORTIUM FOR EXECUTION OF RENDEZVOUS & SERVICING OPERATIONS, https://www.satelliteconfers.org/ [https://perma.cc/W4FR-83FB].

191 *Id.*

192 CONSORTIUM FOR EXECUTION OF RENDEZVOUS & SERVICING OPERATIONS, *supra* note 155, at 1.

193 *Id.*

194 *Id.*

195 *Id.*

The third principle concerns "Responsible Operations" and specifies a short list of measures that contribute to responsible practice, including use of "generally accepted engineering practices appropriate to the proposed activity," debris mitigation, establishment and maintenance of communications during an operation, and a requirement for insurance to "reasonably cover the risk of the activity to third parties."[196] Importantly, the list also includes a common-sense clarification as to what best practices entails, stating that "[b]est practices and standards for commercial servicing will be based upon actual, accumulated operational experience."[197] Not only does this principle serve to unshackle commercial operators from limits based on purely theoretical assessments (at least in an aspirational sense), it also acknowledges the extent to which RPO activities are still in their nascent stage.

The final guiding principle is "Transparent Operations."[198] CONFERS proposes that "[p]arties conducting commercial servicing operations will work within the principle of transparency to promote safety and trust."[199] The guidelines go on to state that "parties conducting the servicing operation will notify the relevant State(s) of the general nature, conduct, locations, and results of servicing operations" and that "[t]he parties conducting the servicing operation will develop and implement a protocol that provides timely public notification of anomalies or mishaps that could have an adverse impact on other entities or the space environment."[200]

Inherent within the guidelines is a compromise. In order to establish best practices and precedent and to improve the environment of "safety and trust," CONFERS suggests that commercial parties should "look for opportunities to share lessons learned from operational successes and anomalies while protecting intellectual property and competition-sensitive information, and complying with export control regulations."[201]

However, the most interesting part of the guidelines is the invocation of the due regard principle.[202] In addition to stating

---

[196] *Id.*

[197] *Id.* at 2.

[198] *Id.*

[199] *Id.*

[200] *Id.*

[201] *Id.*

[202] *See id.*

that all parties should conduct operations in compliance with the Outer Space Treaty, CONFERS specifies that

> [i]n keeping with Article IX and Article XI of the [Outer Space Treaty], the parties conducting the servicing operation will operate with due regard to other space activities. They will ensure sufficient communication and coordination with entities that could reasonably be affected by the servicing operation to support safety and avoid harmful interference.[203]

CONFERS's guiding principles are non-binding, but they represent an important bottom-up process by which parties looking to operate in space recognize that in order to manage risk and ensure ongoing sustainability of operations, there is a strong incentive to self-regulate.[204] Rather than acting as if space were an unregulated "Wild West," which would create significant operational risk and increase the likelihood of unsuitable regulations being hurriedly applied from the top-down at a later date, companies are also themselves beginning to create instruments and fora through which they can define boundaries and answer non-technical questions that inform technological decisions. From an academic STS perspective, we feel that approaches such as that taken by CONFERS could offer a rich opportunity for detailed analysis through contemporary frameworks such as co-production.[205]

VIII. CONCLUDING OBSERVATIONS

A variety of technological developments appears to be provoking challenges to the peaceful uses of space, whether they emerge principally from political, technological, or social is-

---

[203] *Id.* at 2. Article XI of the Outer Space Treaty provides as follows:

> In order to promote international co-operation in the peaceful exploration and use of outer space, States Parties to the Treaty conducting activities in outer space, including the moon and other celestial bodies, agree to inform the Secretary-General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities. On receiving the said information, the Secretary-General of the United Nations should be prepared to disseminate it immediately and effectively.

Outer Space Treaty, *supra* note 3, art. XI.

[204] *See* CONSORTIUM FOR EXECUTION OF RENDEZVOUS & SERVICING OPERATIONS, *supra* note 155, at 1.

[205] *See* SHEILA JASANOFF, STATES OF KNOWLEDGE: THE CO-PRODUCTION OF SCIENCE AND SOCIAL ORDER 2 (2004).

sues—or, as this Article suggests, from entanglements of all three factors and perhaps others as well. While we have focused on debris removal as a way of highlighting some problems (and possible solutions) for space law associated with ADR and RPO, we consider there to be many other areas that spark similar concerns for the core principles of due regard, (potentially) harmful interference, and peaceful uses of space. The utility of autonomous systems and AI in space, for example, is becoming increasingly evident, and as with ADR and RPO systems, technical measures are less useful for legal questions than they may have been in the past.[206]

For space activities in particular, the lack of caselaw to date makes it hard to assess the impact of emerging challenges because doing so requires combining abstract thinking about principles with uncertain future possibilities. While law will continue to play a crucial role, lawyers certainly cannot do this on their own. They simply do not have the tools to do so. All relevant stakeholders must exchange ideas, knowledge and expertise, and they must understand how each can contribute. This requires a broad approach to the analysis of *how space works*.

In such cases, this Article suggests that understanding social and technological complexities as being interwoven with one another in the formation of emerging challenges may be a more helpful approach than trying to split problems into technological questions and social questions and dealing with these questions separately. STS offers frameworks that may allow legal scholars to approach highly networked and entangled questions in ways that make space amenable to legal analysis while viewing it as a part of an *interdependent*—as opposed to independent—context.

Such approaches take into consideration the complex political history of space activities as well as contemporary commercial, academic, and government practices. While this Article does not exhaustively examine STS approaches, it suggests several frameworks that could be explored as a starting point for further discussion. We hope these suggestions prompt thought among readers from all fields, and look forward to the ongoing debate directed towards an appropriate future where space continues to play a vital role in the activities of humankind.

---

[206] Anne-Sophie Martin & Steven Freeland, *The Advent of Artificial Intelligence in Space Activities: New Legal Challenges*, 55 SPACE POL'Y 1, 2, 4–7 (2021).