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The Right Stuff in Geospace: Using Mutual Coercion to Avoid an Inevitable Prison for Humanity

Sarah Louise Vollmer
St. Mary's University School of Law

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COMMENT

THE RIGHT STUFF IN GEOSPACE: USING MUTUAL COERCION TO AVOID AN INEVITABLE PRISON FOR HUMANITY

SARAH LOUISE VOLLMER*

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I. INTRODUCTION

Outer space is, for the lack of a better term, big.¹ Though the same holds true for the volume of space² around Earth, inadequacies in the current body of international space jurisprudence and the finite options available for satellite acquisition services present a unique threat to the long-term sustainability of geospace.³ Foundationally, the architects of the *Corpus Juris Spatialis*—the five multilateral space treaties—perceived space as an infinite ocean of opportunity and sought to provide an equitable regime for unabated exploration, use, and enjoyment of the cosmos.⁴ Anyone capable and willing was—and remains—free to benefit from any manner of activity

1. DOUGLAS ADAMS, *THE HITCHHIKER'S GUIDE TO THE GALAXY* 76 (1979).

2. This Comment focuses exclusively on “geospace,” a region above Earth in which objects maintain relatively consistent orbits with the aid of Earth’s gravitational pull. See Bhavya Lal & Emily Nightingale, *Where is Space? And Why Does That Matter?*, in *SPACE TRAFFIC MGMT. CONF.*, Paper 16 at 1 n.1 (2014) (delineating between various regions of space); see also R.A.N. Araujo et al., *Sphere of Influence and Gravitational Capture Radius: A Dynamical Approach*, 391 *MONTHLY NOTICES ROYAL ASTRONOMICAL SOC'Y* 675, 675 (2008) (“The concept of the sphere of influence [is] . . . the region in which the gravitational influence of a body prevails over the gravitational influence of other bodies.”). The majority of space activity is concentrated in this “bubble” around Earth. See *infra* Appendix.

3. See Mary Button, Note, *Cleaning Up Space: The Madrid Protocol to the Antarctic Treaty as a Model for Regulating Orbital Debris*, 37 *WM. & MARY ENVTL. L. & POL'Y REV.* 539, 539 (2013) (“The space near Earth, the orbit, is different from any other place in the universe due to its proximity to our planet and the impact humans have on the area. Humanity needs to stop thinking of the planet’s orbit as just a part of the vastness of space[.]”).

4. See Rep. of the Comm. on the Peaceful Uses of Outer Space on Its Sixty-Second Session, at 50, U.N. Doc. A/74/20 (2019) [hereinafter COPUOS, Sixty-Second] (“[O]uter space should remain an operationally stable and safe environment that is maintained for peaceful purposes and open for exploration, use and international cooperation by current and future generations, in the interest of all . . .”).

in space, so long as the spacefarer operates through peaceful means.⁵ Yet conceptually, “outer space” is distinguishable from “geospace” in that geospace is slowly approaching a modern-day tragedy of the commons.⁶

Within the region of geospace, the prime utility lies with satellite orbits—a finite commodity.⁷ Since 1957, mankind has placed approximately 9,453 objects into Earth orbit.⁸ Annually, geospace acquires an average of 150 satellites⁹ providing valuable scientific data and transmission services vital to our development on Earth.¹⁰ This steady accumulation accelerated

5. See Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies art. IV, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty] (prohibiting States Parties from placing weapons in orbit or using celestial bodies for ill-intentioned purposes).

6. The tragedy of the commons occurs when utilization of land is unbounded, and persons exploit the land to the extent of their own self-interest with remorseless disregard of the possibility that others might do the same, despite the resource’s finite utility. See Garrett Hardin, *The Tragedy of the Commons*, 162 SCI. 1243, 1248 (1968) (concluding legal solutions rather than technical solutions will prevent a tragedy of the commons); see also Benjamin David Landry, *A Tragedy of the Anticommons: The Economic Inefficiencies of Space Law*, 38 BROOK. J. INT’L L. 523, 577 (2013) (“The commercialization of outer space is suffering from a tragedy of the anticommons. No state or private entity has been willing to bear the cost of commercialization because international law prohibits national and, potentially, private appropriation[.]”); Scott J. Shackelford, *Governing the Final Frontier: A Polycentric Approach in Managing Space Weaponization and Debris*, 51 AM. BUS. L.J. 429, 443 (2014) [hereinafter Shackelford, *Governing the Final Frontier*] (“Technological advancements and resource scarcity are driving interest in the space commons, yet thus far governance has failed to keep pace.”); Scott J. Shackelford, *The Tragedy of the Common Heritage of Mankind*, 28 STAN. ENVTL. L.J. 109, 111 (2009) [hereinafter Shackelford, *Tragedy of the Common Heritage*] (“[I]n particular the communal property principle of the [Common Heritage of Mankind] are under pressure with the need for greater private economic development. With resources becoming increasingly scarce and technology advancing to meet surging demand, longstanding principles of communal property in the international commons will either be reinterpreted or rewritten outright.”).

7. Comm. on the Peaceful Uses of Outer Space, Rep. of the Sci. & Tech. Subcomm. on Its Fifty-Fourth Session, at 12, U.N. Doc. A/AC.105/C.1/2017/CRP.12 (2017) [hereinafter COPUOS, Fifty-Fourth]. Accordingly, in support of Mary Button, it is the author’s view that international space law should be bifurcated, with separate regimes for outer space and geospace, yet for markedly different reasons. See generally Button, *supra* note 3, at 539–40 (advocating for a protocol to the space treaties that mirrors the Antarctic Treaty’s Montreal Protocol). *Contra* Definition and Delimitation of Outer Space and the Character and Utilization of the Geostationary Orbit, 2001 DIGEST OF UNITED STATES PRACTICE IN INTERNATIONAL LAW, ch. 12, § C(4) at 721 (“[D]elimiting outer space is not necessary. No legal or practical problems have arisen in the absence of such a definition.”).

8. As of April 30, 2020, roughly 5,841 objects occupy geospace. See *Online Index of Objects Launched into Outer Space*, UNITED NATIONS OFF. FOR OUTER SPACE AFF., http://www.unoosa.org/oosa/osoindex/index.jsp?lf_id= (follow “To Search the Online Index, Click Here,” then toggle filters) (last Apr. 30, 2020).

9. COPUOS, Fifty-Fourth, *supra* note 7, at 9.

10. *Id.* at 12 (“[Peaceful usage of outer space] is also integral in contributing to governance mechanisms in addressing a wide array of global problems, for example, monitoring climate change

abruptly with the advent of satellite constellations. In 2019 alone, 457 satellites were added to the geospace environment. This only exacerbates the accumulation of space debris, arguably the most dangerous byproduct of space activity.¹¹ And despite the ample treaty bodies, the textual vagaries¹² present spacefarers an opportunity to devour the usability of geospace without internalizing the negative externalities of their usage.¹³ In consideration of our global dependence on satellite-based communication, remote sensing, and simply having a gateway to outer space, the current legal framework is unsustainable and requires binding international cooperation rather than voluntary, nebulous guidelines.¹⁴

and providing early warnings for natural disasters through the use of satellite images, supporting local development through connecting communities to the internet, and providing the infrastructure necessary for development in information technology industry.”).

11. See STUFF IN SPACE, stuffin.space (last visited Apr. 26, 2020) (click on any dot, then click “Find all objects from this launch.” Or, click “Groups” to view various satellite constellations) (providing an interactive interface to view all current objects, including space debris and non-functional objects, in Earth orbit).

12. In this context, spacefaring nations take advantage of the gaps and ill-defined language of the space law treaties to skirt the responsibility of protecting the global commons. Essentially, the treaties are exploited, not necessarily space. Though the byproduct of this interpretive exploitation and the lack of holistically internalized mitigation procedures exhibits the threat to the geospace commons. See generally Frans G. von der Dunk, *Too-Close Encounter of the Third Party Kind: Will the Liability Convention Stand the Test of the Cosmos 2251-Iridium 33 Collision?*, 28 SPACE CYBER & TELECOMM. L. 199 (2010) (discussing the difficulties of assigning liability for satellite collision due to vagaries within the Liability Convention and failure to comply with the Registration Convention).

13. Due to the inability to appropriate property in space and the absence of resource use delimitation, any entity with the financial means can exploit geospace resources. Landry, *supra* note 6, 527–28; see also Joseph Kurt, Note, *Triumph of the Space Commons: Addressing the Impending Space Debris Crisis Without an International Treaty*, 40 WM. & MARY ENVTL. L. & POLY REV. 305, 309 (2015) (criticizing China’s blatant use of an anti-satellite missile to destroy its own faulty satellite).

14. The tragedy of the commons occurs when utilization of land is unbounded, and persons exploit the land to the extent of their own self-interest with remorseless disregard of the possibility that others might do the same despite the resource’s finite utility. See Hardin, *supra* note 6, at 1248 (concluding legal solutions rather than technical solutions will prevent a tragedy of the commons); see also Landry, *supra* note 6, at 577 (“The commercialization of outer space is suffering from a tragedy of the anticommens. No state or private entity has been willing to bear the cost of commercialization because international law prohibits national and, potentially, private appropriation[.]”); Shackelford, *Tragedy of the Common Heritage*, *supra* note 6, at 111 (“[I]n particular the communal property principle of the [Common Heritage of Mankind] are under pressure with the need for greater private economic development. With resources becoming increasingly scarce and technology advancing to meet surging demand, longstanding principles of communal property in the international commons will either be reinterpreted or rewritten outright.”); Shackelford, *Governing the Final Frontier*, *supra* note 6, at 443 (“Technological advancements and resource scarcity are driving interest in the space commons, yet thus far governance has failed to keep pace.”).

To cure a tragedy of the commons, Garrett Hardin's classic economic solution entails either (1) establishing articulable property rights or (2) promulgating coercive regulatory regimes.¹⁵ International law poses obvious difficulties for implementing such solutions due to the contractual nature of treaties.¹⁶ Fortunately, most launching states and indirect beneficiary nation-states consented to the Outer Space Treaty (OST) and the Convention on International Liability for Damage Caused by Space Objects (Liability Convention), with the continued accession of remaining nation-states.¹⁷ In terms of the international community's sentiments towards rectifying environmental degradation, protocols to the OST and Liability Convention could conceivably reflect the changing attitudes toward sustainability and emerging international custom.¹⁸ Yet any Hardin-esque solution affecting a new property regime would directly contravene the object and purpose of the *Corpus Juris Spatialis*.¹⁹ As such, a workable

15. See Hardin, *supra* note 6, at 1247 (discussing the behavioral effects of taxation and private property regimes).

16. See Vienna Convention on the Law of Treaties art. 9, Jan. 27, 1980, 1155 U.N.T.S. 331 (denoting the consent of all States requirement to adopt a treaty).

17. Comm. on the Peaceful Uses of Outer Space, Rep. of the Legal Subcomm. on Its Fifty-Seventh Session, at 10, U.N. Doc A/AC.105/C.2/2018/CRP.3 (2018) [COPUOS, Fifty-Seventh].

18. Cf. Kurt, *supra* note 13, at 320–22 (evidencing international environmental cooperation signals hope for restoration even without treaties); David Tan, *Towards a New Regime for the Protection of Outer Space as the "Province of All Mankind"*, 25 YALE J. INT'L L. 145, 177–79 (2000) (extending the emerging custom of sustainable development to the space environment). The global commons of Antarctica faced concerns similar to those in outer space, and the OST is modeled after a significant portion of the Antarctic Treaty System (ATS). See Shackelford, *Tragedy of the Common Heritage*, *supra* note 6, at 141 ("The governing treaties of space law share many similarities with . . . the ATS."). The ATS also prohibits sovereign appropriation and weapons proliferation and covenants to ensure any usage be purely scientific in nature and equitably shared with the global community. The Antarctic Treaty art. I–III, Dec. 1, 1959, 12 U.S.T. 794, 402 U.N.T.S. 71. Analogous to the OST, the ATS failed to provision for sustainable usage and once mining operations threatened its environmental integrity, a protocol to the ATS was annexed to arrest the potential destruction of Antarctica. Protocol on Environmental Protection to the Antarctic Treaty art. 7, Oct. 4, 1991, T.I.A.S. No. 98-114, 20 I.L.M. 1455 [hereinafter Madrid Protocol].

19. Holistically, the object and purpose of the *Corpus Spatialis* prohibits sovereign nations from asserting ownership over any location or volume of space in the interest of maintaining a commons for all of mankind. *E.g.*, Outer Space Treaty, *supra* note 5, at pmb. & art. II ("Reaffirming the importance of international co-operation in the field of activities in the peaceful exploration and use of outer space . . ."). In spite of the OST's anti-appropriation clause, the International Telecommunications Union is tasked with the responsibility to:

[E]ffect allocation of bands of the radio-frequency spectrum, the allotment of radio frequencies and the registration of radio-frequency assignments and, for space services, of any associated orbital position in the geostationary-satellite orbit or of any associated characteristics of satellites

solution must balance contemporary global interests with intergenerational equity.²⁰

This Comment proposes a regulatory solution through the implementation of a conceptual liability regime. This proposal finds support through emerging custom and the values systems which inform the perceived utility of the global commons for all of mankind. It proffers a workable solution that allows continued accessibility to geospace while simultaneously coercing spacefaring entities and Earth-side beneficiaries alike to incorporate reasonable care, aggressive debris clean-up solutions, and binding mitigation procedures.²¹ Sovereign nations and private corporations need not abate their participation in geospace but must not encroach humanity's future enjoyment of the "final frontier."²² This proposal addresses the coterminous interests of stakeholders, incorporating equitable benefit-sharing without placing undue liability on the space majors, such as the United States, Russia, and China.²³

in other orbits, in order to avoid harmful interference between radio stations of different countries.

International Telecommunications Union Const. art 1(2)(a) *adopted by* Plenipotentiary Conference (Minneapolis, 1998).

20. Cf. Tan, *supra* note 18, at 175 ("Although the content of the 'province of all mankind' is disputed, it nevertheless, at a minimum, imposes a duty upon states to use outer space in a manner that jeopardizes neither the interests of present spacefaring states nor the potential interests of other states.").

21. Many mitigation standards exist, but the United Nations guidelines are non-binding. See UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, COMPENDIUM: SPACE DEBRIS MITIGATION STANDARDS ADOPTED BY STATES AND INTERNATIONAL ORGANIZATIONS 56 (2018) [hereinafter COMPENDIUM: SPACE DEBRIS MITIGATION], http://www.unoosa.org/documents/pdf/spacelaw/sd/Space_Debris_Compodium_COPUOS_21_sep_2018.pdf [https://perma.cc/KRP9-74UH] ("Through resolution 62/217, the United Nations General Assembly invited Member States of the United Nations to implement those voluntary guidelines through relevant national mechanisms 'to the greatest extent feasible,' through space debris mitigation practices and procedures."). Though nation-states have domestic laws, those laws still lack enforcement mechanisms and do not create any duty to mitigate the further creation of space debris. *E.g.*, 51 U.S.C. § 31501 (2010) (enabling NASA administrator to take steps to reduce risk of orbital debris). The United States, for example, grants regulatory authority to various executive agencies, such as the Federal Aviation Administration (FAA), Federal Communications Commission (FCC), and the National Oceanic and Atmospheric Administration (NOAA), to regulate space activities under its authority. See 14 C.F.R. § 400.1 (2019) (enabling FAA to license space launches and re-entries); 47 C.F.R. § 25.108 (2018) (enabling FCC to allocate satellite radio frequencies); 15 C.F.R. § 960.1 (2006) (enabling NOAA to regulate licenses for private remote sensing satellites).

22. Shackelford, *Governing the Final Frontier*, *supra* note 6, at 430; *Star Trek: The Original Series* (NBC television broadcast Sept. 8, 1966).

23.

First, a separate regime must be established for geospace. Part II provides a historical overview of space law, exploring the progressive delimitation of airspace which carefully balanced the interests of stakeholders. Second, it is crucial to understand the vulnerabilities of our aging body of space law, and the specific challenges arising from the privatization of space activity. Part III examines the textual limitations of the treaties, domestic statutory schemes, and the voluntary international standards for space debris mitigation. Third, equal weight must be given to both public and private interests, but any rights conferred necessitates counterbalancing those duties. Part IV analyzes what motivates nation-states to consent to binding international legal conventions and combines those behavioral realities with Hardin's coercion theory to effectuate a practical liability regime. Finally, environmental security discourse must include the rising threat of space debris. Part V concludes with a summary of current decontamination efforts and the path of least resistance to a global liability regime.

II. THE PROGRESSIVE DELIMITATION OF AEROSPACE

The Cold War marked a monumental shift in modern space law development, but scholars often overlook its true beginnings.²⁴ Indeed, the primordial maxim of *ad coelum et ad infernos*²⁵ marks the genuine

International cooperation, while taking into particular account the needs of developing countries, should aim, inter alia, at the following goals, considering their need for technical assistance and rational and efficient allocation of financial and technical resources: (a) Promoting the development of space science and technology and of its applications; (b) Fostering the development of relevant and appropriate space capabilities in interested States; (c) Facilitating the exchange of expertise and technology among States on a mutually acceptable basis.

G.A. Res. 51/122, annex ¶ 5, Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries (Dec. 13, 1996) [hereinafter Benefits Declaration].

24. See Landry, *supra* note 6, at 528 (signifying Cold War tensions as primary impetus for space law); Shackelford, *Tragedy of the Common Heritage*, *supra* note 6, at 143 (stating Sputnik initiated the development of law of outer space); Daniel A. Porras, Comment, *The "Common Heritage" of Outer Space: Equal Benefits for Most of Mankind*, 37 CAL. W. INT'L L.J. 143, 147–48 (2006) (chronicling President Eisenhower's response to the Sputnik launch, deeming space exploration as the mark of military superiority).

25. Translated, the maxim, while not binding law, expresses the generalization that one owns everything up to the sky and down to the center of Earth. *Ad coelum et ad inferos*, BLACK'S LAW DICTIONARY (10th ed. 2014); J. Joseph Cummings, *Ownership and Control of Airspace*, 37 MARQ. L. REV. 176, 176 (1953).

commencement of space jurisprudence. As meager as the delimitation of airspace seems, the historical progression of boundary demarcation resulted out of necessity.

Prior to the 1900s, private property owners possessed an absolute right to their property's superadjacent airspace.²⁶ After the advent of sustained aeronautical flight, the United States Congress promulgated the Air Commerce Act of 1926 (ACA), establishing the foundations of our modern aerospace transportation network.²⁷ The ACA, as amended by the Civil Aeronautics Act of 1938,²⁸ prescribes national airspace as part of the public domain. Some viewed this demarcation as a subversion of the common law property maxim and challenged the Act's constitutionality in *United States v. Causby*.²⁹ In *Causby*, the Supreme Court rejected *ad coelum et ad infernos*, deeming it unworkable for modern aviation.³⁰ The Court reasoned that economic development justified a delineation between private and public rights, but only if public usage did not render private property uninhabitable.³¹ This exemplifies the first delimitation of airspace rights,³² which balanced the interests of the competing stakeholders to ensure the best use of the commons at issue.³³

Consistent with the international community, the ACA also granted the United States government exclusive sovereign authority over the nation's

26. See Cummings, *supra* note 25, at 176 n.1 (discussing the first reported case to solidify the principle that a property owner is entitled to the land as well as everything above and below).

27. Air Commerce Act of 1926, Pub. L. No. 69-254, ch. 344, 44 Stat. 568.

28. Civil Aeronautics Act of 1938, Pub. L. No. 75-706, ch. 601, § 1107(i)(3), 52 Stat. 973, 1028.

29. Private landowners equated sovereignty over the airspace commons as a regulatory taking. See *United States v. Causby*, 328 U.S. 256, 258 (1946) (“The problem presented is whether respondents’ property was taken, within the meaning of the Fifth Amendment, by frequent and regular flights of army and navy aircraft over respondents’ land at low altitudes.”).

30. *Id.* at 261.

31. See *id.* (“[T]hat doctrine has no place in the modern world. The air is a public highway Were that not true, every transcontinental flight would subject the operator to countless trespass suits. . . . To recognize such private claims to airspace would clog these highways, seriously interfere with their control and development in the public interest[.]”). The boundary of navigable airspace is at an altitude where aircraft pass without unduly interfering the subjacent land or safety of the aircraft in question. 49 U.S.C. § 40102(a)(32) (2018).

32. The boundary of navigable airspace is at an altitude where aircraft pass without unduly interfering the subjacent land or safety of the aircraft in question. 49 U.S.C. § 40102(a)(32) (2018).

33. See Chad J. Pomeroy, *All Your Air Right Are Belong to Us*, 13 NW. J. TECH. & INTELL. PROP. 277, 290 n.77 (2015) (“[The *Causby* court] chose a middle ground, limiting air rights to those that are within ‘the immediate reaches of the enveloping atmosphere.’”).

airspace.³⁴ In the interest of national security, this second demarcation of sovereign jurisdiction over superadjacent airspace³⁵ empowered nation-states to dictate the permissible uses of their navigable airspace, while leaving international airspace free for peaceful uses.³⁶ Yet, unlike the ACA, jurists avoided declaring any substantive separation between air space and outer space.³⁷ Once engineers designed aircraft capable of crossing over into “the ether . . . beyond the control of subadjacent states,”³⁸ commentaries opined that once free from the atmosphere, any subsequent conquest of the great beyond invoked consideration of “the heritage of mankind.”³⁹ The international community thus loosely defined the third delimitation, the beginning of space, at the Kármán Line.⁴⁰ With the momentum of consensus on the upper limit of national sovereignty, the

34. Air Commerce Act of 1926, Pub. L. No. 69-254, ch. 344 § 6, 44 Stat. 568, 572 (current version at 49 U.S.C. § 40103(a)(1) (2018)).

35. Convention on International Civil Aviation art. 1–2, Apr. 14, 1947, 61 Stat. 1180, 15 U.N.T.S. 295.

36. *Id.* at art. 5. Foreign nationals can still obtain permission for “innocent passage” if necessary. United Nations Convention on the Law of the Sea, pt. II § 3 art. 17–19, Dec. 10, 1982, 1833 U.N.T.S. 397 [hereinafter UNCLOS] (stating “innocent passage of territorial waters” is applicable to ships and aircraft).

37. Russian jurist, Zarzar Valentin Ananevich, did not believe in assigning definitions for international altitude zones, leaving such up to principles of sovereignty. Stephen E. Doyle, *A Concise History of Space Law: 1910–2009*, in *NEW PERSPECTIVES ON SPACE LAW: PROCEEDINGS OF THE 53RD IISL COLLOQUIUM ON THE LAW OF OUTER SPACE, YOUNG SCHOLARS SESSION 2* (Mark J. Sundahl & V. Gopalakrishnan eds., 2010).

38. *Id.* at 4. The first scholarly writing with a strict focus on space law presupposed “the entire area beyond the atmosphere would have to be considered free territory both on technical grounds founded on the law of nature and for reasons of legal construction and policy.” Welf Heinrich, *Air Law and Space*, 5 ST. LOUIS U. L.J. 11, 67 (1958).

39. Doyle, *supra* note 37, at 4.

40. Despite the extensive debate on the true boundary and Jonathan C. McDowell’s recent proposal to reduce its altitude, in the interest of brevity, the 100-kilometer Kármán Line will represent the demarcation for this Comment. Compare Button, *supra* note 3, at 541, with Jonathan C. McDowell, *The Edge of Space: Revisiting the Karman Line*, 151 ACTA ASTRONAUTICA 668 (2018) (cataloguing the arguments surrounding the Kármán Line and proposing the demarcation of space lies at an altitude of eighty kilometers). The United Nations has taken a firm stance regarding the location of geosynchronous orbit (GSO). In 1976, a convention comprised of the equatorial nation-states of Colombia, Congo, Ecuador, Indonesia, Kenya, Uganda, Zaire and Brazil attempted to claim sovereignty over GSO, asserting the valuable region was a natural resource of Earth. Declaration of the First Meeting of Equatorial Countries, *adopted* Dec. 3, 1976 (Bogota), available at <https://bogotadecclaration.wordpress.com/declaration-of-1976/> [<https://perma.cc/F9D7-VQVU>]. However, the international community expressly rejected the countries’ claims because they defied the non-appropriation clause of the OST. Ferdinand Onwe Agama, *Effects of the Bogota Declaration on the Legal Status of Geostationary Orbit in International Space Law*, 8 NNAMDI AZIKIWE U.J. INT’L L. & JURIS. 24, 25–27 (2017).

international community next looked toward a legal regime for the governance of space, but motivations were limited to prohibiting the weaponization of space.⁴¹

A. *The Outer Space Treaty*

When the Soviet Union successfully placed *Sputnik I* into orbit in 1957, preeminent legal minds were blinded by the national security issues implicated by the “space race”; tempering fears of a potential “star war” took priority over any other potentially dangerous situation in space.⁴² Cognizant of the potential military utility of the space commons,⁴³ the United Nations formed the Standing Committee on the Peaceful Uses of Outer Space (COPUOS) in 1959.⁴⁴ Primarily, COPUOS focused attention on maintaining peace in regions beyond the immediate control of subadjacent nations and a means to ensure that spacefaring nations could not appropriate any area of space out of neocolonial self-interest.⁴⁵ In 1967, these goals materialized with the OST, the first internationalized document for space law.⁴⁶

The object and purpose of the OST aims to ensure a global commons in the interest of mankind for scientific research and economic development,⁴⁷ while simultaneously restricting the militarization of space.⁴⁸ The text expressly declared that “[o]uter space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by other means.”⁴⁹ While

41. See Doyle, *supra* note 37, at 1, 4 (“[O]ver flights of national territory at any speed or altitude could involve threats to safety and security, and states have a right to defend and protect their national integrity by any appropriate means available to them, “from the seizure of the crew . . . to reprisals of all kinds.”).

42. Jijo George Cherian & Job Abraham, *Concept of Private Property in Space—An Analysis*, 2 J. INT’L COM. L. & TECH. 211, 212 (2007).

43. Chester Ward, *Projecting the Law of the Sea into the Law of Space*, 1957 JAG J. 3, 3 (1957) (“Are the uses of space going to be primarily of military value—or will they be primarily of commercial benefit?”).

44. Cherian & Abraham, *supra* note 42, at 212.

45. Years earlier, Arthur C. Clarke cautioned that “there must be an upper limit to national sovereignty because otherwise ‘in the course of a day, [on a rotating globe] every country will lay claim to a large portion of the Universe!’” Doyle, *supra* note 37, at 1, 5–6 (alterations in original).

46. Outer Space Treaty, *supra* note 5.

47. See *id.* at pmb. (“Desiring to contribute to broad international co-operation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful purposes[.]”).

48. *Id.*

49. *Id.* at art. II.

denouncing any means of acquiring property in outer space, COPUOS granted freedom for unabated, albeit peaceful, use of shared resources. However, this allowance failed to consider the unique characteristics of space.⁵⁰ While outer space is theoretically infinite, in contrast, objects in geospace congregate within a confined region specifically due to orbital mechanics.

Further, the OST severely lacks language addressing sustainability and any flexibility for future technological developments.⁵¹ As spacefaring capabilities advanced, the *Corpus Juris Spatialis* increased with four additional treaties between 1968 and 1979 that governed liability for accidents,⁵² duties to assist in the rescue and return of persons and spacecraft,⁵³ registration obligations,⁵⁴ and a notably unsuccessful framework for resource recovery on the Moon.⁵⁵ Each successive document echoed the object and purpose

50. COPUOS, Fifty-Fourth, *supra* note 7, at 12. It seems as though COPUOS relied on the magnitude of space as a fail-safe for resource management.

51. COPUOS also failed to consider the positive utility of nuclear power as a fuel source, rather than just a trump card for military engagement. See Jason Krause, *The Outer Space Treaty Turns 50. Can it Survive a New Space Race?*, 103 A.B.A. J. 45, 46 (2017) (“The treaty . . . is a product of the Cold War and primarily addresses concerns of that era, including nuclear war. So for 50 years, the treaty has prevented belligerent nations from putting weapons of mass destruction into space.”). Considering the insurmountable distance between celestial destinations from Earth, nuclear technology comprises the bulk of current research and development efforts, ironically adverse to the original purposes behind the OST. Compare John Wenz, *NASA Targets Next-Gen Nuclear Reactors for Spacecraft, Space Colonies*, ASTRONOMY.COM (Sept. 17, 2018), <http://www.astronomy.com/news/2018/09/next-gen-nuclear-reactors-may-power-nasa-spacecraft-and-space-colonies> [https://perma.cc/SAP4-T435] (“I don’t think we can expand into deep space without nuclear power[.] . . .” says David Poston, who leads the Kilopower team.”), with Krause, *supra* note 51, 46 (quoting then-U.S.-Representative-now-NASA Administrator, Jim Bridenstine, “[f]ifty years ago . . . our main concern was nuclear proliferation”).

52. See Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter *Liability Convention*] (expanding on article VII of the OST by addressing liability for space activity which could potentially damage the surface of Earth and other objects in space).

53. See Agreement on the Rescue of Astronauts, the Return of Astronauts and Return of Objects Launched into Outer Space, Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119 (responding to the need to further develop duties of nations to provide assistance to space activity participants).

54. See Convention on Registration of Objects Launched into Outer Space, Jan. 24, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15 (implementing duties to register all objects launched into space to foster situational awareness).

55. See Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, pmbl., art. 4, Dec. 18, 1979, 1363 U.N.T.S. 3 (reiterating the object and purpose of the OST, but providing a potential mechanism for surface and subsurface use of celestial bodies). Largely rejected, the Moon Treaty does not boast international support because it endorses the appropriation of resources under a tenuous benefit-sharing regime. COPUOS, Fifty-Seventh, *supra* note 17 at 10. An amendment to the United Nations Law of the Sea (UNCLOS) similarly implements a benefit-sharing mechanism for resources recovered in international waters but remains unratified by the United States

of the OST and refrained from establishing a separate regime for geospace specifically.

III. A TRAGEDY OF THE GEOSPACE COMMONS

The common heritage of mankind anchors the governance of global commons.⁵⁶ While some scholars have yet to accept such verbiage as international custom,⁵⁷ others submit it as establishing an emerging principle of *jus cogens*.⁵⁸ Proponents suggest that because “mankind” replaces the typical language of “all States,” then any mention of “mankind” insists humanity must be able to enjoy the collective benefits of resources within a global commons.⁵⁹ As a result, mankind itself has become the

Senate. The Senate’s reluctance lies in national security concerns and the potential to create unwanted precedent for resource recovery operations in space. Kristina Wong, *Rumsfeld Still Opposes Law of Sea Treaty*, WASH. POST (June 14, 2012), <https://www.washingtontimes.com/news/2012/jun/14/rumsfeld-hits-law-of-sea-treaty/> [<https://perma.cc/RN5D-KQ6S>].

56. The principle clearly exists within the text of UNCLOS and the OST. Outer Space Treaty, *supra* note 5, at pmbli.; UNCLOS, *supra* note 36, at pt. XI § 2 art. 136. While the ATS has traces of the principle it is not entirely clear whether Antarctica’s global commons falls within the scope of the common heritage of mankind. But when compared to the five generally accepted principles mentioned in this section, it seems more likely than not that Antarctica is subject to the common heritage of mankind due to the provisions concerning benefit-sharing, non-appropriation, nonproliferation, and the subsequent sustainability protections afforded by the Madrid Protocol. *But see generally* Jeffrey Loan, *The Common Heritage of Mankind in Antarctica: An Analysis in Light of the Threats Posed by Climate Change*, 1 N.Z.Y.B. INT’L L. 149 (2004) (pointing to the existence of the common heritage of mankind principles in the ATS but arguing against any definitive proof).

57. See Christopher C. Joyner, *Legal Implications of the Concept of the Common Heritage of Mankind*, 35 INT’L & COMP. L.Q. 190, 199 (1986) (“The [Common Heritage of Mankind] must remain only a conceptual ideal, not an international legal reality supported by State practice.”).

58. See Tare C. Brisibe, *Customary International Law, Arms Control and the Environment in Outer Space*, 8 CHINESE J. INT’L L. 375, 389 (2009) (“It is even possible to go further in this direction and affirm that the fundamental principles of [the OST] have become preemptory norms of general international law/*jus cogens* accepted and recognized by the international community of States as a whole.”); Rüdiger Wolfrum, *The Principle of the Common Heritage of Mankind*, 43 HEIDELBERG J. INT’L L. 312, 316–17 (1983), http://www.zaoerv.de/43_1983/43_1983_2_a_312_337.pdf [<https://perma.cc/DRJ6-CJVT>] (discussing the common heritage of mankind principle in relation to UNCLOS, equating the Sea-Bed Authority to a representative of mankind). It seems illogical to deny *jus cogens* status to any global commons as the common heritage of mankind, particularly when the treaty bodies governing such commons boast extensive ratification or signature. *Contra* Carol R. Buxton, *Property in Outer Space: The Common Heritage of Mankind Principle vs. The First in Time, First in Right, Rule of Property*, 69 J. AIR L. & COM. 689, 706 (2004) (concluding the improbability of the validity of the common heritage of mankind principle due to the polarized interests of developed and developing nations). Despite the cleavages that exist between developing and developed nations, geospace provides benefits to all of mankind, whether directly or indirectly.

59. As Rüdiger Wolfrum explains:

“one to dispose of . . . resources,” and upon invoking the interest of mankind “the interests of future generations have to be respected in making use of [resources].”⁶⁰ One can analogize this position to property principles against waste in the context of a present interest holder’s duty to vested future interests.⁶¹ In summarizing the five shared conceptions of the common heritage of mankind principle, Dr. Shackelford provides support to this construction:

First, there can be no private or public appropriation of the commons. Second, representatives from all nations must manage resources since a commons area is considered to belong to everyone. Third, all nations must actively share in the benefits acquired from exploitation of the resources from the common heritage region. Fourth, there can be no weaponry or military installations established in commons areas. Fifth, the commons should be preserved for the benefit of future generations.⁶²

Logically following, the OST’s presentment of outer space as the common heritage of mankind grants an implied property right to all persons in the geospace commons. Applying Dr. Shackelford’s principles, the credible

This term provokes several questions: Does this constitute a new subject of international law? Would it be possible to argue that the interests of mankind have to be distinguished from the interests of all States? Or does the term ‘mankind’ indicate that the interests of those parts of mankind have to be taken into account which are not represented by the very States? The documents available are silent on these questions with one exception. The Convention on the Law of the Sea mentions [mankind] as potential beneficiaries of the utilization of the sea—and this should be regarded as a logical conclusion to be drawn from the term ‘mankind’—also peoples who have not attained full independence or other self-governing status.

Wolfrum, *supra* note 58, at 318.

60. *See id.* at 317–18 (referring to the joining of “mankind” and “heritage” language in the OST).

61. RESTATEMENT (FIRST) OF PROPERTY ch. 13, topic 2 § 204(b) (AM. LAW INST. 1936) (“[Owner of present interest] shall not intentionally inflict harm upon the owner of such future interest[.]”); *see* Wolfrum, *supra* note 58, at 318–19 (arguing the utilization of resources within a global commons requires recovery activities to limit undue waste of resources and a mechanism for protecting the environment).

62. Shackelford, *Tragedy of the Common Heritage*, *supra* note 6, at 111 (citations omitted); *see also* Jennifer Frakes, *Notes and Comments: The Common Heritage of Mankind Principle and the Deep Seabed, Outer Space, and Antarctica: Will Developed and Developing Nations Reach a Compromise?*, 21 WIS. INT’L L.J. 409, 412–13 (2003) (cataloguing the common five elements of the common heritage principle represented in non-appropriation, common management, benefit sharing, peaceful purposes, and preservation for future generations).

treaties⁶³ operate in tandem with the non-appropriation, nonproliferation, and equitable benefit-sharing elements of the common heritage principle. Permanently enjoining claims of sovereignty thus prohibits the establishment of exclusive economic rights and reinforces equitable benefit-sharing.⁶⁴ However, the lack of resource management and preservation language disallows mankind a mechanism to protect its interest in the geospace commons if its usage results in damage, waste, or destruction of its resources.⁶⁵

A. *Orbital Utility*

In the context of orbital real estate, spacefaring entities formulate satellite acquisition strategies for either low earth orbit (LEO) or geosynchronous orbit (GSO).⁶⁶ While each particular orbit can accommodate most space objects,⁶⁷ satellite positioning requires careful consideration due to the

63. With less than 20 parties to the treaty, the Moon Treaty is considered a categorical failure. Cf. Shackelford, *Tragedy of the Common Heritage*, *supra* note 6, at 158 (“It remains legally unclear whether such activity [under the Moon Treaty] is allowed under established space law.”).

64. The exclusive economic zones under the UNCLOS regime is a key point of contention for the United States.

65. Within the context of law and economics, if a property interest is efficiently assigned it will afford the interest holder a procedure for protecting those interests, either through payment of damages, granting an injunction, or special negotiation. See R. H. Coase, *The Problem of Social Cost*, 3 J. L. & ECON. 1, 16 (1960) (examining the effect of the delimitation of property rights on the ability to negotiate).

66. For brevity, this Comment will focus on these two broad orbits, though other orbits exist, such as highly eccentric orbit, medium earth orbit, escape orbit, and various subtypes. *ESA's Annual Space Environment Report*, EUR. SPACE AGENCY 5 (May 18, 2018) [hereinafter *ESA's Annual Report*], https://www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf [https://perma.cc/T2B9-GM6N]. Geosynchronous and geostationary are used interchangeably, but for the purposes of this Comment, the geosynchronous nomenclature will suffice. Both orbital horizons allow a satellite to remain above a fixed point; geostationary orbits merely lie on the same plane as the equator. See Lawrence D. Roberts, *A Lost Connection: Geostationary Satellite Networks and the International Telecommunication Union*, 15 BERKELEY TECH. L.J. 1095, 1101 n.30 (2000) (“The determination of whether a satellite is geostationary or geosynchronous is one of degree rather than of strict definition.”); *Remote Sensing: Geosynchronous vs Geostationary Orbits*, GISGEOGRAPHY (Feb. 23, 2018), <https://gisgeography.com/geosynchronous-geostationary-orbits/> [https://perma.cc/2LQH-U2NF]. Regardless of the terminology, sources referring to the geostationary orbit subtype equally support arguments regarding geosynchronous orbit resource use.

67. For instance, large structures such as the late-Mir Space Station and the International Space Station (ISS) can only feasibly reside in low earth orbit (LEO). Elizabeth Howell, *Mir Space Station: Testing Long-Term Stays in Space*, SPACE.COM (Feb. 5, 2013), <https://www.space.com/19650-mir-space-station.html> [https://perma.cc/46RZ-QBMX].

distinct orbital mechanics appurtenant to each orbit.⁶⁸

1. Low Earth Orbit

Objects in LEO orbit between 100 to 1,200 miles above Earth's surface.⁶⁹ Because it is so “close,” LEO acquisition provides spacefarers a lower cost option as launches require relatively low energy budgets to achieve proper positioning.⁷⁰ However, unlike GSO, LEO satellites are not fixed above a targeted location, which necessitates the placement of multiple satellites at various inclinations if a telecommunications operator intends to provide uninterrupted service to its subscribers.⁷¹ In the past five years, LEO has become riddled with massive satellite constellations, further compounding the negative utility of LEO.⁷² To the dismay of the International Space Station's (ISS) residents, every piece of jettisoned launch vehicle debris—whether rocket bodies, mission-related objects, or paint

68. *Three Classes of Orbit*, NAT'L AERONAUTICAL & SPACE ADMIN. (Sept. 4, 2009), <https://earthobservatory.nasa.gov/features/OrbitsCatalog/page2.php> [<https://perma.cc/7RV5-LB7G>].

69. Matt Williams, *What is Low Earth Orbit?*, UNIVERSE TODAY (Jan. 6, 2017), <https://www.universetoday.com/85322/what-is-low-earth-orbit/> [<https://perma.cc/VH5M-22BF>].

70. The advent of “CubeSats” has also increased coverage capabilities and lowered the cost of satellite manufacturing, making LEO an attractive option for satellite internet services. Notice of Proposed Rulemaking and Order on Reconsideration, *In re Mitigation of Orbital Debris in the New Space Age*, IB Docket No. 18-313, 33 FCC Rcd. 11352, 11353 (Nov. 19, 2018). Because of the relatively short travel distance and fuel requirements, construction and habitation of the ISS makes LEO the most economically feasible orbital location. Robert Frost, *Why the International Space Station Stay So Close to Earth*, FORBES (Dec. 9, 2015, 12:44 PM), <https://www.forbes.com/sites/quora/2015/12/09/why-the-international-space-station-stays-so-close-to-earth/#2d73a518477d> [<https://perma.cc/5LXL-3P4M>].

71. *Telecommunications & Integrated Applications: Orbits*, EUR. SPACE AGENCY, http://www.esa.int/Our_Activities/Telecommunications_Integrated_Applications/Orbits%20 [<https://perma.cc/Q4C5-XGJE>].

72. *See generally* Application for Authority to Launch and Operate a Non-Geostationary Satellite Orbit System in Ka-Band Frequencies, IBFS File No. SAT-LOA-20190704-00057, Call Sign S3051 (July 4, 2019) (requesting authority to launch Amazon's Kuiper System consisting of 3,236 satellites in LEO); Memorandum Opinion, Order and Authorization, *In re Space Exploration Holdings, LLC*, 33 FCC Rcd. 11434 (Nov. 15, 2018) (addressing SpaceX's proposal to add 7,518 more satellites to its previously authorized constellation of 4,425 satellites); Order and Declaratory Ruling, *In re WorldVu Satellites Ltd.*, 32 FCC Rcd. 5366 (June 23, 2017) (approving OneWeb's request for 720-satellite constellation in LEO); *see also* Application for Modification, *In re WorldVu Satellites Ltd.*, IBFS File No. SAT-MOD-20180319-00022 (Mar. 19, 2018) (proposing increase of OneWeb's satellite constellation to 1,900 satellites).

flecks⁷³—resides in LEO.⁷⁴ While most of these objects eventually find their way into various decay or graveyard orbits, the transient status of debris still poses a substantial threat to functional satellites and human lives.⁷⁵

2. Geosynchronous Orbit

To contrast, reaching GSO requires an increased energy budget,⁷⁶ but once attained, the orbital mechanics of GSO allows space objects to remain stationary above one location throughout the object's entire orbital transit, with minimal requirements to adjust for perturbances caused by Earth's gravity.⁷⁷ This stationary attribute creates incredible demand on GSO acquisition services because, unlike LEO, only one satellite is necessary for the same transmission services in GSO. But unlike LEO, the physics of radio frequency allocation places spatial restrictions on the permissible number of GSO satellites. Additionally, due to the distance between GSO satellites and radio transmitters on Earth, only three suitable radio frequencies exist.⁷⁸ While these limitations prevent harmful radio

73. *ESA's Annual Report*, *supra* note 66, at 3–4.

74. See SCOTT KELLY, ENDURANCE: MY YEAR IN SPACE, A LIFETIME OF DISCOVERY 397–405 (2017) (recalling the notification of a “red late-notice conjunction” on the ISS, which signifies that tracking devices missed an approaching piece of space debris but the temporal proximity renders avoidance maneuvers an unavailable option); see also COPUOS, Fifty-Fourth, *supra* note 7, at 9 (“Moreover, by following the number of collisions recorded by the [ISS], and the number of times the ISS has had to manoeuvre to avoid debris, one can see the true impact of these objects on space operations.”).

75. Rubicon Global, *Space Waste & Debris: The Biggest Problem We Can't See?*, RUBICON (Jan. 9, 2018) [hereinafter *Space & Waste Debris*], <https://www.rubiconglobal.com/blog-space-waste-debris/> [<https://perma.cc/W7DZ-33RX>]; see also Matthew Shoupe, *The IRAS/GGSE 4 Close Approach*, MEDIUM (Jan. 31, 2020), https://medium.com/@leolabs_space/the-iras-ggse-4-close-approach-a99de19c1ed9 [<https://perma.cc/9WP2-2YHD>] (describing an incident on January 27th, 2020 when two non-functioning satellites came within 18 meters of each other, at relative velocities of 32,900 miles per hour).

76. See Rae Paoletta, *Why SpaceX Won't Be Landing Its Rocket Today*, GIZMODO (May 16, 2017, 9:00 AM), <https://www.gizmodo.com.au/2017/05/why-spacex-wont-be-landing-its-rocket-today/> [<https://perma.cc/EJM8-DLJD>] (“[B]ecause the payload is so heavy and geostationary orbit is at a much higher altitude [than LEO], SpaceX has to use pretty much all its fuel to get its satellite in the right spot.”).

77. *Three Classes of Orbit*, *supra* note 68. These adjustments are known as “stationkeeping.” E.g., T. S. Kelso, *Basics of the Geostationary Orbit*, SATELLITE TIMES (May 1998), <http://www.celestrak.com/columns/v04n07/> [<https://perma.cc/3A25-7TXH>].

78. See Roberts, *supra* note 66, at 1104 (describing the usage and limitations of C band, Ku band, and Ka band frequencies); *Telecommunications & Integrated Applications: Satellite Frequency Bands*, EUR. SPACE AGENCY (Oct. 3, 2018), https://www.esa.int/Our_Activities/Telecommunications/Integrated_Applications/Satellite_frequency_bands [<https://perma.cc/J7K8-CQ9F>] (identifying the different frequency designations and their respective uses).

interference, it inflates the scarcity of GSO slot availability.⁷⁹ As a result, GSO is the highest valued orbit available.⁸⁰

B. *Kessler Syndrome—Fueling the Tragedy*

Today, over eighty sovereign actors and private organizations participate in space activity.⁸¹ The OST's Cold-War-inspired objectives failed to make substantial allowances for future development, despite the cautions of such short-sighted construction.⁸² Over-utilization evaded the immediate concern of signatory nations because the then-current technology did not lend itself to significant exploitation of analogous commons, such as the oceans and Antarctica.⁸³ Considering the dimensions of contemporary real

79. Int'l Telecomm. Union [ITU], Const. art. 1(2)(a), *adopted by* Plenipotentiary Conference (Minneapolis, 1998); *see* Roberts, *supra* note 66, at 1101 (“A variety of factors hinder the continued use of the geostationary orbit. In particular, the medium is restricted by (1) the physical nature of the geostationary orbit, (2) the industry’s technological capabilities, (3) the realities of the telecommunication marketplace, and (4) regulatory limitations imposed by the international community.”). Essentially, if an entity wants to acquire stationary positioning over the United States, it must compete with similarly motivated entities. *See* Paul R. Portney & Molly K. Macauley, *Slicing the Geostationary Pie: Property Rights in Orbit*, AM. ENTERPRISE INST. (July 26, 1984), <http://www.aei.org/publication/slicing-the-geostationary-pie-property-rights-in-orbit/> [https://perma.cc/EN74-MEXW] (“Once it has decided on slot-widths, how then does the FCC choose among commercial applicants for these valuable pieces of galactic real estate? How does it decide between an application for expanded service from a well-established satellite company and one for unique services from an entrepreneurial newcomer? . . . [T]hrough an administrative process known as ‘allocation under a public interest standard.’”).

80. Roberts, *supra* note 66, at 1101.

81. This activity includes operating meteorological, telecommunication, and global positioning system (GPS) satellites, as well as activity on the ISS. *See generally Online Index of Objects Launched into Outer Space*, *supra* note 8 (indexing known objects currently in space attributable to certain states or organizations). Commercial participation is expected to grow substantially due to NASA’s plans to privatize LEO and the ISS for purposes other than scientific research. NAT’L AERONAUTICS & SPACE ADMIN., NASA PLAN FOR COMMERCIAL LEO DEVELOPMENT TO ACHIEVE A ROBUST LOW-EARTH ORBIT ECONOMY FROM WHICH NASA CAN PURCHASE SERVICES AS ONE OF MANY CUSTOMERS 5 (June 2019), https://www.nasa.gov/sites/default/files/atoms/files/commleodevt_plan_6-7-19_final-links-new.pdf [https://perma.cc/B7NU-NN59].

82. *See* Ward, *supra* note 44, at 3 (“Today neither lawyers nor governments are prepared to state the legal flight rules applicable to presently operating rockets and planned satellites. For the second time in the present century science and engineering have far out-stripped the law.” (quoting John Cobb Cooper, Address before the American Society of International Law (Apr. 26, 1956))).

83. Shackelford, *Tragedy of the Common Heritage*, *supra* note 6, at 120–21 (“[UNCLOS, ATS, and the OST] were created during the Cold War at a time before technological progress fully opened up these areas to economic activity.”). However, protocols and amendments subsequently shored up the deficiencies in the ATS and UNCLOS text. Currently, all mining efforts are suspended in Antarctica until 2048 unless a binding agreement to that effect enters into force. Madrid Protocol, *supra* note 18, at arts. 7, 25(5). When technology outgrew the original provisions of UNCLOS, nation-states sought

property, one can visualize the boundaries and confines of a tract of land.⁸⁴ Even in the context of more abstract property interests, such as minerals or the sea, one can envisage the inherent spatial limitations.⁸⁵ Contrary to Earth-side property, legal scholars proffer that space lacks tangible parameters.⁸⁶ This mischaracterization marks the point of departure between the current sustainability of geospace and this Comment's proposed construct.⁸⁷

The laws of astrophysics physically limit our ability to occupy geospace. And because it is finite, every satellite launched into space adds a corresponding negative utility to geospace.⁸⁸ In 2019 alone,⁸⁹ the potential for an interruption capable of derailing any derivative benefit from space drew ever closer—the essence of the tragedy of the commons.⁹⁰ Without a binding mitigation framework, continued satellite proliferation will only catalyze the destruction of our correlative rights⁹¹ in the geospace commons.

to recover mineral resources outside of their territorial waters, necessitating the creation of the International Seabed Authority, which facilitates the operation of deep-sea mining enterprises. G.A. Res. 48/263, annex, Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982 (Aug. 17, 1994). The following year, binding conservation measures for vulnerable fish stocks became available for signature. Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, Aug. 4, 1995, T.I.A.S. No. 01-1211. We are overdue for an update to the *Corpus Juris Spatialis*.

84. For example, metes and bounds signify the finite extent of use and dominion over a set acreage.

85. See Jordan Hanania, Kailyn Stenhouse & Jason Donev, *Energy Education: Oil and Gas Traps*, UNIV. CALGARY, https://energyeducation.ca/encyclopedia/Oil_and_gas_traps [<https://perma.cc/NP4H-257W>] (illustrating varieties of stratification where oil and gas deposits form, indicative of physical confinement and an exhaustible nature of the resource).

86. See Shackelford, *Tragedy of the Common Heritage*, *supra* note 6, at 141 (“What makes space unique, however, is its status as the ultimate international commons, replete with infinite resources sufficient to satisfy infinite demand.”).

87. Button, *supra* note 3, at 539–40.

88. Hardin, *supra* note 6, at 1244–45.

89. See *Online Index of Objects Launched into Outer Space*, *supra* note 8 (indicating 581 satellites were added in geospace in 2019).

90. Hardin, *supra* note 6, at 1244–45.

91. Similar to the development of oil and gas law, space jurisprudence is *sui generis*, or “of its own kind.” *Sui generis*, BLACK'S LAW DICTIONARY (10th ed. 2014); Wm. E. Colby, *The Law of Oil and Gas: A Consideration of Landonners' Rights, Particularly as Developed in California*, 31 CALIF. L. REV. 357, 357 (1943). Parallel to oil and gas law's use of *ferae naturae* in developing correlative rights, analogizing the construct of correlative rights to the global commons in orbital space is an appealing corollary. See *Elliff v. Texon Drilling Co.*, 210 S.W.2d 558, 581–82 (Tex. 1948) (rejecting the wild-animal analogy but

The 2017 Scientific and Technical Subcommittee of COPUOS made a chilling summary of the reality of the space debris threat when it explained:

More than 20,000 pieces of space debris the size of a tennis ball or larger orbit the Earth with a velocity of nearly 17,500 mph. These uncontrolled fragments and other debris (such as discarded rocket bodies, and retired satellites) can collide with each other and generate more debris, in a cycle popularly known as the “Kessler syndrome.” The Kessler syndrome in turn results in an exponential growth of orbital debris as time progresses, with an ever-increasing risk for operational bodies in orbit. In addition to their number, these pieces of debris have enough energy to break the rigid wall of satellites, and destroy satellites.⁹²

Donald J. Kessler cautioned that we would eventually reach a tipping point, triggering a chain reaction in near-Earth orbit of hypervelocity collisions⁹³ that will trap humanity on Earth.⁹⁴ Prospectively, because the “delay in implementation of [debris mitigation] methods reduces their effectiveness,”⁹⁵ without comprehensive compliance, once Kessler Syndrome begins, the result will likely revert our telecommunication abilities back to the late 1800s. Yet self-interested parties continue to exploit highly sought-after orbital resources.⁹⁶

respecting its precursory benefit in developing the rule of capture and correlative rights). Though correlative rights relate to interests in a *mineral* tract common to contiguous landowners, one could analogize this construction to the common heritage of mankind to justify granting an equitable opportunity to benefit from a common space resource. See Wolfrum, *supra* note 58, at 318 (“The adoption of the term ‘mankind’ from the Outer Space Treaty taken together with the term ‘heritage’ at least indicates that the interests of future generations have to be respected in making use of the sea-bed.”).

92. COPUOS, Fifty-Fourth, *supra* note 7, at 9. These figures only represent the fragments under direct observation from debris tracking devices. It is estimated that over 166 million pieces of debris—ranging in size from 1 millimeter to 1 centimeter—reside in geospace, and regardless of size, these tiny materials have the potential to vaporize objects upon collision. *Space Debris by the Numbers*, EUR. SPACE AGENCY, (Jan. 2018) https://www.esa.int/Our_Activities/Operations/Space_Debris/Space_debris_by_the_numbers [<https://perma.cc/2J9M-WUBJ>]; Donald J. Kessler & Burton G. Cour-Palais, *Collision Frequency of Artificial Satellites: The Creation of a Debris Belt*, 83 J. GEOPHYSICAL RES. 2637, 2639 (1978).

93. Kessler & Cour-Palais, *supra* note 92, at 2639–40.

94. Kurzgesagt—In a Nutshell, *End of Space—Creating a Prison for Humanity*, YOUTUBE (Nov. 25, 2018), <https://www.youtube.com/watch?v=yS1ibDImAYU> (last visited May 11, 2020).

95. Kessler & Cour-Palais, *supra* note 92, at 2645.

96. See Portney & Macauley, *supra* note 79 (discussing entities competing desires for a “slice” of the “geostationary pie”).

C. Domestic Legislation

One of the primary challenges jurists face when formulating international standards for space activity lies with COPUOS, because the unanimous support of its delegates is a prerequisite for concluding any multilateral agreement.⁹⁷ While the consensus method initially provided a great deal of strength to the *Corpus Juris Spatialis*'s mandates, the Committee's ever-expanding membership has frustrated the adoption of any *binding* principles and guidelines since the 1980s.⁹⁸ Despite the dearth of compulsory language, non-binding declarations of law inform us of the likely trajectory toward binding agreements in the future. Even without mandatory language, domestic legislation has mirrored COPUOS's instruments addressing mitigation efforts.⁹⁹

The National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), and Federal Communications Commission (FCC) serve key administrative functions in the mitigation of debris attributable to U.S. space activity. Prior to the passage of the Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015 (SPACE Act),¹⁰⁰ NASA facilitated many of humanity's first triumphs in space faring and still plays an active role in tracking, cataloging, and formulating debris mitigation standards in the U.S.¹⁰¹ The 2019 update to these standards reflected the culmination of debris research, and sets benchmarks on permissible debris creation.¹⁰² While NASA has long been

97. Eilene Galloway, *Consensus Decisionmaking by the United Nations Committee on the Peaceful Uses of Outer Space*, 7 J. SPACE L. 3, 3 (1979).

98. GLOBAL SPACE GOVERNANCE: AN INTERNATIONAL STUDY 32 (Ram S. Jakhu & Joseph N. Pelton eds., 2017); *see generally* INTERNATIONAL SPACE LAW: UNITED NATIONS INSTRUMENTS (U.N. Office of Outer Space Affairs, 2017) (compiling documents adopted by General Assembly since 1967).

99. Though this Comment focuses on U.S. law specifically, other nation-states have corollary statutory schemes. For a more comprehensive review of other nation-states' domestic legislation, see COMPENDIUM: SPACE DEBRIS MITIGATION, *supra* note 21.

100. Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015, Pub. L. 114-90, 129 Stat. 704 (codified in scattered sections of 51 U.S.C.).

101. NASA ACAD. OF PROGRAM/PROJECT & ENG'G LEADERSHIP, ORBITAL DEBRIS MANAGEMENT & RISK MITIGATION §§ 2–3 (Daniel Connell et al. eds., 2012).

102. U.S. OFF. OF SCI. & TECH. POL'Y, ORBITAL DEBRIS MITIGATION STANDARD PRACTICES (2019). The Orbital Debris Mitigation Standard Practices (ODMSP) consist of five objectives which seek to (1) control debris release, (2) minimize the creation of new debris from accidents, (3) increase capacities for better spacecraft design, (4) dictate methods for post-mission disposal of defunct spacecraft, and (5) establish probability benchmarks for special mission—such as satellite constellations—disposal plans. *Id.*

one of the three major space agencies operating in space, the reality of political cycles has forced NASA to look elsewhere to sustain project funding and support of existing national laboratories, namely the ISS.¹⁰³ Still, much of the commercial activity in space consists of NASA-awarded government contracts for resupply missions, payload transport, and other collaborative projects with other nations.¹⁰⁴ However, in the last decade, independent commercial activity has exploded. The SPACE Act thus initiated the privatization of space, as commercial payloads are now being launched into geospace unilaterally without any precursory relationship with NASA, other than the occasional use of NASA launch facilities.¹⁰⁵

In order to access space and place a satellite into orbit, a launching party must obtain a launch license from the FAA,¹⁰⁶ and an authorization for

103. Due to the cancellation of the Space Shuttle Program:

Between 2006 and 2018, NASA will pay Roscosmos approximately \$3.4 billion to ferry 64 NASA and partner astronauts to and from the ISS in its Soyuz spacecraft at prices ranging from approximately \$21.3 million to \$81.9 million for each roundtrip.

The goal of the Commercial Crew Program is to foster an industry that would meet the Agency's needs as well as those of other Government and nongovernmental entities. As of May 2016, NASA had spent approximately \$3.4 billion on this effort. The final phase of this effort began in September 2014 when NASA awarded the Space Exploration Technologies Corporation (SpaceX) and The Boeing Company (Boeing) firm-fixed-price contracts to complete development of their crew transportation systems and, assuming they meet the Agency's safety and performance requirements, receive certification to begin flying astronauts to the ISS on a regular basis.

NASA OFFICE OF INSPECTOR GEN., IG-16-028 (A-15-010-00), NASA'S COMMERCIAL CREW PROGRAM: UPDATE ON DEVELOPMENT AND CERTIFICATION EFFORTS 1 (2016).

104. For instance, all human transport to and from the ISS is on the Russian Soyuz which launches from and re-enters the atmosphere near the Baikonur Cosmodrome in Kazakhstan. *Id.* This, in and of itself, is powerful evidence of the global interest in routine access to space, considering the tenuous political relationship between the United States, Europe, and Russia.

105. SpaceX uses NASA's 39A launch complex, but often lands its reusable rocket bodies on two seaward barges—Of Course I Still Love You and Just Read the Instructions. It has also constructed a private launch facility at Boca Chica Beach near the U.S.–Mexico border. *About SpaceX*, SPACEX, <https://www.spacex.com/about> [<https://perma.cc/R3HJ-AQ8N>]. BlueOrigin has constructed a launch facility near Van Horn, Texas and VirginGalactic has signed a twenty-year lease to provide private space flights from Spaceport America in Truth or Consequences, New Mexico. FAA OFFICE OF COMMERCIAL SPACE TRANSP., ANNUAL COMPENDIUM OF COMMERCIAL SPACE TRANSPORTATION 29–30 (2017).

106. 14 C.F.R. § 413.3 (2019). As a prerequisite to licensure, the FAA reviews launch applications for safety, potential environmental impact, liability exposure, and airspace integration of the proposed launch and eventual orbital position. *Id.* pt. 415 app. B. Notably, the FAA requires a debris analysis be submitted with license application materials, and licensees must ensure that any debris jettisoned from any payload not come within 200 feet of another *manned* or *mannable* space object

satellite radio frequency transmission from the FCC.¹⁰⁷ Because commercial space contractors have created business models that operate to the exclusion of government contracts, this upsurge of private activity affords the FCC a substantial level of influence over the future of geospace. Aware of its normative power, the FCC proposed a rulemaking for updated debris mitigation standards as part of its licensure reviews.¹⁰⁸ But as part of the current administration's policies toward economic growth and competition, the FCC's efforts to create these new standards have been "paused."¹⁰⁹ Without NASA oversight and the FCC's final rule for mitigation standards, COPUOS has become the only feasible avenue for promulgating a framework that considers economic incentives in tandem with intergenerational equity. Under Hardin's analysis, coercive regulation and management of the commons provide a workable solution to free us from our current trajectory.¹¹⁰

during launch. *Id.* §§ 417.211; 417.107(e). As such, the FAA is specifically concerned with the safety of humans rather than the lasting utility of geospace.

107. 47 C.F.R. § 25.115 (2019). The FCC is the domestic counterpart to the ITU and is "responsible for managing and licensing the electromagnetic spectrum for commercial users" seeking satellite acquisition services. *Licensing*, FCC, <https://www.fcc.gov/licensing-databases/licensing> [<https://perma.cc/HL6B-9VSP>]; see *supra* text accompanying note 19 (discussing the role of the ITU). An application is reviewed concurrently by both the FCC and ITU to coordinate allocation of the radio frequency spectrum. See, e.g., 47 C.F.R. § 25.146(c) (requiring a satellite operator to obtain a finding from the ITU that proposed frequency exposure limits are "favorable" prior to a satellite operator's utilization of assigned frequency in LEO).

108. Mitigation of Orbital Debris in the New Space Age, 84 Fed. Reg. 4,742 (proposed Feb. 19, 2019).

109. Daniel Wilson, *Commerce Asks FCC to Pause Space Junk Mitigation Rule*, LAW360 (7:57 PM, Apr. 9, 2019), <https://www.law360.com/articles/1148129/commerce-asks-fcc-to-pause-space-junk-mitigation-rule> [<https://perma.cc/5W5T-EMQM>]. Rather, the recent Space Policy Directive created the Office of Space Commerce under the U.S. Department of Commerce, and the FCC has become but a meager cog in the interagency wheel. The Space Policy Directive intends to consolidate the launch and reentry process into the Department of Commerce, rather than across the FCC, the Federal Aviation Administration, and the National Oceanic and Atmospheric Administration. Space Policy Directive-2, 83 Fed. Reg. 24,901, 24,901 (May 24, 2018).

110. Hardin restates Georg Wilhelm Friedrich Hegel's maxim, "Freedom is the recognition of necessity" to emphasize that assigning rights, such as property rights, forces society to abandon flooding the commons without restraint, yet results in freedom from a self-inflicted demise. See Hardin, *supra* note 6, at 1247-48 (illustrating the success of abandoning unabated commons usage by restricting waste disposal that would otherwise have led to condemning an entire commons); Shackelford, *Tragedy of the Common Heritage*, *supra* note 6, at 130 ("[O]nce occupation of a territory is possible, [regulations] become necessary to catalyze development.").

IV. NECESSITY FOR REGULATION TO PRESERVE THE HERITAGE
OF MANKIND—A PROPOSAL

Conceptually, all persons hold an implied property right in the space commons.¹¹¹ As such, spacefaring entities and developing nations possess an equitable right to access and use orbital resources.¹¹² But the *sui generis* nature of geospace presents a paradox requiring a unique regime for the sustainable usage of its resources.¹¹³ The international community cannot realize the advantages of the common heritage principle under a property regime because any conceivable assignment would violate the non-appropriation clause or unjustly enrich a particular interest.¹¹⁴ This

111. *Accord* Shackelford, *Tragedy of the Common Heritage*, *supra* note 6, at 110 (“[T]heoretically, all of humanity became the sovereign over the international commons.”).

112. *Cf.* International Covenant on Economic, Social and Cultural Rights pt. 1, art. 1, Jan. 1, 1976, 993 U.N.T.S. 3 (“1. All people have the right of self-determination. . . . 2. All people may, for their own ends, freely dispose of their natural wealth and resources without prejudice to any obligations arising out of international economic co-operation, based upon the principle of mutual benefit, and international law.”). Even though the United States has yet to ratify the International Covenant on Economic Social and Cultural Rights (ICESCR), its signature obligates it not to act in such a way that would defeat the object and purpose of the treaty. Vienna Convention on the Law of Treaties, *supra* note 16, at art. 18.

113. Aside from the limitations of LEO and GSO, it seems prudent to mention that satellites can only maintain their orbital positions through small orbital maneuvers. Unlike conventional airplanes which change altitude and speed without losing any degree of control, satellites cannot freely move about the thermosphere or exosphere without compromising the utility of their permissible slots or endangering the operation of neighboring objects. Alicia Ault, *Ask Smithsonian: How Does a Satellite Stay Up?*, SMITHSONIAN MAG. (Feb. 6, 2015), <https://www.smithsonianmag.com/smithsonian-institution/ask-smithsonian-how-does-satellite-stay-180954165/> [<https://perma.cc/EP8W-AZNL>] (describing how satellites stay in orbit by counteracting the downward pull of Earth’s gravity with forward momentum); *cf.* Roberts, *supra* note 66, at 1101 (“[F]or the purposes of most policy discussions, the geostationary orbit can be considered a one-dimensional line describing a great circle around the planet.”). Any excessive propulsion in the wrong direction could cause radio interference, loss of a particular orbit, or an uncontrolled satellite. *See generally* Craig E. Roberts, *The SOHO Mission L1 Halo Orbit Recovery From the Attitude Control Anomalies of 1998*, Proceedings of the Libration Point Orbits and Applications Conference (Spain, 2002) (detailing the difficulty of maintaining halo orbits and the potential adversities of over-propulsed satellites). Fundamentally, using geospace requires spacefaring entities to occupy the resource for an extended period of time to realize any benefit from their capital investment. *See* JOHN G. SPRANKLING, THE INTERNATIONAL LAW OF PROPERTY 192 (2014) (“[ITU] continues to consider limiting the duration of assignments, while recognizing the importance of ensuring an adequate period of time for owners to amortize the investments that are required to launch and operate satellites.”).

114. Some proposals unnecessarily burden the entities capable of reaching space with capital investment but require a distribution of benefits to states that did not make a contribution to the endeavor. Landry, *supra* note 6, at 540–42. Similarly inequitable proposals suggest property auctions, awarding space realty based on a “monstrous” bureaucratic valuation mechanism. *Id.* at 558–560. Another allocates property proportionate to a state’s Earth-side landmass. *Id.* at 546–50. Property

means that only regulatory solutions can protect the interests inherent in a commons protected for the common heritage of mankind.

A. *The Motivations for International Compliance*

The crux of a workable treaty lies in the consent of the parties to the agreement.¹¹⁵ Thereafter, signatories internalize the agreement's object and purpose into their domestic law, or in the case of international organizations, into an institutional framework.¹¹⁶ To implement a binding international instrument, we must therefore ask the question: Why do nations follow international law,¹¹⁷ and how can we use those behavioral realities to construct a workable framework to ensure geospace survives?¹¹⁸

regimes provide legal clarity and allow property owners a means to protect their interests through damages, nuisance, or conversion claims. Definitive property rights force the internalization of negative externalities, an ideal enforcement measure for space jurisprudence. See Harold Demsetz, *Toward a Theory of Property Rights*, 57 AM. ECON. R. 347, 348 (1967) ("A primary function of property rights is that of guiding incentives to achieve a greater internalization of externalities."). The ITU's allocation of orbital slots technically evades violation of the non-appropriation clause because it provides a means for merely *using* orbital real estate, even though permissible use resembles that of a leasehold. *Accord* Int'l Telecomm. Union [ITU], Const. art. 44(2), *adopted by* Plenipotentiary Conference (Minneapolis, 1998) ("In using frequency bands for radio services, Member States shall bear in mind that radio frequencies and any associated orbits, including the geostationary-satellite orbit, are *limited* natural resources and that they must be used rationally, efficiently, and economically . . . so that countries or groups of countries may have equitable access to those orbits and frequencies, taking into account the special needs of the developing countries.") (emphasis added). Regardless of this quasi-property right, the OST and Liability Convention do not adequately force the internalization of externalities. One's liability for damages is only invoked if sufficient evidence connects the space object to the identity of the responsible party. Liability Convention, *supra* note 52, at art. X. For example, it is nearly impossible to establish the origination of a bolt after hypervelocity impacts. Kessler & Cour-Palais, *supra* note 92, at 2639. A more effective treaty would address the actual creation of debris. Timothy Joseph Trapp, Note, *Taking Up Space By Any Other Means: Coming to Terms With the Nonappropriation Article of the Outer Space Treaty*, 2013 U. ILL. L. REV. 1681, 1693 (2013).

115. Vienna Convention on the Law of Treaties, *supra* note 16, at art. 9.

116. See Benefits Declaration, *supra* note 23, at ¶ 2 ("States are free to determine all aspects of their participation in international cooperation in the exploration and use of outer space on an equitable and mutually acceptable basis."); Krause, *supra* note 51, at 48 ("[I]ncreasingly, nations are enacting legislation and regulations for commercial space activity. 'Space law is at the jagged edge between legislative and executive power[.]'"). The European Space Agency, while not a sovereign nation, has ratified the provisions of the Liability Convention, Rescue Agreement, and Registration Convention. COPUOS, Fifty-Seventh, *supra* note 17, at 10.

117. However, some scholars suggest that this multifarious body of national and international space law could work as the foundation for a workable mitigation regime. Shackelford, *Governing the Final Frontier*, *supra* note 6 at 433–34, 433 n.30.

118. Compare HANNEKE VAN TRAA-ENGELMANN, COMMERCIAL UTILIZATION OF OUTER SPACE: LAW AND PRACTICE 5–6 (1993) ("Preconditioned by the international and even universal nature of outer space affairs, it was self-evident that international relations were bound to play a leading

At the dawn of civilized society, depending on a particular jurisdiction's values, the laws of nature and morality compelled obedience and social order.¹¹⁹ When nation-states concluded international agreements, it represented the coalescence of the various values-based systems, the overlap of which formed a universal understanding of the law of mankind.¹²⁰ “[The] fundamental conceptual boundary between municipal and international law . . . view[s] international law largely in terms of contractual relations, therefore assigning to the ‘sovereign’ a central place in the construction of the two orders.”¹²¹ In other words, transnational cooperation operated through balancing the competing autonomy and values of the parties involved. Despite centuries of debate, values systems remain the principal motivating factor of compliance with international law.¹²² Effective regulatory regimes must, therefore, strike at the heart of what nation-states value the most, which is often related to national security.¹²³

When entering an international agreement, whether or not a nation-state will ratify it informs us of the value a nation-state places on the instrument's subject matter. That value equates to the utility a nation-state places on certain allowances or prohibitions.¹²⁴ Incorporating these motivating

role in the regulation of the fourth environment and man's activities therein.”), with Harold Hongju Koh, *Why Do Nations Obey International Law?*, 106 YALE L.J. 2599, 2600 (1997) (“[I]f we cannot predict when nation-states will carry out their international legal obligations respecting trade retaliation, environmental protection, human rights, global security, and supranational organizations, how can we count on ‘multilateralism[.]’”).

119. Koh, *supra* note 118, at 2604–05 (detailing the religious influence on early legal systems).

120. However, the free-will of humanity explains the varied systems of law among nation-states. *Id.* at 2606–07 (marking Hugo Grotius' declarations of free will as the proverbial wedge driven between sovereign concerns and those of the international community).

121. *Id.* at 2607.

122. See Terry Nardin, *International Ethics and International Law*, 18 REV. INT'L STUD. 19, 23–24 (1992) (“[C]ustomary international law reflects the inevitably plural character of international society and may be said to constitute a morality of states, one that is a morality of coexistence.”). Three schools of thought interpret the probability of compliance with international law. Koh, *supra* note 118, at 2632–34. First, various rational choice theories proffer that compliance hinges on whether the regulatory scheme will further the self-interest of parties involved. *Id.* at 2632–33. Second, liberal international relations theories consider well-defined democratic institutions as the preferred mechanism of enforcing rights and obligations. *Id.* at 2633. Third constructivism advances the theory that rules and normative values are a direct reflection of the evolution of social interaction and shared ideas which validate mechanisms ensuring peace and security. *Id.* at 2633–34.

123. *Id.* at 2658 (concluding that international regulatory schemes that cause nation-states to internalize the object and purpose of an agreement as the best means to bolster adherence).

124. The Vienna Convention and Montreal Protocols on Substances that Deplete the Ozone Layer became the first treaty body in world history to achieve universal ratification. *Most-Ratified*

factors with Hardin's regulatory solution, any freedoms infringed upon must manifest a higher utility than currently realized. If COPUOS proposes a protocol for sustainable uses of space, the provisions must either have a negligible effect on the global community's perceived utility of space access or substantially increase that utility. Assuming the propositioned regulatory scheme aligns with the values system of each nation-state, the probability of internalizing such regulations through domestic codification is high.

To ascertain the interests of nation-states, we must look to the factors motivating current space utilization. Routine access to space undeniably aids our technological advancement. The ISS's antigravity environment provides unique conditions to study medicine.¹²⁵ Satellites provide real-time tracking of environmental conditions and transmit crucial information for disaster recovery planning.¹²⁶ Space telescopes track objects with the potential to cause the extinction of life of Earth.¹²⁷ Free from the veil of our hazy atmosphere, satellites can produce better imagery and ascertain the composition of potential resource deposits on celestial bodies.¹²⁸ And simply receiving satellite imagery of our planet forces us to confront the realities of our fragile existence. These benefits signify the tangible realization of the OST's object and purpose, which flow to all

International Treaties, U.N. BLOG (Sept. 24, 2012), <https://blogs.un.org/blog/2012/09/24/most-ratified-international-treaties/> [<https://perma.cc/VT72-8QPV>]. Beyond a reasonable doubt, humanity values the integrity of the atmosphere and will make sacrifices to protect its utility.

125. ISS experiments have led to advances in treatments for osteoporosis and muscular pathologies, as well as the cardiovascular side-effects from radiation exposure, a fatal byproduct of long-term space travel currently preventing us from becoming a multiplanetary species. Comm. on the Peaceful Uses of Outer Space, Rep. of Rep. of Sci. & Tech. Subcomm. on Its Thirty-Fifth Session, U.N. Doc. A/AC.105/697, at 28 (1998). The technology behind the Canadian Space Agency's Canadarm2 robotic arm, which captures resupply vessels, is utilized in the removal of once-inoperable tumors. *15 Ways the International Space Station is Benefitting Earth*, NAT'L AERONAUTICS & SPACE ADMIN. (Oct. 30, 2015), https://www.nasa.gov/mission_pages/station/research/news/15_ways_iss_benefits_earth [<https://perma.cc/D877-8F8L>].

126. Earth observation satellites impart more precise prediction of natural disasters allowing for more effective disaster mitigation and evacuation planning. NAT'L AERONAUTICS & SPACE ADMIN., *supra* note 125.

127. *See generally* Comm. on the Peaceful Uses of Outer Space, Rep. of Sci. & Tech. Subcomm. on Its Fiftieth Session, U.N. Doc. A/AC.105/C.1/L.330 (2013) (reporting the active and planned satellite missions tracking near-Earth objects).

128. Planetary Resources' ARKYD satellite platform mission seeks to identify the composition of resources on near-Earth asteroids. *The ARKYD Spacecraft Development Platform*, PLANETARY RESOURCES (2015) <https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=3273&context=smallsat> [<https://perma.cc/47V9-NAVF>].

members of the global community.¹²⁹ If we do not begin active decontamination and mitigation of space debris, the utility of geospace will cease to exist. Imagining our existence without these advances is a potent method to stress the criticality of unabated pollution in geospace.

B. *Existing Proposals*

Legal scholars have formulated several frameworks to mitigate space debris. Some recommend implementing a market-share liability regime, which assigns liability according to the volume of each nation-states' exploits.¹³⁰ Opponents of this construction rightfully highlight the inequities inherent in such a scheme. Considering the United States, Russia, and China make up the bulk of spacefaring activity, market-share liability would unduly burden these nations, and coerce a categorical exit from the space industry or a repeat of the Moon Treaty.¹³¹ Another scholar advocates for an environmental law approach, asserting that the space commons would benefit from a protocol closely mirroring the Madrid Protocol.¹³² While prospective applications of such a model could prevent additional accumulations, it would not feasibly abate the current collection of debris.¹³³ The strengths of Mary Button's mitigation proposal lie in the binding nature of the Madrid Protocol and compulsory environmental impact requirements. And though it advocates for a more collaborative conference mechanism, rather than the strict unanimous consent required of UNCOPUOS's resolutions, it still shies away from compulsory

129. See, e.g., G.A. Res. A/RES/61/110, United Nations Platform for Space-Based Information for Disaster Management and Emergency Response (Jan. 15, 2007) (implementing UN-SPIDER to foster satellite information sharing with developing nations to increase disaster mitigation capacities).

130. E.g., Peter L. Limperis, Note, *Orbital Debris and the Spacefaring Nations: International Law Methods for Prevention and Reduction of Debris, and Liability Remains for Damage Cause by Debris*, 15 ARIZ. J. INT'L & COMP. L. 319, 342 (1998).

131. Cf. Landry, *supra* note 6, at 525 ("No state or private entity has been willing to bear the enormous cost of commercialization in part because international law prohibits nation and, potentially, private appropriation, and even if the laws are interpreted to allow private appropriation, they require private entities to share some unclear quantity of returns ('benefits') with every state on Earth.").

132. Button, *supra* note 3, at 563 (proffering that the compulsory environmental impact assessment framework of the Madrid Protocol could act as a viable enforcement mechanism for any planning space launch).

133. The Madrid Protocol obligates parties to remove the waste attributable to their activity in Antarctica. Madrid Protocol, *supra* note 18, at annex III & art. 1. In geospace, despite the Registration Convention, debris smaller than ten centimeters cannot be tracked or identifiably connected to a responsible party, yet still has the potential to start a destructive chain reaction. *Space Waste & Debris*, *supra* note 75.

requirements for active debris removal. Along with the Antarctic Treaty (ATS), the Law of the Sea (UNCLOS) also served as a model for the *Corpus Juris Spatialis*. But oddly, the law of salvage was omitted from the treaties. Unlike abandoned objects at sea, once a nation-state places an object into space, ownership exists in perpetuity. Sandra Drago addressed removing the OST's property-in-perpetuity mechanism¹³⁴ so as to permit the active salvage of inoperable satellites.¹³⁵ Drago's proposal is vital to any mitigation framework. But while this removes a substantial bar currently restricting debris removal, it does not address free-riding, and spacefaring enterprises are free to choose more lucrative space activities other than salvage operations.¹³⁶

C. *A Coercive Proposal*

Mutual coercion lies at the core of Hardin's solution.¹³⁷ To summarize, law-abiding citizens make concessions to regulatory social constructs in the interest of conserving some utility otherwise lost.¹³⁸ The coercive element lies in relinquishing one's ability to exploit some freedom, the detriment of which cannot be realized at that moment in time.¹³⁹ Conceding to a regime that tempers free exploitation of the commons allows everyone to benefit from the positive externalities of individual usage. Equated to space, nation-states currently concede to non-appropriation in the interest of maintaining equitable access. But because of the *sui generis* nature of geospace, even non-participants receive a benefit from the use of the

134. See Emily M. Nevala, *Waste in Space: Remediating Space Debris Through the Doctrine of Abandonment and the Law of Capture*, 66 AM. U. L. REV. 1495, 1520 n.160 (2017) ("Article VIII of the Outer Space Treaty allows jurisdiction and control over space objects so long as they remain in space, but at the same time it seems to grant ownership rights in perpetuity.").

135. Sandra Drago, Note, *No Man's Sky: Utilizing Maritime Law to Address the Need for Space Debris Removal Technology*, 59 SANTA CLARA L. REV. 389, 419 (2019).

136. *Cf. id.* at 419–21 (discussing salvage awards as an incentive to clean up space debris). One sharp criticism to Drago's proposal is the promise of SpaceX's innovation. If anything, SpaceX is exacerbating the danger of debris proliferation with the StarLink satellite internet constellation. Apart from SpaceX, the Space Resource Exploration and Utilization Act of 2015 authorized the commercial recovery of asteroid resources as long as such is acquired in accordance with the OST, which will prove lucrative with the requisite technological capabilities. Space Resource Exploration and Utilization Act of 2015, Pub. L. 114-90, 129 Stat. 721, 722 (disclaiming any extension of extraterritorial sovereignty implicated through activities authorized by the act).

137. Hardin, *supra* note 6, at 1247.

138. *Id.* at 1248.

139. See Demsetz, *supra* note 114, at 349 ("It is the prohibition of a property right adjustment, the prohibition of the establishment of an ownership title that can henceforth be exchanged, that precludes the internalization of external costs and benefits.").

commons. In effect, beneficiaries are free-riding from the capital investment of spacefaring nations and entities. This informs the structure of the ensuing two-part framework: geospace delimitation and global liability.

1. Geospace Delimitation

The history of regulatory delimitation illustrates its effectiveness at balancing the rights of individuals, sovereigns, and mankind. Each instance explained in Part II *infra*, arose out of public necessity to ensure and protect the maximum utility of the global commons, without the deleteriousness of inhabitability, sovereign interference, or over-exploitation.¹⁴⁰ The regimes governing Antarctica, the High Seas, the Atmosphere, and the radio-frequency spectrum evidence that mutually coercive delimitation can honor the common heritage of mankind, without encroaching on the peaceful enjoyment and benefits attributable to these areas.

a. Antarctica

In the 1950s, there was concern that Antarctica would succumb to Cold War hysteria, becoming a target for international discord and nuclear arms testing.¹⁴¹ In a move to reestablish global scientific exchange, the international scientific community hosted the International Geophysical Year project, and after identifying the potential of Antarctica, sought to protect it from any ruinous power posturing.¹⁴² This necessity for regulating permissible activity resulted in the formation of the ATS.¹⁴³ Subsequent technological advancement revealed mineral deposits, triggering

140. Part of Garrett Hardin's thesis emphasizes necessity as the catalyst for regulatory solutions:

Every new enclosure of the commons involves the infringement of somebody's personal liberty. Infringements made in the distant past are accepted because no contemporary complains of a loss. It is the newly proposed infringements that we vigorously oppose; cries of "rights" and "freedom: fill the air. But what does "freedom" mean? When men mutually agreed to pass laws against robbing, mankind became more free, not less so. Individuals locked into the logic of the commons are free only to bring on universal ruin; once they see the necessity of mutual coercion, they become free to pursue other goals.

Hardin, *supra* note 6, at 1248.

141. Seven countries have attempted to claim sovereignty over Antarctica, but these claims were suspended at the conclusion of the ATS. Bureau of Arms Control, Verification, and Compliance, *Antarctic Treaty*, U.S. DEP'T OF STATE, <https://www.state.gov/t/avc/trty/193967.htm> [<https://perma.cc/78VE-4LLA>].

142. *Id.*

143. The Antarctic Treaty, Dec. 1, 1959, 12 U.S.T. 794, 402 U.N.T.S. 71.

commercial interest in exploiting its natural resources. The threat catalyzed the promulgation of the Madrid Protocol.¹⁴⁴ Again, these delimitations did not sever humanity's utility in Antarctica. Rather, mankind conceded to the prohibition of deleterious usage in the interest of preserving its scientific utility.¹⁴⁵

b. The High Seas

Similar to Antarctica, the High Seas faced threats in the 1960s when nation-states began unilaterally and arbitrarily, extending resource recovery activities further into the depths of international waters.¹⁴⁶ In the interest of equity, particularly the interests of landlocked nations, UNCLOS delimited sovereign access to the seas, allowing usage only within the established exclusive economic zones (EEZs).¹⁴⁷ An annex to UNCLOS provided a procedural framework in which resource recovery enterprises could operate in international common areas beyond the EEZs, precluding the unilateral capture of global resources by one nation.¹⁴⁸ Once more, a mutually coercive framework removed certain freedoms in the interest of mankind without unjustly limiting equitable access to resources.

c. The Atmosphere

Divergent from the problems of the ice and sea, atmospheric regulation resolved an issue more analogous to geospace debris proliferation. Atmospheric utility is quite simple: breathable air and protection from deadly cosmic radiation. When satellite imagery revealed the sizable hole in the ozone layer, the Montreal Protocol to the Vienna Convention placed an

144. Madrid Protocol, *supra* note 18, at art. 7.

145. Antarctica's frozen territory contains a time capsule of *in situ* climate data, playing a valuable role in climate change models. *Why Study Antarctica?*, ANTARCTICA N.Z., <http://www.antarcticanz.govt.nz/science/why-study-antarctica/> [https://perma.cc/N3SU-N78A]. The Madrid Protocol provisions contain conservation mechanisms, such as compulsory environmental impact assessment requirements for planned expeditions to the region. Madrid Protocol, *supra* note 18, at art. 3.

146. Ian Hedges, Note, *How the Rest was Won: Creating a Universally Beneficial Legal Regime for Space-Based Natural Resource Utilization*, 40 VT. L. REV. 365, 384–85 (2015).

147. UNCLOS, *supra* note 36, at pt. V art. 57.

148. G.A. Res. 48/263, *supra* note 83. It should be noted that this annex remains unratified by the United States for the same reasons the Moon Treaty failed. *Law of the Sea Convention*, U.S. STATE DEPT. (Mar. 7, 2019), <https://www.state.gov/law-of-the-sea-convention/> [https://perma.cc/45ZW-TU57]. Sovereign claims to tangible natural resources in global common areas remains a contentious issue.

outright ban on ozone-depleting chemicals in everyday consumables.¹⁴⁹ This prohibition directly addressed the source of the negative externality, forcing humanity to internalize the externality through alternate investment in refrigerants. Recent evidence of the reduction of ozone loss validates the mutually coercive delimitation within the Montreal Protocol.¹⁵⁰

d. Regulating the Telecommunication Spectrum

The business model and financial strategy of telecommunications entities influence satellite deployment planning. Typically, orbital placement aims to “maximize [a] potential user base,” and if that base happens to encompass, for instance, the continental United States, market competition drastically narrows the availability of slots for satellite positioning.¹⁵¹ Realizing that satellite acquisition becomes moot without conscientious “use of telemetry and control . . . required for spaceflight,”¹⁵² the Space Radiocommunication Conference convened to revise the Radio Regulations in 1963,¹⁵³ granting the ITU authority to allocate radio frequencies among spacefaring entities.¹⁵⁴ Originally, the ITU:

[A]llocated orbits and frequencies solely through a first-in-time system. This led to concern that developed countries would secure all of the available slots before developing countries had the technological capacity to use them. Although some orbits and frequencies are still allocated on a first-in-time basis, each state is now guaranteed a certain number of future orbits and frequencies, regardless of its current technological capacity.¹⁵⁵

149. Montreal Protocol on Substances that Deplete the Ozone Layer, Sept. 16, 1987, T.I.A.S. No. 89-101, 1522 U.N.T.S. 3.

150. Though difficult to ascertain whether the reduction of ozone loss directly resulted from ozone-depleting chemical prohibition, such should not discount the international community’s compliance with production phase-out measures. Michael Carlowicz, *Measurements Show Reduction in Ozone-Eating Chemicals*, NAT’L AERONAUTICS & SPACE ADMIN. (Feb. 13, 2018), <https://earthobservatory.nasa.gov/images/91694/measurements-show-reduction-in-ozone-eating-chemical> [https://perma.cc/T3EY-CUHY].

151. Roberts, *supra* note 66, at 1102. For example, NOAA’s GOES satellites provide weather information and can act as a rescue beacon. *Three Classes of Orbit*, *supra* note 68.

152. Doyle, *supra* note 37, at 12–13.

153. *Radio Conference on Space Communications: Rewarding Results*, 30 TELECOMM. J. 366, 366 (1963).

154. The frequency at which space craft, satellites, and other object can operate without disruptive interference is limited. *Overview of ITU’s History*, ITU 2 (Jan. 3, 2019), <http://search.itu.int/history/HistoryDigitalCollectionDocLibrary/12.28.71.en.pdf> [https://perma.cc/YQ2P-S24F].

155. SPRANKLING, *supra* note 113, at 191.

The FCC regulates the segment of the electromagnetic spectrum allocated to the United States.¹⁵⁶ Arguably, the ITU and agencies like the FCC engage in de facto appropriation of the more highly sought-after orbits.¹⁵⁷ Yet to an extent, the ITU's delimiting of the radio-frequency spectrum remedied the negative externalities of non-appropriation in geospace, such as the overcrowding of *active* satellites and the resultant interference. Where the ITU's scheme does not remedy the byproduct of geospace resource use, it succeeds in ensuring communication capabilities remain free from inequitable use.¹⁵⁸

e. The OST's Ineffective Delimitations

The recurrent theme among the aforementioned regulatory schemes is the preservation of utility within the commons concerned.¹⁵⁹ The frameworks each provide a means to enjoy shared resources while removing the potential for destruction. The OST's nonproliferation provisions properly regulate the usage of the space commons to further the enjoyment of space's true utility: scientific discovery and telecommunications. Likewise, the Liability Convention reinforces the necessity to maintain heightened situational awareness to guarantee the mutual, uninterrupted enjoyment of activity in space.¹⁶⁰ But nation-states exploit the loop-holes within these documents to avoid internalizing some of their externalities. Specifically, the Liability Convention only assigns liability for damage caused to space objects when fault can actually be

156. 47 C.F.R. § 25.108 (2019).

157. Rob Frieden, *Balancing Equity and Efficiency Issues in the Management of Shared Global Radiocommunication Resources*, 24 U. PA. J. INT'L ECON. L. 289, 321 (2003).

158. See Int'l Telecomm. Union [ITU], Const. art. 1(2)(a), *adopted by* Plenipotentiary Conference (Minneapolis, 1998) ("[ITU] shall . . . effect allocation of bands of the radio-frequency spectrum, the allotment of radio frequencies and the registration of radio-frequency assignments and, for space services, of any associated orbital position in the geostationary-satellite orbit or of any associated characteristics of satellites in other orbits, in order to avoid harmful interference[.]").

159. One could argue that minerals are the true utility of Antarctica. This view fails to realize that those resources simply remain because the consultative parties have yet to reach a consensus on an equitable framework for mining enterprises. The utility of a commons protected under the common heritage of mankind principle requires equitable benefit sharing. So, the delimitation of resource usage in Antarctica merely operates to prohibit remorseless extraction of shared resources. Hardin, *supra* note 6, at 1244.

160. See Liability Convention, *supra* note 52, at pmb1. ("Recalling the [OST], . . . [and] recognizing the need to elaborate effective international rules and procedures concerning liability for damage caused by space objects[.]").

determined.¹⁶¹ Though it would be simple to assign fault to a collision caused by an intact and inoperative satellite, it is virtually impossible to identify the owner of smaller pieces of debris. Further, while the ITU reserves slots for nations not represented in space,¹⁶² it does nothing to stop those capable of reaching geospace from littering the commons and destroying the utility of reserved slots.¹⁶³ Holistically, none of the delimitations in the *Corpus Juris Spatialis* negate the *cause* of the growing belt of debris in geospace.

As a *sui generis* resource, the mere occupation of LEO or GSO equates to the reduction of the overall utility of geospace. When an entity launches a rocket into space, the accompanying payload causes either (1) temporary reduction of the aggregate utility of geospace or (2) permanent reduction of the aggregate utility of geospace.¹⁶⁴

The first delimitation prong will recommend bifurcating the applicability of the *Corpus Juris Spatialis*, with separate regimes for outer space and geospace. While the commercialization of *outer* space is not overly injurious to the international commons or interests of developing nations, the overcrowding of affluent spacefaring entities vying for orbital acquisition puts immense pressure on the finite resources within *geospace*. Therefore, demarcating the upper limit of geospace will allow entities to continue exploring the universe without imposing the restrictions placed on those seeking geospace positioning.¹⁶⁵ This modification will allow continued

161. *Id.* at art. III. Article II assigns absolute liability for “damage caused by its space object on the surface of the earth or to aircraft in flight,” which adequately addresses space debris on reentry. *Id.* at art. II.

162. SPRANKLING, *supra* note 113, at 191.

163. See Tyler A. Way, *The Space Gap, Access to Technology, and the Perpetuation of Poverty*, 5 INT’L RESEARCHSCAPE J. no. 7, 2018, at *3–4 (discussing a 2017 study of the Union of Concerned Scientists which found that for every satellite a developing nation launched, the United States, China, and Russia launched three satellites in aggregate). In the event that international cooperation cannot convene an agreement to promulgate a binding mitigation regime, the value of a developed nation’s reserved orbital slots are substantially devalued. Cf. Richard A. Posner, *Gratuitous Promises in Law and Economics*, 6 J. LEGAL STUD. 411, 412 (1977) (arguing for legal enforcement of gratuitous promises because to do otherwise significantly decreases the value and overall utility of a promise).

164. Most of the material jettisoned from rocket stages fall back to Earth, burning up in the atmosphere on re-entry, but not all. *Space Waste & Debris*, *supra* note 75.

165. It is pertinent that there be language permitting additional bifurcations, should it ever become necessary. For instance, the imminent James Webb Space Telescope, the successor of the Hubble Space Telescope, will be placed at the second Lagrange point, an orbital position that fixes the telescope in the shadows of the Moon so Earth blocks the Sun, keeping mission-critical infrared instruments from overheating. *Comparison: Webb vs Hubble Telescope*, NASA, <https://jwst.nasa.gov/content/about/comparisonWebbVsHubble.html> [<https://perma.cc/DRR3-LZM6>].

use of both regions, but coerce more sustainable usage of geospace with the assistance of the secondary prong below.

2. Global Liability

Operating under the theory that humanity holds an implied property right in the global commons but limited under the non-appropriation clause to protect those interests through traditional property mechanisms, the logical alternative is to impose liability on actions violative of the global interest.¹⁶⁶ Further, assuming humanity collectively benefits from utilization of this commons, then humanity likewise must internalize the cost of the negative externalities imposed.¹⁶⁷ This means that spacefarers, as members of the global collective, hold both the right and obligation to protect that right for others.¹⁶⁸ Therefore, anyone utilizing or benefitting from the utilization of the geospace commons has an equitable duty to ensure its sustainability. Under traditional tort theories, when one has a duty, breach of that duty causally linked to a measurable injury is actionable. In terms of the duty to humanity when utilizing geospace, the culmination of Kessler Syndrome represents the measurable injury.

Kessler informed the scientific community in 1970 of the probable cataclysmic chain-reaction and destructive conclusion of unabated geospace debris pollution.¹⁶⁹ This theory, reiterated consistently since its

166. Under Guido Calabresi and A. Douglas Melamed's property and liability rules, a nuisance claim under property regimes entitles the interest holder the grant of injunction; liability rules allow the nuisance to continue but requires a payment of damages to the injured party. James E. Krier & Stewart J. Schwab, *Property Rules and Liability Rules: The Cathedral in Another Light*, 70 N.Y.U. L. REV. 440, 442–43 (1995).

167. The collective right to share in the benefits of a global commons comes with a reciprocal obligation:

[T]he common heritage of mankind principle is not solely about benefit sharing. [It] is just as much about conservation and preservation. The principle is about solidarity; solidarity in the preservation and conservation of a good we all share and therefore should protect. But also solidarity in ensuring that this good, which we all share, is for all our benefit.

Aline Jaeckel et al., *Conserving the Common Heritage of Mankind – Options for the Deep-Seabed Mining Regime*, 78 MARINE POL'Y 150, 150 (2017) (quoting D. Tladi, *The Common Heritage of Mankind and the Proposed Treaty on Biodiversity in Areas Beyond National Jurisdiction: The Choice Between Pragmatism and Sustainability*, 25 Y.B. INT'L ENVTL. L. 113 (2015)).

168. *Id.*

169. Theoretically, even if we stopped traveling to space, Kessler Syndrome could still materialize without active reduction of existing debris. See Kessler & Cour-Palais, *supra* note 92, at 2642 (“With time, enough collisional fragments could be produced to become important in producing new

dissemination, materialized in 2009.¹⁷⁰ Fundamentally, every spacefaring entity and approving launching state knows of this monumental threat to the utility of geospace. Yet to date, mitigation guidelines remain non-binding, and four-figure satellite constellations continue to receive approval.¹⁷¹ To incorporate a time-honored risk calculation method, the Hand Formula is instructive and evidences a trend toward unapologetic endangerment to the utility of geospace in isolation of the associated tort regime.

Let us assume the burden to mitigate space debris is \$18.5 million¹⁷² but the probable magnitude of not mitigating the accumulation of space debris equates to reverting our technological capabilities back to the 1800s. Considering the accumulation of debris from the accidental or intentional breakup of geospace satellites, the probability of Kessler Syndrome fully concluding in the absence of a comprehensive mitigation protocol is one hundred percent.¹⁷³ While difficult to quantify, the value of our scientific progress attributable to the advent of space travel far outstrips the burden to mitigate space debris. Should Kessler Syndrome become our reality, the measurable injury is the cost of reestablishing global communications without the usage of satellite relays. To add insult to injury, the invaluable utility of geospace will cease to exist.

A viable alternative would institute a regime of shared global liability which makes consideration of capital investors as well as nonparticipating beneficiaries in the interest of equity. That is, should the inevitable prison

collisional fragments. When these conditions apply, the number of objects will increase exponentially with time, even though no new objects may be placed into orbit by man.”).

170. The IRIDIUM 33 and COSMOS 2251 collision marked the first accidental collision, though several malfunctioning satellites have previously exploded. Additionally, a Chinese anti-satellite test created *intentional* debris in 2007. By May 2010, ten separate incidents produced 7,903 pieces of trackable debris, with thousands more too small to catalogue. The fact that accidental collisions are occurring within a four year margin of Kessler’s prediction is chilling. NASA’s Orbital Debris Program Office, *Top Ten Satellite Breakups*, 14 ORBITAL DEBRIS Q. NEWS, no. 3, at 2–3 (2010).

171. See *supra*, text accompanying note 72.

172. Launched in March 2018, European Space Agency’s RemoveDEBRIS satellite, the first to test debris removal technology, cost \$18.5 million. Tony Reichhardt, *SpaceX Cargo Ship Will Carry First Test of Space Debris Cleanup*, AIR & SPACE (Mar. 30, 2018), <https://www.airspacemag.com/daily-planet/first-test-space-debris-cleanup-about-get-under-way-180968631/> [https://perma.cc/2STJ-AU3Z].

173. See Kessler & Cour-Palais, *supra* note 92, at 2642 (“With time, enough collisional fragments could be produced to become important in producing new collisional fragments. When these conditions apply, the number of objects will increase exponentially with time, even though no new objects may be placed into orbit by man.”).

for humanity become a reality, the entire global community will be liable to pay an equitable share of the overall cost of recovery efforts.¹⁷⁴ The Liability Convention should undergo a similar trifurcation, adding this new scheme to the current strict and absolute liability mechanisms.¹⁷⁵ As such, shared global liability will consider the responsibility of nation-states and private entities in isolation.¹⁷⁶ This will coerce cooperation among all agencies, nations, and private entities because the equitable share of responsibility will drive collective resolution.

V. CONCLUSION

In light of the emerging global sentiments regarding environmental conservation and sustainability, instituting a regime that clearly defines a legal consequence in the event of environmental ruin boasts greater coercive force than non-binding resolutions. It appropriately delimits the permissible uses of geospace without removing any level of utility appurtenant to the geospace commons. It allows all activity to continue, but with a measurable consequence that will influence behavior, which will flow positively to all of mankind. This international agreement aligns with the universal value that the international community places on the utility of geospace.¹⁷⁷ In

174. To clarify, this will not be the holistic cost of restoring the full utility of geospace to a *tabula rasa*, but certainly the cost of reestablishing a workable communications network and recovery program. Additionally, special allowances will be afforded to entities whom actively participate in the research and development of mitigation and sustainable technology, such as the ESA, for its efforts with RemoveDEBRIS and SpaceX for its reusable rocket platform. Reichhardt, *supra* note 172. Ideally, for the least developed nations, equitable solutions beyond the scope of this Comment would balance the benefits received and level of involvement in space technology endeavors.

175. The outcome of the Iridium-Cosmos incident is unclear principally due to the flexibility of the Liability Convention's fault regime. *See generally* von der Dunk, *supra* note 12 (discussing the difficulties of assigning liability for satellite collision due to vagaries within the Liability Convention and failure to comply with the Registration Convention).

176. At current, liability is determined by identifying the "launching state" responsible for a particular space object. Liability Convention, *supra* note 52, art. I(c). Accordingly, a nation-state is responsible for any space object launched from its jurisdiction, subject to indemnity and liability waivers that are beyond the scope of this Comment. But, removing the shield of the state will further coerce private entities to actively remedy the debris crisis.

177. Interestingly, the ISS provides no direct monetary revenue and all capital investment is a sunk cost. The return on investment is not represented in financial gain but the scientific discoveries realized from the activities within. This evidences that it is not unrealistic to assume that the global community will allocate funds for debris mitigation. Though a categorically sunk cost, our investment secures our continued enjoyment of the geospace commons for generations to come. The technological advancement likely to flow from this focus bolsters the argument that complete ratification is possible.

essence, it protects geospace by forcing the signatory to face the reality of their negative externalities. It is unlikely that a nation-state exists that does not value space exploration and the benefits attributable.

In April of 2019, in the spirit of the Sustainable Development Goals (SDGs), COPUOS adopted an agenda that focused on the long-term sustainability of the space commons, space traffic management, equitable uses of GSO, and the mitigation of space debris.¹⁷⁸ Mindful of space's critical role in attaining many of the SDGs, the Committee put forth guidelines to facilitate capacity building without prejudice to any one nation-states' economic capabilities. To be sure, the Guidelines for the Long-Term Sustainability of Outer Space Activities are an important step forward, but many delegates reiterated the importance of developing binding instruments, particularly in light of developments in "space resource exploitation, large constellations, and space debris remediation."¹⁷⁹

Looking forward, research continues to advance the availability of debris mitigation mechanisms, such as the European Space Agency's newly-commissioned ClearSpace-1 satellite.¹⁸⁰ Mission objectives increasingly include end-of-life procedures to place satellites in appropriate orbits to decrease clutter in areas where active satellites operate.¹⁸¹ In the context of private entities, Planetary Resources—originally positioned to become a principle player in the space mining industry—merged with Consensus Space and quickly launched TruSat, a crowd-sourced situational awareness forum that compiles the reports of private citizens to track objects in geospace.¹⁸² These developments instill confidence in the international community's sentiments toward ameliorating this

178. COPUOS, Sixty-Second, *supra* note 4.

179. *See id.* at 26 ("[A]lthough non-legally binding instruments had been a success in that they had guided States in conducting their activities in outer space in a safe and secure manner, they should not replace treaties and custom as the valuable sources of international law that they are.")

180. *ESA Commissions World's First Space Debris Removal*, EUR. SPACE AGENCY (Sept. 12, 2019), https://www.esa.int/Safety_Security/Clean_Space/ESA_commissions_world_s_first_space_debris_removal [<https://perma.cc/JU4M-C4DS>].

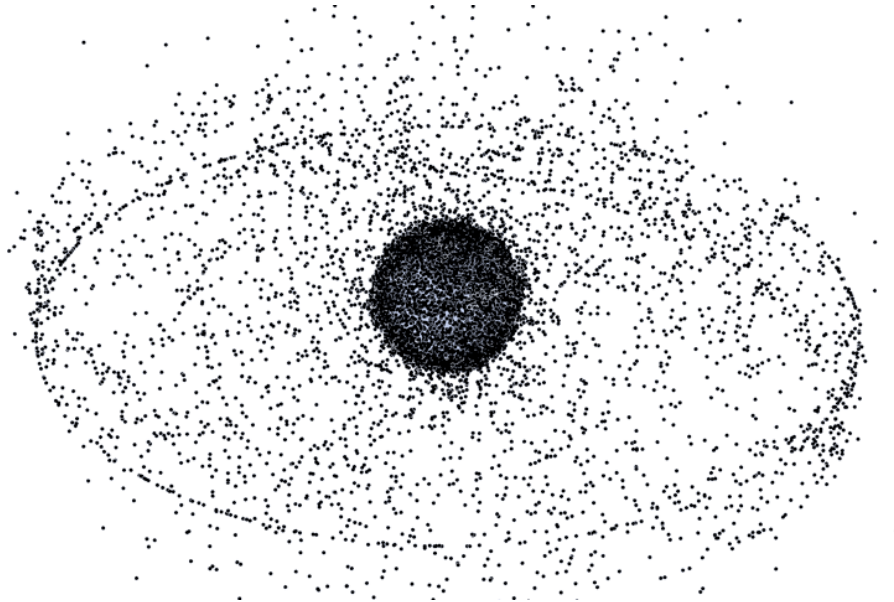
181. The ITU now requires that satellites commence transition into decay or graveyard orbits at the end of its functional life, a principle echoed in the ODMSP standards. Recommendation ITU-R S.1003-2, at 1 (Dec. 2010).

182. *TruSat as a Space Sustainability Tool*, CONSENSYS SPACE: TRUSAT, <https://learn.trusat.org/docs/space-sustainability> [<https://perma.cc/L6UQ-QBCF>] ("Private commercial providers of SSA data rely on satellite operators for their revenue and do not have incentives for calling out non-conforming orbital behavior. TruSat is designed to fill this gap through a new approach to SSA uncoupled from government or commercial interests."). Anyone with an augmented-reality-equipped smart phone can contribute to TruSat's mission.

ever-approaching catastrophe. It is with great hope that this trend continues, and COPUOS promulgates binding regulations to ensure the sustainability of geospace for the common heritage of mankind. “But we can never do nothing. That which we have done for thousands of years is also action. It also produces evils.”¹⁸³

183. Hardin, *supra* note 6, at 1247.

VI. APPENDIX



NASA rendering of space debris. The objects obscuring Earth are those in LEO. The faint outer line represents objects in the geosynchronous orbit subtype of geostationary orbit.¹⁸⁴

184. NASA Orbital Debris Program Office, *Space Debris*, NAT'L AERONAUTICS & SPACE ADMIN. (Sept. 11, 2009), <https://earthobservatory.nasa.gov/images/40173/space-debris> [<https://perma.cc/X3S6-FKR9>].