Cosmic Cleanup: How Attempting to Regulate the Sanctity of the Cosmos Highlights the Failing Incentive Structures of Space Law

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Abstract

Humans put the first object into space almost 70 years ago and they haven't stopped since. The space industry's rapid growth and expansion has filled the dark skies with tens of thousands of space objects. As a result, it is necessary to regulate this new domain to protect its long-term viability. There are two main policies that aim to achieve this goal—protected astronomical zones and debris management. Protected astronomical zones are governed by various guidelines to protect scientific research from harmful radio interference and ensure that satellites avoid collision. Debris management consists of debris mitigation guidelines that aim to reduce the debris that enters space. However, for debris that already exists, a novel approach called active debris removal (ADR) is gaining in popularity.

Unfortunately, as this Comment explores, these policies are in legal conflict with each other. An analysis of how these policies interact reveals clashing incentives for nations. Digging deeper, this Comment explores how the current space environment is built upon failing incentive structures—the root cause of this conflict. The tragedy of the commons framework clarifies the incentive regimes. These structures encourage nations ex ante to engage in self-interested activity and ex post fail to incentivize adherence in the face of defectors. This is detrimental not only to upholding long-term incentives of the space environment, but also to international law on a macro scale.

Lastly, this Comment looks at different legal and policy solutions to shift these incentive structures in a direction that supports the long-term benefits of the space environment. If these incentives can be transformed, then protected astronomical zones and debris management can coexist in harmony. Solutions focus on regulatory frameworks, priority management, collective action funds, and an insurance regime.

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If space law's underlying incentives in the current space environment can be reversed, then the long-term protection of outer space is more likely to succeed.

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I. INTRODUCTION

Technological advances are creating more opportunities to enter outer space. As the frequency of entering outer space increases, so does the need to consider the regulation of this domain. There are currently two major proposals for regulation grounded in existing international law. The first is the pursuit of protected astronomical zones. The other is the concentrated effort to remove debris from our orbit, known as debris management. While both pursuits have important objectives, achieving both highlights a conflict in space law: they are incompatible due to a lack of priority. The root of this conflict stems from ineffective incentive systems. Not only does the current regime encourage ex ante self-interested violating behavior, but it also fails ex post to incentivize nations to adhere after another nation violates a policy. By employing a variety of solutions, it is possible to shift these incentives and thus harmonize the conflicts between protected astronomical zones and debris management.

In Part II, this Comment will briefly overview the important authority that defines space law. Then it will dive into an analysis of protected astronomical zones, exploring their legal footholds and scientific importance. Then, it will conclude with an exploration of debris management's legal foundations and scientific relevance. Part III will begin looking at how the two policies conflict with each other by looking at interactions in specific protected astronomical zones. These interactions will highlight the inoperable incentive systems followed by an explanation rooted in the tragedy of the commons. Lastly, Part III concludes with ex ante and ex post incentive shifting solutions focused on regulatory and enforcement regimes and different collective action fund structures.

II. WHAT IS SPACE LAW?

A. The Foundational Underpinnings

Before diving into the nuances of protected astronomical zones, debris removal, and their resulting conflicts, one needs to understand space law and its underlying principles. Space law "is the body of law governing space-related activities,"[1] such as asteroid mining,[2] launching privatized space stations,[3] and

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1 *See* U.N. Office for Outer Space Affairs, *Space Law*, U.N., https://perma.cc/D49R-WJ25 (last visited May 15, 2026).

2 *See* Rebekah Shields, *Towards a New Orbit: Addressing the Legal Void in Space Mining*, 40 AM. U. INT'L L. REV. 229, 230 (2024).

3 *See* Paul Stephen Dempsey, *National Laws Governing Commercial Space Activities: Legislation, Regulation, & Enforcement*, 36 NW. J. INT'L L. & BUS. 1, 3 (2016).

managing conflicts that expand beyond earthly jurisdictions.[4] Due to the parties and areas that space law attempts to govern, it is much like international law, comprising international instruments—treaties, conventions, and accords, to name a few. It is commonly understood that there are five governing authorities[5]: (1) the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty),[6] (2) the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Space (Rescue Agreement),[7] (3) the Convention on International Liability for Damage Caused by Space Objects (Liability Convention),[8] (4) the Convention on Registration of Objects Launched into Outer Space (Registration Convention),[9] and (5) the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement).[10]

Since space law is between nation-states, it faces the same challenge that international law more broadly faces—enforceability. Some scholarship attributes this to the fact that violating international law is "contagious," despite nations seeking to maximize benefits,[11] while others argue it is because this body of law lacks sufficient remedies as it perpetuates the principle of efficient breach.[12]

It is important to remember that although there are international instruments for space law, the field is still impacted by the broader challenges of international law. Nonetheless, the instruments underpinning space law are important because they create the contours of legal obligations. Further, to avoid overshadowing the more nuanced inadequacies in space law, there will be less focus on the broad-

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4 *See* Trevor Kehrer, *Closing the Liability Loophole: The Liability Convention and the Future of Conflict in Space*, 20 CHI. J. INT'L L. 178, 196 (2019).

5 *See* Alexander P. Reinert, *Updating the Liability Regime in Outer Space: Why Spacefaring Companies Should Be Internationally Liable For Their Space Objects*, 62 WM. & MARY L. REV. 325, 333 (2020).

6 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205https://perma.cc/6CD8-A6WV [hereinafter Outer Space Treaty].

7 The Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Space, Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119https://perma.cc/T8ZB-DGG4 [hereinafter Rescue Agreement].

8 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] https://perma.cc/PQ23-X29U.

9 Convention on Registration of Objects Launched into Outer Space, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15 https://perma.cc/3XB3-Q2FX [hereinafter Registration Convention].

10 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, Dec. 18, 1979, 1363 U.N.T.S. 3, https://perma.cc/FX22-EXCW [hereinafter Moon Agreement].

11 *See* Shai Dothan, *Violating International Law Is Contagious*, 23 CHI. J. INT'L L. 80, 81 (2022).

12 *See* Eric A. Posner, *Efficient Breach of International Law: Optimal Remedies, 'Legalized Noncompliance,' and Related Issues*, 110 MICH. L. REV. 243, 245 (2011).

scale issue of nonuniformity of member states. This Comment acknowledges that the foundational authorities are not binding on all nation-states, as even the most signed authority—the Outer Space Treaty—only has 117 parties to it of the 193 United Nations (U.N.) members.[13] It is true that all the major space superpowers are signed to the treaty, but there are still emerging space-faring nations who are not. For example, Angola,[14] Costa Rica,[15] and Turkmenistan[16] have all gotten satellites into outer space without even being signatories, let alone ratifying the treaty. As space technology rapidly grows, it is expected that more countries that are currently unsigned will have space capabilities. Although this highlights macro-level enforceability and jurisdictional issues, this Comment will focus on a plethora of micro-level issues caused by other factors.

The Outer Space Treaty is the foundational document for space law, frequently referred to as the "Magna Carta" of space law.[17] Thus, it best represents the overarching goals of the field. The two exemplifying provisions are found in Article I and Article IX. Article I states, "the exploration and use of outer space . . . shall be carried out for the benefit and in the interests of all countries . . . and shall be the province of all mankind" further elaborating it "shall be free for exploration and by all States without discrimination of any kind . . . there shall be free access to all areas of celestial bodies." And lastly, "there shall be freedom of scientific investigation in outer space . . . States shall facilitate and encourage international co-operation."[18] Article IX goes on to explain that States "conduct exploration . . . as to avoid their harmful contamination [of outer space] . . . [and] to avoid . . . harmful contamination and . . . adverse changes in the environment of Earth."[19]

Despite the importance of these goals, the Outer Space Treaty fails to define key terms. In fact, the Outer Space Treaty fails to define any terms, as it does not contain a definition section. This creates ambiguity as to the meaning of "discrimination," "contamination," and at what atmospheric point "outer space" even begins. Because the foundation that space law is built on leaves many key

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13 Committee on the Peaceful Uses of Outer Space, *Status of International Agreements Relating to Activities in Outer Space as at 1 January 2025* (May 16, 2025), https://perma.cc/X2GP-HNC3.

14 Samuel Nyangi, *Angola Establishes National Space Agency Following Presidential Announcement*, SPACE IN AFRICA (Oct. 15, 2025), https://perma.cc/3WAE-XAAQ.

15 Laura Alvarado, *Costa Rica launches Its First Satellite Into Space with SpaceX*, COSTA RICA STAR (Mar. 15, 2026). https://perma.cc/8D5U-XWCK.

16 Mike Wall, *SpaceX Falcon 9 Rocket Launches Turkmenistan's First-Ever Satellite*, SPACE.COM (Apr. 27, 2015), https://perma.cc/VS49-SAPU.

17 Frans G. von der Dunk, *The Origins of Authorisation: Article VI of the Outer Space Treaty and International Space Law*, 69 U. NEB.-LINCOLN DIGIT. COMMONS 1, 4 (2011).

18 Outer Space Treaty, *supra* note 6, art. I.

19 *Id.* art. IX.

terms open for interpretation, efforts to honor the goals of the Outer Space Treaty are challenging.

Unfortunately, the issues of vagueness and unenforceability are common to other governing texts in this area. The Rescue Agreement requires the finding party to give notice to the launching party if the launching party's space object is found; however, there is no specific timeliness requirement.[20] Moreover, there are no enforcement mechanisms.

The Liability Convention only allows for the finding of liability for damages caused in outer space if "fault"[21] can be proven. In an environment where tiny[22] space objects are moving incredibly fast[23] it is almost impossible to tell whose debris are causing damage, making the provision essentially unenforceable.

The Registration Convention requires notice to the Secretary-General of the U.N. "to the greatest extent feasible and as soon as practicable."[24] This is a subjective undefined length of time that the launching party can use to avoid providing an important registration notice under the guise of something like national security.

Lastly, the Moon Agreement only has twenty-one parties to it of the 193 U.N. member nations, and those twenty-one don't include the major space superpowers like the U.S., China, and Russia.[25]

Nonetheless, the endeavors to regulate space aren't fruitless. As observed in other areas of law, effective liability regimes,[26] regulatory priorities,[27] and licensing mechanisms[28] are all tools that can help combat vagueness and enhance enforceability in governing law.

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20 Rescue Agreement, *supra* note 7, art. V.

21 Liability Convention, *supra* note 8, art. III.

22 *See* Aerospace*, Space Debris 101: A Piece of Space Debris the Size of a Blueberry Can Create the Impact of a Falling Anvil. Here's Everything Else You Need to Know About Space Debris,* https://perma.cc/LLX8-RWTL (last visited Apr. 12, 2026).

23 *Id.*

24 Registration Convention, *supra* note 9, art. IV.

25 Status of Agreement governing the Activities of States on the Moon and Other Celestial Bodies, U. N. TREATY COLLECTION, https://perma.cc/8KR8-N2MU (last visited May 15, 2026).

26 Amanda M. Rose, *The Multienforcer Approach to Securities Fraud Deterrence: A Critical* Analysis, 158 U. PA. L. REV. 2173, 2176 (2010) (arguing that a unitary enforcement mechanism better carries out the goals fraud enforcement under federal securities law).

27 Nicholas Bagley, *The Procedure Fetish*, 118 MICH. L. REV. 345, 360–61 (2019) (highlighting that procedure can reduce agency efficiency in carrying out their "legislatively assigned mission").

28 Jodi L. Short, *In Search of the Public Interest*, 40 YALE J. ON REG. 101, 109–10, 147–48 (2023) (highlighting how agency permitting—exemplified by the Federal Energy Regulatory Commission—successfully clarifies statutory standards like "public interest" because the agency must explain its reasoning thus creating measurable standards).

Although these issues complicate the implementation of policies like protected astronomical zones and debris management, these efforts can still be effective. To understand facilitating the cohesion of two conflicting space law policies, it is important to understand each of these policies independently.

B. Protected Astronomical Zones

The idea of a protected astronomical zone can be described as regulating the activities in an area in outer space deemed to be significant for some purpose. This description necessarily appears broad because there is no universal definition for protected astronomical zones. As discussed above, the Outer Space Treaty does not define any zone; it merely invokes general principles against "contamination."[29]

The Artemis Accords[30] are the most recent development in a global effort to more clearly define a concept of protected astronomical zones for the purposes of developing and clarifying the international practice of space-related activities.[31] However, they create a zone that attempts to protect things outside of the zone, not the zone itself.[32] The Artemis Accords introduce the term "safety zone" and define it as "the area in which nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference."[33] They operate under the presumptions of notification and coordination to prevent harmful interference. The safety zone aims to protect parties outside the zone from activities within the zone. Contrarily, the traditional safety zone aims to protect a designated area from outside activity. The Artemis Accords make a brief mention of the traditional kind of application in § 9 "Preserving Outer Space Heritage." This section is incredibly limited and only offers protection of "historically significant . . . landing sites, artifacts, spacecraft, and other evidence of activity on celestial bodies" that each signatory can decide is significant in accordance with mutually developed standards.[34] This definition still fails to encompass ongoing, scientifically significant areas like the shielded zone of the Moon (SZM), which traditional protected zones cover.

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29 Outer Space Treaty, *supra* note 6, art. IX.

30 The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes, Oct. 13, 2020, 62 I.L.M. 888 (2023). [hereinafter Artemis Accords].

31 *Id.* § 11.

32 U.S. ENV'T AGENCY (EPA), *Safety Zones*, (Sep. 12, 2025), https://perma.cc/D436-CU7U. Contamination zones that the EPA creates are similar in this regard.

33 *See* Artemis Accords, *supra* note 32, § 11.

34 *See* Artemis Accords, *supra* note 30, § 9.

The foundational idea for traditional protected zones was established in the U.S. via West Virginia's Radio Astronomy Zoning Act[35] in 1956. The National Radio Astronomy Observatory describes it as the "first legislation in the world intended specifically to protect basic research,"[36] and the Act eventually led to the creation of National Radio Quiet Zone in 1958.[37] However, these zones protected only against interference with space activity that occurs on Earth. It was not until the World Administrative Radio Conference for Space Telecommunication of 1971 (WARC-71) that the first protected astronomical zone for an area in outer space was created—the SZM.

Scientists argue that this zone is essential for space research, as it allows for the detection of radio signals that are undetectable from Earth.[38] Not only is this the first zone to be protected in outer space, but it is also internationally and legally binding on all members of the U.N. This is because WARC-71 is managed by the International Telecommunications Union (ITU), a specialized U.N. agency for digital technologies.[39] WARC-71 concluded with the passing of the Final Acts of WARC–71 which stated "administrations, in accordance with the intent of this Recommendation, take all practicable steps to ensure that there will be no interference to radio astronomy observations on the [SZM]."[40]

The ITU continues to be the best authority on protected astronomical zones for the purpose of scientific considerations,[41] as they have also recommended "soft-law" protected zones and are endorsed by the International Astronomical Union (IAU) and its adjacent bodies.[42] Soft law is "typically characterized as a set of nonbinding legal principles that aim to establish standards and best practices

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35 W. VA. CODE § 37A (2026).

36 Nat'l Radio Astronomy Observatory, *Timeline of NRAO History,* https://perma.cc/34QV-5M4Y (last visited Apr. 12, 2026).

37 *Id.*

38 Lauren Biron, *Listening to the radio on the far side of the moon*, BERKELEY LAB (Sep. 26, 2023), https://perma.cc/9FDS-NDXY.

39 *About the International Telecommunication Union*, ITU, https://perma.cc/3AHD-MLLX (last visited Apr. 12, 2026).

40 ITU, Final Acts of the World Administrative Radio Conference for Space Telecommunication 340 , (1971), https://perma.cc/Z5JJ-EUBB.

41 Kristen Cordell, *The ITU: The most Important UN Agency You Have Never Heard Of*, CTR. FOR STRATEGIC & INT'L STUDS. (Dec. 4, 2020), https://perma.cc/HR3H-QQBZ.

42 To clarify, when looking at reports and documentation in this area they frequently contain organizing bodies that are not named the IAU. This is because the union is co-sponsored with the International Union of Radio Science and together, they form the Inter-Union Committee on Allocation of Radio Frequencies to Astronomy and Space Research, which formally makes recommendations to the ITU. *See also* J. Andersen, *History, Strategy and Status of IAU Action*, 196 IAU SYMPOSIUM 10, 13 (2001).

for a particular activity."[43] Practically, this means that soft-law instruments are nonbinding but nonetheless offer valuable insight. Indeed, soft-law approaches reflect critical concerns of the scientific community. For example, the IAU, whose mission is "to promote and safeguard the science of astronomy in all of its aspects . . . through international cooperation," strongly endorsed and advocated for the ITU to protect the far side of the moon via protective zone in 1970[44] before the ITU imposed legal enforcement.

Throughout the ITU's history, it has also created soft-law recommendations to protect important deep space research sites.[45] Although these recommendations do not name or protect a specific point in space, they functionally work to protect that geographic point. This is because they protect against the use of certain radio frequencies that may interfere with observance of deep space research sites. By protecting these bands, they then protect the points in space that need these bands to be observed, essentially creating astronomical protected zones.

Recommendations from 2023[46] detail specific band frequency protections that concern the Sun-Earth Lagrange points L1 and L2.[47] These Recommendations work on preventing harmful interference that can interrupt the delicate study occurring in these areas.

Lagrange points exist between "the gravitational pull of two large masses" and create a unique environment that is incredibly beneficial for satellites and scientific study. A given system contains five points.[48] L1 is unique in that it gives an uninterrupted view of the sun and is currently the home of observatory satellites.[49] On the other hand, L2 is perfect for deep space observation as it is positioned away from the sun to the right of Earth,[50] and is currently home to the

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43 Laura C. Byrd, *Soft Law in Space: A Legal Framework for Extraterrestrial Mining*, 71 EMORY L.J. 802, 831 (2022).

44 *See* Union Radio-Scientifique Internationale (Int'l Union of Radio Sci.) Bulletin No. 176 (Sep. 1970), https://perma.cc/9CL6-YEC9.

45 *See* Rec. ITU-R SA.1157-1, *Protection Criteria for Deep-space Research* (2006), https://perma.cc/YGZ2-RWMB.

46 *See* Rec. ITU-R SA.2307-1, *Protection of SRS and FSS systems sharing the 37.5-38 GHz Band* (2023), https://perma.cc/D965-8VSH.

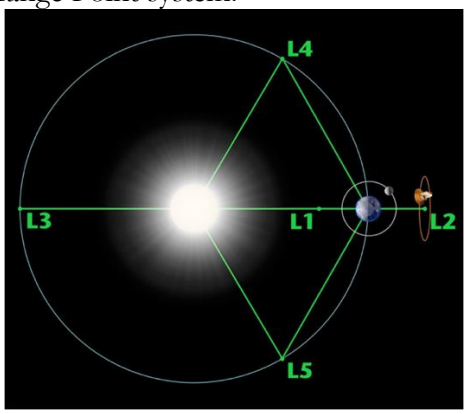
47 *Id.* at 2.

48 NAT'L AERONAUTICS & SPACE ADMIN. (NASA), *What is a Lagrange Point*, (Mar. 27, 2018), https://perma.cc/P4DN-99MX.

49 *See* The European Space Agency, *L1, the first Lagrangian Point* (discussing the Solar and Heliospheric Observatory satellite at L1) https://perma.cc/ZZJ8-JD5T (last visited Apr. 12, 2026); *see also* NASA, *IMAP Arrives at L1*, (Jan. 27, 2026) (highlighting a very recent and exciting development that arose during the writing of this Comment on January 10, 2026—the Interstellar Mapping and Acceleration Probe reached L1), https://perma.cc/V846-TSC2.

50 *Id.*

recently launched James Webb Space Telescope.[51] Currently L3 is limited in its application because it is hidden behind the sun, but achieving monitoring at L3 would provide us with a view that cannot be seen from Earth due to the sun's position. Lastly, L4 and L5 are excellent places to park satellites as they are stable, but no satellite has been able to reach these locations yet.[52] Below is an illustration of the Earth-Sun Lagrange Point system.[53]



Moving even further from Earth, there are Recommendations for band frequencies used in the observations of the planet Neptune.[54] Indeed, Recommendations go even further. There is a Recommendation[55] for a broad range of frequencies used for very long baseline interferometry (VLBI),[56] which observes things like quasars[57] and supernovae.[58] Moreover, it is thanks to VLBI and accompanying frequency regulations that allowed astronomers to capture the first image of a black hole in 2024.[59] There is also a plethora of other frequency

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51 *See* NASA, *Webb's Orbit at Sun-Earth Lagrange Point 2 (L2),* (May 19, 2021), https://perma.cc/447A-433A.

52 NAT'L ENV'T SATELLITE, DATA, & INFO. SERV., *Lagrange Points: An Orbital Parking Spot for Satellites*, https://perma.cc/JD4F-5AH4 (last visited Apr. 12, 2026).

53 *See* NASA, *What is a Lagrange Point*, supra note 48.

54 *See* Rec. ITU-R SA.1014-4, *Radiocommunication requirements for manned and unmanned deep space research*, 1, 3 (2023), https://perma.cc/CMD9-WG2M.

55 *See* Rec. ITU-R RA.769-2, *Protection criteria used for radio astronomical measurements* (2003), https://perma.cc/7PRS-4MD7.

56 *Id.*

57 *See* Center for Astrophysics | Harvard & Smithsonian, *Very Long Baseline Interferometry*, https://perma.cc/KVS9-Q9BL.

58 *See* M. F. Bietenholz et al., *The First VLBI Image of the Young, Oxygen-Rich Supernova Remnant in NGC 4449*, 409 MONTHLY NOTICES ROYAL ASTRONOMICAL SOC'Y 1594 (2010).

59 *See* NASA, *How Scientists Captured the First Image of a Black Hole*, (May 12, 2022), https://perma.cc/56VA-HAFB.

bands that are regulated by the ITU's Recommendations that can be cross-referenced with NASA's list of frequencies that are used in outer space.[60] Since there are so many bands that could potentially cause interference, the ITU's Recommendations are crucial guidance.

While the regulations for deep space research and the moon may appear distant, the ITU also has Recommendations for geographic protective zones in Earth's orbit—the geostationary Earth orbit (GEO).[61] GEO causes satellites to appear stationary from a fixed point on Earth. This means that when someone is standing on Earth looking at the satellite, it appears as if the satellite is not moving. This is because Earth's orbit and GEO have the same angular velocity.[62] In layman's terms, this means they move at the same speed. This makes satellites in this area incredibly cost-effective. For example, three well-placed satellites can approximately reach global coverage, and telecommunications for radio and television for an entire nation can be provided by one satellite. Moreover, since they provide consistent monitoring over a fixed point, they are ideal for meteorology, which helps with the tracking of hurricanes.[63] However, these benefits come with a major caveat—limited real estate. Experts estimate that there can only be 1800[64] to 2000[65] satellites in GEO without risking collision or radio interference. Although there are only 518 satellites in GEO as of 2025,[66] satellites do not last forever and eventually die. One cannot rely on natural deorbiting of dead satellites since experts predict deorbiting can take anywhere from decades to hundreds of years and they increase the risk of collision.[67] Further, some satellites in GEO could potentially stay indefinitely despite being inoperable if left to natural deorbiting.[68] This is where the ITU Recommendations come in for

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60 *See* NASA, *NASA Spectrum Usage*, (Sep. 25, 2023) https://perma.cc/X4P9-PLNC.

61 *See* Rec. ITU-R S.1003.2, *Environmental protection of the geostationary-satellite orbit* (2010), https://perma.cc/2FJU-PASM.

62 *See* Andrea Grillo, *Geostationary Earth Orbit (GEO): An Overview*, DEEP INSECURITY (Jan. 22, 2025), https://perma.cc/HM2P-BA7H.

63 *Id.*

64 Stephan Hobe, *Geostationary Orbit, in* MAX PLANCK ENCYCLOPEDIA OF PUBLIC INTERNATIONAL LAW, https://perma.cc/P2LG-KSLD (last visited Apr. 12, 2026).

65 Michael J. Finch, *Limited Space: Allocating the Geostationary Orbit*, 7 NW. J. INT'L L. & BUS. 788, 789 (1986).

66 *Geostationary/Geosynchronous Orbit,* ORBIT.ING-NOW.COM, https://perma.cc/9ZYL-6HMU (last visited May 15, 2026).

67 Alexis Wall, *GEO Satellites Don't Decay in 38 Years, Do They?* ANSYS BLOG (Mar. 17, 2023) https://perma.cc/6LQQ-PJKQ.

68 U.N. Office for Outer Space Affairs (UNOOSA), *Updated UNOOSA and ESA space debris infographics and podcasts*, https://perma.cc/HLZ4-38B6 (last visited Apr. 12, 2026).

protecting GEO.[69] They recommend thrusting satellites into a graveyard orbit[70]––an orbit above an operational orbit specifically for non-operational satellites so they can retire and not risk collision with active GEO satellites.[71] Also, experts advise against allowing satellites to reenter because it is dangerous.[72] Moreover, in the industry it is considerably more expensive to thrust satellites back to Earth due to fuel costs.[73]

Lastly, even closer to Earth is the zone of low earth orbit (LEO) that the ITU recommends regulations for. LEO is the closest to Earth's surface[74] and has the most activity compared to all other orbits.[75] The ITU attempts to make LEO a protected zone by regulating the usage of radio frequencies. The ITU requires that prior to the launch of a satellite into LEO a plan must be filed[76] and approved for compliance with radio frequency requirements.[77] Specifically, they require "[s]atellite and constellation plans, complete with radio frequencies and spectrum-sharing proposals . . . operators must then agree on how they will avoid harmful interference to each's other systems."[78] These regulations exist because like GEO, there is limited space in LEO. With too many satellites, not only does the risk of collision increase, but also the risk that satellites will interfere with each other's radio frequencies also increases.

Although there are existing regulations on LEO, critics argue that they are ineffective.[79] These critiques stem from the drastic increase of satellites entering

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69 *See* Rec. ITU-R S.1003.2 Environmental protection of the geostationary-satellite orbit (2010), https://perma.cc/5LWG-9EZ3.

70 *See* The European Space Agency, *Mitigation scenarios: Graveyard orbit 300 km above GEO*, (Oct. 4, 2008), https://perma.cc/7GKT-ES92.

71 *See* U.N. Inst. for Disarmament Rsch., Space Security Lexicon*, Graveyard Orbit*, https://perma.cc/WS2L-SAT6 (last visited Apr. 12, 2026).

72 *See* Rec. ITU-R S.1003.2, *Environmental protection of the geostationary-satellite orbit* (2010), https://perma.cc/K9QP-LE3B.

73 *See* Wall, *supra* note 67.

74 *See* THE EUROPEAN SPACE AGENCY, *Low Earth Orbit*, (Feb. 3, 2020), https://perma.cc/5YU2-NQHR.

75 Ctr. for Strategic & Int'l Studs. *Popular Orbits 101* AEROSPACE (Nov. 30, 2017) https://perma.cc/772V-XJ5B.

76 ITU, PRESENTATION TO UNOOSA ACCESS TO SPACE TO ALL WEBINAR, THE PRACTICAL STEPS TO FILE A SATELLITE NETWORK AT ITU (Nov. 11, 2020) https://perma.cc/8YVJ-ME74.

77 *See* Rec. ITU-R S.1586-1, *Calculation of unwanted emission levels produced by a non-geostationary fixed-satellite service system at radio astronomy sites* (2007), https://perma.cc/FWW9-AMB4.

78 ITU, *Space Connect: The rise of LEO satellite constellations*, (Feb. 11, 2025), https://perma.cc/YK5L-J4HM.

79 *See* Quian Sun, *Space safety in the age of LEO constellations: The role of spectrum management,* 12 J. SPACE SAFETY ENG'G 542 (2025); *see also* Bob Yirka, *Study shows need for ITU to tighten regulations for low orbit satellites as filing numbers grow,* (Oct. 18, 2023) https://perma.cc/LL4M-7NYX?type=standard.

our orbit. Some predict that over 43,000 are expected to be launched by 2035,[80] with the European Space Agency (ESA) expecting up to 100,000 by 2030,[81] which is what scientists predict as the maximum capacity.[82] As of 2025 there are approximately 13,000 active satellites in orbit,[83] which is an exponential increase from 2010.[84] Moreover, the ESA gives credence to these critics with its Annual Space Environment Report published in 2025.[85] There they predict that it is likely that the number of collisions in LEO will continually increase in the future as the environment gets more saturated. Moreover, even if all launches were halted, the number of objects in LEO are enough to predict continual collisions well into the future.[86] Despite the arguable inadequacies of the regulations, the ITU is still attempting to maintain LEO as a protected astronomical zone by issuing its soft law recommendations. The ESA also agrees with this classification calling it a "protected orbital region."[87]

As the space industry continues to grow exponentially, it is imperative that law does not continue to lag severely. Moreover, although these are the existing astronomical protected zones, it is not implausible to assume there will be more in the future. Legal lag is a documented phenomenon, especially in scientific regulation.[88] In the novel *All the King's Men*, author Robert Penn Warren aptly wrote "[h]alf the things weren't in the Constitution but they are now, by God. And how did they get there? Simply because somebody did 'em."[89] Even looking at the history of protected astronomical zones, the first zone was established twelve years after its discovery.[90] Arguably one of the greatest scientific

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80 *See* Press Release, Novaspace, Novaspace Projects $665B in Satellite Build and Launch Activity (Oct. 7, 2025) https://perma.cc/D39H-GHBH.

81 *See Around 100 000 satellites are expected to be in orbit by 2030,* EUR. SPACE AGENCY (Jan. 4, 2025), https://perma.cc/4BJ5-P5L5.

82 *See* Harry Baker, *How many satellites could fit in Earth orbit? And how many do we really need?*, LIFESCIENCE (May 30, 2025), https://perma.cc/W3BP-282S; Tereza Pultaravoa, *How many satellites can we safely fit in Earth Orbit?*, SPACE.COM (Feb. 27, 2023), https://perma.cc/7U99-6H85.

83 *See* Jonathan's Space Pages, *Satellite statistics: Satellite and Debris Population*, https://perma.cc/X58V-WMGB (last visited Apr. 12, 2025).

84 *See* Wall, *supra* note 68.

85 ROBERT B. STRASSE, EUR. SPACE AGENCY, ESA SPACE DEBRIS OFFICE, ESA'S ANNUAL SPACE ENVIRONMENTAL REPORT 31 (2025).

86 *Id.*

87 *See* The European Space Agency, *Protected orbital regions* (Feb. 2, 2009), https://perma.cc/DHP2-TTUN; *see also supra* note 85.

88 *See* Frederick K. Beutel, *The Lag Between Scientific Discoveries and Legal Procedures*, 33 NEB. L. REV. 1 (1953).

89 ROBERT PENN WARREN, ALL THE KING'S MEN, 145 (1st ed. 1946).

90 *See* Ben Evans, *How Luna 3 first unveiled the Moon's farside*, ASTRONOMY (Oct. 16, 2020), https://perma.cc/76LY-E64A.

breakthroughs at the time, the zone still took over a decade to receive protection despite scientific literature recognizing its importance almost immediately.[91] Based on the existing literature and the growing threat of environmental damage due to the rapid explosion of the space industry, protections for other Lagrange points,[92] the peaks of eternal light on the moon,[93] and in LEO (protecting against deep space light pollution)[94] are likely. The Hague Academy of International Law reminds us "[t]he law can take us so far; but beyond a certain point we are, as it were, on our own."[95] In other words, while it may be expected that law may be inadequate, this should not paralyze nations from developing that law and mitigating harm in the interim as required by the Outer Space Treaty.[96]

C. Debris Management

The ESA estimates that there are over a hundred million pieces of space debris.[97] As of 2024 they suggest that there are 140 million pieces of debris measuring between 1 mm and 1 cm, 1.2 million between 1 cm and 10 cm, and 54,000 greater than 10 cm.[98] Although most of this debris is small and appears harmless, it is incredibly dangerous. This is because each piece of debris is traveling at around 25,200 km/h.[99] For reference, that's ten times faster than the speed of a bullet. Moreover, because everything in orbit is moving at around that speed (not only debris), if a satellite or astronaut were moving in the other direction the relative speed upon collision could be doubled. The title of

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91 Claire Hooker, *"To the US National Radio Astronomy Observatory*, 1961," *in* JOE PAWSEY AND THE FOUNDING OF AUSTRALIAN RADIO ASTRONOMY 653, (1st ed. 2023); *see also* SPACE RESEARCH II: PROCEEDINGS OF THE SECOND INTERNATIONAL SPACE SCIENCE (H.C. van de Hulst et al. eds., 1961); Danny Robb*, Exploring the Far Side of the Moon: A Visual History* (Apr. 6, 2026) https://perma.cc/KZ7L-8WE2.

92 David A. Koplow, *Pave Outer Space and Put Up A Parking Lot: Lagrange Points Should Be the Common Heritage of Mankind*, 46 MICH. J. INT'L L.403 (2025).

93 *See* Martin Elvis, *The Peaks of Eternal Light: A Near-term Property Issue on the Moon*, 38 SPACE POL'Y 30 (2016).

94 *See* Josef Koller, *Light Pollution From Satellites*, CTR. FOR SPACE POL'Y & STRATEGY (2021), https://perma.cc/UF7J-36YA.

95 Jessy Schingler, *Imagining Safety Zones: Implications and Open Questions*, SPACE REV. (June 8, 2020), https://perma.cc/L4C6-J5SK (citing Vaughan Lowe, *The Limits of the Law Inaugural Lecture*, 379 HAGUE ACAD. COLLECTED COURSES ONLINE, (2016)).

96 *See* Outer Space Treaty, *supra* note 6, art. IX.

97 *See Space Debris by the Numbers,* EUR. SPACE AGENCY, (Jan. 6, 2026), https://perma.cc/SMJ8-8WRC.

98 *Id.*

99 *See* Isobel Whitcomb, *How do Tiny Pieces of Space Junk Cause Incredible Damage?*, LIFESCIENCE (Mar. 14, 2021) https://perma.cc/SL2D-R86S.

Aerospace's article cleverly describes this concept—"A Piece of Space Debris the Size of a Blueberry Can Create the Impact of a Falling Anvil."[100]

Not only are these collisions dangerous to astronauts and satellites, but they also result in an increase of debris. This is because after pieces of debris collide, they explode into debris fragments, which can result in thousands of more shards of debris.[101] Once new shards of debris are created, they remain in orbit for decades or even centuries, all the while increasing the chance of colliding with more debris fragments.

Scientists worry that this multiplication of debris fragments could eventually result in Kessler Syndrome. The founding proponent of the theory, astrophysicist Donald J. Kessler, predicts a chain reaction of debris explosions where "the density of debris could reach a point where entire regions of orbit become unusable."[102] Furthermore, this issue is compounded by the fact that most pieces of space debris are too small to track. It is estimated that "there are hundreds of thousands of objects that could be fatal or catastrophic to a space mission, and millions of objects that are capable of causing damage."[103]

These reasons have contributed to the push for debris management regulations over the past few decades. Debris management can be divided into two distinct categories—mitigation and removal. Together, these processes attempt to protect Earth's orbit[104] and other key areas of outer space.[105]

Starting with debris mitigation, this soft-law policy is focused on preventing debris from entering outer space and mitigating the risks of existing debris such as multiplication and collision. Compared to debris removal discussed below, debris mitigation ideas have existed for a few decades. The catalyst for mitigation occurred in 1986 when an Ariane 1 rocket exploded while carrying satellites into orbit, creating almost 500 pieces of large debris.[106] This prompted NASA to hold an international conference with other space-faring nations to discuss mitigation efforts. Thus, the Inter-Agency Space Debris Coordination Committee (IADC) was formed in 1993.[107] Following these events, NASA released the first ever

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100 *See* Aerospace, *supra* note 22.

101 *Id.*

102 Space PikeOS, *The Growing Threat of Space Debris: Impacts on Satellites, Space Exploration, and Mitigation Strategies* (Nov. 5, 2024), https://perma.cc/DFE9-6PFA.

103 *See* Aerospace, *supra* note 22.

104 *See* NASA, *Debris Mitigation*, https://perma.cc/F5PB-CKTY (last visited Apr. 12, 2026).

105 *See* Japan Aerospace Expl. Agency (JAXA), *Space Debris Mitigation Standard*1 (Apr. 27, 2023), https://perma.cc/S8P3-RZRT.

106 S*ee* Steve Olson, *The Danger of Space Junk*, The Atlantic (July 1998), https://perma.cc/B9PM-AR4P

107 *See* Nicholas Johnson, *Origin of the Inter-Agency Space Debris Coordination Committee*, NASA 1, 70–72 (2015).

mitigation guidelines in 1995.[108] Shortly after, the world saw the first multinational debris mitigation guidelines in 2002,[109] and they were officially endorsed by the U.N. in 2007.[110] The IADC published the latest updated version in 2025.[111] Additionally, other international soft-law guidelines have been proposed such as the ESA's Zero Debris guidelines[112] and the aforementioned Artemis Accords.[113]

The crux of these guidelines revolves around a few core factors: improved designs, tracking, and disposal. Improved designs focus on launching objects that avoid intentional discharge of debris,[114] more resistant paints,[115] and less particulate producing chemicals.[116] Tracking focuses on ensuring launched objects comply with the Registration Convention,[117] but also to improve Earth-side tracking systems for currently untraceable smaller debris.[118] Lastly, there are two main disposal mechanisms. The first is thrusting space debris in GEO into the graveyard orbit.[119] The second is setting LEO debris on a path for uncontrolled reentry where the debris burns up in Earth's atmosphere before making contact with the ground. This second process is subject to the twenty-five-year rule that requires all satellites to have a disposal plan. This plan must have at least a 90%

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108 *See* NASA, *Debris Mitigation*, https://perma.cc/45N3-D7HJ (last visited Apr. 12, 2026); *see also* NASA, GUIDELINES AND ASSESSMENT PROCEDURES FOR LIMITING ORBITAL DEBRIS (1995).

109 *See* U.N. General Assembly, *Inter-Agency Space Debris Coordination Committee space debris mitigation guidelines,* U.N. Doc. A/AC.105/C.1/2025/CRP.9 (2002).

110 *See* U.N. Office For Outer Space Affairs, *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space*, U.N. Doc. ST/SPACE/49 at iv (2010).

111 *See* Committee on the Peaceful Uses of Outer Space, *IADC Space Debris Mitigation Guidelines* (2025).

112 *See ESA's Zero Debris Approach*, EUR. SPACE AGENCY, https://perma.cc/9838-8V28 (last visited Apr. 12, 2026); *see* T. Soares, *ESA's Zero Debris Approach: A Responsible Path to Mitigate Space Debris in Valuable Orbits*, 1 (2023).

113 *See* Artemis Accords, *supra* note 30, § 12.

114 *See* Committee on the Peaceful Uses of Outer Space, *IADC Space Debris Mitigation Guidelines*, 1, 11 (2025).

115 *See* Tereza Pultarova*, Coating Satellites with Super-Dark Vantablack Paint Could Help Fight Light Pollution Crisis* (June 10, 2025), https://perma.cc/ZC5W-7UBM; *see also* Joyce A. Dever et al., *Issues and Advancements in Space Durable Multi-Functional Thermal Control Coatings,* 813 AIP CONF. PROC. 3 (2006).

116 *See* NASA, *Orbital Debris Management & Risk Mitigation* 1, 10–11 (2018).

117 *See* Registration Convention, *supra* note 9.

118 *See* Pawel Matuszak, *Sybilla Technologies Partners EU SST for Groundbreaking Space Surveillance Project*, SYBILLA TECHS., https://perma.cc/X9Q2-2VKG (last visited Apr. 12, 2026);.; *see also* , Off. of Dir. Nat'l Intell., *Space Debris Identification and Tracking*, IARPA, https://perma.cc/6QAE-XV3Y (last visited Apr. 12, 2026); ASTRA: Advanced Space Science & Technology Research Center, *Soliton Signatures: A New Strategy for Tracking Teeny Tiny Space Debris* (Aug. 12, 2025), https://perma.cc/Q8QH-KTVQ; *See also* Adam Slade, *European Debris Tracking Radar Advancements,* https://perma.cc/5KUJ-V5ZQ (last visited Apr. 12, 2026).

119 *See* Committee on the Peaceful Uses of Outer Space, *IADC Space Debris Mitigation Guidelines*, 1, 14 (2025).

success rate of ensuring that the satellite will burn up upon reentry within twenty-five years of being decommissioned.[120] With the rapid increase of satellite launches, some guidelines like the ESA's Zero Debris[121] and the U.S.' national policy[122] require this rule to be five years instead. However, a new study urges further research on the impacts of uncontrolled reentry, as some scientists worry that increases may pose long-term damage to Earth's atmosphere.[123]

While debris mitigation guidelines are crucial, they struggle to mitigate two large groups of debris. First are legacy debris—debris that are a result of launches predating the guidelines. For example, in 1958 the U.S. launched Vanguard I, which provided information before going offline in 1964.[124] As of 2026 it has remained in orbit as space debris for sixty-two years[125] because it was not designed with a disposal plan in mind.

The second kind of debris are those that fail to be mitigated, despite the guidelines. The most prominent example in recent years is the unfortunate collision of Iridium 33 and Cosmos 2251 in 2009. It was calculated that the collision "produced about 2,600 fragments large enough to be tracked from Earth and 7,900 pieces too small to be reliably monitored but big enough to damage or even destroy other satellites."[126] As of 2024, it is estimated that about 1,128 of the trackable objects remain in orbit. These are the most dangerous because their large size causes to greater collision damage and more fragmentation into smaller debris.[127] Additionally, between 2007 and 2021, four countries, the U.S., India, China, and Russia have begun testing ASATs[128]—weapons systems capable of

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120 *See* Committee on the Peaceful Uses of Outer Space, *ADC Space Debris Mitigation Guidelines* (2010).

121 *See* Soares, *supra* note 113, at 2–3.

122 *See Space Innovation & Mitigation of Orbital Debris in the New Space Age*, Second Report and Order, FCC 22–74 ¶ 4 (Sep. 30, 2022).

123 *See* Leonard Schultz et al., *Space Waste: An Update of the Anthropogenic Matter Injection Into Earth Atmosphere,* 77 ADVANCES SPACE RSCH. 9589 (2025).

124 *See* Leonard David, *Vanguard 1 is The Oldest Satellite orbiting Earth. Scientists Want to Bring it Home After 67 Years*, SPACE INSIDER (Apr. 4, 2025), https://perma.cc/CSU6-PWTV.

125 *See* NASA, *Vanguard Satellite, 1958*, https://perma.cc/6SUF-F4SX (last visited May 16, 2026). March 17, 2026 marks the 62nd year.

126 Tereza Pultarova, *Avoiding orbital mayhem*, ROYAL AERONAUTICAL SOC'Y (Mar. 22, 2024), https://perma.cc/8CAG-X8SW; Theodore Kruczek, *The Day Two Satellites Said Hello at 26,000 Miles Per Hour*, KEEPTRACK (Feb. 10, 2026) ("Radar observations suggested that an additional 70,000 fragments larger than one centimeter had been created—pieces too small to catalog reliably but perfectly capable of destroying another satellite."), https://perma.cc/4FA7-HNLP.

127 *Id.*

128 *See* Jim Cooper, *From the Space Age to the Anti-Satellite Age*, CSIS (Oct. 31, 2024), https://perma.cc/J3WM-A5BW.

destroying satellites in orbit.[129] The U.S. and India conducted their tests at low altitudes and successfully reported that all space debris has burned up and reentered.[130] However, China's test in 2007 "was the worst debris-generating event on record, generating at least 2,087 pieces of debris large enough to be tracked."[131] The test was further described as "significantly increas[ing] the amount of debris in Earth orbit."[132] Furthermore, "much of the debris will likely remain in orbit for centuries."[133] Russia's test in 2021 "created over 1500 pieces of trackable debris (10 cm in diameter or larger) and is likely to generate hundreds of thousands of smaller pieces."[134] Not only was it harmful to the space environment, but it also "endanger[ed] the civilian and military activities of both states and private actors, including the military space assets of Russia and its allies."[135]

To help deal with these situations, debris management evolved and attempted to employ its second form of policy: removal. ADR is "[t]he process to rendezvous with a piece of space junk and remove it from orbit."[136] Although the concept was theorized by NASA as early as 1989,[137] ADR was never seriously pursued until decades later.[138] This was due partly to the technological inadequacy of the 1990s and partly to a reliance on the developing debris mitigation guidelines during that time period. However, the deleterious effects of China's ASAT test and the Iridium 33 and Cosmos 2251 collision created a demand for ADR. In 2010, the U.S. announced its updated Space Policy to include not only mitigation of debris but also removal.[139] Shortly after, the Defense Advanced Research

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129 *See* Mark Smith, *Anti-satellite weapons: History, types and purpose*, SPACE.COM (Aug. 10, 2022), https://perma.cc/7KQL-64QW.

130 *See* Doris Urrutia, *India Says Its Anti-Satellite Weapon Test Created Minimal Space Debris. Is That True?*, SPACE.COM (Aug. 10, 2022), https://perma.cc/9V2W-CYU4; *see also Fact Sheet: U.S. Direct-Ascent Anti-Satellite Testing*, SECURE WORLD FOUND. 4, 6 (2025).

131 T.S Kelso, *Analysis of the 2007 Chinese ASAT Test and the Impact of its Debris on the Space Environment*, PROCEEDINGS OF THE ADVANCED MAUI OPTICAL AND SPACE SURVEILLANCE TECHS. CONF., 1, 10 (2007).

132 *Id.* at 1.

133 *Id.*

134 Nivedita Raju, *Russia's Anti-Satellite Test Should Lead to a Multilateral Ban*, STOCKHOLM INT'L PEACE RSCH. INST. (Dec. 7, 2021) https://perma.cc/SRE8-Z9QN.

135 *Id.*

136 *See Active Debris Removal*, EUR. SPACE AGENCY, https://perma.cc/L7HY-D3AM (last visited Apr. 12, 2026).

137 *See* Interagency Group (Space), *Report on Orbital Debris*, 1, 33–34 (1989).

138 *See* Barack Obama, *National Space Policy of the United States of America*, 1, 7 (2010).

139 *Id.*

Projects Agency published the Catcher's Mitt idea,[140] and in 2011, NASA published a study considering the use of laser satellites.[141] Since then, ADR has been undertaken by various countries around the world like the ESA's mission in 2011[142] and their anticipated ClearSpace-1 in 2029,[143] Japan's ADRAS-J in 2024,[144] and China's Shijian-21 in 2021.[145] Moreover, the International Space Station successfully completed test mission RemoveDEBRIS, demonstrating net capture and harpoon capture ADR methodologies.[146]

Despite major scientific breakthroughs, the technologies have yet to be implemented for ADR. This is likely due to a lack of international guidelines to help facilitate a collaborative effort. As it currently stands, bodies like the IADC,[147] and the United Nations Office for Outer Space Affairs, prioritize mitigating the creation of new debris over ADR.[148] Nonetheless, it is very likely that ADR technology will become more prevalent as the market continues to expand[149] and the need for removal grows paramount.

III. THE CONFLICT

Now that the concepts of protected astronomical zones and debris management have been explored independently, this Comment will continue with an analysis of how they interact and the resulting legal conflict that exists.

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140 Wade Pulliam, *Catcher's Mitt Final Report*, DEFENSE ADVANCED RSCH. PROJECTS AGENCY 1, 66 (2011).

141 *See* Sang Choi & Richard S. Papa, *Assessment Study of Small Space Debris Removal by Laser Satellites*, 2011 INST. ELECTR. & ELECTRS. ENG'RS AEROSPACE CONF. 1, 9 (2011).

142 *See Active Removal of Space Debris Expanding Foam Application for Active Debris Removal*, EUR. SPACE AGENCY 1, 4 (2011).

143 *See Clearspace-1*, EUR. SPACE AGENCY, https://perma.cc/48TH-LAXW (last visited Apr. 12, 2026).

144 *See* Astroscale, *Astroscale's ADRAS-J Achieves Historic 15-Meter Approach to Space Debris*, https://perma.cc/7BLT-C829.

145 *See* Andrew Jones, *China's Shijian-21 Towed Dead Satellite to a High Graveyard Orbit*, SPACENEWS (Jan. 27, 2022), https://perma.cc/35R2-9WQV.

146 Press Release, Airbus, RemoveDEBRIS Spacecraft Launched from ISS with Airbus Space Debris Capture Removal Technology (June 20, 2018) https://perma.cc/33SH-6M3Q.

147 *See* Inter-Agency Space Debris Coordination Committee, *IADC Statement on Active Debris Removal*, 1, 3 (2022).

148 *See* U.N. Office for Outer Space Affairs, *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space* (2010).

149 *See* Grand View Research, *Space Debris Monitoring and Removal Market (2025-2033*), https://perma.cc/T7AA-YUMU.

A. The Legal Conflict

This part of the Comment will look at the following protected astronomical zones: safety zones, heritage zones, the SZM, Lagrange Points, GEO, and LEO, demonstrating how they conflict with debris management. These interactions will highlight two recurring problems. First, the policies on their face are inherently at odds with each other. Protected astronomical zones advocate for a decrease in space activity to prevent interference. Whether that be changing orbits or physically attempting to remove debris, debris management necessitates an increase in space activity. With the current state of debris management technologies, this increase in space activity is difficult to minimize.[150] The second issue is the resulting cross-jurisdictional claims. The policies do not make it clear which claim has priority, nor how the claims should interact. Moreover, because space is an international domain, it does not address how to deal with multi-party or third-party scenarios.

1. Safety Zones

The Artemis Accords' safety zones may allow for activities that undermine debris management efforts. To recap, the Artemis Accords create the concept of safety zones, defining them as "the area in which nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference."[151] However, safety zones may perpetuate further debris issues.

An "anomalous event" is undefined in the Artemis Accords. Merriam-Webster defines anomalous as "inconsistent with or deviating from what is usual, normal, or expected."[152] ASAT testing is a heavy debris-creating event that can be characterized as "deviating from what is usual." It would arguably have benefited Russia to declare a safety zone during its test in 2021 because it "endanger[ed] the civilian and military activities of both states and private actors, including the military space assets of Russia and its allies."[153] However, the safety zone would act as justification for this "harmful interference" since they followed the Artemis Accords by providing notification and attempted to mitigate their harmful

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150 *See* Jacopo Prisco, *Long-Dead Satellite Emits Strong Radio Signal, Puzzling Astronomers*, CNNSCIENCE, (June 30, 2025), https://perma.cc/2J3W-U8DW; *see also* Committee on the Peaceful Uses of Outer Space*, Active Debris Removal — An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space*, 1, 40 (2012).

151 *See* Artemis Accords, *supra* note 30, § 11.

152 *Anomalous*, MERRIAM-WEBSTER'S COLLEGIATE DICTIONARY (11th ed. 2003), https://perma.cc/YN26-VW24.

153 Nivedita Raju, *Russia's Anti-satellite Test Should Lead to a Multilateral Ban*, STOCKHOLM INT'L PEACE RSCH. INST. (Dec. 7, 2021), https://perma.cc/Q7GL-LEKS.

interference.[154] Moreover, § 11 says signatories commit to use safety zones in a manner that encourages "technology demonstration," which is exactly what ASAT testing is.[155]

The Accords designate § 12 for "Orbital Debris," but these guidelines are subpar.[156] They discuss the mitigation of debris by focusing specifically on end-of-life planning and limiting debris to the "extent practicable."[157] If a country is doing a "technology demonstration" for the range of an ASAT weapon there may be no way to mitigate debris entirely. The "extent practicable" could be choosing a satellite, which produces 200 pieces of space debris instead of 1,000. Nonetheless, 200 pieces are detrimental to the space environment. Even if ASAT testing is a rare occurrence now, it is likely to become more prominent due to the brewing space arms race,[158] despite calls from the space community to cease this activity.[159] Lastly, the Artemis Accords do not provide any mechanism to challenge a nation's declared safety zone.

While critics may argue that the Artemis Accords do not perpetuate harmful debris activities because the Outer Space Treaty and Liability Convention would hold ASAT testing countries accountable, they don't in practice. Under Article IX, ASAT testing generates orbital debris, which appears to be "contamination," although the term remains undefined.[160] Even if one overcomes this hurdle, prosecuting on this ground is difficult. All space-faring nations have contaminated outer space—evidenced by the growing space debris problem. Moreover, the Outer Space Treaty only permits parties to the treaty (nation states) to enforce its provisions, but does not permit independent international bodies to do so.[161] Thus, the treaty's enforcement relies on the bad actors to enforce it—a collective action problem. This problem is like challenging false advertising claims in the U.S. Competitors are less likely to bring claims in industries where it is common practice for claims to be dubious. For example, the health supplement industry

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154 *See* Artemis Accords, *supra* note 30, § 11.

155 *Id.*

156 *Id.* § 12.

157 *Id.*

158 *See* Talia Blatt, *Anti-Satellite Weapons and the Emerging Space Arms Race*, HARV. INT'L REV. (May 26, 2020), https://perma.cc/PS68-J6QQ; *see also* Bogdan Stojanovic, *Astropolitics and the Militarisation of Space: The New Arms Race?*, DIPLOFOUNDATION (Jan. 20, 2025), https://perma.cc/U2WH-2SEK.

159 *See* Brian Weeden, *It's Time for a Global Ban on Destructive Antisatellite Testing*, SCIENTIFIC AMERICAN (Jan. 14, 2022), https://perma.cc/T3W8-K5YY.

160 Outer Space Treaty, *supra* note 6, art. IX.

161 *Id.* art. VI.

frequently misleads consumers about health loss claims.[162] Since competitors will not enforce claims against each other, the Federal Trade Commission (FTC) steps in to protect consumers. There is no independent third party in space law to enforce the Outer Space Treaty.

The Liability Convention is also ineffective for two reasons. First, it has only ever been enforced once in 1978[163] because nations avoid engaging in enforcement processes. Without a judge, tribunal, or any governing body, it is solely up to the nations to negotiate, interpret the vague terms, and reach a resolution. Since the treaty has no method of concrete enforcement, aside from their international relationships, nations are not pressured to reach a solution. Second, the Liability Convention only finds liability for actual damage, not for the threat of being harmed.[164] Since most pieces of space debris are untraceable due to their small size, it is practically impossible to attach liability to a given nation. Therefore, although nations are facing the threat of harm from the debris of others, they cannot recover from most damage.

2. Heritage Zones

The Artemis Accords also creates a conflict concerning cross-jurisdictional claims related to the designation of Heritage Zones. Heritage Zones are "historically significant human or robotic landing sites, artifacts, spacecraft, and other evidence of activity on celestial bodies" that each signatory can decide if they deem to be "significant" in accordance with mutually developed standards.[165] Undoubtedly, the areas of the moon that were reached by humans would be classified as Heritage Zones, and to preserve their sanctity, should have limited activity. Unfortunately, the moon also has debris from observational equipment[166]

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162 *See e.g.,* Complaint, *In re* S. Health Sols., Inc., No. C-4824, 2025 WL 2355503 (F.T.C. June 2, 2025); FTC v. Roca Labs, Inc*.,* 345 F. Supp. 3d 1375 (M.D. Fla. 2018); Complaint, *In re* L'Occitane, Inc., No. C-4445, 2014 WL 1410214 (F.T.C. Apr. 8, 2014)); FTC v. HCG Diet Direct, LLC, No. CV-14-00015-PHX-NVW, 2016 WL 647355 (D. Ariz. Feb. 18, 2016); FTC v. Sensa Prods., LLC., No. CV-00072, (N.D. Ill. Dec. 10, 2014).

163 *See* Alex Li, *Who Picks Up the Bill When Rockets Rain Down?*, #THESPACEBAR (Feb. 25, 2025), https://perma.cc/2TB3-ZLHR. In 1978, U.S.S.R. nuclear-powered satellite, Cosmos 954, crashed in Canada. The U.S.S.R. wanted to help Canada cleanup, but Canada didn't want the U.S.S.R. officials wandering around its territory. Ultimately, Canada faced a $14 million CAD cleanup cost. After three years of negotiating between Canada and the U.S.S.R., the U.S.S.R. paid $3 million CAD.

164 *See* Liability Convention, *supra* note 8, § 2.

165 *See* Artemis Accords, *supra* note 30, § 9.

166 *See Chandrayaan-2: Indian Helps Nasa Find Moon Probe Debris*, BBC (Dec. 3, 2019), https://perma.cc/QBY4-G776.

and debris from orbit.[167] The Heritage Zone creates an obligation by the international community to respect a given area; however, the area is ultimately owned by a single nation. If there are nations that cast debris into the zone, the debris cannot be removed. This is because the launching state retains jurisdiction over its space objects indefinitely; another nation cannot touch the object even if it is debris unless the owner consents.[168] This can lead to situations where, by no bad faith of the launching nation state, it is in a powerful holdout position because a piece of space debris floated problematically. If a nation does not give consent, the Heritage Zone owner does not have any recourse because no discernible damage has been caused. This problem is compounded by the fact that removing the debris is incredibly costly, but the cost of leaving the debris where it is is relatively low. Due to the powerful holdout position, the launching state can leverage its consent.[169]

Another issue is if the zone owner itself creates more debris in the zone. Although the international community agrees to mitigate debris, the zone owner ultimately has control over their own zone, and there are no methods of compelling compliance. This can lead to unbalanced incentives. Other nations' only incentive to avoid interference with a zone they do not own is reciprocity. Apart from a general guideline, there are no real incentives for non-zone owners to comply. Especially since debris are difficult to track, there are reduced incentives for claiming responsibility. In this situation, the zone holder gains immense leverage over nations that want to preserve the sanctity of that zone. If the zone holder wants to act in bad faith, they can demand monetary incentives from other environmentally concerned nations. Ultimately, this kind of zone creation creates a race amongst nations to be the first to lay claim to the zone, whether it be in good or bad faith.

3. SZM

The goals of the traditional protected zone and debris management necessarily conflict. The SZM is an official protected zone upheld by the ITU. The purpose of this protected zone is to create a zone almost entirely free of radio

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167 *See* Elizabeth Howell, *A Rogue 3-Ton Piece Rocket Debris Just Collided with the Moon*, SPACE.COM (Mar. 4, 2022), https://perma.cc/75E6-NNPB.

168 *See* Outer Space Treaty, *supra* note 6, § VIII.

169 Consent in exchange for value in negotiations is not unprecedented in the law. For example, in restructuring indentures, courts have upheld the use of exit consents in certain instances of bond exchanges. *See* Kass v. Eastern Air Lines, Inc., 1986 WL 13008, at *1 (Del. Ch. 1986) ("Eastern has offered to pay each debenture holder *who consents* to the proposed amendments."); Marblegate Asset Mgmt., LLC v. Educ. Mgmt. Corp., 846 F.3d 1 (2d Cir. 2017); *see also* Lee C. Buchheit, *Exit Consents in Sovereign Bond Exchanges*, 48 UCLA L. REV. 59 (2000); Benjamin Liu, *Exit Consents in Debt Restructurings* 13 CAPITAL MARKETS L. J. 116 (2017)..

signals, because it allows for the detection of radio signals that are undetectable from Earth.[170] However, debris management necessarily increases the amount of radio signals resulting from an emphasis on tracking debris. Tracking debris and satellites relies on emitting radio signals.[171] It is unclear which priority should be taken when this tracking is occurring near the protected zone. From an authority standpoint, the zone is protected by hard law; however, this line of analysis can lead to unsatisfying policy results. For example, stopping tracking near the zone can result in a significant loss of information, like debris that may collide with equipment monitoring the zone.[172] Losing track of objects would drastically increase the risk of collision, as orbital maneuvering would be harder to implement, since it relies heavily on large amounts of data.[173] Especially as ADR projects continue to develop, they will necessarily emit more radio frequencies. There is no indication in the law as to which is more important: removing a piece of debris that is about to cause damage or avoiding the interruption of sensitive monitoring. In the long term, ADR will lead to fewer radio frequency signals near the zone and protect the zone from debris collisions.[174]

4. Lagrange Points

While the Lagrange Points are indirectly protected by the ITU's frequency regulations (soft law),[175] they face similar issues as the SZM because there is no priority allocation between the two. The issue is compounded by the fact that the Lagrange Points are not even protected by hard law.[176] When debris enters Lagrange Points, there is no allocation of responsibility for who should clean it up. Although scientific discoveries are a cooperative effort, countries ultimately want their investments in space missions to pay off. As a result, they are less incentivized to remove debris from the area when they can rely on another nation for removal.

Another unique issue facing the Lagrange Points is the attempted militarization and race to occupy them.[177] Scientists aptly describe these points as

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170 *See* Biron, *supra* note 38.

171 *See* Federal Aviation Administration, *Satellite Navigation-GPS-How it Works,* https://perma.cc/VN6A-B7PP (last visited May 16, 2026).

172 Riskaware, *Understanding the Role of Space Situational Awareness*, https://perma.cc/NYA9-DRC2.

173 *See* NASA, *Chapter 13:* Navigation, https://perma.cc/TTM2-NXJY.

174 *See* Howell, *supra* note 169..

175 *See* Rep. ITU-R SA.2307-1, *supra* note 48.

176 *See* David A. Koplow, *supra* note 94.

177 *See* Eric Berger, *U.S. Congress Recommends Placing Assets at Lagrange Points to Counter China*, ARS TECHNICA (Dec. 19, 2023), https://perma.cc/5W35-QEDD; *see also* United States Space Force, *About the United States Space Force*, perma.cc/LN4K-BM75 (last visited May 16, 2026).

an "orbital parking spot for satellites."[178] Despite the vastness of space, like our orbits, these specific areas are still limited in size. The restrictions on radio frequencies compound these issues further as only so many satellites can emit radio frequencies in these areas, making each spot even more valuable. These restrictions can make it difficult to implement effective ADR for these areas because, as already mentioned, this technology requires radio emission.

The more concerning issue is that it can incentivize cutting corners on mitigation efforts for various reasons. First, implementing the most mitigating technologies takes time since frequently these are emerging technologies in need of development and refinement. Once a country has planted its satellite to secure this limited resource, they won't want to give it up.[179] A country rushing to the Lagrange Points will instead use existing technology that is still approved but won't actively pursue better technology. Even if the fuel costs are minimal to move a satellite from a Lagrange point to graveyard orbit,[180] nations have no incentives to do so. In this functionally first-in-time, first-in-right environment,[181] nations want to secure as much of the resource as they can. The fastest way to do so is by maximizing the number of satellites entering those areas, which comes at the expense of mitigation. As a result, the space environment is flooded with satellites that don't mitigate debris creation as effectively as they could. Second, an increase in debris makes it harder for other nations to get their spacecraft to these points. This essentially incentivizes using space debris to stall other nations or even temporarily occupy space at Lagrange Points.

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178 Nat'l Env't Satellite, Data, and Info. Svc., *Lagrange Points: An Orbital Parking Spot for Satellites*, https://perma.cc/G9WN-Q4H3 (last visited May 16, 2026).

179 *See* Dark Energy Articles, *The Surprising Reasons Behind Space Mission Delays*, MEDIUM (Jan. 19, 2024), https://perma.cc/MEB3-JPA5.

180 *See* Camilla Colombo, *End-of-life Disposal Trajectories for Libration Point and Highly Elliptical Orbit Missions*, CONFERENCE: INTERNATIONAL ASTRONAUTICAL CONGRESS (2013).

181 Formally, the Outer Space Treaty prohibits a first-in-time, first-in-right environment. Instead, art. II upholds the rule of non-appropriation: "[o]uter space. . .is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means." Outer Space Treaty, *supra* note 6, art. II. Nonetheless, in practice, occupying space via satellites functions as appropriation. *See* Johnson & Graham's Lessee v. McIntosh*,* 21 U.S. 543, 573 (1823*)* ("establish a principle . . . as the law . . . the right of acquisition . . . [t]his principle was that discovery gave title to the government"). It is difficult to square the practice with the former and not the latter. *See also* 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, 692, 702–05 (arguing that the difference between access and ownership is blurry, and that in the name of access the ITU's *a posteriori* and *a priori* systems function as first-in-time, first-in-right appropriation of satellite orbit slots). Practice does not always reflect the formal international law when compliance mechanisms are lacking. *See* Oona A. Hathaway, *Do Human Rights Treaties Make a Difference?*, 11 YALE L. REV. 1935, 1938 (2002) (describing challenges in enforcement of formal human rights law due to lack of "major engines of compliance").

Since there is a lack of enforcement between protecting the zones and debris mitigation, and priority is disputed, the space environment suffers.

5. GEO and LEO

The discussion of GEO and LEO is relatively self-evident. As mentioned above, the policies of protected zones and debris management are inherently at odds with each other. The space for radio frequencies in these zones is limited, yet ADR in this area is incredibly important. The commercialization of these orbits incentivizes launching satellites into orbit as opposed to encouraging mitigation because of the limited real estate.

Cross-jurisdictional claims are also a major issue here because all space-faring nations have a presence in these orbits, so they all contribute to the debris. Although they all have a duty to preserve the environment, it is currently taking a backseat to the relative growth of the industry, as nations are racing to put their satellites into outer space. The incentive and rewards associated with getting into space are significantly greater than debris mitigation. It is easier to adhere to radio frequency regulations of the protected orbits as opposed to ADR in these areas, especially when factoring in opportunity costs. A nation that decides to step back and focus on preserving the environment is benefiting itself and other nations, but nations that continue launching and occupying space benefit themselves much more.

B. Failing Incentive Structures are the Cause

This section will explore how the aforementioned legal tensions are a result of failing incentive structures within space law. As discussed, the authorities that govern space law are ineffective at implementing its goals. However, foundational authorities are not solely to blame. Mitigation guidelines from the IADC and the ITU's regulations also fail to include sufficient enforcement mechanisms.

The theoretical scenario that considers the incentives of self-interested behaviors is the tragedy of the commons. This scenario manifests itself when the economic good meets four criteria. The good must be in competition, non-excludable, scarce, and exist in finite supply.[182] In this instance, the economic good is the limited real estate of outer space itself.

This good is pursued in competition given the functional first-in-time property rights of the system. While there are collaborative efforts to explore space, nations still inherently compete for first-mover advantage. The above-mentioned militarization and arms race towards Lagrange Points are examples.

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182 *See* Michael Boyle, *Understanding the Tragedy of the Commons in Economics: Causes and Solutions*, INVESTOPEDIA (Apr. 25, 2026), https://perma.cc/8GX6-W76C.

The privatization of space has further enhanced competition. Not only are private companies assisting nations' space agencies in entering space,[183] but they are also racing to capture space real estate with their private satellites.[184] However, according to Articles I and II of the Liability Convention,[185] only a launching state can register space objects, and registration is required for all launched objects. Furthermore, the Outer Space Treaty in Article VI[186] requires states to take responsibility for non-governmental entities. In other words, private companies must get authorization to launch on behalf of a nation. This requirement poses the issues of "flag states" where private companies register in countries that have less restrictive laws to gain an advantage.[187] For example, the U.S. company Rocket Lab registered in New Zealand to enjoy the benefits of a private launch facility that it couldn't get in the U.S.[188] Moreover, private companies are getting major tax benefits for registering in the Isle of Man.[189]

The next factor is that access to the good is not excludable. This means that entities cannot meaningfully prevent others from accessing the good. First, this is an underlying tenet of space law expressed in Article II of the Outer Space Treaty. The treaty explicitly states that "[o]uter space . . . is not subject to national appropriation."[190] Second, given the international nature of outer space, it would be very difficult to physically prevent another nation from accessing it without causing an international incident. Although this Comment has reiterated that the legal underpinnings of space law are weak, the fear of an international incident that could occur indirectly upholds Article II. Lastly, while it is true that a nation's use of radio frequencies reduces the overall availability of the resource, that doesn't mean that nations can preclude others from using that resource, even if they had gotten there first.

Next, the good itself is scarce. A good is scarce if the quantity demanded exceeds the quantity supplied. Given the sheer size of the known observable

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183 *See* Willis Ryder Arnold & Meghna Chakrabarti, *How Private Companies are Influencing the New Space Race*, WBUR (Sep. 25, 2025), https://perma.cc/WF5B-G65Q.

184 *See* Mike Wall*, SpaceX Launches Private Space Station Pathfinder 'Haven Demo,' 17 Other Satellites to Orbit (Video*) SPACE.COM (Nov. 2, 2025), https://perma.cc/MJZ9-QHLP.

185 *See* Liability Convention, *supra* note 8 § 1, 2.

186 *See* Outer Space Treaty, *supra* note 6 art. VI.

187 *See generally* Adrian Taghdiri, *Flags of Convenience and the Commercial Space Flight Industry: The Inadequacy of Current International Law to Address the Opportune Registration of Space Vehicles in Flag States*, 19 B.U. J. SCI. & TECH. L. 405 (2013).

188 IRC, *International regulatory cooperation on space activities*, MINISTRY OF BUSINESS, INNOVATION & EMP. (NZ), https://perma.cc/ES6N-MLVW (last visited May 16, 2026).

189 *See generally* Helmut Kessler, *Man and Space – The Isle of Man, the IISC and the New Space Economy*, 27 SPACE POL'Y 222 (2011).

190 *See* Outer Space Treaty, *supra* note 6 art. II.

universe—92 billion light-years in diameter and 410 nonillion cubic lightyears by volume[191]—the resource seems practically infinite. However, with current technology, only a minuscule fraction is accessible and valuable to nations. The demand to enter outer space is continually growing; however, regulations by the ITU show there is a limited supply. The ITU can only authorize a certain number of satellites to enter orbit before the supply of real estate has run out (presumably the estimated 100,000).[192]

Lastly, the good itself is finite. A good is finite because there is a fixed and limited quantity of it. The outer space areas in competition are finite. The Sun-Earth and Moon-Earth system Lagrange Points, LEO, and GEO are all finite because they can only physically hold so many satellites before the risk of collision is too great. No matter the increases in technology, these areas themselves will not increase in quantity.

Now that it has been established that space is a resource that is subject to the tragedy of the commons, we can further analyze how this leads to powerful self-interested incentives. Outer space and nations trying to capitalize are very similar to whales and whalers. A classic example is documented by Robert Ellickson where he observed whales as a tragedy of the commons during the mid-1800s.[193] One of the main drivers for whaling was competition over being the first to benefit from capturing the whale. For every whale that was captured by a vessel, the benefit outweighed the cost of capturing it. This is the rational choice of wealth maximization. However, as competition increased, the choice of wealth maximization got more complicated because it involved maximizing wealth in either the short or long-term. Continuing to exploit every available whale would result in large short-term profits, but it would eventually lead to the elimination of the resource. In the long term, wealth was better maximized as it would allow for a greater total profit across the years since the resource could regenerate. Unfortunately, without regulation to halt short-term wealth maximization, it is implausible for actors to prioritize long-term wealth maximization. This is because if even one actor doesn't adhere to the long-term rationale, all long-term decision-

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191 *See* Alastair Gunn, *How Big is the Universe? This is What Astronomers Think the Size of the Cosmos Is, and How They Worked It Out*, BBC SKY AT NIGHT MAG. (Aug. 29, 2025), https://perma.cc/AM6J-ZS2Q.

192 *See* Bob Yirka, *Study Shows Need for ITU to Tighten Regulations for Low Orbit Satellites as Filing Numbers Grow,* PHYS.ORG. (Oct. 18, 2023), https://perma.cc/5TLT-42EU; *see also Harry* Baker, *How Many Satellites Could Fit in Earth orbit? And How Many Do We Really Need?*, LIVESCIENCE (May 30, 2025), https://perma.cc/ZB4C-9GTU; Tereza Pultaravoa, *How Many Satellites Can We Safely Fit in Earth Orbit?*, SPACE.COM (Feb. 27, 2023), https://perma.cc/7BS6-L3EF.

193 *See generally* Robert Ellickson, *A Hypothesis of Wealth-Maximizing Norms: Evidence from the Whaling Industry*, 5 J. L. ECON. & ORG. 83 (1989).

makers are impacted since the resource is still being depleted.[194] Coupled with advances in technology that made whaling even more efficient, it eventually led to the downfall of the whaling industry. In other words, the incentives of self-interested behavior outweighed the incentives for collective action.

When it comes to outer space, we observe the same problem. Each nation significantly benefits from launching more satellites into outer space and is harmed every time another nation gets there before it. Although most nations recognize that the long-term preservation of outer space is important for wealth maximization, short-term exploitation is still heavily incentivized. There is a lack of regulations that penalize short-term wealth maximization. As a result, other nations will not idly sit by when even just one nation begins to consume the limited real estate of outer space. Moreover, space technology is increasing rapidly, making it easier for nations to get more satellites into space.[195]

Another way to explain this is with externalized and internalized costs. Every time a nation decides between taking action(s) that would allow them to enjoy short-term versus long-term benefits, they do a cost calculation. In the current environment, costs are externalized. This means that when a nation launches a satellite, the greater cost of exploiting the space environment impacts all nations, not just the offending nation. Moreover, when a nation exploits this environment, it is internalizing virtually zero cost. Minus the investment in the satellite itself, the nation is not feeling the cost of space debris creation or risk of interference with space research in a protected zone. This is because those negative externalities take a long time to materialize while the benefit to the nation is immediate.

An interesting observation Ellickson found is that where law had failed, norms developed and perpetuated wealth maximization.[196] These norms were ideas such as iron holds the whale and fast-fish, loose-fish that whaling ships adhered to.[197] They were effective because they benefited all competitors as it reduced conflict costs between parties and reduced the waste of the good. Ellickson found that norms developed based on interdependent, localized groups, with enforcement capabilities[198] and Hardin's epigraph corroborates this.[199]

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194 *See* Florian K. Diekert, *The Tragedy of the Commons From a Game-Theoretic Perspective*, 4 SUSTAINABILITY 1776, 1777–73; 1782–83 (2012) (analyzing how the tragedy of the commons is exemplified by game theory's "Prisoner's dilemma" game and how modifications to the game can mitigate straying from cooperation).

195 *See* Daniela Jovic, *Emerging Space Economies: The Next Chapter of the New Space Era*, IMPULSO.SPACE (July 15, 2025), https://perma.cc/7PWK-UPLZ.

196 *See* Ellickson *supra* note 193.

197 *Id.*

198 *See* Ellickson *supra* note 193.

199 Garret Hardin, *The Tragedy of the Commons,* 162 SCIENCE 1243, 1243 (1968) ("The population problem has no technical solution; it requires a fundamental extension in morality."); Florian, *supra*

However, in the context of space, norms are unlikely to develop in place of law, and that is why it is crucial that law develops. Norms are unlikely to form and function as self-government because competitors function independently. Those vying for power in space are members of an incredibly large community[200]—Earth. As explained by Elinor Ostrom's principles, norms form and defy the tragedy of the commons when they are dictated by "local people."[201] Moreover, if norms were to develop, it is difficult to enforce said norms through formal penalties or ostracization. Powerful nations can sustain blows to their reputation and resist economic sanctions if they are a major player in the global economy and thus can continue exploiting the space environment without the help of the group. This highlights the necessity of regulatory mechanisms to help combat the powerful underlying incentives of self-interest.

C. Why This is Problematic

The current space environment (lacking concrete regulation and suitable enforcement) incentivizes short-term, self-interested economic exploitation of outer space and thus fails. There are three main reasons why these failing incentive structures are problematic and indeed failing. First, they don't maximize the long-term benefit of protecting the space environment. Second, they make it difficult to challenge the conflict between protected astronomical zones and debris management. Third, they erode cooperation amongst nations, creating international instability and hampering problem-solving.

Despite the short-term incentives for entering outer space, the cost of fully exploiting the space environment is catastrophic—confinement to our planet by hampering exploration and eliminating access to nonrenewable resources. As a result, it is important that nations are incentivized to prioritize the long-term benefits, such as functional satellite-based communication, scientific research, and planetary discovery.

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note 194 at 1785 (expanding on the epigraph, "achieving sustainable development still requires, at its root, a change of human relationships with the environment"). Note that, norms are a system for reshaping this relationship by altering the existing underlying incentives. Due to their inapplicability here, the ex ante and ex post solutions proposed below are alternative ways of shifting incentives to pressure change on the fundamental human relationship with the space environment.

200 *See* Pammela Q. Saunders, *A Sea Change off the Coast of Maine: Common Pool Resources as Cultural Property*, 60 EMORY L. REV. 1323, 1349 (2010) (applying Ostrom's principles for the increased likelihood of norm formation in the context of self-regulating Maine lobstermen); *see also* Henry J. Friendly, *Federal Jurisdiction: General View* 46, 200 (1973) (critiquing large Courts of Appeals and highlighting how small groups perpetuate simple norms like communal dining, "the desirability of judges of a collegial court really knowing each other, by talking together, lunching together even—perhaps particularly drinking together").

201 Jeremy Williams, *Elinor Ostrom's 8 rules for managing the commons,* EARTHBOUND REP. (Jan. 15, 2018), https://perma.cc/46ND-PY5P.

When incentives are structured for nations to act in their own self-interest, it results in decreased adherence to prospective and existing laws. As discussed above, compliance issues between protected astronomical zones and debris removal are difficult to resolve. This is because instead of a nation looking to adhere to both policies and balance their long-term benefits, they are inclined to violate and prioritize the short-term benefits.

Lastly, instability and distrust in one area of international law have rippling effects across the entire international system. Aside from space law, international law is important for collaborative efforts in trade, humanitarian support, and global peace. Therefore, it is essential to reduce the amount of instability in the international environment.[202] Furthermore, when there are instability and distrust, problem-solving suffers.[203] Collaborative efforts not only generate better ideas but can lead to faster technological breakthroughs. Moreover, the creation of international law is inherently a collaborative effort, so to create better laws, nations must be willing to effectively work together. For these reasons, it is important to address the failing incentive structures that are revealed by the conflicting space law policies.

D. Potential Solutions to the Conflict

1. Shifting Ex Ante Incentives

This Comment aims to shift away from the ex ante incentives that lead to the self-interested maximization of short-term goals. For example, ASAT testing. This creates immediate short-term benefit for the testing nation, as they demonstrate their military strength and gain valuable information about their weapon, while creating lasting debris damage

The two common approaches to shifting away from the depletion of the good are the assignment of property rights and government regulation.[204] In the context of space law, the formal[205] assignment of property rights is not a feasible solution because the Outer Space Treaty forbids appropriation.[206] Nonetheless, government regulation can be applicable.

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202 *See Timeline-EU Sanctions Against Russia*, COUNCIL OF THE EU (last visited May 16, 2026), https://perma.cc/S4AQ-J87Y (Russia violated international humanitarian law and received sanctions impacting a different area of international law—banking).

203 *See* Ban Ki-Moon, *To Solve Global Challenges, Leaders Must Work Together in the National Interest*, THE ELDERS (Feb. 14, 2020), https://perma.cc/9BHY-BTBW.

204 *See* Boyle, *supra* note 182.

205 *See* Nat'l Env't Satellite *supra* note 181.

206 *See* Outer Space Treaty, *supra* note 6, art. II.

The first kind of regulation that could help shift incentives is one that creates an effective liability regime. For example, Amanda Rose argues that a unitary enforcement mechanism better carries out the goals of fraud enforcement under federal securities law.[207] Similarly, this is seen with the FTC discussed above.[208] Having a centralized international dispute resolution entity could be helpful in promoting enforcement for violations. This would force nations to bear greater internalized costs making them less incentivized to act in self-interest. This cost doesn't have to be reserved to monetary damages. An effective enforcement mechanism could have serious reputational impacts. Currently when a nation is acting in self-interest, its reputation doesn't suffer since it is common practice for nations to compete to enter outer space. However, an effective enforcement mechanism could set a precedent that self-interested violations are no longer tolerated. Nations that continue to offend may be viewed as untrustworthy, exposing them to other international legal repercussions. This is a well-known enforcement tool since the "international legal system often relies on the reputation costs for non-compliant states . . . or the pressure exerted by international public opinion."[209] Although it is not currently applied in the space law context, attitudes may shift when the consequences of the existing system begin to materialize—irreversible exploitation of the space environment.

Another effective kind of regulation would be one that has regulatory priorities. As Nicholas Bagley argues, inefficient procedures can reduce agency efficiency in carrying out their "legislatively assigned mission."[210] This implementation would focus on clearly laying out priorities between conflicting space law policies. For example, this Comment highlighted how astronomical protected zones and debris management policies can conflict. Either one of these policies could have been written with priority regulations in mind. To address cross-jurisdictional claims, allocate responsibility, and properly adhere to the law, the guidelines should consider priority. For example, the hard law protections of the SZM were very important in the 1970s, but in the modern environment, debris are a much more pressing concern. To reflect changes in priorities the guidelines should be explicit on this point.

2. Shifting Ex Post Incentives

This Comment aims to shift away from the ex post incentives that lead nations to the self-interested betterment of their position once another nation

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207 *See* Rose, *supra* note 26, at 2176.

208 *See* FTC, *supra* note 162.

209 *What are the Challenges of Enforcing International Law?*, SUSTAINABILITY DIRECTORY (Dec. 3, 2025), https://perma.cc/V3J4-LYX7.

210 *See* Bagley, *supra* note 27, at 360–61.

defects. When dealing with ex post incentives there are two types of approaches–carrots and sticks.[211] In other words, nations can receive rewards for not defecting or the fear of punishment will prevent them from defecting.

Starting with the punishment application (sticks), it mirrors the discussion of ex ante regulations. If nations are being forced to pay large fines or suffer serious reputational damage, then other nations will not want to follow suit. Another way that punishment could work would be by reordering priorities. For example, the ITU is responsible for confirming and reviewing submitted satellite plans.[212] If launch priority is given to non-defecting nations this would prevent nations from following the defector. This is because although the defecting nation received immediate benefit of launching a satellite, the non-defecting nations also receive the substantial benefit that their priority to launch is now above the defector, and they can launch more often. In other words, this increases internalized costs for the violator while mitigating the cost of adherence. Ultimately, launching without ITU approval greatly increases the risk of collision and potential interference with radio frequencies. This in itself deters defectors because the cost of destroying your satellite is expensive, especially if it also damages others'.[213] Lastly, since the ITU is empowered by the U.N. and is already in charge of filing plans, issuing soft law recommendations, and establishing hard law, they are the body that should push forward enforcement mechanisms. Moreover, some nations have passed internal laws to make compliance with the ITU a hard law obligation,[214] further validating the ITU's authority.

Moving on to rewards (carrots) there are three potential solutions. First is a cost-sharing fund. This is a tool used frequently to address collective action problems. One of the largest collective action problems in the modern day is climate change. Cost-sharing funds are employed and play a meaningful role in mitigating collective action problems facing climate change.[215] These cost-sharing funds incentivize nations to work together by assisting poorer nations in their compliance costs. For example, if a poorer nation is struggling to implement new expensive debris mitigation technology, they may be more inclined to defect. The cost-sharing fund allocates capital to assist these nations so they can afford the

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211 Saul Levmore, *Carrots and Sticks in Law (and Life)* CHICAGO'S BEST IDEAS (Jan. 1, 2016) https://perma.cc/A495-CY4Z.

212 *See supra* notes 76–78 and accompanying text.

213 *See* GlobalCom, *The Cost of Building and Launching a Satellite*, https://perma.cc/B9YX-UMBH (last visited May 16, 2026). Satellites can range from $50-$400 million in cost.

214 ITU, *Frequently Asked Questions on ITU Satellite Filings*, (2025) ("[I]n many countries, it is illegal to operate a satellite without a proper ITU filing.").

215 *See* Green Climate Fund, *Resource Mobilisation,* https://perma.cc/ASV6-9GZS (last visited May 16, 2026).

more expensive adherence costs. Unfortunately, the main incentive for nations to invest in the cost-sharing fund is a desire to solve the collection-action problem. If a powerful regulatory body, like the ITU, is given more authority, they could force nations to participate, making it more effective.

The second solution is indemnification funds. These are collective funds that distribute the cost of noncompliance across multiple nations.[216] These funds reward nations for not violating. If you are the nation that intentionally violates, you distribute costs to the other nations in the fund because the fund collectively pays for the infringement. Initially this may seem to benefit the violator because it reduces their personal cost, but it hurts them in the long run. The nation that intentionally violated will unlikely be able to join future indemnification funds because they will be viewed as high risk and untrustworthy. This exposes them to the full brunt of future liability that they can no longer disperse. On the other hand, nations that comply are rewarded with reputational benefits and better risk management opportunities. An incentive for nations that don't have the capacity to partake in the fund, would be to not defect in the first instance since they risk crippling their nation's economy in the face of liability.

Lastly, there is the insurance solution. Under this regime nations would be insured against defectors. For example, if one nation is working on developing ADR technology and another nation engages in debris creation, the insured will be compensated. The complying nation will be rewarded if another nation attempts to defect, which also rewards them for adherence. Moreover, the defector will have to pay out an insurance claim. This insurance regime protects nations who comply and reduces the cost of guideline adherence whilst also making it more costly for violating. The insurer could potentially be the ITU if nations were obligated to pay into it for protection. [217] However, including private sector insurers could make this more feasible given the established nature and deep pockets[218] of the private insurance practice.[219]

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216 *See* Thomas Mensaht, *International Oil Pollution Compensation Funds*, *in* MAX PLANCK ENCYCLOPEDIAS OF INTERNATIONAL LAW (2011).

217 *See Automobile Financial Responsibility Laws By State*, INS. INFO. INST., https://perma.cc/6AA5-YQ5Y, (last visited May 16, 2026) In the U.S., car insurance is mandatory is essentially all states; *see also Workers' Compensation Laws – State by State Comparison*, NFIB BLOG (June 17, 2017), In the U.S., workers compensation insurance is mandatory is essentially all states. https://perma.cc/3M9L-V3NE.

218 *See The Insurance Industry is Quietly Making Record Profits*, AM. ASS'N JUST. (Apr. 1, 2025), https://perma.cc/U2ZE-E6U6 ("[I]nsurers made a record $169 billion in profit in 2024.").. https://perma.cc/U2ZE-E6U6.

219 Even if it may seem costly for insures to engage in this scheme, insures are found in incredibly costly environments. For example, mass torts. *See generally* Tom Baker, *Where's the Insurance in Mass Tort Litigation?*, 101 TEX. L. REV. 1569 (2023) (highlighting that although unusual, insures exist in the costly mass torts context); Alanna Andersen, *The Impact of Mass Tort Litigation on Insurance Carriers*,

IV. CONCLUSION

To conclude, an analysis of two important outer space guidelines—protected astronomical zones and debris management—revealed a legal tension. This conflict stems from the ineffective incentive regimes inherent to space law. Not only does the current regime encourage ex ante self-interested violating behavior, but also ex post fails to incentivize nations to adhere after another nation violates. By employing a variety of solutions, it is possible to shift these incentives and thus harmonize the conflicts between protected astronomical zones and debris management. For solutions to be effective they require an entity to drive them forward. Given the experienced nature of the ITU and the fact that they are a leading authority, makes them a ripe candidate for imposing enforcement. Especially since nations attempt to adhere to the ITU by passing their own hard law for self-imposed legal obligations.[220] If the U.N. moved to further empower the ITU, there may be an opportunity for greater enforcement, effective solutions, successful incentive structures, and a long-term, sustainable space environment.

WISEDOCS (May 20, 2024) ("Mass torts are a financial hurricane for insurance carriers.") https://perma.cc/9SD2-XWBQ.

220 *See* ITU *supra* note 214.