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Advancements in Space Law: Satellite Communications Industry Regulations and Obligations for Orbital Debris Mitigation

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Abstract

The proliferation of satellite technology has ushered in an era of opportunity and challenge for the existing international legal framework of space law. International regulatory bodies have looked to existing treaties governing space activities like the Outer Space Treaty, the Liability Convention, and the Registration Convention. In this new era, the challenges that have emerged cannot be enforced by the broad language of the treaties and outdated terms. For example, the deployment of large constellations of smaller satellites poses new challenges, like orbital debris damage and evasive responsibility, which the legal landscape for outer space must address. Space law stresses geopolitical considerations and strategic international legal frameworks that work to reduce the militarization of space and ensure that space is for all. This paper explores current treaties and challenges and proposes legal and policy solutions for the satellite industry's responsible use of outer space.

Keywords: space law, satellite communications industry, Outer Space Treaty, orbital debris, satellite constellations, Space Object Index

Introduction

On October 19, 2024, IS-33e, a satellite owned and operated by Intelsat, a multinational satellite provider, experienced an anomaly that caused the satellite to break up into five hundred pieces of debris that ranged from the size of a softball to the size of a car door.[1] The satellite revolved in the Geostationary Orbit (GEO), about thirty-six thousand kilometers above the Earth's equatorial plane. What caused the anomaly is still unknown at the time of this writing. On June 27, 2024, a defunct Russian satellite broke into more than one hundred pieces in orbit, forcing the International Space Station to take shelter in the aftermath.[2] The satellite disintegrated at an altitude of 355 kilometers in low-earth orbit (LEO), a region that has become increasingly congested due to the deployment of large constellations, including Starlink's constellation network and a rapidly expanding Chinese competitor, Shanghai Spacecom Satellite Technology.[3]

The event underscores a growing threat to operational satellites' resilience, a feature that the global telecommunications landscape increasingly relies on. Satellite operators must now prepare for the threat that debris

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[1] Jason Rainbow, "ExoAnalytic observes 500 pieces of debris from Intelsat 33e breakup," SPACENEWS, Oct. 28, 2024, https://perma.cc/TVQ5-3TEU.

[2] Joey Roulette, "Russian satellite breaks up in space, forces ISS astronauts to shelter," Reuters, last modified June 27, 2024, 16:37 (CDT), https://www.reuters.com/technology/space/russian-satellite-blasts-debris-space-forces-iss-astronauts-shelter-2024-06-27/.

[3] "China launches first satellites of constellation to rival Starlink, state media says," Reuters, last modified Aug. 6, 2024, 04:14 (CDT), https://www.reuters.com/technology/space/china-launches-first-satellites-constellation-rival-starlink-state-media-says-2024-08-06/.

dispersion poses to their satellites in the shared orbit. Clearly, the world is embarking on a new era in space—a crowded space era. Space debris tracking is now essential for operational satellites' longevity.[4] Indeed, the concept of a crowded space is difficult to envision, as space is perceived as an endless void. However, the void is becoming smaller. The space that satellites use is becoming a limited natural resource as the number of commercial actors in the field grows. An economic tipping point could arise from the unchecked accumulation of orbital debris emanating from collisions involving governments' commercial and non-commercial space objects. A potential scenario could exist in which the marginal cost of debris avoidance increases more rapidly than the anticipated revenue, potentially making space operations prohibitively expensive.[5] The Intelsat anomaly and the Russian satellite explosion are canaries in a coal mine. Satellite operators must seek international collaboration to prevent space debris collisions and call for the modernization of the existing international legal frameworks or at least policy tools to help address these concerns.

This paper begins by exploring the historical development and evolution of space law, the pivotal role of satellites in modern society, and the significance of the international satellite communications industry. It then examines the United Nations (UN) treaties that form the foundation of the international legal framework governing the industry, focusing on key agreements such as the Outer Space Treaty (OST)[6] and related instruments that have shaped space law. Furthermore, the paper addresses pressing challenges the industry faces, including space debris, orbital congestion, and equitable access to orbital slots and spectra. The US's legal framework for space is presented as an example of regulations developed and imposed at the national level. Policy recommendations for the responsible use of outer space are also presented, which include this author's proposal for mitigating orbital debris by drafting a new treaty and creating an informal database where satellite operators could input information about satellites' life expectancies and potential hazards. This proposed database aligns with the cooperative and informational goals of the UN treaties, fostering safer and more sustainable exploration and utilization of space.

Backgrounds of Space Law, Satellites, and the Satellite Communications Industry

Space law emerged as a response to the global scale of space exploration, necessitating extensive international cooperation. In the international context, space law encompasses a wide array of issues ranging from insurance contracts for space launches to overarching principles that govern the liability of States and commercial entities for their activities in outer space.[7] The development of space law has been significantly influenced by principles of contract law and tort law. For instance, concepts like vicarious liability have shaped treaty formation by assigning responsibility to States for overseeing their national entities,[8] ensuring compliance with international obligations—a relationship analogous to that of principal and agent.[9]

The expansion of the satellite communications industry has ushered in an era of opportunity and challenge for the existing multilateral legal framework for space activity. The legal framework of practical space law represents the international community's response to the challenges and opportunities presented by outer space activities. Legal liability in outer space encompasses the establishment of new structures and procedures to address space-related

[4] Paul B. Larsen, "Solving the Space Debris Crisis," *Journal of Air Law and Commerce* 83, no. 3 (2018): 475–520, 482. Tracking is an important tool for satellite operators to avoid collisions. "The U.S. Air Force Space Surveillance Network (SSN) tracks 23,000 debris larger than ten centimeters in LEO and larger than thirty centimeters in GEO."

[5] Nodir Adilov et al., "An economic indicator of the orbital debris environment," *Journal of Space Safety Engineering* 11, no. 3 (Sept. 2024): 539–45, 544.

[6] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (hereinafter OST), opened for signature Jan. 27, 1967, entered into force Oct. 10, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205.

[7] Francis Lyall and Paul B. Larsen, *Space Law: A Treatise*, 3rd ed. (Routledge, 2024), 2–4.

[8] OST, art. VI (n 6).

[9] Deb Soumyaditya and Paul Priyongshu, "Challenges of Legal Liability in Outer Space Exploration," *International Journal of Law Management & Humanities* 6 (2023): 82–89, 86–87. Today's space era demands an "international legal system to uphold equality, equity and justice in outer space." The authors examine the applicability of tort law for both public and private contractors in space exploration. For example, India's tort of vicarious liability holds private corporations liable for the tortious acts of their employees during the course of their employment.

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issues, the application of existing domestic legal principles to space activities and materials, and the implementation of international agreements within a nation's legal framework.[10]

The blend of government agencies, private companies, and international organizations actively participating in the space industry is growing at an unprecedented rate. However, the applicability of existing space law must keep pace and align with current practices, or the field risks becoming ungovernable. Indeed, there are significant enforcement gaps in the application of space law within the framework of international law. Contemporary legal scholars are working to address these gaps and propose solutions to strengthen public international space law.[11] As of 2024, the International Court of Justice (ICJ) has not rendered any decisions directly related to space law. However, it is likely that the ICJ will eventually need to resolve complex international disputes involving space activities.[12]

Satellites are essential for routing data, broadcasting events, navigating to and from remote locations, sustaining cellular networks, and enabling communication during natural disasters, among other critical services. Satellite communications technology is integral to modern communication systems that depend on instantaneous data transfer. Communication satellites enable global telecommunications systems by relaying signals with voice, video, and data with a lower infrastructure requirement. Satellites and other space assets are crucial in that "[h]umanity depends on space assets across various sectors including the telecommunications, financial and transportation sectors."[13]

In this new era, emerging challenges have strained the enforcement of space law treaties, as treaty language is broad and lacks specific guidelines for modern satellite operation and regulation. The deployment of large constellations of small satellites that could disrupt the demand for satellite connectivity is shaping the industry.[14] These deployments are happening in the LEO area, about 160 to 2,000 kilometers above the Earth's surface. Such deployments allow satellites to take advantage of lower-latency data transfers and greater cost-effectiveness, among other benefits. Satellites deployed in the LEO are non-geostationary satellite orbits (NGSOs), which are satellites that operate in orbit and do not maintain a fixed position relative to the Earth's surface, unlike GEO satellites that orbit over the Earth's equator in a specific orbital slot. LEO satellites are smaller and more cost-effective than their GEO counterparts. Their affordability, combined with advancements in technology, incentivizes the deployment of larger constellations of satellites.

The trend towards utilizing smaller satellites presents new challenges that are not adequately addressed in international fora, primarily because these challenges did not exist before the emergence of large satellite constellations. These challenges, which include heightened risks of orbital debris, a greater potential for collisions, and ambiguities in liability allocation, did not exist at the current level before the rapid expansion of these technologies. Effective satellite regulation must prioritize not only technical solutions for debris mitigation and orbital traffic management but also the incorporation of broader geopolitical considerations. For example, it is essential to establish strategic international legal frameworks that promote responsible behavior in space and that foster transparency and cooperation among nations that are parties to the OST.[15] Such frameworks should ensure equitable

[10] Lyall and Larsen, *Space Law*, 28 (n 7).

[11] For a scholarly work on strengthening existing international space law, see Jack Wright Nelson, "Is International Space Law Interactional?," *Columbia Journal of Transnational Law* 62, no. 2 (2024): 331–414, 338. Rather than expanding the legality, he argues that priority should be given to enhancing and sustaining the existing legality within the space regime. Based on Stephen Krasner's definition, Nelson defines regime as "[a] set of implicit or explicit principles, norms, rules, and decision-making procedures around which actor expectations converge in a given area of international relations." For an analysis of the need for an international regulatory body to prevent the escalation of conflict, see Dylan Houle, "Preventing the Next Global Crisis: Addressing the Urgent Need for Space Debris Removal," *California Law Review* 111, no. 6 (Dec. 2023): 1955–78.

[12] The 2003 Space Shuttle Columbia disaster killed all seven international astronauts on board. The families of the astronauts chose not to sue the private contractors involved, which would have involved private and public entities and individuals of different nationalities. Soumyaditya and Priyongshu, "Challenges of Legal Liability in Outer Space Exploration," 86 (n 9).

[13] Nelson, "Is International Space Law Interactional?," 378 (n 11).

[14] Chris Daehnick, Isabelle Klinghoffer, Ben Maritz, and Bill Wiseman, *Large LEO Satellite Constellations: Will It Be Different This Time?* (McKinsey & Company, May 4, 2020), https://perma.cc/27W3-WQ4F.

[15] See Rebekah Shields, "Towards a New Orbit: Addressing the Legal Void in Space Mining," *American University International Law Review* 40, no. 1 (2024): 229–62, 249. In 2024, only four signatory countries to the OST had passed national legislation aligned with the treaty: the US, Luxembourg, the UAE, and Japan.

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access to orbital resources, including orbital slots and frequency spectra, thereby preventing the formation of monopolies by technologically advanced nations or corporations.

In addition to reexamining existing treaties and agreements, these efforts may require the creation of new governance that specifically addresses the unprecedented challenges posed by smaller satellites and mega-constellations. These efforts could include measures such as creating internationally recognized standardized debris mitigation protocols for satellite operators, providing greater oversight of private actors, and developing frameworks for liability allocation in the event of collisions or operational failures.

BACKGROUNDS OF THE UN TREATIES, UN ENTITIES, AND ITU

The history of space law is rooted in international collaboration among the leading nations of the 1960s era.[16] On January 27, 1967, under the UN's purview, the US, the UK, and the Soviet Union entered into the aforementioned Outer Space Treaty (OST), a multilateral agreement that formed the basis of space law.[17] The year the OST was adopted, only 70 operational satellites were in orbit. In 2024, there were an estimated 10,036 active satellites in orbit, with 60% of these satellites belonging to one company, SpaceX.[18] As of January 2025, 115 countries are parties to the OST, while an additional 89 nations have signed but not ratified it.[19] The OST, as the foundational framework of international space law, establishes principles for the peaceful use and exploration of outer space. By becoming parties to the treaty, States accept responsibility to ensure that both governmental and non-governmental organizations (NGOs) within their jurisdictions comply with their treaty obligations. This responsibility extends to private companies and other non-State actors, requiring States to implement appropriate regulatory and supervisory measures to adhere to the treaty's principles.

Furthermore, the OST holds States accountable for the activities of space objects launched from their territories or facilities. Under Articles VI and VII of the treaty, States assume liability for damage caused by their space objects, whether they are operated by government agencies or private entities. This reinforces the principle of State accountability in outer space, ensuring that nations bear ultimate responsibility for all activities conducted under their authority.

The exponential growth in satellite launches underscores the urgent need to reevaluate the international legal frameworks and manage the complexities of contemporary satellite operations. When the OST was enacted, States were the primary actors in the space industry. However, the landscape has shifted dramatically, with private companies like SpaceX, a disruptive force in the industry, playing an increasingly dominant role. The treaty's drafters could not have anticipated a scenario where NGOs and private entities might surpass States in their influence on space activities.

Given this transformation, it is imperative to reevaluate the OST's language to ensure it remains effective in the current context. If necessary, amendments should clarify NGOs' and States' duties, rights, and privileges within the satellite communications industry. While the OST already holds State parties accountable for ensuring that governments and NGOs comply with its provisions, the mechanism for oversight and enforcement may require strengthening to address challenges that private actors pose.[20]

The 1972 Convention on International Liability for Damage Caused by Space Objects, also known as the Liability Convention (LC), imposes absolute liability on the "launching State" for damages caused by a space object on the Earth's surface or to aircraft in flight, and fault liability in the event of damage that a space object causes elsewhere. The Convention on Registration of Objects Launched into Outer Space, also known as the Registration

[16] See Nelson, "Is International Space Law Interactional?," 371–72 (n 11), explaining that the Legal Principles Declaration, drafted before the OST, was the "first substantive General Assembly resolution regarding international space law." It was "negotiated privately by the United States and the Soviet Union, building upon a series of bilateral agreements between NASA and the Soviet Academy of Sciences."

[17] OST, art. VI (n 6).

[18] Eric Mack, "There Are 10,000 Active Satellites in Orbit. Most Belong to Elon Musk," *Forbes*, July 19, 2024, https://perma.cc/N43N-LZYH.

[19] OST, art. VI (n 6).

[20] For examples of national space laws that regulate private space activities, see Gustavo Boccardo, "Planetary Protection Obligations of States Pursuant to the Space Treaties and with Special Emphasis on National Legislations Provisions," *GlobaLex*, New York University School of Law, Jan. 2018, https://www.nyulawglobal.org/globalex/Planetary_Protection.html.

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Convention (RC), created a national registry system for space management. Article IV of the RC requires registered States to provide the UN Secretary-General with information about each space object included in the registry. Article II distinguishes the date of launch as the point in time when the object was registered.[21]

The UN Office for Outer Space Affairs (UNOOSA) promotes international cooperation in the peaceful use and exploration of space and in the utilization of space science and technology for sustainable economic and social development. It also maintains the Online Index of Objects Launched into Outer Space, wherein countries register satellites and other space objects they launch. The International Telecommunication Union (ITU) also plays a pivotal role in the management and regulation of global satellite communications by coordinating the use of radio frequencies and orbital slots.[22]

As a UN specialized agency, the ITU oversees a cooperative international system to ensure that radio frequencies and associated orbits, which are finite and valuable resources, are used efficiently and equitably. In addition, the ITU's responsibilities include allocating specific frequency bands for satellite communications, preventing harmful interference between satellite networks, and managing the GEO to avoid overcrowding.[23] This is achieved through the Radio Regulations Treaty (RR), an international treaty governing the global use of radio-frequency spectra and satellite orbits.[24] Countries and operators seeking to deploy satellites must register their frequency assignments and orbital positions with the ITU to ensure compatibility with existing satellites and avoid interference. In the context of the rapidly growing satellite industry, including the deployment of mega-constellations, the ITU faces increasing challenges in managing orbital congestion and ensuring the sustainable use of frequencies. Its role has become more critical than ever in maintaining order and promoting fairness in the increasingly competitive domain of satellite communications.[25]

CURRENT CHALLENGES AND EXAMPLES

Orbital Debris Mitigation

Communication satellites are not built to last forever, with few operating for more than two decades. GEO satellites use different types of propulsion systems for critical orbital stabilization, orbital insertion, and end-of-life (EOL) disposal in outer space. How satellites create orbital debris varies. For example, a satellite can run out of fuel or experience component failure, causing it to lose its ability to maintain an orbit or avoid collisions. Collisions, accidental or intentional, between satellites or other space objects can create thousands of small fragments.[26]

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[21] Alexander Soucek, "Legal and Practical Questions in Applying Articles II and IV of the Registration Convention," *Zeitschrift fur Luft- und Weltraumrecht – German Journal of Air and Space Law* 65, no. 1 (2016): 22–43, 39. The acceptable time to register an object is after launch, and the reasonable time to provide Article IV notifications cannot be longer than one month after launch. The one-month period is a reasonable time for space objects to arrive in their destined orbit and to submit the related notifications.

[22] According to Nelson, "Is International Space Law Interactional?," 403 (n 11), "the common denominator for most space activities is the ITU—the United Nations specialized agency responsible for coordinating the international management of radio-frequency spectrum and satellite orbits."

[23] See Diego Zannoni, "The Radio-Spectrum: International Regulation and Current Challenges," *Annals of Air and Space Law* 40 (2015): 679–718, 693. "[T]he use of a frequency band in a manner that intentionally prevents other States from using immediately adjoining frequency bans is unlawful because it violates the positive rule contained in Article 33 of the ITU Constitution establishing that Member States 'shall endeavor to limit the number of frequencies and the spectrum used to the minimum essential to provide in a satisfactory manner the necessary services.'"

[24] See ITU, "ITU Publishes Updated Global Treaty to Optimize Radio Spectrum Management and Advance Technological Innovation," press release, Aug. 28, 2024, https://perma.cc/8ASF-ATEB.

[25] Nelson, "Is International Space Law Interactional?," 410 (n 11), explains that "the contradiction between ITU practice and the ITU Constitution's equitable goals is intensified in the age of megaconstellations." There is a current gap in the international regulation of mega-constellations. Companies like SpaceX have filed information on 30,000 satellites through the relevant US authorities. Private actors are "shap[ing] the ITU regime in ways that will not tend toward equality."

[26] Houle, "Preventing the Next Global Crisis: Addressing the Urgent Need for Space Debris Removal," 1977 (n 11), explains that "[c]ommitments surrounding the use of weapons and weapons testing in space, […] [is] key to eventually getting Russia and China to support an international regulatory body for space debris. Agreeing to follow the Registration Convention would be one method of achieving both transparency and building confidence. Another step towards getting Russia and China's

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Orbital debris is integrated into the definition of "space debris," which refers to all man-made objects, including satellite fragments, within the Earth's orbit or those reentering the atmosphere that are non-functional.[27] The human-made objects in orbit around the Earth pose significant risks to active satellites and remain in orbit for at least one hundred years.[28] Operators must now incorporate projected trajectories of nearby debris that pose potential destructive harm to their satellites. Orbital debris threatens the operation of satellites in orbit and the safety of astronauts in space and poses the risk of triggering international conflicts.[29] In 1993, the Inter-Agency Space Debris Coordination Committee (IADC) was established as an international forum comprising governmental space agencies and organizations. Its primary purpose is not to create a binding international framework of debris mitigation but to foster the exchange of research, data, and strategies related to space debris outcomes and mitigation efforts.[30] By promoting collaboration and information-sharing among member agencies, the IADC has played a key role in advancing the global understanding of orbital debris and encouraging the adoption of best practices.[31]

The IADC provides technical guidance on minimizing space debris risk and supports compliance with the OST. Parties to the OST reached a compromise and formalized the States' obligation to ensure that both governmental and non-governmental entities comply with the treaty's provisions. This relationship has been described as "private activity but public responsibility," which is in line with Article VI of the OST.[32] This provision further mandates that State parties must authorize and continuously supervise space activities conducted by NGOs and other entities within their jurisdictions. Under Article VI, State parties bear international responsibility for ensuring such entities implement planetary protection measures while engaging in space activities. Failure to uphold these obligations would result in a breach of the treaty and related agreements, such as the so-called Moon Agreement.[33] The responsibilities that the OST imposes emphasize the critical role of State oversight and accountability in safeguarding the international community's shared interest in outer space. The growing threat of space debris has escalated into a tragedy-of-the-commons scenario, where the shared nature of outer space resources leads to collective neglect and overuse. Despite the increasing risks, there has been a lack of urgency in addressing

participation in regulating space debris could be limiting ASAT testing to altitudes where any debris that is generated is burnt up within a year. This would be an effective incremental step, as it would still allow ASAT testing but would begin the process of regulating the generation of space debris and ensure that any testing does not cause long-term risk."

[27] Christos Kypraios and Elena Carpanelli, "Space Debris" (last updated Sept. 2018) in *Max Planck Encyclopedia of Public International Law*, ed. Anne Peters (Oxford University Press).

[28] Gen V. Milowicki and Joan Johnson-Freese, "Strategic Choices: Examining the United States Military Response to the Chinese Anti-Satellite Test," *Astropolitics* 6, no. 1 (2008): 1–21, 2–3. In 2007, a Chinese anti-satellite missile destroyed one of China's defunct weather satellites causing a debris cloud in LEO wherein "'85 percent of that debris cloud will be in orbit in 100 years'" (quoting Dr. T.S. Kelso of the Center for Space Standards and Innovation in Carl Hoffman, "China's Space Threat: How Missiles Could Target U.S. Satellites," *Popular Mechanics*, Dec. 17, 2009, https://www.popularmechanics.com/space/satellites/a1782/4218443/).

[29] Andreas Witte, "A Tragedy of the Night Sky? International Law as a Regulator for Satellite Megaconstellations," *Annals of Air & Space Law* 45 (2020): 307–40, 316. The Inter-Agency Space Debris Coordination Committee (IADC), has called for mega-constellations to be disposed of within twenty-five years to manage risk.

[30] Lawrence Li, "Space Debris Mitigation as an International Law Obligation: A Critical Analysis with Reference to States Practice and Treaty Obligation," *International Community Law Review* 17, no. 3 (July 2015): 297–335.

[31] See Anish Dey and Jithin Jagadanandan, "Study on Space Debris Mitigation under the National Space Law," *University of Bologna Law Review* 9, no. 1 (2024): 45–72, 57. In 2022, the IADC updated its space debris guidelines because it was "concerned about space debris and its effects on future space exploration. It also agreed that international intergovernmental organisations and Member States with permanent observer status should continue to provide details on research about space debris; the safety of spacecraft with nuclear power sources; and its collisions with space debris […]."

[32] Nelson, "Is International Space Law Interactional?," 340 (n 11), explains, "Article VI means that 'states are responsible for national activities and the activities of nationals in outer space […] [and] are under a duty to authorize and a continuing duty to supervise such activities'" (citing Francis Lyall and Paul B. Larsen, *Space Law: A Treatise*, 2nd ed. (2017), at 64).

[33] Francis Lyall, "On the Moon," *Journal of Space Law* 26, no. 2 (1998): 129–38. Although the Moon Agreement might fall short in providing adequate duty in a particular instance, or justify an alleged breach by a State, it sets the foundation for a formal structure in parallel to the International Sea-Bed Authority.

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this issue.[34] However, with emerging technologies capable of removing debris, scholars emphasize that the time to resolve the legal and regulatory challenges of debris mitigation is now.[35]

The tendency to downplay the urgency of space debris mirrors the global response to climate change, where unpredictable disasters are often perceived as distant or unlikely. Proactively addressing the legal dimensions of space debris today will not only provide a clear foundation for liability but also serve to prevent potential international conflicts. Such conflicts could arise from worst-case scenarios, including cascading collisions resulting from what is known as the Kessler Effect,[36] which would render parts of the Earth's orbit unusable. A hypothetical scenario in LEO could see such a high density of satellites and space debris that the likelihood of collisions becomes significant. Each collision could trigger a cascading effect generating additional debris and increasing the risk of further collisions. To curb this phenomenon, government mitigation regulations require adequate enforcement.

Orbital Debris Mitigation: US Federal Regulations

The US Federal Communications Commission (FCC) mandates that all space station applicants, including those seeking authorization for geostationary space stations, submit a statement confirming that the space station operator has assessed and minimized the risk of the station contributing to space debris. This includes evaluating and mitigating the probability of collisions with large debris or other operational space stations. The US National Aeronautics and Space Administration (NASA) tracks objects with diameters exceeding ten centimeters (approximately four inches) and expects debris to be the primary source of collisions.[37]

The FCC enforces several other regulations that operators must comply with to promote the safe and sustainable use of outer space. To ensure that FCC requirements remain relevant and aligned with industry practices, the FCC actively seeks input from key operators within the satellite and space industries. One of the FCC's most notable requirements regarding orbital debris is the so-called "disclosure rule" under 47 C.F.R. § 25.123 – Application for streamlined small spacecraft authorization. This rule mandates that operators assess the risk of collision and take all reasonable steps to mitigate such risk when necessary.[38] These measures reflect the FCC's commitment to reducing the risk of orbital debris and adopting the OST's collaborative approach that fosters communication among space operators and other international bodies.[39]

International Registration Challenges

Private actors have transformed the field and have exposed gaps that can result in regulatory uncertainty and more complicated enforcement. The OST and RC confer primary responsibility on States and not private companies. State responsibility, as well as that of non-governmental entities, is attributed to "national activities," and liability rests with the "launching State," and jurisdiction and control over a space object and its associated personnel are

[34] Houle, "Preventing the Next Global Crisis," 1968 (n 11): "A similar model [to cap-and-trade programs] could be incorporated to fuel space debris removal technology development and then to eventually encourage space debris removal."

[35] See Denton Hunter and Quinn McKemey, "The Time is Now: How the United States Can Lead Active Debris Removal Efforts," *Journal of Space Law* 45, no.2 (2021): 437–64, 458. Active debris removal requires international cooperation, and the US should ally with mutually interested parties and enact collaborative efforts. The authors also point to the Artemis Accords, which have "ADR concepts currently in development and would be prime candidates for international cooperation."

[36] Donald J. Kessler and Burton G. Cour-Palais, "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt," *Journal of Geophysical Research* 83, no. A6 (1978): 2637–46. The Kessler Effect is the cascade effect of uncontrolled collisions caused by the proliferation of space debris, undermining the use of the Earth's orbit.

[37] Nicholas L. Johnson, *Orbital Debris Management & Risk Mitigation*, (NASA APPEL, 2018), https://perma.cc/N6R5-3WFW.

[38] For reasonable steps to mitigate risk, see 47 C.F.R. § 25.123. (Steps may include, but are not limited to, contacting the operator of any active spacecraft involved in potential collision warning, sharing ephemeris data and other operational information with relevant operators to facilitate coordination, adjusting the space station's altitude, or modifying its operational parameters to avoid potential collisions.)

[39] Nicholas Romici Goldstein, "Beyond Free Use: Stewardship, Orbital Debris and the Due Regard and the Due Regard Standard in the Outer Space Treaty," *Auckland University Law Review* 28 (2022): 137–67, 149 (explaining that the due regard standard from art. IX of the OST can play a strong role in regulating orbital debris).

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linked to its national registration.[40] According to Article II of the RC, if there are two or more launching States concerning any space object, a joint determination is made on which nation will register the object.[41] Problems exist when States provide different information or information that is too vague.

Space law is now in a commercialized era where commercial entities could force States to ultimately ignore the ITU and treaties' norms and permit satellites to operate in locations that are lawfully occupied. The fear is that commercial entities will force the hands of their own governments for the sake of national defense. The war in Ukraine, for example, has brought commercial space companies into the battleground, and their space objects have proven to be essential to modern combat.[42] As these commercial entities continue to become more interwoven—not just with everyday activities but also with wartime activities—it is crucial to determine who or what is responsible for their supervision.

This is where the OST falls short. Although Article VI requires "continuing supervision" over activities of nationally engaging actions in outer space, there is a serious omission in national oversight.[43] The RC created a national registry system for space management in Article IV that requires each State to provide the UN Secretary-General with information about each space object in its registry as soon as possible.[44] The term "launching [S]tate" means the following: (i) A State that launches or procures the launching of a space object; and (ii) A State from whose territory or facility a "space object" is launched.[45] The definition of a space object is defined in the RC as components of a space object as well as its launch vehicle and parts thereof.[46] That State has a duty to register an object launched into outer space, and it retains jurisdiction and control over such object and any personnel while the object is in outer space or on a celestial body.[47]

Developing countries should be wary of any further costs associated with their space technologies. Launching a satellite is not the only expensive endeavor; navigating a satellite to avoid orbital debris costs around US$10 million.[48] The latest arrivals in the satellite industry include a blend of commercial and State actors. International uniformity would help create equitable access to space, which in turn would also help decrease the chance of military escalation in space.

Multiple-State Registration of a Space Object

A satellite launch involves a complex network of entities, including the State where the launch takes place, the space agencies overseeing launch operations, the launch service providers, the satellite owners and operators, and other remaining stakeholders. The OST and LC were originally designed to promote the peaceful use of outer space and establish a basic accountability framework. However, the modern realities of satellite launches have introduced a complicated web of operators and stakeholders, making it challenging to determine liability in various scenarios.

Today's typical satellite launch involves multiple registering States because satellites are frequently procured by entities in different jurisdictions than the launching State.[49] Additionally, satellites are sometimes

[40] Tanja Masson-Zwaan et al., "The Need to Improve Registration Practices in the Context of Space Traffic Management," *Acta Astronautica* 223 (2024): 242–43.

[41] United Nations, Convention on Registration of Objects Launched into Outer Space (hereinafter RC), Jan. 14, 1976, art. II, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/registration-convention.html.

[42] Rinchen Kyi and Neeraj Laishram, "Concerns, Implications and Possible Barriers to Licensing: A Legal and Operational Analysis on Setting up Starlink in India," *Jus Corpus Law Journal* 3, no. 3 (Mar. 2023): 575–97, 581. "Starlink was the direct participant in the ongoing Russia-Ukraine conflict and a legitimate military target, [and] Starlink has been actively involved in directing Ukrainian military drones and missiles against Russian military installations."

[43] Frans von der Dunk and Fabio Tronchetti, *Handbook of Space Law* (Martinus Nijhoff Publishers, 2015), 425.

[44] RC, art. IV (n 41).

[45] Von der Dunk and Tronchetti, *Handbook of Space Law*, 82 (n 43).

[46] RC, art. I (n 41).

[47] RC, art. II (n 41).

[48] Houle, "Preventing the Next Global Crisis," 1959 (n 11).

[49] See Katherine Latimer Martinez, "Lost in Space: An Exploration of the Current Gaps in Space Law," *Seattle Journal of Technology, Environmental & Innovation Law* 11, no. 2 (2021): 322–49, 344. Besides multiple States registering a satellite, licensing regulations are at risk of being inconsistent by individual governments, and there is an "unpredictable recognition of property rights, and lack of a uniform STM and other safety regimes […]."

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owned by multiple operators, each with differing incentives to register the satellite under their respective jurisdictions. This creates ambiguities in the application of international treaties, which fall short of providing clear guidance on liability allocation across diverse scenarios. When an operator is ready to launch a satellite into orbit, it is required to register the object with the appropriate national or international authorities. Under the OST, the State where the object is registered retains jurisdiction and control over the object once it is in space. The responsibility extends to ensuring that the satellite's activities comply with international obligations.[50]

Maintaining not only an accurate registry but also an updated one is critical for States, as ownership of a space object may change after it has been placed in orbit. However, ownership transfer does not absolve the original registering State of its responsibilities. Ownership of a space object cannot be abandoned, and a State cannot divest itself of the liability and accountability attached to the object.[51] This is an issue that current operators must address because as satellites become defunct and move into graveyard orbits, they can collide with other objects and potentially break into debris that collides with operational satellites.

Liability Ambiguity

The LC was drafted during an era when State actors dominated space exploration and activity. As a result, it does not fully address the complexities that the rise in the number of private and commercial space activities has introduced. Article II of the LC imposes absolute liability on launching States for damage that their space objects have caused on the Earth's surface or to aircraft in flight.[52] By contrast, Article III establishes a fault-based liability regime for damage caused by space objects in outer space.[53] Mega-constellations of satellites operate in non-sovereign outer space. Yet, States of registry are becoming increasingly concerned about protecting their nationally registered satellites from potential interference by other States or private entities.[54]

However, what happens if a satellite involved in a collision is owned and operated by multiple entities? Determining fault in such scenarios becomes a complex legal question. The LC does not explicitly address situations where multiple States or operators share responsibility for a single satellite, leaving significant gaps in the allocation of liability. This omission is problematic in the current era, where international partnerships in satellite ownership and operations have become increasingly common.

For decades, developed countries have collaborated with nations possessing established satellite industries to share costs, transfer technology, and gain mutual insight. In one 2012 study involving eight countries, each reported obtaining at least one satellite through a relationship with a foreign partner.[55] Procuring satellites from foreign partners involves the conveyance of information needed to sustain the satellite's operation. It is in the foreign partners' best interests to pass on registration and liability standards to developing-country partners. Holding developing countries to a registration standard ensures that space traffic is efficient and does not impair satellite providers' daily operations. While such partnerships have driven innovation and expanded access to space, they have also introduced legal ambiguities regarding accountability and liability in the event of collisions or other operational mishaps.

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[50] OST, art. 8 (n 6).

[51] Von der Dunk and Tronchetti, *Handbook of Space Law*, 425 (n 43).

[52] Convention on International Liability for Damage Caused by Space Objects (hereinafter LC), Sept. 1, 1972, 961 U.N.-T.S. 187, art. II.

[53] Ibid., art. III.

[54] See Steven Freeland and Anne-Sophie Martin, "A Sky Full of Stars, Constellations, Satellites and More! Legal Issues for a 'Dark' Sky," *Oslo Law Review* 10, no. 3 (Apr. 2024): 1–22, 2,12. Mega-constellations are tied to the "miniaturisation" of technology, which includes the large number of small satellites in LEO. The authors state that art. IX of the OST deals "with mechanisms of consultation with regard to the avoidance of potentially harmful interference […] to the activities of […] other States in the peaceful exploration and use of outer space."

[55] See Danielle Wood and Annelisa Weigel, "Charting the Evolution of Satellite Programs in Developing Countries – The Space Technology Ladder," *Space Policy* 28 (2012): 15–22. Eight countries from Africa, Asia, and Latin America were analyzed as they pursued the technological capability of space technology. The introduced framework of the "Space Technology Ladder" was the descriptive tool that defined the path to national space technology capability.

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ANALYSIS OF FINDINGS: EXISTING LEGAL FRAMEWORK AND PROPOSALS

The existing international space treaties, crafted during an era of State dominance in space activities, are increasingly ill-equipped to address the complexities of modern satellite operations and the rapid expansion of the private sector into this arena. In today's space environment, the primary actors are no longer exclusively State entities but rather commercial operators with significant capital, enabling them to deploy hundreds of satellites in short timeframes. These commercial actors often prioritize national regulatory frameworks, which are typically more aligned with their operational goals over adherence to broader international legal standards. This trend poses significant challenges to the safety of outer space, as the lack of coordinated global oversight increases the risk of collisions and other conflicts.

The pressing issue exacerbating these risks is the lack of transparency and data-sharing among operators. Military considerations, coupled with geopolitical tensions reminiscent of a "Cold War" environment, often lead to the safeguarding of critical information that could otherwise prevent potential collisions or mismanagement of space activities. To address these challenges, the due regard principle, which is articulated in the OST, must be reinforced and expanded in practice.

The Due Regard Principle

Scholars have observed that the OST lays the foundational grounds for an obligation of debris mitigation because it includes an obligation of due regard; specifically, Article IX requires parties to conduct outer space activities in consideration of other States' interests in a safe and navigable outer space.[56] This principle, known as the due regard principle, establishes an obligation for OST parties to take the rights of other parties into account when exercising their own rights.[57] This foundational concept in international space law underpins the registration of satellites by focusing on transparency, accountability, and coordination in outer space activities.

In 2021, an UNOOSA working group convened to discuss potential recommendations for the registration of large constellations and mega-constellations, which came to be named the Registration Project of 2021.[58] The international group of experts from the areas of business, engineering, and policy created a list of shortcomings "regarding the law and practice of registration," which echoed the due regard principle of Article IX of the OST.[59] Their recommendations were reinforced by the mechanisms of Article IX concepts, such as dealing with harmful interference.[60] The group made several recommendations for lunar activities applicable to satellite operators that included the following: notifying and providing the UN Secretary-General with fundamental information on the Index of Submissions by States under the OST's Article XI to identify corresponding interests, including relevant information on the prevention, mitigation, and remediation of potentially harmful interference and designated points of contacts; proactively coordinating notifications in conjunction with the licensing of activities; and restructuring Article XI of the OST's Index of Submissions to facilitate a fully digital internet-based interface with the ability to search.[61]

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[56] Goldstein, "Beyond Free Use," 142 (n 39). Art. IX of the OST provides environmental protection but is short on providing language on how to regulate orbital debris.

[57] John S. Goehring, "Can We Address Orbital Debris with the International Law We Already Have? An Examination of Treaty Interpretation and the Due Regard Principle," *Journal of Air Law and Commerce* 85, no. 2 (2020): 309, 317.

[58] United Nations, *Status and Application of the Five United Nations Treaties on Outer Space*, A/AC.105/C.2/2021/CRP.10, Apr. 21, 2021, https://documents.un.org/doc/undoc/ltd/v21/041/53/pdf/v2104153.pdf.

[59] Mark J. Sundahl and Antonino Salmeri, "The Registration of Lunar Activities: Recommendations from the Registration Project," *Proceedings of the International Institute of Space Law* 64 (2021): 93–112, 95–96. Critical shortcomings include the following: no registration for space activities; current registration provides insufficient information for operators to avoid interference; existing mechanisms do not encourage updates regarding changes in the location or function of an object/activity; no mechanisms for sharing information; registration can be delayed under the RC due to the "as soon as practicable" language; and States are deterred from undertaking registration due to the correlation with liability.

[60] Ibid., 94. The sharing of information on planned and existing space activity is critical for compliance with the duty to act with "due regard" and to avoid potential harmful interference that requires further consultation under the OST.

[61] Ibid., 98.

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A Proposed Orbital Debris Mitigation Treaty

The Kessler Effect stands as a stark warning about the dangers of unchecked space debris accumulation and long-term consequences for space exploration and satellite operations. Without decisive action, the risk of overcrowding and in-orbit collisions will grow, potentially triggering a chain reaction of debris-generating events that could render key orbital regions unusable for decades or even centuries. To address this looming threat, a new treaty with binding commitments is necessary, requiring States to integrate robust debris mitigation practices into their national laws.

The treaty must prioritize international cooperation and be overseen by entities such as the ITU and UNOOSA. These organizations can provide the oversight needed to ensure the compliance of both State and private actors. This proposed new treaty should mandate adherence to an international framework and create a unified approach to debris mitigation and space traffic management. Companies like SpaceX, which primarily launch space objects from the US, exemplify the rapid expansion of LEO activities. This places the US in a position to lead the development of the next generation of orbital debris management practices. Indeed, the US has an unprecedented opportunity to set high standards and play a pivotal role in shaping the future of space operations.

The current nation-based regulatory model fosters regulatory arbitrage and uneven enforcement of safety standards. This has led to significant gaps in satellite registration, particularly for shared missions involving multiple actors. Moreover, the current space object registry cannot keep pace with the rapid rate of launches and the frequent movements of satellites in orbit. However, operators possess the technical capacity to provide critical information that could help prevent collisions and improve coordination.

One proposed solution is to hold orbital slot designations contingent upon meeting specific provisions outlined in the proposed treaty. Other authors have recommended that space industries be required to disclose data that is crucial to establishing space situational awareness.[62] These provisions would thus address the current inadequacies while preparing for future challenges. For example, a fifteen-month reregistration window could be introduced, requiring operators to update their satellite status and report potential concerns, such as operational risks or mitigation efforts to address impending failures. To encourage adherence, drastic measures such as modifying or abrogating the LC could be considered. By linking obligations to compliance with the new registration and debris mitigation processes, States would have a strong incentive to adopt the updated framework. Such measures would address the gaps in accountability and registration, ensuring that shared responsibilities in space are effectively managed.

An Informal Space Object Index

The Space Object Index is an online repository of objects launched into outer space, which is maintained by UNOOSA. According to UNOOSA, the index "provides a quick and efficient means to access information provided to […] [UNOOSA] in accordance with the [RC]."[63] To enhance the index's utility, UNOOSA must collaborate closely with operators to ensure the index remains up-to-date. As such, UNOOSA could sponsor an informal index with added information to promote adhesion to newly introduced or amended treaties, focusing on data sharing and collision prevention. One important improvement would be the addition of a "life expectancy" field for each satellite. Such a feature would allow operators to inform others of the expected lifespan of neighboring satellites, fostering a cooperative and transparent environment. This initiative would encourage responsible satellite constellation management, benefitting all operators. While some operators might hesitate to disclose such information, the increasing threat of orbital debris will likely create an environment where transparency becomes essential for the safety of all space operations.

[62] See, e.g., Michael B. Runnels, "Protecting Earth and Space Industries from Orbital Debris: Implementing the Outer Space Treaty to Fill the Regulatory Vacuum in the FCC's Orbital Debris Guidelines," *American Business Law Journal* 60 (2023): 175–229. Space situational awareness requires applicants to share data that follows the guidelines of the 2020 FCC guidelines for commercial satellite applicants; Michael Winter, "Orbital Debris: A Common Concern of Humanity?," *Annals of Air and Space Law* 43 (2018): 323–64, 331 (explaining that the ability to track debris is essential). "[N]ot disclosing to a space-active State, either intentionally or inadvertently, may result in a collision."

[63] United Nations Office for Outer Space Affairs, *Outer Space Index* (2025), https://www.unoosa.org/oosa/osoindex/search-ng.jspx?lf_id=.

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An informal Space Object Index could be designed to operate like social media platforms with a centralized server hosting user information. This would evolve into a dynamic, user-friendly platform giving satellite operators, like users, the ability to upload and update satellite data in real-time, subject to UNOOSA's approval, and significantly improve the index's efficiency. The current system operates as a unilateral platform where only UNOOSA can make modifications, a process that may be too slow to accommodate the fast-paced nature of modern satellite operations given the recent launch volume. Because of the complexities of recent space activities, UNOOSA may require external assistance to manage and update any index effectively.

Readily available data that can be queried, such as launch date, EOL filters, fuel levels, etc., is a resourceful tool to mitigate liability. For example, SES, a Luxembourg-based satellite telecommunications network provider, operates satellites with registered launches from India, Russia, and the US, which is the common practice of operators who often launch satellites from multiple jurisdictions.[64] Some of these satellites are in graveyard orbits, but others remain operational, raising concerns about accountability in the event of a collision. A dynamic informal index allowing SES, as a user, to update space object information (for example, ownership details, satellite drifting, etc.) could inform adjacent satellite operators quickly.

An informal Space Object Index could also address current concerns by including accessible and accurate orbital satellite data. State parties to the OST would be encouraged to collaborate to reach an agreement regarding liability for damages caused by launched satellites. Withholding information would be discouraged, as it would undermine international cooperation and safety in space. A transactional approach to combat this issue would be to require contract provisions to include adherence to the OST's transparency principle of sharing information with the international community. Further, an informal index would not necessarily be overly ambitious since informal structures and arrangements already exist for space activities, like the Consultative Committee for Space Data Systems (CCSDS), which "develops agreed-upon space data-handling systems, sets standards for inter-operability and contributes to reducing both development costs and time."[65] A standard promoting the use of the informal index would foster a cooperative and informed industry that reduces collision risks, shares potential hazards, and contributes to the safe practice of future satellite communications practices.

CONCLUSION

The rapid growth of mega-constellations created by private entities demands immediate action to update existing treaties and introduce a new Orbital Debris Mitigation Treaty capable of addressing the evolving challenges of space governance. Current treaties, such as the OST, were enacted in an era that could not have foreseen private entities' noncompliance with international regulations. These entities often operate under inconsistent regulatory standards and, in some cases, disregard existing guidelines altogether, posing risks to orbital sustainability, space safety, and equitable access.

To address these pressing concerns, a two-pronged approach is essential. First, an orbital mitigation treaty would incorporate clear and enforceable rules emphasizing collision avoidance, debris mitigation, and the equitable use of orbital resources. The treaty would also need to establish end-of-life disposal standards and coordination among operators to reduce the risk of orbital congestion and debris generation. Second, informal mechanisms, such as a globally accessible update to UNOOSA's Space Object Index, would provide much-needed transparency. This informal index would serve as a centralized database to track satellite launches, their operators, and orbital parameters. By encouraging voluntary participation and collaboration among governments, private entities, and international organizations, the index would foster responsible satellite operations. Moreover, the index would support orbital debris mitigation efforts by promoting data sharing, early collision warnings, and the monitoring of compliance standards.

[64] United Nations, Secretariat, Information Furnished in Conformity with Article IV of the Convention on Registration of Objects Launched into Outer Space (June 29, 2022), ST/SG/SER.E/1043, https://documents.un.org/doc/undoc/gen/221/014/6e/pdf/2210146e.pdf.

[65] Lyall and Larsen, *Space Law*, 33 (n 7).

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