A WASTE OF SPACE: A CALL FOR ACTION TO ELIMINATE SPACE DEBRIS

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I. Introduction

Picture yourself stepping onto the space shuttle EXPLORER alongside Sandra Bullock, George Clooney, and a team of astronauts tasked with the mission of servicing the Hubble Space Telescope. This occasion marks your first encounter with the vastness of outer space. You, Bullock, and Clooney embark on a spacewalk to execute crucial hardware upgrades to the Hubble. Tethered together and linked to the EXPLORER by parachute cords, you are floating 372 miles above Earth. The view is breathtaking. Suddenly, a deafening "BOOM!" resonates through the vacuum of space. You are violently torn away from the EXPLORER, drifting aimlessly in the boundless abyss.

A cloud of space debris, created by Russia's attempt to shoot down a defunct satellite, has collided with the EXPLORER, inflicting catastrophic damage. Clooney, equipped with a man maneuvering unit, executes a daring rescue, retrieving you and Bullock. Returning to the crippled EXPLORER, you discover the grim aftermath. The rest of the crew floats lifeless. As you desperately cling to a fragment of the shuttle, all communication with Earth is severed. With the impending threat of the debris field completing an orbit and returning, the clock is ticking.[1]

What was once science fiction has now become science fact. Today, the escalating accumulation of space debris poses a formidable obstacle, potentially impeding humanity's pursuit and exploration of outer space. The problem of space debris is exacerbated by the growing presence of man-made spacecraft in space, the absence of enforcement mechanisms, the lagging advancement of debris removal technology, the high cost of debris removal technology, and the absence of comprehensive regulations governing liability and mitigation. This Comment endeavors to highlight shortcomings within the international regulations regarding space debris while offering proactive solutions to ensure that space exploration can continue to grow without the hindrance posed by space debris. In its entirety, this Comment proposes to strengthen the Outer Space Treaty and the Liability Convention by imposing explicit obligations on states regarding space debris management. It further advocates for enhanced registration requirements in the Registration Convention, including a global uniform launch licensing policy, amended timeframes for registration, and mandates for states to submit disposal plans for spacecraft. Additionally, it recommends incorporating salvage law provisions into an international resolution to create financial incentives for both states and private actors to develop debris removal technology.

Part II of the Comment delves into the rapid growth of the space industry, the characterization of space debris, and the significance of the threat posed by space debris. Part III introduces the international legal frameworks and guidelines pertaining to space debris liability. Part IV addresses current international mitigation efforts and initiatives aimed at tackling the issue of space debris. Part V introduces the overarching issue concerning the current guidelines governing space debris. Part VI proposes a solution that aims at strengthening the foundational treaties to establish state accountability. Part VII offers a solution grounded in the maritime law of salvage to incentivize the creation of debris removal technology. Finally, Part VIII briefly concludes the discourse.

II. The Tangible Threat of Space Debris

[1] The preceding story was derived from the movie "Gravity" directed by Alfonso Cuarón, starring Sandra Bullock and George Clooney. GRAVITY (Warner Bros. Pictures 2013).

Since the beginning of the Space Age in 1957, there have been roughly 6,700 rocket launches, placing about 19,590 satellites into Earth's orbit.[2] This surge in space exploration has been termed the "New Space Race."[3] The fascination with mining rare minerals from the moon or asteroids, colonizing space, and the prospect of encountering extraterrestrial beings has spurred nations to channel substantial financial resources into the space industry with the hope of reaping the benefits of the unlimited resource. In a CNBC interview, astrophysicist Neil deGrasse Tyson boldly declared, "The first trillionaire there will ever be is the person who exploits the natural resources on asteroids."[4] In just over a decade, the global space economy has nearly doubled, skyrocketing from 276 billion dollars in 2010[5] to a staggering 546 billion dollars in 2023.[6] Undergoing steady linear growth, the National Space Society "estimates the industry's size could eventually swell to as high as [one trillion dollars]."[7]

Today, the United States, Russia, China, Japan, the United Kingdom, and India continue to stand as dominant players in the global space industry.[8] Concurrently, the private sector is experiencing a boom, led by industry giants SpaceX and Boeing.[9] The year 2023 witnessed a remarkable increase in global launch activity, due to technological advancements unfolding at an exponential rate.[10] The Space Foundation's Q4 edition of *The Space Report* highlights this trajectory, revealing the escalation in satellite deployment—a staggering 23% increase compared to 2022, with more than 2,800 satellites entering Earth's orbit.[11] In addition, the private sector

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[2] *Space Debris User Portal Statistics*, EUR. SPACE AGENCY, (last visited Dec. 6, 2023), https://sdup.esoc.esa.int/discosweb/statistics/ (last updated Sept. 20, 2024).

[3] *See* Elizabeth Howell, *The New Space Race*, BRITANNICA, https://www.britannica.com/explore/space/the-new-space-race/#:~:text=Space%20exploration%20today%20is%20a%20long%20way%20from,the%20fast- (last visited Oct. 30, 2024).

[4] Katie Kramer, *Neil deGrasse Tyson Says Space Ventures Will Spawn the First Trillionaire,* NBC NEWS (May 3, 2015), https://www.nbcnews.com/science/space/neil-degrasse-tyson-says-space-ventures-will-spawn-first-trillionaire-n352271.

[5] *2010 – Economy – Snapshot*, THE SPACE REPORT, https://www.thespacereport.org/resources/2010-economy-overview/ (last visited Sept. 20, 2024).

[6] *Space Foundation Releases The Space Report 2023 Q2, Showing Annual Growth of Global Space Economy to $546B*, SPACE FOUND. (Jul. 25, 2023), https://www.spacefoundation.org/2023/07/25/the-space-report-2023-q2/.

[7] Kramer, *supra* note 4.

[8] *The 10 countries most active in space*, AEROSPACE TECH. (Dec. 21, 2015), https://www.aerospace-technology.com/features/featurethe-10-countries-most-active-in-space-4744018/.

[9] *See* Drew Baker, *10 Largest Space and Exploration Companies in the World*, HISTORY-COMPUTER (Feb. 15, 2024), https://history-computer.com/10-largest-space-and-exploration-companies/.

[10] *The Space Report 2023 Q4 Shows Record Number of Launches for Third Year in a Row, Technological Firsts, and Heightened Focus on Policy*, SPACE FOUND. (Jan. 23, 2024), https://www.spacefoundation.org/2024/01/23/the-space-report-2023-q4/#:~:text=The%20Space%20Report%202023%20Q4%20Shows%20Record%20Number,new%20launch%20vehicles%20set%20to%20launch%20in%202024.

[11] *Id.*

experienced rapid growth as commercial launch activity surged by over 50% from the preceding year.[12] This momentum calls attention to the impressive growth and substantial improvement of technology, leading to an outer space crowded with more satellites, spacecraft, and space debris.

A. The Orbital Junkyard

As the space industry experiences sustained expansion, one can reasonably anticipate that this growth trajectory will create an increase in the accumulation of space debris. The real consequences of space debris accumulation are becoming increasingly apparent. Outer space is currently littered with more than 170 million pieces of debris.[13] To clarify, the mention of space debris does not allude to discarded pizza boxes or crushed cans of Coke thrown out of a rocket ship by astronauts. In the simplest of terms, "space debris" refers to "any piece of machinery or debris left by humans in space."[14] Space debris encompasses larger items like defunct satellites left in orbit, as well as smaller objects such as metal fragments or paint flecks that have fallen off of a rocket.[15] Space debris is primarily created from three sources: (1) accidental collisions between space objects, (2) the deliberate disposal of spacecraft during the operation launch vehicle orbital stages, and (3) the intentional breakup of discarded spacecraft.[16]

In July 2024, the European Space Agency's (ESA) Space Debris Office released its eighth edition of the *Space Debris Environment Report*, providing an insightful overview of the prevailing conditions of debris in space.[17] By employing radar and radio telescopes, the trajectories of sizable chunks of space debris can be effectively tracked.[18] However, a significant portion of space debris "is composed of very small metallic objects," presenting the impossible challenge of detecting the objects with the technology that is available today.[19] The Space Surveillance Network currently tracks 36,860 debris objects, with the office estimating that over 650 collisions or events leading

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[12] *Id.*

[13] *How many space debris objects are currently in orbit?,* EUR. SPACE AGENCY, https://www.esa.int/Space_Safety/Clean_Space/How_many_space_debris_objects_are_currently_in_orbit (last visited Oct. 30, 2024).

[14] Jonathan O'Callaghan, *What is space junk and why is it a problem?*, NAT. HIST. MUSEUM, https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html (last visited Oct. 30, 2024).

[15] *Id.*

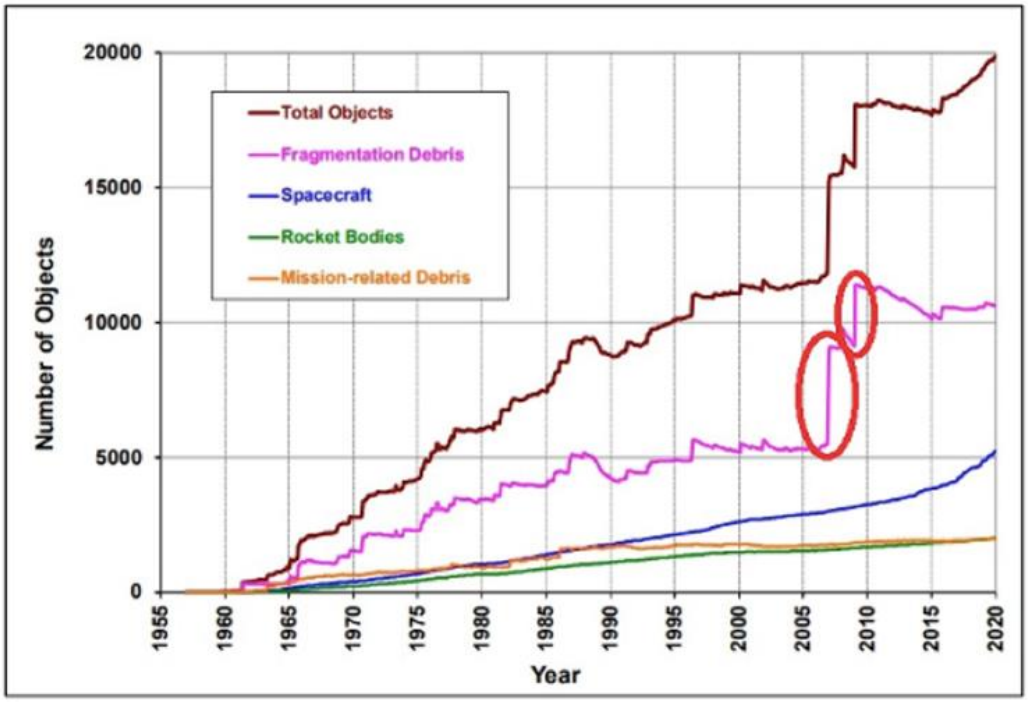
[16] *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space*, UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, https://www.unoosa.org/documents/pdf/spacelaw/sd/COPUOS-GuidelinesE.pdf (last visited Oct. 30, 2024).

[17] *Space Debris User Portal Statistics*, *supra* note 2; *see ESA's Annual Space Environment Report*, ESA SPACE DEBRIS OFFICE (Jul. 19, 2024), https://www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf.

[18] Frederica Massimi et al., *Deep learning-based space debris detection for space situational awareness: A feasibility study applied to the radar processing*, 18 THE INST. OF ENG'G AND TECH. 635 (Mar. 6, 2024), https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/rsn2.12547#:~:text=To%20mitigate%20the%20risks%20posed%20by%20space%20debris%2C,such%20as%20optical%20telescopes%2C%20satellite-based%20sensors%2C%20and%20radars.

[19] *Id.* at 635–36.

to debris fragmentation occurred in 2023.[20] Despite the presence of 11,500 tons of space objects in Earth's orbit, the striking fact remains that nearly 6,000 tons of space debris are concentrated in Earth's low orbit.[21] With "more than t[hree hundred] commercial and governmental entities [announcing] plans to launch a staggering 478,000 satellites into space by 2030",[22] the accumulation of space debris is expected to triple.[23] The National Aeronautics and Space Administration (NASA) has deemed the Low Earth Orbit as the "[w]orld's largest garbage dump."[24]



[25]

B. The Rise of Damage Caused by Space Debris and Satellite Collision

[20] *Space Debris User Portal Statistics*, *supra* note 2.
[21] *Space Debris User Portal Statistics*, *supra* note 2.
[22] Bill Weir, *Nearly 30,000 objects are hurtling through near-Earth orbit. That's not just a problem for space*, CNN (Feb. 21, 2024), https://edition.cnn.com/2024/02/21/climate/space-debris-solution-climate-scn/index.html (cautioning that this number is likely inflated).
[23] Leonard David, *Ugly Truth of Space Junk: Orbital Debris Problem to Triple by 2030*, SPACE.COM (May 9, 2011), https://www.space.com/11607-space-junk-rising-orbital-debris-levels-2030.html.
[24] *Space Debris*, NASA, https://www.nasa.gov/headquarters/library/find/bibliographies/space-debris/ (last updated Nov. 3, 2023).
[25] James Dunstan, *Regulating Outer Space: Of Gaps, Overlaps, and Stovepipes* 1, 49 THE CENTER FOR GROWTH AND OPPORTUNITY (July 2023), https://www.thecgo.org/wp-content/uploads/2023/07/Regulating-Outer-Space.pdf. This image highlights the linear relationship between the increase in total objects in space and the increase in space debris. The red circles reference China's anti-satellite test and the 2009 satellite collision between the United States and the defunct Russian satellite. These debris fragmentation events will be discussed in Part II.C.

The danger posed by space debris cannot be ignored, as it undeniably poses a tangible threat to spacecrafts and the broader pursuit of space exploration.[26] Due to the substantial velocity of space debris coupled with erratic trajectories, orbital debris poses a collision risk to operational spacecrafts, satellites, and human beings.[27] This debris presents a danger given its ability to travel at speeds exceeding "18,000 miles per hour, almost seven times faster than a bullet."[28] Traveling at such a velocity, even the smallest fragment of debris poses a significant threat to spacecrafts.[29] NASA has offered the comparison of a ten-centimeter projectile amounting to seven kilograms of TNT.[30] With the increasing number of spacecrafts entering outer space, there has been a proliferation of spacecraft collisions with debris, shedding light on the tangible threat posed by space debris.[31]

With regard to the substantial risks posed by space debris, recent occurrences of space debris threatening or colliding with space missions highlight the reality of the danger. In 2007, China sparked considerable controversy by deliberately destroying the FENGYUN-1C weather satellite as part of an anti-satellite missile test.[32] This explosion resulted in the creation of more than 3,500 pieces of orbital debris.[33] A NASA researcher characterized the aftermath as "the most severe artificial debris cloud in Earth['s] orbit since the inception of space exploration."[34] Initially, the potential threat posed by the debris cloud remained unclear.[35] However, in 2021, the International Space Station faced imminent danger with a potential collision and had to urgently alter its course to avoid damage.[36] Notably, NASA reported that since 1999, the International Space

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[26] Nikolai Khlystov, *Space debris is a growing problem. These leaders have a plan to tackle it*, WORLD ECONOMIC FORUM (Jun. 14, 2023), https://www.weforum.org/agenda/2023/06/orbital-debris-space-junk-removal/#:~:text=Orbital%20debris%20threatens%20this%20progress.%20Since%20these%20pieces,entire%20missions%20or%20creating%20large%20new%20debris%20fields.

[27] *Space Debris*, *supra* note 24.

[28] *Space Debris*, *supra* note 24.

[29] Mike Wall, *Kessler Syndrome and the space debris problem*, SPACE.COM, https://www.space.com/kessler-syndrome-space-debris#section-kessler-syndrome-tipping-point-how-bad-are-things-now (last updated Jul. 14, 2022).

[30] Heather Riley, *Micrometeoroids and Orbital Debris*, NASA (Jun. 14, 2016), https://www.nasa.gov/centers-and-facilities/white-sands/micrometeoroids-and-orbital-debris-mmod/#:~:text=Orbital%20debris%20is%20the%20number%20one%20threat%20to,scenario%20and%20cause%20catastrophic%20failures%20in%20the%20worst.

[31] *Space debris: A quantitative analysis of the in-orbit collision risk and its effects on Earth*, PHYS.ORG (Jun. 30, 2023), https://phys.org/news/2023-06-space-debris-quantitative-analysis-in-orbit.html.

[32] Ed Browne, *Chinese Space Debris Heading Towards International Space Station, Russian Scientists Say*, NEWSWEEK (Jun. 10, 2021), https://www.newsweek.com/chinese-space-debris-international-space-station-russian-scientists-iss-1647883.

[33] Mark Rigby & Brad Carter, *A chunk of a Chinese satellite almost hit the International Space Station. They dodged it – but the space junk problem is getting worse*, SPACE.COM (Nov. 15, 2021), https://www.space.com/chinese-satellite-debris-almost-hit-international-space-station.

[34] Browne, *supra* note 32.

[35] Browne, *supra* note 32.

[36] Wall, *supra* note 29.

Station has undertaken a total of 29 evasive maneuvers specifically to navigate around potential collisions with space debris.[37]

In 2009, an accidental collision occurred between a United States satellite and a Russian satellite, both traveling through space at speeds exceeding 22,000 miles per hour.[38] This collision resulted in the generation of 1,800 new fragments of space debris.[39] The Russian satellite was already deemed to be space debris, having been nonfunctional and dormant since its launch in 1993.[40] This marked the first occurrence of a satellite collision, drawing significant attention to the looming threat posed by space debris collisions.[41]

Furthermore, in a recent incident in 2021, Russia conducted a missile test that resulted in a collision with a Russian satellite, generating approximately 1,500 pieces of trackable space debris.[42] Additionally, the test likely produced hundreds of thousands of smaller debris fragments which are undetectable and capable of causing damage to spacecrafts.[43] This event sparked significant international backlash. General James Dickinson of the U.S. Space Command declared, "The debris created by Russia's DA-ASAT will continue to pose a threat to activities in outer space for years to come, putting satellites and space missions at risk, as well as forcing more collision avoidance maneuvers."[44] As the accumulation of space debris grows, there is a looming concern about the emergence of Kessler Syndrome.[45]

C. Debris Accumulation Could Lead to Kessler Syndrome

In order to fully comprehend the phenomenon of Kessler Syndrome and the danger it may present, let's draw a comparison to a bingo machine. Picture the bingo machine: a glass sphere where air circulates, creating a random selection of balls. Think of the sphere as Earth's low orbit and the balls as man-made objects launched into space. Envision these balls as fragile glass, prone to shattering upon contact with one another. When there is only one ball in the machine, the chances of a collision are very low. However, as more balls are added, the collision frequency increases, leading to a consistent shattering of the glass balls. This continuous cycle of collisions results in an ever-growing population of glass fragments circulating within the bingo machine. This hypothetical serves as a real-life depiction of Kessler Syndrome.

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[37] Wall, *supra* note 29.
[38] David Wright, *Colliding Satellites: Consequences and Implications,* UNION OF CONCERNED SCIENTISTS (Feb. 26, 2009) https://www.ucsusa.org/sites/default/files/2019-10/SatelliteCollision-2-12-09.pdf, at 1.
[39] Johnson Nicholas, *The Collision of Iridium 33 and Cosmos 2251: The Shape of Things to Come* (60th Astronautical Congress at Daejeon, Republic of Korea, Oct. 16, 2009), https://ntrs.nasa.gov/api/citations/20100002023/downloads/20100002023.pdf.
[40] Wright, *supra* note 38, at 1.
[41] Wright, *supra* note 38, at 1.
[42] *U.S. Response to Russian Anti-Satellite Test*, U.S. DEPARTMENT OF COMMERCE, OFFICE OF SPACE COMMERCE (Nov. 15, 2021), https://www.space.commerce.gov/u-s-response-to-russian-anti-satellite-test/.
[43] *Id*.
[44] *Id.*
[45] Wall, *supra* note 29; *see also infra* Part II.C for further explanation of Kessler Syndrome.

In 1978, NASA scientist Donald Kessler articulated the above-illustrated concept that was later termed Kessler Syndrome.[46] This phenomenon suggests that as the volume of spacecraft and space debris in Earth's low orbit accumulates, collisions between the objects become more frequent, perpetuating a continuous cycle of the generation of additional space debris.[47] At its core, Kessler Syndrome lays out the idea that the probability of satellite collisions escalates with the increasing number of spacecraft launched into orbit.[48] Kessler highlighted the key threat associated with this idea, stating, "Satellite collisions would produce orbiting fragments, each of which would increase the probability of further collisions, leading to the [formation] of a belt of debris around the Earth."[49]

The gravity of the space debris threat cannot be overstated. This issue is not a problem for the future; it demands immediate attention and sufficient solutions on the international front. Hence, it is crucial to evaluate the existing international frameworks that regulate the issue of space debris.

III. An Inadequate International Space Framework

International space law is broadly divided into two categories: (1) binding instruments, "such as treatises, standards, and national regulations," and (2) non-binding agreements that are utilized to set out aspirational initiatives and encourage international cooperation.[50] Together, the binding and non-binding agreements form the foundation of the "global space governance framework."[51] The subsequent sections will delve into the chronological evolution of international laws and guidelines governing space, with a focus on space debris liability and mitigation.

A. UNOOSA and COPUOS

Since its creation in the aftermath of World War II, the United Nations (UN) has served as the "primary facilitator of global space governance and law."[52] The mission of the United Nations is "to maintain international peace and security, and to that end: to take effective collective measures for the prevention and removal of threats to the peace."[53] Amidst the escalating tensions of the Cold War and in response to the developing Space Race, the United Nations took it upon itself to establish an entity tasked with establishing legal and regulatory frameworks for space activities.[54] In 1958, the UN established the UN Office for Outer Space Affairs (UNOOSA).[55] Given the growing necessity for the development of law in space, the United Nations Committee

[46] Wall, *supra* note 29.
[47] Wall, *supra* note 29.
[48] Wall, *supra* note 29.
[49] Wall, *supra* note 29.
[50] Sophie Goguichvili et al., *The Global Legal Landscape of Space: Who Writes the Rules on the Final Frontier?,* WILSON CENTER (Oct. 1, 2021), https://www.wilsoncenter.org/article/global-legal-landscape-space-who-writes-rules-final-frontier.
[51] *Id.*
[52] *Id.*; *United Nations*, HISTORY.COM (Aug. 21, 2018), https://www.history.com/topics/stories/united-nations.
[53] Charter of the United Nations, 59 Stat. 1031, T.S. 993, 3 Bevans 1153, entered into force Oct. 24, 1945, at art. I.
[54] Goguichvili, *supra* note 50.
[55] Goguichvili, *supra* note 50.

on the Peaceful Use of Outer Space (COPUOS) was established under the supervision of UNOOSA.[56] COPUOS was created "to govern the exploration and use of space for the benefit of all humanity: for peace, security and development."[57] Under the authority of the United Nations, UNOOSA and COPUOS are ultimately responsible for the development and implementation of the five treaties that serve as the cornerstone of contemporary global space governance.[58]

The United Nations, with the help of UNOOSA and COPUOS, has adopted five pivotal space treaties: The Outer Space Treaty,[59] The Rescue Agreement,[60] the Liability Convention,[61] the Registration Convention[62] and the Moon Agreement,[63] which collectively form the foundation of space governance.[64] Notably, the Outer Space Treaty, the Liability Convention, and the Registration Convention hold particular relevance to this discourse on space debris. Complementing these treaties, the Inter-Agency Debris Coordination Committee (IADC)[65] and COPUOS's Space Debris Mitigation Guidelines[66] provide crucial guidance in tackling the global issue of space debris.

B. The Outer Space Treaty

On October 10, 1967, the Outer Space Treaty became the foundation for international space law governance.[67] Space lawyers have deemed the Outer Space Treaty as, "a constitution . . . in

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[56] Goguichvili, *supra* note 50.

[57] *Committee on the Peaceful Uses of Outer Space (COPUOS)*, UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, https://www.unoosa.org/oosa/en/ourwork/copuos/index.html (last visited Oct. 14, 2024).

[58] Goguichvili, *supra* note 50.

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

[60] Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched Into Outer Space, *opened for signature* Apr. 22, 1968, 672 U.N.T.S. 119 (entered into force Dec. 3, 1968).

[61] Convention on International Liability for Damage Caused by Space Objects, *opened for signature* Mar. 29, 1972, 861 U.N.T.S. 187 (entered into force Sept. 1, 1972) [hereinafter Liability Convention].

[62] Convention on Registration of Objects Launched into Outer Space, *opened for signature* Jan. 14, 1975, 1023 U.N.T.S. 15 (entered into force Sept. 15, 1976) [hereinafter Registration Convention].

[63] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, *adopted* Dec. 5, 1979, 1362 U.N.T.S. 22 (entered into force July 11, 1984) [hereinafter Moon Agreement].

[64] Goguichvili, *supra* note 50.

[65] *What's IADC*, INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE, https://iadc-home.org/what_iadc (last visited Nov. 1, 2024).

[66] *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space*, *supra* note 16.

[67] Outer Space Treaty, *supra* note 59; *see* Loren Grush, *How an international treaty signed 50 years ago became the backbone for space law,* THE VERGE (Jan. 27, 2017), https://www.theverge.com/2017/1/27/14398492/outer-space-treaty-50-anniversary-exploration-guidelines.

the sense that all international and national advancements on space activities should be measured against the standard."[68] The primary purpose of the Outer Space Treaty is to ban "the stationing of weapons of mass destruction in outer space, prohibit military activities on celestial bodies, and detail legally binding rules governing the peaceful exploration and use of space."[69] The United States, the Soviet Union, and the United Kingdom were among the first nations to ratify the Outer Space Treaty.[70] Today, more than one hundred nations have signed on to the Outer Space Treaty.[71]

Countries that have ratified the Outer Space Treaty are technically obligated to adhere to its provisions.[72] Nonetheless, enforcement of the treaty is hindered by the voluntary nature of the agreement itself, resulting in a lack of enforcement mechanisms.[73] Presently, the Outer Space Treaty primarily functions as a set of guidelines and principles aimed at fostering international cooperation and collaboration.[74]

During its inception, the creators of the Outer Space Treaty were primarily concerned with the heightened tensions among nation-states exacerbated by the aftermath of war.[75] The limited scope of the Outer Space Treaty focuses on preventing the placement of nuclear weapons in space and ensuring the peaceful use of outer space.[76] Despite the members of the United Nations' intent to establish forward-looking standards to address the potential problems that could arise with space exploration, the Outer Space Treaty fails to define, mention, or develop standards governing space debris.[77] During its formation in 1967, the Treaty's drafters did not consider the concept of space debris. The issue simply did not factor into their deliberations, rendering the Treaty outdated and ineffective in addressing the contemporary challenges posed by space debris.

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[68] Lilian Srour, *Who is going to take out the trash? Addressing space debris under international law*, PUBLIC INTN'L LAW AND POLICY GROUP (Mar. 14, 2022), https://www.publicinternationallawandpolicygroup.org/lawyering-justice-blog/2022/3/14/who-is-going-to-take-out-the-trash-addressing-space-debris-under-international-law.

[69] Daryl Kimball, *The Outer Space Treaty at a Glance*, ARMS CONTROL ASSOC. (July 2024), https://www.armscontrol.org/factsheets/outerspace.

[70] *Outer Space Treaty*, BRITANNICA (Mar. 11, 2024), https://www.britannica.com/event/Outer-Space-Treaty.

[71] Hugo Britt, *Understanding the Outer Space Treaty*, THOMASNET INSIGHTS (Apr. 30, 2021), https://www.thomasnet.com/insights/is-the-outer-space-treaty-outdated/.

[72] Saharsh Panjwani, *Fifty Years of the Outer Space Treaty: Challenges and Need for a New Treaty*, PROJECT STATE CRAFT, https://www.projectstatecraft.org/post/fifty-years-of-the-outer-space-treaty-challenges-and-need-for-a-new-treaty#:~:text=The%20outer%20space%20treaty%20is%20technically%20binding%20on,body%2C%20makes%20the%20peace%20and%20security%20aspects%20delicate (last updated Aug. 24, 2021).

[73] Douglas Ligor, *Reduce Friction in Space by Amending the 1967 Outer Space Treaty*, WAR ON THE ROCKS (Aug. 26, 2022), https://warontherocks.com/2022/08/stabilize-friction-points-in-space-by-amending-the-1967-outer-space-treaty/.

[74] *Id.*

[75] Outer Space Treaty, *supra* note 59, at Proclamation.

[76] Outer Space Treaty, *supra* note 59, at Proclamation.

[77] Srour, *supra* note 68, at 4.

Despite the absence of explicit standards for regulating space debris, the compilation of articles within the Outer Space Treaty promotes a broader theme of responsibility for state actions in space.[78] However, when reading the Treaty's articles, discerning a definitive standard for space debris regulation is nearly impossible due to the inherent ambiguities. Articles VI, VII, and IX of the Outer Space Treaty are the most relevant articles regarding the issue of space debris.

Articles VI and VII of the Outer Space Treaty establish the structure for addressing liability in space.[79] Article VI specifies that states bear responsibility "for their national space activities, whether carried out by government bodies or non-governmental entities."[80] It creates an obligation that states must "authorize and continuously supervise [the] activities of their non-governmental entities."[81] Expounding upon Article VI of the Treaty, Article VII states, "Each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or its natural or juridical persons by such object or its component parts on the Earth, in air or in outer space."[82] While both articles are intertwined in establishing a generalized framework for liability, they do not explicitly mention "space debris" nor do they factor in the challenge of attributing liability for debris fragments that may be too small to identify the responsible state party. The articles are overly broad to effectively address the complex issue of space debris.

While the aforementioned articles provide a broad framework for liability, Article IX is the only other provision within the Outer Space Treaty that could be interpreted as imposing obligations on state parties concerning the matter of space debris.[83] Specifically, Article IX states,

> States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose.[84]

In essence, Article IX could be construed to encompass space debris issues by encouraging states to undertake actions to mitigate debris generation and avert potential harm. However, the terms "harmful contamination" and "appropriate measures" are far too broad, rendering it challenging to ascertain states' specific obligations regarding space debris mitigation.[85] Determining whether a fragment of a spacecraft or a defunct satellite falls under the classification of "harmful contamination" poses a challenge.

Due to the absence of explicit provisions and the resulting wide scope for interpretation, enforcing the Outer Space Treaty is difficult. Nonetheless, the Treaty has established the

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[78] *See* Outer Space Treaty, *supra* note 59, at Proclamation.
[79] Ram Jakhu & Md Tanveer Ahmader, *The Outer Space Treaty and states' obligation to remove space debris: a US perspective*, THE SPACE REVIEW (Nov. 13, 2017), https://www.thespacereview.com/article/3370/1.
[80] *Id.*
[81] *Id.*
[82] Outer Space Treaty, *supra* note 59, at art. VII.
[83] *See* Outer Space Treaty, *supra* note 59, at art. IX.
[84] Outer Space Treaty, *supra* note 59, at art. IX.
[85] Outer Space Treaty, *supra* note 59, at art. IX.

fundamental framework for space governance, facilitating the emergence of additional agreements and guidelines to build upon its foundation.

C. The Convention on International Liability for Damage Caused by Space Objects

In an effort to further define the terms of the Outer Space Treaty governing liability, the Liability Convention was adopted on September 1, 1972.[86] The Liability Convention was adopted to lay out the fundamental principles governing liability for damage caused by space objects.[87] The Convention stipulates that launching states bear responsibility for damages resulting from their spacecraft.[88] A pivotal advancement within the Convention was the clarification of the term "launching state." Article I defines "launching state" as "a state which launches or procures the launching of a space object [or] . . . a state from whose territory or facility a space object is launched."[89] The clarification of "launching state" hammered home the idea that states are responsible for the actions of both government and non-government actors.[90]

Moreover, the Convention also acknowledges and addresses damages arising from space objects for the first time. The Convention's definition of "space object" is of particular relevance to holding states liable for damage caused by space debris. The Convention defines this term to encompass "component parts of a space object as well as its launch vehicle and parts thereof."[91] Although the term "space debris" is not explicitly mentioned, it can be construed that space debris potentially falls within the scope of a "space object" based on this definition.[92] However, the Liability Convention's definition of "space object" is inadequate, as it does not comprehensively hold states liable for damages caused by space debris.[93]

While the Liability Convention does not tackle the entire space debris issue or introduce mitigation guidelines, its imposition of liability on states for damages caused by space objects is effective in compelling member states to at least engage in resolving the problem, as they could be held financially responsible for orbital debris damages.[94] However, this imposition of liability is only theoretical. Specifically, Article XIX of the Liability Convention states, "The decision of the Commission shall be final and binding if the parties have so agreed; otherwise[,] the Commission shall render a final and recommendatory award, which the parties shall consider in good faith."[95] Said differently, if the parties do not come to a consensus on the decision rendered by the Commission, the Liability Convention is unenforceable.[96]

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[86] Liability Convention, *supra* note 61.
[87] Liability Convention, *supra* note 61.
[88] Liability Convention, *supra* note 61.
[89] Liability Convention, *supra* note 61, at art. I.
[90] Frans von der Dunk, *Space Debris and the Law*, *in* PROCEEDINGS OF THE THIRD EUROPEAN CONFERENCE ON SPACE DEBRIS, 19-21 MARCH 2001, DARMSTADT, GERMANY 865 (Huguette Sawaya-Lacoste ed., 2001).
[91] Liability Convention, *supra* note 61, at art. I.
[92] von der Dunk, *supra* note 90, at 865.
[93] von der Dunk, *supra* note 90, at 868.
[94] Sandra Drago, *No Man's Sky: Utilizing Maritime Law to Address the Need For Space Debris Removal Technology*, 59 SANTA CLARA L. REV. 389, 415 (2019).
[95] Liability Convention, *supra* note 61, at art. XIX.
[96] Liability Convention, *supra* note 61, at art. XIX.

To further elaborate on the shortcomings, the Liability Convention lacks provisions mandating the elimination of current orbital debris or incentives for the development of debris removal technology.[97] In addition, the Liability Convention fails to address the challenge of attributing fault for small debris, which poses the impossible task of determining which launching state is ultimately responsible. These problems add to the inherent difficulty in enforcing the agreement. Consequently, the United Nations endeavored to create a registry that would enhance the enforcement of the Liability Convention; it is commonly referred to as the Registration Convention.[98]

D. The Registration Convention

In 1976, the Convention on Registration of Objects Launched into Outer Space came into effect.[99] The registry operates to determine individual state liability and international responsibility regarding the ownership of space objects.[100] Signatory states must establish their own national registries and furnish the Secretary-General with information about their space objects.[101] Specifically, Article IV states, "Each State shall furnish to the Secretary-General of the United Nations, as soon as practicable, . . . (a) [the] name of the launching state; (b) an appropriate designator of the space object or its registration number; (c) the date and territory or location of launch; (d) the basic orbital parameters. . . ; and (e) the general function of the space object."[102] Currently, 86% of the space objects launched into Earth's orbit have been registered.[103] In addition to requiring states to furnish registry information to the Secretary-General, Article IV also requires states to notify the Secretary-General of objects that are no longer in Earth's orbit "to the greatest extent feasible and as soon as practicable."[104]

There is no question that the Registration Convention was adopted to significantly enhance space governance, transparency, and liability enforcement. The Convention sought to simplify the process of identifying ownership of launched space objects, making it easier to determine the responsible launching state.[105] Furthermore, this increased clarity would make it more likely that the responsible state would be held accountable for any damages caused by space objects under the Liability Convention.[106] Hence, if a specific state was determined to be the registered owner of a piece of space debris, the Registration Convention implies that the state would bear the financial liability for any damages caused by the debris.

However, in spite of the diligent effort to incentivize states, the Registration Convention does not actually impose a formal obligation on states to register their space objects, as it appears

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[97] Drago, *supra* note 94, at 416.
[98] Registration Convention, *supra* note 62.
[99] Registration Convention, *supra* note 62, at art. VII.
[100] Goguichvili, *supra* note 50, at 8.
[101] *United Nations Register of Objects Launched into Outer Space*, UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, https://www.unoosa.org/oosa/en/spaceobjectregister/index.html (last visited Nov. 5, 2024).
[102] Registration Convention, *supra* note 62, at art. IV.
[103] Registration Convention, *supra* note 62.
[104] Registration Convention, *supra* note 62, at art. IV.
[105] Registration Convention, *supra* note 62.
[106] Drago, *supra* note 94, at 416.

to do.[107] The language in Article IV suggests that states are encouraged to furnish the registry information to the Secretary-General "as soon as practicable."[108] Furthermore, states are only required to notify the Secretary-General of objects no longer in Earth's orbit "to the greatest extent feasible."[109] The phrases "as soon as practicable" and "to the greatest extent feasible" have been utilized by countries as a loophole to evade registering their space objects with the registry, resulting in the avoidance of liability.[110] Failing to register your object would not be considered a breach of the Registration Convention if it was not practicable or feasible to do so at the time.[111] As a consequence, the registry's capability to track and determine ownership of all space objects, including space debris, is hindered. Apart from the flawed language, the Registration Convention also fails to address the issue of liability with regard to much smaller debris that cannot be linked to a specific state.[112] Thus, the ambiguities and the absence of formal obligations imposed on states to assume liability and register their space objects make the current adoption of the Treaty ineffective.

IV. Mitigation Helps, but It Won't Solve the Issue

Since the adoption of the Registration Convention, significant progress has been made with the establishment of international agencies and the development of space debris mitigation guidelines focused on addressing the space debris issue. Specifically, the IADC[113] and COPUOS[114] have played a vital role in coordinating efforts among states to implement guidelines for mitigating space debris internationally.

On October 25, 1993, the IADC was established to "exchange information on space debris research activities between member space agencies, to facilitate opportunities for co-operation in space debris research, to review the progress of ongoing co-operative activities and to identify debris mitigation options."[115] Today, the IADC consists of thirteen member agencies, most notably the ESA and NASA.[116] The IADC's most notable accomplishments include the publication of the first comprehensive international guidelines for space debris mitigation and the establishment of a network for the exchange of space debris data.[117]

The Space Debris Mitigation Guidelines were established on three fundamental principles: "(1) preventing in-orbit breakups; (2) removing spacecraft and orbital stages that have reached the end of their mission operations from the useful densely populated orbit regions; and (3) limiting

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[107] von der Dunk, *supra* note 90, at 869.
[108] Registration Convention, *supra* note 62, at art. IV.
[109] Registration Convention, *supra* note 62, at art. IV.
[110] von der Dunk, *supra* note 90, at 869.
[111] von der Dunk, *supra* note 90, at 869.
[112] von der Dunk, *supra* note 90, at 869.
[113] *What's IADC*, *supra* note 65.
[114] *Committee on the Peaceful Uses of Outer Space*, UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS, https://www.unoosa.org/oosa/en/ourwork/copuos/index.html (last visited Nov. 5, 2024).
[115] INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE, IADC SPACE DEBRIS MITIGATION GUIDELINES 4 (Rev. 2 2020).
[116] *Id.*
[117] Nicholas Johnson, *Origin of the Inter-Agency Space Debris Coordination Committee*, *in ARES Biennial Report 2012 Final*, 71 (Eileen K. Stansbury, ed., 2012).

the objects released during normal operations."[118] Adherence to the Space Debris Mitigation Guidelines is strictly voluntary.[119] In the IADC's Report on the Status of the Space Environment, the Committee highlighted that global compliance with the Guidelines is slowly increasing.[120] Although the growing trend of international cooperation is encouraging, the IADC has acknowledged that "the successful implementation of the guidelines is still at too low of a level to ensure a sustainable environment in the long run."[121] The IADC's Space Debris Mitigation Guidelines represent the initial step towards global cooperation in addressing the challenge of space debris.[122] Nevertheless, the Guidelines focus solely on mitigating space debris and do not address the extraction of existing debris from Earth's low orbit. Despite their limited scope, the Guidelines have been utilized as the foundation for the development of the Space Debris Mitigation Guidelines of COPUOS.[123]

In conjunction with the IADC's efforts, COPUOS sought to develop its own set of space debris mitigation guidelines, aiming to achieve wider acceptance among the global space community.[124] In 2007, the Space Debris Mitigation Guidelines of COPUOS were endorsed by the United Nations.[125] Although the guidelines are not legally binding, they are considered to be the most significant set of international standards relating to space debris because they have been more widely accepted.[126] The initiative undertaken by COPUOS sets forth seven debris mitigation guidelines.[127] Specifically, the guidelines seek to limit the release of debris, minimize the potential for break-ups, limit the probability of collisions, avoid intentional breakups of spacecraft, and limit the post-mission presence of spacecraft in Earth's orbit.[128] These guidelines echo the primary debris mitigation principles highlighted in the IADC's Space Debris Mitigation Guidelines, yet they are much broader.[129] In fact, COPUOS's guidelines call for states to consult the IADC's guidelines for a more detailed description of space debris mitigation measures.[130] While both sets of guidelines are intended to encourage states to address the space debris issue, they are merely recommendations. Thus, they lack the authority needed to prioritize the space debris issue. Since

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[118] INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE*, supra* note 114, at 5.
[119] INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE, IADC REPORT ON THE STATUS OF THE SPACE DEBRIS ENVIRONMENT, 5 (2024).
[120] *Id.* at 6.
[121] *Id.*
[122] Johnson, *supra* note 117, at 71.
[123] J.-C. Liou, *Effectiveness of Satellite Postmission Disposal To Limit Orbital Debris Population Growth in Low Earth Orbit*, *in ARES Biennial Report 2012 Final*, 72 (Eileen K. Stansbury, ed., 2012).
[124] *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space*, UNITED NATIONS OFFICE FOR OUTER SPACE Affairs, (2010) https://www.unoosa.org/pdf/publications/st_space_49E.pdf at *5 [hereinafter "Guidelines"].
[125] *Id.* at *6.
[126] *Mitigation of Space Debris: An Overview of Main International Guidelines*, EBRARY.NET, https://ebrary.net/197304/engineering/mitigation_space_debris_overview_main_international_guidelines (last visited Nov. 5, 2024) [hereinafter "An Overview"].
[127] *Id.*
[128] UNITED NATIONS OFFICE FOR OUTER SPACE Affairs, *supra* note 124, at 90–92.
[129] An Overview, *supra* note 126.
[130] An Overview, *supra* note 126.

these guidelines are advisory and lack accompanying enforcement mechanisms, states operate with unchecked discretion.

V. The International Problem

The international challenge posed by space debris stems from a combination of factors, including a lack of accountability, international cooperation, a consistent governing framework, debris removal technology, and financial incentives. Marshall Kaplan, an orbital debris expert at Johns Hopkins University, discussed his concerns, saying, "The fact is that we really can't do anything. We can't afford it. We don't have the technology. We don't have the cooperation. Nobody wants to pay for it. Space debris is a 'growth industry,' but there are no customers."[131] While Kaplan's statement is somewhat rooted in reality, acknowledging the notion that nothing can be done to resolve the issue of space debris is a hopeless outlook. Over time, the world has made strides in working together to at least acknowledge and begin to address the issue of space debris. In fact, the ESA, with the assistance of the Swiss startup ClearSpace, has announced plans to launch CLEARSPACE-1 in 2025, which will be the first space mission dedicated to retrieving a piece of space debris from Earth's low orbit.[132] While progress falls short in addressing the totality of the issue, there is a solid foundation of international agreements and mitigation guidelines that can be built upon to force the international space community to care about space debris.

As the world faces the increasing challenge of space debris, the time has come for the space community to come together to adopt a resolution, amending the United Nations' treaties, dedicated to effectively addressing the issue of space debris. The upcoming sections will introduce a proposed resolution specifically addressing the issue of space debris. First, the resolution will enact policies aimed at strengthening the United Nations' foundational space treaties, with a particular emphasis on state accountability and transparency. Second, the resolution will introduce policies that align with the principles contained in the International Convention on Salvage (1989), with the goal of incentivizing the development of space debris removal technology.

VI. Reinforcing Space Accountability and Transparency

A. Defining Space Debris and Creating an Obligation

As previously discussed, the Outer Space Treaty and the Liability Convention contain ambiguities in their language, which compromises their effectiveness. The lack of clarity ultimately leads to the failure to establish a formal obligation for states to take accountability with regard to space debris. To address this issue, the first proposed amendment to the treaties should start with adopting a clear definition of space debris. Both the Outer Space Treaty and the Liability Convention may seem to impose obligations on states with regard to accountability for space debris. Nevertheless, the interpretation of whether space debris falls within the scope of the terms "harmful contamination" and "space object" is open for debate. Therefore, it would be beneficial for the Outer Space Treaty and the Liability Convention to incorporate a specific definition of space debris. The definition proposed by the IADC could serve as a solution. According to the

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[131] Leonard David, *Ugly Truth of Space Junk: Orbital Debris Problem to Triple by 2030*, SPACE.COM (May 9, 2011), https://www.space.com/11607-space-junk-rising-orbital-debris-levels-2030.html.

[132] *ESA commissions world's first space debris removal*, EUR. SPACE AGENCY, (Sept. 12, 2019), https://www.esa.int/Space_Safety/Clean_Space/ESA_commissions_world_s_first_space_debris_removal.

IADC, space debris encompasses "all man-made objects, including fragments and elements thereof, in Earth's orbit or re-entering the atmosphere, that are non-functional."[133] Implementing this definition into the treaties would impose clear obligations on states to refrain from further contributing to the space debris issue, and it would make the states well aware that they are liable for damages caused by the space debris generated by their space missions.

B. Strengthening the Registration Convention

In regard to all three treaties, strengthening the Registration Convention could serve as the most practical solution to heightening state accountability with regard to the issue of space debris. As it stands, the Registration Convention includes language such as "to the greatest extent feasible" and "as soon as practicable," which has created loopholes allowing states to avoid registering their objects and providing the necessary information to the Secretary-General.[134] This language needs to be eliminated. The Registration Convention should impose much tighter registration requirements. For example, the Registration Convention should require states to provide a statement acknowledging accountability for the creation of space debris. In addition, the Registration Convention should require states to register the spacecraft with the Secretary-General within a specific timeframe prior to the launch. If the states fail to adhere to the registration requirements, they should be subjected to fines or sanctions. The current language of the Registration Convention enables states to disregard the sole purpose of its original adoption: global transparency. Implementing stricter registration requirements and eliminating ambiguous language is likely to lead to an increase in transparency with regard to space launches across the globe. Consequently, this increase in transparency will lead to a heightened level of accountability on the part of the states.

Furthermore, the Registration Convention should promote a consistent licensing policy for states to adopt. While many states maintain their own national licensing systems, the Registration Convention should outline the minimum requirements for each state's system. Specifically, the Convention should require that states or private companies provide a thorough analysis of the spacecraft's compliance with the space debris mitigation guidelines. This analysis should serve as a prerequisite for obtaining a license to launch. In addition, this analysis should include plans for the spacecraft's disposal once its intended purpose has been fulfilled. By verifying that a spacecraft has satisfied the stricter requirements, issuing a license would signify a state's acknowledgment of accountability concerning space debris.

Currently, the United States has taken action that aligns with this resolution, as the Federal Communications Commission now requires small satellite and small spacecraft license applicants to assure that the launch will not release planned debris and to provide a brief description of their disposal plan.[135] This effort by the United States undoubtedly imposes stricter requirements for obtaining a launch license, with an emphasis on debris mitigation. However, launch license requirements are not uniform across the globe. The increase in uniformity will lead to an increase in transparency and accountability. Therefore, strengthening the Registration Convention to

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[133] INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE, IADC SPACE DEBRIS MITIGATION GUIDELINES 4 (Rev. 2 2020), at *6.

[134] von der Dunk, *supra* note 90, at 4.

[135] *Small Satellite and Small Spacecraft Licensing Process*, FEDERAL COMMUNICATIONS COMMISSION, https://www.fcc.gov/space/small-satellite-and-small-spacecraft-licensing-process (last updated Oct. 27, 2023).

require states to adopt and impose much stricter requirements for their national registries and licensing regimes is the most formidable resolution to ensure that states are aware of and held accountable for the issue posed by space debris.

VII. One Man's Trash Is Another's Treasure: Law of Salvage

Like a sailor navigating the high seas, spacefarers enjoy the freedom of exploring outer space in its entirety. There is a strong parallel between the legal frameworks governing outer space and those regulating the high seas.[136] Both the high seas and outer space are considered "common spaces."[137] A "common space" is defined as "a domain where a state may not exercise sovereign rights as it does on Earth."[138] Therefore, since no state has the ability to exercise jurisdiction over outer space or the high seas, they are predominantly regulated by international treaties.[139] For this reason, there are legal concepts grounded in maritime law that can be applied to solve issues in space. Here, the maritime law of salvage provides a framework for addressing the space debris problem by offering financial incentives to states or private entities for the development of space debris removal technology.[140]

A. The Law of Salvage

The law of salvage, as defined in maritime law, asserts that "a person who recovers another person's ship or cargo after peril or loss at sea is entitled to a reward commensurate with the value of the property so saved."[141] The rationale behind this principle is to provide fair compensation to individuals who willingly endanger themselves and their vessel in the act of rescuing another man's vessel or cargo at sea.[142] In the maritime industry, the concept of salvage has led to the advancement of side-scan sonar technology, submersibles, and remote-robotic technologies capable of recovering property from shipwrecks at the very bottom of the ocean.[143]

In 1989, the International Maritime Organization of the United Nations adopted the Salvage Convention, which establishes the conditions that must be met for a salvor to assert a valid claim for compensation.[144] Under the law of salvage, there are three conditions that must be met

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[136] Anitha Krishnamurthy & Tejas Krishnamurthy, *International Law & Space Law: Comparison With Law of Seas*, 4 J. OF LEGAL STUDIES AND RSCH 255, 255 (2018).

[137] Almudena Azcárate Ortega, Topic 4: Applicable elements of the legal regimes governing aviation and the sea in the context of threats arising from State behaviours with respect to outer space in Open-Ended Working Group on "Reducing space threats through norms, rules and principles of responsible behaviours" (May 12, 2022).

[138] *Id.*

[139] Drago, *supra* note 94, at 418.

[140] Drago, *supra* note 94, at 418.

[141] *Law of Salvage*, Duke University, https://people.duke.edu/~dgraham/ECO_463/Handouts/Law%20of%20salvage.pdf#:~:text=Historically%2C%20salvage%20is%20a%20right%20in%20law%2C%20when,or%20other%20recognized%20subject%20of%20salvage%20from%20danger.

[142] *Id.*

[143] David Bederman, *Historic Salvage and the Law of the Sea*, 30 U. MIAMI INTER-AM. L. REV. 99, 102 (1998).

[144] International Convention on Salvage, Apr. 28, 1989 (entered into force Jul. 14, 1996), 1953 U.N.T.S. 193 [hereinafter Convention on Salvage].

to ensure a valid claim for compensation: (1) the vessel or cargo must be in danger; (2) the salvor must be acting voluntarily; and (3) the salvor must be successful in retrieving the vessel or cargo.[145] Preceding the adoption of the Salvage Convention, laws seeking to provide compensation to salvors for the successful retrieval of cargo and vessels in danger were already in existence.[146] However, the existing law did not provide a means for compensating salvors who sought to prevent pollution or minimize damage to the environment.[147] This gap in the law of salvage created little incentive for salvors to undertake salvage operations that would benefit the environment due to the small chance of success and the fear of not being compensated.[148] In order to eliminate the deficiency in the law and to create a financial incentive for environmental protection, the Salvage Convention of 1989 includes a provision that would allow a salvor to be compensated for a salvage that is necessary to protect the environment.[149] Specifically, the Convention defines "damage to the environment," under Article I as "substantial physical damage to human health or to marine life or resources in coastal or inland waters or areas adjacent thereto, caused by pollution, contamination, fire, explosion or similar major incidents."[150] In determining the appropriate compensation to be paid to the salvor, the Convention highlights factors to be considered, such as: the value of the vessel or property, the skill required, the measure of success, the degree of danger, the time and expenses incurred by the salvors, and the risk of liability.[151]

B. Implementing the Law of Salvage in Space

Financial incentives are critical to motivating states and private entities to address the space debris issue. While implementing salvage law principles for this purpose requires international cooperation and poses challenges, adopting salvage-based provisions into an international resolution will offer the necessary financial motivation for both states and private entities to prioritize the issue and develop debris removal technology.

The first order of business in implementing the law of salvage into space is to tailor the language contained in the Salvage Convention of 1989 to space debris salvage operations. The Salvage Convention has provided adequate definitions of vessel, salvage operation, and property.[152] Consequently, the space debris salvage resolution must include a comprehensive definition of space debris. The best approach would be to adopt the definition of space debris provided by the IADC, which states, "Space debris are all manmade objects including fragments and elements thereof, in Earth['s] orbit or re-entering the atmosphere, that are non-functional."[153] In doing so, it would effectively identify the target of the space debris salvage operation.

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[145] Law of Salvage, *supra* note 141 at 2.
[146] *International Convention on Salvage*, INT'L MAR. ORG., https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-Salvage.aspx (last visited Nov. 5, 2024) [hereinafter "Convention on Salvage"].
[147] *Id.*
[148] *Id.*
[149] Convention on Salvage, *supra* note 146, at art. 1.
[150] Convention on Salvage, *supra* note 146, at art. 1.
[151] Convention on Salvage, *supra* note 146, at art. 13.
[152] Convention on Salvage, *supra* note 146, at art. 1.
[153] INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE, IADC SPACE DEBRIS MITIGATION GUIDELINES 4 (Rev. 2 2020), at 6.

Second, the space debris salvage resolution must establish a framework for compensating space salvors engaged in the retrieval of space debris. Historically, the law of salvage has determined that the validity of a claim for compensation hinges on the state of danger of the vessel or cargo, the voluntary nature of the salvor's actions, and the success of the salvage.[154]Accordingly, the space debris resolution should adopt analogous principles that require that (1) the salvaged property fall under the IADC's definition of space debris and (2) the retrieval of the space debris be successful. Considering the threat that space debris poses to spacecraft and space exploration, it is clear that space debris falls within the scope of danger or danger to the environment as laid out in the Salvage Convention.[155] Space debris not only puts the safety of astronauts in danger but also endangers the spacecraft of states and the space environment as a whole. A claim for space debris salvage is entirely justified in accordance with the principles outlined in the maritime law of salvage. Given the need for international cooperation and the urgency of the issue, the voluntary nature of space debris salvage is insignificant. The objective is to encourage space debris removal. Therefore, space debris salvors should be compensated for the successful extraction, regardless of whether their actions were voluntary or not.

Finally, the most complicated part of integrating the law of salvage into space is determining the appropriate amount of compensation and determining who should be responsible for compensation. As mentioned above, the compensation for a valid salvage claim hinges on a number of factors.[156] This approach to calculating compensation should be applied to space debris salvage operations. The value of the space debris, the skill involved, the expense of the space mission, the degree of danger of the launch, and the risk of liability are all relevant factors that should be considered when calculating the appropriate compensation.[157]

While the calculation method for compensating a successful space debris salvage is straightforward, determining who is responsible for paying is not. Under the International Convention on Salvage, the owner of the vessel or cargo that has been successfully recovered bears the responsibility of compensating the salvor.[158] Therefore, in the event of a successful retrieval of a defunct satellite, the launching state in which the defunct satellite is registered would be responsible for covering the entire expense of the salvage mission as well as the value of the salvaged debris. This method would not be the most suitable option for space. Given that adherence to this resolution is strictly voluntary, it is unlikely that states would sign on to it. States would be unlikely to agree to subject themselves to significant expenses, particularly given the costs of space technology and space missions. In addition, because current technology is ineffective with regard to tracking smaller pieces of space debris, determining the state responsible for compensation would pose an impossible task. The purpose of integrating the law of salvage is to encourage innovation, not to punish states.

Therefore, an alternative to the compensation method outlined in the Salvage Convention should involve establishing an international fund specifically dedicated to space sustainability with the initiative of compensating and investing in space debris salvage operations. By establishing a fund, the compensation for a successful space debris salvage would be spread amongst the

[154] Law of Salvage, *supra* note 141.
[155] Drago, *supra* note 94 at 419.
[156] Convention on Salvage, *supra* note 146, at art. 13.
[157] Convention on Salvage, *supra* note 146, at art. 13.
[158] Convention on Salvage, *supra* note 146, at arts. 13–14.

contributors to the fund. Currently, the United Nations has developed several funds and programs, such as the UN Environment Programme[159] and UN Children's Fund,[160] that provide the financial backing to support several global initiatives.[161] These funds and programs are established by a resolution adopted by the UN General Assembly, and they are primarily funded through voluntary contributions.[162] While it remains uncertain who would voluntarily contribute to the space debris salvage fund, all states have an interest in the long-term sustainability of space exploration, so it is likely that they would feel compelled to contribute.

In addition, as another means of contributing to the space debris salvage fund, states should impose a space debris tax on commercial launches. Currently, in the aviation industry, airlines and their passengers are subjected to several taxes to support a number of initiatives including environmental protection, infrastructure enhancement, and airport and airway operations.[163] Globally, airlines and their customers generate over one hundred billion dollars in annual tax revenue.[164] Although the aviation industry is much more prevalent, imposing a space debris tax on commercial space launches will inherently generate revenue. Consequently, this revenue should be contributed to the space debris fund for the purpose of investing in space debris salvage operations, developing space debris removal technology, and compensating space debris salvors.

The primary goal of implementing the law of salvage to address space debris is to establish a compensation framework that motivates spacefarers to care. Just as the implementation of maritime salvage law spurred the advancement of technology capable of reaching the deep depths of the sea, implementing a framework for space debris salvage is likely to facilitate the development of technology capable of bringing space debris back to Earth. Today, the world's leading technology developers are not focused on developing such technology because there is no financial incentive. The only advantage would be to preserve the sustainability of space exploration. Hopefully, with the introduction of space debris salvage, a space engineer will develop a space debris removal prototype, launch it into outer space, successfully retrieve a haul of debris, and receive lucrative compensation for their efforts from the space debris fund.

Incentivizing space debris salvage will not only lead to a sustainable space environment but will also reduce the cost of space exploration as a whole. Specifically, a majority of the space debris in Earth's low orbit is made up of valuable materials such as aluminum, titanium, steel,

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[159] *Frequently Asked Questions*, UNITED NATIONS ENVIRONMENT Programme, https://www.unep.org/who-we-are/frequently-asked-questions (last visited Nov. 5, 2024).

[160] *Who We* Are, UNICEF, https://www.unicef.org/who-we-are (last visited Nov. 5, 2024).

[161] *See Frequently Asked Questions*, UNITED NATIONS ENVIRONMENT PROGRAMME, https://www.unep.org/who-we-are/frequently-asked-questions (last visited Nov. 5, 2024); *see also Who We Are*, UNICEF, https://www.unicef.org/who-we-are (last visited Nov. 5, 2024).

[162] United Nations*, UN Funds, Programmes & Other Entities*, DAG HAMMARSKJOLD LIBRARY, https://research.un.org/en/docs/unsystem/fundsprogs#:~:text=UN%20Funds%2C%20Programmes%20%26%20Other%20Entities.,governing%20body%20that%20reviews%20their%20activities.&text=UN%20Funds%2C%20Programmes%20%26,that%20reviews%20their%20activities.&text=Programmes%20%26%20Other%20Entities.,governing%20body%20that%20reviews (last visited Nov. 5, 2024).

[163] *U.S. Government-Imposed Taxes on Air Transportation*, AIRLINES FOR AMERICA (Oct. 1, 2024), https://www.airlines.org/dataset/government-imposed-taxes-on-air-transportation/.

[164] IATA, ECONOMIC PERFORMANCE OF THE AIRLINE INDUSTRY, 2 (2019).

Kevlar, plastics, silicon, ceramics, and residual fuels.[165] When technology is developed to extract debris from Earth's low orbit, recycling these materials to implement into future space missions will no doubt result in a financial advantage. In fact, Dr. Bryan Biegle, the Special Assistant for Exploration Technology at NASA, stated "Every kilogram of space debris that can be recycled is one less kilogram that needs to be launched. That saves time, fuel, and money."[166] With a significant amount of international cooperation, the space debris salvage market could have the potential to become highly profitable. Although the size of the debris salvage market is unknown, market survey studies estimate that the active debris removal market is projected to generate 980 million dollars in revenue by 2031, hinging upon the enactment of space sustainability policies.[167] This opportunity for financial gain is likely to incentivize further investment in the space debris removal market. However, it is imperative that a solid legal infrastructure is in place first.

VIII. Conclusion

The current framework governing international space debris fails to sufficiently enforce accountability, encourage global collaboration, and promote the advancement of debris removal technology. Despite the obstacles associated with addressing the issue, it is not an impossible task when supported by sufficient legal frameworks. Enhancing the core outer space treaties while implementing the principles of salvage law will not only strengthen the obligations of states and private actors but also motivate them to invest capital for the purpose of solving the space debris issue. It is important to take action now before the consequences of Kessler Syndrome become irreversible.

As this discourse on space debris concludes, I leave you with one quote uttered by the American astronaut, Neil Armstrong, while he stood where no man had been before: "One small step for man, one giant leap for mankind." Because of the unknown surrounding the exploration of outer space, this "one giant leap" cannot be measured. The opportunities for mankind are as endless as outer space itself. The need for enhanced legal frameworks and financial incentives for space debris salvage operations cannot be overlooked. As humans, we must ensure that we do not create or contribute to the barrier of space debris that will hinder our own maximization of this "one giant leap."

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[165] Sarah Douglas, *NASA Seeks Help From Public To Recycle Spacecraft Resources*, NASA (Apr. 27, 2022), https://www.nasa.gov/directorates/stmd/stmd-prizes-challenges-crowdsourcing-program/nasa-seeks-help-from-public-to-recycle-spacecraft-resources/#:~:text=As%20of%202021%2C%20the%20NASA%20Orbital%20Debris%20Program,residual%20fuels%20may%20be%20recycled%20for%20future%20use.

[166] *Id.*

[167] THOMAS COLVIN, ET AL., COST AND BENEFIT ANALYSIS OF ORBITAL DEBRIS REMEDIATION, 10 n.7 (Patrick Besha & Bo Naasz, eds. 2023).