THE TIME IS NOW: HOW THE UNITED STATES CAN LEAD ACTIVE DEBRIS REMOVAL EFFORTS

Denton Hunter and Quinn McKemey[*]

ABSTRACT

Satellites form an indispensable arm of critical infrastructure in the United States (US). Unfortunately, they face increased collision risk due to the increase in the debris population in low Earth orbit (LEO). The US must support and develop active debris removal (ADR) measures in order to assure the safety of satellites and continued access to orbit and beyond. Large debris objects, such as defunct rocket boosters and dead satellites, should be prioritized for ADR efforts to stabilize the debris environment. The US must work with the international community on a multilateral agreement for ADR as a long-term solution. In the meantime, it must recognize that ADR is urgently needed to address the existing threat debris poses to critical space assets and focus on immediate and attainable solutions. The US can accomplish this by implementing an "inverted" approach by executing a domestic, commercially-developed ADR demonstration that subsequently grows to involve international allies who share concerns about the debris population in LEO. Employing contractual agreements and Memorandums of

[*] Denton Hunter holds a B.A. in International Business from Mississippi State University and is a 2022 Juris Doctor candidate at the University of Mississippi School of Law. She would like to thank her family for their support as she closes out her life as a student. Quinn McKemey is a Graduate Certificate candidate at the University of Mississippi School of Law (2022) and Legal Fellow for the National Space Society. In 2020, he co-founded Clean Orbit, an advocacy non-profit focused on active debris removal. Quinn earned a Master in Business Administration from the University of Mississippi in 2019 preceded by a B.A. in Political Science in 2018 and would like to thank his family for your ceaseless support. Both authors would like to thank Professor Michelle Hanlon for the opportunity to write for the Journal of Space Law and continuing to push young people to use their voice on space issues, and Christiana Paissios for being instrumental in the editing process.

Understanding (MOU's) among involved parties can remove legal ambiguity regarding ownership and liability and will inform precedent for necessary international ADR efforts in the future. This model offers an immediate solution to an immediate problem that can enhance efforts to incentivize the growth of ADR investment.

I. INTRODUCTION

The National Aeronautics and Space Administration (NASA) defines orbital debris "as human-made objects in space that no longer serve a useful purpose, such as decommissioned satellites and parts of spacecraft."[1] This debris can remain in orbit for decades until it "decays, deorbits, explodes, or collides with another object thus creating more debris."[2] In fact, millions of orbital debris fragments orbit the Earth at high velocity due to both decades of launch activity and collisions among objects.[3] These fragments pose a mission-critical threat to space activities in low Earth orbit (LEO).[4] The United States (US) operates approximately half of the functioning spacecraft in LEO, and as a result the nation bears the greatest risk of sustaining major losses from satellite collisions with orbital debris.[5] In January 2021, an internal report from NASA's Office of the Inspector General (OIG) found that mitigation-only measures are no longer effective in stabilizing the debris environment in space.[6] Large debris objects, such as defunct rocket boosters and dead satellites, have the highest collision probability and should be prioritized for active debris removal (ADR) efforts in

---

[1] Office of Inspector General, NASA's Efforts to Mitigate the Risks Posed by Orbital Debris, NASA 1 (Jan. 27, 2021), https://oig.nasa.gov/docs/IG-21-011.pdf [hereinafter NASA's Efforts].

[2] *Id.*

[3] Paul M. Sutter, *Who's Going to Fix the Space Junk Problem?,* SPACE.COM (July 31, 2021), https://www.space.com/space-junk-growing-problem-complicated-solution. ("In Earth orbit, there are more than 23,000 objects larger than about 4 inches (10 centimeters), another half a million objects larger than about 0.4 inch (1 cm) and possibly 100 million more smaller than that . . .").

[4] *See* NASA Efforts, *supra* note 1, at 2.

[5] *Space Debris from Anti-Satellite Weapons,* UNION OF CONCERNED SCIENTISTS, https://www.ucsusa.org/sites/default/files/2019-09/debris-in-brief-factsheet.pdf.

[6] NASA's Efforts, *supra* note 1, at 14.

order to stabilize the debris environment as soon as possible.[7] However, legal uncertainty regarding ownership and liability in ADR activity under existing treaties such as the Outer Space Treaty[8] (OST) and Liability Convention[9] are often cited as prohibitively complicating rapid development of a market-ready solution for this pressing problem.[10]

The National Space Society (NSS) recommends the implementation of actions that can incentivize State parties and private entities to collaborate on rapidly developing ADR methods and use economic means to enable the creation of a new market for debris removal.[11] NASA's OIG report also recommends the NASA Administrator lead national and international efforts to mitigate debris by encouraging ADR through investment in relevant methodologies.[12] Given that the US considers continued access to space a vital interest of economic prosperity and national security,[13] the US—as the leading nation in space activity[14]—must not wait for lengthy negotiation for international agreements to clarify legal questions regarding the practice. The nation must, instead, focus on solutions that are achievable *now*.

Part II of this article provides an overview of the development of and challenges posed by orbital debris in LEO. Part III describes

---

[7] Tyler A. Way & Josef S. Koller, *Active Debris Removal: Policy and Legal Feasibility*, AEROSPACE CORP. (Apr. 2021), https://csps.aerospace.org/sites/default/files/2021-08/Way_Koller_ADR_20210422.pdf.

[8] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html [hereinafter Outer Space Treaty].

[9] Convention on the International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 961 UNTS 187 https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/liability-convention.html [hereinafter Liability Convention].

[10] US Space Policy Directive-3, Nat'l Space Traffic Mgmt. Pol'y, 83 FED. REG. 28969 PRESIDENTIAL MEMORANDUM, (June 18, 2018) [hereinafter SPD-3].

[11] *See Space Debris Removal, Salvage, and Use: Maritime Lessons*, NAT'L SPACE SOC'Y (Oct. 2009), https://space.nss.org/wp-content/uploads/NSS-Position-Paper-Space-Debris-Removal-2019.pdf.

[12] NASA's Efforts, *supra* note 1, at 4.

[13] SPD-3, *supra* note 10, at 28970.

[14] Nicolas Rapp & Brian O'Keefe, *50 Years After the Moon Landing, Money Races into Space*, FORTUNE (July 22, 2019), https://fortune.com/longform/space-program-spending-by-country/. In 2018, the US spent approximately $41 billion on space programs. This is more than 8 times the amount of the second highest-paying State (China, $5.8 billion).

existing ADR efforts and Part IV reviews relevant international law governing those efforts and how US domestic law fits in the international framework. Finally, in Part V we argue that the US must immediately initiate a domestic ADR demonstration with the ultimate goal of supporting collaboration with international allies – both from a legal and engineering standpoint – before offering some concluding thoughts in Part VI.

II. OVERVIEW OF THE ORBITAL DEBRIS CHALLENGE

A. How It Started

On October 4, 1957, Sputnik 1 became the first human-made object to launch into space and successfully orbit the Earth.[15] This launch also produced the first pieces of human-generated orbital debris—a nose cone and an empty rocket core stage.[16] While many space objects, including Sputnik 1, naturally disintegrate in the Earth's atmosphere in a relatively short time period, many do not. Vanguard I, launched only one year later, has remained in orbit for more than sixty years and continues to be the oldest human-made object in space.[17] Human activity in space has markedly increased in scope and frequency over the last seven decades, yet debris mitigation and remediation efforts remain limited at both national and international levels.[18] As a result, orbital debris, has also grown exponentially since the launch of Sputnik, a result of both "accumulating and increasing amounts of" space objects and "intentional and accidental collisions."[19]

The current debris population is generally broken down into three categories based on size.[20] Objects roughly ten centimeters (cm) and larger—ranging from softball-sized fragments to dead satellites as large as a school bus –number at least 26,000 in LEO

---

[15] Elizabeth Howell, *Sputnik: The Space Race's Opening Shot,* SPACE.COM (Sept. 29, 2020) https://www.space.com/17563-sputnik.html.

[16] NASA Video, *Space Policy and History Forum: The History and Politics of Space Junk*, YOUTUBE.COM (July 7, 2021), https://www.youtube.com/watch?v=yve597kNKbg.

[17] Alice Gorman, *60 Years in Orbit for 'Grapefruit Satellite'- The Oldest Human Object in Space*, THE CONVERSATION (Mar. 21, 2018), https://theconversation.com/60-years-in-orbit-for-grapefruit-satellite-the-oldest-human-object-in-space-93640.

[18] NASA's Efforts, *supra* note 1, at 14.

[19] *Id.* at 1.

[20] NASA's Efforts, *supra* note 1, at 3.

alone and pose a catastrophic threat to current space operations.[21] A 2020 survey by Darren McKnight of Centauri catalogued a top-50 list of "statistically most concerning" debris objects in LEO.[22] The top 20 objects in that master list are all a single class of upper stages known as SL-16, from the Zenit family of rockets.[23] These objects are considered to be the most pressing debris threat due to their size and the likelihood that they will create additional debris through collisions with other operational or defunct space objects.[24] There are at least another 500,000 objects that are between one and ten centimeters (marble-sized) which could result in mission-critical damage to space operations upon impact.[25] Debris fragments one millimeter and smaller number in the hundreds of millions and are too small and numerous to be tracked.[26] In fact, precise measurements of the debris population three millimeters and smaller in LEO are based solely on statistical probability.[27]

B. How It Grows

The character of space activity today is markedly different from the early 1960s. Space activities, once solely the purview of dual superpowers, are now executed by the more than 45 countries and international organizations that own or operate space assets.[28] Indeed, while governments may remain power players in the space industry, the current advancement of space technology is being driven by the private sector.[29] More actors, national and private, means more activities and while these activities provide

---

[21] *Id.*

[22] Jeff Foust, *Upper Stages Top List of Most Dangerous Space Debris*, SPACENEWS (Oct. 13, 2020), https://spacenews.com/upper-stages-top-list-of-most-dangerous-space-debris/; *See also*, Matthew Stevenson *et al.*, *Identifying the Statistically-Most-Concerning Conjunctions in LEO*, AMOSTECH (2021), https://amostech.com/TechnicalPapers/2021/Poster/Stevenson.pdf.

[23] Darren McKnight et al., Derelict Space Situational Awareness (SAA) for Free), AMOSTECH (2020), https://amostech.com/TechnicalPapers/2020/Poster/McKnight.pdf.

[24] *Id.*

[25] NASA's Efforts, *supra* note 1, at 8.

[26] Mark Garcia, *Space Debris and Human Spacecraft*, NASA (May 27, 2021), https://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

[27] NASA's Efforts, *supra* note 1, at 12.

[28] NASIC Public Affairs Office, *Competing in Space*, NASIC (Dec. 2018), https://media.defense.gov/2019/Jan/16/2002080386/-1/-1/1/190115-F-NV711-0002.PDF.

[29] *Id.*

innumerable benefits to humanity, they all have the potential to contribute, whether purposefully or inadvertently, to potentially catastrophic orbital debris scenarios.

i. Collisions

Collisions of larger debris objects create numerous smaller fragments and contribute significantly to the debris population when they occur.[30] The impact of Russia's Cosmos 2251 with the Iridium 33, a satellite regulated by the United States, exemplifies the danger of debris production from a singular event involving large objects.[31] On February 10, 2009, the two objects crashed into each other, resulting in over 2,000 fragments of debris.[32] Only 89 of these fragments have vaporized upon atmospheric reentry[33] and NASA estimates that more than half of the debris from the collision will remain in orbit for at least another century.[34] Successful ADR combined with accurate tracking mechanisms could prevent any future large collisions. Quick deployment of such technology could remove inoperable spacecraft before any incidents occur.

ii. Anti-Satellite (ASAT) Weapon Testing

Debris congestion in LEO is also the result of deliberate actions by spacefaring nations.[35] While some objects - such as rocket boosters - are intentionally left behind after fulfilling their purpose, these detachments are planned and currently a necessary part of

---

[30] A.B. Kiselev & V.A. Yarunichev, *A Study on the Fragmentation of Space Debris Particles at High-Speed Collision*, 2 UNIV. SER. 1. MAT. MEKH. 25 (2009), http://www.mathnet.ru/php/archive.phtml?wshow=paper&jrnid=vmumm&paperid=856&option_lang=eng.

[31] Brian Weeden, 2009 Iridium-Cosmos Collision Fact Sheet, SECURE WORLD FOUND. (Nov. 10, 2010), https://swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf.

[32] Guy Faulconbridge, *U.S. and Russia track satellite crash debris*, REUTERS, (Feb. 12, 2009).

[33] *China Debris Reaches New Milestone*, 14 ORBITAL DEBRIS QUARTERLY NEWS 4, (Oct. 2010).

[34] TS, Kelso, Analysis of the Iridium 33 and Cosmos 2251 Collision, Advanced Maui Optical and Space Surveillance Conference (Sep. 2009), http://www.centerforspace.com/downloads/files/pubs/AMOS2009.pdf.

[35] *Space Debris and Human Spacecraft*, NASA (May 26, 2021), https://www.nasa.gov/mission_pages/station/news/orbital_debris.html.

take-off operations within the constraints of current technology.[36] Moreover, these boosters were predominantly launched before 2000, when countries began adopting international orbital debris mitigation guidelines.[37] Anti-Satellite (ASAT) testing, however, is conducted intentionally by nations using ground-based, missile-intercept technology and is a major contributor to the debris population in LEO.[38] Only four countries – the US, Russia, China and India – have performed ASAT operations.[39] Initial ASAT testing began in the early 1960's by the US and former USSR before being largely phased out by April 1975.[40] Due to the financial burdens and ineffectiveness, many programs slowed after the Cold War, but did not halt the development of ASAT capability altogether.[41]

More recent ASAT tests conducted by China and India have drawn concern from the international community regarding their contribution to the debris environment.[42] During a singular test in 2007, China purposely destroyed the Fengyun-1C weather satellite and created 3,400 pieces of debris – one-sixth of all current trackable debris in orbit.[43] While the nation has stated it may move to debris-free" tests due to the resulting international outrage, more than half of the debris stemming from this single action will remain in orbit through 2027.[44]

India also recently joined the short list of countries to test an ASAT weapon.[45] However, their 2019 test seemed to indicate an effort to mitigate debris generation. For this demonstration, India

---

[36] *Id*.

[37] Foust, *supra* note 22.

[38] Milton Leitenberg, *Studies of Military R&D and Weapons Development*, SCH. PUB. POL'Y (Jan. 1, 1984), https://fas.org/man/eprint/leitenberg/asat.pdf.

[39] Justin George*, History of Anti-Satellite Weapons: US Tested 1st ASAT Missile 60 Years Ago*, THE WEEK (Mar. 27, 2019), https://www.theweek.in/news/sci-tech/2019/03/27/history-anti-satellite-weapon-us-asat-missile.html.

[40] *Id*. *See also*, Laura Grego, *A History of Anti-Satellite Programs*, UNION OF CONCERNED SCIENTISTS, 2 (Jan. 2012), https://www.ucsusa.org/sites/default/files/2019-09/a-history-of-ASAT-programs_lo-res.pdf.

[41] *Id*.

[42] Mike Gruss, US Official: China Turned to Debris-free ASAT Tests Following 2007 Outcry, SPACENEWS (Jan. 11, 2016), https://spacenews.com/u-s-official-china-turned-to-debris-free-asat-tests-following-2007-outcry/.

[43] *Id*.

[44] *Id*.

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

chose to launch a small satellite into a low altitude orbit specifically for this test.[46] The ASAT missile intercepted it in a downward trajectory back towards the Earth's atmosphere, allowing most of the debris to burn up shortly thereafter.[47] While increased mitigation measures were undertaken compared to previous ASAT tests, the impact still created over 60 pieces of trackable debris, half of which reached altitudes higher than that of the International Space Station (ISS).[48]

The most recent ASAT test, conducted by Russia on November 15, 2021, saw pushback and condemnation from around the international community.[49] In taking down a defunct satellite, the projectile debris threatened numerous other spacecraft, including the ISS, forcing all seven residing astronauts to take cover – two of which were Russian nationals.[50] In response, many countries and private companies reiterated calls for a halt to international ASAT tests[51] The repeated practice of such tests further inhibits the ability to stabilize the debris environment, and international consensus regarding their discontinuation will be a critical part of debris remediation.

iii. Satellite Breakups & Explosions

Satellites occasionally break up due to design malfunctions or explosions.[52] ADR could prevent these break-ups and the large amounts of debris they create by removing them from orbit when they show signs of deterioration.[53] In March 2021, a polar-orbiting

---

[46] *Id*.

[47] *Id*.

[48] Sarah Lewin, *India's Anti-Satellite Test Created Dangerous Debris*, NASA Chief Says, Space.com (Apr. 1, 2019), https://www.space.com/nasa-chief-condemns-india-anti-satellite-test.html

[49] Chelsea Gohd, *Russian Anti-Satellite Missile Test Draws Condemnation from Space Companies and Countries*, SPACE.COM (Nov. 22, 2021), https://www.space.com/crussian-anti-satellite-missile-test-world-condemnation.

[50] *Id*.

[51] Nivedita Raju, *Russia's anti-satellite test should lead to a multilateral ban*, SIPRI.COM (Dec. 7, 2021), https://www.sipri.org/commentary/essay/2021/russias-anti-satellite-test-should-lead-multilateral-ban.

[52] V. Braun et al., *Analysis of Breakup Events*, ESA SPACE DEBRIS OFF. (Apr. 18, 2017), https://conference.sdo.esoc.esa.int/proceedings/sdc7/paper/1005/SDC7-paper1005.pdf.

[53] NASA's Efforts, *supra* note 1, at 17.

weather satellite NOAA-17 broke up for reasons unknown.[54] Two years prior, several of the US Air Forces' weather satellites broke up due to a battery malfunction, creating at least 147 pieces of large debris.[55] These satellites were allowed to remain in orbit even after there were known technical issues that could lead to potential break-ups.[56] This is further complicated as many satellites have leftover, pressurized propellant that could explode due to increase in pressure over time or impact with pieces of debris.[57]

iv. Satellite Constellations

The number of satellites occupying LEO is about to exponentially increase without any developed ADR methodology for effectively removing the existing craft congesting the orbital zone.[58] Driven by the push to bring global populations high-speed broadband internet at affordable prices, several companies are planning to launch artificial constellations of satellites.[59] These are groups of small satellites working together as a unified system to provide global internet coverage to remote places on Earth.[60] While satellites are not the sole cause of orbital debris, satellite constellations are relevant to the debris environment due to the unprecedented number of satellites planning to be launched in the coming decade.[61] SpaceX's Starlink program received approval from the FCC in 2018 to launch 11,943 satellites, 4,500 of which are expected to be in orbit by 2024.[62] Similarly, Blue Origin and OneWeb are two

---

[54] Jeff Foust, *Decommissioned NOAA Weather Satellite Breaks Up*, SPACENEWS (Mar. 20, 2021), https://spacenews.com/decommissioned-noaa-weather-satellite-breaks-up/.

[55] Mike Wall, *To Control Space Junk, Remove 5 Pieces a Year, Experts Say*, NBCNEWS (Feb. 27, 2012), https://www.nbcnews.com/id/wbna46542521.

[56] *Id*.

[57] NASA's Efforts, *supra* note 1. *See also*, Foust, *supra* note 22.

[58] Foust, *supra* note 22.

[59] David Jarvis, *The Satellite Broadband Industry is Moving at Hyperspeed*, DELOITTE.COM (Feb. 19, 2020), https://www2.deloitte.com/us/en/insights/industry/technology/future-of-satellite-internet.html.

[60] STARLINK.COM, https://www.starlink.com/ (last visited Sept. 18, 2021).

[61] NASA's Efforts, *supra* note 1, at 38.

[62] Michael Sheetz, *SpaceX Looks to Build Next-Generation Starlink Internet Satellites after Launching 1,000 So Far*, CNBC (Jan. 29, 2021), https://www.cnbc.com/2021/01/28/spacex-plans-next-generation-starlink-satellites-with-1000-launched.html.

of the many competitors poised to occupy this coveted space in orbit as well.[63]

Initial independent studies find that the likelihood of collisions will rise in correlation to the number of objects occupying LEO.[64] This is after SpaceX has placed only 1,500 of its Starlink satellites in orbit, a meager figure compared to the company's total goal.[65] By the time Starlink completes its project in 2027, it will have launched up to 42,000 satellites, 20 times the current number of operational objects in orbit.[66] This figure is dwarfed by the filings made for other satellite constellations, including 115,000 satellites for Canadian company Kepler and another 327,000 satellites proposed by the Rwandan government.[67] ADR technologies would enable these entities to better service their multitude of satellites, preventing malfunction and subsequent damage to nearby objects from large pieces created by occasional impact or breakup.[68] This is critical in the absence of an international enforcement framework for regulating orbital congestion.[69] Thus, time is an essential variable if the US wants to develop a domestic ADR technology that matches

---

[63] Kellen Beck, *SpaceX vs. Amazon: Where We're at In the Internet Space Race*, MASHABLE INDIA (Mar. 2021), https://in.mashable.com/science/20837/spacex-vs-amazon-where-were-at-in-the-internet-space-race.

[64] Morgan McFall-Johnsen, *SpaceX's Starlink Internet Satellites Could Make Astronomy on Earth 'Impossible' and Create a Space-junk Nightmare, Some Scientists Warn*, INSIDER (Nov. 15, 2019), https://www.businessinsider.com/spacex-starlink-satellites-risks-astronomy-space-junk-2019-11.

[65] Jeff Foust, *SpaceX Continues Starlink Deployment with Latest Launch*, SPACENEWS (May 4, 2021), https://spacenews.com/spacex-continues-starlink-deployment-with-latest-launch/#:~:text=Nearly%201%2C500%20Starlink%20satellites%20are,license%20modification%20sought%20by%20SpaceX.

[66] Morgan McFall-Johnsen, *SpaceX's License to Launch Hundreds of Internet Satellites May Have Violated the Law, Experts Say. Astronomers Could Sue the FCC*, INSIDER (Jan. 22, 2020), https://www.businessinsider.com/spacex-starlink-satellite-license-fcc-environmental-law-2020-1.

[67] Jeff Foust, *Satellite Operators Criticize "Extreme" Megaconstellation Filings*, SPACENEWS (Dec. 14, 2021), https://spacenews.com/satellite-operators-criticize-extreme-megaconstellation-filings.

[68] Harriet Brettle et al., *Assessing Debris Removal Services for Large Constellations*, ESA SPACE DEBRIS OFF. (2021), https://conference.sdo.esoc.esa.int/proceedings/sdc8/paper/74.

[69] Foust, *supra* note 67.

pace with innovative private enterprise and the increasing threat of spacecraft collisions.[70]

v. Kessler Syndrome

All of these concerns are compounded by the Kessler Syndrome, a theory proposed in 1978 by NASA scientist Donald J. Kessler upon his observation of spent Delta rockets creating clouds of shrapnel upon exploding in the upper atmosphere.[71] Kessler identified the risk of a self-sustaining, exponential increase in space debris stemming from collisions, and theorized a resulting "self-sustaining cascade of collisions."[72] This cascade can create a field of debris so thick that space activity in LEO and beyond would be rendered impossible or economically infeasible.[73] Also known as collisional cascading, Kessler hypothesized that this process would begin to occur gradually once orbital debris concentration reaches critical mass, a point where derelict objects could begin colliding with one another unprompted by the introduction of additional debris.[74] The debris would eventually form a belt of these fragmented objects, making access to Earth's orbit and outer space impossible.[75]

While Kessler initially estimated that it would take thirty to forty years to reach such a threshold,[76] NASA has reported that

---

[70] Harriet Brettle et al., *Assessing Debris Removal Services for Large Constellations*, ESA SPACE DEBRIS OFF. (2021), https://conference.sdo.esoc.esa.int/proceedings/sdc8/paper/74.

[71] Judy Corbett, *Micrometeoroids and Orbital Debris (MMOD)*, NASA (June 14, 2016), https://www.nasa.gov/centers/wstf/site_tour/remote_hypervelocity_test_laboratory/micrometeoroid_and_orbital_debris.html. *See* Donald J. Kessler & Burton G. Cour-Palais*, Collision Frequency of Artificial Satellites: The Creation of a Debris Belt, 83* J. OF GEOPHYSICAL RSCH.: SPACEPHYSICS*,* 2637 (1978), https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/JA083iA06p02637; *See also,* Donald J. Kessler et al., *The Kessler Syndrome: Implications to Future Space Operations,* AM. AUSTRONAUTICAL SOC'Y *(Feb. 10, 2010),* https://www.threecountrytrustedbroker.com/media/kesseler_syndrome.pdf.

[72] Kelly Kizer Whitt, *Kessler Syndrome of Colliding Satellites Could Make Low-Earth Orbit Unusable,* EARTHSKY (Nov. 15, 2021), https://earthsky.org/human-world/kessler-syndrome-colliding-satellites/#:~:text=Kessler%20syndrome%3A%20A%20scenario%20in,the%20likelihood%20of%20further%20collisions.

[73] *See* Nodir Adilov et al., *Economic Dynamics of Orbital Debris: Theory and Application,* FIRST INT'L ORBITAL DEBRIS CONF. (2019) https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6072.pdf.

[74] *Id.*

[75] *Id.*

[76] Corbett, *supra* note 71.

LEO might be already at critical mass, suggesting the conditions for a disastrous collisional cascade are already present.[77] The need for action is therefore immediate to urgently combat the unfolding effects before they become too costly to fix.

B. The Role of Satellites in the US

The US relies heavily on satellites and their ability to augment daily life through military, civilian, and dual-use applications.[78] This reliance on space capability will increase as in-space manufacturing, satellite servicing, space tourism and satellite constellations emerge over the next decade.[79] The way space technology has enabled multiple aspects of America's modern society underscores the immediate need for domestic ADR efforts in light of the growing debris problem.[80]

Among other things, satellites are utilized to direct and inform military efforts on the ground.[81] Roughly 13% of the satellites in orbit are owned and operated by militaries worldwide and provide services such as communication, navigation and remote sensing.[82] One-tenth of these military satellites are operated by the US Department of Defense, and the country accounts for 49% of all active space objects as of April 2020.[83] While the US military seeks to protect its space assets, these activities consist of mitigation measures via tracking and collisional avoidance maneuvers and do not include any ADR concepts for debris remediation.[84]

---

[77] *Id.*; Paul Ratner, *How the Kessler Syndrome Can End All Space Exploration and Destroy Modern Life*, BIG THINK (Aug. 29, 2018), https://bigthink.com/paul-ratner/how-the-kessler-syndrome-can-end-all-space-exploration-and-destroy-modern-life.

[78] Linda Haller and Melvin Sakazaki, *Commercial Space and United States National Security*, FAS, https://spp.fas.org/eprint/article06.html.

[79] SPD-3, *supra* note 10.

[80] *Id.* These efforts can be multilateral through regulation, the creation of more robust legal frameworks and the creation of incentives for the private sector to participate.

[81] Outer Space Treaty, *supra* note 8.

[82] Therese Wood, *Who Owns Our Orbit: Just How Many Satellites are There in Space?*, WORLD ECON. F. (Oct. 23, 2020), https://www.weforum.org/agenda/2020/10/visualizing-easrth-satellites-sapce-spacex/#:~:text=Right%20now%2C%20there%20are%20nearly,globe%20in%20April%20of%202020.

[83] Therese Wood, *Visualizing All of Earth's Satellites: Who Owns Our Orbit?,* VISUAL CAPITALIST (Oct. 20, 2020), https://www.visualcapitalist.com/visualizing-all-of-earths-satellites/.

[84] NASA's Efforts, *supra* note 1.

Sixty-one percent of Earth's operational satellites are owned by the private sector and play an essential role in administering many of the comforts of the modern world.[85] These assets provide communications necessary for network and cable television, in addition to the mobile phones that are now ubiquitous in day-to-day life.[86] Another twenty-seven percent of active satellites are for Earth Observation, such as monitoring extreme weather systems and long-term climate trends.[87] The US benefits tremendously from these services as it operates half of these satellites while the next closest competitors, China and Russia, operate 13% and 6% of satellites, respectively.[88]Dual-use examples include satellite capabilities such as navigation and remote sensing, which have significant use in both civilian and military applications.[89] The future operating environment in LEO will be defined by the increase in volume of these activities along with those specific to military and commercial capability for the benefit of public life.[90] This will only be possible, however, if we stabilize the debris population in LEO such that the risk of collision continues to pass basic cost-benefit analysis.

Imagine the economic implications if major businesses suddenly lost access to the internet or Zoom during the COVID-19 pandemic. In the case of singular failure, other satellites could provide the necessary signals to maintain services; however, if multiple satellites went offline simultaneously the result would be catastrophic. To protect its significant stake and interest in space assets, the US should focus efforts toward immediately collaborating on a domestic, commercially-developed ADR demonstration that can lay the groundwork for future collaboration at the international level. There is clearly an immediate need for ADR technology and models from NASA's Orbital Debris Program Office suggest we can stabilize the debris environment in space by removing just five large objects from LEO each year.[91]

---

[85] Wood, *supra* note 82; *See also*, *The Impact of Space Activities Upon Society*, ESA, 2-3 (Feb. 2005), http://www.esa.int/esapub/br/br237/br237.pdf.

[86] The Impact of Space Activities Upon Society, *supra* note 85.

[87] Wood, *supra* note 82.

[88] Wood, *supra* note 83.

[89] *Id.*

[90] SPD-3, *supra* note 10.

[91] *Debris Remediation*, NASA, https://orbitaldebris.jsc.nasa.gov/remediation/.

III. EFFORTS IN PLACE

According to the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) Space Debris Mitigation Guidelines, solutions to the orbital debris problem exist in two categories: mitigation and remediation efforts.[92] Mitigation methods are attempts to reduce the creation of additional debris to the fullest extent possible by tracking debris objects, enhanced craft design and post-mission disposal.[93] While mitigation is centered around limiting the risk and creation of additional debris, remediation is equally important and involves removing space objects using ADR.[94]

There are various potential ADR remediation concepts currently in development.[95] The tested capabilities are diverse, ranging from electrodynamic tethers, lasers and nets, to attaching deorbit kits to existing crafts and utilizing nets and other grappling objects.[96] There are also multiple nations working on these solutions such as the European Space Agency's (ESA) ClearSpace[97] to the Japan Aerospace Exploration Agency's (JAXA) collaboration with Astroscale on ELSA-d.[98] Aside from end-of-life disposal, all remediation projects currently being developed are in the early stages of testing and demonstration, meaning that a market-ready solution for this immediate problem does not exist.[99] Although the US Space Force's Orbital Prime program has recently signaled aggressive plans to collaborate with private companies on an ADR

---

[92] UN Off. for Outer Space Aff., *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space* (Vienna; United Nations 2010), https://www.unoosa.org/pdf/publications/st_space_49E.pdf.

[93] *Id*.

[94] SPD-3, *supra* note 10.

[95] C. R. Phipps et al., *Removing Orbital Debris with Lasers*, SCIENCEDIRECT.COM (Oct. 2011), https://www.researchgate.net/publication/51946228_Removing_Orbital_Debris_with_Lasers.

[96] *Id*.

[97] *ESA Commissions World's First Space Debris Removal*, ESA (Sept. 12, 2019), https://www.esa.int/Safety_Security/Clean_Space/ESA_commissions_world_s_first_space_debris_removal.

[98] Elsa-d (End-of-Life Service by Astroscale)-d (Demonstration), Sharing Earth Observation Res., https://directory.eoportal.org/web/eoportal/satellite-missions/content/-/article/elsa-d#launch (last visited Sept. 23, 2021).

[99] *Id*.

demonstration within three years,[100] the US is otherwise falling behind its allies in developing ADR commensurate with its dependence on space technology for its services.[101]

IV. THE LAW

A. Current International Legal Regulation

The current international legal regime inhibits collaboration among States on ADR efforts by complicating ownership and liability assessment of space objects.[102] The following sections analyze existing legal obligations through the lens of our suggested inverted approach, starting with a domestic ADR perspective that grows to encompass a close international ally with a shared interest in the debris problem.

i. The Outer Space Treaty

The OST was adopted by the United Nations and entered into force in October 1967.[103] The treaty serves as the basic framework for international space law. This Cold War-era agreement seeks to bar the militarization of space and encourage peaceful purposes in the uses of space and celestial bodies but does little to provide guidance on the debris problem.[104]

The sections of the OST most applicable to ADR are Articles VI, VII, VIII. Article VI outlines international responsibility for national activities in outer space, holding government agencies and non-governmental entities of State Parties accountable for actions taken in space.[105] In the case of a domestic ADR effort consisting entirely of US-based entities, the commercial entity performing the mission and the US would clearly bear responsibility for any actions taken at the international level. The same would apply under

---

[100] Sandra Erwin, *Space Force wants to Help Fund Technologies to Recycle, Reuse or Remove Space Debris*, SPACENEWS (Jan.5, 2022), https://spacenews.com/space-force-wants-to-help-fund-technologies-to-recycle-reuse-or-remove-space-debris/.

[101] Sandra Erwin, *Space debris expert warns U.S. 'woefully behind' in efforts to clean up junk in orbit*, SPACENEWS (Jan. 6, 2022), https://spacenews.com/space-debris-expert-warns-u-s-woefully-behind-in-efforts-to-clean-up-junk-in-orbit/.

[102] *Id.*

[103] Outer Space Treaty, *supra* note 8.

[104] *Id.* at annex.

[105] *Id.* at art. VI, VII, and VIII.

Article VII which holds the launching State accountable for any damage inflicted upon another State or its assets.[106] An entirely domestic project would not implicate the OST provisions and thus, the US can enter into contractual arrangements outlining liability obligations among the parties. However, care will have to be taken to ascertain liability should the ADR platform itself cause damage to another State whether on-orbit or on Earth as the US would be liable to another country in that event. We recommend that such liability be addressed through a risk sharing mechanism much like those set forth in launch licensing procedures.[107]

The UN 1971 Convention on International Liability for Damage Caused by Space Objects (Liability Convention)[108] extrapolated from Articles VI and VII of the OST in terms of liability assessment. Article II of the Convention in particular holds launching States "absolutely liable" for any damage caused by a space object and Article IV extends that liability to persons of the State or a joint-launching State.[109] Liability assessment is of critical importance especially when considering the recent uncontrolled re-entry of a Russian rocket stage in January 2022 that failed to burn up in the atmosphere and ultimately crashed in the Pacific Ocean.[110] Considering the vast majority of large space objects are owned by governments,[111] the launching States themselves could assume liability for the actions of the commercial ADR service provider, offering liability protection up to a government-determined amount and minimizing the legal risk profile for the operator.[112] Taken as a whole, relevant articles from the OST and Liability Convention combined with a detailed contractual agreement or Memorandum of Understanding (MOU) that addresses remaining questions regarding liability and ownership could pave the way for international cooperation on remediation of large debris objects.[113] This would be

---

[106] *Id.* at art. VII.

[107] 14 CFR Ch. III, Subch. C, Pt. 413.

[108] Outer Space Treaty, *supra* note 8, at art. VI-VIII. *See also*, Liability Convention, *supra* note 9.

[109] Outer Space Treaty, *supra* note 8, art. IV.

[110] Kate Hunt et al, *Russian rocket stage makes uncontrolled entry into Earth's atmosphere*, CNN (Jan. 5, 2022), https://www.cnn.com/2022/01/05/world/russia-rocket-uncontrolled-reentry-scn/index.html.

[111] Foust, *supra* note 22.

[112] Way & Koller, *supra* note 7.

[113] *Id.*

especially true if the US could partner with a close ally that has shown express interest in ADR, such as JAXA and the ESA (both of which own boosters listed in the aforementioned top-50 "most statistically concerning" space objects).[114]

Article VIII of the OST also has applications to ADR as it states any launched object registered to a State Party will remain under the jurisdiction and ownership of that State.[115] There are countless examples of commercial launch companies providing services, such as payload delivery, without assuming ownership of that payload itself.[116] This indicates that ownership transfer is not necessary to provide services in space and could theoretically permit an ADR service provider to remove a given object, especially if a contractual agreement between the two offered express consent for the service.[117]

While it has been proven that removing a defunct object from orbit does not necessarily require a change in ownership, in the same sense that a tow truck does not assume ownership of an automobile using its services or a tug boat doing the same for an ocean freight liner, the transfer of liability remains a point of contention.[118] A domestic ADR initiative between a service provider and the federal government can assess the extent of liability for all parties involved in a contractual agreement.[119] If the debris object scheduled for removal is a rocket booster owned by the US government, the US could assume international liability as the launching State to diminish the liability and financial risk for the ADR provider. In turn, the State is entitled to rigorous technical inspection of the ADR service provider's technology.[120] A system in which the launching State provides liability coverage in exchange for government inspection would promote commercial development and minimize risk exposure for all parties.

---

114 Foust, *supra* note 22.
115 Liability Convention, *supra* note 9.
116 *Id.*
117 *Id.*
118 Way & Koller, *supra* note 7.
119 *Id.*
120 *Id.*

ii. Artemis Accords

While not international law, the Artemis Accords expand on several concepts posited in the OST and offer principles and guidelines to provide a framework for future international agreements.[121] Section 12 of the Artemis Accords addresses debris and commits Signatories to plan for mitigation efforts through post-mission disposal, explicitly assigning primary responsibility for disposal in the event of cooperative missions.[122]

Noticeably absent, however, are any measures encouraging ADR efforts by any State party or international coalition,[123] which underscores the need for urgent action in this area if we are to ensure the continued safety and reliability of space assets. Subsequent international policies governing ADR should be pursued but only in the interest of facilitating a long-term solution as the time required for such an effort does nothing to address the immediate problem.[124] These authors argue the focus should be on establishing a rough baseline for best practices through a domestic-led demonstration until international consensus can become law.

B. United States Law and Regulation

As signatories of international treaties, the US follows and implements international law into its own regulations. Article VI of the OST requires State Parties to provide "continuous supervision" over the entities operating within the State.[125] This provision is enforced by domestic policy initiatives as well as federal agencies. No federal agency specifically governs ADR but all have authority over certain aspects of the practice. While international treaties serve as

---

[121] Chelsea Gohd, *Brazil Makes History in Signing the Artemis Accords for Moon Exploration*, SPACE.COM (June 15, 2021), https://www.space.com/brazil-signs-artemis-accords-moon-exploration; *see also*, National Space Society, *ISDC 2021 Sunday Session 1: Perspectives on the Artemis Accords*, YOUTUBE.COM (June 27, 2021), https://youtu.be/k4FpFZWJsGY [hereinafter 2021 NSS ISDC].

[122] *The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes*, NASA, https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf [hereinafter Artemis Accords].

[123] *Id.*

[124] Way & Koller, *supra* note 7.

[125] Outer Space Treaty, *supra* note 8.

the foundation of US obligations, these internal regulations hold the US space industry to a higher standard.[126]

i. US SPD-3

On June 18, 2018, SPD-3 was announced outlining a new national STM policy to build on the ODMSP.[127] Presidential Directives, which are not law, are considered policies regarding national security and "carry the force and effect of the law."[128] The directive outlined and is notable for explicitly addressing the need for ADR efforts as a matter of national interest.[129] "The United States should pursue active debris removal as a necessary long-term approach to ensure the safety of flight operations in key orbital regimes. This effort should not detract from continuing to advance international protocols for debris mitigation associated with current programs."[130] This is a clear call by the administration to engage the international community in implementing debris remediation measures that incentivize ADR. Unfortunately, SDP-3 has done little to move the conversation forward regarding ADR methods in the years since both at domestic and international levels.[131]

ii. US ODMSP

In November 2019, the United States updated its ODMSP through the National Space Council.[132] Much of these updates fell in line with other international standards, such as the 25-year post-

---

[126] NASA's Efforts, *supra* note 1 (NASA has a 96% compliance rate for post-mission disposal within 25 years compared to a global compliance rate between 20-30%).

[127] SPD-3, *supra* note 10.

[128] *Presidential Directives*, SCI. SAFETY SEC., https://www.phe.gov/s3/law/Pages/Directives.aspx#:~:text=Presidential%20Directives%20are%20a%20specific,requirements%20for%20the%20Executive%20Branch (last visited Sept. 8, 2021).

[129] *Id*. § 5(a)(iii).

[130] *Id*. §§5(a)(iii) & 5(b).

[131] Caleb Henry, *FCC Punts Controversial Space Debris Rules for Extra Study*, SPACENEWS (Apr. 23, 2020), https://spacenews.com/fcc-punts-controversial-space-debris-rules-for-extra-study/.

[132] *See* US Government Orbital Debris Mitigation Standard Practices, NASA (2019), https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf. *See also* J.C. Liou, *The 2019 US Government Orbital Debris Mitigation Standard Practices*, NASA (Feb. 14, 2020), https://www.unoosa.org/documents/pdf/copuos/stsc/2020/tech-24E.pdf. The ODMSP is created and pushed through by the National Space Council and the Office of Space Commerce.

mission deorbit requirement.[133] Objective 5-4: *Safety of Active Debris Removal Operations* requires that any ADR effort should limit the risk of additional debris creation through fragmentation, collision, or explosion resulting from operations.[134] Outside of this singular section, the ODMSP offers little insight on incentivizing ADR and is considered inadequate for largely focusing on mitigation activities alone.[135]

While the updated ODMSP seeks to mitigate the risk of explosion by mandating depletion of propellant and batteries as part of post-mission disposal, many satellites made before mitigation guidelines remain in orbit.[136] Moreover, compliance with the guidelines remains a challenge considering only 70% of rocket stages adhered to the NASA Orbital Debris Mitigation Standard Practices (ODMSP) standards as of 2019 (that number was 20% in 2000).[137] This indicates a need to incentivize compliance with mitigation practices to limit the creation of additional debris as much as possible before ADR has a chance to fully develop.[138]

iii. Federal Agencies

The US enforces provisions of the OST relating to ADR through various federal agencies including the Federal Aviation Administration (FAA), Federal Communications Commission (FCC) and the National Oceanic and Atmospheric Association (NOAA). The FAA has authority over launches and re-entry which will cover the launch of an ADR service provider.[139] l The FCC plays a larger role by comparison as it pertains to communications and spectrum.[140] As most satellites require spectrum to operate, the FCC has become the de facto regulator where there is jurisdictional ambiguity.[141] The agency requires those obtaining a launch license to show proof of compliance with international and national

---

[133] *Id.*
[134] *Id.*
[135] SPD-3, *supra* note 10.
[136] *Id.*
[137] *Id.*
[138] NASA's Efforts, *supra* note 1.
[139] Way & Koller, *supra* note 7.
[140] *Id.*
[141] *Id.*

regulations.[142] These requirements encompass disclosure of probability of successful craft disposal, collision risk,[143] adherence to the ODMSP, and having indemnity insurance to protect the US from liability.[144] In April 2020, the FCC began accepting feedback from the industry on the proposed new rules for the *Mitigation of Orbital Debris in the New Space Age,* which became effective by September.[145] In these new rules, the FCC failed to implement more strict regulations such as shortening the 25-year post-mission disposal timeline, which leaves countless of defunct spacecraft congesting Earth orbits long after their useful life.[146]. Additionally, while the new rule discussed ADR methods, it postponed creating specific regulations so early in development.

In order to address a severe deficiency in legal guidance on ADR activities at both the domestic and international level, the US needs to initiate cooperation with congress, federal agencies and State parties to the UN to update legal regimes so they may incentivize debris removal methods.[147] The production of such guidelines will take time but should serve as a parallel effort to a domestic ADR initiative that can begin laying the groundwork on best practices immediately.

V. SOLUTIONS

Despite the lack of legal regimes at the international level governing space debris and its removal, there is consensus among States that debris poses a threat to space activity as a whole.[148] Given the urgency of the problem, the following section will outline solutions and frameworks for combating the problem immediately.

The most immediate solution would be a domestic ADR initiative consisting of government and private sector partners. As

---

142 *Id.*

143 Henry, *supra* note 131.

144 Outer Space Treaty, *supra* note 8, art. VII. The requirement for insurance is only up to certain point, and the US would be liable for paying the remainder.

145 Mitigation of Orbital Debris in the New Space Age: Final Rule, 85 FR 52422, (2020), https://www.federalregister.gov/documents/2020/08/25/2020-13185/mitigation-of-orbital-debris-in-the-new-space-age.

146 Theresa Hitchens, *FCC Reconsiders Tightening 25-year Deadline for Space Junk Disposal*, BREAKINGDEFENSE (Apr. 23, 2020), https://breakingdefense.com/2020/04/fcc-reconsiders-tightening-25-year-deadline-for-space-junk-disposal/

147 NASA's Efforts, *supra* note 1.

148 2021 NSS ISDC, *supra* note 121.

discussed previously, if Articles VI, VII and VIII from the OST and Articles II and IV of the Liability Convention are observed, combined with a detailed contractual agreement or MOU that addresses remaining questions regarding liability and ownership, such demonstration would be permissible under present legal regimes.[149] The only burden at which point would be development time and cost.

To set precedent of future ADR practice and international cooperation, the US would be best served targeting a close ally with a mutual interest in the debris population for collaborative efforts.[150] Multiple signatories to the Artemis Accords (a US-led initiative) have ADR concepts currently in development and would be prime candidates for international cooperation.[151]

One obstacle frequently cited as a hindrance to this type of collaboration is the dual use of ADR as a potential ASAT weapon or device capable of extracting privileged information. While a valid concern, a contract based on mutual consent between two State parties would clearly delineate prohibited and authorized actions while provisions of the OST would determine liability.[152] An important counter to this notion is an expressed emphasis on transparency and accountability, such that one day even Russia and China would be willing to collaborate on ADR efforts in the longer term.[153]

In October, 2019, the National Space Society (NSS) recommended actions that would incentivize State parties and private entities to collaborate on rapidly developing ADR methods and using economic means to enable the creation of a new market for in-orbit servicing of satellites and debris removal.[154] The NSS suggests decision-makers could look to maritime law when considering space debris regulations.[155] While not a definitive one-to-one comparison, maritime and space operations share enough similarities that

---

[149] Way & Koller, *supra* note 7.
[150] *Id*.
[151] ESA Commissions World's First Space Debris Removal, *supra* note 87.
[152] Way & Koller, *supra* note 7.
[153] *Id*.
[154] Space Debris Removal, Salvage, and Use: Maritime Lessons, *supra* note 11.
[155] *Id*.

maritime law can be used to inform decisions regarding space debris.[156] Orbital debris is not confined to a singular location, which is analogous to debris caused by ocean failures such as sunken vessels, downed planes, and oil spills.[157] As space activities progress, they will somewhat resemble current maritime operations where human-made structures (think oil rigs versus space stations) are built and serviced by mobile vessels.[158] The space tourism industry could also echo maritime tourism through spacewalks in lieu of deep-sea diving, or weeklong orbital flights instead of cruising on an ocean liner.[159] The commercialization of LEO and the development of a large space economy requires assurances of safety and risk mitigation for investors.[160] Keeping orbital zones free of debris obstruction will encourage private investment and public support.[161]

Using maritime salvage law to inform orbital debris regulations could also aid in assigning liability assessment by interpreting defunct objects and other debris as salvage.[162] Drawing from historical practices dating back to ancient Phoenicians, Romans and Greeks, this tradition rewarded commercial salvors special compensation for clearing wrecks or other environmental hazards from shipping lanes and rescuing imperiled or damaged vessels.[163] Salvors would assume the liability in so-called "liability salvage" for compensation in return.[164] In 1972, the London Convention barred dumping, or deliberately disposing of refuse and waste, into the open ocean by boats and aircraft.[165] The ancient tradition of maritime salvage and the London Convention were officially adopted as international law by the International Convention on Salvage in

---

156 Rachel Rogers, *The Sea of the Universe: How Maritime Law's Limitation on Liability Gets it Right, and Why Space Law Should Follow by Example*, 26 Ind. J. Glob. Legal Stud. 741 (2019), https://www.repository.law.indiana.edu/ijgls/vol26/iss2/10.

157 *Id*.

158 *Id*.

159 *Id*.

160 *LEO Commercialization: The Pathway to Earth's Trillion Dollar Space Economy Webinar*, Nat'l Space Soc'y (Sept. 25, 2020), https://space.nss.org/leo-commercialization-the-pathway-to-earths-trillion-dollar-space-economy-webinar/.

161 *Id*.

162 Space Debris Removal, Salvage, and Use: Maritime Lessons, *supra* note 11.

163 *Id*.

164 *Id*.

165 Convention on the International Regulations for Preventing Collisions at Sea, Oct. 20, 1972, 33 UST 1602.

1989.[166] Article 14 of the International Convention on Salvage emphasizes protecting the environment and considers all debris as salvage and redeemable for a reward if the salvor prevented contamination.[167] Applying maritime guidance for debris liability assumption further develops the assumption of "international responsibility" mentioned in OST Article VI.[168]

Additionally, maritime risk mitigation structures could be adapted to launch the creation of new space industries.[169] Spacefaring nations could look to Marine Protection and Indemnity (P&I) Insurance as blueprints for methodologies that pool risk and yield lower costs.[170] Premiums are paid by members based on measurable risks and costs regarding machinery, the hull, or the entire vessel.[171] According to Peter Garretson in *The Space Review*,

If carried out proactively involving multiple launch and satellite companies internationally, such a pool could accrue multiple billions of dollars simply by charging a penny per dollar to satellite service end users. Moreover, an international trust fund could be accessed by multiple P&I space clubs worldwide as a major resource for their funding pools.[172]

This insurance would have the added benefit of making LEO safer and more accessible to all actors,[173] allow for the growth of existing industries and lower the barrier to entry for developing nations seeking to engage in space activity.[174]

The US can incentivize the removal of existing debris threats through active debris removal (ADR) both domestically and internationally through economic channels.[175] Launch costs to orbit

---

[166] International Convention on Salvage, Apr. 28, 1989, S. Treaty Doc. No. 102-12, 1953 U.N.T.S. 193.

[167] *Id*.

[168] Outer Space Treaty, *supra* note 8, art. VI.

[169] Space Debris Removal, Salvage, and Use: Maritime Lessons, *supra* note 11.

[170] Peter Garretson et al., Catalyzing Space Debris Removal, Salvage, and Use, SPACE REV. (Dec. 9, 2019), https://www.thespacereview.com/article/3847/1.

[171] *Id*.

[172] *Id*.

[173] *Id*.; Space Debris Removal, Salvage, and Use: Maritime Lessons, *supra* note 11.

[174] *Id*.

[175] Aaron Carroll, *Preventative Care Saves Money? Sorry, It's Too Good to be True*, NEW YORK TIMES (Jan. 29, 2018), https://www.nytimes.com/2018/01/29/upshot/preventive-health-care-costs.html. Similar to preventative medicines and practices preventing long term expensive medical conditions, removing dangerous objects in space will prevent potential expenses in the future.

average $2,200 per pound, with launch and maintenance costs continually increasing due to the growing population of space debris.[176] Mitigating those costs would save money for government and private sector operators in the long term.[177] While initially expensive, spread over several years, the result will be comparably economic, especially considering the growing market demand from military and commercial operators for orbital zones free of congestion.[178] We estimate it would cost $100 million over seven to eight years for a proof of concept capable of ADR.[179] This is not an unreasonable amount, and the long term impact on increasing the feasibility of a commercial economy in LEO would be a net positive.[180] Additionally, regulations and other measures can be put in place to subsidize the initial cost of remediation.[181]

Debris is raising the cost of building, launching, and maintaining satellites every year.[182] As the debris problem grows, satellites and spacecraft hulls must be engineered to be more durable, thus increasing the cost of materials, amount of propulsion to take off, and increasing the cost of the launch.[183] By focusing resources to remediating the debris problem and clearing up LEO and GEO, the

---

[176] Megan Ansdell, *Active Space Debris Removal: Needs, Implications, and Recommendations for Today's Geopolitical Environment*, J. PUB. & INT'L AFFS. 21 (2010), https://ciaotest.cc.columbia.edu/journals/jpia/v21i0/f_0022076_18192.pdf. *See generally* Will Ailor et al., *Effects of Space Debris on the Cost of Space Operations*, AEROSPACE (Sept. 28, 2010), https://vesta.astro.amu.edu.pl/Staff/Iwona/CostofSpaceDebris.pdf.

[177] Torrey Kim, *Home Maintenance Tasks That Cost More Later*, THE BALANCE (Feb. 18, 2021), https://www.thebalance.com/home-maintenance-tasks-that-cost-more-later-4684185.

[178] *Id.*

[179] Determined after discussion with several industry representatives.

[180] *Id.*

[181] *The Balance Between Taxes*, BRITANNICA.COM, https://www.britannica.com/topic/government-budget/The-balance-between-taxes (lasty visited Sept. 16, 2021).

[182] Ailor et al., *supra* note 176. *Generally*, Hanspeter Schaub, *Cost and Risk Assessment for Spacecraft Operation Decisions Caused by the Space Debris Environment*, 113 ACTA ASTRONAUTICA 66 (Aug. – Sept. 2015), https://www.sciencedirect.com/science/article/abs/pii/S0094576515001289?via%3Dihub.

[183] *See generally* Sylvestre Habimana & Ramakrishna V.R. Parama, *Space Debris: Reasons, Types, Impacts, and Management*, 46 INDIAN J. RADIO & SPACE PHYSICS 1, 24-25 (2017), http://op.niscair.res.in/index.php/IJRSP/article/view/15316. To protect the craft additional layers of protection are built, thus increasing the weight, and thus increasing the amount of propulsion needed to launch.

cost of building and launching rockets will decrease.[184] Similarly, the risk of damage or collision will also decrease so satellites will be safer.[185] Doing so will make for more accessible and less expensive launches.[186]

There are also ways to fund a remediation program without strict government funding. The FAA, through the Department of Transportation, could be reimbursed the funding costs by the final users through several means.[187] First, if the FAA is funded via government programming, an increase to taxes (American end users) should be enough to fund it.[188] The FAA could disperse this fee to companies and satellite owners directly through an additional or increased fee to all new satellite licenses.[189] Those companies could redirect that cost to their consumers, with a $1 increase for all consumers using a satellite would fund most program estimates.[190] A slight increase in the internet bill throughout the population could raise the money needed, the increase to the final consumer would

---

[184] *What Determines the Price of an Auto Insurance Policy?*, INS. INFO. INST., https://www.iii.org/article/what-determines-price-my-auto-insurance-policy (last visited Sept. 16, 2021) (Just like with car and homeowner insurance, reducing risks will make risk prevention cheaper).; *Homeowners Insurance Guide*, TEX. DEP'T INS., https://www.tdi.texas.gov/pubs/consumer/cb025.html (IE insurance drops when risks reduce. The additional protection/coverage of the craft can be reduced).

[185] Kessler et al., *supra* note 71.

[186] By reducing the cost of production, the total launch cost reduces. This would make launching satellites cheaper and more accessible.

[187] The US government (Congress) could increase taxes to all citizens by a marginal amount and put that toward the FAA and its funding of remediation programs.

[188] *Internet/Broadband Fact Sheet*, PEW RSCH. CTR. (Apr. 7, 2021), www.pewresearch.org/internet/fact-sheet/internet-broadband.; Andrew Perrin & Sara Atske, *7% of Americans Don't Use the Internet. Who are They?*, PEW RSCH. CTR. (Apr. 2, 2021), https://www.pewresearch.org/fact-tank/2021/04/02/7-of-americans-dont-use-the-internet-who-are-they/.

[189] Regulatory Fees Fact Sheet, *What You Owe-International and Satellite Services Licensees for FY 2007*, FCC (2007), docs.fcc.gov/public/attachments/DOC-275938A6.pdf (breakdown of FCC fees).; *FCC Proposes Cost-based Application Fee Schedule; Satellite Application Fees Greatly Reduced*, HOGAN LOVELLS (Sept. 18, 2020), https://www.engage.hoganlovells.com/knowledgeservices/news/fcc-proposes-cost-based-application-fee-schedule-satellite-application-fees-greatly-reduced.

[190] *Internet/Broadband Fact Sheet*, *supra* note 188; Andrew Perrin & Sara Atske, *supra* note 188. The US currently has a population of 328.2 million. This population, reduced by 7% who are not using the internet (46885714), comes out to 281,314,286 people. At $1 per internet bill, and a minimum of $280 million, the funds would be well within reach.

be negligible, and the cost to the satellite owner almost non-existent.

Currently, the FCC is considering enforcing satellite owners to pay a bond for successful post-mission disposal.[191] If the owner fails to dispose of the satellite in the permitted 25 years, the bond is forfeited.[192] The FCC could increase the bond to the amount estimated for the cost of the remediation effort for that size satellite. This could be similar to a temporary 'parking fee' for all newly launched satellites.[193] All companies would be charged a small 'parking fee' upon gaining a license.[194] Upon deorbit, rehabilitation, or placement into secure salvage orbits, the fee, or a portion of it, would be returned.[195] If the owner fails to deorbit, the fee would be forfeited.[196] The FAA, working with the Department of Commerce and other entities such as the Satellite Industry Association (SIA) or Space Data Association (SDA), could consult for an ideally assessed fee. This calculation could be based on the debris threat created with each launch and then scaled back modestly. Alternatively, the FCC could have an opt-in program with a discounted amount if the satellite owner 'donates' that money into the remediation initiative, regardless of deorbit.

VI. CONCLUSION

The US can immediately address the threat of orbital debris to its space assets by implementing a domestic, commercially-developed ADR demonstration that satisfies existing ADR legal frameworks and subsequently grows to involve international allies who share concern and interest in the debris population in LEO. While the US works with the international community on a multilateral agreement for ADR as a long-term solution, it must recognize that ADR is urgently needed to address the existing threat debris poses to critical space assets and focus on immediate and attainable

---

191 *FCC Fact Sheet*: *Mitigation of Orbital Debris in the New Space Age*, REP. & ORD. & FURTHER NOTICE OF PROPOSED RULEMAKING, IB Docket No. 18-313 FCC (Apr. 2, 2020), https://docs.fcc.gov/public/attachments/DOC-363486A1.pdf.

192 *Id.*

193 *Orbital Debris: Overcoming Challenges*, NAT'L SPACE SOC'Y 1, 16 (May 2016), https://space.nss.org/wp-content/uploads/NSS-Position-Paper-Orbital-Debris-2016.pdf.

194 *Id.* at 16.

195 *Id.*

196 *Id.*

solutions. Employing contractual agreements MOUs among involved parties removes legal ambiguity regarding ownership and liability and will inform precedent for necessary international ADR efforts in the future. On an issue with ranging geopolitical implications, several States and private entities have already begun taking the lead on remediation technology showing they will step into the role as international leaders in the absence of a multilateral approach. [197] If we have learned anything from the year 2020, it is that unforeseen events with global impact are real and have lasting effects.[198] Space debris has a global impact capable of doing great harm to essential US interests and to all of humanity.[199] Every space-based operator and entity requires a safe space environment to launch as desired and to utilize the benefits of Earth orbits, and as such has a stake in the success of effectively removing hazardous debris. Provided that the US considers these interests vital to the economic prosperity and security of the nation, we urgently recommend that the US initiate a domestic ADR program, through NASA, appropriate federal agencies and congressional action, to prevent the degradation of LEO to the extent future operating costs overwhelm our burgeoning orbital economy.

---

[197] NASA's Efforts, *supra* note 1.

[198] Patrick Van Kessel et al., *In Their Own Words, Americans Describe the Struggles and Silver Linings of the COVID-19 Pandemic*, PEW RSCH. CTR. (Mar. 5, 2021), https://www.pewresearch.org/2021/03/05/in-their-own-words-americans-describe-the-struggles-and-silver-linings-of-the-covid-19-pandemic/.

[199] NASA's Efforts, *supra* note 1.