Comments of

TechFreedom

James E. Dunstan[1]

In the Matter of

OSTP Request for Comment on:

NATIONAL ORBITAL DEBRIS RESEARCH AND DEVELOPMENT PLAN

A Report by the

ORBITAL DEBRIS RESEARCH AND DEVELOPMENT INTERAGENCY WORKING GROUP
SUBCOMMITTEE ON SPACE WEATHER, SECURITY, AND HAZARDS
COMMITTEE ON HOMELAND AND NATIONAL SECURITY
of the

NATIONAL SCIENCE & TECHNOLOGY COUNCIL

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Table of Contents

I. Background

TechFreedom files these comments in response to the White House's Office of Science and Technology Policy's (OSTP) Request for Comment on the Orbital Debris Research and Development Plan (Orbital Debris Strategic Plan), first published in January 2021.[2]

Founded in 2010, TechFreedom is a non-profit think tank dedicated to promoting the progress of technology that improves the human condition. To this end, we seek to advance public policy that makes experimentation, entrepreneurship, and investment possible, and thus unleashes the ultimate resource: human ingenuity. Wherever possible, we seek to empower users to make their own choices online and elsewhere.

TechFreedom, and the undersigned author, have almost 40 years' experience in outer space law and policy, and specifically regarding orbital debris and space sustainability. A short list of our work includes:

- Testimony before the United States Senate on the proper role of government in meeting its obligations under Article VI of the Outer Space Treaty (OST);[3]
- Amicus briefs in key court cases related to outer space law and policy;[4]
- Law review articles addressing orbital slot allocation and orbital debris;[5]

[2] The Request for Comment was published in the Federal Register on November 5, 2021, 86 Fed. Reg. 61335 (November 5, 2021), and called for comments to be filed by December 31, 2021. These Comments are timely filed.

[3] *Reopening the American Frontier: Exploring How the Outer Space Treaty Will Impact American Commerce and Settlement in Space: Before the Senate Committee on Commerce, Science, & Transportation Subcommittee on Space, Science, and Competitiveness*, 115th Cong. (2017) (written testimony of James E. Dunstan & Berin Szoka), https://www.commerce.senate.gov/services/files/A9AD88B2-9636-4291-A5B0-38BC0FF6DA90, video of hearing available at https://www.commerce.senate.gov/2017/5/reopening-the-american-frontier-exploringhow-the-outer-space-treaty-will-impact-american-commerce-and-settlement-in-space.

[4] Amicus curiae brief of TechFreedom in Viasat v. FCC, No. 21-1123, filed September 28, 2021, https://techfreedom.org/wp-content/uploads/2021/09/File-Stamped-TechFreedom-Amicus-Brief-Viasat-v-FCC.pdf.

[5] *See* J. Dunstan, *"Space Trash:" Lessons Learned (and Ignored) from Space Law and Government,* 39 J. OF SPACE L. 23 (2013); J. Dunstan, *Toward a Unified Theory of Space Property Rights*, chapter in Space: The Free-Market Frontier, CATO Institute, 2002; W. Potts & J. Dunstan, *Creeping CANCOM: Canadian Distribution of American Television Programming to Alaskan Cable Systems*," 7 PACE L. REVIEW 127-58 (1986); J. Dunstan, *et al., The Geostationary Orbit: Legal, Technical and Political Issues Surrounding Its Use in World Telecommunications*,"16 CASE WESTERN RESERVE JOURNAL OF INTERNATIONAL LAW, 223-63 (1984).

- Presentations at scientific conferences on outer space law and policy, including on issues related to orbital debris;[6]
- Comments in agency proceedings on a variety of space-related issues;[7]
- Submissions to Congress on key orbital debris issues;[8]
- Op-Eds commenting on U.S. policy related to orbital debris;[9] and

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[6] J. Dunstan and B. Werb, *Legal and Economics Implications of Orbital Debris Removal: Comments of the Space Frontier Foundation*, DARPA Orbital Debris Removal (ODR) Request for Information for Tactical Technology Office (TTO), Defense Advanced Research Projects Agency (DARPA), Solicitation Number: DARPA-SN-09-68, October 30, 2009; J. Dunstan, *Doing Business in Space: This Isn't Your Father's (or Mother's) Space Program Anymore*, Space Manufacturing 13: Proceedings of the Fifteenth Space Studies Institute/Princeton Conference on Space Manufacturing, 290, 2001; J. Dunstan, *Earth To Space - I Can't Hear You: Selling Off Our Future To The Highest Bidder*, Proceedings of the Thirteenth Space Studies Institute/Princeton Conference on Space Manufacturing, 1997; J. Dunstan, *Is Launching a Rocket Still an Ultra-Hazardous Activity? Toward a Negligence Theory for Launch Activities*, Proceedings of the Eleventh Space Studies Institute/Princeton Conference on Space Manufacturing, 1993; J. Dunstan, *From Flag Burnings to Bearing Arms to States Rights: Will the Bill of Rights Survive a Trip to the Moon?*, Proceedings of the Tenth Princeton/AIAA/Space Studies Institute Conference on Space Manufacturing, 1991; J. Dunstan, *Funding the High Frontier: Old Lessons We Must Once Again Learn*, Proceedings of the Ninth Princeton/AIAA/Space Studies Institute on Space Manufacturing, 1989; J. Dunstan, *Generating Revenues in Space: Challenging Some of the Economic Assumptions of Space Exploitation*, Proceedings of the NASA Symposium on Lunar Bases and Space Professional Activities in the 21st Century, April 1988.

[7] Comments of TechFreedom to FCC in ET Docket No. 13-115 (allocation of spectrum for non-federal space launches), https://techfreedom.org/wp-content/uploads/2021/09/TechFreedom-Reply-Comments-13-115-9-10-21.pdf; Letter to FCC filed November 2, 2020, warning of danger of FCC granting "market access" to a company proposing very large satellites and licensed by a government (Papua New Guinea) which is not a signatory to the Liability Convention, https://techfreedom.org/wp-content/uploads/2021/03/TechFreedom-Letter-to-FCC-11-2-20.pdf; Comments filed on April 27, 2021 with the Department of Agriculture urging that any grant for rural broadband deployment be technology neutral such as to allow satellite broadband providers to participate, http://techfreedom.org/wp-content/uploads/2021/04/TF-Comments-USDA-4-27-21.pdf.

[8] Letter to Senate Subcommittee on Space and Science concerning the loophole of allowing U.S. companies to get "flag of convenience" licenses from foreign jurisdictions (July 21, 2021) relate to its hearing on Space Situational Awareness, Space Traffic Management, and Orbital Debris: Examining Solutions for Emerging Threats Hearing, https://techfreedom.org/wp-content/uploads/2021/07/Letter-to-Senate-Space-Subcommittee-7-21-21.docx-1.pdf.

[9] J. Dunstan, *Who want to step up to a $10 billion risk?,* Space News, June 25, 2021, https://spacenews.com/op-ed-who-wants-to-step-up-to-a-10-billion-risk/; J. Dunstan, *The FCC and Spectrum Policy: Sometimes It Hz So Bad,* Townhall, November 16, 2020, https://townhall.com/columnists/jamesdunstan/2020/11/16/the-fcc-and-spectrum-policy-sometimes-it-hz-so-bad-n2580049; C. Barthold, *Rival Wants Regulators to Cripple Elon Musk's Satellite Project*, The Bulwark, August 3, 2021, https://www.thebulwark.com/rival-wants-regulators-to-cripple-elon-musks-satellite-project/; J. Dunstan, *Bring On the Space Barons*, September 14, 2021, https://medium.com/@TechFreedom/bring-on-the-space-barons-e425129fbff6; J. Dunstan, *Do We Care About Orbital Debris at All?*, Space News, January 30, 2018, https://spacenews.com/op-ed-do-we-care-about-orbital-debris-at-all/; J. Dunstan and B. Szoka, *Space Property Rights: It's Time, and Here's Where to Start*,

- Podcasts.[10]

We are therefore well-versed in issues related to space sustainability and orbital debris and welcome the opportunity to comment on OSTP's Orbital Debris Strategic Plan.

II. Introduction

Orbital debris is a real problem. But it is nothing new. One of the world's first outer space lawyers, Andrew G. Haley, wrote about it in one of the first books on space law in 1963:[11]

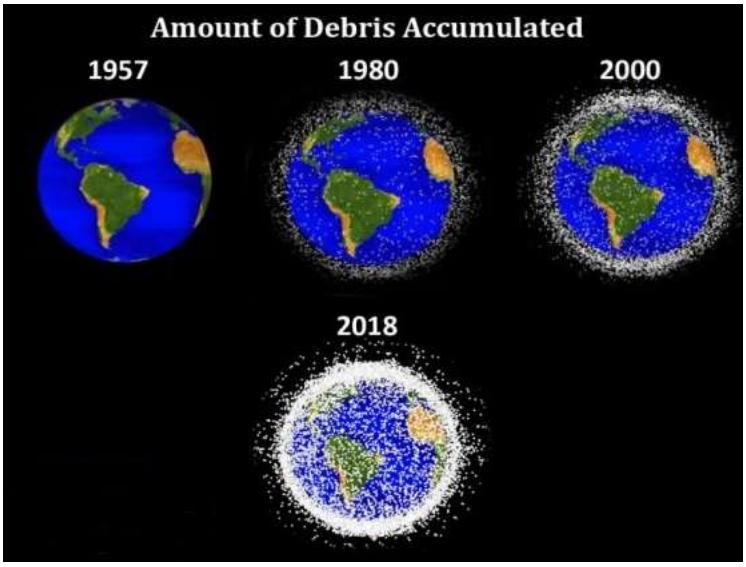
> Then, too, the Soviet Union and the United States have already sent into outer space many vehicles which are not controllable. A collision in which two orbital bodies would hit and exfoliate, but continue in some irregular orbit for many more hundreds of years, would constitute a threat to life and property in outer space-and many similar threats are possible. Objects have been placed in orbit-both satellite vehicles and spent rocket stages-that could come back to earth at almost any place. Such objects might land on the Kremlin, on the Vatican, or on Buckingham Palace; as far as the dispersion factor is concerned, we still do not know enough. We do know that satellites do not come back as small particles or completely exfoliated, because they would burn up; but objects in space may come back as great chunks if they were large enough to start with and if they are not brought down in a controlled re-entry. Finding answers to these problems, naturally, is not easy. Ideally, however, no objects should be allowed to go into outer space without a code of law requiring that they be controllable; they should be earth-returnable, or capable of being

Space News, January 27, 2014, https://spacenews.com/39294space-property-rights-its-time-and-heres-where-to-start/; B. Szoka & J. Dunstan, *Beware of Space Junk*, Forbes, December 17, 2009, https://www.forbes.com/2009/12/17/space-junk-environment-global-opinions-contributors-berin-szoka-james-dunstan/?sh=6b7d6da16b6c.

[10] Tech Policy Podcast Episode #13: Space Law! (Part 1) (February 1, 2016): http://podcast.techfreedom.org/e/13-space-law-part-1/; Episode #28: Space Law (Part 2) Property Rights in Space (February 23, 2016): http://podcast.techfreedom.org/e/space-law-party-2-property-rights-in-space/; Episode #33: Space Law (Part 3) Mining in Space (March 1, 2016): http://podcast.techfreedom.org/e/33-space-law-part-3-mining-in-space/; Episode #306: The New Space Race (November 23, 2021): http://podcast.techfreedom.org/e/306-the-new-space-race/.

[11] ANDREW G. HALEY, SPACE LAW AND GOVERNMENT (Meredith Press, 1963).

projected into orbits around the sun or into some other area where they could not be injurious to life, property, and near-terrestrial navigation.[12]



Space is big; there can be no doubt of that. For instance, the total area of the 800 kilometer orbital sphere[13] encompasses 664 million square kilometers (or 411 million square miles). Were the approximately 6000 currently operating satellites (up from just over 1,000 a decade ago) all bunched in this one orbit (which they obviously are not), each would have some 111,000 square kilometers (68,000 square miles) in which to operate.[14] The mindset of many in the early years of spaceflight was that space was so vast that the likelihood of two objects actually colliding was so remote as to not be worth worrying about, and certainly not worth taking into consideration when planning space activities. This became known as the "Big Sky" theory of space operations.[15] Recent debris generating

[12] *Id.* at 11.

[13] The 800-kilometer orbit was chosen for this calculation because it is considered one of the more crowded orbits.

[14] This calculation is a significant oversimplification since in addition to assuming that the approximately 6000 operating satellites all occupy the 800-kilometer orbit, the calculation assumes that all are exactly orbiting on the surface of a perfect sphere 800 kilometers above the mean surface of the Earth (and hence 7271 kilometers above the center of the Earth). Therefore, it only calculates the square kilometers surface area of the sphere. Since satellites don't operate at exactly the same orbital altitude, even within a designated orbit, and since orbits aren't entirely circular (the apogee – or high point – of an orbit is usually slightly different than the perigee – or low point), to be more accurate the calculation should be made using a three dimensional slice of sphere centered around 800 kilometers above the surface of the Earth, making the amount of "Big Sky" surrounding each satellite appear much larger. However, what also makes the calculation incorrect is the assumption that somehow all of satellites are flying "in formation," while in reality, they are orbiting in a variety of directions (predominately West to East, North to South (polar) or South to North (polar)), such that their orbits cross each other.

[15] The origin of the term "Big Sky" is unknown. Most likely it comes from aviation traffic modeling where the assumption is that two randomly flying bodies are unlikely to collide because of the size of the three dimensional space in which they operate. The earliest reference this author can find to such a theory being applied to space is the SURVEY OF SPACE LAW, STAFF REPORT OF THE SELECT COMMITTEE ON ASTRONAUTICS AND SPACE EXPLORATION, H. R. DOC. NO. 89, 86TH CONG., 1ST SESS., at 7 (1959) [hereinafter SURVEY OF SPACE LAW] (where Dr. John Haden, the director of Project Vanguard is quoted as saying "space is a very big area").

collisions (both accidental and intentional) have demonstrated, however, that the days of the "Big Sky" theory are relegated to the pages of history, if the theory ever had any validity to begin with.)

The NASA Inspector General's 2021 report provides an excellent summary of the state of orbital debris today:

> Millions of pieces of orbital debris exist today—at least 26,000 of which are the size of a softball or larger that could destroy a satellite on impact; over 500,000 of these are the size of a marble big enough to cause damage; and over 100 million are the size of a grain of salt that could puncture a spacesuit—amplifying the risk of catastrophic collisions to spacecraft and crew. Moreover, the growing volume of orbital debris threatens the loss of important space-based applications used in daily life, such as weather forecasting, telecommunications, and global positioning systems that are dependent on a stable space environment. Orbital debris is a global concern with stakeholders across public, civil, and private sectors who have adopted an array of guidelines, standards, and policies to limit the generation of future debris. However, global compliance with these guidelines, standards, and policies remains low, and global remediation activities designed to remove existing debris from space are limited and largely in the planning phases of development. [16]

Efforts to both minimize new debris as well as develop ways to remove existing debris (Active Debris Removal or ADR) are nothing new either.[17] What is new is the array of emerging non-geostationary orbit (NGSO) constellations being deployed by SpaceX and others, and the launch cadence deploying these constellations, rapidly increasing the number of objects in space. A comprehensive approach to debris mitigation and remediation clearly is in order, raising a host of questions, technical, policy, and legal.

In these Comments, we produce seven major recommendations:

1) OSTP should recommend to the Administration that the FCC be given a full seat on the National Space Council;

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[16] "NASA's Efforts to Mitigate the Risks Posed by Orbital Debris," NASA Office of Inspector General, Office of Audits, January 27, 2021, at 2, https://oig.nasa.gov/docs/IG-21-011.pdf.

[17] For a comprehensive study of the origins and development on orbital debris law and policy, *see* J. Dunstan, *"Space Trash:" Lessons Learned (and Ignored) from Space Law and Government,* 39 J. OF SPACE L. 23 (2013).

2) The United States should pursue a limited international agreement declaring that the testing, deployment, or use of ASATs violates international law;
3) The United States should adopt a policy whereby its regulatory agencies only grant access to U.S. markets to entities that abide by U.S. orbital debris regulations and are licensed by countries who accept international responsibility for any accidents;
4) OSTP should recommend to the Administration that maximum effort be put forth to improve orbital models and conjunction analysis;
5) OSTP should recommend to the Administration the completion of the hand-off of SSA from DoD to Commerce, including necessary funding and personnel to do so;
6) OSTP should recommend SBIR and STTR funding to spur private sector participation in space sustainability; and
7) OSTP should prioritize R&D into ADR methods for large objects, especially spend upper stages.

III. OSTP's Strategic Plan for Orbital Debris is Far Too Narrow in Scope

The Orbital Debris Strategic Plan is self-limiting, and by design. As such, this document will contribute little to the national and international debate on space sustainability. The Strategic Plan admits that Active Debris Removal (ADR)

> presents economic, legal, and policy issues outside of the scope of this plan that will have to be addressed if it is to become a realistic option for mitigating risks posed by orbital debris.[18]

Yet, according to its website, OSTP

> advises the President and others within the Executive Office of the President on the scientific, engineering, and technological aspects of the economy, national security, homeland security, health, foreign relations, and the environment. OSTP leads efforts across the Federal government to develop and implement sound science and technology policies and budgets.[19]

How can OSTP hope to provide the White House guidance on key issues surrounding space sustainability while ignoring the "economic, legal, and policy issues," implicated by orbital

[18]National Science and Technology Council, National Orbital Debris Research and Development Plan, 11 (2021).

[19] Off. Of Sci. and Tech. Pol'y, Mission Statement, https://www.whitehouse.gov/ostp/.

debris? Indeed "Policy" is in OSTP's name, in addition to its charter. By focusing only on narrow research initiatives, the Strategic Plan ultimately must fail in even this narrow endeavor. This "stovepiped" approach to policy development is doomed to fail. For the same reasons that a stovepipe approach to intelligence gathering contributed to the 9/11 attacks,[20] and the Bush Administration's ultimate policy failure in going to war with Iraq,[21] ignoring the key legal and policy issues related to orbital debris will not provide the necessary inputs to the Biden Administration in addressing orbital debris.

Further, the Strategic Plan is fundamentally flawed in its failure to acknowledge the key role the Federal Communications Commission has in analyzing satellite applications and determining whether such applications are consistent with U.S. regulations on orbital debris.[22] Without fully integrating the FCC into this Plan, OSTP will be "shooting in the dark" in determining the key research areas that the U.S. government should fund in combatting orbital debris. Indeed, in the President's recent "Executive Order

Recommendation 1:

OSTP should recommend to the Administration that the FCC be given a full seat on the National Space Council

[20] *See* J. Yager, *Ten years after 9/11, report details gaps in intelligence networks*, The Hill, August 21, 2011, https://thehill.com/news-by-subject/defense-homeland-security/177639-ten-years-after-911-report-details-gaps-in-intelligence-networks.

[21] *See* S. Hersh, *The Stovepipe: How conflicts between the Bush Administration and the intelligence community marred the reporting on Iraq's weapons*, The New Yorker, October 19, 2003, https://www.newyorker.com/magazine/2003/10/27/the-stovepipe.

[22] The sole reference to the role of the FCC in the Strategic Plan is as follows:

> The Federal Aviation Administration (FAA), the National Oceanic and Atmospheric Administration (NOAA),8 and the Federal Communications Commission (FCC) all have policies or regulations that are intended to limit the creation or accumulation of debris. Fn8/ NOAA defers to the FCC orbital debris requirements as almost all commercial remote sensing systems have an FCC license and are therefore subject to the FCC rules.

Orbital Debris Strategic Plan, 2-3.

on the National Space Council,"[23] which expanded membership on the National Space Council, the FCC is left without a seat at the table. Once again, the "stovepipe" looms large.

IV. Key Legal and Policy Issues That Dominate the Space Sustainability Debate

For OSTP to properly advise the Administration on areas of research to support space sustainability, the underlying key legal issues must be addressed. We propose these key issues below.

A. Orbital Debris Mitigation is Useless so Long as ASATs Create New Clouds of Debris

The Orbital Debris Strategic Plan clearly depicts the steady rise of trackable orbital debris.[24] Figure 1 clearly demonstrates that the dangerous increase in orbital debris is not a function of normal space operations, but rather, is triggered by unique collision events.

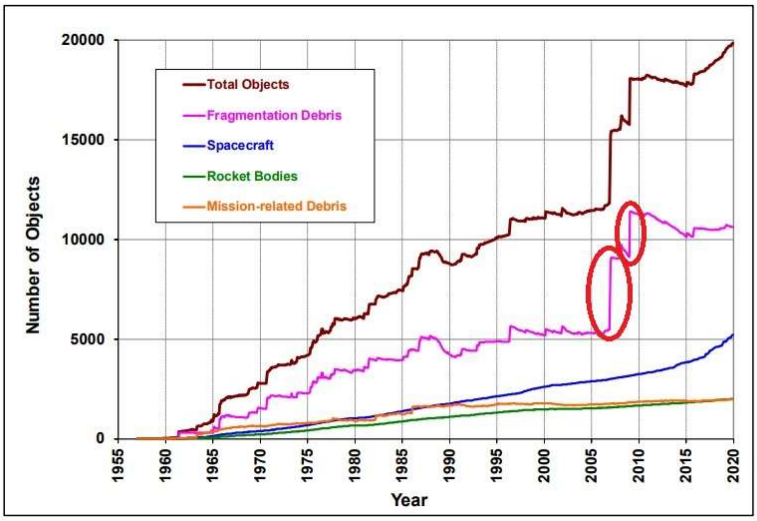

Figure 1. Growth of orbital debris objects over time by object type

[23] https://www.whitehouse.gov/briefing-room/statements-releases/2021/12/01/executive-order-on-the-national-space-council/.

[24] Orbital Debris Strategic Plan, 1 (Figure 1).

The Orbital Debris Strategic Plan admits as much.[25] We've modified Figure 1 to highlight the largest "jumps" in orbital debris. The larger red circle represents new debris caused by the 2007 Chinese anti-satellite ("ASAT") test, in which China purposefully destroyed its Feng-yun-1C weather satellite.[26] The total debris cloud created by the ASAT explosion is estimated to be between 2,392[27] and 3,000[28] trackable pieces of debris. One estimate of the total debris produced exceeds 100,000.[29] The second red circle represents the increase in debris caused by the 2009 collision between an arguably controllable Iridium 33 satellite and the derelict Cosmos 2251 satellite.[30] This collision produced over 2,200 pieces of trackable debris.[31]

Yet these two data points are not the end of major collisions, or even the end of ASATs. Just last month, on November 15, 2021, the Russia got into the ASAT game[32] when it destroyed its COSMOS 1408 intelligence satellite, producing some 1,500 new pieces of trackable debris.[33] Some of that debris "rained down" on the International Space Station, forcing astronauts to seek refuge in their more heavily shielded return vehicles.[34]

The conclusion that must be reached from these data is clear: While we should endeavor to minimize the production of new debris through diligent mitigation practices, it is on-orbit

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[25] *Id.*, 2 ("Deliberate actions, including scientific experiments and tests of anti-satellite weapons (ASATs), have also significantly increased orbital debris." (Footnote omitted.)). *See also, id.,* 5 ("Fragmentation debris objects dominate the tracked debris population.").

[26] *See* L. David, *China's Anti-Satellite Test: Worrisome Debris Cloud Circles Earth*, Space.com, February 2, 2007, https://www.space.com/3415-china-anti-satellite-test-worrisome-debris-cloud-circles-earth.html.

[27] *See* J. Lambert, *Fengyun-1C Debris Cloud Evolution Over One Decade*, https://amostech.com/TechnicalPapers/2018/Poster/Lambert.pdf.

[28] *See* I. Klotz, *Orbital Debris from Chinese Satellite Tops 3,000 Pieces*, https://www.seeker.com/orbital-debris-from-chinese-satellite-tops-3000-pieces-1765128675.html.

[29] *See* L. David, *Effects of Worst Satellite Breakups in History Still Felt Today*, Space.com, January 28, 2013, https://www.space.com/19450-space-junk-worst-events-anniversaries.html.

[30] *See* https://ntrs.nasa.gov/citations/20100002023.

[31] *See Iridium 33/Cosmos 2251 Collision*, http://celestrak.com/events/collision/.

[32] The United States is not free of the urge to blow things up in space either. In 1985 it tested its own ASAT weapon, destroying a 1-ton satellite orbiting at 525 km. Thousands of pieces of debris were created, with "the vast majority" reentering the atmosphere within a decade, meaning that *some* of that debris remains in orbit. *See* Union of Concerned Scientists, *Space Debris from Anti-Satellite Weapons: Fact Sheet*, https://www.ucsusa.org/sites/default/files/2019-09/debris-in-brief-factsheet.pdf.

[33] *See* https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1982-092A.

[34] *See* https://www.iflscience.com/space/russia-blows-up-satellite-causing-iss-astronauts-to-shelter-from-debris/.

collisions that should most concern us, and most importantly, we ***must not*** in any way condone the use of ASATs in any form (testing, deployment, or use).

The Pentagon's call for a stop to testing anti-satellite weapons is not enough.[35] OSTP should recommend that the Administration adopt the official U.S. position that the use of ASATs in any form violates international law. Indeed, just as the "no nukes in space" movement finally convinced the international community to enter into the 1967 Outer Space Treaty,[36] the United States should lead an international diplomatic effort to create a new, limited treaty to ban further testing, deployment, or use of anti-satellite weapons that could create orbital debris. We do not undertake this recommendation lightly, for in the past we have not supported significant amendments to the OST or entering into a new treaty. [37] The ASAT threat,

Recommendation 2:

The United States should pursue a limited international agreement declaring that the testing, deployment, or use of ASATs violates international law.

[35] *See* M. Sheetz, *Pentagon calls for stop to anti-satellite weapons testing after Russian demo debris threatened ISS*, CNBC, December 1, 2021, https://www.cnbc.com/2021/12/01/pentagon-calls-for-stop-to-anti-satellite-weapons-testing.html.

[36] *See* "Reopening the American Frontier: Exploring How the Outer Space Treaty Will Impact American Commerce and Settlement in Space," U.S. Senate Commerce Committee, Subcommittee on Space, Science and Competitiveness, transcript, 88 (written response of James E. Dunstan to questions submitted by Hon. Bill Nelson, referencing the "no nukes" provisions in the OST), https://www.govinfo.gov/content/pkg/CHRG-115shrg29998/html/CHRG-115shrg29998.htm.

[37] *See* Written Testimony of James E. Dunstan & Berin Szoka, Senate Committee on Commerce, Science, & Transportation Subcommittee on Space, Science, and Competitiveness, "Reopening the American Frontier: Exploring How the Outer Space Treaty Will Impact American Commerce and Settlement in Space, May 23, 2017, https://www.commerce.senate.gov/services/files/a9ad88b2-9636-4291-a5b0-38bc0ff6da90. We said there:

> Precisely because the "authorization" and "supervision" provisions of Article VI are aspirational and not self-executing, and because the U.S. Constitution gives Congress the ability to craft domestic legislation that implements Article VI in a way that is both consistent with the core provisions of the OST and Congress' desire to promote rather than stifle free enterprise in space, Congress should not suggest to the Administration or the State Department that the U.S. should begin discussions in the international community about amending the OST or augmenting Article VI with a new treaty (such as was done to flesh out the liability provisions of OST Article VII into the 1972 Liability Convention). The result of such efforts would inevitably be a treaty that the United States would not be able to ratify, because it would either (a) contain specific regulatory provisions akin to those adopted in the Moon Treaty that would be antithetical to U.S. economic interests, or (b) provide international lawyers a way to close the "Medellin loophole" by specifically stating that the requirement that countries supervise and

however, provides a very precise and focused problem that could be solved through a tightly written treaty. The treaty should be crafted such that refusing to accede to it would be tantamount to declaring the intent to make space a battlefield.

B. The United States Must Deny U.S. Market Access to Entities Unwilling to Follow International Law and Norms Related to Orbital Debris

The United States market for space-based commercial services is vital to any company seeking to provide space-based services. Estimates vary as to the U.S. market share of the $400-plus billion space economy, but the Federal Aviation Administration (FAA) estimated that the U.S. space industry was valued at approximately $158 billion in 2016.[38]

Because of the expense and complexity of the U.S. regulatory regime, many entities choose to obtain licenses in foreign jurisdictions and then seek "market access" to provide services in the United States through the FCC. This is increasingly leading to a "flag of convenience" scenario with serious consequences for U.S. interests. This came into sharp relief in 2020 when a U.S. company (AST SpaceMobile), received a license from Papua New Guinea, then filed a "market access" petition with the FCC. NASA and several others objected to the application, mainly because this startup was proposing a constellation of gigantic satellites

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authorize the activities of their citizens is self-executing — by adopting language specifying what that regulatory regime must look like.

Either way, the United States would lose the flexibility it now enjoys, which provides it with a unique opportunity to establish domestic law in the United States that is both consistent with Article VI, yet still provides U.S. citizens with a light regulatory approach that encourages innovation and investment in new outer space activities. Most of all, that flexibility means that U.S. policymakers can design a regime that will heavily influence what other countries do, and the concomitant evolution of international law through new conventions (such as those on registration, liability, rescue and return) or through customary international law.

In short, nothing good can come from diving down the "rabbit hole" of treaty (re)making at this stage. In the future, after the U.S. has shown its world leadership by establishing a domestic regulatory approach that encourages private sector advancement into space while protecting the core values of the OST, then the U.S. will be able to negotiate a future treaty from a position of strength, as by that time U.S. entrepreneurs will already have established themselves as the "first movers" in a huge new economic arena and U.S. domestic law will have shown itself to work, not just for American companies, but also for foreign companies that interact with American companies in space, or that choose to launch out of the U.S. to take advantage of American domestic space law.

[38] "Measuring the Value of the U.S. Space Economy, Survey of Current Business, December 2019, https://apps.bea.gov/scb/2019/12-december/pdf/1219-commercial-space.pdf.

stationed in a highly congested orbit that could pose significant orbital debris risks if one or more became uncontrollable. TechFreedom filed a letter with the FCC raising these issues, further noting that Papua New Guinea, the entity ultimately responsible for AST SpaceMobile's space operations, is not a signatory to the U.N.'s Liability Convention,[39] or the Registration Convention,[40] and has zero rules regarding orbital debris.

> The fact that AST, a U.S. entity, sought its licenses not from the FCC, but from Papua New Guinea, should give the FCC further pause. The FCC should undertake a dialog with its counterpart in Papua New Guinea to determine the extent to which that regulatory agency is capable of overseeing AST's activities. The Petition certainly smacks of a "flag of convenience" arrangement with little hope of effective oversight of potential future orbital debris problems.[41]

We also warned that an AST SpaceMobile accident could create more than $10 billion in damages to other assets in the 700 km orbit, and that injured foreign entities or governments might seek damages from United States because AST SpaceMobile is a U.S. company with (potentially) an FCC market access grant.

> In short, [Papua New Guinea] has not stepped up to accept specific international responsibility or liability for the activities of commercial entities it has licensed. Under the Liability Convention, countries agree to be liable for any damages caused in space "due to its fault or the fault of persons for whom it is responsible." AST & Science recently admitted to the FCC that PNG has not "acceded" to the Registration Convention but claimed that PNG would voluntarily register the constellation. This narrative brushes over the fact that voluntarily registering the constellation, which PNG has only done once previously, isn't the same as taking legal responsibility for it.
>
> PNG has in no way assumed the potentially huge liability of a collision. To put this in perspective, PNG's entire governmental budget is less than $6 billion, and its entire gross domestic product (GDP) is roughly $25 billion. The value

[39] Convention on International Liability for Damage Caused by Space Objects, *opened for signature* Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention].

[40] Convention on Registration of Objects Launched into Outer Space, *opened for signature* Jan. 14, 1975, 28 U.S.T. 695, T.I.A.S. 8480 (hereinafter Registration Convention].

[41] TechFreedom November 2, 2020, letter to the FCC, https://techfreedom.org/wp-content/uploads/2021/03/TechFreedom-Letter-to-FCC-11-2-20.pdf.

> of the satellites in the 700-kilometer orbit easily exceeds $10 billion. AST & Science's request is much like asking the United States to shoulder a $10 trillion dollar risk — half the U.S. GDP of $21 trillion.
>
> Who, then, will shoulder the risk of the liability? Is the United States going to step into PNG's shoes and absorb that risk?[42]

This situation, and ***all*** instances in which foreign-licensed companies seek market access to the United States, underscores the truly global nature of space sustainability. Yet because access to American markets is so important to the global space economy, the United States, and especially the FCC, plays an outsized role in influencing the behavior of space actors. Because of this, the United States is in a unique position to help shape worldwide orbital debris policies and practices. As such, OSTP should urge the Biden Administration to request that all U.S. regulatory agencies adopt measures to assure that any entity seeking to serve U.S. markets with space assets abide by American orbital debris regulations, and further require that any company seeking U.S. market access be licensed only by countries who both are signatories to the key space treaties and have domestic laws and regulations which are at least as comprehensive as those adopted in the United States.[43]

Recommendation 3:

The United States should adopt a policy whereby its regulatory agencies only grant access to U.S. markets to entities that abide by U.S. orbital debris regulations and are licensed by countries who accept international responsibility for any accidents.

[42] J. Dunstan, "Who Wants to Step Up to a $10 Billion Risk?, Space News, June 25, 2021, https://spacenews.com/op-ed-who-wants-to-step-up-to-a-10-billion-risk/ .

[43] Since the key licensing authorities for spaceflight (the FAA for launches and the FCC for satellites) are independent agencies, there is an open question as to whether the Biden Administration could "order" these independent agencies to do anything. *See* United States Telecom Association v. FCC, 855 F.3d 381, 393 (D.C. Cir. 2017) (Order denying *en banc* review) (Brown, dissenting) ("On Constitution Avenue, the man — the government — is the threatening one, grasping the reins on both sides of the animal's head; it appears he is trying to overpower a valiant and sympathetic horse. Here, as with the statues, an independent agency sits at the crossroads of competing visions — the President's view of the Internet as threatening consumers, and the libertarian view of government as strangling the greatest market innovation of the last century. But an orthodox view of checks and balances leaves the choice of vision to Congress.").

C. The United States Must Not Allow U.S. Regulations to be Weaponized by Internal Competitors or External Enemies to Slow U.S. Commercial Dominance in Outer Space

The U.S. goal to reduce orbital debris and enhance space sustainability cannot be absolute: space operations cannot be made so difficult, or so expensive, that no American company can afford to participate. This is especially true if the United States is alone in imposing these regulatory burdens. More important, such out-sized burdens cannot be employed by foreign enemies and domestic competitors to build "moats"[44] around incumbent space users that choke off future innovative uses of space.

In *Viasat v. FCC*,[45] currently pending before the D.C. Circuit Court of Appeals, one of SpaceX's competitors to provide satellite-delivered broadband appealed a decision of the FCC to amend SpaceX's licenses to move some of the satellites into a lower orbit. Viasat argued that the FCC failed to conduct a complete environmental assessment under the National Environmental Policy Act (NEPA), even though the FCC order contained an extensive analysis of the environmental impacts of its decision, as well as concluding that SpaceX had met all of the FCC's orbital debris mitigation requirements.[46] TechFreedom filed an amicus brief challenging whether NEPA itself even applies to outer space.[47] We argued that extraterritorial application of U.S. laws is warranted only where Congress explicitly decides to do so:

> "It is a longstanding principle of American law that legislation of Congress, unless a contrary intent appears, is meant to apply only within the territorial jurisdiction of the United States." EEOC v. Arabian Am. Oil Co., 499 U.S. 244, 248 (1991). A court is to "presume," in other words, "that statutes do not apply extraterritorially[.]" Hernandez v. Mesa, 140 S. Ct. 735, 747 (2020). What this means, in concrete terms, is that "absent clearly expressed congressional intent to the contrary, federal laws will be construed to have only domestic application." RJR Nabisco,

[44] It's a time-honored tradition in the American economy that when a disruptive technology comes along, entrenched users attempt to spin the levers of the regulatory system to slow down or stop the new entrant in order to protect their lines of business. In doing so, a business attempts to build a "moat" (a term coined by Warren Buffet in 1999, https://archive.fortune.com/magazines/fortune/fortune_archive/1999/11/22/269071/index.htm) around its business to keep its market advantage.

[45] Viasat v. FCC, No. 21-1123, oral argument December 3, 2021, decision pending.

[46] *In the Matter of Space Exploration Holdings, LLC,* FCC 21-48, released April 27, 2021 (includes a 17-paragraph analysis of SpaceX's compliance with orbital debris rules and a 22-paragraph analysis of the applicability of NEPA to the application).

[47] Amicus brief of TechFreedom in No 21-1123, https://techfreedom.org/wp-content/uploads/2021/09/File-Stamped-TechFreedom-Amicus-Brief-Viasat-v-FCC.pdf.

> Inc. v. Euro. Cmty., 136 S. Ct. 2090, 2100 (2016) (emphasis added). Any "lingering doubt" should be "resolved" against extraterritoriality. Smith, 507 U.S. at 203-04.[48]

There are also strong foreign policy reasons why the U.S. should not apply its domestic environmental laws to outer space when other countries have failed to do so:

> Congress presumably wants the foreign-policy benefits of American-provided satellite broadband. It presumably doesn't want to cede those benefits to another nation, such as China. See Andrew Jones, China establishes company to build satellite broadband megaconstellation, SpaceNews, https://bit.ly/3EHvFyS (May 26, 2021). And it presumably doesn't want private parties meddling in these foreign-policy issues by claiming to "represent" other countries' "environment." NRDC, 647 F.2d at 1367. Nothing in NEPA unsettles any of these presumptions. And the presumptions hold even though satellite launches can conceivably create ancillary costs (e.g., a small chance of falling debris) back on Earth. There is no sign in NEPA that Congress would want the mitigation of those costs to be prioritized over the acquisition of the benefits, in soft power and international good will, that could come from an American company's providing Internet to remote and poverty-stricken regions around the world.
>
> At the very least, this Court cannot know whether applying NEPA in outer space would erroneously create "foreign policy consequences not clearly intended by the political branches." Mesa, 140 S. Ct. at 747. That uncertainty is all it takes for NEPA not to apply in outer space.[49]

Whatever the U.S. does in terms of space sustainability, it cannot establish a regulatory regime which allows competitors to weaponize the regulatory system to slow down innovators. We do so at the risk of losing our commanding lead in commercial space.

Adopting regulatory policies which squander U.S. dominance in space is nothing new. In 1998, U.S. companies were found to have inadvertently assisted in the troubleshooting of a Long March launch failure in 1995, thus providing valuable "technical assistance" to China. In response, Congress placed virtually all space payloads on the Munitions List, subject to tight regulation under the International Trafficking in Arms Regulations (ITAR). The U.S. went from a dominant position in satellite manufacturing to "also rans" within a decade. The

[48] *Id.,* 7.

[49] *Id.* 17-18.

industry is just beginning to recover from this debacle — thanks largely to the Obama Administration's decision to move communications and most exploration satellites and their components back to the regulatory authority of the Department of Commerce in 2013.[50]

Thus, in placing any additional burdens on U.S. companies to combat orbital debris, the United States government must consider the approaches taken by our competitors and adversaries. America cannot so shackle the U.S. space industry that we repeat the ITAR mistake of 1998; doing so would cede space operations to other countries which may have far more lenient approaches to combating orbital debris.

D. The U.S. Must Change the Legal Definition of Space Debris

The Orbital Debris Strategic Plan touches on, but significantly understates, the legal implications of active debris removal: "ADR methods may inadvertently generate more debris or increase the probability of collision raising questions of liability and, possibly, intent."[51] Those who have been involved in this debate for any length of time recognize that the legal issues involved in ADR may, in fact, be the "long poles in the tent."

The Defense Advanced Research Projects Agency (DARPA) requested comment on technical, economic, and legal issues involved in removing space debris in 2009,[52] which DARPA followed up with a three-day workshop on December 8-10, 2009, at which this author and others presented ideas for debris remediation.[53] Suggested technical solutions covered in the DARPA symposium and suggested elsewhere, include the use of electromagnetic tethers,[54]

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[50] *See* https://www.defensedaily.com/obama-administrationissues-final-rules-for-export-control-reform/budget/.

[51] Orbital Debris Strategic Plan, 11. *See also, id.,* 3 ("While some challenges related to orbital debris may require legal, regulatory, or policy solutions, many of the challenges will require research and development activities.")

[52] *See* DARPA Solicitation DARPA-SN-09-68, FEDBIZOPPS.GOV (Sept. 17, 2009).

[53] *See* Stephen Clark, *Military agency studying space garbage service*, SPACEFLIGHT NOW (Dec. 12, 2009), http://www.spaceflightnow.com/news/n0912/12debris/.

[54] *See* J. Pearson, E. Levin, and J. Carroll, *Affordable Debris Removal and Collection in LEO*, *in* 63RD INT'L ASTRONAUTICAL CONG., Paper IAC-12-A6.6.7 (Oct. 1-5, 2012), http://www.star-tech-inc.com/id27.html.

lasers,[55] solar sails,[56] tractor beams,[57]and a variety of "snatch and deorbit" technologies.[58] Each advocate of a particular technological approach to active debris removal ("ADR"), passionately argues that there are no technical "show stoppers" to ADR. This is not to say that the technical solutions are easy (or cheap); most would take years, if not decades, of technology development, and, unless the market forces which are driving down launch and satellite prices are translated to ADR, ultimately it might cost as much to take down a piece of space trash as it did to launch it into orbit in the first place.[59] As with any tragedy of the commons, figuring out who will pay for orbital debris removal is a difficult issue, and the economic solutions to the problem are not readily apparent to most.[60]

In addition to the technical and economic issues, however, there are significant legal issues related to removing orbital debris which are every bit as vexing as the technical and economic issues. These former issues must be resolved if we have any hope of resolving the latter; for legal uncertainty about debris removal currently deters investment in removal technologies and business opportunities. The major difficulty the international legal community has had in coming to grips with the orbital debris problem stems from four aspects of international law:

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[55] *See e.g.,* C. R. Phipps, et al., *Removing orbital debris with lasers*, ADVANCES IN SPACE RES., 49, 1283-1300 (2012).

[56] *See* Ray Sanders, *NASA to Test New Solar Sail Technology* (Oct. 13, 2011), http://www.universetoday.com/89869/nasa-to-test-new-solar-sail-technology/ (Report on NASA's solar sail program and the possibility of using solar sails for orbital debris removal).

[57] *See, e.g.,* L. Boness, *Tractor beams may become a reality,* SCIENCE ILLUSTRATED (Nov. 2, 2011), http://scienceillustrated.com.au/blog/science/tractor-beams-may-become-a-reality/.

[58] *See, e.g.*, Leonard David, *"Sling-Sat" Could Remove Space Junk on the Cheap*, SPACE.COM (Mar. 1, 2013), http://www.space.com/20024-space-junk-removal-sling-sat.html.

[59] Many of the more exotic proposals, such as tethers and the "Sling-Sat" hope to be able to retrieve multiple space objects with a single spacecraft, thus reducing the cost, per debris object removed, substantially. Yet each of these missions could easily run hundreds of millions of dollars, even if they could remove multiple pieces of debris.

[60] At the 2009 DARPA symposium, this author proposed the establishment of a bounty system for orbital debris removal whereby all satellite operators would pay into a fund an amount based on the size, orbit, and history of successful debris mitigation, an authority would be established to place a value on each piece of orbital debris (with the highest value assigned to those pieces which pose the greatest threat of collision), and then private entities would be awarded money from the fund for successful removal. A copy of that paper is attached to the email transmitting these comments.

1) Under the Outer Space Treaty, a state launching an object retains "jurisdiction and control" over that object, presumably forever;[61]

2) No international treaty or agreement explicitly requires removal of an object from space once its useful life is over (notwithstanding the various debris mitigation guidelines adopted by various countries);[62]

3) The Registration Convention lacks any enforcement mechanisms or sanctioning provisions which would require a launching state to register each part of a launch, and any subsequent debris coming from a launch, even large objects such as spent upper stages of rockets; and

4) Under the Liability Convention, fault must be established before liability can be assigned to any activity occurring in orbit.[63]

As discussed above, there has been every reason for the spacefaring nations to ignore the orbital debris problem: to acknowledge it, and to establish norms of conduct, would go a long way toward establishing the "duty" and a "standard of care" found in standard negligence liability analysis. The 1995 Inter-Agency Report on Orbital Debris explained the perverse incentives created by current international law and the resulting conundrum this way:

> Although the Liability Convention provides a legal mechanism for establishing liability and damages, there would likely be problems of proof associated with a claim based on damage caused by orbital debris. In the likely event that damage to or destruction of a space objects was caused by a small, unobservable fragment, it would be difficult to establish the identity of the launching state and therefore to invoke the Liability Conventions.
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> * * *
>
> Liability would then depend on whether a state's actions in controlling its space objects were 'reasonable.' The present state of space technology does not permit activities in space that are completely debris free; hence, a negligence regime might imply an obligation of states to take reasonable steps to prevent foreseeable

[61] Outer Space Treaty, art. VIII.

[62] *See, e.g.,* "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space," https://www.iadc-home.org/documents_public/file_down/id/4155. These guidelines are voluntary.

[63] Liability Convention, art. III.

> damage. Many factors would come into play in decide what steps are reasonable and what damage is foreseeable, including the proximity of other space objects, the reason for the creation of the debris, the cost of preventing the creation of the debris, and the feasibility of providing warnings to states potentially affected by the debris.[64]

Thus, it has always been easier for countries to conduct themselves and their activities as if there wasn't any actual duty to remove their orbital debris (just vague, unenforceable guidelines), and let "God sort it out."

States interested in actually cleaning up the cluttered space environment face the same legal conundrum, in that it can be argued that the removal of someone else's junk is a violation of international law, since the ownership and nominal "control" of the object remains with the launching state under Article VIII of the Outer Space Treaty, even if the launching state no longer has any actual ability to control the object, either to use it or to remove it. As the 1995 Interagency Report concluded:

> If the launching state consented to the destruction or removal of its orbital debris, or if it abandoned its rights to the debris through a clear expression of intent, destruction or removal could be considered lawful. However, under customary international law, state property remains state property unless expressly relinquished. (Under maritime law, for example, the U.S. has consistently maintained that sunken state ships remain the property of the flag state until title is expressly transferred or abandoned, and that abandonment cannot be implied from the absence, even over a long period of time, of acts evidencing an interest in such property.)[65]

As that same report points out, however, such a refusal to allow removal of hazardous debris directly conflicts with the duty established under Article IX of the Outer Space Treaty, of states to conduct their activities "with due regard to the corresponding interests of all other States Parties to the Treaty."[66] Article I guarantees the right of all states to enjoy the "exploration and use" of outer space, Article XI creates a consultation mechanism by which states

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[64] *See* Office of Science and Technology Policy, *Interagency Report on Orbital Debris,* 12 (Nov. 1995), https://ntrs.nasa.gov/api/citations/20000011871/downloads/20000011871.pdf., *Id*. at 46.

[65] The National Science and Technology Council Committee on Transportation Research and Development, *Interagency Report on Orbital debris 1995*, 47 (1995).

[66] *Id. See* Outer Space Treaty, art. IX.

can vindicate this right of they expect interference with their operations, and the Liability Convention implements that principle. But in practice, there is no effective remedy: a state would have to prove the element of negligence, that there is a duty of care as it relates to orbital debris that has been violated, which brings us back where we started, with no enforceable international norms for liability for orbital debris, no sanctions for a country that fails to deorbit or move satellites to safe orbits at end-of-life, and nothing more than "irate expressions of disdain for the violator."[67]

The 1995 Interagency Report on Orbital Debris notes that, like the Outer Space Treaty, maritime law establishes that ownership of a seagoing vessel remains with the state of flagging even after such a vessel is sunk.[68] But in most instances, sunken ships sit quietly on the ocean floor, posing little danger to navigation while derelict satellites pose real hazards to space navigation, and must be treated as such. Another maritime law concept can help resolve this problem: under both international and U.S. domestic law, vessel owners are required to clear their vessels from navigable waters and not place impediments to free passage within their territorial waters,[69] and, more importantly, failure to do so constitutes abandonment.

Under customary international law, the rules of navigation and the right of "innocent passage" have existed for hundreds, if not thousands of years.[70] Article 17 of The Law of the Sea Convention guarantees that ships of all states "enjoy the right of innocent passage through the territorial sea."[71] Furthermore, coastal states may adopt laws and regulations relating to innocent passage that provide for "the safety of navigation and the regulation of maritime traffic."[72]

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[67] SPACE LAW AND GOVERNMENT, 150.

[68] *Interagency Report on Orbital Debris 1995,* 47.

[69] *See* Corfu Channel Case (U.K. v. Alb.), 1949 I.C.J. 4 (Apr. 9) In *Corfu Channel,* the International Court of Justice (ICJ) held Albania liable for damage caused to two Royal Navy destroyers by mines placed in its territorial waters in the Corfu Channel. The court further found that Albania had a duty to notify both the international shipping community, and to warn the destroyers once they entered the Channel of the existence of these mines.

[70] *See*, SPACE LAW AND GOVERNMENT, 57 ("A judicial decision of 1871 [The Scotia, 81 U.S. (14 Wall.) 170 (1871)], in a case involving a collision of a British and an American ship, held that the pertinent rules of navigation having been accepted as obligatory by more than thirty of the principal commercial states of the world, these rules became the law of the sea.").

[71] United Nations Convention on the Law of the Sea, art. XVII, *opened for signature* Dec. 10, 1982, U.N. Doc. A/CONF.62/122 (1982), 21 I.L.M. 1261 (1982).

[72] *Id.* at 18, art. XXI.

The United States, although not a signatory to the Law of the Sea Convention, has adopted specific rules as to vessels which endanger the safety of navigation, for instance:

> It shall not be lawful to tie up or anchor vessels or other craft in navigable channels in such a manner as to prevent or obstruct the passage of other vessels or craft; or to sink, or permit or cause to be sunk, vessels or other craft in navigable channels . . .. And whenever a vessel, raft or other craft is wrecked and sunk in a navigable channel, it shall be the duty of the owner, lessee, or operator of such sunken craft to immediately mark it with a buoy or beacon . . . and it shall be the duty of the owner, lessee, or operator of such sunken craft to commence the immediate removal of the same, and prosecute such removal diligently, and failure to do so shall be considered as an abandonment of such craft, and subject the same to removal by the United States as provided for in sections 411 to 416, 418, and 502 of this title.[73]

Many U.S. state laws declare as abandoned "any watercraft that is inoperative and neglected, submerged or partially submerged or that has been left by the owner in coastal waters without intention of removal."[74] Under the Federal Abandoned Barge Act of 1992, it is illegal to abandon a barge in navigable waters. "Barge" is defined as a "non-self-propelled vessel,"[75] and "abandoned" is defined as "to moor, strand, wreck, sink, or leave a barge of more than 100 gross tons . . . for longer than forty-five days.[76] Under general American maritime law, "abandonment" is

> an intentional relinquishment of all right, title and possession of a thing without the intention of ever reclaiming it. It consists of two elements, act and intention, with intention to abandon being the most important. It is a question of fact determined from all the circumstances. A mere passage of time will not necessarily work an abandonment if the owner has clearly shown a constant intent to salvage it.[77]

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[73] 33 U.S.C. § 409.

[74] *See, e.g.,* Title 12 Maine Rev. Stat. § 1866.

[75] 46 U.S.C. § 102.

[76] 46 U.S.C. § 4701.

[77] *See* Lawrence Lipka, *Abandoned Property at Sea: Who Owns the Salvage "Finds"?*, 12 WM. & MARY L. REV. 97, 102, n. 28 (1970).

The analogy to space and orbital debris is clear. Space orbits, like the waters of the oceans, must be free for passage by all — a concept already at the heart of Article I of the Outer Space Treaty. Hazards to navigation need to be removed. This is especially true for derelict or abandoned vessels and space objects. The same definitions of abandoned used in maritime law can easily be applied to space objects. Indeed, the Inter-Agency Space Debris Coordination Committee (IADC) orbital debris guidelines already make a clear distinction between "spacecraft" and "space debris," which is defined as "all man made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non functional."[78]

Some might dispute this analogy because the United States, and other countries, claim that government property in the form of shipwrecks can never become abandoned under Articles 95 and 96 of the Law of the Sea Convention,[79] and that under Article VIII of the OST, jurisdiction over all manmade objects placed in space remain with the launching state, and can never be lost.[80] Yet Articles 95 and 96 cannot be read in total isolation. Rather, Articles 95 and 96 of the Law of the Sea Convention must be read against the provisions cited above that guarantee the right of safe passage. As the *Corfu Channel* case makes clear, because the fact that an object obstructing safe passage belongs to a state government (and not a state-flagged vessel belonging to a private entity) does not absolve the state from its duties to protect the right of safe passage. Articles 95 and 96 are clearly intended to protect states from the seizing or looting of their property (including shipwrecks). They do not trump states' responsibilities to take *due regard* of the activities of others under customary international maritime law. In the aviation context, this has been made clear via treaty. While the Convention on International Civil Aviation of 1944 (Chicago Convention) exempts "state aircraft" from International Civil Aviation Organization (ICAO) procedures, it nonetheless requires "state aircraft" to fly with "due regard for the safety of civil aviation."[81]

In the same way, we must balance the rights ***and responsibilities*** established under OST Articles I, VII, VIII and IX to bring them into conformity with maritime and aviation law. A state should not retain jurisdiction over a satellite it can no longer control and which it has effectively abandoned by any definition under maritime law, escape liability for the

[78] IADC Space Debris Mitigation Guidelines, IADC-02-01, arts. 3.1 & 3.2 (*revised* Sept., 2007) (hereinafter IADC Guidelines).

[79] Law of the Sea Convention, arts. 95 & 96.

[80] Outer Space Treaty, art. VIII.

[81] Convention on International Civil Aviation, art. 3, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295.

destruction a collision would cause, and allow that satellite to remain in an uncontrollable orbit contaminating outer space, interfering with the rights of other nations not to have their activities interfered with.

Some have suggested that this legal conundrum can be solved only by amending either the OST or the Liability Convention. In fact, the problem can be solved through use of customary international law, which can develop far more quickly in the context of an area of the law that remains underdeveloped, and where activities are open and apparent to all. As a foundational space law treatise predating the Outer Space Treaty observed:

> There is in any event, no rule in international law which would require that consent, clearly shown, must be fortified by prolonged usage. Long ago Triepel recognized that under certain conditions one single act of international practice based on usage might suffice for a rule of international law. Normally a long period of usage has been required before a principle could become established as a part of international law, but this is so only because in most cases the consent of nations could not be ascertained by other nations except over a long period of years. . .. The present situation, however, is entirely different. An earth satellite will pass over numerous countries in a period of hours and these nations are immediately aware of the launching. Knowledge of the impending launching may even have been available for a considerable time prior to the actual event. In view of this, the nations could be expected to express their consent-or non-consent-in a timely manner.[82]

We can learn much from the writings of this treatise's author, early space lawyer Andrew G. Haley. He concluded that the concept of free overflight was established by the single event of the Soviets orbiting Sputnik I.[83] Other events in the history of spaceflight have established customary international law through single events, or a small series of events. For example, the right to own objects found in space returned to Earth was established by the United States (and to a lesser extent the Soviet Union) through their Apollo and Luna sample return missions and their approaches to those samples.[84]

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[82] SPACE LAW AND GOVERNMENT, 60-61.

[83] *Id.*

[84] *See* J. Dunstan*, Toward a Unified Theory of Space Property Rights*, *in* SPACE: THE FREE-MARKET FRONTIER (CATO Institute, 2002) (wherein this author pointed out that the United States claims the Apollo samples as a "national resource," citing NASA policy as to release of Apollo samples, and argued that the exchange of Apollo

Based on Haley's argument, we can envision one or more events which could establish a new customary international law as it relates to space debris, more in line with the safe passage and due regard concepts of maritime and aviation law. Below are four different scenarios. Although these are considered to be independent events, the combining of more than one of these would strengthen the argument that customary international law has been established.

1) The United States, or any other launching state, could adopt a policy that clearly states that any commercial[85] satellite, component, or upper stage in orbit which is no longer operating and controllable shall be deemed to be "abandoned property" and subject to the Law of Finds.[86]

2) The United States, or any other launching state, could mount an ADR mission and deorbit a non-functional commercial satellite, component, or orbiting upper stage launched from its state, and declare that the deorbiting was necessary because of the threat such object placed on space navigation, citing its responsibilities under Article VI and IX of the OST (requiring authorization and supervision over its nationals to ensure compliance with Article IX's requirement of conducting space activities with due regard to the rights of other states).

3) The IADC could adopt a guideline declaring any "non-functional" object to be "abandoned."

4) A spacefaring nation could deorbit an upper stage launched by another state after demonstrating through detailed conjunction analyses the danger to space

samples for Soviet Luna samples evidenced one of the classic indicia of ownership – the ability to exchange a piece of property for another piece of property).

[85] The scenario is limited to commercial (*i.e.*, non-governmental) objects both to avoid the conflict with the maritime law proposition that governments can't abandon property, and to protect the national security interest of the declaring country in ensuring that another country doesn't deorbit and recover derelict surveillance satellites to discover their functionality and possibly use that technology in their own surveillance satellites.

[86] The Law of Finds dates far back into the common law, and grants title to unowned property according to principle of "finders-keepers;" actual possession of property creates an interest in that property that can ripen into clear title if no better possessory interest is interposed. To acquire title to property in this fashion, a finder would have to prove the property was either (1) never owned or (2) once owned but since abandoned. *See e.g. Armory v. Delamire,* 93 Eng. Rep. 664 (K.B. 1722); *Adams v. Unione Mediterranea Di Sicurta*, 220 F.3d 659,670 (5th Cir. 2000) (distinguishing the law of salvage and the law of finds based on the latter's affording an award of title); *Fairport Int'l Exploration v. Shipwrecked Vessel Known as the Captain Lawrence*, 105 F.3d 1078, 1084 (6th Cir. 1997) (discussing how a claimant acquires title under the law of finds).

navigation of allowing the derelict object to remain in orbit and claiming the right of action by necessity.

While the first two actions would constitute the unilateral domestic acts of a single country, as Haley noted, because the activity would occur outside the territory of the United States (or other initiating state) and instead in the *res communis* of outer space, such actions, if accepted by the international community either through assent or even silence, could lead to customary international law.[87] The third scenario would represent a more traditional international organizational approach to establishing customary international law through the consensus-building process. The IADC, which to date has appeared far less political than any of its international organizational siblings such as COPUOUS or the ITU, might be capable of adopting this position. Given its membership structure, however, it is far more likely that one of its members would either veto such a position, stall any efforts to pass such a resolution, or worst yet, oppose such a position on the international stage.

The final scenario is by far the most daring but may well be the most likely to occur. At some point, evolving space situational awareness (SSA) capabilities to track objects and conduct even more "all-against-all" conjunction analyses will allow interested parties to predict a future collision with enough lead time to avoid it by actively intervening to remove an object from orbit, rather than require multiple other satellites to take defensive measures by conducting orbital maneuvers to avoid a collision. The argument of action by necessity is intriguing. The International Law Commission Draft Articles on State Responsibility outline the provisions of customary international law on necessity.[88] Under Article 33, a State is absolved from liability under a claim of necessity if its action was "the only means of safeguarding an essential interest of the State against a grave and imminent peril."[89] Several candidate upper stages exist in the 800 km polar orbit that were placed there by the Soviet Union. Because of their size and orbit, they present the greatest risk to space navigation.[90] A compelling case could be made that the removal of one or two of these stages would lessen the

[87] Indeed, were a bounty system established, similar to the one proposed by this author at the DARPA Orbital Debris Workshop in 2009, the United States government could establish a commercial market for orbital debris remediation that could actually be funded through the users of orbital slots.

[88] Articles on Responsibility of States for Internationally Wrongful Acts, International Law Commission, U.N. Doc. A/RES/56/83 (Jan. 28, 2002).

[89] *See id.,* art. 33.

[90] *See* Chris Bergin, *Project ADR: Removal of Large Orbital Debris Interests NASA*, NASA SPACEFLIGHT.COM (Jan. 9, 2011), http://www.nasaspaceflight.com/2011/01/project-adr-removal-large-orbital-debris-nasa-study/.

probability of plunging us into (or further into) the Kessler Syndrome, and therefore be consistent with the Outer Space Treaty. The party conducting such active debris removal (ADR) activities would have to make clear that the objects removed qualified as "orbital debris" under the IADC guidelines.[91]

V. How the U.S. Should Spend its Research Dollars Related to Space Sustainability

If the rise of "NewSpace"[92] tells us anything, it is that "space is a place, not a program," and that the future of space development will not be anchored by large government "top down" programs, but the blooming of thousands of space businesses in a "bottom up" ecosystem where the best ideas and implementations are rewarded, while those that don't work, or can't attract business capital, are destined to fail. We spent two generations of the space era using totally expendable rockets that were thrown away after each delivery to orbit.[93] Fortunately, that is changing rapidly, thanks to innovative thinking. Today, a SpaceX Falcon 9 vehicle can deliver objects to LEO for $2,500 per kilo, a more than 20-times reduction in cost over the semi-reusable Space Shuttle.[94] For SpaceX's newest vehicle, the "Starship," Elon Musk has boasted that launch prices to LEO could be as low as $10 per kilogram.[95] The Falcon

[91] Obviously, the easiest approach to doing this would be to receive the approval of the Russian government to remove the Soviet upper stages. Given that absolute liability would remain on Russian in the event that the upper stages caused damage to persons or property on the surface of the Earth under the Liability Convention, art. II), receiving such approval might be problematic, and for the sake of this discussion, it is assumed that the party conducting the ADR would be doing it without the expressed permission of the state that originally launched the object.

[92] The origin of the term "NewSpace" is a mystery to all but the few who have toiled in the field of space advocacy over the past few decades. A good explanation of "NewSpace" can be found at: https://blog.satsearch.co/2019-02-26-lets-talk-about-newspace.

[93] Although NASA's Space Shuttle was partially reusable, it was never designed to be an efficient or cheap operational vehicle. When the total $209 billion (in 2010 dollars) of the space shuttle program is spread across its 135 flights, that yields a per-flight cost of almost $1.6 billion. *See* M. Wall, "NASA's Shuttle Program Cost $209 Billion — Was it Worth It?," Space.com, July 5, 2011, https://www.space.com/12166-space-shuttle-program-cost-promises-209-billion.html. With a cargo capacity of 29,000 kg (65,000 pounds), that yields a price-per-pound cost to LEO of $55,000 per kilo, hardly a bargain. *See* https://www.nasa.gov/centers/johnson/pdf/584722main_Wings-ch3a-pgs53-73.pdf.

[94] "How SpaceX Lowered Costs and Reduced Barriers to Space," available at https://theconversation.com/how-spacex-lowered-costs-and-reduced-barriers-to-space-112586.

[95] R. Zafar, "Elon Musk Reiterates Insanely Low Starship Launch Costs of $10/kg," Wccftech, November 18, 2020, https://wccftech.com/elon-musk-starship-launch-cost-reiterate/. Other "armchair rocket scientists"

9 was built with government money, yes, but through NASA's innovative Commercial Orbital Transportation Services (COTS) and Commercial Resupply Services (CRS) program.[96] Rather than dictate every aspect of the Falcon 9's design and construction, under COTS/CRS, NASA merely provided specifications as to payload mass and volume (along with other launch envelope requirements such as G loads and vibration maximums), and allowed the competing companies to build to those requirements. In stark contrast, NASA's Space Launch System (SLS), which is being built using a traditional cost-plus contracting model with NASA fly-specking every aspect of design and construction, is now six years behind schedule,[97] will cost more than $20 billion to develop, and will cost over $2 billion per flight (even without amortizing that $20 billion development cost).[98]

The contrast in approaches cannot be starker — yet is totally lost in the Orbital Debris Strategic Plan. That document concludes that active debris removal will be very expensive. "Cost and cost-benefit are not well characterized. Demonstrations of ADR are likely to be very costly compared to efforts to reduce the creation of new debris. Determining a balance between mitigation efforts and removal and remediation efforts is important."[99] Of course ADR will be expensive (possibly prohibitively expensive), if we treat space sustainability as a huge government program run by bureaucrats doling out cost-plus contracts to traditional aerospace companies. For example, in November 2020, the European Space Agency entered into a $100 million contract with Swiss start-up ClearSpace SA for a space debris on-orbit test, with another $27 million slated to be kicked in by ClearSpace's investors.[100]

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have estimated that that figure will be closer to $20 per kilogram. *See* https://www.quora.com/What-will-be-the-cost-per-kilogram-of-payload-delivered-to-a-low-Earth-orbit-for-SpaceXs-new-rocket-Starship#:~:text=Ultimately%20SpaceX%20expect%20a%20StarShip,So%20around%20%2420%2Fkg. Either way, that's a 2,750-times reduction in cost of the Space Shuttle (3 times three orders of magnitude).

[96] *See* E. Zapata, "An Assessment of Cost Improvements in the NASA COTS/CRS Program and Implications for Future NASA Missions," available at https://ntrs.nasa.gov/api/citations/20170008895/downloads/20170008895.pdf.

[97] E. Berger, "NASA's Big Rocket Misses Another Deadline, Now Won't Fly Until 2022," Ars Technica, August 31, 2021, https://arstechnica.com/science/2021/08/nasas-sls-rocket-will-not-fly-until-next-spring-or-more-likely-summer/.

[98] E. Berger, "NASA has begun a study of the SLS rocket's affordability," Ars Technica, March 15, 2021, https://arstechnica.com/science/2021/03/nasa-has-begun-a-study-of-the-sls-rockets-affordability/.

[99] Orbital Debris Strategic Plan, 11.

[100] A. Parsonson, "ESA signs contract for first space debris removal mission," Space News, December 2, 2020, https://spacenews.com/clearspace-contract-signed/.

Instead, OSTP should provide the Administration with alternative thinking on ***how*** to fund R&D for active debris removal. Innovative programs such as COTS/CRS should be explored. Edgar Zapata's analysis both justifies a similar commercial approach to funding ADR and provides a roadmap for it.[101]

But OSTP should not stop there. Because of the importance of space sustainability for the future of humanity, ***everything*** should be on the table. We list below some approaches which OSTP should study as a pathway for funding sources and efficient use of R&D funding for space sustainability.

A. Federal Prizes

The current push toward suborbital tourism was fueled by the 2004 award of the Ansari X Prize worth $10 million. By some estimates, this has sparked over $2 billion in total investment in the private launch sector.[102] NASA has also utilized prizes to spur the development of key technologies needed to return to the Moon and go on to Mars.[103] The Congressional Research Service has recognized the benefits of using prizes to spur research and development:

> According to the Office of Management and Budget and the Office of Science and Technology Policy, prize competitions benefit the federal government by allowing federal agencies to (1) pay only for success; (2) establish ambitious goals and shift technological and other risks to prize participants; (3) increase the number and diversity of individuals, organizations, and teams tackling a problem, including those who have not previously received federal funding; (4) increase cost

[101] See supra note 96.

[102] *See* https://www.xprize.org/prizes/ansari. "Over the course of the competition, 26 teams invested over $100 million in aggregate for research and development in suborbital space flight. Breakthroughs made as a result of this successful competition led to a private space industry worth over $2 billion today." https://www.xprize.org/prizes/ansari/articles/mojave-aerospace-ventures-wins-the-competition.

[103] *See, e.g.,* "Teams Engineer Complex Human Tissues, Win Top Prizes in NASA Challenge," June 9, 2021, https://www.nasa.gov/press-release/teams-engineer-complex-human-tissues-win-top-prizes-in-nasa-challenge ("The prize competition aims to accelerate tissue engineering innovations to benefit people on Earth today and space explorers in the future."). *See also,* "NASA Awards Challenge Prizes to Startup Companies," November 12, 2021, https://www.nasa.gov/press-release/nasa-awards-challenge-prizes-to-startup-companies ("NASA has awarded $90,000 each to seven entrepreneurial startup companies under its Entrepreneur's Challenge program. The awards will advance new technology concepts ranging from novel materials with properties not found in nature to innovative technologies that will enable small satellite (SmallSat) science missions.").

> effectiveness, stimulate private-sector investment, and maximize the return on taxpayer dollars; and (5) motivate and inspire the public to tackle scientific, technical, and societal problems.[104]

Whereas some have argued that prizes can't be the exclusive avenue for R&D,[105] especially in the area of space development, they have proven highly successful, and induced greater participation by private industry. The Orbital Debris Strategic Plan recognizes this, if only in passing.[106] OSTP should study, and recommend, prize structures to the Administration as one avenue for space sustainability research.

B. Payload Bonding as a Source of Research and ADR Operational Funding

The Orbital Debris Strategic Plan properly notes the disconnect between risk, costs, and incentives when it comes to space sustainability:

> The market for debris removal and supporting R&D is small, largely due to the lack of defined responsibility for orbital debris removal or economic incentives to do so. The economic, scientific, and national defense losses associated with the future orbital debris environment are potentially large but highly uncertain, and they are an externality that the market has little incentive to address.[107]

Whatever orbital debris rules the United States might promulgate relating to launch and operations, unless satellites are deorbited (or placed in safe "graveyard" orbits) at end-of-life, the orbital debris problem will continue to grow. "Although NASA's compliance rate for end-of-mission disposal within 25 years stands at approximately 96 percent over the last decade,

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[104] "Federal Prize Competitions," Congressional Research Service, updated April 6, 2020, https://sgp.fas.org/crs/misc/R45271.pdf.

[105] *Id.* at 4 ("a 2014 report by the U.S. Chamber of Commerce Foundation specifically states that prizes are not a substitute for long-term basic research.").

[106] Orbital Debris Strategic Plan, 13 ("R&D conducted outside of the Federal Government—including by industry, academia, and international partners—can also contribute significantly to the R&D priorities identified in this report. The private sector has contributed throughout the space age as a valuable supplier and partner to the Federal Government.").

[107] Orbital Debris Strategic Plan, 11.

the global compliance rate has only averaged between 20 to 30 percent—much lower than the 90 percent required to slow the rate at which debris is generated in LEO."[108]

When presented with an analogous problem of the "warehousing" of space frequencies and orbital slots, the FCC has adopted a bonding requirement for licensees, to ensure that satellites are launched, and frequencies used, in a timely manner.[109] The FCC is currently conducting a rulemaking that could extend this bonding requirement to satellite end-of-life.[110]

This proposal has met significant opposition from the satellite industry because of the allegedly high costs involved, but the real problem is that the funds generated by the forfeiting of a "disposal bond" would go into the general treasury, and not to fund debris remediation or actual ADR activities.

OSTP should study whether creation of a separate fund created through the FCC's proposed bond forfeiting procedures could create a sustainable source of funding for future ADR research and potential deployment of such systems. Because a change in statute would be required, OSTP should call on the Administration to propose new legislation to Congress.[111] Because the threat of orbital debris stems not only from derelict satellites, but from launch upper stages,[112] any legislation should apply to launch licensing by the FAA/AST as well, e.g., requiring surety bonds for spent upper stages left in orbits for decades.

C. Establishing a Bounty System for ADR

Another approach to incentivize the private sector to invest in ADR would be the establishment of a bounty system for the removal of the most dangerous space flotsam and jetsam.

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[108] *See* "NASA's Efforts to Mitigate the Risks Posed by Orbital Debris," NASA Office of Inspector General, Office of Audits, January 27, 2021, ("*NASA IG Report*") https://oig.nasa.gov/docs/IG-21-011.pdf.

[109] *See* 47 C.F.R. § 25.165.

[110] *See In the Matter of Mitigation of Orbital Debris in the New Space Age*, Report and Order and Further Notice of Proposed Rulemaking, FCC 20-54, ¶¶ 193-205, April 24, 2020 (*Mitigation of Orbital Debris FNPRM*) (discussion of requiring bonds for proper satellite disposal at end-of-life).

[111] It is questionable under the non-delegation doctrine whether the FCC has sufficient ancillary jurisdiction to impose such a bonding requirement for satellites. *See* "FCC's Indemnification Proposal Violates Nondelegation, The Federalist Society, December 23, 2021, https://fedsoc.org/commentary/fedsoc-blog/fcc-s-indemnification-proposal-violates-nondelegation.

[112] *See infra,* Section VI(D) for a discussion of the unique dangers of derelict launch upper stages.

Attached to the email forwarding these comments is a study the undersigned author co-authored in response to the 2009 DARPA Request for Information, which noted:

> From an economic perspective, the worst possible technique for [Orbital Debris Removal] would be to use general tax revenues to fund cost-plus contracts. The use of general tax revenues separates the economic consequences of generating additional debris from the parties in a position to minimize its creation. The use of cost-plus contracts creates perverse incentives, rewarding failure and delay with additional funding. Fortunately, a number of other techniques are available to government with much greater prospects for success.
>
> The needed funding could at least partially be raised from parties who generate debris. An Orbital Debris Removal and Recycling Fund (ODRRF) could be created and funded in one of several ways. The debris potential of a particular launch could be evaluated and charged an upfront fee paid into the fund. Alternatively, parties could be required to purchase insurance that would pay into the fund in the event that any debris is actually generated. Government launches could also be required to pay into the ODRRF and it may make sense for government to seed the fund by paying for debris already in space. Whatever funding mechanism is chosen factors directly relevant to the danger posed by the debris should be effectively priced including: mass of all objects that will remain in orbit (vehicle and upper stages,) congestion of the orbit into which the vehicle (and upper stages) will be launched, EOL plan for all components and track record related to EOL operations.
>
> ODR providers could be compensated in one of several ways. The ODRRF could make payments for debris removal based on a clear set of published criteria. Alternatively, the ODRRF might prefer the greater flexibility and simplicity of placing a fixed price on each object, or set of objects. Or perhaps, the ODRRF would issue performance-based debris removal contracts to qualified service providers. Whatever the pricing and payment mechanism chosen, it should be based on the danger posed by the object (orbital altitude, orbital inclination, mass, and trajectory analysis of potential impact) and the action taken to "safe" the object (whether the object is deorbited, captured and controlled, placed into a safer orbit, or physically tagged for better accuracy of measuring its risk.)[113]

[113] J. Dunstan and B. Werb, *Legal and Economics Implications of Orbital Debris Removal: Comments of the Space Frontier Foundation*, DARPA Orbital Debris Removal (ODR) Request for Information for Tactical Technology

More closely linking the risk created by new orbital debris to those potentially creating that added risk reduces the externalities posed by this "tragedy of the commons."[114] But more importantly, funneling that money toward a solution to orbital debris would have far greater benefit than merely having it flow into the general coffers. OSTP should explore "bounty" and other systems to incentivize ADR R&D and deployment.

VI. Where the U.S. Should Focus Its Research Efforts in Combatting Orbital Debris and Further Space Sustainability

Having dedicated the bulk of these Comments to issues that the Orbital Debris Strategic Plan fails to address, we now turn to the specific questions raised in the Request for Comment as to where OSTP should recommend placing emphasis on future R&D. Specifically, the Request for Comment asks:

> (1) The extent to which progress in the R&D topical areas identified in the Orbital Debris R&D Plan will address the orbital debris challenges. What, if any, R&D areas are missing?
> (2) Among the topic areas listed in the R&D Plan, what are the highest priority R&D areas (up to five) for making progress in addressing the challenges posed by orbital debris to the space environment?
> (3) What near-term actions can be taken by the Federal government to make progress towards high priority R&D areas? How would these specific actions address the orbital debris challenges in the near term?
> (4) What R&D activities would be most valuable in the long-term or would be the most transformative to addressing orbital debris challenges?

Office (TTO), Defense Advanced Research Projects Agency (DARPA), Solicitation Number: DARPA-SN-09-68, October 30, 2009 (attached to the email transmitting these comments).

[114] The term "Tragedy of the Commons" has its origins in British land use, and the ability of farmers and ranchers to use common ground to graze cattle and sheep. In 1833 William Forster Lloyd published a pamphlet pointing out that with no one taking care of the common grounds, while each rancher profited from the common ground usage in proportion to his/her use, all ranchers would ultimately suffer if the common ground was overgrazed and became unusable. The term itself has been attributed to the article "The Tragedy of the Commons," published by Garrett Hardin in the journal Science in 1968 dealing more generally with the economics of the misuse of commonly held resources.

(5) What are the opportunities to partner with entities outside the Federal government, nationally and internationally? What are the viable and potentially innovative mechanisms to partner most effectively?[115]

A. Updating Conjunction Modeling Should Be the Top Priority (Research Area 2.3)

Our space situational awareness (SSA) is improving rapidly, although the White House-mandated shift of responsibility from the DoD to the Department of Commerce is lagging behind schedule.[116] The "space fence" has been deployed on the Kwajalein Atoll in the Marshall Islands, and with this new capability, the Space Force can detect objects as small as 1 to 2 centimeters.[117] "Due to Space Fence's sensitivity, we've identified over 5,000 new objects for potential inclusion into the space catalog."[118] Gathering new data are critical to SSA, but unless collision/conjunction models are improved significantly, all that means for space operators are more warnings and more avoidance maneuvers. Updates to the engineering models have been implemented, but the next major update from NASA is not expected for five more years.[119]

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[115] Request for Comment, 86 Fed. Reg. 61335 (November 5, 2021).

[116] *See* J. Feldscher, "As Space Junk Multiplies, Pentagon Is Stuck Tracking It for Civilians," Defense One, May 27, 2021, https://www.defenseone.com/business/2021/05/space-junk-multiplies-pentagon-stuck-tracking-it-civilians/174340/ ("Then-President Trump's 2018 directive was meant to allow the Defense Department's orbital trackers to go back to their original mission: using their sensors to protect national security assets in space. Commerce was supposed to build a more comprehensive tracking system that combined the U.S. military data with information from commercial tracking services and other governments. This new public database would notify civil and international operators when their satellites — or crewed spacecraft — were in peril. But that handoff stalled amid staff turnover in the Office of Space Commerce and, later, the presidential transition. Now as the pace of space launches accelerates, the likelihood of collisions is high and rising — and so, some industry officials say, is the chance that America's longstanding leadership in international space policy may slip away.").

[117] Y. Tadjdeh, "U.S. Strengthening Space Domain Awareness," National Defense, July 30, 2021, https://www.nationaldefensemagazine.org/articles/2021/7/30/us-strengthening--space-domain-awareness.

[118] *Id., quoting* E-mail from Bryan Sanchez, Space Force Major, Dir. of Operations, Cyber, and Exercises, to National Defense.

[119] *NASA IG Report*, 6:

> ODPO periodically updates its engineering models to more accurately reflect the current debris environment, including the addition of data on intentional and accidental explosions that increase the amount of debris as well as information on the material types and density of individual debris. Updates to the engineering models have been released three times—in

The Orbital Debris Strategic Plan recognizes this current disconnect between improved data collection and when to issue conjunction warnings:

> Improvements to supporting models could reduce the number of conjunction data messages and provide better information to support satellite owner and operator assessments of collision risk. Specifically, R&D in space environment characterization, as specified in Section 2.1, and integrating real-time science data and space environment prediction with propagation models could lead to reduced uncertainties in orbit propagation. Agencies should therefore consider an examination of orbital propagation accuracy that could be realized from improvements to supporting models to reduce uncertainty and improve close approach predictions. Agencies should also consider providing more frequent tracking as a mechanism for reducing propagation times, thereby minimizing the accrued errors. Given the challenges in identifying custody of uncorrelated tracks, agencies should pursue R&D into improving custody determination algorithms for trackable debris. In addition, agencies should consider R&D focused on both improved probability-of-collision calculations and covariance realism that could lead to more consistent estimates throughout the close approach engagement.[120]

Improving these models should be the top priority for space situational awareness; it is where increased government funding could do the most good. As stated above, the only thing worse than a collision in space is the increased frequency of the issuance of warnings, forcing satellite operators to constantly expend station precious station-keeping fuel in an effort to "dance around" ever-increasingly congested orbits.

Recommendation 4:

OSTP should recommend to the Administration that maximum effort be put forth to improve orbital models and conjunction analysis.

2002, 2013, and 2019—since the first model was released in 1996. According to ODPO, the next update is expected in about 5 years and will incorporate the element of debris shape into the models, which will allow NASA to better predict impact damage and risks to spacecraft that could be caused by debris of differing shapes. In addition to the engineering models, ODPO has a more forward-looking model it uses to predict the future debris environment. (Footnote omitted.)

[120] Orbital Debris Strategic Plan, 9.

B. Prioritize the "Hand-Off" of SSA from DoD to Commerce (Impacts Research Areas 2.1-2.5)

As noted above, the Trump White House in 2018 in Space Policy Directive 3 (SPD-3)[121] ordered the transition of SSA from DoD to the Department of Commerce. Unfortunately, Congress failed to appropriate any money for this transition until 2021, and then, a mere $10 million in new funding was appropriated to Commerce's Office of Space Commerce to effectuate the transition. Even then, Commerce has failed to deliver a report to Congress indicating how it will spend that money toward the transition. Senate appropriators have threatened to withhold further funding until the Office can show some progress.[122] "The lack of action is likely due to the change of administration, since many of the personnel who were pushing for this during the Trump administration are gone."[123] President Biden has yet even to nominate a new Director of the Office of Space Commerce, leaving the position vacant a full year into this Administration.

OSTP should urge the Administration to name a head of the Office of Space Commerce at the earliest possible time and task that individual to move forward with implementing the transition of SSA from DoD to Commerce. The Administration should also push Congress to continue funding for the Office's activities.

Recommendation 5:
OSTP should recommend to the Administration the completion of the hand-off of SSA from DoD to Commerce, including necessary funding and personnel to do so.

[121] "Space Policy Directive – 3, National Space Traffic Management Policy," https://trumpwhitehouse.archives.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/ ("To facilitate this enhanced data sharing, and in recognition of the need for DoD to focus on maintaining access to and freedom of action in space, a civil agency should, consistent with applicable law, be responsible for the publicly releasable portion of the DoD catalog and for administering an open architecture data repository. The Department of Commerce should be that civil agency.").

[122] *See* J. Foust, "Senate appropriators frustrated with lack of progress on civil space traffic management," Space News, October 20, 2021, https://spacenews.com/senate-appropriators-frustrated-with-lack-of-progress-on-civil-space-traffic-management/ ("The Committee is extremely disappointed with NESDIS's execution of the fiscal year 2021 funding provided to initiate a space traffic management pilot program, with seemingly little progress made in implementing the pilot.").

[123] J. Feldscher, "As Space Junk Multiplies, Pentagon Is Stuck Tracking It for Civilians," Defense One, May 27, 2021, https://www.defenseone.com/business/2021/05/space-junk-multiplies-pentagon-stuck-tracking-it-civilians/174340/.

C. Prioritize Private Sector Participation in Operationalizing SSA (Research Areas 2.4 & 2.5)

The Orbital Debris Strategic Plan notes the role the private sector can play in space sustainability.[124] A number of companies are developing new software and data collection capabilities for SSA.[125] The private sector has always been interested in sustainable space, as evidenced by the 80 companies that participated in DARPA's International Conference on Orbital Debris Removal, December 8-10, 2009.[126] Unfortunately, because DARPA did nothing more with its "Catcher's Mitt" study than issue a report,[127] many of those companies, especially the smaller start-ups, have long gone out of existence. OSTP should encourage the Administration to nurture an ecosystem of companies, both large and small, to engage on space sustainability. A long-term series of Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grants could both support these innovative companies and also yield substantial results to advance ADR.

Recommendation 6:
OSTP should recommend SBIR and STTR funding to spur private sector participation in space sustainability.

D. Prioritize Technologies and Techniques for Large Debris Objects (Research Area 3.1)

Large objects (mainly spent upper stages) present the largest "targets" for future collisions, representing over 99 percent of the collision area and mass, even though they represent less

[124] Orbital Debris Strategic Plan at 13 ("The private sector has contributed throughout the space age as a valuable supplier and partner to the Federal Government.").

[125] *See* "Space Situational Awareness Market to Reach USD 1.73 Billion in 2028," GlobalNewsWire, https://www.globenewswire.com/news-release/2021/06/30/2255778/0/en/Space-Situational-Awareness-Market-to-Reach-USD-1-73-Billion-in-2028-Usage-of-Radio-Frequency-Data-to-Monitor-Space-Objects-will-Aid-Growth-Says-Fortune-Business-Insights.html (listing top-10 private sector businesses engaging in SSA activities).

[126] *See* https://en.wikipedia.org/wiki/Catcher%27s_Mitt.

[127] W. Pulliam, "Catcher's Mitt Final Report," https://apps.dtic.mil/sti/pdfs/AD1016641.pdf.

than one percent of the overall debris population.[128] NASA has long advocated for the removal of larger pieces of debris[129] to avoid future massive collisions that could cascade into a "Kessler Syndrome" event, rending some orbits unusable.[130] Unfortunately, following DARPA's 2009 "Catcher's Mitt" exercise, it was concluded that technology to deorbit large debris was too expensive.

> Multiple active debris removal studies and concepts have been proposed, but cost-effective methods for removing large debris (such as defunct spacecraft) are not yet available. For example, between 2009 and 2011 the Defense Advanced Research Projects Agency (DARPA) conducted a study that evaluated the necessity and feasibility of actively removing debris to decrease the overall population of debris. DARPA, with support from NASA's ODPO, gathered information on potential active debris removal concepts and technologies from the aerospace community through roundtables, requests for information, and an international conference. The study found that "Compliance with existing international debris mitigation guidelines coupled with the pre-emptive removal of the sources of future medium debris [i.e., large debris such as defunct spacecraft] is by far the most cost-effective strategy." After reviewing the proposed concepts, DARPA found that removing large objects would generally entail advanced rendezvous operations to first grab or attach to the debris, and complicated techniques to subsequently

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[128] J. Pearson & J. Carroll, "ElectroDynamic Debris Eliminator (EDDE): Design, Operation, and Ground Support," https://apps.dtic.mil/sti/pdfs/ADA531867.pdf. *See also*, J. Dunstan & B. Werb, *Legal and Economics Implications of Orbital Debris Removal: Comments of the Space Frontier Foundation*, DARPA Orbital Debris Removal (ODR) Request for Information for Tactical Technology Office (TTO), Defense Advanced Research Projects Agency (DARPA), Solicitation Number: DARPA-SN-09-68, October 30, 2009.

[129] *See* "NASA's Efforts to Mitigate the Risks Posed by Orbital Debris," NASA Office of Inspector General, Office of Audits, January 27, 2021, 18, https://oig.nasa.gov/docs/IG-21-011.pdf ("Stabilizing the future orbital debris environment requires a 90% global post-mission disposal rate ***plus the active removal of 5 defunct spacecraft per year."*** (Emphasis added.)).

[130] The "Kessler Syndrome" is named after (and not directly by), retired NASA engineer Donald J. Kessler. According to Kessler, the term was coined by a colleague, John Gabbard, a NORAD analyst. *See* Donald J. Kessler, *The Kessler Syndrome* (Mar. 8, 2009), http://webpages.charter.net/dkessler/files/KesSym.html. *See also* Donald J. Kessler & Burton G. Cour-Palais, *Collisional Frequency of Artificial Satellites: The Creation of a Debris Belt*, Paper 8A0210, 83(A6) J. GEOPHYSICAL RES., 2637 (June 1, 1978); Donald J. Kessler, *Collisional Cascading: The limits of population growth in low earth orbit*, 11(12) ADVANCES IN SCIENCE RES., 63-66 (1991). *See also* James Rendleman, *Space Traffic Management – Private Regulation*, *in* PROC. OF THE AIAA SPACE 2012 CONF. & EXPO., n. 6, AIAA 2012-5124 (Sept. 2012), http://arc.aiaa.org/doi/abs/10.2514/6.2012-5124.

For a fascinating PBS interview with Donald Kessler about orbital debris and the "Kessler Syndrome," *see* https://www.youtube.com/watch?v=LaKz8VDkDkI (last visited Sept. 29, 2013).

> move the debris to less congested orbits or to burn up in the Earth's atmosphere—activities that will likely be expensive. Proposals for capturing large objects included nets, harpoons, and lassos, and suggestions for moving or relocating debris included using thrust or electromagnetic energy. At the time of the DARPA study, these concepts were in the early stages of research and development.[131]

Much has changed in the last decade, including an order-of-magnitude reduction in the price of launching ADR missions. With SpaceX's Starship promising a volume of 8 meters by up to 22 meters in height,[132] the "nets, harpoons, lassos," and other devices used to capture objects and deorbit them may have far easier and cheaper access to space than ever before. In order to leverage these innovations in space launch, we must invest now in developing technologies that can perform ADR on these most dangerous pieces.[133]

Recommendation 7:
OSTP should prioritize R&D into ADR methods for large objects, especially spend upper stages.

VII. Conclusion

The problem of orbital debris is not new. What is new, however, is the explosion of innovation in space, both in the launch sector, and what that launch sector can deliver. Whereas in the past, the technological hurdles to ADR seemed insurmountable, as DARPA found in 2011, today, we ***can*** develop those technologies, if we spend our money wisely. But the key

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[131] *See* "NASA's Efforts to Mitigate the Risks Posed by Orbital Debris," NASA Office of Inspector General, Office of Audits, January 27, 2021, 12, https://oig.nasa.gov/docs/IG-21-011.pdf

[132] "SpaceX Starship Users Guide," March 2020, https://www.spacex.com/media/starship_users_guide_v1.pdf.

[133] TechFreedom does take issue with the Orbital Debris Strategic Plan's conclusion that there is a scalability issue with ADR technology. "It is difficult to scale ADR methods from one piece of debris to many, or from large debris to small debris. Proposed ADR technologies are somewhat specific to debris type, and removing one or two pieces of debris at a time may not be cost-effective nor improve the debris environment significantly." Orbital Debris Strategic Plan, 11. While this may be true in the "gross" sense of the same technology not being appropriate to capture a one ton derelict satellite and a 10 cm cubesat, there is ample reason to believe that within discreet classes of debris, a particular technology may scale well (as between, for example, a one ton and a ten ton satellite). *See, e.g.* J. Carroll, J. Pearson & E. Levin, "Wholesale LEO Debris Capture and Removal Using EDDE," 70th International Astronautical Congress (IAC), Washington D.C., United States, 21-25 October 2019, http://www.star-tech-inc.com/papers/EDDE_2019_IAC_Submitted_Paper_Oct07.pdf.

impediments to space sustainability ultimately may turn out not to be technological development, but rather the glacially slow pace of the development of outer space law and policy. Again, we turn to the words of Andrew G. Haley to conclude these comments:

> In context after context as problems are examined it must be kept in mind that as space science and technology move forward at hypersonic speed, the law cannot afford to remain earthbound. The mildest possible penalty for such a lag will be confusion. The maximum price we may pay is mutual destruction.[134]

Respectfully submitted,
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[134] Space Law and Government,123.