ON-ORBIT SERVICES ARE READY FOR LIFT OFF:

EXISTING U.S. REGULATIONS CAN USHER IN A NEW ERA OF COMMERCIAL SPACE ACTIVITY

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International and U.S. laws and regulations do not explicitly address commercial on-orbit servicing.[1] *Congress should not delay in delegating clear, light touch, regulatory authority over on-orbit servicing to an appropriate executive or independent agency; however, despite what some commentators assert, the current regulatory framework is sufficient under international law to authorize commercial on-orbit services. The Federal Communications Commission (FCC) and the National Oceanic and Atmospheric Administration (NOAA) set a prudent yet ambitious precedent by authorizing Space Logistics to launch a mission extension vehicle (MEV) to perform the first commercial on-orbit*

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1. *See* Executive Office of the President, Office of Sci. and Tech. Pol'y, Letter Submitted in Fulfillment of a Reporting Requirement Contained in the U.S. Commercial Space Launch Competitiveness Act. 4, 3 (Apr. 4, 2016) [hereinafter OSTP Report]; *see* Brian J. Egan, The Next Fifty Years of the Outer Space Treaty, Galloway Symposium on Critical Issues in Space Law (Dec. 7, 2016), https://2009-2017.state.gov/s/l/releases/remarks/264963.htm [https://perma.cc/R6GE-G7F8] (recognizing that the U.S. does not have an existing licensing framework for burgeoning commercial space activities that, by themselves, enable the U.S. to fulfill its OST Art. VI obligations.); *see* Matthew Schaefer, *The Contours of Permissionless Innovation in the Outer Space Domain*, 39 U. PA. J. INT'L L. 103, 137 (2017) (identifying shortcomings in the current U.S. regulatory scheme in dealing with on-orbit services while complying with international law); *see* Major John S. Goehring, *Properly Speaking, the United States Does Have an International Obligation to Authorize and Supervise Commercial Space Activity*, 78 A.F. L. REV. 101, 104 (2018) (identifying the need for Congress to fill in regulatory mechanisms in order to fulfill U.S. obligations pertaining to "authorization and continuing supervision" of outer space activities under the OST).

proximity operation (on-orbit service) on an Intelsat satellite.[2] *This note argues that the Space Logistics authorization is legal under international law and should be used as a model for authorizing future on-orbit services until legislation enables a more directly applicable regulatory framework.*

Specifically, agencies should conditionally authorize discrete portions of on-orbit service missions, focused on mission extension or orbital transportation, in low-risk graveyard or VLEO orbits, while withholding authorization of long-term and higher risk missions until on-orbit servicing craft prove safe and effective.[3] *Moreover, by conforming to industry best practices on-orbit service providers can responsibly launch the industry forward until a more applicable regulatory framework is developed.*

By authorizing low-risk, on-orbit service missions on a case-by-case basis until a more directly applicable statutory and regulatory framework is developed, the United States can ensure that it continues to lead the global space industry.

2. *See* Debra Werner, *Orbital ATK's Giant Leap into Satellite Servicing Begins With Baby Steps*, SPACENEWS (June 11, 2018), https://spacenews.com/orbital-atks-giant-leap-into-satellite-servicing-begins-with-baby-steps [https://perma.cc/7TB9-GZSS].

3. *See* Popular Orbits 101, AEROSPACE SECURITY (last updated Oct. 4, 2019), https://aerospace.csis.org/aerospace101/popular-orbits-101 [https://perma.cc/W2GK-ZJW5]; Marcus Schladebach, *Fifty Years of Space Law: Basic Decisions and Future Challenges*, 41 HASTINGS INT'L & COMP. L. REV. 245, 258 (2018) ("There are lower orbits between 200 and 5,500 km (LEO), medium orbits between 10,000 and 20,000 km (MEO), and highly elliptical orbits between 1000 km and 40,000 km. However, the most interesting orbit is the Geostationary Orbit (GSO) at a height of around 36,000 km."); *see* Josep Virgili Llop, et. al., Very Low Earth Orbit mission concepts for Earth Observation. Benefits and challenges, Reinventing Space Conference, 1 (Nov. 2014) (VLEO stands for "very low earth orbit" and refers to orbits under 450km) https://www.researchgate.net/publication/271499606_Very_Low_Earth_Orbit_mission_concepts_for_Earth_Observation_Benefits_and_challenges [https://perma.cc/CAT3-2ASN].

INTRODUCTION

The commercial space industry is large and growing.[4] From communications, GPS, and internet backbone services, to geo-sensing, credit card transactions, and military support, satellites play an important role in the modern economy, national security, and our everyday lives.[5] As the number of satellites and the services they provide skyrocket, on-orbit services will emerge as a viable means of reducing barriers to entry and providing sustainability in the satellite industry.[6] However, international and U.S. laws and regulations do not explicitly address on-orbit services.[7] Thus, U.S. agencies are not currently specifically authorized by Congress to establish such regulations and none have.[8]

This regulatory gap is both an opportunity and a challenge for the on-orbit service industry. It is widely acknowledged by scholars, industry experts, and government officials that Congress must act quickly to address this regulatory gap to provide certainty for investors in the industry, maintain US leadership in space, and

4. *See 2017 SIA State of the Satellite Industry Report*, SATELLITE INDUSTRY ASS'N (2017), https://www.sia.org/annual-state-of-the-satellite-industry-reports/2017-sia-state-of-satellite-industry-report [https://perma.cc/43ZB-WPQV] [hereinafter SIA SSIR 2017]; *2018 SIA State of the Satellite Industry Report*, SATELLITE INDUSTRY ASS'N (2018), https://www.sia.org/2018_ssir [https://perma.cc/FQ53-3LRJ] (satellite manufacturing and services exceeding $144 billion with a record 345 satellite launches in 2017) [hereinafter SIA SSIR].

5. *10 Ways that Satellites Helped You Today*, CANADIAN SPACE AGENCY, http://www.asc-csa.gc.ca/eng/satellites/everyday-lives/10-ways-that-satellites-helped.asp [https://perma.cc/9ESL-NP3R] (last visited Oct. 9, 2019).

6. Sandra Erwin, *In-Orbit Services Poised to Become Big Business*, SPACENEWS (June 10, 2018) https://spacenews.com/in-orbit-services-poised-to-become-big-business [https://perma.cc/ZY7A-Q4XR].

7. *See* Goehring *supra* note 1, at 104.

8. *See* OSTP Report, *supra* note 1 (identifying need for new regulatory mechanism to govern on-orbit services if U.S. is going to comply with international law).

fulfill US obligations under the Outer Space Treaty (OST).[9] While Congressional action may be forthcoming, it is not necessary to launch the US on-orbit servicing industry.[10] The U.S. agencies currently responsible for regulating commercial space activity– the FCC, FAA, and NOAA–can, have, and should continue to authorize low-risk on-orbit service operations in VLEO and graveyard orbits on a case-by-case basis under the existing regulatory framework.[11] Moreover, they should withhold authorization for long-term high-risk missions in mid-range orbits until on-orbit service activities are proven safe and reliable. This will not only incentivize industry investment, but also serve as a driver for legislative and regulatory action.

This Note will first provide background on the current state of the US commercial space industry, how we got here, and its rapid growth. It will identify how on-orbit services are distinguished from typical satellite operations. This differentiation will lead to the relevant international and domestic laws and regulations that currently govern the space industry. Second, this Note will explain how on-orbit services fit into the space industry but do not perfectly fit into existing regulatory schemes. Third, this Note will demonstrate that the regulatory gaps have and can be filled without Congressional action and comply with international law if agencies exercise appropriate discretion when authorizing on-orbit services. Fourth, this Note will describe the shortcomings of a case-by-case authorization scheme and how such a scheme can be effectively managed in the short term. Finally, this Note concludes by identifying the need for Congressional action to provide greater assurance to the industry and protection under international law.

9. *See* Danielle Miller & Elsbeth Magilton, *On-Orbit Satellite Servicing Standards Are a Necessity for the Private Space Industry*, 31 AIR & SPACE LAW. 1, 4 (2018); OSTP Report, *supra* note 1; *see also* Michael Simpson & Christopher D. Johnson, *Transparency and Security Assurances for Commercial NewSpace On-Orbit Servicing*, SECURE WORLD FOUND., https://swfound.org/media/205365/transparency-and-security-assurances-for-commercial-newspace-onorbit-servicing_m_simpson_c_johnson.pdf [https://perma.cc/S5QC-TSQN] (last visited Mar. 23, 2019); Goehring, *supra* note 1, at 105.

10. *See* Werner, *supra* note 2.

11. *See id.*

I. BACKGROUND

A. *Current state of commercial space activity and how on-orbit servicing is distinguished from, yet similar to, typical satellite operations*

Space is more accessible than ever; it is occupied by university researchers, national defense agencies, amateur radio operators, and private commercial communications companies.[12] National status and power are no longer prerequisites to entering space. Indeed, the new age of space activity is defined by the rising dominance of commercial actors.[13]

As of January 2019, there are approximately 2,000 active satellites operating in Earth's orbit.[14] Of these satellites, 80% are operated by private companies providing a range of services from communications and earth sensing, to space exploration and broadband internet.[15] Many of these private satellites contract with governments to provide communication and security services domestically and abroad.[16] This number is expected to grow exponentially within the next few years, with thousands of satellites slated to deploy in low-earth orbit (LEO) by 2020.[17] The rapid growth of the satellite industry is in lockstep with that of the launch industry.[18] Lower-cost private launch options make it easier

12. *See* Comments of University Small-Satellite Researchers, In the Matter of: Streamlining Licensing Procedures for Small Satellites, FCC IB Docket No. 18-86 (Apr. 5, 2019), https://ecfsapi.fcc.gov/file/1040566700182/2019.04.05%20University%20Researchers%20Orbital%20Debris%20Comment%20final.pdf [https://perma.cc/27K3-H5UZ]; Kendall Russell, *Satellite Launches to Increase Threefold Over the Next Decade*, VIA SATELLITE (Oct. 12, 2017), https://www.satellitetoday.com/innovation/2017/10/12/satellite-launches-increase-threefold-next-decade [https://perma.cc/S6WR-R3UV]; Caleb Henry, *Space Startup Investments Continued to Rise in 2018*, SPACENEWS (Feb. 4, 2019), https://spacenews.com/space-startup-investments-continued-to-rise-in-2018 [https://perma.cc/W5RM-7F7B].

13. *See* SIA SSIR, *supra* note 4.

14. *Id.*

15. SIA SSIR 2017, *supra* note 4, at 8.

16. *See* Benjamin D. Forest, *An Analysis of Military Use of Commercial Satellite Communications*, CALHOUN 2 (Sept. 2008), https://calhoun.nps.edu/bitstream/handle/10945/3991/08Sep_Forest.pdf?sequence=1&isAllowed=y [https://perma.cc/VHU9-9QDM]; *see also* Sandra Erwin, *Space Force Proposal Shifts Satellite Communications Procurement to Air Force Secretary*, SPACENEWS (Feb. 25, 2019), https://spacenews.com/space-force-proposal-shifts-satellite-communications-procurement-to-air-force-secretary [https://perma.cc/L9FF-QY7Z].

17. *See* Todd Shields, *Elon Musk's SpaceX Wins FCC Approval to Deploy 7,518 Satellites*, BLOOMBERG (Nov. 15, 2018), https://www.bloomberg.com/news/articles/2018-11-15/elon-musk-s-spacex-wins-fcc-approval-to-launch-7-000-satellites [https://perma.cc/92X5-BWRM].

18. *See* Global Market Insights, Inc., *Global Space Launch Services Market Trends, Forecast To 2024*, HERALD KEEPER (Nov. 8, 2018), http://heraldkeeper.com/market/global-space-launch-services-market-trends-forecast-2024-162453.html [https://perma.cc/S66A-4LGP].

to deploy satellites, driving the growth of the satellite industry, and private launch providers benefit from this growth as their customer base grows.[19]

Space industry growth is a positive thing for humanity. It increases global connectivity, improves our understanding of weather patterns, informs agricultural production, enables more effective forest management, and more.[20] Yet, increasing the number of satellites in orbit also introduces risk. More satellites in orbit means more capital investment on behalf of satellite companies but results in a greater likelihood of collisions with other satellites or with one or more of the millions of pieces of orbital debris traveling around the earth at over 17,000 mph.[21] These incidents have the potential to cascade into uncontrollable collisions breaking up satellites into pieces of orbital debris that impact other satellites in a chain reaction.[22]

These catastrophic events threaten to destabilize entire orbital planes resulting in what has become known as the Kessler Syndrome.[23] To mitigate the risk of these events, the FCC and NOAA have included orbital debris mitigation in their licensing requirements.[24] However, once satellites are launched, physical realities dictate that agencies have no practical power to prevent or address rogue satellites from breaking up or colliding with other satellites. Moreover, it is up for debate whether the FCC, the FAA, or NOAA possess the requisite authorization from Congress to regulate orbital debris mitigation in the first place.[25]

19. *See* Kenneth Chang, *Rocket Lab's modest launch is giant leap for small-rocket business*, THE SEATTLE TIMES (Nov. 18, 2018), https://www.seattletimes.com/business/rocket-labs-modest-launch-is-giant-leap-for-small-rocket-business [https://perma.cc/KFL8-A6TJ].

20. *See generally What Are Satellites Used For?*, UNION OF CONCERNED SCIENTISTS, https://www.ucsusa.org/nuclear-weapons/space-weapons/what-are-satellites-used-for#.XDeFN89KhE4 [https://perma.cc/PXM6-PWAM] (last visited Mar. 24, 2019).

21. *See* Martin N. Sweeting, *Modern Small Satellites-Changing the Economics of Space*, PROCEEDINGS OF THE IEEE, Mar. 2018, at 343; *see also* Nodir Adilov, Peter J. Alexander, Brendan M. Cunningham, *An Economic "Kessler Syndrome": A Dynamic Model of Earth Orbit Debris*, 166 ECON. LETTERS 79-82 (2018); *Space Debris and Human Spacecraft*, NAT'L AERONAUTICS AND SPACE ADMIN. (Sept. 26, 2013), https://www.nasa.gov/mission_pages/station/news/orbital_debris.html [https://perma.cc/DEQ6-Z73C].

22. *See* Adilov et al., *supra* note 21.

23. *Id.*

24. Applications for Space Station Authorization, 47 C.F.R. § 25.114(d)(14) (2018); Licensing of Private Land Remote-Sensing Space Systems, 15 C.F.R. § 960.11 (2006).

25. *See* Laura Montgomery, *FCC's Proposed New Orbital Debris Rules: Jurisdiction, Duplication, and Indemnification*, GROUND BASED SPACE MATTERS (Feb. 21, 2019), https://groundbasedspacematters.com/index.php/2019/02/21/fccs-proposed-new-orbital-debris-rules-jurisdiction-duplication-and-indemnification [https://perma.cc/S4CV-23FX]; Brian Weeden, *US Space Policy, Organizational Incentives, and Orbital Debris Removal*, THE SPACE REVIEW (Oct. 30, 2017), http://www.thespacereview.com/article/3361/1 [https://perma.cc/W6S6-9T74].

Nevertheless, in November of 2018 the FCC issued a Notice of Proposed Rule Making (NPRM) on the Mitigation of Orbital Debris in the New Space Age in which they re-presented the question originally posed in the 2004 Orbital Debris Order: whether or not the FCC has the authority to regulate orbital debris.[26] In the 2004 Orbital Debris Order, the FCC rooted its authority in "the Commission's authority with respect to authorizing radio communications" born of the Communications Act. [27] The Act charged the FCC with encouraging "the larger and more effective use of radio in the public interest," and provided for licensing of radio communications, upon a finding that the "public convenience, interest, or necessity will be served thereby."[28] The latest orbital debris concerns sparking the 2018 Orbital Debris NPRM originate from the rapid proliferation of satellites, including small satellites, which rely on radio communication to operate.[29]

Small satellites make up the lion's share of planned deployments over the next few years, mainly in LEO orbits.[30] At the same time, big and expensive communication satellites in GEO orbits are approaching the end of their operational lifetime because of depleted fuel, propellants, or failing components.[31] These satellites occupy coveted orbital locations in geosynchronous orbit and deliver high-value services across the globe.[32] Satellites in GEO orbits are of such great value that extending their mission life by just a few years can be worth the increased risks associated with mission extensions.[33] Intelsat has determined that this calculus is true for two of their GSO satellites and have contracted with Space Logistics to provide on-orbit life extending services.[34] Thus, Space Logistics' MEV is the first licensed commercial on-orbit service craft, designed to dock with a target satellite and extend its life by

26. *See* Notice of Proposed Rulemaking, In the Matters of Mitigation of Orbital Debris in the New Space Age and Mitigation of Orbital Debris, 33 F.C.C. Rcd 11352 (2018) [hereinafter 2018 Orbital Debris NPRM]; *see* Second Report and Order, In the Matter of Mitigation of Orbital Debris, 19 F.C.C. Rcd 11567 (2004) [hereinafter 2004 Orbital Debris Order].

27. 2018 Orbital Debris NPRM, *supra* note 26, at ¶ 15 (citing 19 FCC Rcd at 11575, para. 14).

28. *Id.* (quoting 19 FCC Rcd at 11575, para 14).

29. *See* 2018 Orbital Debris NPRM, *supra* note 26, at ¶¶ 1-2.

30. *See* Popular Orbits 101 *supra* note 3; *see also, e.g.,* SpaceX Authorization, IBFS File No. SAT-LOA-20170301-00027 S2992, Attachment: Legal Narrative 2 (Nov. 15, 2018).

31. *See* Sweeting, *supra* note 21; *see also* "The Future of Satellites," THE NEW ATLANTIS (2003); Mark Holmes, *Satellite Servicing Becomes an Actual Market*, VIA SATELLITE (March 2019), http://interactive.satellitetoday.com/via/march-2019/satellite-servicing-becomes-an-actual-market [https://perma.cc/4CJP-2RUU].

32. *See* Holmes, *supra* note 31.

33. *See id.*

34. *See id.*

taking over maneuvering capabilities.[35] Later in this note, this authorization will be used as the primary example for how agencies should address subsequent on-orbit service licensing. Subsequent commercial on-orbit service license applications are sure to come as aging, yet otherwise functional, satellites and the increasing risk associated with orbital debris create increasing demand for on-orbit services.

On-orbit services, as a concept and in practice, date as far back as 1973 when the United States sent a manned mission to repair its Skylab launched weeks earlier.[36] Although government operated missions have historic precedent, such as those to the Hubble space telescope, ISS, and various satellites, commercial on-orbit services are something new entirely due to the commercial realities and the satellite regulatory framework they are subject to.[37]

Commercial on-orbit service craft essentially operate as a typical satellite would when not performing services. Operating as a typical satellite includes being controlled remotely by radio signals to and from Earth stations or other satellites, moving from the deployment location to various orbital locations using onboard propulsion, utilizing remote sensing capabilities, and sometimes performing evasive maneuvers to avoid collisions with other objects in space.[38] Moreover, the Space Logistics MEV is authorized to conduct tracking, telemetry, and control (TT&C) operations in the 5925-6425 MHz and 13.75-14.5 GHz (Earth-to-space), and 3700-4200 MHz and 11.45-12.25 GHz (space-to-Earth) frequency bands allocated for fixed-satellite operations.[39] Thus, as will be explained below, commercial on-orbit service craft fit into the FCC's and

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35. Mike Wall, *First-of-its-Satellite Kind Servicing Spacecraft Launches on Russian Rocket*, SPACE.COM (Oct. 9, 2019), https://www.space.com/mev-1-satellite-servicing-spacecraft-launch-success.html [https://perma.cc/5CKH-VY5E].

36. *See* MARTIN LOSEKAMM, JACOB HACKER, NIKITA SARDESAI, ANJA NAKARADA PECUJLIC, AND ADAM VIGNERON, LEGAL AND POLITICAL IMPLICATIONS OF FUTURE ON-ORBIT SERVICING MISSIONS 1, INTERNATIONAL ASTRONAUTICAL FEDERATION (2015).

37. *See id.* (STS grabbing satellites and performing other on-orbit services); *see also* Jen DiMascio, *The Beginning Of Commercial, On-Orbit Servicing*, AVIATIONWEEK (June 25, 2019), https://aviationweek.com/space/beginning-commercial-orbit-servicing [https://perma.cc/274L-THEH].

38. *See* *Satellite Basics*, INTELSAT GENERAL, https://www.intelsatgeneral.com/satellite-basics [https://perma.cc/XL52-C3BA] (last visited Mar. 3, 2019); see *Satellite Safety*, NAT'L AERONAUTICS AND SPACE ADMIN., https://satellitesafety.gsfc.nasa.gov [https://perma.cc/NB5J-QN8Q] (last visited Oct. 18, 2019); *see A Practical Introductory Guide on Using Satellite Technology for Communications*, INTELSAT GENERAL, https://www.intelsatgeneral.com/wp-content/uploads/2011/02/5941-SatellitePrimer-2017.pdf [https://perma.cc/V6BD-HMU6] (last visited Oct. 18, 2019).

39. *See* Space Logistics, LLC, I.B.F.S., File No. SAT-LOA-20170224-00021 (Dec. 5, 2017) (Grant in Part/Defer in Part); *see also* FCC Online Table of Frequency Allocations, 47 C.F.R. § 2.106 (May 7, 2019), https://transition.fcc.gov/oet/spectrum/table/fcctable.pdf [https://perma.cc/8BA9-DZKB].

NOAA's jurisdiction because they require radio frequencies and remote sensing capabilities to operate.

However, on-orbit services are distinguished from typical satellites because of the nature of their primary mission. Unlike typical satellite operations, on-orbit services are not communications based, earth sensing, or research oriented as a primary function. Rather, the missions that commercial on-orbit service craft are likely to conduct include: on-orbit refueling, AOCS (Altitude and Orbit Control System) life extension, deorbit or orbital transfer, array operations, and mechanical intervention.[40] While typical satellite operations seek to avoid activities in close proximity with other satellites, the primary functions of on-orbit service missions are conducted not only in close proximity to, but in contact with other spacecraft.[41]

Operating in close proximity to other spacecraft increases the risk of orbital debris resulting from docking, undocking, and collisions.[42] Moreover, many satellites host an abundance of proprietary technology and information sensitive to business interests or national security.[43] Consequently, the advanced sensor technology and close proximity inherent in on-orbit services result in an increased risk of corporate and international espionage.[44] In addition, under the OST, satellites are treated as islands of sovereignty in space, presenting international legal liability when one country's satellite collides with another country's satellite.[45]

It is clear that proximity operations, the defining characteristic that set on-orbit services apart from traditional satellite operations, pose unique challenges that typical satellites do not. Yet, despite

40. "On-orbit refuelling: The servicer attaches to a satellite and transfers fuel to extend its operational life. AOCS (Altitude and Orbit Control System) life extension: The servicer attaches to a satellite and extends its operational lifetime by performing station-keeping and attitude control maneuvers. Deorbit or orbital transfer: The servicer attaches to a satellite and removes it from its operational orbit by either deorbiting it (if the satellite is in LEO) or moving it to a graveyard orbit (if the satellite is in GEO). The same technology may also be used to transport satellites from one orbit to another where the satellite would then continue operations. Array operations: The servicer attaches to a satellite and connects to its electrical subsystem. It then uses its own power to provide electrical power to the satellite, thereby extending its operational lifetime. Mechanical intervention: The servicer uses a robotic arm to assist with the deployment of equipment that has not deployed correctly after launch." LOSEKAMM ET AL., *supra* note 36, at 3-4.

41. *See id.* at 3.

42. *See* NASA., PROJECT REPORT, ON-ORBIT SATELLITE SERVICING STUDY 124, 125 (Oct. 2010) [hereinafter NASA Project Report].

43. *See* DEF. INTELLIGENCE AGENCY, CHALLENGES TO SECURITY IN SPACE 21 (Jan. 2019); *see also* SPACE GENERATION ADVISORY COUNCIL, ON-ORBIT SERVICING COMMERCIAL OPPORTUNITIES WITH SECURITY IMPLICATIONS, UNITED NATIONS PROGRAMME ON SPACE APPLICATIONS, FINAL REPORT - SPACE GENERATION CONGRESS TORONTO 59 (2014).

44. *See* SPACE GENERATION ADVISORY COUNCIL, *supra* note 43.

45. *See* Simpson & Johnson, *supra* note 9, at 8.

the critical differences in primary functions and risk implications, operating on-orbit service craft up to, and following, the service performed closely aligns with typical satellite operations. Thus, the general operations of on-orbit service craft can fit within the current regulatory framework governing commercial space activity. Despite assertions that such services fall outside of both U.S. and international law, the FCC and NOAA have both authorized Space Logistics to launch and operate the first commercial on-orbit service to extend the life of an aging commercial satellite.[46]

B. Existing international and domestic laws governing outer space activity and their gaps

Today the space industry is a vibrant ecosystem of government and commercial actors engaged in launch services, communications, space exploration, and scientific research.[47] The burgeoning industry is on track to usher in commercial on-orbit services including orbital location transfers, mission extension, array operations, mechanical repairs, and refueling.[48] But the space industry was not always this way. Understanding how space activity has evolved is helpful to understanding the current status of law governing space activity within international and domestic contexts, the gaps that may hinder emerging services, and how we can utilize the current regulatory framework to achieve progress today.

Beginning in the second half of the twentieth century, the great powers, specifically the United States and the U.S.S.R. (now Russia), set their sights on space, launching satellites, manned missions to the moon, telescopes, and eventually what has been lauded as one of the most incredible examples of multinational cooperation: the International Space Station.[49] Recognizing the incredible potential that space possessed, both for advancement and cooperation, and also for rivalry and disaster, the international community established the OST to safeguard the peaceful use of space.[50] This agreement and its progeny, including the Liability

46. *See* Werner, *supra* note 2.

47. *See* SIA SSIR 2017, *supra* note 4 (highlighting variety of services in space).

48. *See* LOSEKAMM ET AL., *supra* note 36, at 3; *see* Simpson & Johnson, *supra* note 9, at 2.

49. *See* Roger Handberg, There is No Space Race, THE SPACE REVIEW (Jan. 21, 2019), http://www.thespacereview.com/article/3645/1 [https://perma.cc/WES9-CA92].

50. *See* Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Oct. 10, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty or OST]; *see* Simpson & Johnson, *supra* note 9, at 6.

Convention, place liability and duties onto states, for their own space-based-activity and that of their citizens.[51]

Although space activity was spearheaded by governments flexing their scientific, engineering, and capital muscles, commercial participants entered the scene as early as 1962, when space activity was just getting off the ground.[52] Since then, the number of satellites and services has drastically increased while the life-cycle of the industry has essentially remained the same: invest in research and development, manufacture a satellite, launch it into space, place it in orbit, operate it using radio waves directed at the earth or space for the duration of its useful life, and move it to a graveyard orbit or let it burn up upon reentry in the atmosphere at the end of its lifecycle.[53]

Under this model, satellites ideally never interact physically with another object once in orbit.[54] This was because on-orbit servicing to extend the life of aging or malfunctioning spacecraft was impractical due to technical and financial hurdles.[55] The cost of developing the technology, building a service craft, launching it into orbit, and conducting operations has been daunting given liability issues and myths regarding a limited customer base and lack of profitability.[56]

As the actors comprising space-based operations have increased and diversified over the last sixty years, the services and operations diversified as well. It is within this overarching trend of space activity that international and domestic law and regulations governing the industry have developed.[57]

1. International Space Law

As a party to the Outer Space Treaty, the United States is under an international obligation to "authoriz[e]" and provide "continuing supervision" for its non-governmental (commercial)

51. *See* OST, *supra* note 50, at Art. VI-VII; *see* 1972 Convention on the International Liability for Damage Caused by Space Objects (Space Liability Convention), Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187.

52. *See* Handberg, *supra* note 49; *see A History of Excellence*, TELESAT, https://www.telesat.com/satcom/year-major-anniversaries-telesat [https://perma.cc/BW2T-CE4P] (last visited Oct. 10, 2019).

53. *See* Victoria Hodges, *Designs on Space: The Lifecycle of a Satellite*, CATALYST (Feb. 2009).

54. *See* Mahashreveta Choudhary, *What is On-Orbit Satellite Servicing?*, GEOSPATIAL WORLD (Oct. 15, 2019), https://www.geospatialworld.net/blogs/on-orbit-satellite-servicing-process-benefits-and-challenges [https://perma.cc/998S-FHEX].

55. *See id.*

56. *See* NASA Project Report, *supra* note 42, at 27-32.

57. *See* Major Susan J. Trepczynski, *New Space Activities Expose A Potential Regulatory Vacuum*, 43 THE REPORTER 12 (2016).

space activities.[58] The United States registers its commercial actor satellites on its registry of space objects, an important mechanism for maintaining jurisdiction over objects and transparency among state actors.[59]

Pursuant to the OST and related treaties, most notably the Registration and Liability Conventions (referred to collectively as "the Space Treaties"), states are ultimately responsible for the actions, and their effects, of non-state actors that operate/launch under their flag.[60] This essentially creates islands of sovereignty in space associated with any man-made object.[61] Under the Liability Convention, incidents that occur on Earth and in the atmosphere as a result of space activity, including launch and reentry, are treated with absolute liability.[62] Alternatively, anything that occurs in orbit is fault based.[63] These standards apply to all space activities, regardless of how they are regulated, how they align with typical space activity, or how they differ.[64]

Furthermore, the Liability Convention establishes a dispute resolution framework for space based activities.[65] These disputes are "subject to diplomatic negotiations, adjudication by a commission assembled by the parties, or ultimately adjudication by the International Court of Justice."[66] There is good reason to believe that "without knowing what activities the U.S. government considers acceptable" operators will be hesitant to invest in new services for fear that the United States will not defend them against "the capricious (or valid) claims of foreign operators."[67]

In addition to the Space Treaties, the United States is a member of the International Telecommunication Union (ITU), a United Nations entity responsible for establishing international laws, rules, and guidelines on the use of electromagnetic spectrum

58. *See* Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, *supra* note 50, at art. 6.

59. Simpson & Johnson, *supra* note 9, at 8.

60. *Id.* at 7.

61. *Id.* at 9.

62. *See* Space Liability Convention, *supra* note 51, at Art. II. *See* Simpson & Johnson, *supra* note 9*,* at 9 ("Absolute liability requires merely that cognizable damage has occurred and that the defending party caused it.").

63. *See* Space Liability Convention, *supra* note 51, at Art. IV; *see* Simpson & Johnson, *supra* note 9, at 9 ("fault-based liability requires a showing of the existence of a duty, that the defendant violated that duty, that the violation was the actual and proximate cause of damage, and also that the damage which resulted was of the type for which law allows compensation.").

64. *See* Space Liability Convention, *supra* note 51, at Art. II.

65. *See* Miller & Magilton, *supra* note 9, at 4.

66. *See id.*

67. *See id.*

for radio communications.[68] As satellites and spacecraft rely on radio communications to operate and provide their services, satellite operations must meet the standards and requirements established by the ITU related to frequency usage, priority of services, and orbital location standards established to mitigate interference with satellites in the same region.[69]

Although the ITU is instrumental to establishing a globally coordinated communications scheme and the Space Treaties provide a framework within which states must establish their own laws and regulations governing outer space activity, most rule-making and regulation of space activities is left to state actors.[70] It is up to states to ensure that they enact laws to govern their own space activity, and that of their citizens, that comply with the Space Treaties' requirement that they authorize and provide continuing supervision over such activities.[71]

2. Domestic Space Law and Regulation

The United States meets its obligations under international law with a patchwork of domestic laws and regulations spread among various agencies. While the FAA regulates launch and reentry, its authority to provide oversight to activities outside the atmosphere is limited.[72] In addition, although they do not regulate in the space, the Department of Defense and the State Department play roles in authorizing commercial space activity.[73] Notably, the National Space Policy, issued by the Executive branch, provides non-binding direction and overarching goals with which agencies can align their rules.[74] NOAA regulates certain aspects of commercial space activity if a spacecraft has remote sensing abilities.[75] Finally, under its mandate to regulate radio communications in the public interest, the FCC provides the most

68. *See generally* Schaefer, *supra* note 1, at 129-33.
69. *See id.*
70. *See id.,* at 137-140.
71. *See* Simpson & Johnson, *supra* note 9, at 8-9.
72. *See* 14 C.F.R. §§ 415.1, 415.15 (2019).
73. Miller & Magilton, *supra* note 9, at 3.
74. *See National Space Policy*, OFF. OF SPACE COM., https://www.space.commerce.gov/policy/national-space-policy [https://perma.cc/B5EJ-S299] (last visited Mar. 24, 2019).
75. *About the Licensing of Private Remote Sensing Space Systems*, NAT'L OCEANIC AND ATMOSPHERIC ADMIN., https://www.nesdis.noaa.gov/CRSRA/licenseHome.html [https://perma.cc/6YUP-76BM] (last visited Oct. 5, 2019) ("Who is Required to Apply for a License? It is unlawful for any person who is subject to the jurisdiction or control of the United States, directly or through any subsidiary or affiliate to operate a private remote sensing space system without possession of a valid license issued under the Act and the regulations.").

robust oversight among U.S. agencies over commercial activity that occurs in space.[76]

The FCC has statutory and regulatory authority to govern the non-federal use of spectrum.[77] Pursuant to this authority, the FCC has promulgated rules pertaining to commercial, amateur, and experimental satellite operations to meet U.S. obligations as a member of the ITU.[78] These rules allocate spectrum among the various types of satellite services, establish licensing procedures to assign spectrum to satellite operators, set standards for the use of the spectrum, mandate spacing for certain types of satellites, and regulate certain aspects of information gathering and operation of satellite operation.[79] Moreover, the FCC requires applicants to provide statements and disclosures regarding the assessments and plans they have completed to mitigate the risk of orbital debris.[80] The FCC points to standards developed by NASA as guidance on conducting analysis and compiling the required orbital debris mitigation statement.[81]

In 2018 the FCC issued an NPRM to revise its orbital debris mitigation rules.[82] The NPRM seeks comments on how to most appropriately apply more robust informational and operational requirements on satellite operators to mitigate the risk of orbital debris.[83] This includes additional disclosures regarding the potential for debris released during normal operations, minimizing debris generated by release of persistent liquids, design and fabrication reliability requirements, casualty risk assessments, disclosure of capability of performing "space rendezvous or proximity operations," tracking telemetry and control coordination between satellite operators rather than on non-interference basis, maintaining and sharing ephemeris data to enhance ability to avoid collision with systems in the same region, TT&C encryption requirements, potential to mandate that space station licensees indemnify the United States against any costs associated with a

76. 47 U.S.C. § 151 (1996)*; see* 2004 Orbital Debris Order, supra note 27, at 39; *see* Mitigation of Orbital Debris in the New Space Age, 84 Fed. Reg. 4742, 4743-4744.

77. Trepczynski, *supra* note 57, at 14.

78. *See generally* 47 C.F.R. §§ 25, 5, 95.

79. Schaefer, *supra* note 1, at 117-133.

80. *See* 47 CFR § 25.114 (2018).

81. Public Notice of Guidance on Obtaining Licenses for Small Satellites, 28 F.C.C. Rcd 2555 (Mar. 15, 2013); *see Debris Mitigation*, NAT'L AERONAUTICS AND SPACE ADMIN., https://orbitaldebris.jsc.nasa.gov/mitigation [https://perma.cc/ZFS5-UZVW] (last visited Oct. 5, 2019).

82. *See generally* Mitigation of Orbital Debris in the New Space Age, *supra* note 76, at 4742-4743.

83. *See id.*

claim brought against the United States related to the authorized entity, and potential for insurance requirements.[84]

Despite how comprehensive the FCC's current and proposed rules are with regard to commercial space communications, there are strikingly few rules pertaining to actual satellite operations following launch and prior to reentry.[85] This is especially true for rules pertaining to intentional contact between spacecraft. Moreover, the FCC does not have explicit congressionally delegated authority to regulate orbital debris.[86]

To safeguard national security, NOAA issues licenses that govern satellites capable of remote sensing.[87] NOAA's authorization considers "rigorous conditions on the operation of a system, including the requirement that the licensee maintain operational control of its system from a U.S. territory at all times and incorporate safeguards to ensure the integrity of system operations and security of its data."[88] In addition to operational requirements, NOAA licenses also require orbital debris mitigation assessments, disclosures, and plans, referring to the U.S. Government Orbital Debris Mitigation Standard Practices, developed based on the NASA Standard, for guidance on fulfilling this requirement.[89] These requirements are similar, but not quite as robust as the FCC's, because the NOAA is more focused on end of life than general operations.[90] Similar to the FCC, NOAA has no explicit authority to regulate orbital debris or proximity operations.[91]

The FAA is involved in regulating the launch and reentry aspects of space activity, but has no role in the on-orbit operations of satellites.[92] Specifically, the FAA is responsible for conducting payload review; however, they do not review payloads subject to

84. *See generally id.*

85. *See generally* Schaefer, *supra* note 1, at 133-35.

86. *See* Miller & Magilton, *supra* note 9, at 3.

87. *See* Trepczynski, *supra* note 57, at 16.

88. *See Commercial Remote Sensing Regulatory Affairs*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., https://www.nesdis.noaa.gov/CRSRA/licenseHome.html [https://perma.cc/5QBQ-GYKG] (last visited Oct. 6, 2019).

89. *See U.S. Government Orbital Debris Mitigation Standard Practices*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., https://www.nesdis.noaa.gov/CRSRA/files/USG_Orbital%20Debris_Standard_Practices.pdf [https://perma.cc/93VY-QP7J] (last visited Mar. 24, 2019); *see* Debris Mitigation, *supra* note 82.

90. *See* DANIEL MORGAN, CONG. RESEARCH SERV., R45416, COMMERCIAL SPACE: FEDERAL REGULATION, OVERSIGHT, AND UTILIZATION 15 (2018); *see also* 15 C.F.R. §960.11 (2006) (noting only fourteen conditions for operations of remote sensing systems).

91. Marlon Sorge, *Commercial Space Activity and Its Impact on U.S. Space Debris Regulatory Structure*, THE AEROSPACE CORP. 2 (Aug. 2017), https://aerospace.org/sites/default/files/2018-05/CommercialDebrisRegulation.pdf [https://perma.cc/3PMB-GV3E].

92. *See* Trepczynski, *supra* note 57, at 17.

regulation by the FCC, Dept. of Commerce, or NOAA.[93] Interestingly, "[t]he U.S. government currently indemnifies launch companies against losses over a statutorily established liability cap in the event of a catastrophic occurrence during launch;" however, the current U.S. regulatory framework does not address similar issues as they relate to on-orbit servicing.[94] Importantly, the FAA "consults with other federal agencies, including the National Aeronautics and Space Administration, authorized to address issues [affecting U.S. national security or foreign policy interests, or international obligations], associated with an applicant's launch proposal."[95] These consultations include FCC and NOAA licenses for spectrum and remote sensing use.[96]

The Department of Defense (DOD) is also involved in the satellite licensing process, ensuring that proposed payloads and sensing equipment meet security requirements.[97] Additionally, the State Department's Office of Space and Advanced Technology (OES/SAT) ensures that U.S. space policies and multilateral science activities support U.S. foreign policy objectives and enhance U.S. space and technological competitiveness, essentially ensuring compliance with international obligations.[98]

The National Space Policy (NSP) promulgated by the executive branch helps guide agencies and lawmakers in establishing rules that align with U.S. policy objectives in space and the space industry.[99] However, in 2017 a federal court found that "[u]pon reviewing the NSP. . . the inescapable conclusion is that it represents a series of internal management directives and does not have the force of law."[100]

Despite an abundance of laws and regulations surrounding space-based activities, there are no laws or regulations that specifically address on-orbit servicing. Regardless of its lack of specific rules and international obligations to regulate space activity, the U.S. regulatory framework can and should

93. 14 C.F.R. § 415.53.
94. *See* Miller & Magilton, *supra* note 9, at 3; 51 U.S.C. § 20148 (2018).
95. 14 C.F.R § 415.23(b)(3).
96. *See* Ken Wong, *Regulating and Licensing Commercial Space Transportation*, FED. AVIATION ADMIN. 25 (Oct. 17, 2018), https://www.nesdis.noaa.gov/CRSRA/pdf/FAA_COMMERCIAL_TRANSPORTATION.pdf [https://perma.cc/54S4-9SQV].
97. Miller & Magilton, *supra* note 9, at 3.
98. *See About Us – Office of Space and Advanced Technology*, U.S. DEPT. OF STATE, https://www.state.gov/about-us-office-of-space-and-advanced-technology [https://perma.cc/J9V4-ZWBS] (last visited Oct. 6, 2019).
99. *See National Space Policy, supra* note 74.
100. *See* Orbital ATK, Inc. v. Walker, No. 117CV163LMBIDD, 2017 WL 2982010, at *8 (E.D. Va. July 12, 2017).

accommodate the authorization of on-orbit services in compliance with international law.

II. DISCUSSION

Because space activity has been relatively limited in scope since its emergence, the laws and regulations governing it are similarly limited. Although U.S. agencies are not specifically designated to address on-orbit services, they have taken positive steps toward establishing leadership in on-orbit services by authorizing Space Logistics' MEV.[101] Lack of specifically applicable laws and regulations means less certainty when it comes to protection under domestic and international law, and thus less security of investments in emerging technologies and services; however, this should not be an insurmountable barrier to the viability of on-orbit services and technologies.[102] The following discussion identifies how U.S. authorization of specific on-orbit services complies with international law despite assertions that such authorizations of on orbit services run afoul of international law. Moreover, it demonstrates how this precedent should be used as a model for future regulatory and Congressional action.

A. The United States has appropriately utilized existing regulations to authorize the first privately operated on-orbit service mission, but limitations of this process warrant a more specifically applicable regulatory regime.

The FCC and NOAA have set a positive precedent in their grants of authority for Space Logistics to launch their MEV.[103] This authorization should be used as a model for future case-by-case authorizations of on-orbit services as well as any potential legislative and more permanent regulatory schemes. The following analysis will demonstrate that the authorization complies with international law, avoids infringing upon state sovereignty, and minimizes the potential impact of orbital debris created as a result of the mission.

101. *See* Werner, *supra* note 2.
102. *See* Schladebach, *supra* note 3, at 267 ("This cost-intensive industry sector is highly interested in legal certainty. Big financial investments into the space industry need reliable legal conditions and such a national act can offer legal certainty and predictability."); Schaefer, *supra* note 1, at 160.
103. *See* Werner, *supra* note 2.

1. The current legal framework is good enough for on-orbit services to lift off, but requires agency discretion.

Because the FCC and NOAA include orbital debris mitigation assessments and practices as part of their licensing requirements, authorizing on-orbit service missions comports with international law if it is done in discrete mission segments and between U.S. licensed operators. Authorizing such operations in low-risk orbits to demonstrate proof of concept prior to authorizing risky missions in more populated orbits will reduce the likelihood that such authorizations will be challenged.

a. By requiring orbital debris assessment reports as part of their licensing requirements, the FCC and NOAA provide sufficient "authorization" of on-orbit services to satisfy international law.

Because the FCC and NOAA both address mitigating orbital debris as a result of on-orbit collisions in their authorization processes, the distinguishing feature of on-orbit transportation services, physical contact with a third-party spacecraft, is sufficiently encompassed in the authorizations provided by these agencies to meet international "authorization" obligations.[104]

Under Article VI of the OST, the United States is obligated to authorize "the activities of non-governmental entities" operating under the U.S. flag.[105] When authorizing non-governmental space activities, at minimum, a state must seek to assure conformity by its commercial space actors with OST provisions.[106] Article I of the OST dictates that "[t]he exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries."[107] Moreover, Article IX requires that State Parties "conduct exploration" of the Moon and other celestial bodies "so as to avoid their harmful contamination" and also requires States "where necessary… [to] adopt appropriate measures for this purpose."[108] As increased orbital debris contributes to the possibility of the Kessler syndrome becoming a reality, thereby harmfully contaminating Earth's orbit and reducing the ability of all countries to explore and use outer

104. *See generally* Communications Act of 1934, 47 U.S.C. §§ 151-163; 2004 Orbital Debris, *supra* note 26; 47 C.F.R. § 25.114(d)(14) (2018); National and Commercial Space Programs Act (NCSPA), 51 U.S.C. § 60121 (2018); 15 C.F.R. § 960.11 (2006).

105. *See* OST, *supra* note 50, at Art. VI.

106. *See* Schaefer, *supra* note 1, at 142; Egan, *supra* note 1.

107. OST, *supra* note 50, at Art. I.

108. *Id.*, at Art. IX; *see* Egan, *supra* note 1.

space, it stands to reason that spacefaring nations authorize activities that could potentially create unreasonable orbital debris.

With regard to satisfying obligations under the OST, Major Goehring points out that Article VI "is commonly understood to require 'a certain minimum of licensing and enforced adherence to government-imposed regulations' for commercial entities."[109] The FCC and NOAA leverage elements of their general regulatory authority to fill the vacuum of specifically delegated regulatory authority to govern orbital debris mitigation. The FCC accomplished this by invoking its authority to ensure the "public interest" is served when authorizing commercial space craft.[110] On the other hand, NOAA extends its responsibility to regulate end of life disposal to orbital debris mitigation.

Thus, NOAA interprets the mandate that licensees shall, "upon termination of operations under the license, make disposition of any satellites in space in a manner satisfactory to the President," to mean that licensees shall mitigate orbital debris released during the disposal of its satellite.[111] Both agencies point to the technical standards and related software tools made publicly available by NASA to guide their orbital debris assessment report (ODAR) and mitigation disclosures required for authorization.[112] The NASA Standard incorporates guidance on how to assess and mitigate debris generated by on-orbit collisions.[113] Although this guidance does not specifically address on-orbit services, it requires that the assessment of "accidental collisions with space objects" be "less than 0.001."[114] Moreover, the FCC's recently issued 2018 Orbital Debris NPRM promises to buttress existing orbital debris mitigation requirements with additional informational and operational requirements to more effectively address the risks inherent in existing and new space activities, including on-orbit servicing.[115]

Although on-orbit services are distinguished from today's typical satellite operations, the attributes of deorbit, mission extension, and orbital location transport services in particular are not so fundamentally different from traditional satellite operations

109. *See* Goehring, *supra* note 1, at 106.

110. *See* Communications Act, *supra* note 104; 2004 Orbital Debris, *supra* note 26; 47 C.F.R. § 25.114(d)(14) (2018).

111. *See* NCSPA, *supra* note 104, at § 60122; *see* 15 C.F.R. § 960.11 (2006).

112. *See About the Licensing of Private Remote Sensing Space Systems*, *supra* note 75.

113. *See* NAT'L AERONAUTICS & SPACE ADMIN., NASA SAFETY STANDARD § 5-1 (1995), https://transition.fcc.gov/ib/sd/ssr/docs/1740_14.pdf [https://perma.cc/3GA3-LTVP] [hereinafter NASA STANDARD].

114. *Id.*

115. *See* 2018 Orbital Debris NPRM, *supra* note 26, at 24-25.

to require additional regulatory supervision to comply with domestic and international law. On-orbit transportation services are comprised of four main components: communication with earth stations, sensing capabilities required to dock with client spacecraft, docking aparati and procedures to execute the rendezvous with client spacecraft, and propulsion or steering devices to traverse orbits and/or conduct station keeping operations.[116] The only component currently beyond specific regulatory supervision is deliberately attaching to, or intentional physical contact with, a third-party satellite.[117] Although this component is not explicitly addressed under U.S. law, the orbital debris mitigation oversight provided by the FCC and NOAA indirectly address proximity and rendezvous operations; adequately satisfying U.S. obligations under international law until a more robust regulatory scheme is implemented.[118]

By requiring orbital debris risk analysis and mitigation plans as part of the licensing process for commercial on-orbit service craft, the FCC and NOAA both address the collision risk involved in the proximity operations inherent in on-orbit servicing.[119] Moreover, as evident by the FCC's 2018 Orbital Debris NPRM, the FCC is committed to ensuring the rules and regulations that it promulgates governing orbital debris take into account the continuously evolving nature of space activity.[120] Although the 2018 Orbital Debris NPRM is a step toward further mitigating orbital debris, a final order is not necessary for the United States to meet its authorization and supervision obligations under international law. The existing orbital debris mitigation requirements sufficiently encompass collision risk assessment and avoidance, despite lacking specific applicability to on-orbit services.[121]

On-orbit services such as deorbit, transport, and mission extension are sufficiently encompassed in the authorizations provided by the FCC and NOAA to meet international obligations because these agencies incorporate ODAR requirements into their license requirements.

116. *See* Satellite Basics, *supra* note 38.
117. *See* Schaefer, *supra* note 1, at 117-18.
118. *See* 47 C.F.R. § 25.114(d)(14) (2018); *see* 15 C.F.R. 960 App. 1 Sec. V(C) (2006).
119. *Id.*
120. *See generally* 2018 Orbital Debris NPRM, *supra* note 26.
121. *See* NASA STANDARD, *supra* note 113, at § 5-3.

b. The FCC is satisfying the requirement of "continuing supervision" under international law by authorizing discrete missions for a service vehicle, rather than authorizing the extent of a servicer's operational life

Under Article VI of the OST, the United States is also obligated to provide "continuing supervision" for space activities.[122] By authorizing specific and discrete mission segments throughout an on-orbit service spacecraft's operational lifetime, the FCC is satisfying the U.S. responsibility to provide "continuing supervision" over the space activities of non-governmental actors required by the OST.

The precise definition of "continuing supervision" is up for debate. Egan, legal adviser to the U.S. State Department, posits that "'[c]ontinuing supervision'" means a legal link between government and operator sufficient to ensure the activity is carried out in conformity with the [OST]."[123] Similarly, Schaefer takes a more textual approach to defining the term, identifying "[t]he ordinary meaning of 'supervision' [as] to 'monitor,' and the ordinary meaning of 'continuing' [as] 'occurring in a cyclical or repetitious pattern.'"123 Thus, authorization and continuing supervision requires processes to "give official permission or approval" and "monitor" in some "cyclical or repetitious pattern" for the purpose of assuring that commercial actors are complying with OST obligations.[124] States have discretion in the means they employ to satisfy this obligation, despite the inclusion of a "non-discretionary obligation to authorize and supervise" in Article VI, because "it does not prescribe any method or standards for meeting the obligation."[125]

The United States must provide "continuing supervision" to any space activities performed by non-governmental actors operating under its jurisdiction; however, so long as the system chosen ensures conformity with the OST, the specific means of accomplishing this requirement are left to the state actors' discretion.[126] The aspects of the OST implicated by on-orbit services pertain to the equal access to space resources (orbital slots in this case) and conducting space operations in the interest of all states.[127] The FCC and NOAA have established licensing procedures to

122. *See* OST, *supra* note 50, at Art. VI.
123. *See* Egan *supra* note 1, at 5.
124. *See* Schaefer, *supra* note 1, at 142.
125. *See* Goehring, *supra* note 1, at 105.
126. *Id.*
127. *See* OST, *supra* note 50, at Art. IX.

ensure that U.S. international obligations are met by limiting harmful interference created by radio interference and orbital debris.[128] Both agencies have determined that for typical satellites, one-time orbital debris assessment reports are valid through the term of the license, but the FCC requires an additional assessment when renewing an expired license.[129]

As the risk of potential on-orbit collisions increases with proximity operations, requiring on-orbit service providers to renew their licenses more frequently is an appropriate way to provide "continuing supervision." Specifically, limiting licenses to discrete missions of service craft, rather than to their entire operational lifetime, enables the U.S. government to ensure that the risk of collision is appropriately mitigated with each new service mission. For example, the FCC's authorization of Space Logistic's MEV was only for a discrete portion of its overall mission.[130] Space Logistics applied for a license to conduct six stages of its mission, including: i) deployment, ii) orbit raising, iii) rendezvousing with Intelsat-901 in a graveyard orbit, iv) relocating the satellite in a new orbit for operation, v) traveling back to a graveyard orbit at the end of its mission life, and vi) undocking with Intelsat-901.[131] However, Space Logistics was only authorized for the first three segments of its overall mission: to deploy, raise, and dock with Intelsat-901.[132] It is arguable that the United States could meet its OST obligations even if it licensed the full operational lifetime of on-orbit service craft; however, by licensing discrete missions within the craft's operational life the United States is undoubtedly providing sufficient "continuing supervision."

The FCC satisfies the U.S. responsibility to provide "continuing supervision" over the space activities of non-governmental actors by authorizing specific and discrete mission segments throughout an on-orbit service spacecraft's operational lifetime.

128. *See* Schaefer, *supra* note 1, at 128-34. (mitigating harmful radio frequency interference is required by the ITU, not OST or related treaties).

129. *See* 47 C.F.R §§ 25.114(d)(14) (2018), 25.121; *see* 15 C.F.R §§ 960.9 (license term), App. 1 Sec. V(C) (2006).

130. Space Logistics, LLC, Launch and Operating Authority Grant in Part/Deferred in Part, 32 FCC Rcd. 10270 (2017) (only authorized for first phase rendezvous with Intelsat-901, orbital relocation and undocking deferred) [hereinafter Space Logistics Authorization].

131. Space Logistics, LLC, Application for Authority to Launch and Operate a Mission Extension Vehicle, IBFS File No. SAT-LOA-20170224-0021, 6 (Feb. 24, 2017) https://licensing.fcc.gov/myibfs/download.do?attachment_key=1189525 [https://perma.cc/D932-S2NX].

132. *See* Space Logistics Authorization, *supra* note 130.

c. The United States should avoid complications arising from issues of state sovereignty in space by limiting authorizations to those for services by a U.S. licensed spacecraft on U.S. licensed spacecraft.

Because proximity operations performed on space objects registered to a foreign government require consent of that foreign government, thereby implicating state sovereignty, the United States should only authorize on-orbit services between U.S. licensed spacecraft until more specifically applicable domestic and international laws are implemented.

Under the Space Treaties, states retain jurisdiction over their domestically registered space objects and "perpetually retain responsibility and potential liability over their launched space objects."[133] Simpson and Johnson point out that the jurisdiction and responsibility bestowed on nations in the Space Treaties create slices of sovereignty in space objects and that "any interference with a state's space object… constitutes a transgression of state sovereignty, and therefore a violation of international law."[134]

Although it is possible to avoid sovereignty concerns by working through diplomatic channels to ensure that multinational business-to-business servicing contracts have the blessing of all state actors whose space objects are involved, it is far easier to limit on-orbit service authorizations to U.S.-licensed spacecraft. By limiting on-orbit service authorizations to U.S. licensed spacecraft the United States would not need to work with foreign governments to receive permission to service assets that they are responsible for. Thus, until more directly applicable domestic and international regulations are instituted, U.S. based service providers and recipients can work directly with each other without having to worry about navigating diplomatic channels and risk liability surrounding issues of state sovereignty.

The United States should only authorize on-orbit services between U.S.-licensed spacecraft until more specifically applicable domestic and international laws are implemented because proximity operations with space objects registered with foreign governments require consent of those foreign governments, creating potential issues regarding state sovereignty.[135]

133. *See* OST, *supra* note 50, at Art. VII, VIII; Simpson & Johnson, *supra* note 9, at 10-12 ("As other states retain jurisdiction over their Domestically registered space objects, and responsibility and liability over space objects they have launched, these aspects of state sovereignty must be respected lest an argument that their sovereignty has been infringed upon – a serious violation of the law of nations.").

134. Simpson & Johnson, *supra* note 9, at 11.

135. *See* OST, *supra* note 50, at Art. VIII.

d. Authorizing missions in low risk orbits prior to more active and populated orbits will reduce the likelihood of international liability.

Because many orbits are more densely populated, some deorbit timelines are inordinately long, and collisions in these orbits pose greater risk to their overall sustainability than VLEO and junk orbits, the FCC should only authorize proof of concept missions in VLEO or junk orbits before authorizing service missions in higher risk orbits.[136] Doing so will reduce the potential for U.S. liability under international law and increase the viability of long-term industry growth.

The OST states that:

> If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space … would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space … it shall undertake appropriate international consultations before proceeding with any such activity or experiment.[137]

Thus, reducing the risk of causing interference with the activities of other space actors will reduce the obligation to consult with third parties.

Authorizing on-orbit service missions that reduce orbital debris after they are proven safe advances the principles of the Space Treaties. This requires consent from the satellite owners and operators being serviced, as the FCC, FAA, and NOAA lack authority to authorize the removal of private property. Nevertheless, by actively enabling the removal and extension of existing satellites by authorizing mission extension and orbital transportation services between consenting parties, the United States would be reducing the amount of potential debris in orbit and thereby improving access to space resources in the interest of the global space community.

The FCC authorized Space Logistics to prove the functionality of its MEV by rendezvousing with an Intelsat satellite in a

136. VLEO stands for "very low earth orbit" and refers to orbits under 450km. *See* Josep Virgili Llop, et. al., *Very Low Earth Orbit Mission Concepts for Earth Observation. Benefits and Challenges*, REINVENTING SPACE CONFERENCE, 1 (Nov. 2014), https://www.researchgate.net/publication/271499606_Very_Low_Earth_Orbit_mission_concepts_for_Earth_Observation_Benefits_and_challenges [https://perma.cc/GF7T-AC5B].

137. OST, *supra* note 50, at Art. IX.

"graveyard orbit."[138] Although Space Logistics plans to relocate the satellite to a lower orbit, it has not yet been authorized to perform this portion of its mission.[139] Graveyard orbits are those at least 300km above the more populated GEO orbits.[140] The rationale behind moving inoperable satellites into graveyard orbits is that it would take too much fuel, or be too dangerous, to de-orbit by burning up in Earth's atmosphere, and moving out of more congested GEO orbits reduces the likelihood of catastrophic collision.[141] Similarly, VLEO orbits, although more populated than GEO orbits, reduce the likelihood of catastrophic collisions that destabilize entire orbital planes because the additional drag of the atmosphere at the low altitudes assures orbital lifetimes of less than five years.[142]

Barring some emergency situations, agencies should hesitate to authorize commercial on-orbit service missions that involve satellites in GEO, MEO, or LEO orbits prior to receiving specific grants of authority as the risk of catastrophic collisions is too great. Although requiring service operators to prove the efficacy of their service craft in higher orbits will increase the cost of such services, most of the immediate clientele are large telecommunications satellites that are in GEO or GSO orbits, just below graveyard orbits.[143] Because the cost of these satellites and the value added from just a few years of continuing service ultimately makes for a profitable long-term business model, testing on-orbit service craft nearby them before engaging them could prove effective.[144]

To reduce the risk of interfering with the operations of other space actors, agencies should only authorize commercial on-orbit services in graveyard and VLEO orbits until they are proven safe. Graveyard orbits pose lower risks of collision and therefore lower risks of developing the Kessler Syndrome in the event of such a collision. Although reaching such orbits is expensive, as launch vehicles must travel further from Earth, proving on-orbit service reliability in these orbits will be beneficial to developing the industry and subsequently cleansing GEO orbits of non-operational satellites. Moreover, if on-orbit service operators want to reduce the

138. Space Logistics Authorization, *supra* note 130, at 1.

139. *Id.*

140. *Graveyard Orbits and the Satellite Afterlife,* NAT'L OCEANIC & ATMOSPHERIC ADMIN. (Oct. 31, 2016), https://www.nesdis.noaa.gov/content/graveyard-orbits-and-satellite-afterlife [https://perma.cc/N5N3-N22Y].

141. *See* Launchspace Staff, *The GEO Graveyard May Not Be Permanent*, SPACE DAILY (Nov. 9, 2010), http://www.spacedaily.com/reports/The_GEO_Graveyard_May_Not_Be_Permanent_999.html [https://perma.cc/P8DP-TTKD].

142. *See* Llop et al., *supra* note 136, at 4.

143. *See* NASA Project Report, *supra* note 42, at 27-28.

144. *See generally id.*

cost of proving the reliability of their service craft, they should be authorized to operate in VLEO orbits where any debris created from accidental collision will be deorbited in a few short years.[145] By reducing the risk of collision and the impact of debris that results from such collisions, U.S. agencies and the service operators they authorize can more effectively avoid liability and challenges to their authorizations and operations.

The FCC can reduce the potential for U.S. liability by authorizing proof of concept missions in lower-risk orbits before authorizing service missions in higher-risk orbits because high-risk orbits are more densely populated, deorbit timelines are longer, and collisions in these orbits pose greater risk to their overall sustainability than junk orbits.

2. Until a specific grant of authority to govern on-orbit services is enacted by Congress, allowing case-by-case authorization by the FCC and NOAA will be beneficial to establishing U.S. leadership in emerging space industries.

By authorizing Space Logistics to operate their MEV, the FCC and NOAA established positive precedent supporting case-by-case authorization of on-orbit service missions.[146] This precedent will prove instrumental to maintaining U.S. leadership in space technology and services. Specifically, the key precedents from the authorization include authorizing the MEV to operate with a U.S.-licensed satellite in a low risk orbit and only authorizing a discrete portion of the MEV's mission to enable launch.[147]

Transparently authorizing the mission in a low risk orbit signals to satellite operators and the international community that the FCC takes international obligations and orbital sustainability seriously.[148] Missions should not be authorized in GEO, MEO, or LEO until service is proven to be safe and reliable.

Authorizing a discrete portion of missions assures that "continuing supervision" is applied to on-orbit services. This means that if Congress is able to pass legislation prior to subsequent mission stages, the new regulator could be responsible for the next authorization. If a new regulator establishes more robust requirements governing proximity operations, service craft that

145. *See generally* NASA Standard, *supra* note 113, at 4-5 ("Lower the altitude at which the breakup occurs. This is by far the most effective response for reducing both the near-term and long-term risk to other users of space.").

146. Werner, *supra* note 2.

147. *See* Space Logistics Authorization, *supra* note 130.

148. Simpson & Johnson, *supra* note 9, at 15 ("Specific measures include announcing the mission publicly, having operators report where the satellite to be serviced is, and having the satellite servicing mission maintain healthy distances with other satellites.").

have already launched and proven their efficacy should be grandfathered in or able to apply in a streamlined process. This will prevent chilling investment and development in on-orbit services leading up to any such regulatory delegation.

By only authorizing TT&C on on-orbit craft, the risk of interference to systems in the same region is reduced. This is because service crafts can utilize the same frequencies as the space object they are servicing and coordinate with the operator of the space object to avoid interference, as the Space Logistics MEV does.[149] This reduces the need for specific band allocations while limiting interference.

This precedent benefits U.S. leadership in emerging space industries by signaling to industry participants and potential investors that the United States is open to innovation and that on-orbit servicers do not need to look to other states to launch and operate their service craft. Moreover, limiting authorizations to U.S. licensed satellites will incentivize launching satellites under the U.S. flag in the first place. Although smaller and less expensive satellites are a growing trend, large satellites used for geo-imaging or communications are still launched each year.[150] Given the choice between launching under a state where on-orbit services have yet to be developed and the U.S., where services are authorized, an operator faces the choice between allowing its satellite asset to potentially experience a shorter mission life due to unforeseen issues or natural fuel expenditure, or having the ability to service its asset. The ability to extend mission life is an invaluable option that would drive operators to launch their satellites under the U.S. flag.[151]

Enabling operators to service their valuable space assets will drive innovation as well as standardization in satellite technology.[152] Servicing options will incentivize satellite manufacturers to conform to certain standards in order to ensure that their satellites are able to be serviced by emerging on-orbit service providers.[153]

Moreover, enabling on-orbit services will make developing satellites more affordable because they would no longer need heavy, long-term, fuel solutions because they could be serviced while on-orbit instead. Furthermore, satellite operators would no longer need to seek out particular launches with narrow parameters because they would be able to receive post-launch transport service

149. *See* Space Logistic Authorization, *supra* note 130.
150. *See* Sweeting, *supra* note 21.
151. *See* NASA Project Report, *supra* note 42, at 27-28.
152. *See id.,* at 30-31.
153. *Id.*

to the orbit they need, regardless of where the launch vehicle deploys them.[154] Eventually, services will also make prototyping satellites easier as services can be conducted on-orbit in the event that things go wrong. In addition, authorizing new services in orbit would also increase the clientele of the launch industry, driving the positive feedback loop of innovation that produces reduced costs.

The FCC and NOAA have set a positive precedent by authorizing the first commercial on-orbit service to launch under the U.S. flag. This authorization will lead to greater investment in satellite technologies and incentivize global satellite operators concerned about the long-term viability of their asset to launch under the U.S. flag.

III. NAVIGATING THE STATUS QUO: HOW PITFALLS DEMAND CLEAR LEGISLATIVE AUTHORITY TO COMPREHENSIVELY REGULATE ON-ORBIT SERVICES AND HOW BUSINESS CAN COPE IN THE MEANTIME.

This section considers the challenges and pitfalls of utilizing the current regulatory framework, not specifically designed to accommodate on-orbit service missions, and what regulators and industry participants can do to overcome these hurdles until Congress delegates authority to specifically regulate on-orbit services.

A. Potential pitfalls of case-by-case authorization demonstrate need for swift action by Congress and regulatory authorities.

Although case-by-case authorization of low risk on-orbit services under the current domestic regulatory framework technically comply with international law, such authorizations run the risk of setting inconsistent precedent and increasing uncertainty in the viability and stability of the on-orbit servicing industry.

The willingness of agencies to approve on-orbit transportation services is a good first step toward advancing investment and innovation. However, the lack of predictability inherent in case-by-case authorization hinders the incentive to invest and innovate in an inherently risky industry.[155] Clear and transparent legislation and regulation must be forthcoming.[156] Space activities are

154. *See generally* Martin Duursma, *Breaking the "New Space" Bottleneck*, MEDIUM (Sept. 27, 2018), https://medium.com/main-sequence-ventures/breaking-the-new-space-bottleneck-e1d0e3cbe792 [https://perma.cc/HA3Q-97UY].
155. Schaefer, *supra* note 1, at 159.
156. *See generally* Simpson & Johnson, *supra* note 9.

inherently high risk and long term investments.[157] Without regulatory certainty of what activity and conduct will or will not be authorized, it is extremely risky to invest in a particular technology or procedure.

Service crafts are often designed to operate for at least five years, which means that regulatory changes could render a spacecraft that received a conditional authorization inoperable prior to the company being able to recoup its costs.[158] This means that service craft launched with conditional authority are risky, unless they are grandfathered into any new regulatory scheme or receive streamlined compliance treatment. Regulatory certainty will help alleviate this risk and incentivize investment in the on-orbit service industry.

B. Industry participants need to lead the way in establishing industry best practices by including provisions to limit U.S. and satellite operator's liability under domestic and international law.

Until a more permanent regulatory framework is established, on-orbit service providers must ensure that they promote forward looking best practices in their operations and contracting with third-party satellite operators. This means striking a balance between taking on disproportionate liability until a more permanent regulatory framework is adopted and ensuring that they are not overly burdened by disproportionate risk so as to deter investment.

To this end, Miller points to The Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) which aims to "[c]reate an industry/government consortium to develop technical standards for safe on-orbit rendezvous and servicing operations."[159] He also points out that Todd Master, Tactical Technology Office Program Manager at DARPA, asserts that CONFERS will:

> Leverage best practices from government and industry to research, develop, and publish nonbinding, consensus-derived technical and safety standards that servicing providers and clients for on-orbit servicing operations would adopt. In doing so, the program would provide a clear technical basis for definitions and expectations of responsible behavior in outer space. The standards would be broad enough to allow individual companies to pursue their own

157. *See* Schaefer, *supra* note 1, at 110.
158. *See* NASA Project Report, *supra* note 42, at 107.
159. *See* Miller & Magilton, *supra* note 9, at 4-7.

> implementations of these standards to suit their individual businesses, while assuring that the implementations adhere to best practices for operational safety.[160]

The guidelines adopted by CONFERS provide basic principles aimed at ensuring legal, peaceful, and successful on-orbit service missions.[161] These guidelines are a good step toward establishing industry norms and best practices. However, as states are ultimately responsible for liability born of the actions of the non-state actors operating under their jurisdiction, commercial actors can take additional steps to demonstrate that they are responsible space citizens. Such steps should include voluntarily procuring liability insurance, indemnifying the United States from liability, or posting bonds that can be used in the event of collision or damage caused during the course of service.[162] Moreover, on-orbit service providers must be sure to clearly identify fault in their contracts with their clients to streamline remedial action should a collision or failure occur.

Until more directly applicable regulation is created, on-orbit service providers should conform to industry best practices to mitigate the liability of states and customers, thereby demonstrating that heavy handed regulation is unnecessary to appropriately limit the risks inherent in proximity operations.

IV. CONGRESS NEEDS TO GRANT AUTHORITY TO GOVERN ON-ORBIT SERVICES IN ORDER TO PROVIDE GREATER CERTAINTY TO EMERGING COMMERCIAL SPACE ACTIVITY.

Although the current U.S. regulatory regime can accommodate on-orbit transport services, Congress should explicitly authorize an appropriate agency to regulate on-orbit services in order to ensure long term viability and stability of the industry. New space policies issued by President Trump and recent excitement around high profile launches and satellite technology have reinvigorated public

160. *See* Miller & Magilton, *supra* note 9, at 4-7; *see* Todd Master, *Consortium for Execution of Rendezvous and Servicing Operations (CONFERS)*, DARPA, https://www.darpa.mil/program/consortium-for-execution-of-rendezvous-and-servicing-operations [https://perma.cc/42WM-WRXS].

161. *See* Consortium for Execution of Rendezvous and Servicing Operations, *Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS)*, CONFERS (Nov. 7, 2018), https://www.satelliteconfers.org/wp-content/uploads/2018/11/CONFERS-Guiding-Principles_7Nov18.pdf [https://perma.cc/Z8CE-PUAS].

162. *See* Miller & Magilton, *supra* note 9.

interest in space.[163] The time is right to push for more robust and appropriately delegated regulatory authority over space activities.

By authorizing an appropriate agency with direct regulatory authority over on-orbit servicing, the United States can less controversially and more directly satisfy its obligations under international law. Moreover, providing more explicit regulatory support will ensure on-orbit service operators that the U.S. government condones their activity and is thus more likely to engage in international conflicts on their behalf should they arise. The designated agency should have experience in complicated space or air traffic management and should not create additional regulatory hurdles for on-orbit service or other satellite operators. However, it is doubtful that the FCC and NOAA can be removed from the process entirely. Thus, license applications should be consolidated such that operators can apply to a single agency who then coordinates with the FCC, NOAA, and other elements of the government on the appropriate components of the application. The FAA, within the Department of Transportation, is a good candidate, but there is room for broader and more creative agency reorganization that is outside the scope of this note.

Whatever agency receives, or is created by, future Congressional authority should look to the FCC's authorization of Space Logistics' MEV when drafting rules that directly address on-orbit servicing. This includes authorizing proof of design reliability in low risk orbits, authorizing discrete portions of missions until such reliability is proven, and establishing clear guidelines on operations that implicate non-U.S.-registered space objects.

CONCLUSION

The legal and regulatory regimes governing space activity were developed in an era with relatively homogeneous and stable space operations since the dawn of the space age. As space activity promises to increase exponentially in the coming years, new services and technologies will test current methodologies and drive future development of legal and regulatory boundaries governing space activity. The foundational instruments to such activity, the Space Treaties, require that states authorize and provide continued supervision of outer space activities conducted by themselves as well as non-governmental actors affiliated with them.

U.S. regulations are sufficient to accommodate the emergence of on-orbit transport services and comply with international law

163. *See* Miller & Magilton, *supra* note 9; *see also* SpaceX Archives, SPACENEWS, https://spacenews.com/tag/spacex [https://perma.cc/5TWZ-Q3CL] (last visited Mar. 24, 2019).

today. This is accomplished by the incorporation of orbital debris mitigation requirements specifically addressing accidental collision into licensing requirements. Moreover, the precedent set by authorizing a discrete portion of the Space Logistics' MEV on-orbit service mission between U.S.-licensed spacecraft in a low risk orbit indicates that U.S. agencies are cognizant of their responsibilities under international law and have utilized their discretion to fulfill them. However, Congress should act swiftly to explicitly authorize an appropriate agency to establish more directly applicable rules to provide greater stability to the industry, thereby incentivizing further investment and innovation.