Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matters of	)	
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Mitigation of Orbital Debris in the New Space Age	)	IB Docket No. 18-313
	)	
Mitigation of Orbital Debris	)	IB Docket No. 02-54 (Terminated)
	)	

NOTICE OF PROPOSED RULEMAKING AND ORDER ON RECONSIDERATION

Adopted: November 15, 2018 **Released: November 19, 2018**

By the Commission: Chairman Pai and Commissioners O'Rielly and Carr issuing separate statements; Commissioner Rosenworcel concurring and issuing a statement.

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I. INTRODUCTION

1. In many respects, we are at a turning point in the history of space development. Driven by innovation from both established commercial enterprises and new entrepreneurial endeavors, a new landscape for the private space industry is emerging, sometimes referred to as "New Space." In fact, the global space economy is estimated at over $383.5 billion.[1] Investment in start-up space ventures alone has been estimated at between $2 and $3 billion in each of the last three years.[2] The United States leads the world in space commerce, totaling approximately 57 percent of global space spending, and accounting for one-third of all orbital launch activities. In this new space economy, innovation has thrived. Companies have proposed new satellite constellations, some with satellites numbering in the thousands, that would provide broadband and other services worldwide. Relatively inexpensive small satellites, many based on what is known as a "CubeSat" form factor,[3] have demonstrated their utility and capabilities across a wide range of satellite services. The launch industry is more dynamic than ever, with new entrants into the launch vehicle market bringing new capabilities, lowering launch costs, and presenting significant economic promise for our nation.

2. There are risks inherent in any operations in space, however, and while we seek to facilitate the development of this new landscape through our role in satellite authorization, the Commission also has a responsibility to ensure that the operations it authorizes are conducted safely and consistent with the public interest.[4] The current period of innovation in the space industry has resulted and will likely continue to result in a significant increase in the number of satellites and types of operations in orbit, both of which have the potential to increase the amount of orbital debris. Thus, mitigating the growth of orbital debris is more critical than ever to ensure continued, safe operations in space and maximize space commerce investments and innovation. Orbital debris, also known as "space debris", consists of artificial objects orbiting the Earth that are not functional spacecraft, and can be created under a variety of scenarios involving satellite systems. Orbital debris can affect the cost, reliability, integrity, and capability of new satellite systems and valuable services to the public, and it has

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[1] *See* Space Foundation, The Space Report 2018: The Authoritative Guide to Global Space Activity, "Space Foundation Report Reveals Global Space Economy at $383.5 Billion in 2017" (July 19, 2018), https://www.spacefoundation.org/news/space-foundation-report-reveals-global-space-economy-3835-billion-2017.

[2] *See* Bryce Space and Technology, Start-Up Space: Update on Investment in Commercial Space Ventures at i (2018), https://www.brycetech.com/downloads/Bryce_Start_Up_Space_2018.pdf.

[3] A "CubeSat" is a standardized small satellite interface consisting of one or more "units." As originally conceived, a CubeSat unit is approximately 10 cm x 10 cm x 10 cm in size. See *Streamlining Licensing Procedures for Small Satellites, Notice of Proposed Rulemaking*, IB Docket No. 18-86, FCC 18-44 at 4, para. 5 (April 17, 2018) (*Small Satellite NPRM*).

[4] *Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567, 11575, para. 14 (2004) (*Orbital Debris Order*). The Commission has observed that robotic spacecraft are typically controlled through radiocommunications links, and thus there is a direct connection between the satellite's radiocommunications functions and the physical operations of spacecraft. *Id.*

the potential to cause physical harm to both people and property.[5] As the Commission has previously found, consideration of orbital debris issues can thus play an important role in preserving access to space for the long term and in ensuring the safety of persons and property in space and on the surface of the Earth.[6] For this reason, several agencies examine the impact of potential space debris in space operation authorizations.

3. This Notice of Proposed Rulemaking (*NPRM* or *Notice*) represents the first comprehensive look at the Commission's orbital debris rules since their adoption in 2004. The proposed changes are designed to improve and clarify these rules based on experience gained in the satellite licensing process and on improvements in mitigation guidelines and practices, and to address the various market developments described above. In addition, we deny a petition[7] seeking reconsideration of the Commission's decision in 2004 to apply orbital debris mitigation requirements to amateur service satellites.[8]

II. BACKGROUND

4. Pursuant to its authority to determine whether the public interest would be served by the authorization of satellite communications systems, the Commission adopted comprehensive rules on orbital debris in 2004.[9] The core of these rules consists of disclosure requirements that yield information critical to the Commission's overall determination of whether the public interest will be served by approving the proposed operations. Under the Commission's satellite application rules, applicants must include a statement that they have assessed and limited the amount of debris released in a planned manner during normal operations, and have assessed and limited the probability of the satellite becoming a source of debris by collisions with small debris.[10] Applicants must also state that they have assessed and limited the probability of accidental explosions during and after completion of mission operations.[11] The rules also require a statement that the satellite applicant has assessed and limited the probability of the satellite becoming a source of debris by collisions with large debris or other operational satellites.[12] Finally, applicants must include a statement detailing the post-mission disposal plans for the satellite as it enters its end-of-life stage, including the quantity of fuel—if any—that will be reserved for post-mission disposal maneuvers.[13]

5. In addition to general disclosure obligations, the Commission has adopted other rules related to physical spacecraft operations, such as requirements for the maintenance of orbital locations in the geostationary-satellite orbit (GSO),[14] and for GSO inclined-orbit operations.[15] In addition, the Commission has specific post-mission disposal requirements for both GSO and non-geostationary

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[5] *Id.*

[6] *Id.*

[7] Radio Amateur Satellite Corporation, Petition for Reconsideration, IB Docket No. 02-54 (filed Oct. 12, 2004) (AMSAT Petition).

[8] *See Orbital Debris Order*, 19 FCC Rcd at 11608, paras. 99-100. In the *Orbital Debris Order*, the Commission amended section 97.207 of its rules, which went into effect on October 19, 2005. *See Mitigation of Orbital Debris*, 70 Fed. Reg. 59,276 (October 12, 2005); Public Notice, Disclosure of Orbital Debris Mitigation Plans, Including Amendment of Pending Applications, SPB-112, DA 05-2698 (rel. Oct. 13, 2005).

[9] *See Orbital Debris Order*, 19 FCC Rcd at 11575, para. 14.

[10] 47 CFR § 25.114(d)(14)(i).

[11] 47 CFR § 25.114(d)(14)(ii).

[12] 47 CFR § 25.114(d)(14)(iii).

[13] 47 CFR § 25.114(d)(14)(iv).

[14] 47 CFR § 25.210(j).

[15] 47 CFR § 25.280.

(NGSO) satellites.[16]

6. The Commission reviews these disclosures and determines, on a case-by-case basis, whether the public interest will be served by approval of the proposed operations.[17] The rules adopted in 2004 provided some general guidance on the content of disclosures, but the Commission generally declined to adopt a particular methodology for the preparation and evaluation of an applicant's orbital debris mitigation plans.[18] Both applicants and the Commission, however, have relied in a number of cases on standards and related assessment tools, such as the technical standards and related software tools developed by NASA for its space activities,[19] to, respectively, prepare such orbital debris plans and assess their adequacy.[20]

7. Since the Commission's orbital debris rules were adopted in 2004, there have been a number of significant developments with respect to this topic. Internationally, within the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS), the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee has developed a set of voluntary guidelines to assist States and international intergovernmental organizations, recognizing that "[t]he proliferation of space debris, the increasing complexity of space operations, the emergence of large constellations, and the increased risks of collision and interference with the operation of space objects may affect the long-term sustainability of space activities."[21] The Inter-Agency Space Debris Coordination Committee (IADC), an inter-governmental committee, updated its Space Debris Mitigation Guidelines in 2007,[22] and more recently, has studied the orbital debris population in the LEO region[23] and

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[16] 47 CFR § 25.283.

[17] *Orbital Debris Order*, 19 FCC Rcd at 11577, para. 19; 47 U.S.C. § 309(a). The Commission's public interest determination regarding an applicant's request for authorization of a satellite communications system is not, of course, based solely on the sufficiency of an applicant's plans for managing orbital debris. It also requires a number of other findings (e.g., that the applicant possesses the basic qualifications to hold the authorization and that the proposed system will conform to the FCC's technical operational rules)).

[18] *Orbital Debris Order*, 19 FCC Rcd at 11577, para. 21

[19] In the *Orbital Debris Order*, the Commission observed that NASA had adopted publicly-available safety standards that provided a handbook for debris mitigation analysis and activities. 19 FCC Rcd at 11577, para. 21. *See* NASA Technical Standard, Process for Limiting Orbital Debris, NASA-STD-8719.14A (with Change 1) (May 25, 2012), http://www.hq.nasa.gov/office/codeq/doctree/871914.pdf (*NASA Standard*). The *NASA Standard* is "consistent with the objectives of the U.S. National Space Policy of the United States of America (June 2010), the U.S. Government Orbital Debris Mitigation Standard Practices (February 2001), the Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines (October 2002), the Space and Missile Center Orbital Debris Handbook, Technical Report on Space Debris (July 2002), the space debris mitigation guidelines of the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Use of Outer Space, (A/AC.105/720, 1999 and A/AC.105/890, Feb 2007)." *Id.* at 5.

[20] *See, e.g., Part 25 Second Report and Order*, 30 FCC Rcd at 14824-25, para. 361 (stating the Commission will rely on the *NASA Standard*, among other guidance, when assessing satellite end-of-life passivation plans); *Orbital Debris Order*, 19 FCC Rcd at 11603-04, para. 88 (providing that entities may wish to look at NASA standards as a guide when preparing their human casualty risk assessments); *Guidance on Obtaining Licenses for Small Satellites*, Public Notice, 28 FCC Rcd 2555, 2558 (IB/OET 2013) ("An orbital debris assessment report prepared consistent with NASA standards is generally sufficient to meet FCC requirements.").

[21] Guidelines for the long-term sustainability of outer space activities, UN Document A/AC.105/L.315 (2018) at 1-2, para. 1.

[22] IADC Space Debris Mitigation Guidelines, IADC, IADC-02-01, Rev. 1 (2007).

[23] Stability of the Future LEO Environment, IADC, IADC-12-08, Rev. 1 (2013).

has issued a preliminary statement on large constellations of satellites in that region.[24] Domestically, NASA has issued revised versions of its Procedural Requirements for Limiting Orbital Debris[25] and its Technical Standard on the Process for Limiting Orbital Debris,[26] and has updated software available to assess compliance with its guidelines.[27] NASA's Orbital Debris Program Office also recently released a Large Constellation Study, which studies the impact of proposed large NGSO constellations in LEO and sets out recommendations.[28]

8. In addition, the number of debris objects capable of producing catastrophic damage to functional spacecraft has increased. The U.S. Department of Defense (DoD) tracks approximately 23,000 man-made objects achieving orbit.[29] One estimate indicates that of the approximately 8650 satellites that rocket launches have placed into Earth orbit, about 4700 are still in space, and only about 1800 of those are still functioning.[30] There are estimated to be 500,000 pieces of debris the size of a marble or larger, and many millions of pieces of debris that are so small they cannot be tracked.[31] Orbital debris objects greater than one centimeter in diameter can cause catastrophic damage to functional spacecraft.[32] Satellite breakups have been a significant contributor to the increase in the orbital debris population. For example, fragments associated with the intentional fragmentation of the Fengyun 1C spacecraft in 2007 and the accidental collision of the Cosmos 2251 spacecraft with the commercial Iridium 33 spacecraft in 2009 account for over 25% of cataloged on-orbit space objects.[33] The orbital altitudes where these fragments

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[24] IADC Statement on Large Constellations of Satellites in Low Earth Orbit, IADC, IADC-15-03 (2017) (IADC Statement on Large Constellations).

[25] NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environment, NPR 8715.6B (Feb. 16, 2017), https://www.orbitaldebris.jsc.nasa.gov/library/npr_8715_006b_.pdf. (NASA Procedural Requirements); Updates to NASA Procedural Requirements for Limiting Orbital Debris," Nov. 24, 2017, http://sma.nasa.gov/news/articles/newsitem/2017/04/24/updates-to-nasa-procedural-requirements-for-limiting-orbital-debris.

[26] *See generally NASA Standard*. A further update is forthcoming.

[27] *See* NASA Orbital Debris Program Office, Debris Assessment Software, https://orbitaldebris.jsc.nasa.gov/mitigation/das.html.

[28] *See* J.-C. Liou, et. al., "NASA ODPO's Large Constellation Study" NASA Orbital Debris Quarterly News, Volume 22, Issue 3 at 4-7 (Sept. 2018), https://www.orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv22i3.pdf (NASA Large Constellation Study). The study analyzed three hypothetical constellations operating at 1000 to 1325 km altitudes. *Id.*

[29] *See* Recommendations for Optimal CubeSat Operations, Space-Track.org (2015), https://www.space-track.org/documents/Recommendations_Optimal_Cubesat_Operations_V2.pdf (CubeSat Recommendations). The DoD currently provides information regarding space situational awareness services through the public website www.space-track.org (last visited Nov. 1, 2018).

[30] European Space Agency, Space Debris by the Numbers, https://www.esa.int/Our_Activities/Operations/Space_Debris/Space_debris_by_the_numbers (last visited Nov. 13, 2018). *See also* European Space Agency, ESA's Annual Space Environment Report (May 18, 2018), https://www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf (including graphic representations of the evolution of the space environment).

[31] NASA, Orbital Debris Program Office, Frequently Asked Questions, https://orbitaldebris.jsc.nasa.gov/faq.html#3 (last visited Nov. 13, 2018).

[32] *Orbital Debris Order*, 19 FCC Rcd at 11570, para. 4.

[33] P.D. Anz-Meador, "The OD Environment in Numbers," NASA Orbital Debris Quarterly News, Volume 21, Issue 2 at 7 (May 2017), https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv21i2.pdf.

are located is an area of significant density of space objects.[34]

9. Proposed deployments of large satellite constellations[35] in the intensely used LEO region, along with other satellites deployed in the LEO region, will have the potential to increase the risk of debris-generating events.[36] Indeed, these planned constellations could add an unprecedented number of satellites to Earth's orbit. If orbital debris mitigation issues are not properly addressed, this could result in an exponential increase in the number of debris objects in LEO.[37] Work continues in international forums, such as in the IADC, on improved debris limitation practices, including with respect to these "mega constellations."[38] New satellite and deployment technologies currently in use and under development also may increase the number of potential debris-generating events, in the absence of improved debris mitigation practices.

III. DISCUSSION

10. We propose a number of changes to our existing disclosure and operational requirements and seek comment on additional potential revisions. In addressing orbital debris mitigation, the Commission has drawn from the technical guidance and assessment tools developed by NASA and the modifications to our rules proposed in this *NPRM* reflect this approach. In some areas where we have proposed general disclosures in lieu of specific design or operational requirements, we believe such disclosures will provide flexibility for us to address ongoing developments in space station design and other technologies. As a general matter, however, if there are well-defined metrics in any of those areas that could provide a basis for a more specific requirement, we ask that those be identified by commenters.

11. As with the Commission's original adoption of comprehensive orbital debris mitigation rules, many of the proposals below are influenced by criteria from existing U.S. and international guidelines and standards. In a number of areas, there are also ongoing studies to assess the impact of innovative technological and market developments, which the Commission has encountered through its licensing role. We seek comment on the suitability of various orbital debris mitigation guidance and standards for application to non-Federal satellite systems.

12. We also note that on June 18, 2018, the President issued Space Policy Directive-3 (SPD-

[34] Inter-Agency Space Debris Coordination Committee, IADC Working Group 2, Action Item 27.1, Stability of the Future LEO Environment at 3 (2013).

[35] *See, e.g.*, WorldVu Satellites Limited (OneWeb) Petition for Declaratory Ruling, IBFS File No. SAT-LOI-20160428-00041, FCC 17-77, 32 FCC Rcd 5366 (granted June 22, 2017) (planned constellation of 720 satellites at approximate altitude of 1200 kilometers); Space Exploration Holdings, LLC (SpaceX) Application, IBFS File Nos. SAT-LOA-20161115-00118, SAT-LOA-20170726-00110, FCC 18-38 (granted March 28, 2018) (planned constellation of 4,425 satellites at approximate altitudes of 1,110 to 1,325 kilometers). *See also* SpaceX Modification Application, IBFS File No. SAT-MOD-20181108-00083, Legal Narrative at ii (filed Nov. 8, 2018) (proposing to operate 1,584 of its previously authorized satellites at an altitude of 550 km instead of 1,150 km).

[36] SpaceX has expressed its general support for the Commission's efforts to foster a safe space environment and urges an approach that relies on performance-based metrics. *See* Letter from Patricia Cooper, Vice President of Satellite Government Affairs, Space Exploration Technologies to Marlene H. Dortch, Secretary, FCC, IB Docket No. 18-313 (filed Nov. 9, 2018).

[37] *See, e.g.*, NASA Large Constellation Study at 5 (describing different model scenarios involving large constellations and potential increase in the debris population in LEO).

[38] *See, e.g.*, IADC Statement on Large Constellations; Inter-Agency Space Debris Coordination Committee, An Overview of the IADC Annual Activities, Sept. 7, 2016 http://www.unoosa.org/pdf/SLW2016/Panel4/1._Krag_IADC-16-03_UNCOPUOS_Space_Law_Workshop.pdf.

3), relating to National Space Traffic Management Policy.[39] Recognizing, among other things, that the volume and location of orbital debris are growing threats to space activities and that it is in the interest of all to minimize new debris and mitigate effects of existing debris,[40] the memorandum directs the Administrator of NASA, in coordination with the Secretaries of State, Defense, Commerce, and Transportation, and the Director of National Intelligence, and in consultation with the Chairman of the Commission, to lead efforts to update the U.S. Government Orbital Debris Mitigation Standard Practices and establish new guidelines for satellite design and operation, as appropriate and consistent with applicable law.[41]

13. In a separate section, SPD-3 states that the United States should eventually incorporate appropriate standards and best practices into Federal law and regulation through appropriate rulemaking or licensing actions, and that such guidelines should encompass protocols for all stages of satellite operation from design through end-of-life.[42] The Commission's efforts to formulate this *NPRM* on orbital debris mitigation have been underway for some time, and we believe our proposals may provide a method of elevating these important issues for consideration among federal policymakers and stakeholders.

14. We recognize the importance of a coordinated, effective regulatory environment that meets the dual goals of orbital debris mitigation and furthering U.S. space commerce. To the extent that there are updates to the U.S. Orbital Debris Mitigation Standard Practices or other domestic orbital debris guidance documents while this proceeding is open,[43] those developments could be considered in this proceeding. We may initiate further inquiries in this proceeding on how those guidelines and other interagency and legislative developments, once completed, should impact our proposals.

15. As part of its original adoption of comprehensive orbital debris rules, the Commission sought comment on the basis of the Commission's statutory authority to adopt rules regarding orbital debris.[44] With respect to the rules proposed here, we revisit the Commission's discussion in 2004, which addressed the Commission's responsibilities and obligations under the Communications Act of 1934 (the Act).[45] The 2004 *Orbital Debris Order* specifically referenced the Commission's authority with respect to authorizing radio communications, including the statements in the Act that charge the FCC with encouraging "the larger and more effective use of radio in the public interest," and provide for licensing of radio communications, upon a finding that the "public convenience, interest, or necessity will be served thereby."[46] Did the 2004 order cite all relevant and potential sources of Commission authority in this area? Do the provisions discussed, or other statutory provisions, provide the Commission with requisite legal authority to adopt the rules we propose today?

16. We also note that the Commission has long recognized a shared a role with other agencies in evaluating orbital debris mitigation plans associated with non-Federal space operations. In

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[39] Space Policy Directive-3, National Space Traffic Management Policy, Presidential Memorandum (June 18, 2018), https://www.whitehouse.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy/.

[40] *Id.* at Sec. 4(b).

[41] *Id.* at Sec. 6(b)(1).

[42] *Id.* at Sec. 5(b)(1).

[43] *See, e.g.,* Space Policy Directive-3 at Section 6(b). The existing U.S. Orbital Debris Mitigation Standard Practices were issued in 2001 and were considered as part of the development of the Commission's orbital debris mitigation rules in the 2000s. *See Mitigation of Orbital Debris,* Notice of Proposed Rule Making, 17 FCC Rcd 5586, 5590, at para. 10 (2002).

[44] *Orbital Debris Order*, 19 FCC Rcd at 11574, para. 12 (citing *Mitigation of Orbital Debris*, Notice of Proposed Rulemaking, 17 FCC Rcd 5586, 5598-99 (2002) (*Orbital Debris Notice*)).

[45] *Id.* at para. 14; Communications Act of 1934, as amended, 47 U.S.C. § 151 *et. seq*.

[46] 19 FCC Rcd at 11575, para. 14 (citing 47 U.S.C. §§ 303(g), 301, 307(a)).

the 2004 *Orbital Debris Order*, the Commission noted that commercial remote sensing satellites are subject to regulation by both the National Oceanic and Atmospheric Administration (NOAA) and the FCC, and that NOAA requires applicants subject to its jurisdiction to provide a plan for post-mission disposal of remote sensing satellites.[47] As a result, the Commission concluded that to the extent that a remote sensing satellite applicant has submitted its post-mission disposal plans to NOAA for review and approval, the Commission would not require such information.[48] At that time the Commission also recognized the role of the Department of Transportation as the U.S. licensing authority for commercial launch operations pursuant to the Commercial Space Launch Act of 1984, as amended,[49] and observed that matters addressed under the Commercial Space Launch Act and its implementing regulations are most appropriately addressed by the Federal Aviation Administration (FAA).[50] In its analysis, the Commission determined that to the extent that a debris mitigation disclosure certifies that an upper stage of the launch vehicle has been, or will be, reviewed by the FAA, no further FCC examination of the debris mitigation plans of the upper stage would be required.[51]

17. We do not propose any changes to the specific conclusions drawn by the Commission in 2004 with respect to the role of the Commission's review of orbital debris mitigation vis-à-vis these other agencies. We do seek comment, however, on whether there are any areas in which proposed requirements may overlap with requirements that are clearly within the authority of other agencies, so that we may seek to avoid duplicative activities. We ask whether exceptions to applications of our rules as proposed or other exemptions may be appropriate in any particular circumstances. In assessing any potential exemptions, we would expect to take into consideration ongoing developments within and among other agencies, such as updates to the responsibilities of the Office of Space Commerce within the Department of Commerce.[52]

A. Control of Debris Released During Normal Operations

18. We start by proposing additional disclosure requirements designed to keep pace with how satellite deployments have evolved over the past decade.

19. In 2004, the Commission observed that satellites used primarily for telecommunications applications do not typically involve the planned release of orbital debris.[53] As part of the orbital debris mitigation disclosure, the Commission nevertheless adopted a requirement that satellite operators represent that they have assessed and limited the amount of debris released in a planned manner during normal operations.[54] It concluded that a statement confirming that no debris would be released by a satellite during normal operations would be sufficient to meet disclosure obligations, and that in any instances where release of operational debris was planned, the Commission would examine such plans on a case-by-case basis and retain the discretion to seek additional information or take action to condition or deny approval, in the event that such a release was found not to serve the public interest.[55] Under this rule, applicants must address any potential operational debris associated with spacecraft operations, except for those directly under the control of the launch vehicle provider.

20. In several recent instances, applicants have sought to deploy satellites using deployment

[47] *Orbital Debris Order*, 19 FCC Rcd at 11610, para. 103.

[48] *Id.* at 11610, para. 104.

[49] *Id.* at 11610-11, para. 105 (citing 49 U.S.C. § 70101 *et. seq.*).

[50] *Id.* at 11610, para. 105 (citing *Orbital Debris Notice*, 17 FCC Rcd at 5600).

[51] *Id.* at 11612, para. 108.

[52] *See* 51 U.S.C. Chapter 507.

[53] *Id.* at 11578, para. 24.

[54] 47 CFR § 25.114(d)(14)(i).

[55] *Orbital Debris Order*, 19 FCC Rcd at 11579, para. 24.

mechanisms that detach from or are ejected from a launch vehicle upper stage and are designed solely as means of deploying a satellite or satellites, and not intended for other operations. Once these mechanisms have deployed the onboard satellite(s), they become orbital debris. For example, special temporary authority was granted for a spacecraft known as SHERPA, designed to deploy smaller spacecraft from five ports.[56] An experimental authorization was also sought for a satellite that would be one of two satellites deployed from a tubular cylinder deployer, using a spring mechanism.[57] Thus, the deployment of two satellites resulted in three objects, one of which became a debris object very shortly following the beginning of its time in orbit. In other cases, the use of deployment devices, such as separation rings used to facilitate the launch of two geostationary satellites on a single launch vehicle, is an established practice and, while involving the release of operational debris, may in some instances reduce overall debris risk, for example by reducing the number of launches from two to one. As with other manmade objects in space, however, such deployment devices have the potential to collide with other objects and thereby create additional orbital debris. In some instances, the deployment device itself may not require an application for a license from the Commission for radio communications, if it does not have any radio frequency (RF) facilities.

21. In general, generation of operational debris, including from deployment devices, should be minimized. We propose to require disclosure by applicants if such devices are used to deploy their spacecraft, as well as a specific justification for their use. In addition, we propose that the disclosure include information regarding the planned orbital debris mitigation measures specific to the deployment device, including the probability of collision associated with the deployment device itself. Where appropriate, this description of orbital debris mitigation measures may be obtained from the operator of the deployment device.[58] If the deployment device is itself the subject of a separate application for authorization by the Commission (e.g., SHERPA), then the entity seeking a license or a grant of U.S. market access for a satellite may satisfy this disclosure requirement by referencing the deployment device's FCC application or grant. We seek comment on this proposed informational requirement. We also seek comment on how this proposal might overlap with informational requirements of other agencies and how we might streamline and minimize informational burden on applicants while mitigating space debris.[59]

B. Minimizing Debris Generated by Release of Persistent Liquids

22. Most conventional propellant and coolant chemicals evaporate or dissipate if released from a spacecraft. However, certain types of liquids, such as low vapor pressure ionic liquids, will, if released from a satellite, persist in the form of droplets. At orbital velocities, such droplets can cause substantial or catastrophic damage if they collide with other objects.[60] In the last several years, there has been increasing interest in the use by satellites (including small satellites) of alternative propellants and coolants, some of which would become persistent liquids when released by a deployed satellite.

23. Our current rules include a disclosure requirement that satellite operators have assessed and limited the probability of accidental explosions during and after completion of mission operations.[61] This includes a demonstration that debris generation will not result from conversion of energy sources on

[56] *Spaceflight Inc.*, IBFS File No. SAT-STA-20150821-00060 (the mission was ultimately cancelled).

[57] *See Open Space Networks*, ELS File No. 0957-EX-ST-2016, Exh. ODAR at 1-2.

[58] *See* Appendix A, Proposed Rule Changes, Section 25.114(d)(14)(i).

[59] To date, we note that deployment devices that are free-flying and are released or detached entirely from the launch vehicle have not been considered upper stages for purposes of FAA regulatory review.

[60] A notable example of this type of debris source involves sodium potassium reactor coolant released from Soviet-era satellites. "New Debris Seen from Decommissioned Satellite with Nuclear Power Source," NASA Orbital Debris Quarterly News, Volume 13, Issue 1 at 1-2 (January 2009), https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv13i1.pdf.

[61] 47 CFR § 25.114(d)(14)(ii); *see Orbital Debris Order*, 19 FCC Rcd at 11580-82, at paras. 29-33.

board into energy that fragments the satellite.[62] But our rules do not require disclosure of liquids that, while not presenting an explosion risk, could nonetheless, if released into space, cause damage to other satellites due to collisions. Accordingly, we propose to include within the rules a requirement to identify any liquids that if released, either intentionally or unintentionally, will persist in a droplet form. We also expect that the orbital debris mitigation plan for any system utilizing persistent liquids should address the measures taken, including design and testing, to eliminate the risk of release of liquids, and to minimize risk from any unplanned release of liquids, for example through a choice of orbit that will result in any released liquids having a very short orbital lifetime. We seek comment on this proposal.

C. Safe Flight Profiles

24. In 2004, the Commission concluded that while the choice of orbit regime (e.g., LEO or GSO) and specific orbital parameters (altitude, inclination, etc.) was generally best left to the operator, in some instances the public interest would be served by a more detailed discussion of how an operator would avoid potential collisions.[63] Our current rules require that an applicant provide a statement regarding the probability of the satellite becoming a source of debris by collisions with large debris or other operational satellites.[64] The existing rule identifies a number of specific disclosures that must be made by applicants in certain circumstances.[65]

25. In an effort to ensure that the physical operations of both existing and planned systems do not contribute to the orbital debris environment, particularly in the heavily-used LEO region, we propose to update our rules. We note that the Commission has fielded an increasing number of applications for NGSO systems for large constellations, as well as for individual small satellites.[66] In an effort to update our rules, as well as implement emerging best practices in an increasingly-crowded space environment, we propose modifications to the current rule, and additional specific disclosures regarding selection of orbit and deployment, trackability, maneuverability, and other related matters.

1. Quantifying Collision Risk

26. Our rules provide for an assessment of the probability of a satellite becoming a source of debris as a result of large object collision, but do not require that the operator quantify this probability.[67] We propose to incorporate into our rules a metric based on the current *NASA Standard*. Specifically, we propose that applicants for NGSO satellites must demonstrate that the probability that their spacecraft will collide with a large object during the orbital lifetime[68] of the spacecraft will be no greater than 0.001.[69] We seek comment on whether, if a spacecraft's orbital debris mitigation plan includes maneuvering to avoid collisions, we should, consistent with current licensing practice, consider this risk to be zero or near

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[62] 47 CFR § 25.114(d)(14)(ii).

[63] *Orbital Debris Order,* 19 FCC Rcd at 11588, paras. 49-50.

[64] 47 CFR § 25.114(d)(14)(iii).

[65] *See id.*

[66] *See Small Satellite NPRM*, FCC 18-44 at 6, para. 9.

[67] 47 CFR § 25.114(d)(14)(iii).

[68] For purposes of this *NPRM* and our proposed rules, "orbital lifetime" is defined as the length of time an object remains in orbit. Objects in LEO or passing through LEO lose energy as they pass through the Earth's upper atmosphere, eventually getting low enough in altitude that the atmosphere removes them from orbit. NASA Technical Standard, Safety and Mission Assurance Acronyms, Abbreviations, and Definitions, NASA-STD 8709.22 at 94 (with Change 2) (October 31, 2012), http://www.hq.nasa.gov/office/codeq/doctree/NS870922.pdf.

[69] *NASA Standard* at 32, Requirement 4.5-1. This is consistent with the Commission's recent proposal for satellites licensed pursuant to the proposed streamlined satellite process. *Small Satellite NPRM*, FCC 18-44 at 18, para. 37. NASA applies this metric to programs and projects involving spacecraft "in or passing through LEO." *Id.* We propose to apply this to all NGSO satellites.

zero during the period of time in which the spacecraft is maneuverable, absent contrary information. The *NASA Standard* applies the 0.001 metric on a per-spacecraft basis.[70] We invite comment on whether this metric should also be applied on an aggregate, system-wide basis, *i.e.*, 0.001 for an entire constellation. If such a requirement is adopted on an aggregate basis, would it provide an incentive for evasion of the aggregate limit, for example, through a single controlling party applying for multiple satellite constellations, each of which meets the limit, but which collectively would not? Are existing procedures adequate to identify any such instances of evasion? We also seek comment on whether we should specify a size for what is considered a large object, or whether we should continue our current case-by-case approach, which in practice typically results in consideration of catalogued objects.[71] We note that advancements in capabilities and practices suggest that smaller objects may be catalogued and perhaps routinely tracked in the coming years. The Space Fence ground-based radar, scheduled to begin regular operations in 2019, is designed to provide the U.S. Air Force with the ability to detect objects smaller than what can be detected by current systems.[72] Nonetheless, the specific ways in which this new data will be incorporated into the space object catalog, and the extent to which the addition of one sensor can support routine tracking, including tracking sufficient for collision avoidance activities, have not yet been specified.

27. We also seek comment on whether we should adopt a specific metric for collision with small debris, that is, debris consisting of small meteoroids or other small (approximately < 10 cm) debris. Our current rules require that applicants provide a statement indicating that the space station operator has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal.[73] Applicants have typically complied with the current rule by providing information on shielding, for example, that would mitigate damage from a small object. The *NASA Standard* provides that for each spacecraft, the NASA program or project demonstrate that during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable post-mission disposal requirements is less than 0.01.[74] We seek comment on whether we should incorporate the NASA probability metric into our rules, such that an applicant certify that for each spacecraft, the probability of accidental collision with small objects that would cause loss of control and prevent post-mission disposal is less than 0.01.[75] In its Large Constellation Study, NASA indicated that the implementation of adequate impact protection from small debris can be an important factor in achieving high post-mission disposal reliability for large constellations.[76] We seek comment on whether this metric should be applied on a per-spacecraft basis, or in the aggregate. Additionally, should we limit this proposed requirement to operations in certain highly-populated orbits, or to large constellations with more than 100 satellites, for example?

28. We also propose other revisions to the NGSO-related provisions of the existing rule

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[70] *Id.*

[71] Space-Track.org, FAQ, https://www.space-track.org/documentation#/faq (stating 10 cm diameter or "softball size" is the typical minimum size object that current sensors can track in LEO and that is maintained by the DoD in its catalog).

[72] *See, e.g.*, Lockheed Martin, Space Fence, https://www.lockheedmartin.com/en-us/products/space-fence.html (last visited Oct. 22, 2018); U.S. Government Accountability Office, Space Situational Awareness, Status of Efforts and Planned Budgets, GAO-16-6R, https://www.gao.gov/products/GAO-16-6R (rel. Oct. 8, 2015).

[73] 47 CFR § 25.114(d)(14)(i).

[74] *NASA Standard* at 32, Requirement 4.5-2.

[75] *See* Appendix A, Proposed Rules.

[76] NASA Large Constellation Study at 7.

regarding collision risk.[77] The existing rule states that where a satellite will be launched into a LEO region orbit that is identical, or very similar, to an orbit used by other satellites, the orbital debris mitigation statement must include analysis of potential risk of collision, disclosures regarding whether a satellite operator is relying on coordination with the other system for collision avoidance, and what coordination measures have been or will be taken.[78] First, we propose to revise the wording of the rule to require that, instead of identifying satellites with similar orbits, the orbital debris mitigation statement must identify the planned and/or operational satellites to which the applicant's satellite poses a collision risk, and indicate what steps have been taken or will be taken to coordinate with the other spacecraft or system and facilitate future coordination, or what other measures the operator may use to avoid collision.[79] This revision may provide applicants with more certainty about what must be included in the disclosure and help to identify additional collision risks. We believe that concerns about the risk of collisions involving active spacecraft may be best addressed in the first instance through inter-operator coordination.[80] Second, we propose to extend this rule to all NGSO satellites, rather than only those that will be launched into the LEO region, since overlap in orbits among NGSO spacecraft in other regions could equally result in collision creating orbital debris.[81] We anticipate that in lightly-used orbits, the statement can simply indicate that there are no other planned or operational spacecraft posing a collision risk.

2. Orbit Selection

29. In addition to quantification of collision risk described above and identification of other relevant planned or operational NGSO satellites, we propose two additional informational requirements with the goals of preventing collisions in crowded orbits, particularly those in the LEO region, and protecting important assets in space.

30. First, for any NGSO satellites planned for deployment above the International Space Station (ISS)[82] and that will transit through the ISS orbit either during or following the satellite operations, we propose that the applicant provide information about any operational constraints caused to the ISS or other inhabitable spacecraft and strategies used to avoid collision with manned spacecraft.[83] For example, will the normal operations of the ISS be significantly disrupted or otherwise constrained by

[77] *See* 47 CFR § 25.114(d)(14)(iii).

[78] *Id.*

[79] *See* Appendix A, Proposed Rule Changes, §25.114(d)(14)(iv).

[80] *See*, *e.g.*, *Telesat Canada, Petition for Declaratory Ruling to Grant Access to the U.S. Market for Telesat's NGSO Constellation*, Order and Declaratory Ruling, FCC 17-147, 32 FCC Rcd 9663, 9668, para. 12 (2017). The Commission conditioned grant of market access to Telesat Canada on the provision of additional information about its orbital debris mitigation plan, including: a discussion of any steps that Telesat has taken to coordinate physical operations with authorized and proposed NGSO systems at similar orbital altitudes (both for the main mission and disposal phases); a discussion of the level of data-sharing that would be required with other operators, including analysis of likely requirements for ephemeris refresh rates and time frames for coordination of planned maneuvers (both for the main mission and disposal phases); and whether Telesat has considered alternative orbital altitudes for its operations and whether those altitudes would materially affect Telesat's ability to provide service. *Id.* at 9669, para. 14.

[81] *See* Appendix A, Proposed Rule Changes, §25.114(d)(14)(iv).

[82] The ISS operates at an altitude of approximately 400 km.

[83] Between 1999 and July 2015, the International Space Station (ISS) conducted 23 total collision avoidance maneuvers. National Aeronautics and Space Administration, Orbital Debris: Quarterly News, "International Space Station Performs Two Debris Avoidance Maneuvers and a Shelter-in-Place," Vol. 19, Issue 3 at 1 (July 2015), https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv19i3.pdf; s*ee also* J.-C. Liou, National Aeronautics and Space Administration, "Orbital Debris Mitigation Policy and Unique Challenges for Cubesats," presentation to the 52nd Session of the Scientific and Technical Subcommittee, Committee on Peaceful Uses of Outer Space, United Nations, February 2015, at 9, *available at* https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150020943.pdf.

the number of collision avoidance maneuvers that may be necessary as satellites in the constellation transit through the ISS orbit, such as during an uncontrolled de-orbit phase?[84] As noted in the *Small Satellite NPRM*, deployment of satellites lacking maneuvering capabilities above the ISS, to orbits from which they will eventually transit through the ISS altitude band, increases the likelihood that the ISS will need to conduct avoidance maneuvers, potentially disrupting ISS operations.[85] In that proceeding, the Commission proposed that satellites without propulsion seeking to be processed on a streamlined basis be deployed either from or at altitudes below the ISS.[86] We do not propose similar criteria for satellites authorized outside the streamlined process, but we believe information regarding operational constraints caused to inhabitable spacecraft could help us and any other interested parties to assess the public interest in authorizing any particular satellite or constellation.

31. Second, we propose that an applicant planning an NGSO constellation that will be deployed in the LEO region above 650 km altitude specify why it has chosen that particular orbit given the number of satellites planned, and describe any other relevant characteristics of the orbit such as the presence of existing debris. Satellites deployed below 650 km will typically re-enter Earth's atmosphere within 25 years,[87] even absent any propulsive or other special de-orbit capabilities. Thus, the collision risks presented by such satellites are generally lower, even if the satellites fail on-orbit and are unable to perform any affirmative de-orbiting maneuvers.[88] Above this approximately 650 km threshold, a satellite that is not affirmatively de-orbited will remain in orbit for significantly longer periods of time. Accordingly, for NGSO deployments above the 650 km altitude, we propose that applicants provide a rationale for choosing a higher orbit, even if the satellites will have propulsive de-orbit capabilities.[89] While we recognize that satellites may be designed to de-orbit within 25 years from altitudes above 650 km, those missions may involve greater risk from an orbital debris perspective due to the possibility of a satellite failure resulting in the satellite remaining in orbit for periods of time in as much as the hundreds or thousands of years.

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[84] *See* NASA NGSO Constellation Comments at 2 (expressing concern about aspect of disposal plan for SpaceX LEO constellation and recommending that SpaceX "seek out creative ways to guarantee they can avoid the ISS and other high value assets" for the entire deorbit phase of their planned spacecraft); Science Applications International Corporation, Orbital Traffic Management Study Final Report, Prepared for NASA Headquarters, at E-1-E-2 (Nov. 21, 2016) (SAIC Orbital Traffic Management Study) ("As debris populations grow in LEO, the odds of [micro-meteoroid or orbital debris] root cause events on ISS will become higher (i.e. worsen)[.]" "Recent analysis by the Aerospace Corporation suggests that the current large planned constellations could increase collision warnings with ISS six-fold, as the decommissioned spacecraft in those constellations decay through the ISS orbit.").

[85] *Small Satellite NPRM*, FCC 18-44 at 17, para. 34.

[86] *Id.* at 17, paras. 33-34.

[87] This is consistent with the benchmark contained in the current *NASA Standard*. *NASA Standard* at 37, Requirement 4.6.2.

[88] This altitude may vary depending upon the characteristics of the spacecraft and solar activity, but 650 km represents an average approximation. *See* Inter-Agency Space Debris Coordination Committee, Support to the IADC Space Debris Mitigation Guidelines, IADC-04-06, Rev. 5.5 at 32 (May 2014) ("It is recommended that orbital lifetime be reduced to less than 25 years at the end of mission (approximately 750 km circular orbit for A/m = 0.05 m2/kg, and approximately 600 km circular orbit for A/m=0.005 m2/kg, depending on solar activity to be more exact."); ESA NGSO FSS Comments at 2 (recommending that for large constellations low operational orbits should be considered, noting that average orbital altitudes of less than 650 km for average satellites (< 1 ton) are normally still compatible with a natural decay within 25 years).

[89] As explained in the *Orbital Debris Order*, the U.S. Government Orbital Debris Standard Practices call for the selection of an orbit from which the spacecraft will remain in orbit no longer than 25 years after mission completion, if the planned disposal method is re-entry into Earth's atmosphere through means of natural atmospheric drag, without the use of propulsion systems. *Orbital Debris Order*, 19 FCC Rcd at 11592, para. 61; U.S. Government Orbital Debris Standard Practices 4-1, *available at* https://www.orbitaldebris.jsc.nasa.gov/library/usg_od_standard_practices.pdf (U.S. Government Standard Practices).

32. Third, we seek comment on whether we should also require a statement concerning the rationale for selecting an orbit from operators of satellites that will remain in orbit for a long period of time relative to the time needed to perform their mission. For example, a technology demonstration mission in LEO that lasts only a few weeks could result in up to 25 years of collision risk to other operators. One example of an alternative guideline is that operators select orbits such that orbital lifetime exceed mission lifetime by no more than a factor of two. We seek comment on this metric, or alternative metrics that could be incorporated into our rules.

33. Fourth, we note that certain areas of space are more populated with debris, such as that from the Cosmos 2251/Iridium 33 collision. It may be in the public interest for new constellations to avoid deployment in such areas to minimize risk, or, stated differently, to design constellations to operate in regions of space where the density of objects is lower, and consequently where the risk of collisions with debris objects is lower.[90] We ask whether to require applicants to include an additional disclosure regarding orbit selection based on such risks, or to provide assurances on how the applicant plans to reduce these risks. We also ask whether we should seek additional information or assurances from applicants in more narrow circumstances, for example, where they seek to deploy a large constellation in certain sun-synchronous orbits that have an increased likelihood of congestion.

34. Fifth, in lieu of an informational requirement, should we require all NGSO satellites planning to operate above a particular altitude to include propulsion capabilities reserved for station-keeping and to enable collision avoidance maneuvers, regardless of whether propulsion is necessary to de-orbit within 25 years? If so, above what altitude?

35. Finally, we ask whether we should adopt a maximum limit for variances in orbit for NGSO systems. That is, should we limit the variance in altitude above or below the operational orbit specified in an application for an NGSO system,[91] in order to enable more systems to co-exist in LEO without overlap in orbital altitude, and if so, how should an appropriate limit be set? If such a limit is adopted, should it apply only to near-circular obits, or also to elliptical orbits? We seek comment on these questions, as well as on any additional changes to our rules and policies that may help operators avoid collisions and ultimately reduce the risk of debris generation in heavily-used or otherwise critical orbits.

3. Tracking and Data Sharing

36. The identification of satellites and sharing of tracking data are important to provide timely and accurate assessments of conjunction with other spacecraft.[92] The increase in the number of small satellites, for example, has begun to pose some unique tracking and identification challenges.[93] We believe that improvements in the ability to track and identify satellites in NGSO may help to reduce the risk of collisions. As an initial matter, we propose to require a statement from the applicant regarding the ability to track the proposed satellites using space situational awareness facilities, such as the U.S. Space

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[90] NASA NGSO Constellation Comments at 2-3 (NASA expressed some concerns regarding proposed orbit of Theia Holdings A, Inc., NGSO satellite constellation, because of the location of other government satellites nearby and the high percentage of Iridium-33/Cosmos-2251 and Fengyun-1C debris in that region).

[91] As an example of the discussion of issues related to variances in orbital altitude for a particular system, SpaceX expressed concern regarding the proposed operational range for OneWeb's planned NGSO system. *See* Letter from William M. Wiltshire, Counsel to SpaceX, to Marlene H. Dortch, Secretary, FCC, at 2-4, IBFS File Nos. SAT-LOA-20161115-00118 and SAT-LOA-20170301-00027 (filed Dec. 12, 2017).

[92] A conjunction event is one in which space objects, such as an two operational spacecraft or an operational spacecraft and a debris object, are predicted to come within close proximity to each other. A conjunction event may or may not result in a collision.

[93] CubeSat Recommendations at 1; *Small Satellite NRPM*, FCC 18-44 at 18-19, para. 38.

Surveillance Network.[94] We propose that objects greater than 10 cm by 10 cm by 10 cm be presumed trackable for any altitude up to the geostationary region,[95] although we seek comment on whether a larger size should be presumed at higher altitudes given any tracking limitations at such altitudes. For objects with any dimension less than 10 cm, we propose that the applicant provide additional information concerning trackability, which will be reviewed on a case-by-case basis. We also propose that applicants for NGSO systems disclose, as part of their orbital debris mitigation plans, whether satellite tracking will be active and cooperative (that is, with participation of the operator by emitting signals via transponder or sharing data with other operators) or passive (that is, solely by ground based radar or optical tracking of the object).[96] We also ask whether applications should certify that the satellite will include a unique telemetry marker allowing it to be readily distinguished from other satellites or space objects.[97] We further seek comment on whether there are hardware or information sharing requirements that might improve tracking capabilities, and whether such technologies are sufficiently developed that a requirement for their use would be efficient and effective.

37. In addition, we note that the Air Force's 18th Space Control Squadron is currently responsible for maintaining the space catalog and managing United States Strategic Command's space situational awareness sharing program to United States, foreign government, and commercial entities.[98] Among other things, the Air Force's 18th Space Control Squadron currently provides satellite owner/operators with on-orbit conjunction assessments.[99] We seek comment on whether we should adopt an operational rule requiring NGSO satellite operators to provide certain information to the 18th Space Control Squadron or any successor civilian entity,[100] including, for example information regarding initial deployment, ephemeris, and any planned maneuvers. As an example, communication with the Air Force's 18th Space Control Squadron may be particularly important in the case of a multi-satellite deployment, to assist in the identification of the satellite.[101]

38. We also propose that applicants for NGSO systems certify that, upon receipt of a conjunction warning, the operator of the satellite will take all possible steps to assess and, if necessary, to mitigate collision risk, including, but not limited to: contacting the operator of any active spacecraft involved in such warning; sharing ephemeris data and other appropriate operational information directly

[94] Space situational awareness facilities track satellites and other space objects using radar and other means.

[95] In the *Small Satellite NPRM*, the Commission proposed that small satellites using the streamlined review process be no smaller than 10 cm x 10 cm x 10 cm, which would help the Commission to process those systems in a streamlined fashion. *Small Satellite NPRM*, FCC 18-44 at 18-19, para. 38.

[96] *See* Committee on Achieving Science Goals with CubeSats – Thinking Inside the Box, Space Studies Board, Division on Engineering and Physical Sciences, National Academies of Sciences, Engineering, and Medicine, Achieving Science Goals with CubeSats: Thinking Inside the Box at C-7 (2016), http://www.nap.edu/catalog/23503/achieving-science-with-cubesats-thinking-inside-the-box (discussing tracking technologies).

[97] *See Small Satellite NPRM*, FCC 18-44, at 19, para. 38. The Commission proposed that small satellites applying under the proposed streamlined process make this certification.

[98] *See* Peterson Air Force Base, Fact Sheets, 18th Space Control Squadron, https://www.peterson.af.mil/About/Fact-Sheets/Display/Article/1060346/18th-space-control-squadron/.

[99] *See* SSA Sharing & Orbital Data Requests, Space-Track.org, https://www.space-track.org/documentation#/odr (last visited Oct. 22, 2018) (Space-Track SSA Services Website); *See* CubeSat Recommendations at 2, 3-4.

[100] *See* Space Policy Directive 3, Section 6(d)(ii) ("[T]he Secretary of Commerce will make the releasable portions of the catalog [of space objects], as well as basic collision avoidance support services, available to the public, either directly or through a partnership with industry or academia.").

[101] *See* CubeSat Recommendations at 1 (noting that there were challenges associated with the ORS-3 mission, launching 37 CubeSats, and the DNEPR rocket, launching 31 CubeSats, both in late 2013).

with any such operator; and modifying spacecraft attitude and/or operations.[102] We seek comment on this approach as one designed to reduce collision risks and enhance certainty among operators, and ask whether any different or additional requirements should be considered regarding the ability to track and identify satellites in NGSO or respond to conjunction warnings.

4. Maneuverability

39. We also propose that applicants for NGSO satellite authorizations describe the extent of any maneuverability. For example, the description could include an explanation of the number of collision avoidance maneuvers the satellite could be expected to make, and/or any other means the satellite may have to avoid conjunction events. We propose that the description include a discussion of maneuverability both during satellite's operational lifetime and during the remainder of its time in space prior to disposal. We tentatively conclude that such information can assist us in our public interest determination, in particular regarding any burden that other operators would have to bear in order to avoid collisions and false conjunction warnings. We seek comment on this conclusion and note that, as proposed, this is an informational requirement, and would not require that all satellites have propulsion or maneuverability. In addition, we observe that some applications have been granted based on an assessment of information regarding differential drag maneuvers. Recognizing that this is an emerging area from the perspective of collision avoidance, we seek comment concerning effectiveness and suitability of this or other particular maneuvering technologies under real world conditions, and on whether we should implement any specific disclosure requirements with respect to this or other types of emerging maneuvering technology.

5. Multi-Satellite Deployments

40. In recent years, we have observed an increasing number of cases where a single launch vehicle will deploy large numbers of NGSO satellites,[103] often involving some groups of satellites having homogenous designs and others of varying design. A single deployment of a number of satellites from a launch vehicle or free-flying deployment device could result in some heightened risk of collision between objects, or on a longer-term basis due to the similarity of orbits for the released objects. We seek comment on whether we should include in our rules any additional informational requirements regarding such launches.[104] Are there mitigation measures that are commonly employed that mitigate such risks, for example through use of powered flight during the deployment phase and/or through phasing of deployment, that we should consider adopting as requirements under some circumstances?

41. In seeking comment, we recognize that an applicant for a Commission license or authorization may not have access to information regarding other satellites that will be deployed, and ask whether an applicant could obtain general information from the launch provider or aggregator that would assist the Commission in evaluating the risk of collision presented by the deployment itself, even if the launch manifest has not been finalized.

[102] *See* Appendix A, Proposed Rule Changes, Section 25.114(d)(14)(iv)(A).

[103] In 2017, for example, a record 104 satellites were launched on a single rocket, the Indian Space Research Organisation's Polar Satellite Launch Vehicle (PSLV). *See* Department of Space Indian Space Research Organisation, "PSLV-C37 Successfully Launches 104 Satellites in a Single Flight," https://www.isro.gov.in/pslv-c37-successfully-launches-104-satellites-single-flight (last visited Oct. 22, 2018); Santanu Choudhury, "India Breaks Record for Launching Most Satellites from a Single Rocket," Wall Street Journal (Feb. 15, 2017), https://blogs.wsj.com/indiarealtime/2017/02/15/india-breaks-record-for-launching-most-satellites-from-single-rocket/.

[104] *See* Spaceflight, Inc., IBFS File No. SAT-STA-20150821-0006 (analysis of "within-plane" collision risk for 91 objects planned for deployment in a single launch).

6. Design Reliability

42. In comments filed regarding proposed large constellations of NGSO satellites, NASA suggested that for such constellations, a design and fabrication reliability standard may be appropriate.[105] A design or reliability flaw resulting in malfunction of spacecraft during deployment or mission operations could result in a significant number of non-functional spacecraft in an operational orbit, contributing to the orbital debris population.[106]

43. We seek comment on whether it would be appropriate to impose a design and fabrication reliability requirement, for example, 0.999 per spacecraft, if a NGSO satellite constellation involves a large number of satellites or will be initially deployed at higher altitudes in LEO.[107] Deployment of large numbers of satellites increases the spatial density of objects in the region of space where the satellites are deployed, and provides an indicator of potential collision risk. We consider a deployment of 100 satellites over a typical 15-year license term to be a deployment of a large number of satellites, but seek comment on whether a different number may be appropriate. We consider higher altitudes to be those with a perigee above 600-650 km.[108] From these orbits, spacecraft will typically remain in orbit for several decades to centuries, and present a long-term collision risk, unless active measures are taken to shorten orbital lifetimes. We also seek comment and suggestions on other possible metrics, and methods for verifying and assessing compliance with any such metric. Further, we are cognizant that technology continues to develop rapidly in the satellite design arena and seek to avoid potential requirements that may wed designers to a current conception of technological limits that could be changed in the future.

D. Post-Mission Disposal

44. Post-mission disposal consists of measures taken, often at the end of a spacecraft's useful life, that result in removal of the spacecraft from Earth's orbit, or relocation of the spacecraft to a long-term orbit that reduces the risk of collision with operational spacecraft. In 2004, the Commission observed that effective disposal of non-functional spacecraft can both protect operational spacecraft from accidental collisions with orbital debris and reduce the probability of non-functioning objects colliding with one another and creating additional debris.[109] The concerns associated with non-functioning spacecraft are magnified as more satellites are launched, particularly to altitudes where a failed spacecraft may remain in orbit more than 25 years.[110] Under our rules, an applicant's orbital debris mitigation statement must include several elements regarding post-mission disposal, including a description of the

[105] Letter from Anne E. Sweet, NASA Representative on the Commercial Space Transportation Interagency Group, Program Executive, Launch Services Office, Human Exploration and Operations Mission Directorate, NASA to Marlene Dortch, Secretary, FCC, IBFS File Nos. SAT-LOA-20161115-00118, SAT-LOA-20161115-00121 at 1-2 (filed June 26, 2017) (NASA NGSO Constellation Comments).

[106] *Id.*

[107] *See id.* (suggesting for discussion purposes a design and fabrication reliability on the order of 0.999 or better per spacecraft in a 4,000+ spacecraft constellation); *see also* Letter from Johann-Dietrich Wörner, Director General, European Space Agency, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 16-408 at 3 (filed Sept. 15, 2017) (ESA NGSO FSS Comments) (noting the exponential relationship between environmental effect and the number of failed spacecraft).

[108] For objects orbiting the Earth, the point in orbit that the object is closest to the Earth is known as the object's "perigee."

[109] *Orbital Debris Order*, 19 FCC Rcd at 11591, para. 58.

[110] *See, e.g.*, IADC Statement on Large Constellations at 6 (noting that most proposed concepts for large constellations in LEO target at operational altitudes above 1000 km, where the average natural atmospheric drag-induced orbital lifetimes are "quasi eternal"); ESA NGSO FSS Comments at 2 (making the same observation).

planned disposal orbit, for GSO satellites, and a casualty risk assessment for NGSO satellites where planned post-mission disposal involves atmospheric re-entry of the satellite.[111]

45. Based on our experience since 2004 in evaluating post-mission disposal plans, as well as concerns regarding satellite reliability and large constellations,[112] we propose below specific revisions to our existing disclosure requirements regarding post-mission disposal of NGSO satellites.

1. Probability of Success of Disposal Method

46. *Incorporation of Disposal Reliability Metrics.* We propose to require that applicants provide information concerning the expected reliability of disposal measures involving atmospheric re-entry, and the method by which that expected reliability was derived. We also seek comment on the metric by which such information should be evaluated; for example, should we specify a probability of success of no less than a set figure, such as 0.90?[113] The NASA *Standard* notes that failure of spacecraft to execute a planned disposal maneuver or operation on a routine basis will result in a more rapid increase in the orbital debris population.[114] Moreover, in the 2004 *Orbital Debris Order*, the Commission noted that "[r]eliability may be relevant to both the assessment of whether the satellite will meet end-of-life goals, and to the assessment of whether the public interest benefits arising from the satellite's activities will, in fact, be provided."[115] Adding a specific metric for reliability of disposal may help us to better evaluate the applicant's end-of-life disposal plan. We also invite comment as to whether, when assessing the reliability of disposal, we should do so on an aggregate, system-wide basis as well as on a per-satellite basis, and on whether, for large constellation deployments, where due to large numbers of spacecraft aggregate effects could be more damaging to the space environment, a more stringent metric should apply. A recent NASA study of large constellations concluded, for example, that a 0.99 spacecraft post-mission disposal reliability is needed to mitigate the serious long-term debris generation potential from large constellations.[116]

47. *Other Requirements for Satellites with Planned Operations in LEO.* We propose two additional disclosure requirements related to reliability and seek comment on other possible requirements as well.

48. First, we propose that the applicant certify that all satellites that will operate at an altitude of 650 km or above will be initially deployed into orbit at an altitude below 650 km and then, once it is determined that the satellite has full functionality,[117] be maneuvered up to their planned operational

[111] 47 CFR § 25.114(d)(14)(iv).

[112] *See, e.g.*, IADC Statement on Large Constellations at 6 ("It is clear that significant improvements in the reliability of the disposal function at end of life will be needed for the new [large LEO] constellations compared with that currently demonstrated by space systems on orbit.").

[113] *See NASA Standard* at 41, Requirement 4.6.3.n (specifying that for NASA missions, the probability of success of post-mission disposal operations should be no less than 0.90). This probability metric would apply where post-mission disposal operations will lead to atmospheric reentry or maneuvering the spacecraft into a storage orbit. *See id.* Consistent with the Commission's discussion in the 2004 *Orbital Debris Order*, we do not propose to foreclose direct retrieval of the spacecraft from orbit as a means of post-mission disposal. *Orbital Debris Order*, 19 FCC Rcd at 11591, para. 60.

[114] *NASA Standard* at 41, Requirement 4.6.3.n.

[115] *Orbital Debris Order*, 19 FCC Rcd at 11602-03, para. 86.

[116] *See* NASA Large Constellation Study at 7.

[117] For example, communications with the satellite have been established and the major satellite systems are operational in accordance with the design, such that the satellite would be able to perform de-orbit maneuvers.

altitude.[118] This would help to ensure that if satellites are found to be non-functional immediately following deployment, such that they will be unable to perform any maneuvers, they will re-enter the atmosphere within 25 years and not persist in LEO for longer periods of time. As briefly discussed above,[119] ensuring functionality of spacecraft in a large constellation may be particularly important, since an unforeseen flaw could result in the failure of hundreds of satellites of a planned constellation immediately following deployment. We recognize that this requirement may involve additional reserves of fuel, for example, for orbit-raising. In some respects, this is similar to the analysis undertaken in the Commission's 2004 *Orbital Debris Order*, which resulted in the adoption of a requirement to maneuver GSO spacecraft at end-of-life to a particularly calculated disposal orbit, even though this maneuver required additional fuel.[120] There, the Commission concluded that the additional costs were warranted in order to achieve the public interest in minimizing the hazard posed by orbital debris to the continued safe and reliable use of the GSO region.[121] Similarly, we posit here that the benefits of the continued viability of the LEO region may outweigh the costs of orbit-raising, and seek comment on the costs and benefits associated with this proposal. Relatedly, we seek comment on whether we should require that applicants for large constellations test a certain number of satellites in a lower orbit for a certain number of years before deploying larger numbers, in order to resolve any unforeseen flaws in the design that could result in generation of debris.[122]

49. Second, we propose that applicants seeking to operate NGSO satellite systems provide a statement that spacecraft disposal will be automatically initiated in the event of loss of power or contact with the spacecraft,[123] or describe other means to ensure that reliability of disposal will be achieved, such as internal redundancies, ongoing monitoring of the disposal function, or automatic initiation of disposal if communications with the spacecraft become limited.[124] These means would be designed to limit the situations in which the satellite remains on-orbit after a spacecraft failure, or otherwise presents an enhanced hazard for explosions, collisions, or other debris-causing events. Consistent with this rationale, this requirement would help ensure that spacecraft failures do not result in concentration of debris in the LEO region.

50. We recognize that these design features have some associated costs. We seek comment on the costs and benefits associated with this proposed requirement. We also ask whether we should simply require the design to include automatic disposal by a de-orbiting device in the event of loss of power, and on whether any such requirement would provide adequate flexibility for operators to react, for example, if the particular failure mode results in further propulsive maneuvers running a high risk of explosive fragmentation. Are there other technologies that can be used to ensure that satellite disposal is

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[118] Appendix A, Proposed Rules. *See* ESA NGSO FSS Comments at 2 (suggesting that spacecraft be injected into orbits 650 km or lower, and then only move to operational altitude after a successful functional check-out).

[119] *See supra* Part III.C.6.

[120] *See Orbital Debris Order*, 19 FCC Rcd at 11593, para. 75.

[121] *Id*. The GSO region is the region surrounding a circular orbit along the plane of the Earth's equator at an altitude of approximately 35,786 kilometers. *Id.* at 11568, n. 4. A spacecraft in this orbit can be maintained at a constant longitudinal position relative to the Earth, thus allowing the satellite to be "seen" continuously from, and at a fixed orientation to, any given point on the Earth's surface. *Id.*

[122] As an example, Telesat Canada, the recipient of a grant of access to the U.S. market for a planned NGSO constellation of 117 satellites, is using prototype satellite(s) for testing and design verification purposes. Telesat Canada, Petition for Declaratory Ruling, IBFS File No. SAT-PDR-20161115-00108, Telesat LOI, Exh. 3 at 5 (granted Nov. 2, 2017). The ESA NGSO FSS comments noted that critical components inducing break-ups are sometimes identified only years after the satellite has been operational, which could result in a large problem with large numbers of satellites, particularly with short production times involved. ESA NGSO FSS Comments at 3.

[123] This type of proposal was suggested by ESA in its comments to the NGSO FSS proceeding, with respect to large constellations. *See* ESA NGSO FSS comments at 3.

[124] Appendix A, Proposed Rules.

completed, even in the event of a major anomaly, and should we require use of those technologies for satellites that will operate in particular regions?

51. We propose that these two requirements would apply to satellites that will operate above 650 km and below 2,000 km, in other words, in the higher portion of LEO.[125] We also seek comment on whether any requirements should only apply to LEO satellite constellations of a certain size or greater or whether they should apply to all LEO satellites that will operate in the area described.

52. *Means of LEO Spacecraft Disposal.* Additionally, we seek comment on whether there are other rule changes we should consider related to the disposal of spacecraft from the LEO region. Should we adopt a rule that disposal of spacecraft in the LEO region must be by either atmospheric re-entry or direct retrieval? The U.S. Government Standard Practices, originally developed in the 1990s, recognize disposal to a region above LEO as an option for non-geostationary satellites,[126] but the IADC Guidelines do not recognize this option. The IADC Guidelines instead list the following options for disposal for spacecraft terminating their operational phase in the LEO region: de-orbit, maneuver to an orbit with a reduced lifetime (where the spacecraft will naturally re-enter the atmosphere), or retrieval.[127]

53. We observe that satellites left at higher altitudes will remain in orbit indefinitely, and removal from orbit is generally preferable.[128] With respect to direct retrieval, the Commission concluded in 2004 that direct retrieval was not feasible at that time, but did not preclude direct retrieval as a possible method of post-mission disposal.[129] In assessing whether a post-mission disposal plan is sufficiently reliable, what weight, if any, and under what circumstances, should we give to proposals to directly retrieve the spacecraft from orbit at its end of life?[130] Should direct retrieval be considered as a valid debris mitigation strategy, for example, only if the retrieval spacecraft are presented for licensing as part of or contemporaneously with the constellation license?

54. At this time, there are a number of specific technologies under development for direct spacecraft retrieval, although generally these are nascent technologies and we are not aware of any planned deployments for commercial applications thus far. Direct spacecraft retrieval involves rendezvous and proximity operations,[131] but with potentially the additional challenge of a target spacecraft that is "non-cooperative," i.e., is spinning, is not providing any telemetry, etc. In the context of orbital debris mitigation, testing is ongoing for technologies such as nets and harpoons,[132] and there are numerous other technologies under discussion such as robotic arms and magnetic capture mechanisms.[133] We seek comment on the status of these and other technologies for spacecraft direct retrieval, including potential future commercial applications. Are there any aids to future use of direct retrieval, such as spacecraft

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[125] Appendix A, Proposed Rules.

[126] U.S. Government Standard Practices at 4-1.

[127] IADC Guidelines at § 5.3.2.

[128] *See* ESA NGSO FSS Comments at 3 (noting that disposal of satellites in large LEO constellations by orbit raising should be avoided).

[129] *Orbital Debris Order*, 19 FCC Rcd at 11591, para. 60.

[130] Direct retrieval of satellites implicates the need to assess rendezvous and proximity operations, and any risk of debris generation from those operations.

[131] *See* discussion *infra* Part III.E.

[132] *See, e.g.*, University of Surrey, Surrey Space Centre, RemoveDEBRIS Mission, https://www.surrey.ac.uk/surrey-space-centre/missions/removedebris (last visited Nov. 13, 2018).

[133] *See, e.g.*, Astroscale, ELSA-d Mission, https://astroscale.com/missions/elsa-d/ (last visited Nov. 13, 2018) (planned future demonstration of a magnetic capture mechanism). Astroscale Pte Ltd. states that a back-up post-mission disposal method should be used in the case where satellites stop functioning in higher portions of LEO. *See* Letter from Charity Weeden, U.S. Managing Representative, Astroscale to Marlene H. Dortch, Secretary, FCC, IB Docket No. 18-313 (filed Nov. 6, 2018) (Astroscale *Ex Parte* Letter).

reflective markers or attachment points, that could be adopted now or in the near future?

55. *Disposal of NGSO Satellites In Orbits Above LEO.* We also seek comment on whether to modify the Commission's existing rules regarding end-of-life disposal for satellites to include additional provisions concerning disposal of certain NGSO satellites operating in orbits above LEO. The current rules require disclosure of such plans, and in 2004 we concluded that we would assess disposal plans for satellites that do not pass through the LEO or GEO regions, such as those in highly elliptical orbits or medium Earth orbits, on a case-by-case basis.[134]

56. As a general matter, there appear to be two types of approaches to post-mission disposal above LEO. One approach is to remove a satellite from its operational orbit to another, relatively stable orbit that is sufficiently distinct from those orbits that are currently used or expected to be used for regular operations, so as to eliminate the risk of collisions with such operating satellites.[135] Another approach is to place a satellite into an unstable orbit, i.e., one in which gravitational forces and solar radiation pressure force a growth in the eccentricity of the orbit, ultimately resulting in lowering of the satellite's perigee and re-entry into the atmosphere.[136] While this latter approach may result in disposed satellites traversing other operational orbits and passing through the LEO region, they can ultimately result in removal of the satellite from orbit. Thus, this latter approach may result in less long-term collision risk, although perhaps at the cost of increased short-term risk.

57. We seek comment on whether these practices are sufficiently developed to formalize in our rules. We also seek comment on whether there are any specific guidelines we should include in our rules with respect to these approaches, or with respect to any particular type of orbit.[137]

2. Post-Mission Lifetime

58. As some types of designs lead to satellites that are smaller and less expensive to construct and launch, there has been a corresponding trend toward shorter mission lifetimes for NGSO satellites deployed into the LEO region. For example, the anticipated lifetime of a typical "CubeSat" operating in the Earth exploration-satellite service is only one or two years.[138]

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[134] *Orbital Debris Order*, 19 FCC Rcd at 11603-04, para 87.

[135] *See Satellite CD Radio Inc.*, IBFS File No. SAT-MOD-20091119-00123, Attachment A at 3-7; *O3b Limited*, IBFS File No. SES-LIC-20100723-00952, Technical Information to Supplement Schedule S at 37-40; *Karousel, LLC*, IBFS File No. SAT-LOA-20161115-00113, Letter from Monish Kundra, Karousel LLC, to Jose P. Albuquerque, Chief, Satellite Division, International Bureau, FCC (April 11, 2017) at 7-8. The geostationary disposal requirement in our rules, intended for satellites orbiting at inclinations of approximately 15 degrees or less, can be viewed as an example of this type of disposal.

[136] *Space Norway AS*, IBFS File No. SAT-PDR-20161115-00111, Technical Information to Supplement Schedule S at 15-18. This approach appears to be more readily available for satellites operating at higher inclinations.

[137] End-of-life Disposal in Inclined Geosynchronous Orbits, Luciano Anselmo & Carmen Pardini, Proceedings of the 9th IAASS Conference, International Association for the Advancement of Space Safety, 2017, pp. 87-94 (outlining modified version of the IADC formula for geostationary satellite disposal, to address satellites in highly-inclined geosynchronous orbits and resulting orbital perturbations).

[138] See, e.g., Planet Labs Inc., Application for Launch and Operating Authority, IBFS File No. SAT-LOA-20130626-00087, Exh. 43 at 2 (describing the nominal lifetime of its Flock 1 satellites as 11 months, with maximum lifetime of 18 months); Planet Labs Inc., Modification Application, IBFS File No. SAT-MOD-20150802-00053, Exh. 43 at 1 (describing expected operational lifetime of a series of additional satellites as approximately two years); Spire Global, Inc., Application for Launch and Operating Authority, IBFS File No. SAT-LOA-20151123-00078, Exh. A at 23 n.73 (describing the operational lifetime of a typical Spire satellite as approximately two years). In the *Small Satellite NPRM*, the Commission proposed that the total on-orbit lifetime, including both mission and time to de-orbit, be five years or less for small satellites licensed under the proposed streamlined process. *Small Satellite NPRM*, FCC 18-44 at 15, para. 28. This proposed five-year on-orbit lifetime would apply only to satellites licensed

59. Consistent with these shorter mission lifetimes, as well as the number of satellites planned for deployment, we ask whether the 25-year disposal guideline contained in the *NASA Standard* remains a relevant benchmark.[139] That is, does the guideline that a spacecraft reenter the atmosphere no more than 25 years after the completion of the spacecraft's mission permit spacecraft designs that result in a longer disposal period than may be in the public interest for a particular satellite mission?[140] Should the disposal guideline instead be proportional to mission lifetime, or specific to the orbital altitude where the spacecraft will be deployed?[141] We also note that solar activity can influence the re-entry periods of satellites in LEO,[142] and that future solar activity may vary from predictions.[143] In what manner, if any, should we account for variations in solar activity in our rules and in crafting conditions on the grant of specific licenses? Should satellite operators planning disposal through atmospheric re-entry be required to continue obtaining spacecraft tracking information, for example by using radio facilities on the spacecraft, to the greatest extent possible following the conclusion of the primary mission? In addition to these questions, we seek comment generally on how to prevent satellites from becoming sources of orbital debris during the period following their mission lifetime and before disposal through atmospheric re-entry.

3. Casualty Risk Assessment

60. The U.S. Government Orbital Debris Mitigation Standard Practices and the *NASA Standard* include a policy of limiting to 1 in 10,000 the risk of at least one human casualty, anywhere in the world, from a single, uncontrolled reentering space structure.[144] In order to assist the Commission in evaluating the spacecraft design with respect to human casualty risk, we propose two specific informational requirements for satellites with a planned post-mission disposal of uncontrolled atmospheric re-entry.[145]

61. First, we propose that the human casualty risk assessment include all objects that would have an impacting kinetic energy in excess of 15 joules. This is consistent with the *NASA Standard*, wherein the potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules.[146]

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under the streamlined process, *see id.*, and we anticipate that if adopted, the streamlined process would be used by some, but not all, CubeSats.

[139] *NASA Standard* at 37, Requirement 4.6.2. The *NASA Standard* provides the option that, for a spacecraft with a perigee altitude below 2,000 km that will be disposed of through atmospheric re-entry, the operator shall leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch. *Id.*

[140] Astroscale Pte Ltd. expresses the view that a 25-year de-orbit time frame which is currently used as a standard practice may no longer be sufficient for the sustainability of space due to increased congestion, both in active satellites and orbital debris. Astroscale *Ex Parte* Letter.

[141] *See* IADC Statement on Large Constellations at 6 (noting that, in reference to the proposed large NGSO constellations, the 25-year lifetime may need to be reduced to limit residence times in orbit).

[142] Relatively weak solar activity can result in a decrease of the atmospheric drag on satellites in LEO, causing longer re-entry periods for retired spacecraft, including beyond a 25-year predicted re-entry period. For a brief summary of satellite drag and its causes, see National Oceanic and Atmospheric Administration, Space Weather Prediction Center, *Satellite Drag*, http://www.swpc.noaa.gov/impacts/satellite-drag.

[143] *See, e.g.*, Robert Lee Hotz, *Strange Doings on the Sun*, Wall Street Journal (Nov. 10, 2013), http://www.wsj.com/articles/SB10001424052702304672404579183940409194498.

[144] *See Orbital Debris Order*, 19 FCC Rcd at 11603, para. 88; *NASA Standard* at 44, Requirement 4.7.3.

[145] For missions planning controlled reentry, we anticipate evaluating such plans on a case-by-case basis, consistent with the *NASA Standard*. *See NASA Standard* at 44, Requirement 4.7.2.

[146] *Id.* The 15 joule limit has been determined to be the limit above which any strike on a person will require prompt medical attention. *NASA Standard*, at 45, Requirement 4.7.3.c. The 1:10,000 standard does not account for

62. Second, we propose that where the calculated risk of human casualty from surviving debris is determined to be greater than zero, as calculated using either the NASA Debris Assessment Software or a higher fidelity model,[147] the applicant must provide a statement indicating the actual calculated human casualty risk, as well as the input assumptions used in modelling re-entry. We tentatively conclude that these additional specifications will enable the Commission to better evaluate whether the post-mission disposal plan is in the public interest and seek comment on this approach. We further invite comment on whether, when assessing human casualty risk, we should do so on an aggregate, system-wide basis as well as on a per-satellite basis, and, if so, what metric should be used to evaluate aggregate risk.

4. Part 25 GSO Satellite License Term Extensions

63. Operators of GSO satellites routinely request that the Commission grant license modifications to extend their authorized satellite operations beyond the initial license terms.[148] When requesting such modifications, licensees typically provide information to the Commission that includes the requested duration of license extension, an estimate of the total remaining satellite lifetime, a statement that the satellite has no single point of failure that would affect its ability to complete end-of-life procedures as planned, a statement concerning the adequacy of remaining fuel reserves to complete deorbit as planned, and a statement on the status of tracking, telemetry, and command links.[149] The Commission reviews these statements and requests additional details when warranted, such as when a satellite has a record of malfunctions, known defects, or experienced other anomalies in its operational history. If satisfied with an applicant's showing, the Commission will grant a modification extending the license term, with the duration of the extension established through a case-by-case analysis.[150]

64. Although there is some evidence that GSO satellites can operate beyond their initial license terms without any significant decrease in their operational capabilities or increase in their risk of on-orbit failure,[151] we are aware of instances in which GSO satellites have experienced sudden failures.[152]

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sheltering, as it is estimated that as much as 80% of the world's population is either unprotected or in lightly-sheltered structures for purposes of protection from a falling object with a kilojoule-level kinetic energy. *NASA Standard*, at 45, Requirement 4.7.3.d.

[147] The Debris Assessment modeling software is available for use without charge from the NASA Orbital Debris Program office at https://www.orbitaldebris.jsc.nasa.gov/mitigation/das.html. The *NASA Standard* notes that the re-entry risk assessment portion of Debris Assessment Software contains a simplified model which does not require expert knowledge in satellite reentry analyses and is designed to be somewhat conservative. *NASA Standard* at 46, Requirement 4.7.4.d. The use of a simplified model may result in a higher calculated casualty risk than models employing higher fidelity calculations and inputs. *See, e.g.*, NASA Orbital Debris Program Office, Orbital Debris Object Reentry Survival Analysis Tool, https://orbitaldebris.jsc.nasa.gov/reentry/orsat.html (last visited Oct. 22, 2018) (explaining that the Object Reentry Survival Analysis Tool (ORSAT) is frequently used for a higher-fidelity survivability analysis after the Debris Assessment Software has determined that a spacecraft is possibly non-compliant with the NASA Safety Standard).

[148] The license terms for grants under Part 25 are specified in Section 25.121 of the Commission's rules. 47 CFR § 25.121. With some exceptions, licenses are typically issued for a period of 15 years. *See id.* We will continue to assess requests for license term extensions for NGSO satellite systems on a case-by-case basis.

[149] *See*, *e.g.*, Intelsat License LLC, Modification Application, IBFS File No. SAT-MOD-20161004-00097 (granted Dec. 8, 2016) (requesting an extension of the license term of the Galaxy 25 satellite).

[150] *See* 47 CFR § 25.121(b).

[151] One study on satellite on-orbit mortality provides evidence that satellites that survive their first years of operation tend to exceed their expected design life. *Cf.* Gregory F. Dubos et al., *A Satellite Mortality Study to Support Space Systems Lifetime Prediction*, IEEE Aerospace Conference Proceedings (Mar. 2013).

[152] *See* EchoStar Satellite Operating Corporation, IBFS File No. SAT-STA-20170728-00112 (granted July 27, 2017) (grant of special temporary authority associated with an anomaly that caused EchoStar to temporarily lose control of the EchoStar III satellite); *see also* SES Americom, Inc., IBFS File No. SAT-STA-20170619-00091 (granted June

Although these cases are exceptional (operators have been able to satisfy their obligation to perform end-of-life procedures in almost all cases), the potential consequences of introducing additional debris to the geostationary arc are significant—debris from a collision in geostationary Earth orbit (GEO) will remain on orbit virtually forever and "[t]he wide-spread distribution of debris across GEO could result in the degradation of the reliability of GEO satellite communications for the foreseeable future."[153]

65. We propose to codify our current practice of requesting certain types of information from GSO licensees requesting license term extensions. The rule would specify that applicants should state the duration of the requested license extension and the estimated total remaining satellite lifetime, certify that the satellite has no single point of failure or other malfunctions, defects, or anomalies during its operations that could affect its ability to conduct end-of life procedures as planned, that remaining fuel reserves are adequate to complete deorbit as planned, and that telemetry, tracking, and command links are fully functional.[154] In the event that the applicant is unable to make any of the certifications, we propose that the applicant provide a narrative description justifying the extension. We seek comment on this approach.

66. We propose to continue to assess the duration of the license term extension on a case-by-case basis, but propose to limit extensions to no more than five years in a single modification application for any satellite originally issued a 15-year license term.[155] We tentatively conclude that five years may be an appropriate upper limit for a single modification to help ensure reasonable predictions regarding satellite health while affording operators some flexibility. Additionally, if subsequent extensions are sought, we would have the opportunity to review those extension requests in intervals of five years or less. We seek comment on this tentative conclusion. We also seek comment on what approach we should take with respect to satellites with initial license terms of less than 15 years.[156]

67. We further seek comment on whether there are certain types of satellite buses[157] that may warrant heightened scrutiny for purposes of license extensions. In addition, we seek comment on whether, apart from the review undertaken when a license is extended, there are types or categories of anomalies that should trigger immediate reporting, in order to assess whether reliability of post-mission disposal has been compromised to the point that immediate actions may be required.

E. Proximity Operations

68. With increasing interest in satellite servicing and other non-traditional missions, there have been an increasing number of commercial missions proposed that involve proximity operations and rendezvous of spacecraft.[158] We propose that applicants be required to disclose whether the spacecraft is

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19, 2017) (grant of special temporary authority associated with an anomaly that caused SES to temporarily lose control of the AMC-9 satellite). We note that in both instances the operators were ultimately able to regain control of the satellites and deorbit them as planned.

[153] *See, e.g.*, *Orbital Debris Order*, 19 FCC Rcd at 11595, para. 66.

[154] Appendix A, Proposed Rules, Section 25.121.

[155] *See* 47 CFR § 25.121(a)(1).

[156] *See* 47 CFR § 25.121(a)(2), (b). This request for comment is to address a concern raised in an *ex parte* letter, filed by Sirius XM Radio Inc. (Sirius XM) that limiting license extensions to five years is not appropriate for the types of GSO space stations that are issued initial licenses for shorter terms, such as the eight-year term for satellite digital radio audio service (SDARS) licensees. Letter from Karis A. Hastings, Counsel for Sirius XM to Marlene H. Dortch, Secretary, FCC, IB Docket No. 18-313 at 1 (filed Nov. 7, 2018).

[157] A satellite "bus" is the colloquial term sometimes used to describe a satellite design (structure, power and propulsion systems, etc.) developed by a manufacturer and adapted for specific missions in response to individual customer requirements.

[158] *See, e.g.,* Space Logistics, LLC, Application for Launch and Operating Authority, IBFS File No. SAT-LOA-20170224-00021, Narrative at 1, 6-7 (filed Feb. 24, 2017, granted December 5, 2017).

capable of, or will be, performing any space rendezvous or proximity operations. The statement would indicate whether the satellite will be intentionally located or maneuvering near another spacecraft or other large object in space. We also seek comment on whether the proposed notification requirement regarding maneuvers, described above,[159] is sufficient in the context of proximity operations, or whether the rules should include anything more specific regarding information sharing about proximity operations with the Air Force's 18th Space Control Squadron or any successor civilian entity. Such operations present a potential collision risk, and operators will need to address that risk, as well as any risk of explosions or generation of operational debris that might occur through contact between spacecraft, as part of debris mitigation plans. Accordingly, we propose a disclosure requirement regarding these types of operations.

F. Operational Rules

69. We also propose several updates to satellite operational rules relevant to physical operations.

1. Orbit Raising

70. The Commission's rules provide that, for satellites authorized for normal operations in the geostationary orbit, the Commission authorization also includes authority for telemetry, tracking, and command functions to raise the satellite to its normal orbit following launch.[160] This rule was adopted to make it clear that orbit-raising types of maneuvers in the pre-operational phrase are authorized operations, even though they may vary from the orbital parameters specified in the license.[161] Such authority is currently limited to operations on a non-harmful-interference, unprotected basis.[162] Because orbit-raising maneuvers are performed by satellites intended for non-geostationary orbits as well as for the geostationary orbit, and the number of satellites engaging in orbit-raising maneuvers may increase if other proposals in this Notice are adopted,[163] we take this opportunity to propose and seek comment on expanding the provision to include NGSO system operations.

71. In addition, similar to the provisions for maneuvering at the end-of-life for a GSO satellite,[164] we propose to require such telemetry, tracking, and command operations to be coordinated between satellite operators as necessary to avoid interference events, rather than require the operations to be performed on a non-interference basis. We tentatively conclude that it is in the public interest that these types of telemetry, tracking and command communications, critical to effective spacecraft maneuvering, be coordinated as necessary to avoid interference, rather than being authorized only on an a non-harmful-interference, unprotected basis. We seek comment on revising our existing rule regarding

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The Defense Advanced Research Projects Agency (DARPA) has initiated a Consortium for Execution of Rendezvous and Servicing Operations to help develop technical and safety standards for performance of on-orbit activities involving commercial satellites. "CONFERS to establish 'Rules of the Road' for On-Orbit Servicing of Satellites," DARPA, News and Events (Oct. 4, 2017), https://www.darpa.mil/news-events/2017-10-04.

[159] *See supra* paragraph 37.

[160] 47 CFR § 25.282; *see also Orbital Debris Order*, 19 FCC Rcd at 11585, para. 40.

[161] *Orbital Debris Order*, 19 FCC Rcd at 11585, para. 40.

[162] *See* 47 CFR § 25.282(b) and (c).

[163] *See supra* Part III.D.1 (proposing that NGSO space stations planned for operation at certain altitudes be initially deployed in a lower orbit, then subsequently moved to the planned operational altitude).

[164] 47 CFR § 25.283(b) (providing for a space station to operate using its authorized tracking, telemetry, and control frequencies for the purpose of removing the satellite from the geostationary orbit at the end of its useful life, "on the condition that the space station's tracking, telemetry, and control transmissions are planned so as to avoid electrical interference to other space stations, and coordinated with any potentially affected satellite networks.").

orbit raising maneuvers to require coordination of such operations to avoid interference events and to extend the application of the rule to NGSO satellites as well as GSO satellites.[165]

2. Maintaining Ephemeris Data

72. The Commission recently adopted a rule requiring that all NGSO FSS licensees or market access recipients ensure that ephemeris data[166] for their constellations are available to all operators of authorized, in-orbit, co-frequency satellite systems.[167] The purpose of the current rule is to ensure compatible operations of NGSO FSS constellations, because knowledge of the physical locations of NGSO FSS satellites is an essential element of spectrum sharing under the Commission's rules.[168] It also may be in the public interest for the physical locations of NGSO satellites to be known for purposes of collision avoidance, regardless of whether that information is necessary for spectrum sharing among systems.

73. We propose that NGSO operators be required to maintain ephemeris data for each satellite they operate and share that data with operators of other systems operating in the same region of space, as well as with the U.S. governmental entity responsible for the civilian space object database and cataloging.[169] Specifically, we propose to require that operators share ephemeris data with any other operator identified in its disclosure described above of any operational space stations that may pose a collision risk. We believe this requirement will help to facilitate communications between operators, even before a potential conjunction warning is given. We also propose that the information be shared by means mutually acceptable to the parties involved, to allow for flexibility and efficiency in sharing of information.[170] We seek comment on this proposed revision to include these proposed requirements regarding availability of NGSO satellite ephemeris data.[171] We also seek comment on including similar requirements in the rules for experimental and amateur satellites.

3. Telemetry, Tracking, and Command Encryption

74. There is currently no requirement in the Commission's rules that space station licensees encrypt telemetry, tracking, and command communications.[172] As a practical matter, most satellites do operate with secure encrypted communications links, and all operators have an interest in securing against unauthorized actors interfering with their mission. Certain low-cost satellite missions—some CubeSats or other small satellites, particularly those operated for academic purposes—may not use encryption for telemetry, tracking, and command communication links.[173] The developers in these cases may have

[165] *See* Appendix A, Proposed Rule Changes.

[166] Ephemeris data give the orbital positions of satellites at a given time or times.

[167] 47 CFR § 25.146(e); *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters,* Report and Order and Further Notice of Proposed Rulemaking, 32 FCC Rcd 7809, 7827-28, paras. 56-58 (2017) (*NGSO FSS R&O*).

[168] *NGSO FSS R&O*, 32 FCC Rcd at 7827-28, paras. 56-57.

[169] Appendix A, Proposed Rules; *see also supra* paragraph 37.

[170] *See NGSO FSS R&O*, 32 FCC Rcd at 7828, para.58.

[171] *See* Appendix A, Proposed Rules, Section 25.271.

[172] Section 25.271 of the Commission's rules, relating to control of transmitting stations, for example, specifies some measures for security of earth stations authorized under Part 25, but does not include any provisions regarding encryption of communications. *See* 47 CFR § 25.271(c) (securing transmitting stations operating by remote control), 25.271(d) (securing transmitting earth station facilities against unauthorized access or use whenever an operator is not present at the transmitter).

[173] A. Kurzrok, M. Diaz Ramos, and F.S. Mechentel, "Evaluating the Risk Posed by Propulsive Small-satellites with Unencrypted Communications Channels to High-Value Orbital Regimes," 32nd Annual AIAA/USU Conference on Small Satellites, at 1 (2018).

concluded that the costs or time associated with implementing encryption of telemetry, tracking, and command communications outweigh the potential risks.[174] Some have observed that a satellite outfitted with onboard propulsion capabilities could pose some risk to the operations of other spacecraft if a malevolent actor were able to take control of and command the satellite and that encryption should therefore be required.[175]

75. We seek comment on whether to include any provisions in our rules concerning encryption for telemetry, tracking, and command communications for satellites with propulsion capabilities, and propose to add a requirement to our operational rules.[176] Should this rule be applicable only to satellites having propulsion systems with certain capabilities, for example, certain ΔV capability? More generally, should we consider such a requirement, regardless of propulsion capabilities, recognizing that other possible harms, such as radio-frequency interference, could result from such scenarios? We anticipate that this rule will have no practical impact for most satellites and systems, which already encrypt communications, and seek comment on whether any burden that would result from adoption of such a rule is justified by the resulting improvements to the security of satellite control operations. Additionally, we seek comment on whether, if such a rule is adopted, there are any criteria that should be identified with respect to the sufficiency of encryption methods.

G. Liability Issues and Economic Incentives

76. In 2004, the Commission noted that, under international law, the United States government could potentially be presented with a claim for damage resulting from private satellite operations such as disposal or generation of orbital debris.[177] At that time, the Commission considered what role liability and insurance considerations should play in licensing.[178] While the Commission declined to adopt a general insurance requirement, it anticipated that insurance and liability relating to the post-launch period could play a role in determining whether approval of a particular debris mitigation plan serves the public interest.[179]

77. As part of this general update of our rules related to orbital debris mitigation, we now revisit the topic of liability. In so doing, we note that the Commission is a regulatory agency, and unlike agencies with statutory authority to conduct space operations, cannot accept risk on behalf of the United States by virtue of undertaking those operations. Our review of an applicant's debris mitigation plan, or grant of a license, does not alter any liability of the applicant or licensee.[180]

78. We seek comment on whether Commission space station licensees should indemnify the United States against any costs associated with a claim brought against the United States related to the authorized facilities. Given the potential risk of a claim being presented to the United States under international law, we seek comment on whether an indemnification by these U.S.-licensed private operators is appropriate. Such an indemnification could take the form of an indemnity agreement, for example, created in consultation with interagency partners, including the U.S. Department of State, to establish the parameters of such an agreement, including the scope of the indemnification and the means to execute the agreement, including by an appropriate U.S. government agency. In the event that a requirement was established, what would be the appropriate form and content of such an agreement?

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[174] *See id.* at 4.

[175] *See id.* at 8; Eleni M. Sims and Barbara M. Braun, "Navigating the Policy Compliance Roadmap for Small Satellites," The Aerospace Corporation, at 9 (2017).

[176] *See* Appendix A, Proposed Rules. Transmissions by amateur stations can include encrypted telecommand (*See* 47 CFR § 97.211(b)), and space telemetry transmissions (47 CFR § 97.207(f)).

[177] *Orbital Debris Order*, 19 FCC Rcd at 11612-13, paras. 109-10.

[178] *Id.*

[179] *Id.*

[180] *Orbital Debris Order*, 19 FCC Rcd at 11614, para. 113.

79. We further seek comment on whether the indemnification agreement would in most cases be completed following grant of a space station license within thirty days. If no indemnification agreement has been approved within thirty days following grant, the space station license would be terminated. In order to ensure that the agreement is approved well in advance of launch of the space station, we also seek comment on whether the agreement would be required to be completed no fewer than 90 days prior to the planned date of launch. In rare instances, this may require applicants to begin the agreement process prior to grant. We seek comment on these timing matters, including on whether the timeline should be based on the date on which the satellite is integrated into the launch vehicle in preparation for launch, rather than launch date. Finally, we seek comment on whether any such requirement should be limited to U.S.-licensees, as U.S. licensees generally have a manifest connection to the United States, or whether there are any circumstances in which non-U.S. licensees should also provide indemnification.

80. Related to liability, we also seek comment generally on the costs and benefits of insurance as an economic incentive for orbital debris mitigation. Insurance could potentially be obtained to provide for payment for any costs associated with a claim brought against the United States related to the authorized facilities, which can be particularly important in the event the licensee is financially unable to satisfy a claim. A number of other spacefaring nations have some insurance requirements.[181] The Commission noted in the 2004 *Orbital Debris Order* that insurance can, in some instances, provide an economic incentive for operators to undertake debris mitigation measures.[182] We seek comment on how insurance might serve as an economic incentive by incentivizing operators to adopt debris mitigation strategies that reduce risk and lower insurance premiums. How might this impact the amount of insurance that might be required? Could insurance requirements in fact encourage industry to be licensed by or launch from the United States rather than other countries? In the context of insurance, we seek comment on whether there are any distinctions that might be made between different types of operations that are higher or lower risk. We also seek comment on whether any distinctions could be made between on-orbit liability and spacecraft re-entry liability, since on-orbit liability is addressed through a fault regime and re-entry liability is addressed through a strict liability regime under the Convention on International Liability for Damage Caused by Space Objects (Liability Convention).[183] For example, should small satellites applying under the new streamlined process proposed in the *Small Satellite NPRM* be exempt from an insurance requirement, since space stations in that category would be relatively lower risk from an orbital debris perspective? As another example, we ask whether GSO space station licensees should be exempt from an insurance requirement since they may present less risk in the post-mission disposal process since they do not typically re-enter Earth's atmosphere.

81. We further invite comment generally on what economic approaches might be feasible and

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[181] In the United Kingdom, for example, the U.K. Outer Space Act of 1986 requires that a party carrying out certain space activity indemnify the government against claims arising out of that activity. Licensees typically must obtain third-party liability insurance in the amount of 60 million euros. *See* UK Space Agency, Guidance; License to operate a space object: how to apply; Obligations of licensees, https://www.gov.uk/guidance/apply-for-a-license-under-the-outer-space-act-1986; Outer Space Act, 1986, c. 38, § 5(2)(f) (U.K.), http://www.legislation.gov.uk/ukpga/1986/38. Other nations similarly have requirements with respect to indemnification and insurance. *See, e.g.,* United Nations Office for Outer Space Affairs, Selected Examples of National Laws Governing Space Activities: The Netherlands, Rules Concerning Space Activities and the Establishment of a Registry of Space Objects (English translation provided by the Netherlands) at Section 3(4), *available at* http://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/netherlands/space_activities_actE.html (insurance); United Nations Office for Outer Space Affairs, Selected Examples of National Laws Governing Space Activities: Sweden, Act on Space Activities (Unofficial Translation) at Section 4, *available at* *http://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/sweden/act_on_space_activities_1982E.html* (indemnification).

[182] Orbital Debris Order, 19 FCC Rcd at 11614, para. 111.

[183] *See* Convention on International Liability for Damage Caused by Space Objects of 1972, Articles I and II.

effective in creating incentives such that appropriate launch vehicle and satellite design choices are made, and appropriate decisions regarding the number of satellites launched are made as well. That is, recognizing debris creation as a negative externality, what approaches might induce private decisions on these design and launch choices to be consistent with the public interest in limiting the growth of orbital debris? Would, for example, a bond requirement, similar to our performance bond for satellite deployment but applied with respect to successful completion of end of life disposal, provide such an incentive?

H. Scope of Rules

1. Amateur and Experimental Operations

82. We are also proposing to amend our rules governing experimental satellite and amateur satellite authorizations to maintain consistency with the proposed revisions to the orbital debris mitigation plan application requirements in our commercial rules.[184] In 2002, the Commission observed that amateur and experimental spacecraft can present the same public interest concerns regarding orbital debris as operations under other rule parts.[185] In the 2004 *Orbital Debris Order*, the Commission adopted rules requiring that a description of the design and operational strategies used to mitigate orbital debris be provided by an applicant seeking to conduct experimental or amateur satellite operations.[186] These disclosure requirements were consistent with the disclosure requirements adopted for commercial satellite applicants.[187] We continue to believe that it is appropriate for amateur licensees[188] and experimental applicants to provide a similar amount of disclosure regarding debris mitigation plans as will be required of commercial satellites under any of the changes to Part 25 discussed above that are adopted by the Commission.[189] We seek comment on this proposal.[190]

83. Since most satellites authorized as amateur operations or licensed as experimental satellites operate at low altitudes, the new proposed informational requirements related to collision avoidance and post-mission disposal for higher LEO altitudes would not apply as a practical matter to amateur or experimental systems, and therefore the burden on applicants for compliance with these new proposed rules would in most instances be non-existent. We tentatively conclude that the proposed requirements that would typically apply, such as quantification of collision risk, would not be unduly

[184] *See* 47 CFR Part 5, Experimental Radio Service; 47 CFR Part 97, Amateur Radio Service. In this document we use the term "commercial" when referring to operations under Part 25 of the Commission's rules, but we note that there is no requirement in Part 25 that operations authorized under that Part must be for an inherently commercial purpose. 47 CFR Part 25.

[185] *Mitigation of Orbital Debris*, Notice of Proposed Rulemaking, 17 FCC Rcd 5586, 5612, para. 63 (2002).

[186] *Orbital Debris Order*, 19 FCC Rcd at 11607-09, paras. 98-101, Appendix B. Specifically, the Commission adopted revisions to Sections 5.63 and 97.207 of the Commission's rules. *Id.* at Appendix B; 47 CFR § 97.207. The relevant disclosure requirements in Section 5.63 for experimental licensing were subsequently moved to Section 5.64 of the Commission's rules. 47 CFR § 5.64(b); *Promoting Expanded Opportunities for Radio Experimentation and Market Trials Under Part 5 of the Commission's Rules and Streamlining Other Related Rules*, *2006 Biennial Review of Telecommunications Regulations – Part 2 Administered by the Office of Engineering and Technology (OET)*, Report and Order, 28 FCC Rcd 758, 823, Appendix B (2013).

[187] *Compare* 47 CFR §§ 5.63, 97.207 *with* 47 CFR § 25.114(d)(14).

[188] In seeking Commission approval of amateur satellite operations, the license grantee of the amateur satellite must submit a pre-launch notification to the Commission, as specified in Section 97.207(g) of our rules. 47 CFR § 97.207(g)(1). This notification must include, among other things, information regarding design and operational strategies for mitigation of orbital debris. *Id.*

[189] *See Guidance on Obtaining Licenses for Small Satellites,* Public Notice, 28 FCC Rcd 2555, 2558 (IB/OET 2013) ("An orbital debris assessment report prepared consistent with the NASA standards is generally sufficient to meet FCC requirements.").

[190] *See* Appendix A, Proposed Rule Changes, Sections 5.64 and 97.207.

burdensome, since these applicants and licensees are already providing orbital debris mitigation information to the Commission, and depending on the types of operations, may currently be asked to provide additional details in order for the Commission to determine that grant of the application or authorization is in the public interest. Including the proposed additional disclosure requirements in the rules applicable to experimental space station applicants and amateur space station licensees would help provide concrete requirements with respect to operations in space. We recognize that there may be differences in the scale and longevity of experimental and amateur satellites versus commercial satellite deployments. In general, however, amateur and experimental operations present the same public interest concerns as operations by commercial operators. For example, some individual amateur or experimental satellites may present the same risks with respect to creation of orbital debris as some individual commercial satellites licensed under Part 25. Thus, we believe that the benefits of the new requirements, such as the disclosure rule relating to the protection of manned spacecraft, in ensuring the continued safe use of the space environment, may outweigh the potential costs to amateur operators or experimental licensees.

84. The proposed rule revisions related to GSO satellite license term extensions[191] and orbit-raising[192] would not, if adopted, apply to amateur or experimental satellites, since those rules are not currently applicable to amateur or experimental services. We also propose to exempt amateur and experimental satellites from the ephemeris data requirement, since authorizations and licenses in those services do not typically involve many satellites.[193] We seek comment on these proposals. Consistent with the above discussion, and bearing in mind that U.S. treaty obligations do not vary based on the Commission's regulatory classification, we also seek comment on indemnification and insurance issues as they relate to experimental licensees and authorized amateur operators.

2. Non-U.S.-Licensed Satellites

85. We generally propose that the new and amended rules discussed in this *NPRM* should be applicable to non-U.S.-licensed satellites seeking access to the U.S. market. In other words, an entity seeking access to the U.S. market must continue to submit the same technical information concerning the satellite involved as is required to be submitted by U.S. satellite license applicants.[194] We seek comment on this proposal. Relating to the above discussion regarding liability, we seek comment on these issues with respect to non-U.S. licensees, for example, where the applicant is substantially U.S.-based and the foreign licensing administration has not committed to registering the satellite with the United Nations as that administration's space object.

86. In the *Orbital Debris Order*, the Commission observed that a categorical exemption for any class of satellites serving the United States would undermine the legitimate public policy objective of mitigating orbital debris.[195] The Commission explained that by requiring technical information concerning orbital debris mitigation from these non-U.S.-licensed space stations, the Commission is ensuring that foreign operators that "seek access to the U.S. market for commercial reasons meet the same public interest requirements as U.S.-licensed operators."[196] In some instances, we note that applicants have sought approval to engage in very limited transmission and reception activities between non-U.S.-licensed space stations and earth stations in the United States, such as communications exclusively for

[191] *See supra* Part III.D.4; Appendix A, Proposed Rule Changes, Section 25.121.

[192] *See supra* Part III.F.1; Appendix A, Proposed Rule Changes, Section 25.282.

[193] Therefore, no rule related to ephemeris data is proposed for either part 5 or part 97 of the Commission's rules. *See* Appendix A, Proposed Rule Changes.

[194] *Orbital Debris Order*, 19 FCC Rcd at 11605, para. 92; *see* 47 CFR § 25.137(b) (requiring legal and technical information for the non-U.S.-licensed space station of the kind that § 25.114 would require in a license application for a space station).

[195] *Orbital Debris Order*, 19 FCC Rcd at 11606, para. 93.

[196] *Id.*

telemetry, tracking, and command. Although applicants seeking approval for communications such as telemetry, tracking, and command only may have a limited commercial connection to the United States, there is nonetheless a commercial reason those applicants are seeking to transmit and/or receive from a U.S. earth station. Therefore, we seek comment on whether these applicants should be subject to the same public interest requirements as a U.S.-licensed satellite operating with a U.S. earth station.

87. We further propose that non-U.S.-licensed satellites may continue to satisfy the disclosure requirement by showing that the satellite system's debris mitigation plans are subject to direct and effective regulatory oversight by the satellite system's national licensing authority.[197] Recognizing that in other countries authority over radiofrequency communications and authority over space operations are often addressed by different entities, in order to satisfy our orbital debris mitigation disclosure requirements, we would expect information showing that the operator has received a license from the entity overseeing space operations, or has initiated that process. This would include information about whether or not that administration is expected to register the space object with the United Nations Register of Objects Launched into Outer Space.[198] We seek comment on whether it is appropriate to continue assessing the direct and effective oversight of a foreign licensing authority on a case-by-case basis. Under this approach, approval of foreign oversight for a system design in one case will not necessarily imply similar approval for a different system design.

I. Regulatory Impact Analysis

88. In this section, we seek comment on whether regulation of U.S. Commission-licensed space stations will help to limit such debris and result in a net benefit, even if it may give rise to some regulatory costs. From an economic perspective, the earth orbital region of space can be viewed as essentially a "commons"— that is, a resource that is "non-excludable" in consumption (use of space is available to all countries), but "rivalrous" (each country's use of space reduces the amount available to others). A significant and fundamental problem with economic commons is the tendency of individuals to exploit the commons in a manner that is unsustainable long term and diminishing the usefulness for others. In the context of the earth orbital environment, operators have an incentive to maximize the use of orbital resources for their own gain, which may result in an unsustainable level of activity for long term use of the same orbits. Space is vast and the distances between objects are generally quite large, and it is generally the case that a large number of operational satellites can share the same or similar orbits with relatively low risk of collision, particularly when they have the ability to maneuver to avoid collisions. However, once a satellite reaches its end-of-life or otherwise ceases to operate, for example, it will become a piece of debris, posing a risk to the safe operations of other existing and future satellites.

89. Debris generation by on-orbit activities is a negative externality, and is one which could lead to the degradation of the commons of the Earth orbital environment. Some unique, relevant aspects of debris include the fact that, particularly at higher orbits, the debris population will not naturally decrease with time even if no additional objects are launched into orbit, and that over time existing pieces of debris will tend to collide with other existing pieces of debris producing a "cloud" of debris which increases the likelihood of future collisions. While the debris problem is a significant consideration for the long-term use of orbital resources, such considerations may not play a significant role in economic decision making in the short-term. Individual satellite operators may have an interest in preserving the earth orbital environment for their continued operations, but a desire to avoid the short-term costs associated with deorbiting satellites to mitigate debris risk could override those long-term interests. Given these incentives, in the long term, the debris population is likely to continue to grow and could result in an exponential increase in the debris population such that use of certain valuable orbital

[197] 47 CFR § 25.114(d)(14)(v); *Orbital Debris Order*, 19 FCC Rcd at 11606, para. 95.

[198] The United Nations Register of Objects Launched into Outer Space is maintained by the United Nations Office for Outer Space Affairs. The United Nations Office for Outer Space Affairs reports that 92% of all satellites and other spacecraft launched into Earth's orbit and beyond have been registered. United Nations Office for Outer Space Affairs, Space Object Register, http://www.unoosa.org/oosa/en/spaceobjectregister/index.html.

configurations may no longer be economically feasible. This tendency of debris to generate yet more debris has come to be known as the "Kessler syndrome," a cascade in which so much debris is created that certain orbits can become unusable for decades or centuries, if ever.

90. Private sector revenues from space-based businesses are in the hundreds of billions of dollars per year, and there are hugely important scientific and national defense uses of certain orbits as well. A Kessler syndrome type of scenario could render the use of certain orbits economically infeasible and could have significant and far reaching impacts on the global economy for years to come.[199] Although orbital debris is a global problem, our focus in this proceeding is limited to reassessing the Commission's rules concerning orbital debris that are in place today, which we propose to strengthen in certain respects. The Commission's efforts in this area are only one component in addressing an issue of global concern, but as noted, such efforts are undertaken alongside other domestic and international efforts related to mitigation of orbital debris.[200] We further reiterate the Commission's statement from the 2004 *Orbital Debris Order* that, "we do not believe that the theoretical possibility that other countries could take ill-considered actions, at variance with international norms, in any way should prevent the Commission from adopting objective and transparent measures concerning orbital debris mitigation that serve the public interest."[201] Moreover, while reduced production of debris by operators with U.S. licenses or market access grants will necessarily benefit the space activities of all nations, we focus here only on benefits to citizens and residents of the U.S.[202]

91. We seek comment on six approaches to reducing debris in orbit, which include the proposals discussed in the individual rule sections above:

92. *Fewer Launches.* One method of reducing orbital debris would be for the Commission to adopt rules that would have the effect of reducing the overall number of satellites launched. This approach is not proposed above, but would involve, as an example, a limit on the number of individual NGSO satellites that could be authorized in a particular time period, which could have the overall effect of limiting the number of satellites launched. It is not clear, however, that such an action by the Commission would in fact reduce the number of satellites launched, since applicants that would normally be licensed by the Commission could potentially seek authorization from a non-U.S. administration. Moreover, the approach could also limit system capabilities and burden new entrants to the satellite industry, even though prior entrants were not subject to a limit. This approach could also prevent the improvement of services and the introduction of new services, and could, perversely, slow technology development that enables improved debris mitigation. Regulations targeted to address particular activities that create risk from an orbital debris perspective may be more effective than a blanket limitation on U.S. commercial activities in space.

93. *Changes in Satellite Design.* Another method of reducing orbital debris would be for the Commission to regulate how satellites or satellite system are designed. These regulations would limit the types of design features that increase the orbital debris population or increase the risk that such debris will be created. Some of the proposals above would potentially have the effect of changes in satellite design, for example, if more fuel was necessary onboard to perform orbit raising for satellites being deployed in an NGSO constellation.[203] We recognize that there may be some costs associated with these types of proposals and seek comment on those potential cost in the discussion above. We do not propose to mandate particular designs for satellites and systems, however, such as use of a particular satellite bus design. While costs related to satellite design may be necessary to help achieve the goal of limiting

[199] *See, e.g.*, Adilov, N., Alexander, P.J., Cunningham, B.M, "An economic analysis of earth orbit pollution," Envr. Resour. Econ. 60, 81-98 (2014).

[200] *See supra* Part II.

[201] 19 FCC Rcd at 11607, para. 97.

[202] This is in accord with established guidance regarding RIAs. *See* Circular A-4 (2003), page 15.

[203] *See supra* Part III.D.1.

creation of orbital debris, we believe such detailed mandates as specific satellite bus design would be too restrictive to cover the wide range of satellite systems and operations, would be difficult to develop and maintain, and could impose hardware and design costs on Commission-authorized satellites as well as costs related to limitations on innovation, that may be beyond what is necessary to achieve the desired ends.

94. *Changes in operations and disposal procedures.* This is the approach we propose in the individual rule sections above. We believe this approach gives operators sufficient flexibility in implementing their systems, while achieving results consistent with the public interest in preserving access to space for the long term, as well as the safety of persons and property in space and on the surface of the Earth. There are some costs associated with this approach in preparation of information for Commission review, and in potential modifications related to satellite design, operations, or choice of launch opportunities, in order to comply with the Commission's proposed rules. For example, there may be satellites which, because of planned design, may have structures which survive atmospheric re-entry resulting in certain risks to persons on Earth.[204] An applicant under the Commission's rules, as proposed, would need to assess its satellite plans and make changes as necessary to comply with the rule. As another example, an operator may need to deploy its satellites to a different orbit than originally planned in order to comply with the Commission's rules, as proposed, which could impact its system operations or require choosing a different launch opportunity. In some instances, additional fuel may be necessary to perform maneuvers in order to achieve compliance with the Commission's proposed rules. We consider these costs, of course, in view of the benefits from mitigation of the orbital debris population, as discussed, including the safety and reliability of long-term operations in space, as well as the benefits of safety of manned spaceflight as well as safety of persons and property on the surface of the Earth. We believe that regulation of the operational and disposal procedures, as discussed in this *NPRM*, will allow satellite operators flexibility in achieving business goals as compared to the other discussed alternatives such as limiting numbers of satellites launched, while helping to limit the creation of orbital debris in ways that are more effective than use of economic incentives alone, or active debris cleanup, for example.

95. *Use of Economic Incentives*. In this NRPM, we ask whether there are other economic incentives available that the Commission could offer that would help achieve the public interest in this area.[205] We seek comment on, for example, the possibility of requiring insurance for on-orbit and re-entry liability.[206] This could encourage satellite applicants to design system operations in ways that would enable them to obtain lower cost insurance products. Economic incentives could serve as a supplement—or an alternative—to adopting the changes in operations and disposal procedures contemplated in this *NPRM*. Given that debris creation is a negative externality, however, we believe that economic incentives alone may not be sufficient.

96. *Active Collision Avoidance*. The Commission could also potentially reduce orbital debris by requiring all operators to engage in active collision avoidance, which would involve coordination and maneuvering of spacecraft by operators to limit collisions with other objects in space. The proposals set forth in this *NPRM* include a certification that the space station operator will take appropriate action(s) following receipt of a space situational awareness conjunction warnings in order to help mitigate risk of collision.[207] We observe that in some instances this may include modifying the spacecraft attitude and/or operations, where possible.[208] Thus, we have proposed a rule that would require an operator to review a conjunction warning and take steps to mitigate collision risk if necessary. This proposed rule would not, however, require execution of collision avoidance maneuvers in response to each and every conjunction

[204] *See supra* Part III.D.3.

[205] *See supra* Part III.G.

[206] *Id.*

[207] *See supra* Part III.C.3.

[208] *Id.*

warning, since many warnings, upon further review by the operator, are found to not require action. In general, we note that operators with maneuvering capabilities already have an economic incentive to determine whether collision avoidance maneuvers are necessary in response to warnings of potential "conjunctions" from organizations that collect and disseminate such data, and to execute any necessary maneuvers.[209] The Commission's proposal does not require all operators to take actions to avoid collisions, and some satellites may not be equipped to make maneuvers. Moreover, if the Commission were to require an operator to take avoidance action based on each conjunction warning it receives, such action would typically require an expenditure of fuel or other changes to the satellite's operational configuration, which can reduce the expected life of the spacecraft or interrupt the satellite's primary mission. Other satellites would have to add maneuvering capabilities to their designs, even where the risk of the satellite being involved in a collision was relatively low, for example because of deployment to a very low altitude and a resulting short orbital lifetime. As such, there would be an economic burden imposed by a requirement that satellites take active collision avoidance maneuvers in all instances. Spacecraft location data is not so precise that it is easy to make decisions about avoiding collisions, and a collision avoidance maneuver could result in a collision with different objects. Thus, there are costs associated with the planning and execution of maneuvers.

97. *Active Debris Cleanup*. Another alternative to the rules proposed in this *NPRM* is for the Commission to consider requiring operators to engage in active debris removal. We ask questions about this disposal method in this *NPRM*.[210] While the technologies needed to conduct these retrieval operations are continuing to be developed and the cost of launching satellites has fallen significantly, these sorts of operations remain at the more experimental side of satellite operations and still have significant costs. Furthermore, direct retrieval is not without its own risks, and attempts to recover satellites directly may result in the production of more debris than the satellite that was to be retrieved. Even when effective, direct retrieval may make sense only for the largest pieces of debris.

98. More broadly, we seek comment on the appropriate role of the Commission given the various stakeholder agencies and other entities. As discussed above, there are a number of agencies and entities with expertise and interest in mitigating the growth of orbital debris. With various entities playing a role, how do we ensure an appropriate, coordinated approach that avoids duplication of efforts? How can we ensure clarity regarding the roles that various entities can or should play? What agency or entity has the greatest expertise when it comes to the technical, engineering, mathematic, and scientific expertise needed to address orbital debris? Additionally, we provide opportunity for comment on the impact of any potential legislation or other developments related to the Commission's role, that may arise during the pendency of this proceeding.

99. We seek comment on this proposed regulatory impact analysis. In connection with this analysis, we also seek comment on the relative costs and benefits of performance-based regulation versus prescriptive regulation in the context of orbital debris mitigation. Although the costs of our proposed approach may in some instances be borne by proponents of amateur satellites as well as experimental licensees, who in some instances may be small businesses, amateur and experimental satellite operations present the same public interest concerns as commercial satellite systems, as discussed above. A Kessler syndrome scenario rendering certain orbits or areas effectively unusable would also impact these types of operations. We believe that from a practical perspective, the additional costs of compliance for amateur and experimental satellites will be limited, and to the extent that there are additional costs, such costs may be reasonable given the potentially significant benefits.

100. In connection with this *Notice*, we seek comment on the benefits and costs of various combinations of these approaches. In addition, to the extent feasible, we identify alternative options, as described in this *Notice*.

[209] *See id.*

[210] *See supra* Part III.D.1.

IV. ORDER ON RECONSIDERATION

101. In this *Order on Reconsideration*, we reject AMSAT's petition for reconsideration of the Commission's decision to apply orbital debris mitigation requirements to amateur service satellites.[211] AMSAT's Petition relies primarily on arguments that were fully considered in adopting those rules. In addition, to the extent that the Petition advances new arguments that could have been raised earlier in the proceeding, there is no basis to consider such arguments favorably.[212] The reconsideration process is not intended to allow petitioners to alter their position or advance new arguments after the rules are adopted, absent new factual developments.[213] In any event, for the reasons stated below, these arguments lack merit. Accordingly, we dismiss or alternatively deny the Petition pursuant to Section 1.429 of the Commission's rules.[214]

102. *Background*.—On July 17, 2002, AMSAT filed comments in IB Docket No. 02-54, supporting the Commission's establishment of policies to regulate orbital debris and commenting on the ability of amateur satellites to comply with the proposed orbital debris mitigation requirements.[215] AMSAT also filed a comment regarding the Initial Regulatory Flexibility Analysis in the *NPRM*.[216] On August 15, 2002, AMSAT filed Reply Comments in that proceeding.[217]

103. In the *Orbital Debris Order*, the Commission applied debris mitigation rules to amateur satellite licensees, noting that no comments had opposed requiring amateur service and experimental radio service licensees to disclose their orbital debris mitigation plans.[218] It concluded that the costs involved with modifying amateur service spacecraft to satisfy the orbital debris mitigation requirements were "justified when balanced against the public interest in mitigating orbital debris."[219]

104. In its Petition, filed on October 12, 2004, AMSAT argued that the requirement to provide an orbital debris mitigation plan should not apply to individual amateur satellite operators because that

[211] AMSAT Petition at 1. In the *Orbital Debris Order*, the Commission amended Section 97.207 of the rules to include debris mitigation requirements for amateur satellite operations. *Orbital Debris Order*, Appendix B – Rule Revisions, § 97.207.

[212] *See* 47 CFR § 1.429(b).

[213] *See id.* Because we are simultaneously initiating a new proceeding concerning these rules, AMSAT may address in that context any factual developments it considers relevant that have occurred since the *Orbital Debris Order*.

[214] *Id*.

[215] *See* Comments of the Radio Amateur Satellite Corporation, IB Docket No. 02-54 (filed July 17, 2002) (AMSAT Comments). In addition, AMSAT filed comments addressing orbital debris mitigation plans in *Amendment of Part 97 of the Commission's Rules Governing the Amateur Radio Services et al.*, Notice of Proposed Rulemaking and Order, 19 FCC Rcd 7293 (2004). *See* Comments of Radio Amateur Satellite Corporation, WT Docket No. 04-140 (filed June 15, 2004). It also made a further filing in that proceeding, citing to the *Orbital Debris Order* and noting its intent to file a petition for reconsideration of the *Orbital Debris Order*. Letter from Perry I. Klein, Vice President, Government Liaison, Radio Amateur Satellite Corporation, to the Commission, WT Docket No. 04-140, at 2 (filed Sept. 16, 2004). In the Commission's Report and Order in the *Amendment of Part 97 of the Commission's Rules Governing the Amateur Radio Services et al.*, it noted that the issue of orbital debris mitigation as previously raised in that proceeding was moot, having already been addressed in the *Orbital Debris Order*. *Amendment of Part 97 of the Commission's Rules Governing the Amateur Radio Services et al.*, Report and Order, 21 FCC Rcd 11643, 11661, para. 37, n.169 (2006).

[216] Comments of the Radio Amateur Satellite Corporation Regarding Initial Regulatory Flexibility Analysis, IB Docket No. 02-54 (filed July 17, 2002) (AMSAT IRFA Comments). The AMSAT IRFA Comments stated that AMSAT, some universities and colleges building and launching amateur satellites, and individual licensed amateurs should be classified as "small entities" for consideration in the Commission's formulation of new rules. *Id.* at 1.

[217] Reply Comments of the Radio Amateur Satellite Corporation, IB Docket No. 02-54 (filed Aug. 15, 2002).

[218] *Orbital Debris Order*, 19 FCC Rcd at 11608, para. 100.

[219] *Id.*

individual may be different than the satellite owner or builder, and the owner or builder should be responsible for matters pertaining to the space vehicle, such as orbital debris mitigation.[220] AMSAT further argued that, to the extent the Commission declines to submit otherwise required filings to the International Telecommunication Union (ITU) due to concerns with debris mitigation plans, such Commission action would be contrary to U.S. obligations under the ITU Radio Regulations.[221] AMSAT also contended that the Commission did not provide any cost-benefit analysis supporting its decision to extend the requirements to amateur satellites, and that the necessary adjustments for amateur satellites to satisfy the rules are cost prohibitive.[222] Finally, it stated that the Commission has not indicated what constitutes an acceptable orbital debris mitigation plan or what action it will take if it finds that a plan is unacceptable, which has resulted in regulatory uncertainty.[223]

105. On November 19, 2004, the Commission issued a Public Notice announcing the filing of AMSAT's Petition.[224] A number of parties filed comments on AMSAT's Petition.[225] On December 27, 2004, AMSAT filed a Reply to Oppositions.[226]

106. *Discussion*. Pursuant to Section 1.429 of the Commission's rules, parties may petition for reconsideration of final orders in a rulemaking proceeding.[227] Reconsideration is generally appropriate only where the petitioner shows either a material error or omission in the original order or raises additional facts not known or not existing until after the petitioner's last opportunity to respond. Under Section 1.429(b) of the Commission's rules, petitions for reconsideration that rely on facts or arguments that have not been previously presented to the Commission will be considered only under certain limited circumstances. AMSAT's Petition does not meet the requirements of Section 1.429(b). The Petition relies on facts and arguments that either could have been presented earlier in the proceeding, or were fully considered and rejected.[228]

107. In its Comments in IB Docket No. 02-54, AMSAT agreed with the approach the Commission proposed, stating that the "FCC licensed amateur . . . would become responsible for meeting whatever orbital debris requirements the Commission might decide to include in Part 97 of the Rules."[229] In its Petition, AMSAT provided no explanation for its adoption of the directly contrary position, that an

[220] AMSAT Petition at 1-5.

[221] AMSAT Petition at 5.

[222] AMSAT Petition at 4-7. AMSAT stated that it would file comments regarding the Paperwork Reduction Act of 1995. *Id.* at 4-5; *see* 44 U.S.C. § 3501 *et seq*. No such comments were filed. AMSAT later stated that it was unable to file its planned Paperwork Reduction Act comments because not enough data was available. Radio Amateur Satellite Corporation, Reply to Oppositions, IB Docket No. 02-54, at 2 (Dec. 28, 2004) (AMSAT Reply to Oppositions).

[223] AMSAT Petition at 7.

[224] *Petitions for Reconsideration and Clarification of Action in Rulemaking Proceeding*, Public Notice, Report No. 2682 Correction (rel. Nov. 19, 2004).

[225] *See* Comments of Clifford Buttschardt, IB Docket No. 02-54 (filed Dec. 16, 2004); Comments of California Polytechnic State University faculty Jordi Puig-Suari, Clifford Buttschardt, and Edward English, IB Docket No. 02-54 (filed Dec. 20, 2004); Comments of Ed Larsen, IB Docket No. 02-54 (filed Dec. 20, 2004), Comments of Emily E. Clarke, Project OSCAR Board Member and Vice President, IB Docket No. 02-54 (filed Dec. 20, 2004); Comments of Peter W. Lawn, IB Docket No. 02-54 (filed Dec. 20, 2004); Comments of Wallace E. English, IB Docket No. 02-54 (filed Dec. 20, 2004); Comments of Jake Schaffner, IB Docket No. 02-54 (filed Dec. 20, 2004 and Dec. 21, 2004).

[226] AMSAT Reply to Oppositions.

[227] 47 CFR § 1.429.

[228] *See* 47 CFR §§ 1.429(l)(2)-(3).

[229] AMSAT Comments at 4.

amateur station license grantee under Part 97 of the Commission's rules is not the appropriate party to hold responsible for reporting orbital debris mitigation plans.[230] Section 1.429(b) of the Commission's rules provides for three specific circumstances in which the Commission may, in response to a petition for reconsideration, consider arguments not previously presented. A party's unexplained reversal of a prior position is not one of the permitted circumstances.[231] Nor is there any basis here under Section 1.429 for advancing new arguments with respect to the application of the Commission's rules to amateur station facilities. Accordingly, we dismiss AMSAT's petition.

108. As an alternative and independent ground for rejecting AMSAT's petition, we conclude that AMSAT's arguments are also unconvincing on the merits. As discussed in the *Orbital Debris Order,*[232] the Communications Act of 1934, as amended (the Act) provides the Commission with broad authority to license radio communications, and encourages "the larger and more effective use of radio in the public interest."[233] In the *Orbital Debris Order*, the Commission stated that "orbital debris and related mitigation issues are relevant in determining whether the public interest would be served by authorization of any particular satellite system, or by any particular practice or operating procedure of satellite systems."[234] AMSAT argues that the definitions of "amateur station" and "satellite" in Section 97.3(a) of the Commission's rules[235] pertain only to the apparatus necessary for carrying on radiocommunications from space, and not to the vehicle on which the amateur station is carried.[236] However, as established in the *Orbital Debris Order*, the Commission's public interest considerations in licensing radiocommunications in the amateur-satellite service extend to the physical operations of the satellites and satellite hardware.[237] Indeed, the Act defines "radio communication" as "the transmission by radio of writing, signs, signals, pictures, and sounds of all kinds, including all instrumentalities, facilities, apparatus, and services . . . incidental to such transmission."[238] The satellite hardware is an integral part of conducting radiocommunications from space. As the Commission explained in the *Orbital Debris Order*, "[b]ecause robotic spacecraft are typically controlled through radiocommunications links, there is a direct connection between the radiocommunications functions we are charged with licensing under the

[230] AMSAT Petition at 1-5.

[231] *See* 47 CFR § 1.429(b).

[232] *Orbital Debris Order*, 19 FCC Rcd at 11575, para. 14.

[233] 47 U.S.C. §§ 301, 307(a).

[234] *Orbital Debris Order*, 19 FCC Rcd 11575, para. 14.

[235] 47 CFR § 97.3(a)(5), (41); *see also* ITU Radio Regulations No. 1.61 (2012) (defining "station" as "[o]ne or more transmitters or receivers or a combination of transmitters and receivers, including the accessory equipment, necessary at one location for carrying on a *radiocommunication service*[.]" (emphasis in original)).

[236] AMSAT Petition at 1-2.

[237] *Orbital Debris Order*, 19 FCC Rcd at 11575, para. 14.

[238] 47 U.S.C. § 153(33). As a general matter, those "instrumentalities, facilities, apparatus, and services . . . incidental to such transmission" could include the physical facilities of a robotic spacecraft, and thus the Commission would have authority to review those physical facilities in connection with authorization of amateur satellite operations. Specific factual scenarios may need to be analyzed in order to determine what is "incidental" to transmissions. In the most common factual scenario, in which the radio transmitter is installed on a robotic spacecraft, and relies on spacecraft power generation facilities, attitude control, or similar equipment needed for successful transmission, the entirety of a satellite on which the transmitting facilities are located can, as a practical matter, be considered a station. Other cases, such as those involving human spaceflight and cargo delivery spacecraft, present a more complex factual scenario, in that a particular transmitting station may be distinct from, but located at least temporarily on another satellite. For example, in recent years numerous small satellites have been deployed from the International Space Station, and many of these have been FCC-licensed. In such cases, Bureau analysis of debris mitigation plans for the small satellite has been limited to the physical apparatus of the deployed satellite, and its operations.

Communications Act and the physical operations of spacecraft."[239]

109. AMSAT contends that the individual amateur licensee should not be required to submit information pertaining to what it describes as a space vehicle because, in most circumstances, the amateur will not be responsible for the space vehicle construction, design, or ownership. AMSAT, however, does not explain why the licensee could not obtain this information from the builder or owner.[240] AMSAT claims that amateur licensees are inherently different from commercial operators, and yet, we observe that commercial licensees also do not typically build or design satellites.[241] Nevertheless, commercial licensees have obtained orbital debris mitigation information related to their proposed operations and have supplied such information to the Commission.[242] Neither amateur nor commercial licensees are required to have the technical competence to single-handedly design an orbital debris mitigation plan. Instead, they must provide information about the plan to the Commission, so the Commission can evaluate whether the proposed operations are in the public interest.[243]

110. AMSAT's newly raised argument that there is an inherent conflict between debris mitigation regulations and coordination and notification procedures in the ITU Radio Regulations is also without merit.[244] Specifically, AMSAT argues that the ITU Radio Regulations themselves may not permit the Commission to delay submitting a notification to the ITU Radiocommunication Bureau because of concerns about orbital debris.[245] We note, however, that there is no duty imposed by the ITU Radio Regulations on any Administration to submit a filing if that Administration is unwilling to authorize such operations. In fact, the ITU Radio Regulations recognize that operations of stations by private persons, such as amateur station operators, are subject to national regulation.[246] Moreover, the Commission's regulations require that, while Commission-licensed amateur operators may operate satellites, the satellite must be on a craft that is "documented or registered" in the United States.[247] We do not consider a craft to be "documented" in the United States if a satisfactory debris mitigation plan has not been prepared, submitted, and favorably reviewed.[248] Further, because Commission authorization is in many instances the sole mechanism by which U.S. amateur satellite operations are authorized and supervised, a contrary interpretation could raise a significant question as to consistency of such operations with U.S. treaty obligations under the Outer Space Treaty.[249]

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[239] *Orbital Debris Order*, 19 FCC Rcd at 11575, para. 14.

[240] To the extent AMSAT argues that a grantee of an amateur club station license should not be responsible for orbital debris mitigation information, this rationale also applies. *See* AMSAT Petition at 2-3.

[241] *See, e.g.,* the Commission's previous Part 25 milestone requirements, which contemplated that a licensee would contract with another party for construction of a satellite system. 47 CFR § 25.164 (2015).

[242] Licensees have often submitted documentation provided by the satellite manufacturer.

[243] *See* 47 CFR §§ 97.207(g)(1), 25.114(c)(14), 25.283.

[244] AMSAT Petition at 5.

[245] *Id*.

[246] *See* ITU Radio Regulations Article 18.1. ("No transmitting station may be established or operated by a private person or by any enterprise without a license issued in an appropriate form and in conformity with the provisions of these Regulations by or on behalf of the government of the country to which the station in question is subject.").

[247] 47 CFR § 97.5(a)(3).

[248] In an effort to improve the transparency of FCC records in this regard, the Wireless Telecommunication Bureau has begun including approved debris mitigation plans in the ULS file associated with the satellite. In the amateur service, this is the file for the satellite amateur station licensee grantee.

[249] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Art. 6 ("States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer

111. AMSAT's remaining arguments are also without merit. AMSAT argues that the Commission failed to consider the costs of modifying spacecraft to meet the orbital debris mitigation requirements, and therefore has not presented a cost-benefit analysis to support applying those requirements to amateur radio operators.[250] Specifically, AMSAT argues that it is impracticable to add a propulsion system for small LEO spacecraft and that the atmospheric re-entry of these spacecraft within 25 years is not feasible.[251] AMSAT also notes that amateur satellites are typically a secondary payload, and as a result, cannot certify delivery to a particular orbit to ensure proper end-of-life disposal.[252] The Commission has previously addressed the concerns from amateur operators that AMSAT now raises.[253] In response to comments from AMSAT and others to the *NPRM*, the Commission declined to exempt amateur service satellites from the rules, on the basis that "amateur satellites pose the same public interest concerns with regard to orbital debris."[254] While recognizing that "post-mission disposal requirements may necessitate modifications in the current design and operation," including the addition of propulsion and or other strategies to cause atmospheric reentry within 25 years, the Commission concluded that "*the costs involved with these modifications are justified* when balanced against the public interest in mitigating orbital debris."[255] The Commission determined that closer adherence to the disposal methods described in the rules was "warranted in order to limit the growth of orbital debris in LEO[,]"[256] despite the fact that "changes in the design and operation of certain types of LEO spacecraft may be necessary in order to follow these practices and may limit an operator's ability to deploy spacecraft in certain orbital regimes or use certain spacecraft designs."[257] In any event, in the years since the debris mitigation rules were adopted, and notwithstanding any costs imposed by FCC regulations, well over 150 small satellites have been authorized, with at least 20 of those considered amateur satellites. It appears that, to the extent that any costs have been incurred, the main contributor to costs for amateur and similar LEO missions has to do with the availability of launches to appropriate orbits.[258]

112. Finally, we address AMSAT's argument that the *Orbital Debris Order* does not outline what would constitute an acceptable orbital debris mitigation plan, which according to AMSAT, makes it difficult for the satellite owner/builder to estimate, budget for, and fund the cost of compliance.[259] The various components of an acceptable orbital debris mitigation plan, including post-mission disposal, were

(Continued from previous page)
space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty."). The U.S. State Department generally considers FCC authorization prior to launch to provide a basis for registering a spacecraft under the U.N. Convention on Registration of Objects Launched into Outer Space. U.S. practice is to register such objects following launch, typically some months following launch. Thus, a U.S. amateur satellite must typically be considered "documented" in order for transmissions to be considered authorized in the period before registration is completed.

[250] AMSAT Petition at 5-6.

[251] *Id.* at 6.

[252] *Id.* at 7.

[253] *Orbital Debris Order*, 19 FCC Rcd at 11608, para. 100.

[254] *Id.*

[255] *Id.* (emphasis added).

[256] *Id.* at 11602, para. 85.

[257] *Id.*

[258] Since most amateur satellites have not been equipped with propulsion or other means of actively de-orbiting, such amateur satellites would need to be launched into appropriate orbits, i.e. those orbits from which the satellites will naturally deorbit within a reasonable period of time.

[259] AMSAT Petition at 7.

addressed extensively in the *Orbital Debris Order*.[260] We observe that in the years since the Commission issued the *Orbital Debris Order*, numerous licensees, including amateur satellites operating in LEO, have successfully satisfied our orbital debris mitigation requirements.[261] In addition, the Commission has issued a Public Notice titled *Guidance on Obtaining Licenses for Small Satellites*, which includes guidance for amateur radio service satellite operators.[262]

113. In summary, the Commission provided ample opportunity for comment on its proposals and then fully considered the public record developed in response to the proposals. The arguments presented by AMSAT should have been presented in AMSAT's Comments to the *NPRM*, or were already fully considered. In addition, its arguments fail on the merits. Therefore, AMSAT's Petition does not warrant further consideration.

V. PROCEDURAL MATTERS

114. *Ex Parte Presentations.* The proceeding this *NPRM* initiates shall be treated as a "permit-but-disclose" proceeding in accordance with the Commission's *ex parte* rules.[263] Persons making *ex parte* presentations must file a copy of any written presentation or a memorandum summarizing any oral presentation within two business days after the presentation (unless a different deadline applicable to the Sunshine period applies). Persons making oral *ex parte* presentations are reminded that memoranda summarizing the presentation must (1) list all persons attending or otherwise participating in the meeting at which the *ex parte* presentation was made, and (2) summarize all data presented and arguments made during the presentation. If the presentation consisted in whole or in part of the presentation of data or arguments already reflected in the presenter's written comments, memoranda or other filings in the proceeding, the presenter may provide citations to such data or arguments in his or her prior comments, memoranda, or other filings (specifying the relevant page and/or paragraph numbers where such data or arguments can be found) in lieu of summarizing them in the memorandum. Documents shown or given to Commission staff during *ex parte* meetings are deemed to be written *ex parte* presentations and must be filed consistent with rule 1.1206(b). In proceedings governed by rule 1.49(f) or for which the Commission has made available a method of electronic filing, written *ex parte* presentations and memoranda summarizing oral *ex parte* presentations, and all attachments thereto, must be filed through the electronic comment filing system available for that proceeding, and must be filed in their native format (*e.g.*, .doc, .xml, .ppt, searchable .pdf). Participants in this proceeding should familiarize themselves with the Commission's *ex parte* rules.

115. *Comment Filing Requirements.* Pursuant to Sections 1.415 and 1.419 of the Commission's rules, 47 CFR §§ 1.415, 1.419, interested parties may file comments and reply comments on or before the dates indicated on the first page of this document. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS). *See Electronic Filing of Documents* in *Rulemaking Proceedings*, 63 FR 24121 (1998).

- *Electronic Filers*. Comments may be filed electronically using the Internet by accessing the ECFS: http://apps.fcc.gov/ecfs.
- *Paper Filers*. Parties who choose to file by paper must file an original and one copy of each filing. If more than one docket or rulemaking number appears in the caption of this

[260] *Orbital Debris Order*, 19 FCC Rcd at 11591-92, paras. 58-63.

[261] *See, e.g.*, Application of Planet Labs Inc., IBFS File No. SAT-LOA-20130626-00087 (granted Dec. 3, 2013); *Space Imaging, LLC*, Declaratory Order and Order and Authorization, 20 FCC Rcd 11964, 11974-75, para. 32 (IB 2005) (finding that the Commission's orbital debris mitigation requirements were satisfied as part of market access determination involving a foreign remote-sensing satellite).

[262] *Guidance on Obtaining Licenses for Small Satellites*, Public Notice, 28 FCC Rcd 2555 (rel. Mar. 15, 2013).

[263] 47 CFR §§ 1.1200 *et seq.*

proceeding, filers must submit two additional copies for each additional docket or rulemaking number.

Filings can be sent by hand or messenger delivery, by commercial overnight courier, or by first-class or overnight U.S. Postal Service mail. All filings must be addressed to the Commission's Secretary, Office of the Secretary, Federal Communications Commission.

- All hand-delivered or messenger-delivered paper filings for the Commission's Secretary must be delivered to FCC Headquarters at 445 12th Street, SW., Room TW-A325, Washington, DC 20554. The filing hours are 8:00 a.m. to 7:00 p.m. All hand deliveries must be held together with rubber bands or fasteners. Any envelopes and boxes must be disposed of before entering the building.
- Commercial overnight mail (other than U.S. Postal Service Express Mail and Priority Mail) must be sent to 9050 Junction Drive, Annapolis Junction, MD 20701.
- U.S. Postal Service first-class, Express, and Priority mail must be addressed to 445 12th Street, SW, Washington DC 20554.

- *People with Disabilities:* To request materials in accessible formats for people with disabilities (braille, large print, electronic files, audio format), send an email to fcc504@fcc.gov or call the Consumer & Governmental Affairs Bureau at 202-418-0530 (voice) or 202-418-0432 (TTY).

116. *Initial Regulatory Flexibility Analysis.* As required by the Regulatory Flexibility Act of 1980, as amended,[264] the Commission has prepared an Initial Regulatory Flexibility Analysis (IRFA) for this Notice, of the possible significant economic impact on small entities of the policies and rules addressed in this document. The IRFA is set forth as Appendix B. Written public comments are requested on this IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines for comments on the Notice provided on or before the dates indicated on the first page of this Notice. The Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, will send a copy of the NPRM, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration.

117. *Paperwork Reduction Act.* This document contains proposed new and modified information collection requirements. The Commission, as part of its continuing effort to reduce paperwork burdens, invites the general public and the Office of Management and Budget to comment on the information collection requirements contained in this document, as required by the Paperwork Reduction Act of 1995.[265] In addition, pursuant to the Small Business Paperwork Relief Act of 2002,[266] we seek specifically seek comment on how we might further reduce the information collection burden for small business concerns with fewer than 25 employees.[267]

VI. ORDERING CLAUSES

118. Accordingly, IT IS ORDERED, pursuant to Sections 1, 4(i), 301, 303, 307, 308, 309, and 310 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 151, 154(i), 301, 303, 307, 308, 309, 310, that this Notice of Proposed Rulemaking IS ADOPTED.

119. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center SHALL SEND a copy of this Notice of Proposed

[264] 5 U.S.C. § 603.

[265] Pub. L. 104-13.

[266] Pub. L. 107-198.

[267] 44 U.S.C. § 3506(c)(4).

Rulemaking, including the initial regulatory flexibility act analysis, to the Chief Counsel for Advocacy of the Small Business Administration, in accordance with Section 603(a) of the Regulatory Flexibility Act, 5 U.S.C. § 601, *et seq*. (1981).

120. IT IS FURTHER ORDERED that, effective upon release of this Order, the Petition for Reconsideration filed by the Radio Amateur Satellite Corporation on October 12, 2004, IS DISMISSED and, on alternative and independent grounds, DENIED, and IB Docket No. 02-54 IS TERMINATED.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

APPENDIX A

Proposed Rules

The Federal Communications Commission proposes to amend title 47 of the Code of Federal Regulations, parts 5, 25, and 97, as follows:

PART 5 – EXPERIMENTAL RADIO SERVICE

1. The authority citation for Part 5 continues to read as follows:

Authority: Secs. 4, 302, 303, 307, 336 48 Stat. 1066, 1082, as amended; 47 U.S.C. 154, 302, 303, 307, 336. Interpret or apply sec. 301, 48 Stat. 1081, as amended; 47 U.S.C. 301.

2. Amend Section 5.64 by revising paragraph (b)(1), revising and redesignating paragraphs (b)(2), (b)(3) and (b)(4) as (b)(3), (b)(4) and (b)(5), respectively, and adding paragraphs (b)(2), (c), and (d), to read as follows:

<u>§ 5.64 Special provisions for satellite systems.</u>

* * * * *

(b) * * *

(1) A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations. Where applicable, this statement must include an orbital debris mitigation disclosure for any separate deployment devices not part of the space station launch that may become a source of orbital debris;

(2) A statement indicating whether the space station operator has assessed in the aggregate and limited the probability to 0.01 or less that the space station(s) will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent post-mission disposal;

(3) A statement that the space station operator has assessed and limited the probability of accidental explosions or release of liquids that could become debris during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy and debris includes liquids that persist in droplet form. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application;

(4) A statement that the space station operator has assessed in the aggregate and limited the probability of the space station(s) becoming a source of debris by collisions with large debris or other operational space stations, including the following information:

(i) Where the application is for an NGSO space station or constellation:

(A) The statement must indicate whether the probability in the aggregate of a collision between the space stations(s) and another large object during the total orbital lifetime of the constellation, including any de-orbit phase, is less than 0.001.

(B) The statement must identify any planned and/or operational space stations that may raise a collision risk, and indicate what steps, if any, have been taken to

coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision. This includes disclosure of any planned proximity operations. If the planned space station operational orbit is above 650 kilometers, the statement must specify why the planned orbit was chosen, and if the space station will transit through the orbit of the International Space Station (ISS) or orbit of any other manned spacecraft, at any time during the space station's mission or de-orbit phase, and the statement must describe the potential impact to the ISS or other manned spacecraft, if any, including design and operational strategies that will be used to avoid collision with manned spacecraft.

(C) The statement must disclose the accuracy – if any – with which orbital parameters will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances, *i.e.*, it lacks a propulsion system for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. All systems should describe the extent of satellite maneuverability, whether or not the space station(s) design includes a propulsion system; and

(D) In addition, the statement must include a description of the means for tracking the spacecraft, including whether tracking will be active or passive. The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review the warning and take all possible steps to assess and, if necessary, to mitigate collision risk, including, but not limited to: contacting the operator of any active spacecraft involved in such warning; sharing ephemeris data and other appropriate operational information with any such operator; modifying spacecraft attitude and/or operations.

(ii) Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap or touch. If so, the statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions; and

(5) A statement detailing the post-mission disposal plans for the space station at end of life, including the quantity of fuel—if any—that will be reserved for post-mission disposal maneuvers. In addition, the following specific provisions apply:

(i) For geostationary-Earth orbit space stations, the statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude.

(ii) For spacecraft terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must indicate whether the spacecraft will be disposed of either through atmospheric re-entry within 25 years following the completion of the spacecraft's mission, or by direct retrieval of the spacecraft.

(iii) Where planned post-mission disposal involves atmospheric re-entry of the space station(s):

(A) The statement must include a demonstration that the probability of success for the disposal method will be no less than 0.90, calculated on an aggregate basis.

(B) For space stations with a planned operational altitude between 650 km and 2,000 km, the statement should include a certification that the satellites will be deployed at an altitude below 650 km, and describe the means that will be used to ensure reliability of disposal, such as through automatic initiation of disposal in the event of loss of power or contact with the space station.

(C) The statement must also include a casualty risk assessment. In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry, including all objects that would impact the surface of the Earth with a kinetic energy in excess of 15 joules, as well as an estimate of the resulting probability of human casualty. Where the risk of human casualty from surviving debris is greater than zero, as calculated using either the NASA Debris Assessment Software or a higher fidelity model, a statement must be provided indicating the actual calculated human casualty risk as well as the input assumptions used in the model.

(c) As a condition of their licenses for experimental satellite facilities, licensees must submit an executed agreement indemnifying the United States against any costs associated with a claim brought against the United States related to the authorized facilities. The agreement, or an updated version thereof, must be submitted no later than 30 days after the grant of the license, an assignment of the license, or a transfer of control of the licensee, or at least 90 days prior to planned launch of the space station, whichever is sooner.

(d) For space stations that include onboard propulsion systems, operators must encrypt telemetry, tracking, and command communications with the space station.

PART 25 – SATELLITE COMMUNICATIONS

3. The authority citation for part 25 continues to read as follows:

Authority: 47 U.S.C. 154, 301, 302, 303, 307, 309, 310, 319, 332, 605, and 721, unless otherwise noted.

4. Amend Section 25.114(d)(14) by revising paragraph (i), revising and redesignating paragraphs (ii), (iii) and (iv) as (iii), (iv) and (v), respectively, redesignating paragraph (v) as (vi), and adding paragraph (ii), to read as follows:

§ 25.114 Applications for space station authorizations.

* * * * *

(d) * * *

(14) * * *

(i) A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations. Where applicable, this statement must include an orbital debris mitigation disclosure for any separate deployment devices not part of the space station launch that may become a source of orbital debris;

(ii) A statement indicating whether the space station operator has assessed in the aggregate and limited the probability to 0.01 or less that the space station(s) will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent post-mission disposal;

(iii) A statement that the space station operator has assessed and limited the probability of accidental explosions or release of liquids that could become debris during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy and debris includes liquids that persist in droplet form. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application;

(iv) A statement that the space station operator has assessed in the aggregate and limited the probability of the space station(s) becoming a source of debris by collisions with large debris or other operational space stations, including the following information:

(A) Where the application is for an NGSO space station or constellation:

1. The statement must indicate whether the probability in the aggregate of a collision between the space station(s) and another large object during the total orbital lifetime of the constellation, including any de-orbit phases, is less than 0.001;

2. The statement must identify any planned and/or operational space stations that may raise a collision risk, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision. This includes disclosure of any planned proximity operations. If the planned space station operational orbit is above 650 kilometers, the statement must specify why the planned orbit was chosen, and if the space station will transit through the orbit of the International Space Station (ISS) or orbit of any other manned spacecraft, at any time during the space station’s mission or de-orbit phase, and the statement must describe the potential impact to the ISS or other manned spacecraft, if any, including design and operational strategies that will be used to avoid collision with manned spacecraft;

3. The statement must disclose the accuracy – if any – with which orbital parameters will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances, *i.e.*, it lacks a propulsion system for orbital maintenance, that fact must be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. All systems must describe the extent of satellite maneuverability, whether or not the space station(s) design includes a propulsion system; and

4. In addition, the statement must include a description of the means for tracking the spacecraft, including whether tracking will be active or passive. The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review the warning and take all possible steps to assess and, if necessary, to mitigate collision risk, including, but not limited to: contacting the operator of any active spacecraft involved in such warning; sharing ephemeris data and other appropriate operational information with any such operator; modifying space station attitude and/or operations.

(B) Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap or touch. If so, the statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions; and

(v) A statement detailing the post-mission disposal plans for the space station at end of life, including the quantity of fuel—if any—that will be reserved for post-mission disposal maneuvers. In addition, the following specific provisions apply:

(A) For geostationary-Earth orbit space stations, the statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude.

(B) For spacecraft terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must indicate whether the spacecraft will be disposed of either through atmospheric re-entry within 25 years following the completion of the spacecraft's mission, or by direct retrieval of the spacecraft.

(C) Where planned post-mission disposal involves atmospheric re-entry of the space station(s):

1. The statement must include a demonstration that the probability of success for the disposal method will be no less than 0.90, calculated on an aggregate basis.

2. For space stations with a planned operational altitude between 650 km and 2,000 km, the statement should include a certification that the satellites will be deployed at an altitude below 650 km, and describe the means that will be used to ensure reliability of disposal, such as through automatic initiation of disposal in the event of loss of power or contact with the space station.

3. The statement must also include a casualty risk assessment. In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry, including all objects that would impact the surface of the Earth with a kinetic energy in excess of 15 joules, as well as an estimate of the resulting probability of human casualty. Where the risk of human casualty from surviving debris is greater than zero, as calculated using either the NASA

Debris Assessment Software or a higher fidelity model, a statement must be provided indicating the actual calculated human casualty risk as well as the input assumptions used in the model.

(D) Applicants for space stations to be used only for commercial remote sensing may, in lieu of submitting detailed post-mission disposal plans to the Commission, certify that they have submitted such plans to the National Oceanic and Atmospheric Administration for review.

(vi) For non-U.S.-licensed space stations, the requirement to describe the design and operational strategies to minimize orbital debris risk can be satisfied by demonstrating that debris mitigation plans for the space station(s) for which U.S. market access is requested are subject to direct and effective regulatory oversight by the national licensing authority.

* * * * *

4. Amend Section 25.121 to add paragraph (f) as follows:

§25.121 License term and renewals.

(f) *Geostationary Satellite License Term Extensions.* For geostationary space stations issued license term under Section 25.121(a)(1), license term extensions authorized by grant of a modification application are limited to five years or less.

5. Amend Section 25.161 to add paragraph (e) as follows:

§25.161 Automatic termination of station authorization.

(e) The failure to file an executed indemnification agreement in accordance with § 25.166.

6. Add Section 25.166 to read as follows:

§25.166 Indemnification.

As a condition of their licenses, space station licensees must submit an executed agreement indemnifying the United States against any costs associated with a claim brought against the United States related to the authorized facilities. The agreement, or an updated version thereof, must be submitted no later than 30 days after the grant of the license, an assignment of the license, or a transfer of control of the licensee, or at least 90 days prior to planned launch of the space station, whichever is sooner.

7. Revise paragraph (e) to Section 25.271 to read as follows[268]:

§25.271 Control of Transmitting Stations.

* * * * *

(e) An NGSO licensee or market access recipient must ensure that ephemeris data for its space station or constellation is available to all operators of operational satellite systems identified pursuant to § 25.114(d)(14)(iv)(A)(2) that may raise a collision risk and to the U.S. governmental entity responsible for the civilian space object database and cataloging.

8. Revise Section 25.282 to read as follows:

§ 25.282 Orbit raising.

[268] Although not included in this Appendix, we also seek comment on similar proposals for Parts 5 and 97.

A space station may operate in connection with short-term, transitory maneuvers directly related to post-launch, orbit-raising maneuvers, in the telemetry, tracking, and command frequencies authorized for operation at the assigned orbital position. Such orbit-raising operations must be coordinated on an operator-to-operator basis with any potentially affected satellite networks.

9. Add Section 25.290 to read as follows:

§ 25.290 Telemetry, tracking, and command encryption.

For space stations that include onboard propulsion systems, operators must encrypt telemetry, tracking, and command communications with the space station.

PART 97 – AMATEUR RADIO SERVICE

5. The authority citation for part 97 continues to read as follows:

Authority: 48 Stat. 1066, 1082, as amended; 47 U.S.C. 154, 303. Interpret or apply 48 Stat. 1064-1068, 1081-1105, as amended; 47 U.S.C. 151-155, 301-609, unless otherwise noted.

6. Amend Section 97.207 by revising paragraph (g)(1)(i), revising and redesignating paragraphs (g)(1)(ii), (g)(1)(iii), and (g)(1)(iv) as (g)(1)(ii), (g)(1)(iv), and (g)(1)(v), respectively, redesignating paragraph (g)(1)(v) as (g)(1)(vi), adding paragraph (g)(1)(ii), and adding paragraphs (h) and (i), to read as follows:

§ 97.207 Space station.

* * * * *

(g) * * *

(1) * * *

(i) A statement that the space station licensee has assessed and limited the amount of debris released in a planned manner during normal operations. Where applicable, this statement must include an orbital debris mitigation disclosure for any separate deployment devices not part of the space station launch that may become a source of orbital debris;

(ii) A statement indicating whether the space station operator has assessed in the aggregate and limited the probability to 0.01 or less that the space station(s) will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent post-mission disposal;

(iii) A statement that the space station licensee has assessed and limited the probability of accidental explosions or release of liquids that could become debris during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy and debris includes liquids that persist in droplet form. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the notification;

(iv) A statement that the space station licensee has assessed in the aggregate and limited the probability of the space station(s) becoming a source of debris by collisions with large debris or other operational space stations, including the following information:

(A) Where the space station is a NGSO space station or constellation:

(1) The statement must indicate whether the probability in the aggregate of a collision between the space station(s) and another large object during the total orbital lifetime of the constellation, including any de-orbit phases, is less than 0.00;1

(2) The statement must identify any planned and/or operational space stations that may raise a collision risk, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision. This includes disclosure of any planned proximity operations. If the planned space station operational orbit is above 650 kilometers, the statement must specify why the planned orbit was chosen, and if the space station will transit through the orbit of the International Space Station (ISS) or orbit of any other manned spacecraft, at any time during the space station's mission or de-orbit phase, and the statement must describe the potential impact to the ISS or other manned spacecraft, if any, including design and operational strategies that will be used to avoid collision with manned spacecraft;

(3) The statement must disclose the accuracy – if any – with which orbital parameters will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances, *i.e.*, it lacks a propulsion system for orbital maintenance, that fact must be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. All systems must describe the extent of satellite maneuverability, whether or not the space station(s) design includes a propulsion system; and

(4) In addition, the statement must include a description of the means for tracking the spacecraft, including whether tracking will be active or passive. The space station licensee must certify that upon receipt of a space situational awareness conjunction warning, the licensee or operator will review the warning and take all possible steps to assess and, if necessary, to mitigate collision risk, including, but not limited to: contacting the operator of any active spacecraft involved in such warning; sharing ephemeris data and other appropriate operational information with any such operator; modifying space station attitude and/or operations.

(B) Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap or touch. If so, the statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions; and

(v) A statement detailing the post-mission disposal plans for the space station at end of life, including the quantity of fuel—if any—that will be reserved for post-mission disposal maneuvers. In addition, the following specific provisions apply:

(A) For geostationary-Earth orbit space stations, the statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude.

(B) For spacecraft terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must indicate whether the spacecraft will be disposed of either through atmospheric re-entry within 25 years following the completion of the spacecraft's mission, or by direct retrieval of the spacecraft.

(C) Where planned post-mission disposal involves atmospheric re-entry of the space station:

(1) The statement must include a demonstration that the probability of success for the disposal method will be no less than 0.90, calculated on an aggregate basis.

(2) For space stations with a planned operational altitude between 650 km and 2,000 km, the statement should include a certification that the satellites will be deployed at an altitude below 650 km, and describe the means that will be used to ensure reliability of disposal, such as through automatic initiation of disposal in the event of loss of power or contact with the space station.

(3) The statement must also include a casualty risk assessment. In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry, including all objects that would impact the surface of the Earth with a kinetic energy in excess of 15 joules, as well as an estimate of the resulting probability of human casualty. Where the risk of human casualty from surviving debris is greater than zero, as calculated using either the NASA Debris Assessment Software or a higher fidelity model, a statement must be provided indicating the actual calculated human casualty risk as well as the input assumptions used in the model.

(vi) If any material item described in this notification changes before launch, a replacement pre-space notification shall be filed with the International Bureau no later than 90 days before integration of the space station into the launch vehicle.

* * * * *

(h) At least 90 days prior to planned launch of the space station, the license grantee of each space station must submit an executed agreement indemnifying the United States against any costs associated with a claim brought against the United States related to the authorized facilities.

(i) For space stations that include onboard propulsion systems, operators must encrypt telemetry, tracking, and command communications with the space station.

APPENDIX B

Initial Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[269] the Commission has prepared this present Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on a substantial number of small entities by the policies and rules proposed in this *Notice of Proposed Rulemaking (NPRM*). Written public comments are requested on this IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines specified in the *NPRM* for comments. The Commission will send a copy of this *NPRM*, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration (SBA).[270] In addition, the *NPRM* and IRFA (or summaries thereof) will be published in the Federal Register.[271]

A. Need for, and Objectives of, the Proposed Rules

The Commission originally adopted comprehensive rules relating to the mitigation of orbital debris in 2004. Consideration of orbital debris issues remains an important part of preserving access to space for the long term, as well as the safety of persons and property in space on the surface of the Earth. This *NPRM* represents the first comprehensive update to our rules on orbital debris mitigation since their adoption. The basis for these revisions and additions to those rules includes the Commission's experience gained in the licensing process, updates in mitigation guidelines and practices, and market developments. Our objective is to ensure that space stations applying for a license or grant of market access, or otherwise authorized by the Commission, including experimental and amateur satellite systems, provide a statement concerning plans for orbital debris mitigation that enables the Commission to fully evaluate whether the proposed operations are in the public interest.

With this in mind, this *NPRM* seeks comment on a number of proposals revising the Commission's rules and policies for limiting orbital debris. Adoption of the proposed changes would modify 47 CFR parts 5, 25, and 97 to, among other things:

1) Require satellite applicants to demonstrate compliance with certain metrics developed for assessing orbital debris mitigation plans by the National Aeronautics and Space Administration (NASA).

2) Require additional disclosures to the Commission regarding risk of collision, trackability, maneuverability, proximity operations, if any, choice of orbit, and impact on manned spacecraft, if any.

3) Require information regarding the probability of success for the chosen disposal method, where disposal is planned by atmospheric re-entry.

4) Require satellite applicants with planned operations in certain orbits to make certifications related deploying at a lower orbit and then raising the satellite(s) for operations.

B. Legal Basis

The proposed action is authorized under Sections 1, 4(i), 301, 303, 307, 308, 309, and 310 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 151, 154(i), 301, 303, 307, 308, 309, and 310.

C. Description and Estimate of the Number of Small Entities to Which the Proposed Rules May Apply

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[269] *See* 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601 *et seq.*, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996, (SBREFA) Pub. L. No. 104-121, Title II, 110 Stat. 847 (1996).

[270] *See* 5 U.S.C. § 603(a).

[271] *Id.*

The RFA directs agencies to provide a description of, and, where feasible, an estimate of, the number of small entities that may be affected by adoption of proposed rules.[272] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[273] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[274] A small business concern is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the Small Business Administration (SBA).[275] Below, we describe and estimate the number of small entity licensees that may be affected by adoption of the proposed rules.

Satellite Telecommunications and All Other Telecommunications

The rules proposed in this *NPRM* would affect some providers of satellite telecommunications services, if adopted. Satellite telecommunications service providers include satellite and earth station operators. Since 2007, the SBA has recognized two census categories for satellite telecommunications firms: "Satellite Telecommunications" and "Other Telecommunications." Under both categories, a business is considered small if it had $32.5 million or less in annual receipts.[276]

The first category of Satellite Telecommunications "comprises establishments primarily engaged in providing point-to-point telecommunications services to other establishments in the telecommunications and broadcasting industries by forwarding and receiving communications signals via a system of satellites or reselling satellite telecommunications."[277] For this category, Census Bureau data for 2007 show that there were a total of 512 satellite communications firms that operated for the entire year. Of this total, 482 firms had annual receipts of under $25 million.

The second category of Other Telecommunications is comprised of entities "primarily engaged in providing specialized telecommunications services, such as satellite tracking, communications telemetry, and radar station operation. This industry also includes establishments primarily engaged in providing satellite terminal stations and associated facilities connected with one or more terrestrial systems and capable of transmitting telecommunications to, and receiving telecommunications from, satellite systems. Establishments providing Internet services or voice over Internet protocol (VoIP) services via client-supplied telecommunications connections are also included in this industry."[278] For this category, Census Bureau data for 2007 show that there were a total of 2,383 firms that operated for the entire year.[279] Of this total, 2,346 firms had annual receipts of under $25 million.[280]

We anticipate that our proposed rule changes may have an impact on space station applicants and licensees, including in some instances small entities.

[272] 5 U.S.C. § 604(a)(3).

[273] 5 U.S.C. § 601(6).

[274] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small business concern" in 15 U.S.C. § 632). Pursuant to the RFA, the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register." 5 U.S.C. § 601(3).

[275] Small Business Act, 15 U.S.C. § 632 (1996).

[276] *See* 13 CFR § 121.201, NAICS codes 517410, 517919.

[277] U.S. Census Bureau, 2007 NAICS Definitions, "517410 Satellite Telecommunications."

[278] U.S. Census Bureau, 2007 NAICS Definitions, "517919 Other Telecommunications."

[279] *See* 13 CFR § 121.201, NAICS code 517919.

[280] U.S. Census Bureau, 2007 Economic Census, Subject Series: Information, Table 5, "Establishment and Firm Size: Employment Size of Firms for the United States: 2007 NAICS Code 517919" (issued Nov. 2010).

D. Description of Projected Reporting, Recordkeeping, and Other Compliance Requirements for Small Entities

The *NPRM* proposes and seeks comment on a number of rule changes that would affect reporting, recordkeeping, and other compliance requirements for space station operators. Each of these changes is described below.

The *NPRM* proposes to require several disclosures specifying compliance with several metrics established by NASA, such as probability of collision between the spacecraft and large objects. Many of the entities, for example, experimental licensees, that would be affected by these proposed rules already use a format for their orbital debris mitigation plans that is consistent with the NASA Orbital Debris Assessment Report (ODAR). The ODAR format includes several of the proposed NASA metrics that are incorporated into the proposed rules such as calculations related to re-entry casualty risk. Thus, to the extent that these entities already use the ODAR format, there would be no change to their existing recordkeeping and compliance requirements as a result of these proposed changes. For other entities that have not or would not use the ODAR format to report their orbital debris mitigation plans, some of these changes will involve some additional proposed calculations to provide the appropriate certifications, such as certifying that the probability of collision between a space station and another large object is less than 0.001 and that the probability of collision with small debris or meteoroids that would cause loss of control and prevent post-mission disposal is less than 0.01. Given the engineering associated with development of a spacecraft, we expect that these calculations will be a natural outgrowth of work already being performed in designing and planning space station(s) operations. The *NPRM* also proposes to require that collision risk information be provided in the aggregate, that is, for the space station constellation as a whole. Since most small entities do not launch and operate large satellite constellations, we do not anticipate that this requirement to provide a collision risk assessment in the aggregate will be burdensome. In addition, we note the new requirement for demonstration that the probability of reliability for a particular disposal method is no less than 0.90, calculated on an aggregate basis. We anticipate that most small entities will be planning disposal of their spacecraft by atmospheric re-entry. So long as the spacecraft is deployed into a low altitude orbit, which most small entities' spacecraft are, atmospheric re-entry will be virtually guaranteed within a certain amount of time.

The *NPRM* also proposes to require that applicants for a space station license or authorization provide disclosures regarding methodologies used for tracking and certifications related to space situational awareness, as well as disclosures regarding choice of orbit and potential impact to manned spacecraft. Information regarding tracking and sharing of data for purposes of space situational awareness should be readily available to applicants and operators. We anticipate that disclosures relating to choice of orbit and potential impacts to manned spacecraft should be an extension of analysis undertaken by a space station operator as part of selection of a launch vehicle and operational orbit.

In addition, the *NPRM* proposes that operators of spacecraft make ephemeris data available to all operators of operational satellite systems identified as potentially raising a collision risk with its system. We anticipate that small entities will generally be operating only a few spacecraft, and so will only need to address this ephemeris data requirement for a limited number of space stations.

We do not expect that the any of the proposed changes relating to the operation of geostationary-orbit (GSO) space stations would affect small entities, since GSO space stations generally cost hundreds of millions of dollars to construct, launch, and operate. Similarly, we do not expect that the proposed requirements applicable to NGSO space stations operating between 650 km and 2,000 km will apply to small entities, since we expect that most lower-cost space systems are deployed at lower altitudes.

The *NPRM* also proposes that U.S. space station licensees or grantees submit an executed agreement indemnifying the United States against any costs associated with a clam brought against the United States related to the authorized facilities. This proposal would apply to experimental licensees and authorized amateur space station license grantees, and would likely increase the compliance requirements

for some entities. The *NPRM* also seeks comment on possible insurance requirements for space station licensees/grantees.

E. Steps Taken to Minimize Significant Economic Impact on Small Entities, and Significant Alternatives Considered

The RFA requires an agency to describe any significant, specifically small business, alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): "(1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance and reporting requirements under the rules for such small entities; (3) the use of performance rather than design standards; and (4) an exemption from coverage of the rule, or any part thereof, for such small entities."[281]

With respect to the additional orbital debris mitigation plan disclosure requirements described above, we believe that the disclosures will in most instances be consistent with, or a natural outgrowth of, analysis that is already being conducted by space station applicants and/or operators. These additional disclosures should be consistent with the types of operations that are in the space station operator's best interest, such as avoiding collision with other spacecraft. In several instances, certifications are proposed, but in other instances, we believe that a descriptive disclosure is superior to a certification alternative, to provide the applicant with an opportunity to fully explain its plans for Commission evaluation. As an alternative to the disclosures, we could propose not to require any additional information, but as described in the *NPRM*, the public interest in mitigating orbital debris and ensuring the long-term viability of the space environment may weigh in favor of the additional disclosures. Several of the proposals apply only to space stations with planned deployment altitudes between above 650 km. This 650 km altitude is based upon anticipated on-orbit lifetimes, as described in the *NPRM*, and we anticipate will not be applicable to most small entities' space stations. That specific altitude was proposed to address orbits where deployments may be of particular concern, without burdening operators planning to deploy in lower orbits. We seek comment in the *NPRM* on the costs and benefits of the proposed requirements applying to space stations deployed above 650 km.

The Commission seeks comment on liability issues related to space station authorizations. In the discussion regarding insurance, for example, the *NPRM* asks whether distinctions might be made between different types of operations that are higher or lower risk. We note that some small entities may be associated with lower risk systems.

The *NPRM* seeks comment from all interested parties. Small entities are encouraged to bring to the Commission's attention any specific concerns they may have with the proposals outlined in the *NPRM*. The Commission expects to consider any economic impact on small entities, as identified in comments filed in response to the *NPRM*, in reaching its final conclusions and taking action in this proceeding.

F. Federal Rules that May Duplicate, Overlap, or Conflict with the Proposed Rules

None.

[281] 5 U.S.C. § 603(c)(1)-(4).

STATEMENT OF
CHAIRMAN AJIT PAI

Re: *Mitigation of Orbital Debris in the New Space Age,* IB Docket No. 18-313*; Mitigation of Orbital Debris,* IB Docket No. 02-54 (Terminated)

You probably thought that I'd start off this statement by discussing a certain movie set in space starring Sandra Bullock and George Clooney. But instead, I'd like to turn your attention to Return of the Jedi. At the end of the movie, after rogue pilots from the Rebel Alliance blow up the "fully operational" Death Star, Princess Leia, Han Solo, and Luke Skywalker celebrate on Endor with the Ewoks. But in the midst of this party, the film leaves a vital question unanswered. What will be done to address the threat posed by all that space debris? The Alliance apparently had no plan to mitigate it, and whatever rules the Empire may have had evaporated with the Empire itself.

Space debris, after all, can be a very serious problem. In space, a very small piece of orbital debris can cause catastrophic damage. It's been over a decade since we last reviewed our orbital debris rules, and in that time, the number of satellites in use has increased dramatically. That's why last year I asked staff to begin looking at ways for the Commission to take up this important topic once again. And now, we're proposing new rules and disclosures to mitigate the threat posed by orbital debris. Indeed, we're exploring six ways to address this problem, including changes in satellite design, better disposal procedures, and active collision avoidance. I look forward to reviewing the feedback on these proposals and then doing our part to keep the final frontier safe for new and innovative uses.

However, I am disappointed that one of my colleagues has chosen to criticize this item even though we accepted every edit she requested. It is difficult to accommodate concerns if they are not voiced until the time of the vote.

Thank you to staff who worked on this important item: Jose Albuquerque, Christopher Bair, Clay DeCell, Stephen Duall, Jennifer Gilsenan, Karl Kensinger, Julia Malette, Sankar Persaud, Walt Strack, Tom Sullivan, Troy Tanner, and Merissa Velez from the International Bureau; Michael Ha, Nick Oros, Jamison Prime, Ron Repasi, and Walter Johnston from the Office of Engineering and Technology; Scot Stone from the Wireless Telecommunications Bureau; and Deborah Broderson, David Horowitz, and Bill Richardson from the Office of General Counsel.

STATEMENT OF
COMMISSIONER MICHAEL O'RIELLY

Re: *Mitigation of Orbital Debris in the New Space Age,* IB Docket No. 18-313*; Mitigation of Orbital Debris,* IB Docket No. 02-54 (Terminated)

The fun part of talking about space and new satellite technologies is considering the exciting new applications for service offerings, which we once again consider during today's meeting. For those technologies to work, however, there needs to be a limited, but sound, framework to deal with accompanying policy issues. Orbital debris is certainly one of the components of such a framework. Failure to properly address the residual parts of launch vehicles and failed, damaged or outdated satellites can lead to cataclysmic outcomes, making future space use and the possibility of space exploration more difficult, if not impossible. It's why we have conditioned each recent satellite application approval on compliance with further Commission action on orbital debris. Having spent considerable time studying the subject, I'm pleased that the Commission is finally taking the next step to establish firmer expectations regarding orbital debris mitigation – and hopefully elimination – by satellite providers. In essence, this item isn't glitzy or glamorous, but represents the real workhorse for our meeting today.

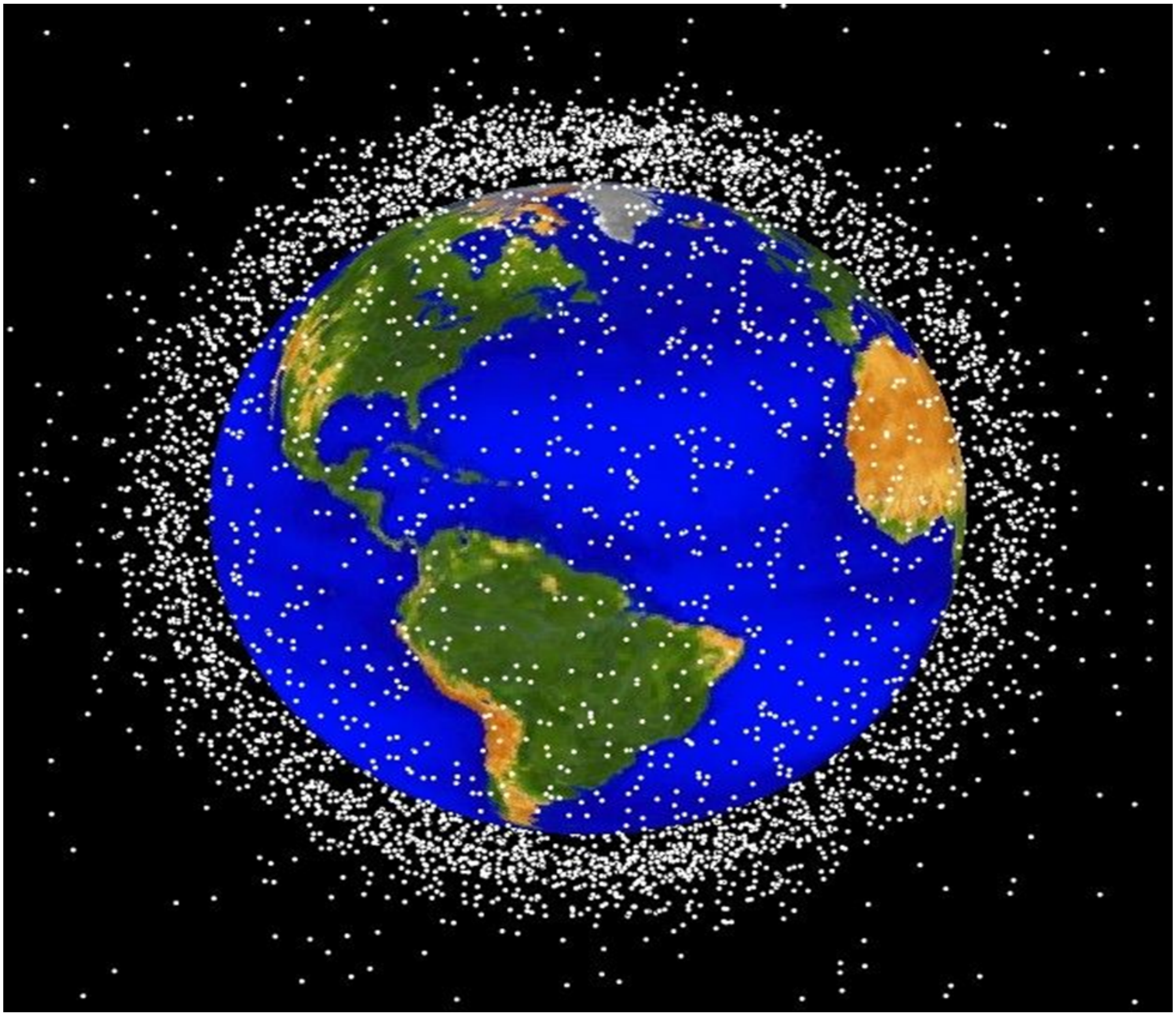
To recognize the importance of addressing orbital debris, we all need to understand the problem at hand. According to estimates from the European Space Agency, there are 29,000 objects larger than 10 centimeters and a whopping 750,000 objects between one centimeter and 10 centimeters in various orbits today. To provide a visual perspective on the scope of existing orbital debris, I've borrowed (legally) a few pictures from NASA's Orbital Debris Program Office, provided below. According to NASA, these are computer-generated images of objects in Earth orbit that are currently being tracked. Each dot represents the current location of each item and is scaled according to the image size of the graphic to optimize visibility.

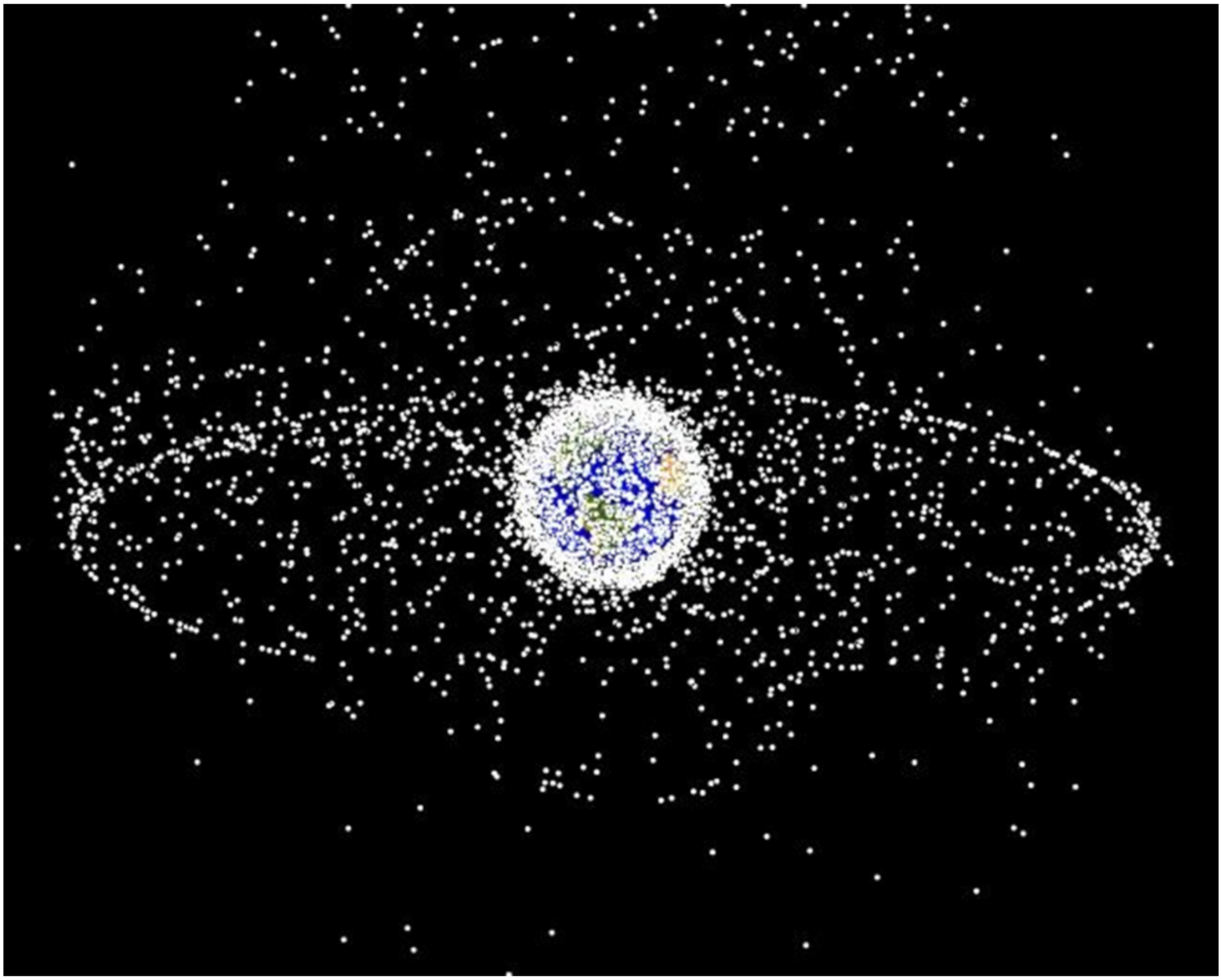
Any successful orbital debris policy will consist of many parts, including modeling, measuring and observation, mitigation, remediation, and planning for orbital re-entry. Importantly, the Commission is not the lead governmental agency dealing with this issue, with both domestic and international entities containing far greater expertise and authority. Our primary role should be to ensure that current satellite providers are good stewards of their orbital and launch activities, to prevent exacerbation of the problem. This important work becomes more difficult when applicants are contemplating satellite constellations with thousands of satellites and multiple launches.

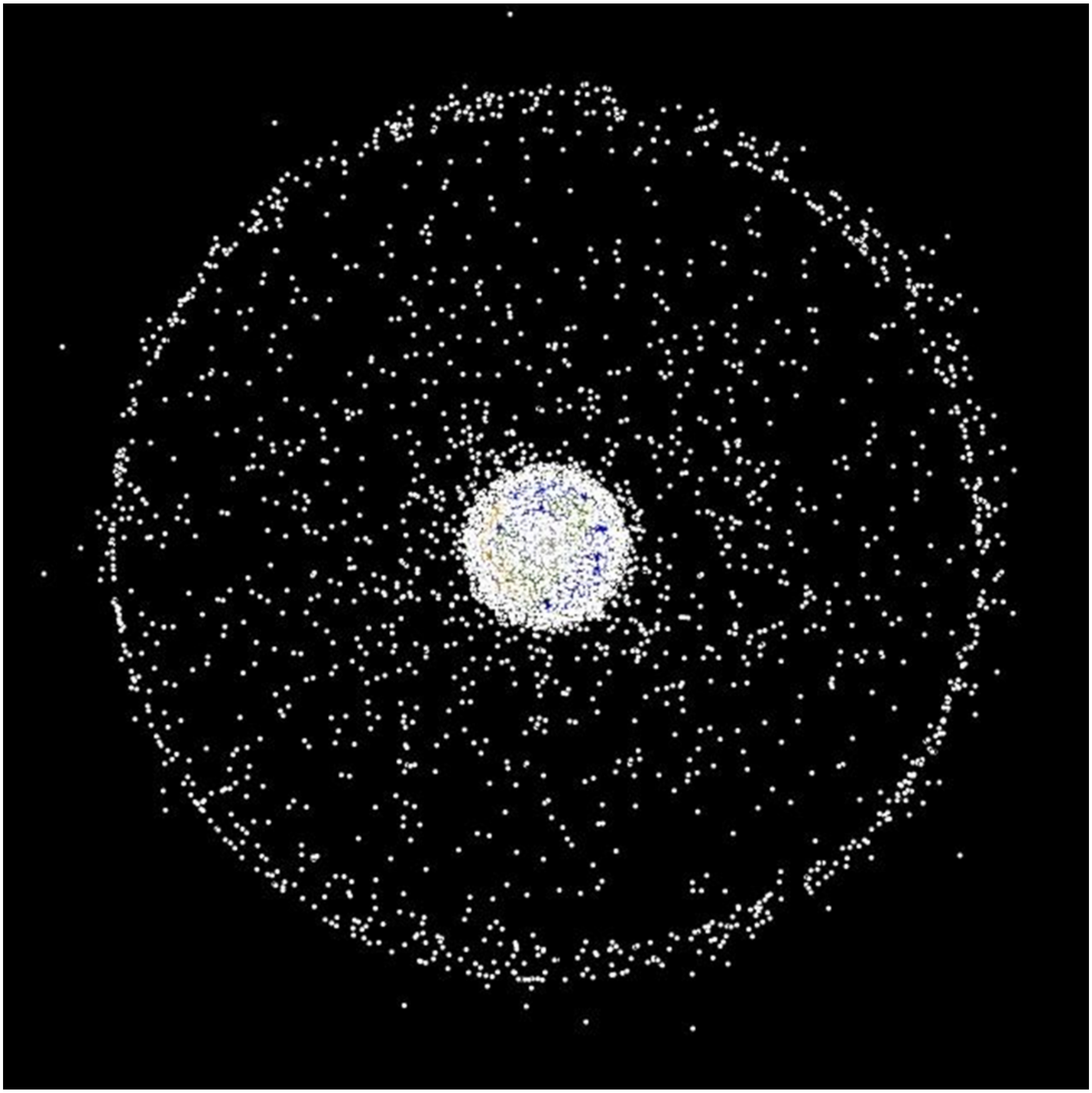
The item before us is a reasonable effort, and I thank the staff for their work. While I find some of the reporting proposals somewhat timid and the preventative ideas may be premature or uncooked, the Notice is in sufficient shape to start the appropriate and necessary conversation on orbital debris.

I appreciate that my colleagues agreed to add information about possible technologies being developed to retrieve orbital debris. While these may be in the early stages, to the extent the Commission is asking about retrieval mechanisms, we should make sure that we have a more complete picture of what is in the works and whether these options, and others, are viable. Proposed solutions involve such devices as harpoons, sails, nets, and others. Consider that just over this last weekend a launch occurred in New Zealand by Rocket Lab that is designed to minimize launch debris and includes an early version of a drag sail to capture and deorbit problematic space junk.

In all, this is a good item on a vital issue. Accordingly, I vote to approve.







STATEMENT OF
COMMISSIONER BRENDAN CARR

Re: *Mitigation of Orbital Debris in the New Space Age,* IB Docket No. 18-313*; Mitigation of Orbital Debris,* IB Docket No. 02-54 (Terminated)

There are a few thousand communications satellites orbiting Earth, and most of them are no longer in operation. They've been downgraded to orbital debris. In the coming years, zombie and active satellites alike will have many more neighbors. One company alone plans to launch more than 10,000 satellites that will be smaller and fly closer together than previous generations.

The new space race poses some tough questions. And they touch on everything from law, to policy, to engineering. Who should control space? What are the rules? And how do we ensure that satellites vital to communications, jobs, and security are launched and disposed of safely and economically? After all, the U.S. Joint Space Operations Center is already tracking over 500,000 pieces of orbital debris.

This last question is the subject of today's Notice. In 2004, the Commission issued its first order on orbital debris. Based on our charge to promote nationwide communications, we determined that satellite licensees should provide an orbital debris mitigation plan. This 2004 approach was largely a disclosure regime that built on NASA standards. Five years later, the importance of this issue was brought home when, for the first time, two communications satellites collided at hypervelocity—more than 26,000 miles per hour. A defunct Russian satellite collided with a then-active one owned by an American company, producing over 2,000 pieces of debris.

Given the expected increase in satellites over the coming years, today's Notice proposes to replace our existing orbital debris regime with a more detailed set of rules. For instance, it asks whether the FCC should:

- set the probability of large object collision during an orbital lifetime at no greater than 0.001
- adopt a satellite design and fabrication reliability standard of 0.999
- rely on gravitational forces and solar radiation pressure to lower a satellite's perigee as a preferred satellite disposal method, and
- set 15 joules as the correct kinetic energy of impact for objects that pose human casualty risk.

All of this raises a more basic question: Are we the expert agency to make these assessments?

We can respond by saying, hey, we've got a lot of smart people at this agency, and this isn't rocket science—except it is. It is literally rocket science we are engaging in.

So I was glad to see that the draft circulated by Chairman Pai three weeks ago noted the expertise that exists elsewhere across the federal government. It recognized a number of our sister agencies that have expertise and jurisdiction over the launch and tracking of satellites, including NASA, DOD, the FAA, the State Department, and the new Office of Space Commerce.

Building on that discussion, I asked my colleagues to expand the questions in the Notice that go to our expertise and authority. And I want to thank them for accommodating my requests. The Notice now takes an even bigger picture view—some would say 30,000 foot view, but this is space, so that

would be far too narrow. What are the right agencies and experts to answers these questions? Should the FCC be one of the lead agencies? Should we play a supporting and coordinating role instead? I am glad that we're now asking these questions as well as inviting additional comment on our legal authority.

I want to thank the International Bureau for its hard work on this item. With the additional discussion, it has my support.

STATEMENT OF
COMMISSIONER JESSICA ROSENWORCEL, CONCURRING

Re: *Mitigation of Orbital Debris in the New Space Age*; IB Docket No. 18-313; *Mitigation of Orbital Debris*, IB Docket No. 02-54 (Terminated)

Across the globe, we generate more than two billion tons of trash a year. But if you think our waste is limited to the ground, think again. That's because humans have been littering our celestial backyard with spent satellites, rocket fragments, and other discarded debris for as long as we've had the technological know-how. My favorite example is an innocuous little screwdriver that slipped through an astronaut's grasp and has been circling low earth orbit at up to 21,600 miles per hour for the last 35 years. At these speeds even a common household item can wreak havoc. That's ten times faster than a bullet with the punch of a hand grenade.

But this little screwdriver is not alone. Today, the United States Space Surveillance Network is tracking more than 23,000 objects larger than a baseball. The number of marble-sized objects has surpassed half a million. If you count objects the size of a grain of salt, there are easily more than 100 million pieces of debris circling our planet.

Whoa—and this problem is about to get a whole lot more complicated. Whether it's the thousands of satellites being launched as part of first-of-their-kind large constellations, the coming nanosat revolution, or an ill-defined Space Force, the likelihood of a debris disaster is higher than it has ever been in history.

That's why, earlier this year I called on the Federal Communications Commission to do more than just accelerate this problem by rubber stamping every next-generation satellite application that comes our way using yesterday's orbital debris rules. I called for us to think about the future. I called for a comprehensive review so that we can mitigate collision risks and ensure space sustainability going forward. I called for the agency to coordinate more closely with other federal actors to come up with clear national policies for this jumble of new space activity.

I thank my colleagues for heeding this call. But today's rulemaking is—let's be honest—only a timid start. Moreover, I am concerned it does not set this agency up for success in the future.

It misses the forest for the trees. It asks loads of technical questions about what sorts of information about orbital debris we should expect from satellite operators, but it fails to set forth a vision for the coming commercial space age. Likewise, it proposes no principles or measurable goals for space safety.

It also muddles the path forward. Compare the draft that was released three weeks ago to the rulemaking we are voting on today. Instead of moving forward aggressively—as our draft effort contemplated—we backtrack and add confusing language about whether or not this work should even continue in these halls.

This is not the leadership we need as we embark on a new era in space. We need clear guidance from this agency. It should rest on three basic principles.

First, everything that goes up in space should be trackable. We will never be able to protect against threats we cannot see. So we need to understand where all of our satellites are and where debris is with a high degree of precision. That includes working with our federal colleagues to improve methods to assess what is truly in orbit.

Second, everything we put up in space should be drivable. That way our satellites can avoid existing orbital debris that might come their way or de-orbit at the end of mission. On a typical day, our military issues 21 warnings of potential space collisions. That number is going to rise dramatically—and drivability is key to preventing collision.

Third, what goes up must come down. Some satellite operators have proposed large constellations of thousands of satellites in low earth orbit that will be launched around the same time. According to our colleagues at the National Aeronautics and Space Administration, 99 percent of these satellites will need to be taken out of orbit as soon as they have completed their missions in space. Doing so will prevent collisions in the future.

I thank my colleagues for kicking off this proceeding. Because it is not everything I hope it can be, I concur. But I hope we can move expeditiously to develop a realistic debris plan that can be implemented soon. The new space age is not waiting—and we have work to do.