April 2, 2020

FCC FACT SHEET*

Mitigation of Orbital Debris in the New Space Age

Report and Order and Further Notice of Proposed Rulemaking, IB Docket No. 18-313

Background: Since 2004, when the Commission first adopted rules regarding orbital debris mitigation for Commission-authorized satellites, there have been a number of developments in technologies and business models that pose new or additional orbital debris risks. These developments include the increasing deployment of lower-cost small satellites and of large constellations of non-geostationary satellite orbit systems, some potentially involving thousands of satellites. This revision of our orbital debris mitigation rules would address these recent developments and incorporate technical guidance from the broad U.S. Government interagency community that developed the recent update to the U.S. Government Orbital Debris Mitigation Standard Practices.

What the Report and Order Would Do:

- Revise existing application disclosure rules to incorporate numeric thresholds, including for:
  - risk of collision with large objects
  - risk of collision with small objects that would disable the satellite
  - probability of successful post-mission disposal
  - casualty risk associated with those satellites that will re-enter Earth's atmosphere
- Adopt a requirement that all satellites must be equipped with maneuverability sufficient to perform collision avoidance maneuvers during any period when the satellite is in an orbit that is above the International Space Station (approximately 400 kilometers altitude).
- Update disclosure requirements and adopt new disclosure requirements related to limiting collision risk, protecting inhabitable spacecraft, maneuverability, use of deployment devices, release of persistent liquids, and proximity operations.
- Adopt disclosure requirements regarding satellite trackability, satellite identification, and how operators plan to share information related to space situational awareness, such as ephemeris data.
- Codify informational requirements for geostationary-orbit satellite license extensions and limit the duration of such extensions to five years maximum per extension.
- Clarify existing high-level Commission requirements regarding maintaining control of authorized stations, including for satellite command communications.
- Clarify liability issues by adopting a requirement that licensees indemnify the United States for costs associated with any claims brought against the United States under international outer space treaties.
- Clarify that the revised rules, with some exceptions, apply to applicants under parts 5, 25, and 97 of the Commission's rules, including applicants for U.S. market access under part 25.

What the Further Notice Would Do:

- Propose a bond requirement for geostationary and non-geostationary orbit space stations associated with successful post-mission disposal.

* This document is being released as part of a "permit-but-disclose" proceeding. Any presentations or views on the subject expressed to the Commission or its staff, including by email, must be filed in IB Docket No. 18-313, which may be accessed via the Electronic Comment Filing System (https://www.fcc.gov/ecfs/). Before filing, participants should familiarize themselves with the Commission's *ex parte* rules, including the general prohibition on presentations (written and oral) on matters listed on the Sunshine Agenda, which is typically released a week prior to the Commission's meeting. *See* 47 CFR § 1.1200 et seq.

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

In the Matter of	)	
	)	
Mitigation of Orbital Debris in the New Space Age	)	IB Docket No. 18-313
	)	

REPORT AND ORDER AND FURTHER NOTICE OF PROPOSED RULEMAKING*

Adopted: [] **Released: []**

By the Commission:

Comment Date: []
Reply Comment Date: []

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* This document has been circulated for tentative consideration by the Commission at its April 2020 open meeting. The issues referenced in this document and the Commission's ultimate resolution of those issues remain under consideration and subject to change. This document does not constitute any official action by the Commission. However, the Chairman has determined that, in the interest of promoting the public's ability to understand the nature and scope of issues under consideration, the public interest would be served by making this document publicly available. The FCC's *ex parte* rules apply and presentations are subject to "permit-but-disclose" *ex parte* rules. *See, e.g.*, 47 C.F.R. §§ 1.1206, 1.1200(a). Participants in this proceeding should familiarize themselves with the Commission's *ex parte* rules, including the general prohibition on presentations (written and oral) on matters listed on the Sunshine Agenda, which is typically released a week prior to the Commission's meeting. *See* 47 CFR §§ 1.1200(a), 1.1203.

I. INTRODUCTION

1. A wide range of new and existing commercial technologies depend on reliable communications with spacecraft. The cost, integrity, and reliability of these communications can be negatively affected by orbital debris, which presents an ever-increasing threat to operational spacecraft. The environment in space continues to change and evolve in the New Space Age as increasing numbers of satellites are launched and new satellite technology is developed. The regulations we adopt today are designed to ensure that the Commission's actions concerning radio communications, including licensing U.S. spacecraft and granting access to the U.S. market for non-U.S. spacecraft, mitigate the growth of orbital debris, while at the same time not creating undue regulatory obstacles to new satellite ventures. This action will help to ensure that Commission decisions are consistent with the public interest in space remaining viable for future satellites and systems and the many services that those systems provide to the public.

2. The Report and Order (Order) comprehensively updates the Commission's existing rules regarding orbital debris mitigation, which were adopted in 2004. Our goal is to provide the clearest possible regulatory framework for applicants for non-Federal satellite communications. We also seek

comment in a Further Notice of Proposed Rulemaking (Further Notice) on adopting a performance bond tied to successful spacecraft disposal.

II. BACKGROUND

3. There are a variety of predictions for how the space economy and space environment will evolve in the coming New Space Age, but one clear indicator of the changes to come is the unprecedented number of non-geostationary orbit (NGSO) space stations[1] for which applications have been submitted at the FCC.[2] Some of the systems have begun preliminary operations, and we expect these activities to accelerate in the coming years. These new large constellations, many of which are designed to provide global broadband services, are likely to bring thousands of new satellites to low-Earth orbit (LEO). At the same time, there are a number of commercial systems with more than a hundred satellites that are already fully operational and providing commercial imaging and other Earth-exploration services.[3] Additional satellite constellations, again in potentially large numbers, will be coming online to provide other innovative services such as "Internet of Things." Moreover, the last decade has seen an exponential increase in the number of operations by small satellites with short duration missions for academic and research purposes, as the miniaturization of electronic components along with increased "rideshare" launch opportunities has led to the flourishing of "CubeSat" spacecraft missions, including launches with unprecedented numbers of satellites on board.[4] In the meantime, operators continue to launch new, technologically-advanced communications satellites into the geostationary orbit (GSO), providing critical services across the globe.

4. At the same time, studies indicate that already in some regions of LEO, the number of new objects and fragments generated from collisions exceeds those removed by natural atmospheric drag.[5] Other regions have sufficient densities of orbital debris to lead some analysts to conclude that they are close to or have already reached a "runaway" status, where the debris population will grow

[1] Throughout this Order, we use the terms "space station," "satellite," and "spacecraft." "Space station" is defined in the Commission's rules as "[a] station" located on an object which is beyond, is intended to go beyond, or has been beyond, the major portion of the Earth's atmosphere." 47 CFR §§ 2.1, 25.103. This is consistent with terminology used by the International Telecommunication Union (ITU). ITU Radio Regulations (R.R.) 1.64. The Commission's rules define "satellite" as "[a] body which revolves around another body of preponderant mass, and which has a motion primarily and permanently determined by the force of attraction of that other body." 47 CFR § 2.1. In this Order we refer only to artificial satellites. The Commission's rules define "spacecraft" as "[a] man-made vehicle which is intended to go beyond the major portion of the Earth's atmosphere." 47 CFR §§ 2.1, 25.103. These terms are used interchangeably in this Order, but we observe that "satellite" and "spacecraft" are more broadly defined than "space station."

[2] Recent reports indicate that commercial services are increasingly being provided by smaller-size NGSO satellites, and that most of these satellites are authorized by the United States. One report indicates, for example, that 62% of those NGSO satellites under 1,200 kilograms are now providing commercial service. *See* Bryce Space and Technology, Smallsats by the Numbers 2020, *available at* https://brycetech.com/reports.html. 899 commercial satellites under 1,200 kilograms were launched between 2012 and 2019, and 70% of these have been operated by Planet, SpaceX, or Spire, all of whom have been have been granted authorization by the Commission. *Id.*

[3] The Earth exploration-satellite service generally includes collection and communication of information related to the characteristics of the Earth and its natural phenomena, as obtained from active or passive sensors. ITU R.R. 1.51.

[4] *See Streamlining Licensing Procedures for Small Satellites*, Report and Order, 34 FCC Rcd 13077, 13078, para. 1 (2019) (*Small Satellite Order*).

[5] Gian Luigi Somma, et. al., "Space Debris: Analysis of a Large Constellation at 1200 km Altitude," at 1, 69th International Astronautical Congress (October 2018) (describing the current status of space debris environment in the introduction).

indefinitely due to collisions between debris objects.[6] The predicted increase in the number of satellites in orbit requires that orbital debris mitigation be taken seriously by all operators in order to ensure the continued safe and reliable use of space for satellite communications and other activities. The number of U.S. commercial satellites in space exceeds the number of U.S. government satellites,[7] and the actions taken by operators today have the potential to impact the orbital environment for hundreds or thousands of years.

5. The Commission first adopted comprehensive rules on orbital debris mitigation in 2004 in its *Mitigation of Orbital Debris* Second Report and Order.[8] The rules require disclosure of an applicant's debris mitigation plans as part of the technical information submitted to the Commission.[9] The Commission reasoned that the disclosures would allow the Commission to examine whether a space station operator has taken orbital debris into consideration, while finding that the costs associated with disclosure would not be unduly burdensome when balanced against the public interest benefits of preserving safe and affordable access to space, and disclosure would provide flexibility for the Commission to address new developments in space station design and permit discretion when granting conditioning, or denying an authorization.[10] As part of its *2004 Orbital Debris Order*, the Commission also explained how its orbital debris rules related to certain regulations of the National Oceanic and Atmospheric Administration (NOAA) and regulations of the Department of Transportation, Federal Aviation Administration (FAA).[11] Additionally, the Commission applied the new rules to amateur and experimental space stations, authorized under parts 97 and 5 of the Commission's rules, respectively,[12] and considered liability issues and insurance as they related to Commission-authorized space stations.[13]

6. Since 2004, there have been a variety of technical and policy updates to orbital debris mitigation standards, policy, and guidance documents. Additionally, scientific research and policy discussions on debris mitigation have continued in a wide variety of existing and new forums both in the United States and internationally.

7. In the United States, Space Policy Directive-3 (SPD-3), titled "National Space Traffic Management Policy,"[14] recognized the growing threat to space activities from orbital debris, and directs the Administrator of the National Aeronautics and Space Administration (NASA), in coordination with the Secretaries of State, Defense, Commerce, and Transportation, and the Director of National

[6] For a more detailed discussion of this phenomenon, *see* National Research Council, Orbital Debris: A Technical Assessment 6-7, 160-167 ((1995). Researchers modeling the orbital environment have concluded that each orbital region has a "critical density," at which point it contains enough objects with sufficient mass that the rate of fragments produced from collisions is greater than the rate at which objects are removed due to forces such as atmospheric drag, creating a collision hazard in the orbital region that may be too high for most space operations. *Id.* at 160-161. This is sometimes referred to as the "Kessler Syndrome" or "Kessler Effect."

[7] The Union of Concerned Scientists, for example, estimates that there are 1,007 active U.S. satellites, with 620 of those being commercial satellites. *See* Union of Concerned Scientists, UCS Satellite Database, https://www.ucsusa.org/resources/satellite-database (last visited March 24, 2020) (database updated with launches as of Sept. 30, 2019).

[8] *Mitigation of Orbital Debris*, Second Report and Order, 19 FCC Rcd 11567 (2004) (*2004 Orbital Debris Order*).

[9] *Id.* at 11576, 11619, para.17, Appendix B, § 25.114(d)(14).

[10] *Id.* at 11576-77, paras. 17-19.

[11] *Id.* at 11609-12, paras. 102-108.

[12] *Id.* at 11608-09, paras. 98-101.

[13] *Id.* at 11612-15, paras. 109-113.

[14] 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/.

Intelligence, and in consultation with the Chairman of the Commission, to lead efforts to update the U.S. Government Orbital Debris Mitigation Standard Practices (ODMSP) and establish new guidelines for satellite design and operation.[15] The ODMSP apply to missions operated or procured by U.S. government agencies, and "provides a reference for to promote efficient and effective space safety practices for other domestic and international operators."[16] SPD-3 stated that the United States should eventually incorporate appropriate standards and best practices, derived in part from the ODMSP, 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.[17] This rulemaking is one such activity.

8. The updated ODMSP were issued on December 10, 2019.[18] This represents the first update to the ODMSP since the practices were originally established in 2001.[19] The preamble states that the revised ODMSP includes "improvements to the original objectives as well as clarification and additional standard practices for certain classes of space operations."[20] The revised ODMSP preamble states that the United States Government "will follow the ODMSP, consistent with mission requirements and cost effectiveness in the procurement and operation of spacecraft, launch services, and the conduct of tests and experiments in space."[21] The preamble goes on to state that "[w]hen practical, operators should consider the benefits of going beyond the standard practices and take additional steps to limit the generation of orbital debris."[22]

9. At the U.S. government agency level,[23] the NASA Technical Standard (NASA Standard) and other NASA documents contain additional detail informing orbital debris mitigation measures when it comes to the development of NASA programs and projects.[24] The NASA Standard provides specific technical requirements for limiting orbital debris generation consistent with NASA policies, and has been

[15] *Id.* at Sec. 6(b)(1). The PDF of the updated U.S. Government Orbital Debris Mitigation Standard Practices (ODMSP) is available for download at: https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf.

[16] *See* ODMSP, Preamble.

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

[18] *See* NASA, Orbital Debris Program Office, U.S. National Space Council Announces Update to the USG ODMSP, https://orbitaldebris.jsc.nasa.gov/mitigation/ (Dec. 10, 2019).

[19] The prior U.S. Orbital Debris Mitigation Standard Practices were considered as part of the development of the Commission's orbital debris mitigation rules in the 2000s. *See 2004 Orbital Debris Order*, 19 FCC Rcd at 11573-74, para. 10.

[20] ODMSP, Preamble.

[21] *Id.*

[22] *Id.*

[23] We note that other U.S. government entities also have policies for limiting orbital debris related to those entities' space operations. For example, the U.S. Air Force Instruction 91-217, Space Safety and Mishap Prevention Program, contains guidance on space safety, including instructions related to minimizing debris for operations of orbital space systems. *See* Air Force Instruction 91-217, Space Safety and Mishap Prevention Program (certified current as of May 16, 2017), *available at* https://static.e-publishing.af.mil/production/1/af_se/publication/afi91-217/afi91-217.pdf (Air Force Instruction 91-217).

[24] *See* NASA Technical Standard, Process for Limiting Orbital Debris NASA-STD-8719.14B (April 25, 2019), https://standards.nasa.gov/standard/nasa/nasa-std-871914 (NASA Standard); NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments, NASA-NPR 8715.6B (February 16, 2017), https://orbitaldebris.jsc.nasa.gov/library/npr_8715_006b_.pdf; Handbook for Limiting Orbital Debris, NASA-HDBK-8719.14 with Change 1 (April 10, 2018), https://standards.nasa.gov/standard/nasa/nasa-hdbk-871914.

updated regularly, with the most recent update on April 25, 2019.[25] The NASA Orbital Debris Program Office also develops and maintains a number of software modelling tools designed to assist with current orbital debris mitigation analysis and help better understand the evolution of the orbital environment.[26] Several of these are available at no cost to the public. The software modeling tool that has been used by many Commission applicants is the NASA Debris Assessment Software, which provides a means of calculating, during the planning and design phase, various metrics-related debris mitigation practices such as assessing collision risk and casualty risk, which are relevant to some, but not all, of the Commission's requirements.[27] The FAA (for launch vehicles and intact re-entry) and NOAA (for commercial remote sensing satellites) both have orbital debris-related regulations which apply to non-government (in most cases commercial) operators licensed by those agencies.[28] Both agencies are currently considering updates to their rules, including some rules relevant to orbital debris mitigation.[29]

10. Internationally, there have been a number of significant developments relevant to the mitigation of orbital debris. The Inter-Agency Space Debris Coordination Committee (IADC), an international forum of government bodies that includes NASA and other space agencies, "for the coordination of activities related to the issues of man-made and natural debris in space[,]" issued an updated set of consensus guidelines for debris mitigation in 2007.[30] The IADC Guidelines cover a wide range of topics including limitation of debris released during normal operations, minimization of the potential for on-orbit break-ups, post-mission disposal, and prevention of on-orbit collisions.[31] Work by the IADC also helped to inform the development of the Space Debris Mitigation Guidelines of the United Nations (UN) Committee on the Peaceful Uses of Outer Space,[32] which were endorsed by the UN General

[25] *See generally* NASA Standard.

[26] *See* NASA, Orbital Debris Program Office, https://orbitaldebris.jsc.nasa.gov/ (with links to several software modeling tools on the homepage).

[27] *See* NASA Software, Debris Assessment Software 3.0, https://software.nasa.gov/software/MSC-26690-1 (last visited Jan. 14, 2020). The software is also updated periodically, with the most recent update in July 2019. NASA also issues a User Guide for the Debris Assessment Software, available at https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20190027721.pdf. Additionally, the software reflects the structure of the NASA Standard and provides the user with tools to assess compliance with the requirements of the NASA Standard for reduction of orbital debris. *See* NASA Software, Debris Assessment Software 3.0.

[28] *See* Department of Transportation, Federal Aviation Administration (FAA), Office of Commercial Space Transportation, Regulations, https://www.faa.gov/about/office_org/headquarters_offices/ast/regulations/ (last visited Jan. 14, 2020); United States Department of Commerce (Commerce Department), National Oceanic and Atmospheric Administration (NOAA), Commercial Remote Sensing Regulatory Affairs, Authorities, https://www.nesdis.noaa.gov/CRSRA/generalAuthorities.html (last visited Jan. 14, 2020). NASA Software, Debris Assessment Software 3.0, https://software.nasa.gov/software/MSC-26690-1 (last visited Jan. 14, 2020). We discuss any concerns related to these below.

[29] *See, e.g.*, Federal Aviation Administration, Streamlined Launch and Reentry Licensing Requirements, Notice of Proposed Rulemaking, 84 FR 15296, 15307 (April 14, 2019); National Environmental Satellite, Data, and Information Service, National Oceanic and Atmospheric Administration, Department of Commerce, Licensing of Private Remote Sensing Space Systems, Proposed Rule, 84 FR 21282, 21286 (May 14, 2019).

[30] Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines, at 3 (2007), https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf (IADC Guidelines).

[31] IADC Guidelines at 5.

[32] *See* IADC Guidelines at 3; United Nations General Assembly, "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space," A/RES/62/217, at iii-iv, 4 (2007), http://www.unoosa.org/pdf/publications/st_space_49E.pdf (UN Guidelines).

Assembly in 2007.[33] As with the IADC Guidelines, the UN Guidelines established voluntary, non-binding consensus principles and guidelines for space debris mitigation.[34] More recent developments include the IADC issuance in 2017 of a "Statement on Large Constellations of Satellites in Low Earth Orbit,"[35] as well as the adoption by the Committee on the Peaceful Uses of Outer Space of a preamble and 21 consensus guidelines for the "Long-Term Sustainability of Space Activities."[36] Additionally, there are international standards-setting organizations, such as the International Standards Organization that have issued standards for space activities, including orbital debris mitigation.[37]

11. The commercial space industry has been increasingly active in developing voluntary, consensus-based principles and guidelines through industry associations and working groups. In 2019, an organization known as the Space Safety Coalition published a set of best practices for long-term sustainability of space operations, which have been endorsed by at least 37 entities, primarily commercial space companies.[38] Also in 2019, the Satellite Industry Association (SIA), a trade association representing satellite operators, service providers, manufacturers, launch services providers, and ground equipment suppliers released a set of "Principles of Space Safety."[39] Both of these documents emphasize the importance of responsible space operations to ensure the long-term sustainability of the space environment. There have also been standards and guidance issued by organizations focusing on specific operational areas, such as the standards and recommended practices developed by the Consortium for Execution of Rendezvous and Servicing Operations for commercial rendezvous, proximity operations, and on-orbit servicing.[40] Additionally, organizations such as the World Economic Forum's Global Future Council on Space Technologies are working toward other approaches to space debris, for example, a "Space Sustainability Rating" that would provide a score representing a mission's sustainability as it relates to debris mitigation and alignment with international guidelines.[41]

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[33] UN Guidelines at iv. The UN General Assembly agreed that the voluntary guidelines "reflected the existing practices as developed by a number of national and international organizations, and invited Member States to implement those guidelines through relevant national mechanisms." *Id.*

[34] *Id.* at 1-2.

[35] Inter-Agency Space Debris Coordination Committee, Statement on Large Constellations of Satellites in Low Earth Orbit, IADC-15-03 (2017), https://iadc-home.org/documents_public/view/id/83#u.

[36] United Nations, Report of the Committee on the Peaceful Uses of Outer Space, Sixty-second session, A/74/20, at 22 (2019) (noting the adoption of the United Nations Committee on the Peaceful Uses of Outer Space, Scientific and Technical Subcommittee, Fifty-sixth session, "Guidelines for the Long-term Sustainability of Outer Space Activities," A/AC.105/C.1/L.366 (2019), https://undocs.org/A/AC.105/C.1/L.366).

[37] *See* International Standards Organization, "Space systems – Space debris mitigation requirements, ISO 24113:2019, Abstract (2019) https://www.iso.org/standard/72383.html. *See also* H. Stokes, et. al., "Evolution of ISO's Space Debris Mitigation Standards," First International Orbital Debris Conference (2019), https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6053.pdf.

[38] *See* Space Safety Coalition, "Best Practices for the Sustainability of Space Operations" (2019), https://spacesafety.org/best-practices/; Space Safety Coalition, Endorsees, https://spacesafety.org/endorsees/ (last visited Jan. 14, 2020).

[39] *See* Satellite Industry Association, "Principles of Space Safety for the Commercial Satellite Industry (Oct. 22, 2019), https://sia.org/space_safety/.

[40] *See* Consortium for Execution of Rendezvous and Servicing Operations, Resources & Publications, https://www.satelliteconfers.org/publications/ (last visited Jan. 14, 2020).

[41] World Economic Forum, Space Sustainability Rating, https://www.weforum.org/projects/space-sustainability-rating (last visited Jan. 14, 2020). The Space Sustainability Rating is being developed by a consortium that includes the European Space Agency (ESA) and Space Enabled Research Group within the Massachusetts Institute of Technology Media Lab, in cooperation with the University of Texas at Austin, Bryce Space and Technology, and the World Economic Forum. *Id.*

12. The Commission adopted a Notice of Proposed Rulemaking (*Notice*) on November 15, 2018 seeking comment on a comprehensive update to its rules relating to orbital debris mitigation.[42] It sought comment on issues ranging from minor updates codifying established metrics into existing rules to how to assess the risks posed by constellations of thousands of satellites, as well as topics such as economic incentives for operators that would align with orbital debris mitigation best practices.

13. Comments on the *Notice* were due April 5, 2019, and reply comments were due May 6, 2019.[43] We received 45 comments and 19 reply comments.[44] A list of commenters, reply commenters, and other filers is contained in Appendix C.

III. DISCUSSION

14. In the discussion that follows, we first address the Commission's overall regulatory approach to orbital debris mitigation, including economic and other issues. We then discuss the need for rule modifications to address topics such as collision risk, orbit selection, trackability, and minimizing release of debris. Next, we address post-mission disposal, as well as other topics such as proximity operations, security of spacecraft commands, and orbit-raising. Then, we discuss liability issues and economic incentives, including indemnification and insurance, and finally, we address the scope of our rules and other miscellaneous issues raised by commenters.

A. Regulatory Approach to Mitigation of Orbital Debris

1. FCC Statutory Authority Regarding Orbital Debris

15. The Commission licenses radio frequency uses by satellites under the authority of the Communications Act of 1934, as amended (the Act).[45] When the Commission adopted debris mitigation rules applying to satellites across all service types, the Commission concluded that its authority to review orbital debris mitigation plans fell within its responsibilities and obligations under the Act, derived from its authority with respect to authorizing radio communications.[46] As the Commission then noted, the Act charges the FCC with encouraging "the larger and more effective use of radio in the public interest."[47] Additionally, the Act provides for the licensing of radio communications, including satellite communications,[48] only upon a finding that the "public convenience, interest, or necessity will be served thereby."[49] These provisions of the Act have remained unchanged since the Commission's previous analysis of its authority in this area, in which it concluded that orbital debris and related mitigation issues are relevant in determining whether the public interest would be served by authorization of any particular

[42] *Mitigation of Orbital Debris in the New Space Age*, Notice of Proposed Rulemaking, 33 FCC Rcd 11352 (2019) (*Notice*).

[43] *See Mitigation of Orbital Debris in the New Space Age*, Proposed Rules, 84 FR 4742 (February 19, 2019).

[44] *See* Federal Communications Commission, Electronic Comment Filing System, IB Docket No. 18-313.

[45] Communications Act of 1934, as amended, 47 U.S.C. § 151 *et seq.* The Commission does not license communications for radio stations "belonging to and operated by" the United States government. *See* 47 U.S.C. 305(a).

[46] *2004 Orbital Debris Order*, 19 FCC Rcd at 11575, para. 14.

[47] 47 U.S.C. § 303(g). The Supreme Court has found that the meaning of a public interest standard in a legislative statute takes meaning from the purpose of that legislation. *NAACP v. Federal Power Commission*, 425 U.S. 662, 669 & FN 7 (1976); *see also Cellco Partnership v. FCC*, 700 F.3d 534, 542 (D.C. Cir. 2012), *citing to NBC v. U.S.*, 319 U.S. 190 (1943) ("[T]he supreme court has emphasized that [Title III] does endow the Commission with 'expansive powers' and a 'comprehensive mandate to…encourage the larger and more effective use of radio in the public interest.'").

[48] 47 U.S.C. § 301.

[49] 47 U.S.C. § 307(a).

satellite-based communications system, or by any particular practice or operating procedure of such satellite systems.[50] The analysis undertaken by the Commission is designed to ensure that the space systems reviewed by the Commission have sufficient plans to mitigate orbital debris, consistent with the public interest. As the Commission also previously concluded, to the extent that spacecraft are controlled through radiocommunications links, there is a direct connection between the radiocommunications functions we are charged with licensing under the Act and the physical operations of the spacecraft.[51] Rules that limit the generation of orbital debris are intended to minimize the orbital debris that would negatively affect the cost, reliability, continuity and safety of all commercial, experimental and amateur satellite operations licensed or authorized by the Commission.[52] Orbital debris also negatively affects the availability, integrity, and capability of both incumbent and newly-authorized satellite systems, thereby raising the potential for impairing the ability of such systems to use the spectrum to the full extent that the Commission authorized.

16. We note that even prior to the adoption of a comprehensive set of rules on orbital debris mitigation in 2004, the Commission was reviewing the orbital debris mitigation plans of satellites and systems on a case-by-case basis.[53] Rules requiring disclosure of plans to mitigate orbital debris were adopted for licensees in the 2 GHz mobile-satellite service in 2000, and those rules were the basis for rules applicable to all services that were adopted shortly thereafter.[54] Thus, as part of its licensing and grant of space systems, the Commission has been reviewing the orbital debris mitigation plans of non-Federal satellites and systems for over 20 years.

17. The *Notice* sought comment on whether the 2004 order cited all relevant and potential sources of Commission authority in this area, and whether the provisions discussed, or other provisions, provide the Commission with requisite authority in this area.[55] Several commenters agree with the Commission taking a refreshed look at its authority in this area.[56] No commenters, however, make specific arguments questioning the Commission's statutory authority generally, express different views on the Commission's authority pursuant to the Communications Act, or offer other views on sources of Commission authority. We therefore see no reason to arrive at a different conclusion than the Commission did in 2004 with respect to the Commission's authority on review of orbital debris mitigation plans.

18. Some commenters emphasize that the Commission should revisit its authority considering the authority of other agencies and organizations, in the interest of avoiding duplicative

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[50] *2004 Orbital Debris Order*, 19 FCC Rcd at 11575, para. 14.

[51] *Id.*

[52] *Id.*

[53] *2004 Orbital Debris Order*, 19 FCC Rcd at 11571, para. 7.

[54] *Id.*; *see Establishment of Policies and Service Rules for Mobile Satellite Service in the 2 GHz Band*, Report and Order, 15 FCC Rcd 16127, 16187-88, paras. 135-138 (2000). *See also Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band*, Report and Order and Further Notice of Proposed Rulemaking, 17 FCC Rcd 7841, 7865-66, para. 81 (2002) (applying to systems operating in the Ku-Band NGSO fixed-satellite service (FSS); *Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ka-Band*, 18 FCC Rcd 14708, 14725-26, para. 55 (2003) (applying to systems operating in the Ka-Band NGSO FSS); *Amendment of the Commission's Space Station Licensing Rules and Policies, Mitigation of Orbital Debris*, First Report and Order, 18 FCC Rcd 10760, 10784-85, para. 53 (2003) (applying to systems that would operate under default service rules).

[55] *Notice*, 33 FCC Rcd at 11358, para. 15.

[56] *See, e.g.*, Space Exploration Technologies Corp. (SpaceX) Comments at 1, 4 (rec. April 5, 2019) (SpaceX Comments); Intelsat License LLC Comments at 1, 2 (rec. April 5, 2019) (Intelsat Comments).

requirements and standards.[57] We recognize, as observed by the Commerce Department, that significant elements of non-Federal space operations are subject to regulation by other Federal agencies, most notably NOAA and the FAA.[58] We continue to work closely with other agencies to ensure that our activities are not duplicative of their activities, and coordinate with other agencies in individual cases, as necessary. To the extent that commenters ask us to refresh the legal analysis of our authority in light of the evolution of international standards,[59] we note that changes in international guidelines related to the mitigation of orbital debris can and do inform regulatory approaches, but do not have the force of law and would not alter the FCC's legal authority in this area.

19. A few commenters correctly observe that some of the Commission's *Notice* proposals go beyond a narrower focus on debris mitigation, such as in the ODMSP, and also relate in part to other functional areas often referred to as space situational awareness or space traffic management.[60] These functional areas generally concern the collection and dissemination of data about objects and activities in space (space situational awareness), and the management of activities in space to ensure safe operations, through measures such as coordination and collision avoidance (space traffic management). As an example of a rule that goes beyond the guidelines in the ODMSP, the rule we codify below regarding ability of an FCC-licensed spacecraft to be tracked can improve both the ability to monitor the space environment (space situational awareness) as well as the ability of operators to coordinate amongst each other and make informed decisions to prevent collisions (space traffic management).[61] These improvements in turn may reduce the likelihood that new debris will be created in space. We conclude that even though some of the rules we adopt in this *Order* may involve or relate to concepts of space situational awareness or space traffic management, because they are directly tied to the mitigation of orbital debris and will contribute to the Commission's ability to ensure that non-Federal satellite systems will serve the public interest, these rules fall within the Commission's broad authority under Title III of the Act to license radio spectrum pursuant to that public interest mandate.

2. Relationship with Other U.S. Government Activities

20. The *Notice* recognized the importance of a coordinated, effective regulatory environment that meets the dual goals of orbital debris mitigation and furthering U.S. space commerce.[62] Specifically, in the *Notice*, the Commission sought comment on whether there are any areas in which the proposed requirements overlap with requirements clearly within the authority of other agencies, in order to avoid duplicative activities, and whether there are any exceptions to applications of our rules that would be appropriate in specific circumstances.[63] The *Notice* also highlighted the ongoing activities of various executive branch agencies of the U.S. government related to the Space Policy Directive-3 (SPD-3),

[57] *See*, e.g., Intelsat Comments at 1; SIA Comments at 3; SpaceX Comments at 4, n.4.

[58] *See* United States Department of Commerce Comments at 2 (rec. April 5, 2019) (Commerce Department Comments).

[59] *See*, *e.g.*, Intelsat Comments at 3; EchoStar Comments at 4.

[60] *See*, *e.g.*, NASA Comments at 1; Comments of Darren McKnight, Integrity Applications, at 2 (filed Dec. 17, 2018) (McKnight Comments). Many aspects of space situational awareness and space traffic management, as relevant to non-U.S. government operators, are managed by the Department of Defense, U.S. Air Force – currently the 18th Space Control Squadron. *See* Peterson Air Force Base, Fact Sheets, 18th Space Control Squadron (March 22, 2018), https://www.peterson.af.mil/About/Fact-Sheets/Display/Article/1060346/18th-space-control-squadron/ (last visited Jan. 14, 2020). The 18th Space Control Squadron is a tactical unit under the U.S. Air Force 21st Space Wing responsible for maintaining and providing foundational space situational awareness for the U.S. Department of Defense, as well as interagency, commercial, and international partners. *See id.*

[61] *See* part III.C.

[62] *Notice*, 33 FCC Rcd at 11358, para. 14.

[63] *Id.* at 11359, para.17.

including the now-completed updating of the ODMSP. In accordance with its consultatory role described in SPD-3, the Commission has been engaged with those ongoing activities.[64] The *Notice* additionally sought comment on the suitability of various orbital debris mitigation guidance and standards.[65]

21. Commenters addressing these topics universally supported interagency coordination, and many mentioned the sharing of expertise regarding space operations.[66] Commenters also generally supported application of consistent principles as well as elimination of regulatory duplication.[67] The Commerce Department provided informative comments describing in detail many of the Commerce Department and interagency initiatives currently underway as a result of the Space Policy Directives.[68] At this time, we are pleased to highlight the recent completion of the revisions to the ODMSP, and look forward to further work with the Commerce Department and other agencies on an evolving "whole of

[64] *See* Space Policy Directive-3, Section 6(b)(1).

[65] *Notice*, 33 FCC Rcd at 11357, para. 11.

[66] *See, e.g.*, SpaceX Comments at 4 (supporting any efforts toward interagency coordination and the pooling of expertise across space operations); EchoStar Satellite Operating Corporation and Hughes Network Systems, LLC Comments at 1-2, 4-5 (rec. April 5, 2019) (EchoStar/Hughes Comments) (recommending that the Commission narrowly construe its jurisdiction to reflect its core competencies with respect to orbital debris and defer to the authority and expertise of other U.S. or international agencies tasked with developing specific technical criteria for mitigating orbital debris); WorldVu Satellites Limited Comments at 2 (rec. April 5, 2019) (OneWeb Comments) (stating that the Commission should ensure that the proceeding contributes to a framework that gives due consideration to subject matter expertise and resources possessed by other Federal agencies and regulatory bodies); Astroscale Holdings, Altius Space Machines, Inc., Nanoracks LLC, OrbitFab, Inc., Roccor, LLC, Spacebridge Logistics, Inc, Space Exploration Engineering, LLC, SpaceNav, LLC (collectively, Global NewSpace Operators) Comments at 21 (rec. April 5, 2019) (Global NewSpace Operators Comments) (suggesting that the Commission collaborate with experts in the debris mitigation review process, while not adding to the complexity or time required towards a license); Lockheed Martin Corporation Comments at 3 (rec. April 5, 2019) (Lockheed Martin Comments) (asserting that the success of any orbital debris mitigation policies depends on a whole-of-government approach in the United States, given the vested interests and critical roles of multiple departments and agencies in the space domain); Satellite Industry Association Comments at 3 (rec. April 5, 2019) (SIA Comments) (stating that the Commission should seek out and take into account the relevant technical expertise of other federal agencies and U.S. governmental bodies, as well as international entities with subject-matter interest); Duke Science Regulation Lab Comments at 12-16 (rec. April 5, 2019) (Duke SciReg Lab Comments) (suggesting that the Commission consider the relevant expertise, experience, and relevance of other federal agencies).

[67] *See, e.g.*, SpaceX Comments at 4 (supporting coordination to establish which Federal agency has the appropriate lead for a given activity, consistent with statutory authority); NASA Comments at 8 (observing that in situations where another U.S. government department or agency has effective oversight over a non-Federal operation in space, duplication may occur, and recommends consultation between respective Federal entities to eliminate any ambiguity and potential duplication); EchoStar/Hughes Comments at 4 (stating that the Commission should avoid adopting debris mitigation requirements that overlap with those within the authority and expertise of other agencies); OneWeb Comments at 2 (agreeing that a coordinated, effective regulatory environment is essential to the health of the satellite industry); Spaceflight, Inc. Comments at 7 (rec. April 5, 2019) (Spaceflight Comments) (suggesting that the Commission update its rules in coordination with other U.S. departments and agencies to ensure that establishment of consistent rules and policies with clear lines of demarcation as to which department or agency may be responsible for authorizing particular missions); SIA Comments at 4 (stating that rules and amendments adopted during this proceeding should support a comprehensive national framework); AT&T Services, Inc. Reply Comments at 3 (rec. May 6, 2019) (AT&T Reply) (observing that the record strongly supports formal coordination among relevant agencies).

[68] Commerce Department Comments at 3. Boeing similarly suggests that the Commission defer adoption of new rules until completion of a "comprehensive examination" by the U.S. Federal government). The Boeing Company Reply Comments at 6 (rec. May 6, 2019) (Boeing Reply). Boeing subsequently submitted an *ex parte* filing commenting on the revisions to the ODMSP as they relate to the Commission's proposals. *See* The Boeing Company, Supplemental Comments *Ex Parte* at ii (filed Feb. 14, 2020) (Boeing *Ex Parte*).

government" approach to space activities. Given the pace that the industry is evolving, and our responsibility to continue licensing satellites and systems on a day-to-day basis,[69] we find that it would not be beneficial at this time to delay our rule updates. We expect that regulation of orbital debris will be an iterative process as new research becomes available and new policies are developed, and as discussions continue concerning approaches to improving the organization of the regulation of space activities. If it becomes clear through a change to the governing law that an activity the Commission is currently undertaking is instead one that another agency is charged with performing, we will modify our process and regulations accordingly.

22. We continue to carefully follow the rulemaking developments of other agencies, in particular those of the FAA and NOAA, as those agencies look to update their rules related to authorization of commercial space activities.[70] The *Notice* did not propose any change to the specific conclusions drawn by the Commission in 2004 with respect to the role of the Commission vis-à-vis other agencies such as the FAA and NOAA.[71] We will continue to coordinate closely with other agencies in any cases where it appears that the other agency may have relevant expertise or in cases that present unique scenarios that implicate overlap with that agency's responsibilities.[72]

23. Consistent with the coordinated approach recommended by many commenters, we look to the recent updates to the ODMSP to help inform our rules. The revised ODMSP addresses the same general topics and issues as the proposals in the *Notice*, and as discussed by commenters in the record developed in this proceeding.[73] Similar to the approach that the Commission took in 2004, the organization of this Order generally follows the organization of the ODMSP objectives, and in the relevant content areas we describe the revised ODMSP approach. As requested by the Commerce Department, we use, to the extent feasible, the most recent updates to the ODMSP.[74]

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[69] *See, e.g.*, Secure World Foundation Comments at 3 (suggesting that at this moment at least the Commission continue to include orbital debris mitigation requirements in its licensing of satellite systems, as it has the broadest reach of any of the existing U.S. regulatory agencies for space, and without the Commission playing the role there would likely be multiple private sector entities conducting space activities that are not adequately covered by other U.S. regulatory authorities); Global NewSpace Operators Comments at 21 (noting that benefits such as transparency and global reach have resulted from the Commission's role in orbital debris mitigation regulation); AT&T Reply Comments at 4-5 (supporting Commission regulation of debris mitigation given its success over the past fifteen years through flexible, performance-based requirements).

[70] *See* Federal Aviation Administration, Streamlined Launch and Reentry Licensing Requirements, Notice of Proposed Rulemaking, 84 FR 15296, 15307 (April 14, 2019); National Environmental Satellite, Data, and Information Service, National Oceanic and Atmospheric Administration, Department of Commerce, Licensing of Private Remote Sensing Space Systems, Proposed Rule, 84 FR 21282, 21286 (May 14, 2019).

[71] *Notice*, 33 FCC Rcd at 11358-59, paras. 16-17.

[72] A good example is our coordination with NASA in cases where the International Space Station (ISS) is implicated in the planned operations of a non-Federal satellite or system. *See, e.g.*, Spire Global, Inc., SAT-LOA-20151123-00078 (deployment of CubeSats from the OA-5 Cygnus launch vehicle into orbit above the ISS, after the launch vehicle docked with the ISS).

[73] *See Notice*, 33 FCC Rcd at 11358, para. 14.

[74] Boeing states that in aligning the Commission's rules with the ODMSP, the Commission should consider both those instances in which a particular requirement was included in the ODMSP and "those instances in which [U.S. government agencies] concluded that the adoption of new requirements or modifications was premature or unwarranted." Boeing *Ex Parte* at 3-4. The ODMSP applies, by its terms, only to government missions that are procured and operated by government agencies for governmental purposes, and is applied within the context of agency procurement and contracting regulations, budgetary processes, etc., rather than in the context of regulatory review. Consequently, there is some tailoring of the ODMSP necessary to incorporate them into the Commission's existing regulatory structure, and there are also areas where we believe it is beneficial to provide more detailed

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24. A number of commenters suggested that the Commission participate in international processes regarding mitigation of orbital debris.[75] We observe that Commission representatives have participated as part of official U.S. government delegations in established international forums, such as the United Nations, IADC, and International Telecommunication Union, and will continue to participate through established channels under the guidance of the U.S. State Department or U.S. government entity with responsibility for overseeing the international activities.

3. Economic Considerations

25. In addition to regulatory requirements to control or mitigate orbital debris, certain commenters argue that developing mechanisms and processes that harness market forces can lead to a close alignment of private and public interests.[76] Market-based methodologies rely upon market dynamics and economic principles that generate efficiencies not always achieved by command-and control regulation. As a growing share of space is accounted for by orbital debris, public welfare is promoted when industry participants have economic incentives to consider the public welfare benefits of reducing orbital debris as offset by any public welfare costs associated with taking measures to reduce the generation of such debris. Such benefits include decreased operational risk due to the reduced potential for collisions with space debris. Moreover, because most useful orbital altitudes are limited but also available for use by others at an effective price that does not necessarily reflect the cost each user imposes on others, they constitute a "common pool resource" such that the effective price[77] to use space does not prevent its over-use. Given the substantial commercial sector investments in space, as noted by the increase in satellite launches and the potential concomitant increase in debris, an important challenge for regulators going forward is to adopt rules and explore economic mechanisms that promote the public interest in the safe and sustainable use of space.

26. In the *Notice*, the Commission included a regulatory impact analysis designed to assess various approaches to reducing debris in orbit from an economic perspective.[78] Many of these approaches were consistent with the rule revisions proposed by the Commission in the *Notice*, and others represented different means of reducing debris. To the extent that the comments directed to this section overlapped with other topics in the *Notice*, we discuss those comments in the various sections below. Commenters generally disagreed with the additional approaches discussed as part of the regulatory impact analysis, such as limiting launches, and as addressed below, we decline to further address those approaches at this time. Several commenters presented views on novel approaches, at least in the space debris context, for incentivizing particular activities.[79] For example, the New York University School of Law Institute for Policy Integrity proposed that the Commission broadly consider market-based alternatives such as

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guidance to operators. As recognized in the ODMSP, its guidelines are one element of space safety, and we also incorporate into our rules other requirements that go beyond the scope of the ODMSP.

[75] *See, e.g.*, Global NewSpace Operators Comments at 22; Spaceflight Comments at 7. *See also* Duke SciReg Lab Comments at 5, 16-17 (suggesting that the Commission use information gained through an inter-agency task force to incorporate the concerns of space actors internationally).

[76] *See* New York University School of Law Institute for Policy Integrity Comments at 1-2 (rec. April 5, 2019) (NYU Comments).

[77] The effective price includes application and regulatory fees and the costs of building and operating a satellite. None of these costs reflect the cost any satellite operator imposes on other operators.

[78] *Notice*, 33 FCC Rcd at 11382-86, paras. 88-100. The Commission sought comment on six approaches: fewer launches, changes in satellite design, changes in operations and disposal procedures, use of economic incentives, active collision avoidance, and active debris cleanup. *Id.*

[79] *See, e.g.*, NYU Comments at 1-2; Duke SciReg Lab Comments at 20-24 (suggesting a priority review voucher system to incentivize certain activities in space).

different liability rules, marketable permits or offsets, and regulatory fees.[80] Although we ultimately conclude that these approaches are not sufficiently robust on their own to address the problem of orbital debris, and thus regulation in this area is necessary, we address these and other approaches below.

27. Given the nature of space, some commenters raise the point that the Commission's actions in this area may be limited in value since they cannot account for activities of actors that are not subject to U.S. law and regulations. Although we address the application of our rules to non-U.S.-licensed satellites in more detail below, as an introductory matter it is worth pointing out that we have been applying, and will continue to apply, our rules on orbital debris mitigation to those operators of existing or planned non-U.S.-licensed satellites seeking access to the United States market. This means that any non-Federal satellite communicating with an earth station in the United States will be subject to an orbital debris assessment under the Commission's rules.[81] Given the interest by many satellite operators in serving the U.S. market, this provides means for our regulations to have a broader reach than if the regulations were just to apply to operators seeking a U.S. license, and helps to ensure that non-U.S. licensees do not gain competitive advantage by following less rigorous debris mitigation practices than U.S.-licensed satellites.

4. Other Introductory Matters

28. A number of commenters state that the Commission should focus its efforts on performance-based regulation, rather than prescriptive regulation (e.g., regulation of satellite performance rather than regulation of design).[82] We have endeavored throughout this *Order* to adopt a performance-based approach where feasible. We agree with those commenters who argue, for example, that performance metrics can enable operators to develop innovative and cost-effective solutions in many instances.[83]

29. Several commenters also request that rules be based on specific metrics to ensure regulatory transparency, and that the Commission provide clear guidance on how to achieve certain metrics.[84] In many areas we are providing metrics and identifying methodology, typically using publicly-available NASA assessment tools, which are already used by many satellite applicants.[85] In these cases, applicants may look to detailed guidance published by NASA in preparing orbital debris mitigation plans. There will continue to be some areas where we will assess issues on a case-by-case basis. Finally, we note that a number of commenters (generally those operators planning large NGSO constellations),

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[80] NYU Comments at 1 (asking that the Commission consider market-based alternatives in addition to the bonding and insurance requirements that the Commission raised in the *Notice*); *see Notice*, 33 FCC Rcd at 11380, para. 81 (seeking comment on what economic approaches might be feasible and 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).

[81] The requirement of providing information on orbital debris mitigation has been, and will continue to be, applicable to part 25 satellites, including those granted U.S. market access, as well as part 5 experimental and part 97 amateur satellites.

[82] *See, e.g.*, NASA Comments at 8; SpaceX Comments at 9; EchoStar/Hughes Comments at 7-8.

[83] *See, e.g.*, SpaceX Comments at ii. *See also* NASA Comments at 8 (noting that the generally performance-based requirements of the NASA Standard have held up well over time).

[84] *See e.g.* SpaceX Comments at 9-12; Boeing Comments at 7; Boeing *Ex Parte* at 5-6.

[85] In some cases we provide the opportunity for applicants to use other software programs, for example, provided that those programs are of equal or higher fidelity. For example, NASA has the Debris Assessment Software, capable of calculating collision risk, casualty risk, etc., and available at no cost, but there are higher fidelity tools as well. Other organizations like the European Space Agency also have well-established software tools. *See* European Space Agency, "ESA makes space debris software available online" (June 25, 2014), https://www.esa.int/Safety_Security/Space_Debris/ESA_makes_space_debris_software_available_online.

expressed concern as a general matter about metrics being applied on an aggregate basis to a constellation of NGSO satellites.[86] For example, if an operator needs to disclose whether the probability of collision with a large object is less than 1 in 1,000 for its system in aggregate, an operator with more satellites in its system will need to meet a lower per-satellite probability of collision. We address these concerns in connection with individual rules. In the case of aggregate application of the same standard regardless of the number of satellites in the system, we recognize that operators with larger systems would be subject to higher-standards on a per-satellite basis, but find that such a requirement is justified based on the need for the Commission to consider the full factual scenario relevant to a licensing decision, including understanding of the complete scope of the risk involved with the proposed operations.

30. In our recent order adopting elective streamlined licensing procedures for qualifying small satellites, the Commission noted that the qualification criteria that we were adopting would be modified as necessary or appropriate to conform to rules adopted in this orbital debris proceeding.[87] Accordingly, in several areas of our decision here, we adopt conforming rules for small satellites that file applications under those elective streamlined procedure.[88] In addition, unless specified otherwise, the rules discussed below will apply to amateur satellites authorized under the procedures specified in part 97 of the Commission's rules and experimental satellites authorized under the procedures specified in part 5 of the Commission's rules.

31. One party, Public Employees for Environmental Responsibility, filed a comment in this docket arguing that the Commission has a responsibility to consider the safety of substances used in satellite construction and operation and environmental issues associated with such operations.[89] Public Employees for Environmental Responsibility proposes that the Commission require review of technical specifications of satellites being launched and in particular to review the proposed use of toxic fuels as propellants.[90] Public Employees for Environmental Responsibility does not raise specific questions, or make specific proposals, regarding the orbital debris rules proposed in the *Notice*, and the issues it raised thus fall outside the scope of this proceeding.

B. Safe Flight Profiles

32. Our existing orbital debris rules include several disclosure requirements designed to ensure that operators are addressing the issue of potential collisions with debris or other objects.[91] We update our rules on safe flight profiles to specify metrics that NASA applies to its missions, require additional disclosures relating to orbital characteristics, and require propulsion or maneuverability for satellites and systems deployed above 400 km in altitude.

1. Collisions with Large Objects

33. *Probability of Collision for a Space Station.* In the *Notice*, the Commission proposed that applicants for NGSO satellites must state whether the probability that their spacecraft will collide with a large object during the orbital lifetime of the spacecraft will be less than 0.001 (1 in 1,000).[92] The current

[86] *See, e.g.*, Boeing Comments at 10-11; Telesat Canada Comments at 3 (rec. April 5, 2019) (Telesat Comments); SpaceX Comments at 14-16; Amazon.com, Inc. Reply Comments at 2-3 (rec. May 6, 2019) (Amazon Reply).

[87] *Small Satellite Order*, 34 FCC Rcd at 13084, para. 20.

[88] *Id.* at para. 20.

[89] *See* Letter from Kevin H. Bell, Staff Counsel, Public Employees for Environmental Responsibility to Marlene H. Dortch, Secretary, FCC, IB Docket No. 18-313 (filed Nov. 19, 2018). The letter was filed prior to the publication of the *Notice* in the Federal Register.

[90] *Id*. at 2.

[91] *See* 47 CFR § 25.114(d)(14)(i), (iii).

[92] *Notice*, 33 FCC Rcd at 11361, para. 26.

NASA Standard defines a "large object" as an object larger than 10 cm in diameter.[93] To date, many applicants have used NASA's Debris Assessment Software to conduct the analysis for LEO spacecraft.

34. Most commenters addressing this issue supported our proposal,[94] and we adopt it. Some commenters appear to have misunderstood this proposal, believing that the proposal was to require a specific threshold for maneuvers in individual instances of predicted conjunctions, for example.[95] The particular metric adopted is intended to address the overall collision risk of a satellite during its orbital lifetime, and not individual conjunction events. In preparing the risk assessment, applicants should use the latest version of the NASA Debris Assessment Software or a higher fidelity assessment tool.[96]

35. *Maneuverability and Collision Probability.* In the *Notice*, the Commission sought comment on whether, for purposes of conducting the analysis, and absent evidence to the contrary, the collision risk with large objects should be assumed zero or near zero during the period of the time when the space station is able to conduct collision avoidance maneuvers.[97] Several commenters agreed with this approach.[98] A number of commenters pointed out that this requires an assumption that maneuvering systems are 100% reliable,[99] and some suggested instead incorporating the probability thresholds at which operators undertake collision avoidance maneuvers into the overall assessment of collision risk.[100] Those thresholds vary among operators, but are typically at lower probabilities than the 0.001 metric as applied through the NASA Debris Assessment Software.[101] As a simplifying assumption,[102] we believe the

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[93] NASA Standard, 4.5.2, at 36 (Requirement 4.5-1). Similar to the NASA Standard, the revised ODMSP states that "a program will estimate and limit the probability of collision with objects 10 cm and larger during orbital lifetime to less than 0.001 (1 in 1,000)." ODMSP, 2-1.

[94] *See, e.g.*, Boeing Comments at 6, 10; The Commercial Smallsat Spectrum Management Association (CSSMA) Comments at 7 (rec. April 5, 2019) (CSSMA Comments); ORBCOMM Inc. Comments at 7 (rec. April 5, 2019) (ORBCOMM Comments); The Commercial Smallsat Spectrum Management Association Reply Comments at 4 (rec. May 6, 2019) (CSSMA Reply).

[95] *See, e.g.*, Intelsat Comments at 8.

[96] This clarification should address those commenters requesting that the Commission specify a standardized tool for assessment, *see, e.g.* University Small-Satellite Researchers Comments at 14-15 (rec. April 5, 2019), as well as clarify that the "large object" assessment must include objects greater than 10 centimeters in diameter, consistent with the current NASA Standard and Debris Assessment Software. *See* NASA DAS 3.0 User's Guide, 3.4, at 24-25; NASA Standard at 4.5.1.2 ("For purposes of evaluation, debris with a diameter of 10 cm or larger will be assumed to cause a catastrophic collision."). *See also* NASA Comments at 3 (use of 10 cm as a large-object threshold is appropriate; The Aerospace Corporation Comments at 8 (rec. Mar. 7, 2019) (Aerospace Comments) (supporting definition of large objects as those of size greater than 10 cm); Boeing Comments at 11-12 (suggesting that the Commission adopt the NASA Standard definition of a large object). LeoSat MA, Inc. (LeoSat) and state that the Commission should not adopt a specific size for a "large object," *see* LeoSat MA, Inc. Comments at 3 (rec. April 5, 2019) (LeoSat Comments); Intelsat Comments at 8-9, but we find it reasonable to adopt NASA's approach to this issue, which is reflected in the NASA Debris Assessment Software.

[97] *Notice*, 33 FCC Rcd at 11361-62, para. 26.

[98] *See* Boeing Comments at 12 (supporting the treatment of any spacecraft that is maneuverable as posing zero or near zero risk of collision with large objects); SES Americom, Inc. and O3b Limited Comments at 1-2 (rec. April 5, 2019) (SES/O3b Comments) (urging Commission to incorporate the current presumption that the risk is effectively zero for operators able to maneuver their spacecraft to avoid a collision).

[99] OneWeb Comments at 16; CSSMA Comments at 8-9; Iridium Communications Inc. Comments at 3 (rec. April 5, 2019) (Iridium Comments); CSSMA Reply at 6; Tyvak Reply.

[100] *See, e.g.*, Aerospace Comments at 8 (Air Force standards specify $1x10^{-6}$ as a risk threshold for triggering avoidance maneuvers).

[101] *See id.*

alternative assumption of zero is warranted.[103] However, in individual cases, to the extent there is evidence that a particular system or operator is unable to effectively maneuver or is maneuvering only at risk thresholds that raise reasonable questions about its ability to meet the 0.001 collision risk metric even with some degree of maneuverability, this assumption will not be applied.

36. *Total Collision Probability for Systems with Multiple Space Stations.* We also conclude that the total probability of collision should be assessed for any space system consisting of more than one space station.[104] The total probability may be calculated as the sum of the probability of collision associated with each individual satellite deployed over a 15-year period,[105] including replacement satellites.[106] Several commenters argue that it would be unfair for the Commission to apply a different standard to individual satellites where the satellites are part of a system consisting of multiple satellites.[107] Other commenters disagree.[108] We conclude that the approach we adopt, which involves consideration of the full factual scenario relevant to a licensing decision, fairly reflects the heightened risk of orbital debris posed by larger satellite constellations.

37. Boeing questions the departure from the NASA Standard, which focuses on the collision probability on a per-satellite basis.[109] After review of the record, we find it is appropriate to apply the collision risk metric on a total system-wide basis as part of tailoring existing standards to the commercial context in which a single commercial venture may be seeking to deploy large numbers of satellites.[110]

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[102] NASA observes that the inclusion of collision avoidance threshold into the overall assessment of collision risk is a difficult technical problem. NASA Comments at 2-3. NASA would ideally include not only the type of collision risk threshold specified by Aerospace, but also account for other aspects of on-orbit collision avoidance residual risk. *Id.* NASA observes that historically a satellite's posture to performing on-orbit collision avoidance has either been not considered or presumed to reduce to zero the risk of collision during the satellite's active mitigation period. *Id.* Despite some drawbacks to these approaches, NASA appears to agree with a historical approach for the time being, and notes that the NASA is just beginning to work on how to derive an omnibus risk value that accurately reflects the on-orbit collision avoidance portion of a satellite's lifetime. *Id.* NASA recommends that the Commission update its rules to include a more comprehensive understanding and apportionment of risk once a comprehensive approach is available. *Id.*

[103] Other commenters appeared to believe the FCC proposal was to require that, in individual conjunction events, collision avoidance must be undertaken in order to reduce the collision probability entirely to zero, regardless of whether the predicted probability of collision was extraordinarily low. This was not the intent of the FCC proposal.

[104] *See Notice*, 33 FCC Rcd at 11567, para. 27.

[105] We conclude that 15 years is a reasonable time frame to adopt for purposes of conducting this assessment, based on the typical 15-year license term for NGSO systems. *See* 47 CFR § 25.121(a), (b).

[106] The provision regarding replacement satellites will only apply to systems authorized under part 25, excluding satellites licensed under the streamlined process, since replacement satellites are not contemplated as part of either a part 5 experimental or part 97 amateur space station authorization, or as part of the streamlined small satellite processes.

[107] *See, e.g.*, SpaceX Comments at 14-15; Amazon Reply at 2-3. As an example, if operators achieve a total probability of collision for its system of less than 0.001, an operator with more satellites in the system will need to meet a lower probability of collision on a per-satellite basis.

[108] *See, e.g.*, ORBCOMM Comments at 9.

[109] Boeing Comments at 10-11; *see also* Boeing *Ex Parte* at 8.

[110] Some commenters suggest that if we do adopt a probability of collision metric applicable on a system-wide basis, we adopt a different metric than 0.001. *See, e.g.*, ORBCOMM Comments at 7; OneWeb Comments at iii; CSSMA Reply at 4 (agreeing that constellation collision risks should be considered on an aggregate basis, but not by applying the 0.001 collision risk metric). Other commenters suggest we take a different approach altogether in assessing the collision risk associated with large systems. *See, e.g.*, CSSMA Comments at 7-8; Amazon Reply at 3. We conclude that the most straightforward approach is to apply the NASA Standard-derived metric as a

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Commenters additionally express concerns regarding the costs associated with achieving a probability of collision of 0.001 or less on a system-wide basis.[111] Ignoring the size of a particular system when assessing collision risk could result in a single operator accruing a significant collision risk related to its operations. We note that even very large systems have several different design options that will help the system achieve compliance. This may include the system operating at a lower altitude, or satellites having maneuvering capabilities,[112] and conclude that requiring applicants to assess the total probability of collision on a system-wide basis is consistent with our public interest obligation in authorizing satellites and systems.

38. Satellites may fail on orbit and no longer be capable of collision avoidance. Collision risk should be evaluated assuming such failures. Those spacecraft must be treated as non-maneuverable for purposes of the collision analysis. Accordingly, we require that those applicants for a multi-satellite systems who are planning to rely on satellite maneuverability to reduce collision risk to perform the analysis of total probability of collision taking into consideration the expected failure rate of the maneuver capability at an orbit that presents the worst case for collision risk. Additionally, we will require that these applicants conduct the assessment assuming a 10% failure rate of the maneuver capability at an orbit that presents the worst case for collision risk. Although the goal for all systems should be to achieve a far lower than 10% failure rate for propulsion or maneuvering capability,[113] we conclude that requiring applicants to provide calculations using both the operator's planned failure rate and an assumed 10% failure rate at the orbit that presents the worst case for collision risk will provide the Commission with information that will assist in licensing decisions by providing a more detailed account of potential collision risk.

39. Some commenters suggest that operators may attempt to disguise the true size of their systems in order to accept risk in excess of any collision risk benchmark.[114] While we could establish rules such as attribution rules, in order to address this concern, we believe it can be adequately addressed on a case-by-case basis. We anticipate that the operational characteristics of an application will often be enough to indicate whether specific space stations are part of the same system or not. If experience suggests a high incidence of applicants attempting to evade the collision risk metric in this way, we can revisit this issue at a later time.

40. We further clarify that our requirement with respect to probability of collision for multi-satellite systems is a disclosure requirement rather than an operational rule. In any instance where the calculated total probability of collision is greater than 0.001, the operator must provide a detailed justification that includes specifying the measures taken to reduce collision risk and why the 0.001 or less metric cannot be achieved for the system. Our expectation is that operators will seek to minimize risk and achieve a total probability of collision of 0.001 or less, and so we would only favorably consider a

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presumptively acceptable probability of collision for a system as whole, but to permit justification for greater total calculated probabilities in exceptional cases provided that the operator has taken significant steps to minimize collision risk.

[111] *See, e.g.*, Boeing Comments at 11; Boeing *Ex Parte* at 8-9.

[112] *See, e.g.*, Aerospace Comments at 19 (stating that aggregate collision risk can be mitigated by using operational orbits with low existing populations and employing collision avoidance). We observe that the large Fixed-Satellite Service constellations that have been granted a license or market access by the Commission will have maneuvering capabilities.

[113] Recognizing the difficulties of fully assessing the reliability of maneuvering capabilities at the application stage, we adopt an assumed 10% failure rate. We believe that a 10% failure rate of maneuverability represents a practical benchmark for making this assessment. Although it measures a different attribute, this 10% failure rate of maneuverability also corresponds to the 0.9 probability of successful post-mission disposal specified in the ODMSP and adopted in the Commission's rules as discussed below. *See* ODMSP, 4-2.

[114] *See, e.g.*, Boeing Comments at 11; SpaceX Comments at 15.

justification for a system not satisfying this total probability in an exceptional case.

41. *Other Issues*. Telesat Canada (Telesat) states that the Commission should "pro-rate" application of this metric and the metric for collisions with small objects based on a 5-year service life.[115] In Telesat's view, the application of the 0.001 metric should apply to those satellites with 5-year service life, but the 0.001 metric should be doubled when applied to those satellites with a 10-year service life.[116] According to Telesat, this would incentivize deployment of satellites with longer missions, since replenishment of shorter-lived satellites can lead to increased risk of debris.[117] While we do not adopt this approach, we agree that satellite service life and system replenishment rates are relevant considerations that should be addressed by applicants, and expect that an applicant seeking a license for a 15-year term would address collision risk for the aggregate number of satellites to be launched during the license term, including expected number of replacement satellites. Thus, we address the issues discussed by Telesat by accounting for the total number of satellites in an assessment of total collision risk, rather than by pro-rating the metric based on an individual satellite's service life.

42. The Aerospace Corporation (Aerospace) suggests that we apply the requirement to GSO satellites as well as NGSO satellites, because GSO satellites can also be involved in collisions that would generate large amounts of untrackable, long-term debris in the geostationary orbit (GEO) region.[118] In the *Notice*, the Commission proposed inclusion of the metric into the disclosure specifically for NGSO satellites.[119] The NASA Standard formulation discussed in the *Notice* applies to "each spacecraft and launch vehicle orbital stage in or passing through LEO."[120] Currently, all space station applicants, including applicants for GSO space stations, must provide a statement that the space station operator has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. We believe that continuing to apply this disclosure approach to applicants for GSO systems is sufficient, without needing to adopt a specific metric at the current time. We encourage GSO operators to provide quantitative collision risk information, but believe that requiring such analysis as part of the initial application materials is unnecessary,[121] given that GSO operators are assigned to particular orbital locations, including a specific "station keeping box,"[122] and must comply with certain well-established disposal procedures.[123]

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[115] Telesat Comments at 3.

[116] *Id.* at 3 and n.4. Conversely, Telesat states that the risk cap would be halved for a satellite with a service life of 2.5 years. *Id.*

[117] *Id.* at 3.

[118] Aerospace Corporation Comments at 8

[119] *See Notice*, Appendix A, Proposed Rules, § 25.114(d)(14)(iv)(A)(1).

[120] NASA Standard, 4.5.2, at 36 (Requirement 4.5-1). Aerospace suggests that we limit the period of assessing collision probability to a finite time such as 100 years. Aerospace Comments at 8. We decline to adopt this into our rules, since we are not adopting a specific metric for GSO space stations. However, NGSO space stations not disposed of through atmosphere re-entry, i.e. space stations in medium-Earth orbit (MEO) may refer to this 100-year outer limit in implementing the collision risk assessment. *See* ODMSP 3-1.

[121] The Commission may request such analysis if there is an application for a particularly unique type of operation in the GEO region, or there is evidence to suggest that certain GSO operations may pose unique risks to the GEO environment.

[122] *See* 47 CFR § 25.210(j) (space stations operated in the geostationary satellite orbit must be maintained within 0.05 degrees of their assigned orbital longitude in the east/west direction, unless specifically authorized otherwise); 47 CFR §25.114(d)(14)(iii) (GSO applicants must disclose if there are any known satellites at the vicinity of the requested GEO location, such that the station keeping volumes of the respective satellites might overlap).

[123] *See* 47 CFR § 25.283(a).

2. Collisions with Small Objects

43. In the *Notice*, the Commission sought comment on adding a quantifiable metric to our existing rules regarding the probability of a 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.[124] The *Notice* referenced the NASA Standard, which states that for each spacecraft, the program or project shall 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 maneuver requirements does not exceed 0.01 (1 in 100).[125] The revised ODMSP includes a similar provision.[126] Our current rules require a statement that operators (both GSO and NGSO) have assessed and limited the probability of the satellite becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control or prevent post-mission disposal.[127] Generally, operators have provided information regarding spacecraft shielding, redundant systems, or other designs that would enable the spacecraft systems to survive a collision with small debris. Some operators have been providing the information specified in the NASA Standard, calculated using the NASA Debris Assessment Software.

44. Most commenters addressing this issue agreed with the inclusion of the NASA Standard-derived metric in our rules, at least for NGSO space stations and systems. NASA notes that this particular agency requirement, when applied to NASA missions, has been achievable and cost-effective with shielding, use of redundant systems, or other design or operational options.[128] OneWeb disagrees with the inclusion of a separate small object collision metric, on the basis that the Commission should adopt a comprehensive deorbit reliability metric that accounts for all failure modes.[129] In our view, adoption of this small object collision metric, along with the disposal reliability metric discussed below, sufficiently addresses potential satellite failure modes, because it takes into consideration both failures due to collisions with small debris and other potential sources of failure for post-mission disposal. We conclude that incorporating the NASA Standard-derived metric into our rules for NGSO applicants is in the public interest as it provides more certainty for operators regarding an acceptable disclosure of risk specifically related to collisions with small objects. We conclude that the benefits of this approach are worth the efforts of operators in performing an additional calculation in preparation of their orbital debris mitigation plan, because this calculation may be completed using the NASA Debris Assessment Software or a comparable or higher fidelity assessment tool, and many applicants already conduct this assessment.[130]

45. We conclude that applicants for GSO space station will also be required to include a disclosure related to this metric. In the *Notice*, the Commission had proposed to add this metric to our rules for both NGSO and GSO space stations,[131] but we received several comments suggesting that inclusion of this metric into our rules for GSO space stations would be of limited utility.[132] One of the

[124] *Notice*, 33 FCC Rcd at 11362, para. 27.

[125] *See id.*; NASA Standard, Requirement 4.5-2, at 36.

[126] ODMSP at 3-2. The ODMSP identifies micrometeoroids and orbital debris smaller than 1 cm. *Id.* As noted, an assessment performed using the NASA Debris Assessment Software will satisfy our rule.

[127] 47 CFR § 25.114(d)(14)(ii).

[128] NASA Comments at 3.

[129] OneWeb Comments at 17-18.

[130] *See* NASA DAS 3.0 Users Guide, 3.5, 25-30.

[131] *See Notice*, 33 FCC Rcd at 11396, Appendix A, Proposed Rules, § 25.114(d)((14)(ii).

[132] Boeing Comments at 13; Eutelsat Comments at 3-4 (suggesting that the orbital dynamics are different for GSO and the risks posed are materially lower).

commenters, Boeing, seems to have changed its view on this point in supplemental comments.[133] Additionally, while Eutelsat suggests that the risks posed to GSO satellites in this area are materially lower than the risks posed to NGSO satellites,[134] we do not see this as a reason not to apply the metric in our rules for GSO spacecraft, since it should be easier for those spacecraft to satisfy the rule. Accordingly, we adopt our proposal.

3. Disclosures Regarding Planned Orbit(s)

46. *Identification of Other Relevant Satellites and Systems.* In the *Notice*, the Commission sought comment on revising the wording of its rule regarding identifying other space stations that are operating in similar or identical orbits in low-Earth orbit.[135] The Commission proposed revising the rule to require that, instead of identifying satellites with similar or identical orbits, the statement must identify planned and/or operational satellites with which the applicant's satellite poses a collision risk, and indicate what steps have been taken to coordinate with the other spacecraft system and facilitate future coordination, or what other measures the operator may use to avoid collisions.[136] The Commission also proposed to extend this rule to all NGSO satellites, rather than just those that will be launched into the LEO region,[137] since overlap in orbits among NGSO spacecraft in other regions may also result in collisions.[138] Several commenters supported these revisions,[139] and we adopt them.[140] As part of the public record, this disclosure can also help to inform other operators that may be operating or plan to operate in the same region of space. Since this wording is similar to the previous rule, we find that there are unlikely to be significant additional costs from compliance with this disclosure requirement,[141] but to the extent there are any additional costs in research and assessment of the environment in which the spacecraft will be located, we conclude they are warranted in the interest of ensuring that operators take into consideration other relevant space stations and systems when preparing orbital debris mitigation plans, and coordinate with those operators when necessary.[142]

47. CSSMA and LeoSat oppose a requirement that the collision analysis include analysis with respect to planned systems, arguing that planned systems change frequently and not all systems are known.[143] We clarify that the rule will require a disclosure identifying potential systems of concern, but

[133] *Compare* Boeing Comments at 13 *with* Boeing *Ex Parte* at 9 (stating that the Commission should follow the ODMSP on this point – which applies the metric to GSO satellites).

[134] Eutelsat Comments at 3-4.

[135] *Notice*, 33 FCC Rcd at 11362-63, para. 28.

[136] *Id.* at 11363, para. 28.

[137] The current rule only applies to those space stations that are launched into the LEO region. *See* 47 CFR § 25.114(d)(14)(iii).

[138] *Id.*

[139] *See, e.g.*, ORBCOMM Comments at 8; Global NewSpace Operators Comments at 7; Boeing Comments at 13-14; OneWeb Comments at 7; SES/O3b Comments at 3. *See also* Iridium Comments at 3 (supporting the disclosure and requesting that to the extent that a proposed satellite system would pose an unreasonable collision risk to existing satellite constellations, the applicant should be not be granted authority to operate).

[140] We also adopt a conforming rule that is applicable to applicants for the streamlined small satellite process in section 25.122 and streamlined small spacecraft process in section 25.123. *See* Appendix A, Final Rules.

[141] While this does represent a new disclosure for applicants for NGSO space stations that would operate above LEO, as a practical matter there are typically few other systems that pose a collision risk at those altitudes, and so this should represent a minimal cost, if any, for those NGSO applicants.

[142] *See, e.g.*, NASA Comments at 3 (recommending that coordination and other measures the operator plans to use to avoid collision be done over the orbital lifetime of the proposed space station).

[143] LeoSat Comments at 3; CSSMA Comments at 9; CSSMA Reply at 6.

does not require that the applicant's calculated collision risk include such systems (which would go beyond what can be assessed using the NASA Debris Assessment Software). It is important, however, that applicants assess planned systems, what impact such systems may have on their operations, and what coordination can be completed with the operators of such systems. While not all planned systems may come to fruition and there may be systems that would be unknown to applicants, such as foreign or government systems, we expect applicants to make best efforts to analyze the environment in which their satellites will be operating[144] and specify how they plan to coordinate, to the extent possible, with other operators to ensure safe operations. Boeing asks that we clarify that the disclosure must specify only those other NGSO satellite systems "the normal operation of which" pose a risk of collision.[145] We concur with Boeing's clarification of the rule, but decline to change the rule language since we believe that it is self-evident that an operator can only take into consideration the planned or normal operations of another operator's system.

48. *Orbit Selection and Other Orbital Characteristics*. In the *Notice*, the Commission also proposed that any applicants planning an NGSO constellation that would be deployed in the LEO region above 650 km in altitude specify why the applicant had chosen the particular orbit and describe other relevant characteristics of the orbit.[146] The Commission reasoned that missions deploying above 650 km altitude may represent a greater risk from a long-term orbital debris perspective, since satellites that fail above that altitude will generally not re-enter Earth's atmosphere within 25 years, and depending on the deployment altitude, may be in orbit for centuries or longer.[147] The Commission also sought comment on whether it should 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.[148]

49. After review of the record, we decline to adopt these proposals.[149] We conclude after further consideration that the long-term risks associated with deployments above 650 km are sufficiently addressed through our other rules, such as collision risk assessment, and reliability of post-mission disposal and that therefore the additional statement is not necessary. Indeed, application of the Commission's other orbital debris mitigation rules may in some instances result in an operator deciding to deploy below 650 km. Moreover, below we adopt a maneuverability requirement for most NGSO satellites, which should ensure that operators plan for satellites to be disposed of within a reasonable time following conclusion of the mission.[150] While SpaceX, for example, supported the proposed disclosure regarding rationale for selecting a particular orbit,[151] we conclude that concerns the Commission may

[144] Applicants may be able to assess planned systems based on filings with the Commission or International Telecommunication Union (ITU). We expect applicants to identify planned systems on a "best efforts" basis.

[145] Boeing Comments at 14.

[146] *Notice*, 33 FCC Rcd at 11364, para. 31.

[147] *Id.*

[148] *Id*. at 11365, para. 32. The Commission gave the example of a technology demonstration mission in LEO that last only a few weeks resulting in up to 25 years of collision risk to other operators. *Id.*

[149] Several operators suggest that applicants should not be required to justify their orbit selection. Among these, CSSMA notes that if an applicant complies with collision risk thresholds, the Commission should consider its collision risk analysis to be sufficiently informative and not require any additional justification for operations above 650 km. CSSMA Comments at 8. Boeing states that the Commission should not involve itself in the business and technical considerations regarding selection of a particular orbit. Boeing Comments at 16.

[150] While LeoSat supported the disclosure proposal on this point, we believe it can be addressed more effectively by other rules. *See* LeoSat Comments at 4.

[151] *See* SpaceX Comments at 19-20 (applicants planning to deploy a system at any altitude should specify why they have chosen that particular orbit, and include characteristics of the planned constellation). Iridium also supported (continued….)

have about risks associated with operations in a particular orbit can be adequately addressed through other measures adopted in this Order.

50. We do adopt our proposal, however, that NGSO systems disclose information regarding other relevant characteristics of the chosen deployment orbit not already covered, such as the presence of a large concentration of existing debris in a particular orbit.[152] Boeing states that the Commission should not adopt regulation in this area, because operators are adequately incentivized to select initial orbits that are sufficiently free of hazards, or invest in other measures to facilitate the safety of their satellites.[153] We find that this disclosure will help to ensure that operators have considered all the characteristics of the deployment and operational orbits, and are fully aware of the risks associated with operations in the particular orbit.[154] This may not always be the case, particularly with smaller operators or operators who use a rideshare launch. If an orbit is particularly congested with debris, for example, an operator may want to consider modifying its operations slightly to avoid having to perform a large number of collision avoidance maneuvers.[155]

4. Orbit Variance and Orbit Selection for Large NGSO Systems

51. The *Notice* sought comment on whether the Commission should adopt an upper limit for variances in orbit for NGSO systems.[156] "Variance" refers to the range of altitude, such as "1025 km plus or minus 10 km," in which a satellite or constellation of satellites will operate. The Commission asked whether variance in altitude should be limited in an NGSO system in order to enable more systems to co-exist in LEO without overlap in orbital altitude, and if so, how an appropriate limit should be set.[157] We received a number of comments related to orbital variance for large NGSO systems, and even more comments on the related topic of whether, and how, the Commission should assign orbital altitude ranges for large constellations of NGSO satellites, such that the altitudes do not overlap.[158]

52. The question of whether two satellite systems can coexist in a given region of space, such as a circular LEO orbit, depends on multiple factors, including the number and size of satellites, the

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the proposed disclosure, suggesting that applicants seeking to operate between 400 km and 2,000 km provide the disclosure. Iridium Comments at 6.

[152] *See Notice*, 33 FCC Rcd at 11364-65, paras. 31, 33 (discussing disclosure of relevant orbital characteristics and discussing selection of orbits with presence of significant debris population); *see* Appendix A, Final Rules. *See also, e.g.*, McKnight Comments at 3 (stating that there are clusters of massive derelicts in LEO at particular altitudes that present unique and significant debris-generating potential); Iridium Comments at 6 (supporting a disclosure regarding the existence of known sources of debris in or nearby the applicant's proposed orbit).

[153] Boeing Comments at 18. *See also* Telesat Comments at 5 (with regard to operations in higher debris regions, an applicant seeking authorization to operate in such a region will necessarily need to account for this debris in demonstrating compliance with the collision risk metrics, and as a result, additional restrictions on operating in more populated areas of space are unnecessary).

[154] *See* ORBCOMM Comments at 10 (disagreeing with a ban on deployments into areas where debris is particularly dense, but supporting a disclosure requirement specifying assurances on how an applicant plans to reduce risks associated with areas of higher collision risk).

[155] NASA notes that depending on how early an operator begins the licensing process, it may be too late for operators to redesignate their orbital destination, and so this assessment would be better performed and approved early in an operator's design/development phase. *See* NASA Comments at 1, 4. We agree that analysis of the planned orbit(s) should occur as early as possible, to avoid a situation in which an operator must change its planned orbit at a later stage.

[156] *Notice*, 33 FCC Rcd at 11365, para. 35.

[157] *Id.*

[158] *See, e.g.*, LeoSat Comments at 4; Iridium Comments at 4; McKnight Comments at 3; Boeing Comments at 21; OneWeb Comments at 3-7.

capabilities of the satellites such as maneuverability, costs of maneuvering (such as interruption of service), availability and timeliness of data on satellite parameters (both from telemetry and from radar or optical observations), planning cycles for maneuvers, and the time required to coordinate operations between systems, etc. Larger deployments of satellites into circular LEO orbits have been into separate orbital "shells." As a practical matter, in cases where two planned systems propose use of the same shell, coordination typically results in one or both systems adjusting planned orbital altitudes, so that the constellations are separated, rather than in the operators coordinating their operations at the same or overlapping altitude ranges. While some commenters urge that we adopt specific requirements for separation of orbits,[159] others argue that coordination, data sharing, and collision avoidance practices should be sufficient to avoid collisions, or that limits are not practicable for the regions in which some operators operate, particularly small satellite operators.[160] ORBCOMM states that the operational availability of NGSO orbits appears likely to become an increasingly scarce resource, but states that it is premature to try and set rules on maximum altitude variance and orbit selections.[161] Other commenters argue, particularly with respect to systems proposing large orbital variances, that the Commission must consider the impact of such systems on the rational, efficient, and economic use of orbital resources.[162] At this time, we decline to adopt a maximum orbital variance for NGSO systems and decline to adopt a required separation between orbital locations, and will instead continue to address these issues case-by-case. There are a wide range of considerations in such cases, and while we are concerned about the risk of collisions between the space stations of NGSO systems operating at similar orbital altitudes, as the Commission has previously stated, we think that these concerns are best addressed in the first instance through inter-operator coordination.[163]

53. As part of the disclosure of system characteristics, we note that some applicants for large systems may be asked to provide a description of the planned orbital variance, and the relationship of that variance to the system's technical capabilities and operational requirements (e.g., ability to avoid collisions). Such applicants may also need to address how their system operations will accommodate spacecraft transiting through the system and other systems, large or small, operating in the same region. If operators require a large orbit variance for their system, particularly if this might substantially constrain operations by other systems, they should plan to describe why and explain whether other less impactful alternatives were considered.

5. Protection of Inhabitable Spacecraft

54. The Commission proposed in the *Notice* that for any NGSO space station deployed above the International Space Station (ISS) and that will transit through the ISS orbit either during or following the space station's operations, the applicant provide information about any operational constraints caused

[159] *See, e.g.*, OneWeb Comments at 4-6, Iridium Comments at 4.

[160] Telesat Comments at 5. *See also* CSSMA Comments at 10 (arguing that orbital separation and orbital variance are not practicable for small satellite operator).

[161] ORBCOMM Comments.

[162] *See, e.g.*, Boeing Comments at 20-21. Boeing states that the ITU Constitute requires the consideration of limits on orbital variances, because Article 44 states that ITU Members States shall bear in mind that orbital resources "are limited natural resources" that must be used "rationally and efficiently, and economically." *Id.* (Citing ITU Constitution, Art. 44).

[163] *Space Exploration Holdings, LLC*, Memorandum Opinion, Order, and Authorization, IBFS File No. SAT-LOA-20161115-00118, 33 FCC Rcd 148, at para. 11 (2018). *See also* Letter from Brian D. Weimer, Counsel to WorldVu Satellites Limited, and Bruce A. Olcott, Counsel to The Boeing Company, to Marlene H. Dortch, Secretary, FCC, IBFS File Nos. SAT-LOI-20160428-00041, SAT-LOA-20160622-00058 (Mar. 23, 2017) (letter indicating that Boeing was planning to alter the orbital altitude of its then-proposed constellation following discussion with OneWeb on maintaining sufficient orbital separation between two constellations).

to the ISS or other inhabitable spacecraft[164] and strategies used to avoid collision with such spacecraft.[165] The Commission explained that normal operations of the ISS could be disrupted or constrained by collision avoidance maneuvers that the ISS would need to perform to avoid satellites transiting through the ISS orbit.[166]

55. We conclude that it is in the public interest to adopt the proposed disclosure requirement.[167] The statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and enable the operator to avoid posing any undue operational constraints to the inhabitable spacecraft. Commenters agree that special protections should be afforded to inhabitable spacecraft.[168] We find that requiring this information will help to ensure that the applicant has taken into consideration the inhabitable spacecraft, and will provide information in the public record to help the Commission and other interested parties, such as NASA, determine if there are any potential issues with the applicant's operations vis-à-vis the ISS or other inhabitable spacecraft. NASA states that disruption to ISS operations may be lessened if a spacecraft in the process of disposal through atmospheric reentry remains active and able to maneuver until the apogee is below ISS altitude.[169] We conclude that the benefits in assuring the safety of human life in space and minimizing disruption to the operations of inhabitable spacecraft outweighs any additional cost to applicants in preparing such a disclosure.

6. Maneuverability

56. *Disclosure.* Maneuverability can be an important component of space debris mitigation, both by enabling space stations to engage in collision avoidance and by facilitating spacecraft disposal. The Commission proposed in the *Notice* that applicants disclose the extent of maneuverability of the planned space stations.[170] The Commission noted that this 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, including the period both during the satellite's operational lifetime and during the remainder of its time in space prior to disposal.[171] The Commission tentatively concluded that this information could assist in the Commission's public interest determination, particularly regarding any burden that other operators would have to bear in order to avoid collisions and false conjunction warnings.[172] Most commenters addressing this topic agree with the maneuverability disclosure,[173] and we adopt this disclosure.

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[164] We use the term "inhabitable spacecraft" to mean any spacecraft capable of having crew aboard. Secure World Foundation points out that there may be additional human-occupied spacecraft on orbit in the coming years, and supports requirements that take these additional spacecraft into consideration. Secure World Foundation Comments at 4.

[165] *Notice*, 33 FCC Rcd at 11363-64, para. 30.

[166] *Id.*

[167] This includes transit either during the applicant space stations' mission or de-orbit phase. *See* Appendix A, Final Rules.

[168] *See, e.g.*, OneWeb Comments at 11; SpaceX Comments at 7.

[169] NASA Comments at 4. Consistent with the rule we adopt in the section that follows, we expect that all applicants with planned operations above the ISS altitude will have maneuvering capabilities.

[170] *Notice*, 33 FCC Rcd at 11367, para. 39.

[171] *Id.*

[172] *Id.*

[173] *See, e.g.*, SES/O3b Comments at 3; NASA Comments at 5; Telesat Comments at 6; CSSMA Comments at 12; OneWeb Comments at 13. *See also* University Small-Satellite Researchers Comments at 10-11 (supporting informational disclosures generally, in lieu of mandatory propulsion requirements).

57. LeoSat disagrees with the proposal, arguing that specific information related to satellite maneuverability is proprietary and competitive in nature, that public disclosure of this information as part of an application could prompt a "race to the bottom" among satellite operators, and that any information initially disclosed in an application will become stale and inaccurate as the operator's satellites age and their propulsion capacity is consumed.[174] It does not appear that LeoSat has support among fellow satellite operators for its proposition that satellite maneuverability information is proprietary and competitive.[175] Further, even if such information has some potential "competitive" value, such information would likely need to be shared with another operator in the event of a potential conjunction, and all operators will be better able to make informed decisions if they have a baseline understanding of the maneuvering potential of other satellites in orbit. Moreover, it is not clear to us how disclosure would cause a "race to the bottom," and even if information became outdated as some spacecraft were no longer able to maneuver, having initial information on what capabilities the satellites were designed with could still assist the Commission in its review of the system and also assist other operators. We find that the benefits of having information regarding maneuverability as part of the record outweigh these commenters' generalized competitive concerns.[176] Boeing also disagrees in some respects with the proposed disclosure on the basis that the Commission has not provided guidance on the number of avoidance maneuvers that would be presumptively deemed acceptable.[177] We plan to consider the maneuverability disclosure as factual information, and at this time do not establish a presumptive number of avoidance maneuvers that would trigger concern.[178] We believe that on balance, this area is an appropriate one for a disclosure and provides useful information, including to other operators. We encourage operators to submit as much information as they reasonably can regarding maneuverability, ideally providing the type of information mentioned by NASA in its comments, including maneuver methods and capabilities, as well as any other mechanisms to mitigate conjunction likelihood (e.g., cross-sectional area modulation).[179] This would also include information regarding the propulsive technology itself (i.e., ion thrusters, traditional chemical thrusters, etc.), thrust level, and a description of the guidance and operations scheme for determining maneuvers, where applicable. Generally speaking, operators should submit a written description of the space stations' expected capabilities, including, if possible, the expected time it would take the space station to modify its orbital location by a certain distance to avoid a collision.[180]

58. *Propulsion or Maneuverability Above a Certain Altitude.* The Commission also sought comment in the *Notice* on whether it should require all NGSO satellites planning to operate above a particular altitude to have propulsion capabilities reserved for station-keeping and to enable collision avoidance maneuvers, regardless of whether propulsion is necessary to de-orbit within 25 years, and if so,

[174] LeoSat Comments at 5.

[175] *See* CSSMA Reply at 10 (stating that it does not believe that just revealing the category of maneuverability of all space stations will disadvantage any applicant significantly).

[176] *Id.*

[177] Boeing Comments at 23. Boeing states that the Commission should not use the information to withhold or condition the authorization of any NGSO system, at least until the satellite industry and the Commission gain more experience regarding the frequency and reliability of collision avoidance techniques. Boeing Comments at 24.

[178] As described below, we do adopt a separate certification regarding maneuverability sufficient to conduct collision avoidance during any period when spacecraft are above 400 km.

[179] *See* NASA Comments at 5.

[180] *See also* OneWeb Comments at 13 (stating that the disclosure should include information detailing the satellite's maneuvering capabilities, including achievable conjunction separation distances based upon decision lead time and the process by which an applicant intends to assess conjunctions and execute required evasive maneuvers).

what altitude should be adopted.[181]

59. Among those supporting this requirement, the majority of commenters identify 400 km as an altitude above which propulsion or other maneuvering capabilities should be required, generally based on the approximate operational altitude of the ISS.[182] We also note that the Commission had raised a similar issue previously in its order on *Streamlining Licensing Procedures for Small Satellites (Small Satellite Order*), and ultimately decided to adopt a propulsion requirement above 600 km, for small satellites seeking streamlined treatment.[183] In that context, a number of commenters had raised concerns regarding small satellites that lacked capabilities to maneuver for collision avoidance and the impact of those satellites on space safety in the LEO environment, and the Commission concluded that it would address those concerns as part of this proceeding.[184] After review of the record, we adopt an approach that we find will address some of the significant concerns regarding uncontrolled satellites being deployed above the ISS. Specifically, we adopt a requirement that all NGSO satellites or systems deployed above 400 km must have the capability to maneuver sufficient to conduct collision avoidance during the time when the spacecraft are located in an orbit with an apogee[185] above 400 km.[186]

60. We agree with the majority of commenters that 400 km is an appropriate cut-off for a propulsion or maneuverability requirement. 400 km is the approximate altitude where the ISS operates, and so requiring a certain level of maneuverability above this altitude would enable operators to more readily avoid the ISS, and therefore should help minimize the number of collision avoidance maneuvers that would need to be undertaken by the ISS.[187] This approach should also ensure that the burden for conducting collision avoidance maneuvers is more evenly distributed among operators, since those operators authorized by the Commission would all have some collision avoidance capability. Additionally, objects deployed below 400 km will typically re-enter Earth's atmosphere in a very short time, usually within months, and in some cases CubeSats with more limited functionality are deployed

[181] *Notice*, 33 FCC Rcd at 11365, para. 34. The Commission had also asked whether it should adopt this requirement in lieu of some proposed disclosures—such as requiring applicants operating above a certain altitude to justify their choice of orbit, and requiring applicants to provide disclosures regarding orbit selection and assurances on how they plan to reduce risks. *Id.* at 11364-65, paras. 31-33. The Commission also sought comment on whether it should seek additional information or assurances from applicants in certain specific circumstances, such as where they seek to deploy a large constellation in certain sun-synchronous orbits that have an increased likelihood of congestion. *Id.*

[182] *See, e.g.*, Iridium Comments at 6 (stating that applicants planning to deploy NGSO spacecraft above 400 km have a responsibility to maintain custody and control of their spacecraft); OneWeb Comments at 11, 14-15 (operators should demonstrate an ability to control the trajectories of their spacecraft and capability to execute timely and effective collision avoidance maneuvers if they are proposing to operate above the ISS); SpaceX Comments at 8 (operators planning to deploy satellites above and around the ISS should be required to have propulsive capabilities); McKnight Comments at 3-4 (maneuverability should be required for any space system deployed above crewed space stations); Aerospace Comments at 10 (stating that active collision avoidance should be required for any spacecraft that would transit the altitude of a crewed spacecraft); Amazon Reply at 4 (stating that the Commission should heed support in the record for imposing maneuverability standard above 400 km).

[183] *Small Satellite Order*, 34 FCC Rcd at 13092, para. 42. In the *Small Satellite Order*, the Commission noted that it was adopting the 600 km certification for streamlined small satellite applicants, pending the additional discussion as part of this proceeding. *Id.* at 10394, para. 45. Based on the updated rules we adopt in this proceeding, we adopt conforming changes to the certification for streamlined small satellite applicants. *See* Appendix A, Final Rules.

[184] *Small Satellite Order*, 34 FCC Rcd at 10394, para. 46.

[185] For objects orbiting the Earth, the point in orbit that the object is farthest from the Earth is known as its "apogee." The point in orbit that the object is closest to the Earth is known as the object's "perigee." These terms are already used in several places in part 25 of our rules. *See, e.g.*, 47 CFR § 25.114(6).

[186] *See* Appendix A, Final Rules.

[187] *See* above for a discussion of requirements specifically addressing the ISS and other inhabitable spacecraft.

from the ISS, spending their mission below that altitude. Thus, at this time, we are less concerned with non-maneuverable space stations deployed below 400 km. Some commenters disagree with requiring maneuverability or propulsion for all satellites above 400 km. These commenters are generally concerned with the impact of such a rule on the utility of CubeSats and on low-cost missions such as academic missions, since such small satellites may not have the volume or electrical capacity to support a propulsion system.[188] As discussed below, rather than a propulsion requirement we adopt a certification that the space station will have sufficient maneuverability for avoiding collisions (whether by use of a propulsion system or otherwise). Additionally, the technology for maneuverability, including propulsion, continues to advance rapidly—and will become increasingly feasible for inclusion on small satellites with low-cost missions, to the extent that operators of those missions want to deploy satellites above 400 km. While we recognize this may limit deployment altitude options for some missions, there are significant benefits to requiring collision avoidance capabilities, as described above. In some instances, operators may need to deploy non-maneuverable satellites at lower orbits anyway in order to achieve an acceptable collision risk.[189] Thus, we conclude that the benefits of the rule, in protecting the ISS, improving space safety by ensuring that more satellites have the capabilities to conduct collision avoidance, and helping to more evenly distribute the burden to conduct collision avoidance maneuvers among operators, justify the limitations it imposes.

61. It is our understanding that on occasion a spacecraft will visit the ISS on a resupply mission, for example, then undock with the ISS and raise the spacecraft orbit to above the ISS before deploying satellites.[190] In these instances, any satellites that are to be deployed may apply for a waiver of the rule regarding maneuverability above 400 km. In reviewing such a waiver request, we will consider whether these operations are already closely coordinated with NASA vis-à-vis the ISS, and are sufficiently unique that they are unlikely to result in a large numbers of non-maneuverable objects at altitudes above the ISS.

62. A few commenters support a propulsion requirement for satellites operating above 400 km,[191] but other commenters suggest that in many instances non-propulsive maneuverability is adequate to minimize collision risk.[192] We conclude that satellite maneuverability sufficient to conduct collision

[188] *See, e.g.*, Global NewSpace Operators Comments at 8-9 (arguing that a requirement for maneuverability above crewed spacecraft should, among other things, be based on realistic standards that do not preclude smaller operations from performing technology demonstrations); CSSMA Reply at 7-8 (observing that imposing an orbital limit of 400 km for propulsion-less satellites would render them non-commercially viable with generally less than 1-year lifetimes); University Small-Satellite Researchers Reply at 2-3 (stating that it would be prohibitively expensive for university researchers to comply with propulsion requirements, and that mandating propulsion would effectively preclude university small-satellite missions from launching since many operate at altitudes between 400 and 600 km).

[189] NASA states that the need for propulsion be driven by the spacecraft's ability to meet the 0.001 lifetime collision risk rule and the "25-year rule." NASA Comments at 4. *See also* Boeing *Ex Parte* at 14. Given the large number of commercial and other non-Federal deployments anticipated in the coming years, we conclude that it is prudent to adopt a maneuverability requirement for all Commission-authorized space stations above 400 kilometers at this time.

[190] *See, e.g.*, Spire Global, Inc., SAT-LOA-20151123-00078 (deployment of CubeSats from the OA-5 Cygnus launch vehicle into orbit above the ISS, after the launch vehicle docked with the ISS).

[191] Iridium Comments at 6; Maxar Comments at 13; SpaceX Comments at 8.

[192] *See, e.g.*, CSSMA Comments at 10; Global NewSpace Operators Comments at 8; Boeing Comments at 19 (arguing that the Commission should allow satellites applicants to provide demonstrations that the techniques they propose to employ are adequate to enable responsive maneuvers); OneWeb Comments at 15 (stating that it does not oppose licensing of spacecraft using differential drag or similar mechanisms if operators can demonstrate that their reliance on these techniques facilitates timely collision avoidance); ORBCOMM Comments at 11 (suggesting that the Commission require "maneuverability" sufficient for collision avoidance and de-orbiting at end of life, since that option would provide satellite system operators with the flexibility to use other potential technologies that could

(continued….)

avoidance maneuvers is appropriate for systems that will operate above 400 km. It appears that at this time propulsion capabilities provide a generally more reliable and effective means for spacecraft to avoid collisions, but we will adopt a performance-based requirement that considers other satellite maneuvering capabilities as well where the operator is able to demonstrate that the capabilities are sufficient to reasonably conduct collision avoidance maneuvers on an ongoing basis. The record indicates that space stations using differential drag may not in some instances be able to reliably perform active collision avoidance.[193] We will, however, consider these types of capabilities on a case-by-case basis and applicants in all cases should describe how far in advance they would need to act if they deem a particular conjunction warning actionable, and describe whether the space station would in fact be able to maneuver sufficiently during that time period to avoid collision. Applicants planning to deploy satellites with propulsion should also provide this information, as not all propulsion systems may have the same capabilities.[194] Some commenters proposed that the Commission consider more specific standards for maneuverability, but we decline to do so at this time, given the lack of consensus as to what standards may be appropriate.[195] We may revisit this issue in the future. We expect that in some instances an operator may need to use propulsion in any event to successfully perform collision avoidance.

63. *Grandfathering.* There are a number of currently-authorized systems that may not satisfy the requirement we adopt today,[196] and we understand that such a requirement could have a significant impact on these systems, which do not have the ability to, for example, add propulsion to existing satellites, and which may not have the ability to add propulsion or maneuverability to satellites already

(Continued from previous page)
accomplish the same goals); Aerospace Comments at 10 (stating that an object could avoid a collision as it transits a crewed spacecraft's altitude using drag modification or some similar approach).

[193] NASA notes, for example, that utilization of differential drag does not provide the full range of collision avoidance functions that best protect safety of flight. NASA Comments at 5. NASA states that because the differential drag approach changes orbit trajectories much more slowly, it is necessary to act significantly earlier in the development of a typical collision avoidance event, using more coarse information which results in more mitigations than would be necessary otherwise. *Id.* NASA further notes that late-notice conjunction events cannot be addressed satisfactorily with differential drag methodology, or in some cases addressed at all. *Id.* at 5-6. *See also* Iridium Comments at 6 (stating that propulsion is necessary for a space station to make effective collision avoidance maneuvers). *But see* CSSMA Comments at 14; CSSMA Reply at 11-12 (supporting consideration by the Commission of differential drag as an effective means of preventing collisions and summarizing its members experience with differential drag); University Small-Satellite Researchers Comments at 2 (noting that university small satellite missions are increasingly investigating the employment of drag devices as means of collision avoidance, maneuverability, and facilitating deorbit).

[194] *See, e.g.* NASA Comments at 6 (stating that electric propulsion, as presently employed, can be slow-acting and in general to mitigate conjunctions it is simply turned off (rather than sustain a change in thrust pattern) to alter the current trajectory).

[195] *See, e.g.*, Telesat Comments at 5 (stating that the spacecraft should be capable of performing timely and effective collision avoidance maneuvers sufficient to reduce probability of a collision per conjunction for the spacecraft to less than 0.001); Amazon Reply at 5 (stating that in order to be considered sufficiently maneuverable for purposes of this requirement, satellites should be capable of maneuvering at least 5 km within 48 hours); Aerospace Comments at 10 (positing that the rule might be stated in terms of reducing the probability of collision to less than some threshold within a specified warning period, but not including a numeric suggestion).

[196] *See, e.g.*, Planet Labs Inc., SAT-MOD-20170713-00103; Spire Global, SAT-PDR-20190321-00018 (granted-in-part Oct. 7, 2019) (including a condition that Spire must comply with any new rules adopted by the Commission as a result of this rulemaking); Swarm Technologies, Inc., SAT-LOA-20181221-00094 (granted Oct. 17, 2019) (including a condition that Swarm's grant is subject to modification to bring it into conformance with any rules or policies adopted by the Commission in this rulemaking). We list here several commercial systems, but there are amateur and experimental authorized satellites in this category as well. Amateur and experimental authorizations typically only include one or two satellites.

under construction without significant cost.[197] Given these considerations, we conclude that any existing authorized systems will not need to meet this requirement for satellites launched within the next two years (i.e., before April 23, 2022).[198] This two-year timeline should account for those satellites that are currently in later stages of construction, for which it would be less feasible to make significant design alterations. We will also require that any licensee with a license that provides for launch of satellites that lack maneuverability required by the new rule, should file an application for a modification with respect to any satellites to be launched on or after April 23, 2022, to include the capability to maneuver.[199] These modification applications must be filed on or before October 23, 2021, to provide the Commission time to process the modification requests before the April 23, 2022 date. As noted, the addition of propulsion or other systems enabling collision avoidance may result in a significant cost for re-design of the satellite systems currently lacking such capabilities, or consideration of an alternative orbit for deployment. We encourage all operators to add enhanced maneuverability capabilities to their satellites in order to enhance the ability to avoid collisions or to consider deployments below 400 km.

C. Tracking and Data Sharing

64. In the *Notice*, the Commission observed that the successful identification of satellites and sharing of tracking data are important factors in the provision of timely and accurate assessments of potential conjunctions with other spacecraft.[200] We continue to believe that improvements in the ability to track and identify satellites may help to reduce the risk of collisions. These factors can help to enable effective collision avoidance through coordination between operators, and improve the accuracy of conjunction warnings, whether those warnings are from a public or private entity specializing in space situational awareness and space traffic management. The Commission made several specific proposals in the *Notice* related to trackability, identification, and sharing of tracking data, which are discussed below. We adopt a number of our proposals in this area, while ensuring that our rules provide flexibility for the continued advancement of space situational awareness and space traffic management functions, including any transition of certain activities in the United States to a civilian entity, and the accommodation of non-governmental associations and other private sector enterprises engaged in these functions.

65. We also received several comments addressing improvements to the U.S. space situational awareness and space traffic management functions more generally.[201] In this proceeding, the Commission has not considered other activities related to space situational awareness and space traffic management, such as maintaining a comprehensive catalog of space objects or providing conjunction warnings.[202] These functions as a general matter are well beyond the type of analysis that we have historically addressed through our rules and licensing process, but we suggest that these comments be filed for consideration in the proceeding currently underway in the Commerce Department,[203] if they have

[197] *See* Maxar Comments at 13 (suggesting that if a requirement is adopted that satellites have propulsive capabilities above 400km, the agency should take steps to ensure that existing satellites are grandfathered). We note that most of the planned large constellations that would provide FSS would also have propulsion capabilities.

[198] *See* part VI, Ordering Clauses.

[199] *Id.*

[200] *Notice*, 33 FCC Rcd at 11365, para. 36.

[201] *See, e.g.*, CSSMA Comments at 14-15; Secure World Foundation Comments at 3; Association of Space Explorers Comments at 2-3; Keplerian Tech Comments at 9-11.

[202] Although a small number of commenters supported an expanded role for the FCC, including in coordination of space traffic management efforts, other commenters stated that the FCC should not take on a prominent role in space traffic management. *See, e.g.* ORBCOMM Comments at 5.

[203] *See* Request for Information on Commercial Capabilities in Space Situational Awareness Data and Space Traffic Management Services, Notice and request for comments, 84 FR 14645 (April 7, 2019) (Department of Commerce RFI); Commerce Department Comments at 8-9.

not been already, so that the comments can be taken into consideration in that context.

66. Relatedly, the Commerce Department notes that its Request for Information on Commercial Capabilities in Space Situational Awareness Data and Space Traffic Management Services (RFI), issued last year, will have bearing on the Commission's proposals in this proceeding, and asked us to take their RFI into consideration in this proceeding.[204] We have reviewed the comments filed in response to the RFI, and note that in some instances they are the same in part, or similar to comments submitted to the docket file for the instant proceeding. Other comments to the RFI focus on space situational awareness and space traffic management functions, such as development of an open architecture data repository, that are not directly germane to the Commission's proposals.[205]

1. Trackability and Satellite Identification

67. *Trackability*. The Commission proposed in the *Notice* to require a statement from an applicant regarding the ability to track the proposed satellites using space situational awareness facilities, such as the U.S. Space Surveillance Network.[206] The *Notice* also proposed that objects greater than 10 cm by 10 cm by 10 cm in size be presumed trackable for LEO.[207] For objects with any dimension less than 10 cm, the Commission proposed that the applicant provide additional information concerning trackability, which will be reviewed on a case-by-case basis.[208]

68. Commenters generally support the proposed approach to size as it relates to trackability.[209] NASA recommends that the term "satellite trackability" be interpreted to mean that an object is trackable if, through the regular operation of space situational awareness assets, it can be tracked and maintained so as to be re-acquirable at will, and that the object's orbital data is sufficient for conjunction assessments.[210] According to NASA, this will typically mean that the object possesses trackability traits (e.g., sufficient size and radar/optical cross-section) to allow it to be acquired routinely by multiple space situational awareness assets in their regular modes of operation.[211] Several commenters agree that in LEO, a 10 x 10 x 10 cm cube should meet this standard.[212] We agree, and adopt the proposed rule stating that space stations of this size in LEO are deemed presumptively trackable, modified

[204] Commerce Department Comments at 8-9.

[205] *See, e.g.*, Response of L3 Applied Defense Solutions to Department of Commerce RFI, posted May 24, 2019 (describing its various capabilities for sensing, analytics, visualization, data sharing, and data management that could be provided through an open architecture); Response of Amazon Web Services, Inc., to Department of Commerce RFI, posted May 24, 2019 (providing information on its capabilities as a cloud services provider to enhance development of an open architecture data repository for space situational awareness/space traffic management data). These comments and others filed in response to the Commerce Department RFI are available at https://www.regulations.gov/docket?D=DOC-2019-0001.

[206] *Notice*, 33 FCC Rcd at para. 36.

[207] *Id.*

[208] *Id.*

[209] *See* OneWeb Comments at 11-12; Iridium Comments at 7; Boeing Comments at 21. *See also* University Small-Satellite Researchers Comments at 11 (agreeing with the Commission's presumed trackability proposal and stating that the Commission should consider an informational disclosure rather than an operational requirement); Aerospace Comments at 11 (stating that requiring trackability is more important than defining size of objects, but stating that the 10 cm tracking size limit can be a rule of thumb, and suggests using a 10 x 10 x 10 cm minimum size for LEO as an exemplar).

[210] NASA Comments at 4-5.

[211] *Id.*

[212] *See, e.g. id.*; Aerospace Comments at 11; OneWeb Comments at 12.

slightly to cover space stations that are 10 cm or larger in their smallest dimension.[213] We clarify that this presumption covers those space stations that are 10 cm or larger in their smallest dimension excluding deployable components.[214]

69. CSSMA proposes that the Commission require applicants to simply certify that they can be tracked reliably by widely available tracking technology.[215] Swarm similarly suggests that the rules permit smaller satellite form factors pursuant to an affirmative demonstration that such spacecraft can be accurately tracked, and that size should be merely one factor in assessing trackability.[216] Although there may be future improvements in standard space situational awareness tracking facilities,[217] at this time we believe it is in the public interest to adopt the presumed trackable approach for space stations in LEO larger than 10 cm in the smallest dimension, and for other cases, including where a satellite is planning to use deployable devices to increase the surface area, we conclude that operators should provide more information to support their conclusion that the space station will be reliably trackable. For a spacecraft smaller than 10 cm x 10 cm x 10 cm, for example, some of the standard space situational awareness tracking facilities may no longer be able to track the satellite. In these instances, part of a demonstration supporting a finding of trackability may be a showing that the operator has taken on the cost of bringing the trackability back up to the level it would be for a larger spacecraft, perhaps by enlisting a commercial space situational awareness provider. CSSMA and others argue that the Commission should permit operators flexibility to choose appropriate solutions,[218] and that ground-based space situational awareness capabilities may improve significantly in the future.[219] We find that our approach provides operators with flexibility to satisfy the Commission's rule, because it permits a case-by-case assessment of trackability where the space station is smaller than 10 cm in the smallest diameter. Global NewSpace Operators argues that we should provide further detail on what information we are looking for in the disclosure, for example, to what accuracy and how often should tracking occur, and whether we will ask for verification from the space situational awareness provider that they can indeed track the proposed satellites.[220] We decline to provide additional detailed guidance in our rules on this topic, as an acceptable disclosure could vary significantly depending on the trackability solution that will be used by the applicant. We expect, however, that applicants will specify the tracking solution and provide some indication of prior successful demonstrated use of the technology or service, either as part of a commercial or government venture. This would include addressing reliability of deployment of any deployable spacecraft parts that are being relied on for tracking. Tracking solutions that have not been well-established or previously demonstrated will be subject to additional scrutiny, and applicants may need to consider a back-up solution in those instances.

70. In addition, our rule provides flexibility for trackability demonstrations above LEO, where Aerospace states that it is not clear that a 10 cm x 10 cm x 10 cm object could be reliably

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[213] This would enable a spherical space station, for example, to presumptively satisfy the rule so long as it has a diameter of 10 cm or greater.

[214] Space stations smaller than 10 cm in the smallest dimension, but which will use deployable components to enhance trackability will be analyzed on a case-by-case basis.

[215] CSSMA Comments at 11.

[216] Swarm Reply at 8.

[217] *See, e.g,* Aerospace Comments at 11 (noting that tracking levels will likely undergo a significant change with the activation of the Space Fence); Swarm Reply at 3-4 (suggesting that implementation of new technologies such as the Space Fence have improved and will continue to improve trackability).

[218] CSSMA Comments at 11; Aerospace Comments at 11 (stating that requiring trackability is more important than defining size of objects, but stating that the 10 cm tracking size can be used as an exemplar for the LEO region).

[219] CSSMA Comments at 11.

[220] Global NewSpace Operators Comments at 9.

tracked.[221] Aerospace states that the assumed size for reliable tracking in the GEO region by the current Space Surveillance Network is one meter, done primarily with optical sensors.[222] The Commission will address the trackability demonstration on a case-by-case basis for satellites that would operate above the LEO region, including in the GEO region, and we do not see the need at this time to include a specific size value in our rules for those space stations.

71. In the *Notice*, the Commission inquired whether there were 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.[223] Aerospace suggests that hardware such as transponders or other signature enhancements and data sharing would benefit trackability, but it is not clear that any commercial transponder hardware or comprehensive data sharing methods currently exist.[224] Aerospace states that a potential rule could drive development in this area, and consider enhancements such as radar reflectors for small objects in orbits well above LEO.[225] NASA cautions against relying on active tracking assistance that would no longer occur once the spacecraft is unpowered, and observes that at the present time, on-board tracking improvement methods such as beacons or corner cube reflectors are not sufficiently supported by space situational awareness assets to enable significant and reliable tracking improvements.[226] Keplerian Tech suggests that the Commission should mandate the use of an independent transponder solution, such as the space beacon that it has developed.[227] Swarm suggests that trackability can be improved through the use of active or passive signature enhancements, such as the passive radar retro reflectors that would be used by Swarm's proposed satellites.[228] CSSMA opposes a specification of any particular type of tracking technology, and suggests that mandating use of an independent tracking solution would impose unnecessary costs on operators.[229] According to CSSMA, the level of trackability needed to maintain a safe orbital environment can already be attained by well-established active or passive tracking methods.[230]

72. We conclude that the provision of position data in addition to standard space situational awareness data, through radiofrequency identification tags or other means, may ultimately be a way to support a finding that a spacecraft smaller than 10 cm x 10 cm x 10 cm is trackable, but until the establishment of the commercial data repository, reliance on most alternative technologies does not appear to be readily implementable. A number of commenters oppose the adoption of any rule that would specify a particular type of tracking technology.[231] We agree. While we encourage operators to use various means to ensure that their spacecraft is trackable and to help ensure that accurate positioning information can be obtained, we believe it is premature to require that operators use a particular tracking

[221] Aerospace Comments at 11.

[222] *Id*.

[223] *Notice*, 33 FCC Rcd at 11365-66, para. 36.

[224] Aerospace Comments at 11

[225] *Id*.

[226] NASA Comments at 5. NASA notes that this could change however, as the commercial space situational awareness industrial base broadens. *Id.*

[227] Keplerian Tech Comments at 14.

[228] Swarm Reply at 7-8. Swarm states that the passive radar retro reflectors increase the radar signature of a 1/4U satellite to more than the signature of the average 1U satellites in operation. *Id.*

[229] CSSMA Reply at 8.

[230] *Id*.

[231] Boeing Comments at 21-22; CSSMA Reply at 8.

solution, such as an independent transponder.[232] As technologies for obtaining spacecraft positioning information continue to evolve, however, we may revisit this issue in the future.

73. We do adopt the disclosure proposed in the *Notice* that applicants specify whether space station tracking will be active (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.[233] This disclosure, in connection with the other descriptive disclosures discussed in this section, will provide a way for the Commission and any interested parties to understand the extent to which the operator is able to obtain satellite positioning information separately from information provided by the 18th Space Control Squadron or other space situational awareness facilities. We believe this requirement presents minimal costs, since an operator will readily have access to this information based on the basic characteristics of its spacecraft (for example, will it be transmitting its Global Positioning System location information via transponder?).[234] Operators are likely to select either active or passive means of tracking depending on the mission specifications, but it is useful for the Commission to understand as part of its holistic review of the application, the overall trackability and ability to identify the satellite.[235]

74. Relatedly, we also adopt the *Notice* proposal that operators certify that their space station will have a unique telemetry marker allowing it to be distinguished from other satellites or space objects.[236] This is the same as the certification we have previously adopted for small satellites applying under the streamlined process,[237] and is unlikely to pose any additional costs for most operators, since the vast majority of operators already distinguish their satellite's signal from other signals through use of unique signal characteristics.[238] Few commenters addressed this issue, and some expressed support[239] or sought clarification.[240] As we clarified in the *Small Satellite Order*, we expect that when a spacecraft transmits telemetry data to the ground it will include in that transmission some marker that allows the spacecraft to be differentiated from other spacecraft.[241] This signal-based identification marker, which should be different from those of other objects on a particular launch, can assist with identification of a satellite for space situational awareness purposes.[242] Boeing argues that the Commission does not need to

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[232] *See, e.g.*, Keplerian Technologies Comments at 11-13 (suggesting that the Commission mandate use of an independent tracking solution on all licensed spacecraft). *See also* Intelsat Comments at 5 (suggesting that new NGSO satellites be equipped with broadcast beacons and/or corner reflectors).

[233] *Notice*, 33 FCC Rcd at 11366, para. 36; *see* Appendix A, Final Rules.

[234] *See* OneWeb Comments at 12 (supporting disclosure of whether satellite tracking will be active or passive); Intelsat Comments at 6 (proposing that NGSO operators certify that they will use available measures to track their satellites).

[235] *See* Boeing Comments at 21 (stating that if the Commission adopts this information disclosure requirement, it should concurrently confirm that it does not require the use of active tracking systems and as long as an applicant's satellites can be tracked using passive measures, a statement is sufficient).

[236] *Notice*, 33 FCC Rcd at 11366, para. 36; *see* Appendix A, Final Rules.

[237] *Small Satellite Order*, 34 FCC Rcd at 13098 para.56.

[238] CSSMA notes, for example, that operators already voluntarily share their NORAD Catalog Number or International Designator, which are standard in the industry, with the 18th Space Control Squadron. CSSMA Comments at 11.

[239] *See, e.g.*, Intelsat Comments at 5.

[240] University Small-Satellite Researchers sought clarification in the small satellite proceeding and here about what the Commission meant by a "unique telemetry marker." University Small-Satellite Researchers Comments at 11.

[241] *Small Satellite Order*, 34 FCC Rcd at 13098, para. 56.

[242] *Id.*

verify whether an active telemetry marker will be unique since satellite operators have adequate incentives to distinguish their own telemetry beacons from those of other satellites,[243] but we disagree, because smaller-scale operators may not have these incentives or know that they should implement this type telemetry marker to help identify their satellite.

75. *Identification.* Additionally, the Commission sought comment on whether applicants should be required by rule to provide information about the initial deployment to the 18th Space Control Squadron or any successor civilian entity.[244] We noted that, as an example, communications with the 18th Space Control Squadron may be particularly important in the case of a multi-satellite deployment to assist in the identification of a particular satellite.[245] We adopt a rule requiring that applicants disclose how the operator plans to identify the space station(s) following deployment, for example, how the operator plans to obtain initial telemetry.[246] We expect that for most operators this disclosure will be fairly straightforward, but requesting this information, alongside the other information requested on satellite trackability, will help the Commission and any other interested parties to understand whether the satellite poses a risk of being misidentified following deployment, for example, in the case of a multi-satellite deployment.[247] As Global NewSpace Operators suggests, we will consider favorably in an application the use of radiofrequency transponder tags or other unique telemetry markers that can support the identification of objects once in orbit.[248] Overall, we want to emphasize the importance of operators planning for satellite identification in advance so that they are able to troubleshoot potential issues, particularly for multi-satellite deployments.[249] Also, as the Secure World Foundation suggests, we encourage additional research in this area on how identification aids may help distinguish one satellite from another early after payload separation.[250]

76. We also adopt a requirement that applicants must disclose whether the satellite will be registered with the 18th Space Control Squadron or successor civilian entity.[251] At this time, the typical registration process for new operators includes contacting the 18th Space Control Squadron via e-mail with information on the satellite common name, launch date and time window, launch location and launching agency, the satellite owning organization and operating organization, the contact information

[243] Boeing Comments at 21-22.

[244] *Notice*, 33 FCC Rcd at 11366, para. 37.

[245] *Id.*

[246] *See* Appendix A, Final Rules. We also adopt a conforming rule in section 25.122 that is applicable to small satellites and small spacecraft applying under the streamlined processes. *See id.*

[247] This approach is also generally supported by Global NewSpace Operators, who suggest that the Commission ask for disclosure from applicants that includes, among other things, the applicant's ability to obtain identification for its satellites. Global NewSpace Operators at 9 (also suggesting that applicants state the ability to obtain or generate prcise orbit determination and identification for its satellite(s)). Once an operator has identified its space station(s), we also encourage the operator to share that information with the 18th Space Control Squadron. *See* Space-Track.org, SSA Sharing and Orbital Data Requests (ODR), "Frequently Asked Questions," https://www.space-track.org/documentation#/odr (last visited January 14, 2020).

[248] Global NewSpace Operators Comments at 9.

[249] *See, e.g.*, Kasandra O'Malia, et. al., "Needle in a Haystack: Finding Two S-band CubeSats in a Swarm of 64 within 24 Hours," 33rd Annual AIAA/USU Conference on Small Satellites (2019) (describing challenges associated with identifying two CubeSats that were part of the multi-satellite Spaceflight SSO-A deployment in 2018).

[250] Secure World Foundation Comments at 4.

[251] *See* Appendix A, Final Rules. We also adopt a conforming rule in section 25.122 of the Commission's rules applicable to the optional part 25 small satellite and small spacecraft licensing process. *Id.*

for the operations center, and any usernames for the website Space-Track.org.[252] A number of established operators also maintain ongoing relationships with the 18th Space Control Squadron, either directly or through intermediary organizations, such as the Space Data Association, and routinely exchange information about upcoming launch activities. It is possible that this process may change in the future, but we adopt a disclosure requirement broad enough to accommodate "registration" generally, even if the process changes. We conclude that the costs associated with the disclosure, to the extent they are not already routinely followed by most established operations, are outweighed by the importance of operators sharing information with a central entity that can provide space situational awareness support. Additionally, the operators themselves benefit from the services that are provided at no charge by the 18th Space Control Squadron, and so the burden of operators disclosing whether they are in fact benefiting from these services is minimal.

2. Ongoing Space Situational Awareness

77. *Sharing Ephemeris and Other Information.* In addition to the sharing of information related to initial identification of a satellite included in the *Notice*, the Commission also proposed that space station operators share ephemeris and information on any planned maneuvers with the 18th Space Control Squadron or any successor civilian entity.[253] The *Notice* sought comment on whether this should be a requirement implemented through a rule.[254] The *Notice* also sought comment on whether NGSO operators should be required to maintain ephemeris data for each satellite they operate and share that data with any other operator identified in its disclosure of any operational space stations that may raise a collision risk.[255] The Commission observed that this requirement would help to facilitate communications between operators even before a potential conjunction warning is given.[256]

78. Most commenters agreed with the goals of the proposed requirements.[257] Some commenters argue that data sharing exchanges should respect owner/operator intellectual property and proprietary information and should be limited to only the information necessary to describe explicit maneuvers, initial deployment, or conjunction avoidance.[258] Several commenters also seek flexibility to share maneuverability and status data using any reasonable method identified by the providing operator.[259] After consideration of the record on this issue, we adopt a disclosure requirement regarding

[252] Space-Track.org, SSA Sharing and Orbital Data Requests (ODR), "Register Your Satellite/Payload with 18 SPCS," https://www.space-track.org/documentation#/odr (last visited January 14, 2020). There is also additional information that is optional, but encouraged, including the launch plan an orbital parameters and mission description. *Id.* Space-Track.org states that as soon as a satellite is registered, a member of the 18th Space Control Squadron will contact the owner/operator to discuss the details of the mission and coordinate conjunction assessment and other required support. *Id.*

[253] *Notice*, 33 FCC Rcd at 11366, para. 37.

[254] *Id.* at 11366, 11377, paras. 37, 73.

[255] *Id.* at 11377, para. 73.

[256] *Id.*

[257] *See, e.g.*, OneWeb Comments at 12; Telesat Comments at 6; Iridium Comments at 7-8; LeoSat Comments at 4; Intelsat Comments 5-6; Sirius XM Comments at 7-8; Iridium Comments at 7-8; Satellite Design-For-Recovery Comments at 2, 3; ORBCOMM Comments at 8.

[258] *See, e.g.*, CSSMA Reply at 9.

[259] *See* Boeing Comments at 22; Secure World Foundation Comments at 4; ORBCOMM Comments at 13; Lockheed Martin Comments at 11-12; CSSMA Reply at 8-9. CSSMA recommends, for example, that operators be encouraged, but not mandated to maintain a publicly available, regularly-updated repository of ephemeris and maneuverability data. CSSMA Comments at 11-12. As CSSMA notes in its comments, some operators, such as Planet and Spire, make ephemeris information public on an ongoing basis. *See* CSSMA Comments at 12 (citing, e.g., Planet Labs Public Orbital Ephemerides, Planet, http://ephemerides.planet-labs.com/).

sharing of ephemeris and other data. Specifically, we adopt a rule stating that applicants must disclose the extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers[260] with the 18th Space Control Squadron or successor entity,[261] or other entities that engage in space situational awareness or space traffic management functions, and/or other operators.[262] This also includes disclosure of risk thresholds for when an operator will deem it appropriate to conduct a collision avoidance maneuver. This disclosure provides an opportunity for the Commission to assess the extent to which the operator is actively engaging with space situational awareness facilities, keeping in mind that the need for such engagement may vary depending on the scale of the system.[263] We observe that for certain types of systems, for example, those using electric propulsion, sharing of ephemeris data is particularly critical in preventing collisions, and so we would look for a detailed description of those plans when assessing the application for those systems. The disclosure will also assist other operators in understanding how they may be able to best coordinate with the applicants' system and provide flexibility for operators to demonstrate how their plans for sharing information will facilitate space safety.[264] As one example, a particular operator may decide to share ephemeris information with the private Space Data Association,[265] which would be indicated in its disclosure.[266] This also addresses any operator's concerns regarding proprietary information and security,[267] since operators concerned with these issues could take them into consideration as part of their

[260] In addition to this information, SpaceX also suggests that operators share information regarding any non-functional satellites or anomalies. SpaceX Comments at 14; *but see* Boeing Reply at 27 (suggesting that some of the information mentioned by SpaceX may not be relevant to the core tracking mission of the 18th Space Control Squadron). We encourage operators to share this information as well, including with the 18th Space Control Squadron or successor entity, if it is useful to that organization, or in the context of an operator-to-operator coordination.

[261] Intelsat suggests that to facilitate data sharing, the Commission should encourage operators to agree on standards and established formats for sharing data, such as those used by the Consultative Committee for Space Data Systems. Intelsat Comments at 6. Aerospace commented that the recipient of the data will need to define the format and mechanism of the data sharing as well as accuracy verification. Aerospace Comments at 12. As part of the disclosure we encourage operators to disclose the format in which they will be sharing data—including whether it will be in a format acceptable to the 18th Space Control Squadron, for example. We note that the 18th Space Control Squadron has established guidance for submission of both ephemeris data and planned maneuvers. *See* 18th Space Control Squadron, Spaceflight Safety Handbook for Satellite Operators, Version 1.4, at 14, 27 (February 2019), *available at* https://www.space-ttrack.org/documents/Spaceflight_Safety_Handbook_for_Operators.pdf. The 18th Space Control Squadron can also support spacecraft end-of-life operations.

[262] *See* Appendix A, Final Rules.

[263] We also adopt a conforming edit in section 25.122 to the rules applicable to small satellite and small spacecraft applicants for streamlined processing. *See* Appendix A, Final Rules.

[264] Iridium, for example, states that it is critical that operators share their data with operators in nearby orbits, as it will help to ensure that operators make decisions related to satellite positioning based on the best situational awareness data available. Iridium Comments at 8. CSSMA notes that the reliability of owner-operator data cannot always be guaranteed, and thus should be used only to supplement any data gathered by a formal entity such as the 18th Space Control Squadron. CSSMA Reply at 9.

[265] The Space Data Association is a private international organization that works with satellite operators in sharing of operational data for space situational awareness and space traffic management. *See* Space Data Association, https://www.space-data.org/sda/ (last visited Jan. 16, 2020).

[266] Association of Space Explorers state that it is unrealistic to assume that any voluntary exchange of information among satellite operators would be sufficient for them to coordinate operations to avoid conjunctions. Association of Space Explorers Comments at 8. We disagree. Based on our understanding of organizations such as the Space Data Association, some voluntary exchanges could support coordination to avoid conjunctions.

[267] *See, e.g.*, Keplerian Tech Comments at 14 (expressing concerns about proprietary rights associated with data generated by spacecraft and their associated transponders); Lockheed Martin Comments at 12 (expressing concern

(continued….)

plan for how to share ephemeris[268]

79. We also extend this disclosure to experimental and amateur systems at the authorization stage.[269] As with the rule updates discussed above, we believe the benefits of this disclosure in encouraging space safety and coordination outweigh any costs to the operator in specifying the extent to which, and how, it will share ephemeris and other information during operations.[270]

80. Tyvak suggests that requiring licensees to submit information pertaining to planned maneuvers is not conducive to the flexibility of agile space,[271] but we do not see how submission of information in advance of planned maneuvers would have any significant impact on an operator's ability to perform such spacecraft maneuvers, and may provide other operators with useful information about the planned scope of operations that will facilitate coordination. Although we are adopting a disclosure requirement rather than an operational requirement, if this information changes during the course of the system's operations, the operator will need to update the file for its license or grant by specifying how it has changed.

81. We conclude that this disclosure is more beneficial than a more specific requirement, as it provides flexibility for operators to use a combination of different resources, including private sector space situational awareness resources, as well as accommodate potential changes in the U.S. entity responsible for space situational awareness and space traffic management functions relevant to non-Federal operators.[272] In the near term, we encourage all operators to engage with the 18th Space Control Squadron, either directly or through intermediary organizations, and avail themselves of the space situational awareness and space traffic management functions that the 18th Space Control Squadron provides.[273] At this time, we do not adopt a separate operational requirement regarding sharing of information with the 18th Space Control Squadron or other operators whose systems may pose a collision

(Continued from previous page)
regarding any requirement for operators to provide data outside the U.S. Government, unless data security can be assured on a going forward basis); CSSMA Reply Comments at 9 (stating that sharing data exchanges should respect owner/operator intellectual property and proprietary information).

[268] We would expect, however, that if there are significant limitations on ways in which information that is being shared, or the quantity of information shared, the operator will demonstrate that it is not compromising space safety.

[269] *See* Appendix A, Final Rules. SES/O3b, ORBCOMM, Global NewSpace Operators ask us not to exempt experimental and amateur systems from obligations to maintain and share ephemeris data. SES/O3b Comments at 5; Global NewSpace Operators Comments at 18; ORBCOMM Comments at 6. *See also* University Small-Satellite Researchers Reply at 12 (agreeing that data sharing initiatives are useful tools for mitigating debris and collision risks). We recognize that some experimental or amateur missions may have more limited ability to provide tracking data, and those operators can specify any mission-related constraints on obtaining and sharing tracking data as part of this disclosure. *See* Global NewSpace Operators Comments at 18 (noting that some operators rely on the Department of Defense (18th Space Control Squadron)-produced ephemeris, and would not have their own ephemeris data to share).

[270] Sirius XM suggests that we expand the scope of our proposal for sharing of ephemeris data to GSO satellites as well. Sirius XM Comments at 7. In the *Notice* the Commission proposed the rule specifically for NGSO systems, and we believe that sharing of GSO ephemeris and related issues are not necessarily a significant issue at least at this time—as our understanding is that there is general ongoing, cooperative participation of GSO operators in space situational awareness and space traffic management activities.

[271] Tyvak Reply.

[272] *See, e.g.*, SPD-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."). *See also* Global NewSpace Operators Comments at 9 (supporting establishment of a civilian agency whose authority will include space situational awareness and space traffic management specifically for civil and commercial space users).

[273] Information and guidance related to the 18th Space Control Squadron is available at www.Space-Track.org.

risk.[274] We conclude that requirement is unnecessary given the application disclosure requirement we adopt here as well as the separate certification that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary—and that the assessment and potential mitigation should include, as appropriate, sharing ephemeris data and other relevant operational information.[275]

82. *Conjunction Warnings.* The *Notice* proposed that applicants for NGSO space stations 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 with any such operator; and modifying spacecraft attitude and/or operations.[276] The Commission also sought comment on whether any different or additional requirements should be considered regarding the ability to track and identify satellites in NGSO or respond to conjunction warnings.[277]

83. As discussed below, based on the record, we adopt the proposal from the *Notice*. We believe this certification will enhance certainty among operators, and thereby help to reduce collision risk. Most commenters addressing this issue agreed generally with the Commission's proposal,[278] although some commenters had varying views on implementation of the proposed requirement. NASA and Aerospace recommend that applicants submit information outlining plans that they intend to follow operationally in order to minimize collision risk.[279] Global NewSpace Operators suggests that the Commission simply require the applicant to have an operational procedure and process for a conjunction warning, rather than a certification.[280] We see the potential benefits of having applicants outline operational steps to minimize collision risk, but we believe that the information that would be included in this type of submission is already addressed by other aspects of the rules. As described above, we will request information on maneuverability of the satellites, and applicants will be required to disclose how they have coordinated or plan to coordinate with other operators whose satellites may pose a collision risk, as well as disclose how they plan to share ephemeris and other information during the course of the spacecraft operations.

84. Other commenters suggest modifications to the language of the proposed rule to provide operators with some additional flexibility when responding to conjunction warnings. The Commission's proposed rule stated that 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 a warning; sharing ephemeris data and other appropriate operational information with any such operator; modifying space station attitude and/or operations."[281] Several commenters, including SIA, Telesat, and others, were concerned that the use of the term "all possible steps" would not give operators enough flexibility to decide how to respond, and proposed the language

[274] *See Notice*, 33 FCC Rcd at 11377, paras. 72-73.

[275] *See* Appendix A, Final Rules.

[276] *Notice*, 33 FCC Rcd at 11366-67, para 38.

[277] *Id.*

[278] *See, e.g.*, LeoSat Comments at 4; University Small-Satellite Researchers Comments at 7; SpaceX Comments at 14; Intelsat Comments at 6; CSSMA Reply at 8-9.

[279] NASA Comments at 5.

[280] Global NewSpace Operators at 10.

[281] *See Notice*, 33 FCC Rcd 11397, Appendix A, Proposed Rules.

"appropriate steps" instead.[282] Taking into consideration the concerns expressed in the record, we adopt a slightly different formulation of the certification. Specifically, the rule we adopt states that the space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations. We believe that the terms "if necessary" and "as appropriate" provide sufficient flexibility for operators to determine what is appropriate in individual cases. Finally, Boeing suggests that this requirement may be unnecessary, because operators already have sufficient incentives to avoid collision risks.[283] We conclude, however, that this certification is useful in ensuring that all space actors, in particular new space actors, are aware of and have planned responses to conjunction warnings, consistent with responsible space operations.

85. We also encourage operators to reference industry-recognized best practices in addressing conjunction warnings. NASA, for example, notes that there are currently industry-recognized best practices of submitting ephemerides to the 18th Space Control Squadron for screening, examining and processing all resultant conjunction warnings from each conjunction screening, mitigating high-interest events at a level consistent with the mission's risk mitigation strategy, and explicit conjunction avoidance screening by the 18th Space Control Squadron of ephemerides that include any risk mitigation maneuvers prior to maneuver execution.[284]

D. Topics Related to Creation of Debris During Operations

86. The Commission's existing orbital debris rules require disclosure of debris released during normal operations.[285] This has been a longstanding requirement, and is consistent with the revised U.S. Government Standard Practices objective regarding "Control of Debris Released During Normal Operations."[286] The Commission observed in 2004 that communications space stations do not typically involve the release of planned debris.[287] Although there are some unique experiments on space stations today that do potentially involve the planned release of debris, we observe that most communications space stations still do not typically release debris absent some type of anomaly. Where there is a planned release of debris, however, we examine such plans on a case-by-case basis.[288] Accordingly, the Commission did not propose to update our general rule in this area, as it has functioned well for the past 15 years. In the *Notice*, the Commission did propose to update its rules, however, in two specific areas related to the release of debris, discussed below, which reflect evolving satellite and launch

[282] *See, e.g.* SIA Comments at 7-8; Telesat Comments at 6.

[283] Boeing Comments at 22.

[284] NASA Comments at 5. NASA further states that if a secondary object in a potentially serious conjunction is an active satellite, a contact protocol between both satellite owners/operators should be initiated, so that potential mitigation actions can be coordinated and any planned maneuvers fully shared.

[285] *See 2004 Orbital Debris Order*, 19 FCC Rcd at 11578, para. 24.

[286] ODMSP, Objective 1. While the revised ODMSP does provide some additional guidance on matters related to the planned release of debris, these detailed issues can be addressed as part of our case-by-case analysis in any instances where there is a planned release of debris. Accordingly, we do not update our rules to explicitly address these issues. *See* Boeing *Ex Parte* at 12-13

[287] *2004 Orbital Debris Order*, 19 FCC Rcd at 11578, para. 24.

[288] *Id.* at para. 24. *See* NASA Comments at 2 (noting that the entity seeking a license should be required to disclose any spacecraft deployed from the entity's spacecraft that does not require an application for a license from the Commission for radio communications).

technologies.[289]

1. Deployment Devices

87. In the Notice, the Commission observed that in several instances applicants sought to deploy satellites using deployment mechanisms that detach from or are ejected from a launch vehicle upper stage and are designed solely as a means of deploying a satellite or satellites, and not intended for other operations—and that once these mechanisms have deployed the onboard satellite(s), they become orbital debris.[290] In one example, the Commission received applications for communications with deployment devices designed to deploy smaller spacecraft after the devices separating from the launch vehicle.[291] In another example, the Commission received an application for an experimental satellite that would be released from a tubular cylinder deployer, using a spring mechanism.[292] There are also more well-established uses of deployment devices, such as a separation ring used to facilitate the launch of geostationary satellites. Several commenters explain the advantages of use of deployment devices such as rings or other deployment vehicles, sometimes referred to as "free-flyers," stating, for example, that such devices can allow safe, reliable deployment of multiple spacecraft.[293] Spaceflight posits that deployment devices contribute to a safe space environment, where such devices allow spacecraft to be placed into orbit using well-established launch services and well-designed and planned deployment missions.[294]

88. The Commission proposed in the *Notice* to require disclosure by applicants if "free-flying" deployment devices are used to deploy their spacecraft, as well as requiring a specific justification for their use.[295] We adopt our proposal, and require that applicants for a Commission license disclose whether they plan to have their spacecraft deployed using a deployment device.[296] This includes disclosure of all devices, defined as separate deployment devices, distinct from the space station launch vehicle,[297] regardless of whether they will be authorized by the Commission.[298] Although in some instances it is difficult to draw a clear line between a launch vehicle and deployment device, for purposes of this rule, as explained below, we consider a deployment device to be a device not permanently physically attached to or otherwise controlled as part of the launch vehicle. For purposes of this discussion, we distinguish between consideration of orbital debris mitigation issues involving such free-

[289] *Notice*, 33 FCC Rcd at 11359-61, paras. 18-23.

[290] *Id*.

[291] *See, e.g., Spaceflight Inc.*, IBFS File No. SAT-STA-20150821-00060 (SHERPA)(mission was ultimately cancelled); *Spaceflight, Inc.*, IBFS File No. SAT-STA-20180523-00042 (SSO-A) (granted Oct. 12, 2018).

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

[293] Spaceflight Comments at 4; *see* Boeing Comments at 8 (use of separating devices can help prevent satellites from damaging each other, thus avoiding satellite components from separating from the satellite, or the catastrophic loss of an entire spacecraft); CSSMA Comments at 4 (deployment devices enable small-to-medium sized spacecraft to be aggregated onto a single mission, making launch efficient and affordable).

[294] Spaceflight Comments at 3-4. Spaceflight asserts that the alternative to its SSO-A mission, for example, would have been 63 separate uncoordinated missions which could cause a real potential re-contact hazard without the kind of engineering analysis and support provided by Spaceflight. *Id.* at 4.

[295] *Notice*, 33 FCC Rcd at 11359, paras. 19-20. As proposed, the rule would apply to both GSO and NGSO space station applicants.

[296] *See* Appendix A, Final Rules.

[297] *See id.*

[298] For Commission-authorized devices, as explained below, this can be disclosed by referencing the deployment device application file number. Devices not authorized by the Commission could include, for example, deployment devices not requiring an authorization for radiocommunications, or obtaining an authorization for radiocommunications from an administration other than the United States.

flying deployment devices and consideration of orbital debris mitigation issues involving multi-satellite deployments generally, including use of deployment devices that are part of or remain attached to the launch vehicle.

89. We have considered the arguments of Eutelsat, University Small-Satellite Researchers, and Boeing, who suggest that it would be burdensome for space station applicants to disclose information regarding free-flying or uncoupled deployment devices.[299] Eutelsat states that satellite operators are not responsible for launch procedure and do not choose the specific deployment device used for launch of their satellite, which may not be determined until after the space station application is submitted.[300] Some commenters suggest that information regarding a free-flying deployment device should be outside the scope of the Commission's purview, either for jurisdictional or practical reasons.[301] We disagree with these points. It is reasonable to consider objects with limited purpose, other than launch vehicles, as part of the deployment or operations of a Commission-licensed spacecraft. Free-flying deployment devices are, in terms of their effect on the orbital debris environment, indistinguishable from lens covers, tie-down cables, and other similar devices, in that they fulfill a limited function and then become debris. In some instances, the required disclosure may be as straightforward as incorporating by reference the information contained in a separate Commission application that has been submitted by the operator of the deployment device.[302] In other instances, the space station operator will need to obtain the information regarding the deployment device from the operator and/or manufacturer of that device.[303] The space station operator will be able to obtain this information, since the space station will be using the

[299] Eutelsat Comments at 2-3 (commenting from the GSO perspective); University Small-Satellite Researchers Comments at 17-18 (stating that requiring additional information from university passengers would be unreasonably burdensome since university researchers' primary means of deployment is to secure excess launch capacities where available); Boeing Reply at 12 (agreeing with Eutelsat's comments). *See also* Tyvak Reply. Boeing further argues that because the ODMSP does not include any specific guidance on the regulation and use of uncoupled deployment devices, the Commission should not adopt any requirements in this area. Boeing *Ex Parte* at 4-5. The ODMSP states that spacecraft should be designed to eliminate or minimize debris released during normal operations. ODMSP at 1-1. We conclude here that it is appropriate to address the use of deployment devices within the scope of this overall objective. Boeing further argues that on this topic the Commission should only adopt the ODMSP guideline stating that all planned released debris larger than 5 mm in any dimension, the total debris object-time product in low Earth orbit (LEO) should be less than 100 object-years per upper stage or per spacecraft. Boeing *Ex Parte* at 13. This guidance elaborates on, but does not replace, the overall guidance that spacecraft be designed to eliminate or minimize debris released during normal operations. *See* ODMSP 1-1. Thus, the debris object-time guideline should not replace our broader requirement that operators have assessed and limited the amount of debris released in a planned manner during normal operations, including a disclosure, where applicable, regarding any separate deployment devices.

[300] Eutelsat Comments at 2-3; *see* Telesat Comments at 2 (stating that the manner of satellite deployment may be unknown to satellite applicants at the time authority to operate the satellite is sought from the Commission).

[301] *See, e.g.*, Eutelsat Comments at 3; University Small-Satellite Researchers Comments at 18; Telesat Comments at 2. *See* also Global NewSpace Operators Comments at 6 (stating that the Commission should harmonize orbital debris mitigation efforts with other governmental efforts in this area). Several of the comments on this topic do not distinguish between unattached, free-flying deployment devices and deployment devices that are considered part of the launch vehicle. Here, we address these comments only to the extent that they relate to those devices that are not part of the launch vehicle.

[302] For example, Spaceflight filed applications for free-flying deployment devices with the Commission, requesting authority to use radiofrequencies to communicate with the deployers. *See Spaceflight Inc.*, IBFS File No. SAT-STA-20150821-00060 (SHERPA) (the mission was ultimately cancelled); *Spaceflight, Inc.*, IBFS File No. SAT-STA-20180523-00042 (SSO-A) (granted Oct. 12, 2018).

[303] We recognize that this information is not always available to applicants at the time when the application is filed, but applicants can supplement their application materials with this information once available, and update the Commission regarding any changes. *See* University Small-Satellite Researchers Comments at 18; Boeing Reply at 12.

deployment device. Second, our experience has been that FAA launch-related analyses do not include consideration of free-flying or separated deployment devices, since such devices are not considered part of the launch vehicle.[304] In this sense, depending on the factual scenario, the devices can be considered either "spacecraft" or "operational debris" related to the authorized space stations.[305] Our goal is to avoid a regulatory gap in which the orbital debris issues associated with a particular deployment device are not under review by any government entity. We will continue to coordinate with the FAA as needed, and in any case where an applicant believes that the deployment device would be under the FAA's authority, the applicant should make us aware so we can coordinate with the FAA in the particular case and avoid overlapping review.[306] Eutelsat points out that in some instances the launching entity may not even be within U.S. jurisdiction or regulatory authority.[307] In these instances, the operator should still provide information regarding use of any free-flying or separated deployment devices, consistent with our policy to require same information related to orbital debris mitigation from market access applicants as from U.S. license applicants.[308] For example, it would not be in the public interest for us to authorize market access for a non-U.S.-licensed satellite where the satellite meets our orbital debris mitigation requirements, but will be deployed by a free-flying device that has a 200-year on-orbit lifetime and presents a significant collision risk. Although, as Eutelsat states,[309] market access may be requested long after the satellite is launched, that fact has not prevented us from applying our orbital debris regulations to such satellites in the past.[310]

90. We will continue to largely assess these on a case-by-case basis at this time, since the individual facts can vary widely and so it is difficult to assess specific disclosure rules for each different type of device that may be used.[311] Consistent with the *Notice* proposal, we will require that applicants disclosing the use of a deployment device also provide an orbital debris mitigation disclosure for any separate deployment devices. The information provided by applicants should address basic orbital debris principles, such as the orbital lifetime of the device, and collision risk associated with the device itself.[312]

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[304] *See, e.g. Spaceflight Inc.*, IBFS File No. SAT-STA-20150821-00060 (SHERPA), Oct. 26, 2016 Attachment to Grant, at condition 3 & n.6); *Spaceflight, Inc.*, IBFS File No. SAT-STA-20180523-00042 (SSO-A), Oct. 12, 2018 Attachment to Grant, at condition 2 & n.10.

[305] In the *Notice*, we proposed that the rule cover any separate deployment devices "not part of the space station launch." 33 FCC Rcd at 11396, Appendix A, Proposed Rules. In an effort to clarify the scope of the rule, we adopt a slightly different formulation here, which states that the rule covers any separate deployment devices that are "distinct from the space station launch vehicle, that may become a source of orbital debris." *See* Appendix A, Final Rules.

[306] *See* Global NewSpace Operators Comments at 6 (stating that if orbital debris mitigation measures overlap with informational requirements of other agencies, then the applicant should provide a reference to the authorization of the other agency).

[307] Eutelsat Comments at 3.

[308] *See, e.g., 2004 Orbital Debris Order*, 19 FCC Rcd at 11606, para. 94.

[309] Eutelsat Comments at 3.

[310] *See, e.g.*, SES Satellites (Gibraltar) Limited, IBFS File No. SAT-MPL-20160718-00063 (grant dated Dec. 14, 2016) (as part of modification application for market access applicant, the Commission granted request for waiver of a Commission rule requiring that space stations must discharge all stored energy sources remaining at spacecraft end-of-life); Satelites Mexicanos, S.A. de C.V., IBFS File No. SAT-PPL-20150227-00008 (grant dated June 12, 2015) (Commission similarly considered, as part of grant of market access application, request for waiver of Commission rule regarding discharge of stored energy sources at spacecraft end-of-life).

[311] We would have concerns regarding use of a deployment device if the device constitutes a debris object that exceeds the 25-year rule or exceeds the 0.001 collision risk that would be assessed if it were an otherwise functional spacecraft, for example.

[312] *See* Spaceflight Comments at 6 (stating that the risk posed by free-flying deployment devices as objects in space can be accounted for under a normal debris risk assessment analysis); Global NewSpace Operators Comments at 6 (continued….)

Where applicable, the information should also address the method, sequencing, and timing by which the spacecraft be deployed into orbit. Boeing opposes the adoption of an information disclosure requirement absent "clear and objective criteria articulating when the use of such devices is permissible."[313] There are a variety of facts to assess in connection with use of deployment device and potential for contribution to the orbital debris environment. In some uses, a deployment device may become debris, but serve to decrease the collision risk associated with the individual deployed objects. In the case of well-established deployment practices, such as use of a detachable separator ring for a GSO deployment, the disclosure should be relatively straightforward, and we would not expect operators to provide significant detail regarding utilization of such a deployment practice. In other instances, use of a deployment device may increase the risk of collision among satellites deployed from the device, as compared to other means of deployment, even where the device itself may present a low risk. The different factual scenarios presented here illustrate the difficulty in making a "one-size-fits-all" rule when it comes to determining what is an acceptable use of a deployment device. We conclude that the more effective approach at this time is to adopt a disclosure requirement, and to continue to assess the specific uses on a case-by-case basis. Disclosure in this instance provides flexibility to address new developments in space station design and facilitates the Commission identifying facts to support decisions to grant, condition, or deny an authorization in a manner consistent with the Communications Act.[314]

91. We also received a number of comments related to the best means in which to evaluate collision risk specifically associated with the deployment of multiple satellites from a deployment device (e.g., re-contact analysis[315]).[316] We expect that recontact analysis will be conducted by operators, and that information will be provided to the Commission, but we do not adopt specific rules in this Order on how to conduct a re-contact analysis in the instance where a deployment device is deploying multiple satellites. Free-flying deployers releasing multiple satellites are still relatively new, and there is not consensus on what constitutes an adequate analysis of re-contact risk,[317] and the extent to which re-contact risk is different from typical collision risk in terms of likelihood of creating debris.[318] Accordingly, we will continue to assess this issue on a case-by-case basis in the context of a particular mission profile. In addition to compiling information regarding collision risk, however, we encourage operators of free-flying deployment devices to adopt practices that will help reduce risks associated with multi-satellite deployments—including formulating a deployment sequence that minimizes re-contact risks and making other operators with satellites nearby aware and updated on the scope of the deployment.[319]

92. Additionally, we do not adopt rules in this Order related to multi-satellite launches more generally, i.e. multi-satellite launches not involving separate, free-flying deployment devices. In the *Notice*, the Commission also sought comment on whether we should include in our rules any additional

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(stating that generally propulsive or powered release mechanisms should be treated as any other satellite and be subject to the same mitigation requirements).

[313] Boeing Comments at 8; Boeing Reply at 11.

[314] Boeing Comments at 8; Boeing Reply at 11.

[315] In this context, re-contact is the potential for two or more satellites or released as part of a multi-satellite deployment to subsequently collide with each other or with any free-flying deployment devices that may be used for the deployment.

[316] *See, e.g.*, Spaceflight Comments at 4-5; ORBCOMM Comments at 15-16; CSSMA Comments at 4-5; Aerospace Comments at 12; D-Orbit Comments at 2.

[317] Spaceflight Comments at 4-5.

[318] *See id.*

[319] *See, e.g.*, NASA Comments at 6; Aerospace Comments at 12.

information requirements for satellite applicants that will be part of a multi-satellite launch. A number of commenters suggested that these issues should be handled by the launch licensing authority and/or that there would be other difficulties involved in requiring additional information regarding launch and deployment from an FCC applicant. We observe that there are a number of established practices for multi-satellite deployment that are associated with low risk of re-contact, or otherwise a low risk of debris creation since any recontact would occur at low velocities. While we decline to adopt any rules related to this topic at this time, we may revisit this issue in the future.

2. Minimizing Debris Generated by Release of Persistent Liquids

93. In the *Notice*, the Commission proposed to update the rules to cover the release of liquids that, while not presenting an explosion risk, could nonetheless, if released into space, cause damage to other satellites due to collisions.[320] Specifically, the Commission proposed to include a requirement to identify any liquids that if released, either intentionally or unintentionally, will persist in droplet form.[321] The Commission observed that there has been increasing interest in use by satellites (including small satellites) of alternative propellants and coolants, some of which would become persistent liquids when released by a deployed satellite.[322] The *Notice* also stated our expectation that the orbital debris mitigation plan for any system using 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.[323]

94. Some commenters addressing this issue disagreed with the Commission adopting a rule to address this issue, with most expressing concern that there was not sufficient evidence that release of certain propellants, for example, would result in persistent droplets or create any additional risk in the orbital environment.[324] Along these lines, Aerospace states that it is important to distinguish between releases that could result in droplets or solids that could be a collision threat and those that dissipate or are too small to cause damage on impact.[325] Aerospace points out, for example, that there are a number of beneficial operations including venting or using excess propellant and oxidizer that constitute release of liquids that are less likely to cause impact damage.[326] Aerospace recommends that the Commission's proposed rule be clarified to explicitly permit the venting of volatile liquids and pressurants that could create future risk of fragmenting the spacecraft if not released, but will not form hazardous droplets.[327] We agree that it is important to distinguish between those releases that could result in a long-term risk to the orbital environment and those that are unlikely to create any significant additional risks, such as release of volatile propellants that are soon dispersed through natural processes. Additionally, we have long recognized the importance of operators limiting the risk of accidental explosions, including by venting pressurized systems at a spacecraft's end of life.[328]

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[320] *Notice*, 33 FCC Rcd at 11360-61, paras. 22-23.

[321] *Id.* at 11360-61, para. 23.

[322] *Id.* at 11360, para. 22.

[323] *Id.* at 11361, para. 23.

[324] *See, e.g.*, CSSMA Comments at 3; Lockheed Martin Comments at 8.

[325] Aerospace Comments at 7.

[326] *Id*.

[327] *Id.*

[328] *See also* 47 CFR §25.114(d)(14)(ii); *2004 Orbital Debris Order*, 19 FCC Rcd at 11580-82, paras. 29-33. Boeing asks that we update our rules regarding removal of stored energy at the spacecraft's end-of-life to acknowledge that stored energy sources can be "safed." Boeing *Ex Parte* at 7-8. It is unclear exactly what Boeing requests, but to the extent that Boeing is concerned that the existing rule does not adequately address removal of stored energy, we note that our existing rules leaves various options for stored energy to be discharged or removed, including by indicating

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95. We adopt our proposed disclosure requirement, but clarified to require that applicants must specify only the release of those liquids that may in fact persist in the environment and pose a risk.[329] Thus, the applicant will determine whether any liquids have a chemical composition that is conducive to the formation of persistent droplets. If so, then the applicant will disclose that fact to the Commission.[330] The main consideration in making this determination is whether the liquid, if released into space, will disperse through evaporation, or remain in droplet form, as is typical of some ionic liquids, such as NaK droplets. If the applicant determines that released liquids will not persist due to evaporation or chemical breakdown, for example, then the applicant need not address the release of such liquids.[331] We conclude that asking applicants—who have the most information regarding the operational profile of the mission and characteristics of the potentially released substances—to assess the risk will address the commenters' concerns that such a requirement may be overinclusive or premature.[332] We clarify that this rule would apply to any liquids, not just propellants.[333] In addition, we clarify that this rule will apply equally to release of liquids throughout the orbital lifetime.[334] We further conclude that the benefit of identifying potential risks associated with use of certain liquids, if such liquids could become long-term debris objects, outweighs any costs to operators in assessing the chemical composition of any liquids to determine the physical properties of such liquids following release into the orbital

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that "other equivalent procedures" or "other appropriate measures" may be used in addition to the enumerated examples provided in sections 25.114(d)(14)(ii) and 25.283(c) of the Commission's rules, respectively. 47 CFR § 25.114(d)(14)(ii), 25.283(c). We view our provisions on this topic as consistent with the ODMSP. Should an applicant seek to use measures not specifically listed in sections 25.114(d)(14)(ii) and 25.283(c), we would expect that the applicants would provide documentation regarding the chosen method, consistent with the types of documentation that listed in the NASA Standard regarding eliminating stored energy sources. *See* NASA Standard 4.4.4.2.

[329] According to Boeing, the Commission must ensure that an adequate mechanism is in place to permit the submission of information regarding such liquids on a confidential basis, since satellite manufacturers treat their propellants as highly proprietary. Boeing Comments at 9. Similar to other contexts, we point out that there are means for applicants to submit information confidentially, in instances where they are able to justify confidential treatment under the Commission's rules. *See* 47 C.F.R. § 0.459.

[330] Boeing states that the Commission should provide clear and objective guidance regarding when the use of such liquids would be permitted. Boeing Comments at 9, Boeing *Ex Parte* at 13. Here, we believe a disclosure requirement should entail minimal costs for most operators and will provide flexibility to address new developments in space station design. As Boeing points out, there may be tradeoffs associated with use of certain new types of propellants in terms of orbital debris mitigation, and we believe these tradeoffs are best addressed on a case-by-case basis. *See* Boeing Comments at 10.

[331] Boeing asks that we state that the use of liquids that would result in persistent droplets if released is presumptively appropriate if reasonable measures are taken to prevent their release. Boeing Comments at 10. If the operator discloses that such liquids would present a risk to the orbital environment if accidentally released, then we would ask operators to describe the measures that are taken to prevent such accidental release. If unintentional release of the liquids would present a significantly greater risk to the orbital environment that would be otherwise posed by an accidental explosion of the spacecraft (not taking into account release of the liquids), for example, then the operator should expect to provide additional information to the Commission regarding measures taken to prevent release as well as potential alternatives.

[332] *See, e.g.*, CSSMA Comments at 5 (opposing regulation of non-traditional propellants and propellant systems that identifies the type of liquid and does not also take into account the design and engineering specific of the particular propulsion system); Tyvak Reply (stating that the Commission should become more familiarized with such risks before adding to the requirements); CSSMA Reply at 3 (same).

[333] *See* Lockheed Martin Comments at 8 (stating that it is unclear whether the discussion extends to liquids other than propellants and asking for specific exemptions).

[334] *See* Telesat Comments at 2 (stating that the Commission's approach regarding release of debris during normal operations should apply to the release of persistent liquids during or at the end of a mission).

environment.

E. Post-Mission Disposal

96. Post-mission disposal is an integral part of the mitigation of orbital debris, and the commercial space industry has increasingly recognized the importance of not leaving defunct objects in orbit after their useful life. In 2004, the Commission established specific rules for GSO space station disposal based on U.S. and international guidance,[335] and in the absence of an anomaly, Commission-authorized space station operators have complied with those rules. In this Order, we adopt specific rules for disposal of NGSO space stations, and address reliability of post-mission disposal for NGSO space stations as well. As in 2004, we base these rules on updated sources of guidance, including the revised ODMSP, adapted for the commercial and otherwise non-governmental context.

97. The orbital lifetime of a particular space station affects the collision risk it presents and reduction in post-mission orbital lifetime reduces collision risk. Spacecraft that are unable to complete post-mission disposal, particularly when left at higher altitudes where they may persist indefinitely, will contribute to increased congestion in the space environment over the long-term and increase risks to future space operations.

1. Post-Mission Orbital Lifetime

98. In the *Notice*, the Commission inquired whether the 25-year benchmark for completion of NGSO post-mission disposal by atmospheric re-entry remains a relevant benchmark, as applied to commercial or other non-Federal systems.[336] The 25-year benchmark has been applied in Commission licensing decisions for NGSO systems. The NASA Standard and ODMSP specify a maximum 25-year post-mission orbital lifetime, with the revised ODMSP stating that for spacecraft disposed of by atmospheric reentry, the spacecraft shall be "left in an orbit in which, using conservative projections for solar activity, atmospheric drag will limit the lifetime to as short as practicable but no more than 25 years."[337] Most commenters supported a reduction in the 25-year benchmark as applicable to non-Federal systems.[338]

99. Given that we are adopting a requirement that all space stations have maneuverability during any period when they are located above 400 km, we find it unnecessary to adopt a rule setting an upper limit for post-mission orbital lifetime for those space stations that will be disposed through atmospheric re-entry. As a practical matter, space stations having maneuverability sufficient to conduct collision avoidance maneuvers will be unlikely to remain in orbit above 400 km for any length of time following the conclusion of the spacecraft mission, since it would serve no purpose to keep the spacecraft above 400 km and continue to conduct collision avoidance maneuvers. Accordingly, we expect that space stations deployed in LEO will maneuver down to 400 km or lower in altitude in a relatively short period. Spacecraft below 400 km generally re-enter Earth's atmosphere as a result of atmospheric drag within, at most, several years. Our approach to requiring maneuverability for space stations located above 400 km will therefore result in space stations re-entering Earth's atmosphere "as soon as practicable," and well within 25 years, either because the space station already planned to operate below 400 km or has been maneuvered down to an orbit below 400 km. This approach has the benefit of being consistent with a shorter than 25-year post-mission disposal lifetime for spacecraft being disposed of by atmospheric re-entry, and is therefore consistent with the view of many commenters that acceptable post-mission disposal lifetimes should be reduced below 25 years for LEO spacecraft. Although we do require applicants

[335] *2004 Orbital Debris Order*, 19 FCC Rcd at 11593-98, paras. 64-76.

[336] *Notice*, 33 FCC Rcd at 11372-73, paras. 58-59.

[337] ODMSP 4-1.b.

[338] *See, e.g.*, SpaceX Comments at 6; Iridium Comments at 8-9; Global NewSpace Operators Comments at 16; Intelsat Comments at 7; Maxar Comments at 13; OneWeb Reply at 5.

planning disposal by atmospheric re-entry to specify the planned time period for post-mission disposal as part of the description of disposal plans for the space station,[339] we do not find it necessary to adopt a rule defining a presumptively acceptable post-mission lifetime.

100. The practical considerations described above should address post-mission lifetime in most cases. If there are some limited scenarios in which spacecraft will remain in orbit for significant amounts of time following the conclusion of the mission, more than five years, for example, we would expect to seek more information from the operator regarding the planned post-mission disposal lifetime, including the reliability of collision avoidance during that extended period. This scenario could occur where an operator plans to rely on atmospheric drag for re-entry, but reserves fuel sufficient to conduct collision avoidance maneuvers during the extended re-entry period. We believe these scenarios are relatively unlikely, however, and can be addressed on a case-by-case basis. We encourage all operators to de-orbit spacecraft from LEO as soon as possible following the end of the mission.

101. We also address some additional related issues raised in the *Notice* related to post-mission lifetime. The *Notice* sought comment on whether we should account for solar activity in our rules or grant conditions.[340] We note that the NASA Debris Assessment Software takes into consideration solar flux that may affect atmospheric drag, among other environmental factors.[341] To the extent that the operator plans to rely on atmospheric drag for re-entry, reliance on NASA Debris Assessment Software or a higher fidelity assessment tool will meet the requirement in our rules with respect to specifying the time period for post-mission disposal.[342]

102. The Commission also sought comment on whether operators planning disposal through atmospheric re-entry should 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.[343] Boeing argues that satellite operators should not be required to maintain communication links and active tracking with the satellite following the end of the missions unless they had initially indicated in the application that active tracking, rather than passive tracking, would be used to monitor the location of the spacecraft.[344] Boeing also states that satellite operators should be required

[339] *See* Appendix A, Final Rules.

[340] *Orbital Debris Notice*, 33 FCC Rcd at 11373, para. 59.

[341] Deviations in solar activity, which generally track the 11-year solar cycle, can affect the force that atmospheric drag exerts on satellites in low-Earth orbit. NASA periodically updates the solar flux value (which measures solar activity) for inclusion in the Debris Assessment Software, retrieved from a model based on NOAA short-term predictions and NASA long-term predictions. *See* NASA Orbital Debris Program Office, Debris Assessment Software, https://orbitaldebris.jsc.nasa.gov/mitigation/debris-assessment-software.html (last visited Jan. 13, 2020) (describing installation instructions for inputting updated solar flux files); DAS User's Guide Version 3.0, at C.4 (July 2019), https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20190027721.pdf; *see also* D. Whitlock, "Modeling the Effect of High Solar Activity on the Orbital Debris Environment," *NASA Orbital Debris Quarterly News*, vol. 10, no. 2, p.4 (April 2006), https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv10i2.pdf.

[342] *See Notice*, 33 FCC Rcd 11373, para. 59. NASA observes that accounting for the effect of small variations in solar activity on orbital lifetime is not necessary given that the effect to the orbital debris environment of, for example, a 25.5 year disposal rather than a 25 year disposal is very small and does not justify additional cost. NASA Comments at 7. *See also* Boeing Comments at 31 (stating that no reason exists to preclude satellite operators from considering the potential impacts of solar activity); Global NewSpace Operators Comments at 16 (stating that a standardized tool taking into account the solar cycle, atmospheric density fluctuations and calculation of the spacecraft's ballistic coefficients is key to accurately predicting de-orbit times).

[343] *Notice*, 33 FCC Rcd at 11373, para. 59.

[344] Boeing Comments at 32. Intelsat states that a broadcast beacon and/or corner reflector equipment could be used for continued passive tracking of the satellite until disposal commences. Intelsat Comments at 7. We encourage use of such enhancements to enable passive tracking during the post-mission period, but do not adopt rules related to their use at this time.

to continue to obtain spacecraft tracking information for retired satellites only if the satellite operator's original calculations regarding acceptable collision risk as the satellite's orbit decays depend upon the operator's ability to conduct collision avoidance.[345] Iridium, on the other hand, suggests that satellites should be controlled all the way through atmospheric re-entry.[346] We do not adopt a specific regulation specifying the extent to which an operator should be required to maintain communications links or otherwise obtain spacecraft tracking information following the conclusion of the satellite's main mission.[347] However, since spacecraft will need to have maneuvering capabilities during the period when the spacecraft are above 400 km, operators will need to maintain communication links sufficient to conduct collision avoidance maneuvers. Given this fact, we conclude that mandating that all operators maintain a certain level of communications all the way through atmospheric reentry is unnecessary at this time. We do, however, encourage all operators to maintain communications links for tracking, control, and collision avoidance purposes for as long as possible following the conclusion of the spacecraft's primary operations, even below 400 km, and to continue to provide location information to the 18th Space Control Squadron and other operators for as long as possible, in accordance with the operators' plan for sharing ephemeris.

2. Reliability and Post-Mission Disposal

103. In the *Notice*, the Commission considered whether to add to the rules a specific metric for reliability of disposal in order to help us better evaluate the applicant's end-of-life disposal plan.[348] The Commission proposed to require that applicants provide information concerning the expected reliability of disposal measures involving atmospheric re-entry, and the method by which the expected reliability was derived.[349] The Commission also sought comment on whether we should specify a probability of no less than a certain standard, such as 0.90, and whether the evaluation should be on an aggregate basis if an operator plans to deploy multiple satellites, for example, in an NGSO constellation.[350] The Commission also asked whether, for large constellation deployments, a more stringent metric should apply.[351] The revised ODMSP states that the probability of successful post-mission disposal should be no less than 0.9, with a goal of 0.99 or better,[352] and further states that each spacecraft in a large constellation of 100 or more operational spacecraft should have a probability of successful post-mission disposal at a level

[345] Boeing Comments at 32-33.

[346] Iridium Comments at 9-10. In particular, Iridium is concerned with those satellites operating above 400 km in LEO. *Id.* With a requirement for maneuverability above 400 kilometers, we expect that most satellites will end up using propulsion in order to successfully de-orbit. *See also* Aerospace Comments at 17 (stating that consideration of collision avoidance and collision risk should be the responsibility of an operator for the entire period that a system is in orbit, including post-mission).

[347] Satellite DFR states that from a debris perspective, responsibility for an object on orbit does not end simply because it has stopped operating and suggests that we should define or make clear what we mean by "end-of-life." Satellite DFR Comments at 2. As detailed in this section, we have a number of rules in place to ensure that the operator has planned responsibly to mitigate orbital debris following completion of the space station mission, and it is clear that these rules relate to disposal of the spacecraft. In this context, we find it unnecessary to further clarify the term "end-of-life."

[348] *Notice*, 33 FCC Rcd 11369, para. 46.

[349] *Id.*

[350] *Id.*

[351] *Id.*

[352] ODMSP at 4-2.

greater than 0.9 with a goal of 0.99 or better.[353]

104. The majority of commenters addressing the issue agree with the Commission revising its rules to incorporate a standard for reliability of disposal. While the Commission sought comment on a broader design and fabrication reliability standard as well, many commenters suggest that focusing on disposal reliability is a more effective way to minimize the long-term impact of failed satellites on the orbital environment.[354] With respect to the specific metric, NASA notes that it currently employs a 0.9 disposal reliability for individual spacecraft not part of a constellation, and, consistent with the revisions to the ODMSP, states that inter-agency discussions have concluded that constellations (100 or more spacecraft) should have a post-mission disposal reliability of greater than 0.9.[355] NASA goes on to state that large constellations (1000 or more spacecraft) should have a post-mission disposal reliability goal of 0.99 or better.[356] A number of commenters agree with a tiered approach to reliability, specifically, with a 0.9 reliability for individual satellites and a higher reliability for individual satellites that are part of a constellation.[357]

105. We conclude that a baseline post-mission disposal reliability of 0.90 is appropriate for individual NGSO space stations,[358] and that larger systems will be evaluated on a case-by-case basis for whether a higher per-spacecraft disposal reliability standard is necessary to avoid significant long-term impacts to the orbital environment. The rule adopted specifies that NGSO applicants provide a demonstration that the probability of successful post-mission disposal is 0.9 or greater for any individual space station.[359] Consistent with the general approach taken in the revised ODMSP,[360] the rule further

[353] ODMSP at 5-1.a. The revised ODMSP further states that for large constellations, in determining the successful post-mission disposal threshold, factors such as mass, collision, probability, orbital location, and other relevant parameters should be considered. *Id.*

[354] *See, e.g.*, NASA Comments at 6; Global NewSpace Operators Comments at 12; CSSMA Comments at 15. We note that reliability of the spacecraft design (i.e. likelihood of a satellite failure) is still relevant in several other specific contexts; reliability of maneuverability systems as a factor in assessing collision risk, ability of the satellite to conduct maneuvers necessary for a controlled re-entry, and trackability, to the extent that trackability is dependent upon deployment of spacecraft with components such as solar arrays.

[355] NASA Comments at 6.

[356] NASA Comments at 6. NASA notes that its recent study for large constellations, assuming constellations totaling approximately 8000 spacecraft at operational altitudes above 1000 km maintained over multiple years, concluded that post-mission disposal reliability should be no less than 0.99 to keep the debris population increase in low-Earth orbit close to an acceptable level for 200 years. *Id.* *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).

[357] *See, e.g.*, Boeing Comments at 26-27; OneWeb Comments at 28; LeoSat Comments at 6; Global NewSpace Operators Comments at 12; Aerospace Comments at 13-14, 15; Boeing Reply at 33 (citing NASA Comments at 6). Boeing also concurs with NASA's conclusion that a reliability of 0.999 should never be required because it will not provide much additional benefit and may not be achievable, at least not in an affordable manner. Boeing Reply at 33. According to Boeing, the higher metric for individual satellites in a large constellation should not exceed 0.95 , and the reliability factor for individual NGSO satellites in smaller constellations should not exceed 0.90. Boeing Comments at 27. *See also* Telesat Comments at 7-8 (arguing that while satellite operators should strive to satisfy 0.95 disposal reliability per satellite, mandatory compliance with this standard would be premature); ORBCOMM Comments (stating that the suggested guideline of 0.99 for post-mission reliability may be appropriate).

[358] We apply this reliability metric to both NGSO space stations that would operate in LEO and those operating above LEO. *See Notice*, 33 FCC Rcd at 11372, para. 57 (seeking comment on whether there are any specific guidelines we should include in our rules with respect to practices for disposal of NGSO satellites in orbits above LEO).

[359] Appendix A, Final Rules. We also note that the terms "post-mission disposal reliability" and "probability of successful post-mission disposal" have the same meaning and are used interchangeably in this Order.

states that for space systems consisting of multiple space stations, the demonstration should include additional information regarding efforts to achieve a higher per-spacecraft probability of successful post-mission disposal, with a goal of 0.99 or better for large systems.[361] Under this approach, particular scrutiny will be given to larger deployments, including consideration of factors such as mass, collision probability, and orbital location.[362] We believe this method will avoid some of the concerns associated with arbitrary cutoffs of numbers of space stations. and will allow assessment of acceptable post-mission disposal reliability taking into account all relevant factors.[363]

106. Many commenters disagree with applying a disposal reliability standard in the aggregate.[364] NASA recommends the use of a reliability metric expressed on a per-satellite basis.[365] For purposes of post-mission disposal reliability, we agree that the target probability of successful post-mission disposal is best expressed on a per-satellite basis rather than in the aggregate. However, and as recognized in the ODMSP, consideration of the risks presented by deployment of large numbers of satellites supports higher per-satellite reliability, particularly for deployments involving larger numbers of satellites.

107. For purposes of calculating the probability of successful post-mission disposal, we define successful post-mission disposal for spacecraft in LEO as re-entry into the Earth's atmosphere within 25 years or less following completion of the spacecraft mission. We recognize that consistent with the discussion above on post-mission lifetime, 25 years will in almost all instances be a longer period than the planned post-mission lifetime of the spacecraft.[366] We believe this is an appropriate balance, however, by giving operators options to meet a performance-based post-mission disposal reliability standard while mitigating the long-term impact of spacecraft failures on the orbital environment.[367] Absent unusual circumstances, this would allow spacecraft and systems deployed at low altitudes to achieve a 100% probability of successful post-mission disposal even if the satellites themselves fail immediately upon deployment.[368] Operators cannot rely on deployment altitude alone to achieve a high post-mission

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[360] ODMSP at 5-1.a.

[361] Appendix A, Final Rules.

[362] *See* ODMSP 5-1.a.

[363] SpaceX suggests that if operators should provide detailed plans regarding disposal on a per satellite basis. SpaceX states that, for example, if an operator plans to rely on fault tolerances, the operator should explain whether it plans to de-orbit its satellites when it reaches a zero-fault threshold. SpaceX Comments at 13. This type of explanation could be part of a demonstration of reliability of the chosen disposal method.

[364] *See, e.g.*, NASA Comments at 6; Telesat Comments at 8 (stating that it would make it impossible to deploy innovative new LEO constellations supporting global coverage).

[365] NASA Comments at 6.

[366] We also adopt a conforming rule regarding post-mission disposal reliability applicable to small satellites that would qualify for the part 25 streamlined process. *See* Appendix A, Final Rules, § 25.122(d)(9).

[367] *See, e.g.*, Hugh G. Lewis, *Evaluation of debris mitigation options for a large constellation*, First International Orbital Debris Conference (2019), *available at* https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6069.pdf (concluding that positioning a percentage of a sample satellite constellation at a 550 km orbital altitude rather than 1100 km reduced the need for a high post-mission disposal success rate in order to limit a longer-term increase in population of debris, but acknowledging that there may be additional burdens on collision avoidance at lower altitudes).

[368] CSSMA, for example, suggests a post-mission disposal success rate of 1.0 for spacecraft operating below 650 km. CSSMA Reply at 13-14. Lockheed states that "requiring a specific probability of success appears arbitrary and unnecessary" for spacecraft deorbiting through atmospheric drag, Lockheed Comments at 13, but CSSMA notes that there may be non-propulsive spacecraft that rely on atmospheric drag that will need to be below 650 km to meet applicable post-mission lifetime requirements. CSSMA Reply at 13-14. This also addresses the concern expressed by University Small-Satellite Researchers regarding specifying a method of determining disposal reliability.

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disposal reliability, however, if they end up with a higher percentage of failed satellites at a lower altitude, because under this scenario the total probability of collision may become too high.[369]

108. Global NewSpace Operators suggests that the Commission should not be prescriptive in how applicants meet post-mission disposal reliability requirements but should instead encourage innovative approaches to how this problem is solved.[370] We agree and expect that operators would include in their demonstration, for example, a description of any backup mechanisms or system redundancies that should be factored into assessment of post-mission disposal reliability.[371]

109. We note that at some point, a very high level of reliability becomes difficult to achieve absent extraordinary cost and effort.[372] We also note that in some instances, development of the spacecraft is likely to be a rapidly iterative process, involving more in-orbit testing than ground testing. In these scenarios, lower deployment altitudes may be required in order to achieve a post-mission disposal reliability consistent with the public interest. In other cases, where the applicant has demonstrated significant ground-based testing commensurate with a high reliability, the lower deployment altitudes may not be as significant a consideration.

110. Operators of large constellations replenishing on a regular basis or otherwise deploying a system through multiple launches should strive to improve reliability with each successive deployment, since it appears such improvements may have significant impact on the longer-term debris environment.[373] Related to this point, Iridium suggests that the Commission require all operators of space stations above 400 km to notify the Commission of any on-orbit satellite failures, whether such failures

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University Small-Satellite Researchers Reply at 6. Since many academic and scientific missions deploy below 600 km altitude, and an increasing number may deploy below 400 km, those missions would be able to point to that fact in order to satisfy the post-mission disposal reliability requirement.

[369] *See also, e.g.*, Space Exploration Holdings, LLC, IBFS File No. SAT-MOD-20181108-00083, Letter from Jose P. Albuquerque to William Wiltshire and Paul Caritj, Harris, Wiltshire & Grannis LLP (Feb. 26, 2019) (requesting information on collision risk assuming a propulsion or other system failure renders satellites incapable of collision avoidance immediately following orbital injection); Letter from William M. Wiltshire, Counsel to SpaceX, Harris, Wiltshire & Grannis LLP to Jose P. Albuquerque (Mar. 13, 2019) (responding with additional information on collision risk of an incapacitated satellite as well as information on risk in the aggregate). In these more unique scenarios, applicants should also be prepared to provide information regarding how many satellite failures would result in a probability of collision of greater than 0.001, when calculated in the aggregate. *See, e.g.*, Hiber, Inc., SAT-PDR-20180910-00069, Letter from Tony Lin, Counsel to Hiber, Inc., Hogan Lovells US LLP to Marlene H. Dortch, Secretary, FCC, Attach. at 3-4 (April 15, 2019) (applicant indicating that with a satellite propulsion failure rate of 1/11 or higher, the aggregate lifetime collision probability for its planned 24 satellite system will exceed the 0.001 threshold).

[370] Global NewSpace Operators Comments at 11-12.

[371] *See also* McKnight Comments at 4 (stating that it is important that space systems show an ability to react to and operate through anomalies).

[372] *See, e.g.*, ORBCOMM Comments at 12 (stating that satellite manufacturers and operators should be encouraged to follow established industry quality and reliability practices by rigorously testing spacecraft and systems on the ground, as well as follow established pre-operational on-orbit testing, but noting that satellites system failures can and do occur regardless of the diligence in designing, fabrication, and testing); Boeing Comments at 27 (stating that 0.95 is the maximum of what is achievable for satellites that employ lengthy and often complex disposal sequences, such as using multiple electric propulsion maneuvers).

[373] *See* D. Gates, et. al., "An Extended Parametric Study of the Effects of Large Constellations on the Future Debris Environment," Orbital Debris Quarterly News, vol. 23, issue 3, at 7 (2019) (stating that to decrease the number of debris over the long-term, it is in the best interest of constellation operators to continuously improve the post-mission disposal rate of their spacecraft over time).

occur before or during operations.[374] According to Iridium, once an operator makes such a notification, the Commission should require the operator to identify and correct the root causes of failure on the ground prior to launching any additional satellites.[375] Other commenters similarly request that the Commission address how it will verify compliance with operator disclosures on post-mission reliability and other issues.[376] In instances where an applicant for a system consisting of multiple satellites submits information that the expected total probability of collision, post-mission disposal reliability, or casualty risk is close to the acceptable threshold, the Commission will require, as an initial condition of the license, that, in case a rate of failure that would result in values above the risk threshold(s) described in the application is observed, such occurrence be reported to the Commission. The Commission could also require reporting as a result of information that comes to the attention of the Commission during the licensee's operations. In appropriate circumstances, the Commission could subsequently modify the license to address a rate of failure that departs materially from the expected reliability level, since that departure would affect the public interest assessment underlying grant of the license.

a. Deployment Orbit

111. *Initial Deployment Below 650 km.* The Commission sought comment on whether applicants for space stations in LEO certify that the satellites that will operate at an altitude of 650 km or above would be initially deployed into an orbit at an altitude below 650 km and then, once it was established that the satellites had full functionality, they could be maneuvered up to their planned operational altitude.[377] The Commission reasoned that this may help to ensure that if satellites are found to be non-functional immediately following deployment, the satellites would re-enter the atmosphere within 25 years.[378]

112. Commenters addressing this issue generally disagree with the *Notice* proposal.[379] NASA recommends that a post-mission disposal reliability metric be adopted rather than requiring an initial deployment altitude below 650 km, stating that the lower deployment would add to the complexity of the deployment of spacecraft and not significantly reduce risk.[380] Other commenters suggested that this would create additional difficulties in development of a constellation and meeting of milestones, without significant benefits, and that the goal of reducing dead-on-arrival satellites could be met by other means.[381] We decline to adopt a uniform requirement that NGSO satellites deploy first to 650 km and

[374] Iridium Comments at 5.

[375] *Id.*

[376] *See* Global NewSpace Operators Comments at 22 (urging the Commission to outline how it intends to monitor licensee activities and specify methods of enforcement); Secure World Foundation Comments at 6 (noting that a critical part of limiting orbital lifetimes or requiring post-mission disposal is the ability to monitor whether or not a licensee has complied with those requirements); SpaceX Comments at 12 (stating that an effective enforcement structure should encourage operators to report immediately whenever debris is generated); OneWeb Comments at 28 (stating that any failure or anomaly of propulsion systems on demonstration spacecraft should be reported to and reviewed by the responsible regulator). *See also* D-Orbit Comments at 2 (suggesting that reliability should be re-assessed after a critical event is experienced by a satellite, and if the reliability level at that point is lower than the required threshold, the satellites shall be decommissioned even if the declared end-of-life is not reached).

[377] *Notice*, 33 FCC Rcd at 11369-70, para. 48.

[378] *Id.* at 11370, para. 48.

[379] *See, e.g.*, Telesat Comments at 8; ORBCOMM Comments at 12; Lockheed Martin Comments at 13; Boeing Comments at 27-28; OneWeb Comments at 24-25. In its comments, the United Church of Christ agreed with this proposal, on the basis that the benefits from the continued viability of LEO would outweigh the costs of orbit-raising. United Church of Christ Comments at 3 (rec. April 3, 2019).

[380] NASA Comments at 7.

[381] *See, e.g.*, OneWeb Comments at 24-25; Telesat Comments at 8; LeoSat Comments at 6-7; Lockheed Martin Comments at 13-14.

then raise their orbits to deployment altitude. We conclude that reliability of post-mission disposal and collision risk standards we adopt here more effectively address the same underlying issues regarding the long-term impact of non-functional satellites on the orbital environment.[382] It should be noted, however, that in order to achieve post-mission disposal reliability objectives, the use of this strategy may be necessary, particularly for deployments involving larger numbers of satellites.

113. *Testing.* The Commission also sought comment on whether applicants for large NGSO constellations should be required to test a certain number of satellites in a lower orbit for a certain number of years before deploying larger numbers of satellites, in order to resolve any unforeseen flaws in the design that could result in the generation of debris.[383] Several commenters pointed out that operators of new constellations of NGSO satellites have conducted testing of a few satellites to verify their performance before launching larger numbers.[384] Boeing suggests that the Commission should not dictate the length of such test operations, since operators are usually able to determine fairly quickly whether satellites are operating as intended or whether any anomalies are apparent that may necessitate an extended period of monitoring. Other commenters agree that operators should be able to set their own timelines for in-orbit testing.[385] Boeing further argues that operators have sufficient incentives to employ a testing approach to avoid the significant costs that would result from an unanticipated fault affecting a large number of satellites.[386] OneWeb contends that required testing could impact an operator's ability to comply with the Commission's NGSO milestone rules.[387]

114. We observe that there are tradeoffs with different testing modalities, and we expect that there will be some systems that will undergo a rapidly iterative development process following initial deployments. In such cases, those operators should consider deploying at lower altitudes and with smaller numbers of satellites, to ensure minimal impact on the orbital debris environment. We agree with those commenters suggesting that it may be difficult to fully determine on the ground how a satellite will perform in the space environment. As Boeing points out, several operators of planned NGSO systems have launched test satellites, usually consisting of just a few satellites, prior to any larger deployment.[388] We believe the economic incentives are generally aligned to encourage such testing by operators of larger systems, given the costs involved in launching satellites, and we therefore at this time do not see the need for a regulatory specification regarding how much testing should be done before a certain level of constellation deployment. As discussed above, we expect that operators will be testing systems related to satellite disposal as well, and, if the operators conclude after deployment of a few satellites that they are not able to meet the reliability for post-mission disposal specified in their application, the operators will make changes to these systems to ensure that the required reliability is achieved.[389]

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[382] Global NewSpace Operators suggests that the Commission ensure that the license applicant has a pathway to deorbit should their satellite(s) malfunction, regardless of altitude. Global NewSpace Operators Comments at 13. We address these issues in the section below on automatic disposal.

[383] *Notice*, 33 FCC Rcd at 11370, para. 48.

[384] *See, e.g.,* Boeing Comments at 28.

[385] *See, e.g.,* Global NewSpace Operators Comments at 3 (stating that the commission will not have the technical insight to know how long is enough for testing of various satellite technologies in orbit, and industry should lead in determining the right parameters to ensure its satellite technology is truly functional).

[386] *See* Boeing Reply at 32, 35.

[387] OneWeb Comments at 25-26.

[388] Boeing Comments at 27-28.

[389] *See, e.g.,* OneWeb Comments at 25-26 (proposing that satellites of new design should be launched in limited numbers and if a systematic problem is experienced, subsequent launches should be postponed until resolution is identified and implemented on subsequent satellites).

b. Automatic Initiation of Disposal

115. In the *Notice*, the Commission proposed that applicants seeking to operate NGSO space stations should provide a statement that the spacecraft disposal will be automatically initiated in the event of loss of power or contact with the spacecraft, 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 become limited.[390] The Commission also sought comment on the costs and benefits associated with these design features.[391] After review of the record, we decline to adopt any regulations at this time with respect to automatic de-orbit.

116. Most commenters addressing this issue disagreed with the Commission's proposal,[392] although some expressed support.[393] Commenters generally felt that a rule on this topic would not adequately address the wide range of factual scenarios involved in disposal operations,[394] that technologies for automatic disposal are not sufficiently developed,[395] or that autonomous systems may not provide true redundancy, which satellite operators already incorporate into their designs.[396] Several commenters suggest future work in this area may be appropriate.[397] One commenter suggests use of autonomous decommissioning devices on the satellite that would duplicate critical functions of the spacecraft.[398] It states that such a device could ensure absolute capability to perform decommissioning maneuvers, and would avoid investment in re-designing the satellite platform itself.[399] Although we decline to adopt a specific requirement for automatic initiation of disposal, we note that such operations could factor into the review described above with respect to post-mission disposal reliability.[400] For

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[390] *Notice*, 33 FCC Rcd at 11370, para. 49.

[391] *Id.* at 11370, para. 50.

[392] *See, e.g.*, Lockheed Martin Comments at 14; Telesat Comments at 8; LeoSat Comments at 7-8; Boeing Comments at 28-29; OneWeb Comments at 26; ORBCOMM Reply at 3; Boeing Reply at 36-37; University Small-Satellite Researchers at 7, 11; CSSMA Reply at 14.

[393] *See, e.g.*, D-Orbit Comments at 3. D-Orbit suggests that use of autonomous, rather than automatic de-orbiting devices would provide operators with the desired control over their spacecraft. *Id.*

[394] Some commenters argue that autonomous deorbit could complicate operations and have negative consequences, including potentially increased risk of collisions. *See, e.g.*, Telesat Comments at 8; OneWeb Comments at 26; Lockheed Martin Comments at 14; Aerospace Comments at 14-15; LeoSat Comments at 7-8; ORBCOMM Comments at 17-18; Global NewSpace Operators Comments at 13; Boeing Reply at 36. NASA recommends that failsafe or automatically initiated disposal actions carefully examine associated risks, including unintended consequences. NASA Comments at 7.

[395] *See, e.g.*, Aerospace Comments at 15.

[396] Boeing Reply at 36.

[397] University Small-Satellite Researchers urge that we address the issue of automatic de-orbit in further proceedings once in has been demonstrated that the benefits outweigh the costs or a further record on the availability of novel disposal systems has been developed. University Small-Satellite Researchers Reply at 11. ORBCOMM suggests that a further examination of these concepts in a further notice of proposed rulemaking appears necessary to determine if automatic de-orbit regulation is useful, practical, or feasible. ORBCOMM Comments at 18. Given the record developed in this proceeding, we conclude that it does not make sense to adopt any regulations on this topic at the current time, and, while we decline to include this issue in the Further Notice below, we do not rule out re-visiting this concept at a later time.

[398] D-Orbit Comments at 3. D-Orbit suggests that use of autonomous, rather than automatic de-orbiting devices would provide operators with the desired control over their spacecraft. *Id.*

[399] D-Orbit Comments at 3.

[400] *See* D-Orbit Comments at 2 (suggesting that use of autonomous decommissioning devices can contribute to achieving and maintaining the threshold of reliability because it shifts the need to assess the reliability of the satellite (continued….)

example, to the extent that such devices can improve such reliability by way of back-up and redundancy, they can be considered.[401] We observe that the development of robustly reliable autonomous systems could help to establish a high-level of reliability for post-mission disposal, but we will consider such technologies on a case-by-case basis.

c. Direct Spacecraft Retrieval

117. The Commission sought comment in the *Notice* on what weight, if any, the Commission should give to post-mission disposal proposals relying on direct spacecraft retrieval, i.e., the use of one spacecraft to retrieve another from orbit.[402] As discussed in the Notice, this also includes activities referred to as "active debris removal". The Commission observed in the *Notice* that there are a number of specific technologies under development for direct spacecraft retrieval, and sought comment on whether it should be considered as a valid debris mitigation strategy in certain circumstances.[403] We observe that the revised ODMSP provides for direct retrieval of a structure preferably at the completion of the mission, but no more than 5 years after completion of mission.[404] The revised ODMSP also provides that active debris removal operations should follow the objectives generally applicable to other operations.[405]

118. We generally agree with those commenters stating that it would be premature to establish more detailed regulations in this area.[406] To the extent that any applicants seek to rely on direct retrieval as a means to dispose of their spacecraft, the plan may be considered on a case-by-case basis, keeping in mind that the technology would need to be sufficiently developed at the time of the application for the Commission to be able to assess the reliability of the disposal method.[407] Although the technology for

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to the assessment of the reliability of the device); Global NewSpace Operators Comments at 14 (stating that the Commission should consider applicants favorably that have backup deorbit devices so long as it is effective to remove within 25 years or lower, but suggesting that other means may be better to improve post-mission reliability for spacecraft in higher orbits).

[401] *See* Global NewSpace Operators Comments at 14 (suggesting that for larger satellite constellations even below 650, some backup means of disposal should be encouraged).

[402] *Notice*, 33 FCC Rcd at 11371, para. 53.

[403] *Id.* at 11371, paras. 53-54.

[404] ODMSP, 4-1.f.

[405] ODMSP, 5-4.

[406] *See, e.g.*, Boeing Comments at 30; OneWeb Comments at 27; Iridium Comments at 10; Aerospace Comments at 15-16. *See also* Lockheed Martin Comments at 14-15 (combining the discussion of direct retrieval with the discussion of disposal of spacecraft operating between Leo and GEO). As NASA points out, SPD-3 states that the "United States should pursue active debris removal as a necessary long-term approach to ensure the safety of flight operations in key orbital regimes [and] this effort should not detract from continuing to advance international protocols for debris mitigation associated with current programs." NASA Comments at 7 (quoting SPD-3).

[407] *See* Satellite DFR Comments at 2 (absent a solid demonstration of successful retrievals, operators should not be permitted to substitute retrieval in lieu of an effective post-mission disposal plan using the satellite's onboard systems); Global NewSpace Operators Comments at 14-16 (describing a number of current technologies under development for either backup deorbit systems or deorbit "tugs."). To the extent that direct retrieval could serve as a backup means of disposal, for example, by the inclusion of a magnetic plate or grappling fixture on a spacecraft, we could include that in our consideration of the reliability of post-mission disposal, but the technology would need to be sufficiently developed for the Commission to assess it as a component of reliability. *See, e.g.*, Global NewSpace Operators Comments at 16 (urging the Commission to consider appropriate ways to encourage applicants to evaluate and incorporate backup deorbit systems, capture interfaces and other cooperative servicing aids, and transponder beacons into their spacecraft or constellation's post-mission disposal plans, instead of relying solely on the assumption that their spacecraft will never fail). *See also* OneWeb Comments at 27 (stating that OneWeb plans to include a grappling fixture and fiducials on every NGSO spacecraft to facilitate capture and encourage standardization of interfaces); Aerospace Comments at 16 (stating that it is prudent to include grappling fixtures, (continued….)

direct retrieval is not sufficiently developed for commercial applications at the moment, in the future this type of technology may enable some missions that would not otherwise be possible currently.[408]

3. MEO Disposal

119. In the *Notice*, the Commission sought comment on whether to include provisions in the rules regarding disposal of certain NGSO satellites operating in orbits above LEO.[409] Specifically, the Commission sought comment on whether there were particular practices for post mission disposal above LEO that were sufficiently developed to formalize in our rules.[410] We observe that the revised ODMSP addresses disposal of spacecraft in medium-Earth orbit (MEO), defined as the region between the LEO region (below 2,000 km) and the GEO region (between 35,586 and 35,986 km).[411] The ODMSP provides options of both long-term storage between LEO and GEO, and removal from orbit using unstable disposal orbits that will result in atmospheric re-entry of the spacecraft.[412]

120. Several commenters suggest that continuing a case-by-case assessment regarding disposal of spacecraft operating above LEO remains appropriate.[413] Aerospace provides some additional technical detail regarding options for disposal above LEO, as well as with respect to high-eccentricity disposals.[414] We will continue to assess disposal for spacecraft operating between LEO and GEO on a case-by-case basis. This includes those systems that would be considered to be operating in MEO as well as in highly-elliptical orbits (HEO). Applicants for such spacecraft should identify the planned method of disposal and explain their plans.[415] In developing a description of the planned disposal, applicants should be aware of and address the issues described in Objective 4 of the ODMSP, including, for example, limiting collision risk, and limiting time spent by the spacecraft in certain zones.[416] Applicants should also discuss the rationale for the selected disposal strategy. We observe that compared to storage strategies, which result in risk of debris generation that lasts essentially forever, the removal of satellites from orbit using eccentricity growth reduces the risk of debris generation over the long-term.[417] This strategy should therefore be seriously considered by mission designers.

F. GSO License Extensions and Related Issues

121. *Assessment of Request for Extension.* In the *Notice*, the Commission proposed to codify the current practice of requesting certain types of information from GSO licensees requesting license term

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radar corner reflectors, and optical reflectors in spacecraft designs even if there is no active plans for retrieval); Satellite DFR Comments at 2 (stating that operators should be required to design their satellites for recovery including documentation for retrieving those that fail to deorbit as planned).

[408] Other commenters raise issues related to direct retrieval that are outside the scope of this proceeding. *See* Secure World Foundation Comments at 5 (proposing programmatic initiatives to foster active debris removal); Satellite DFR Comments at 3 (suggesting global and national initiatives to advance active debris removal).

[409] *Notice*, 33 FCC Rcd at 11372, para. 56.

[410] *Id.* at 11372, para. 57.

[411] ODMSP at 4-1.e.

[412] ODMSP, 4-1c,e.

[413] *See, e.g.* Telesat Comments at 8; Lockheed Martin Comments at 14-15.

[414] Aerospace Comments at 16-17.

[415] *See* Appendix A, Final Rules.

[416] *See* ODMSP at 4-1.c,e. We note that Aerospace's comments on this topic also suggest several options for disposal, which overlap in some, but not all respects with the ODMSP. *See* Aerospace Comments at 16-17.

[417] *See* ODMSP, 4-1,e.

extensions.[418] The Commission proposed that the rule would specify that the applicants should state the duration of the requested license extension and the total remaining satellite lifetime, certify that the satellite has no single point of failure 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.[419] The *Notice* noted that in the event that an applicant is unable to make any of the certifications, the applicant could provide a narrative description justifying the extension.[420] We adopt the proposed rule, modified to address commenter's concerns with the proposed certification concerning single point failures, as described below.

122. Commenters are concerned that the proposed certification 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" could unduly restrict the ability of operators to obtain extensions for satellites with years of useful life remaining and suggest a more flexible, case-by-case approach, as is currently followed.[421] We modify our proposed rule on single points of failure or other malfunctions, defects, or anomalies to accommodate a description rather than a certification.[422] An operator could specify, for example, that despite a single point of failure, the reliability of post mission disposal remains within acceptable levels.[423] We will continue our case-by-case approach to assessing requests for license extensions,[424] and the descriptive nature of this disclosure will enable an operator to provide additional information about potential risk and disposal reliability. Additionally, Space Logistics requests that the Commission adopt rules that would permit a GSO space station licensee to extend its satellite license term by the length of any mission extension service in lieu of such certifications.[425] We would also address this under our case-by-case approach.

123. *Limit of 5 Years Per Extension Request.* The Commission proposed in the *Notice* to limit license term extensions to no more than five years in a single modification application for any satellite originally issued a fifteen-year license term.[426] Currently, the Commission receives license extension requests for varying numbers of years and processes those requests on a case-by-case basis. The Commission tentatively concluded that five years may be an appropriate limit for a single modification to help ensure reasonable predictions regarding satellite health while affording operators some flexibility.[427] We adopt this rule as proposed.

124. A number of commenters, primarily operators or manufacturers of existing GSO

[418] *Notice*, 33 FCC Rcd at 11375, para. 65.

[419] *Id.*

[420] *Id.*

[421] *See* AT&T Comments at 2-3; Intelsat Comments at 9; Sirius XM Comments at 4; Eutelsat Comments at 5-6; AT&T Reply at 6; Boeing Reply at 39-40. AT&T also states that operators should be entitled to confidential treatment of disclosures. AT&T Comments at 3. We refer to the existing Commission rules providing a means for a party to seek confidential treatment of material submitted to the Commission. *See, e.g.*, 47 CFR § 0.459.

[422] *See* Appendix A, Final Rules.

[423] Intelsat suggests that instead of a certification related to single points of failure, an applicant certify to a particular de-orbit reliability figure, such as 90% probability of successful de-orbiting. Intelsat Comments at 9.

[424] *See* Astranis Space Technologies Corp. Reply Comments at 6 (rec. May 6, 2019) (stating that the Commission should assess requests on a case-by-case basis); Lockheed Martin Comments at 15 (suggesting that in some instances other information regarding satellite performance metrics may be relevant to the extension inquiry).

[425] Space Logistics Comments at 8.

[426] *Notice*, 33 FCC Rcd at 11375, para. 66.

[427] *Id.*

satellites, oppose a cap on how many years may be requested at a time through an extension request.[428] Telesat, for example, states that the Commission should continue its current flexible approach because it minimizes regulatory proceedings and costs for the Commission and licensees.[429] Although the limitation of a single license term extension to five years could potentially result in more modification requests being filed with the Commission as operators seek multiple license extensions, we conclude that the additional costs of preparing an application and paying a modification application fee are outweighed by the benefits of revisiting license extensions within five years—namely, ensuring that the extension continues to be consistent with the public interest by reevaluating the satellite health and functionality information that provides a basis for extending the license term. Lockheed Martin contends that it is not appropriate to limit extensions to five years if a longer term is justifiable based on a review of the provided specifics.[430] Similarly, SIA argues that a five-year limit would significantly constrict the ability of GSO operators to leverage the full value of their in-orbit assets.[431] According to SIA, the Commission should continue to permit GSO operators to demonstrate, through the modification application process, that the satellite is capable of continuing to serve the public interest for an appropriate additional term.[432] We fully recognize that there are satellites capable of providing service well beyond the initial 15-year license term, and in appropriate cases will license those satellites for additional license extensions. Under the approach we adopt here, GSO satellite licenses may be extended for more than five years in total, but the extensions will be granted in increments of five years, at most, through applications for modification.[433] While GSO space station licensees understandably want to provide service for as long as possible using their existing space station(s), they are not necessarily incentivized to make conservative estimates when requesting license term extensions. The five-year limit per extension will allow for reassessment of satellite health on a regularized basis even for those satellites with longer lifetimes, which serves the public interest.

125. Intelsat argues that the Commission should not limit the duration of license extension requests because in some countries, such as Brazil, landing rights are granted for the term specified in the original U.S. license and only one renewal is permitted, and so the landing rights are limited to the duration of the initial U.S. license term plus the length of the extension.[434] Therefore, Intelsat argues, the Commission's five-year cap on an individual license term extension would limit the maximum period for landing rights in other countries.[435] While we appreciate that operators are navigating regulatory processes in other nations as well as the United States, we cannot be responsible for the approach that

[428] *See, e.g.*, SIA Comments at 6-7; AT&T Comments at 4; Eutelsat Comments at 5-6; EchoStar Comments at 7; Eutelsat Comments at 4-5; Intelsat Comments at 9-11; Lockheed Martin Comments at 15; Telesat Comments at 9; SES/O3b Reply at 7; AT&T Reply at 8; Boeing Reply at 39. *But see* ViaSat Comments at 8 (agreeing with the Commission's proposal).

[429] Telesat Comments at 9. *See also* Eutelsat Comments at 4-5; Intelsat Comments at 10-11; Lockheed Martin Comments at 15; SIA Comments at 6; AT&T Comments at 4.

[430] Lockheed Martin Comments at 15. *See also* Boeing Comments at 34; EchoStar Comments at 7. We also decline to adopt a maximum of five years as a rebuttable presumption, since this not substantially different from the current approach to assessment of license extensions, and would involve the Commission making additional assessments to predict satellite health more than five years in advance.

[431] SIA Comments at 6-7.

[432] *Id.*

[433] Several operators agree that if we do adopt a five-year license term, we permit multiple extensions. *See* Boeing Comment at 34 (stating that it is appropriate to allow licensees to seek multiple extensions if warranted, given the increasingly long periods that GSO satellites are able to safely operate, particularly with the introduction of new fuel types, such as electronic propulsion); Eutelsat Comments at 4-5.

[434] Intelsat Comments at 10. *See also* SIA Comments at 7 & n.17.

[435] Intelsat Comments at 10-11.

other countries take with respect to landing rights—and have no control over whether and when another administration attaches significance to Commission decisions. We find that this rule change is in the public interest for the reasons discussed above, and if operators have concerns regarding the approaches of other administrations they should address those issues with the relevant administration(s).

126. Sirius XM asks that we exempt Satellite Digital Audio Radio Service (SDARS) licensees with eight-year license terms from the proposed five-year limit on license extensions.[436] Sirius XM states that it would unfairly disadvantage SDARS licensees since the initial license term for those operations is shorter.[437] In the *Notice* we proposed that the five-year limit on license extensions would apply to only those satellites with an initial 15-year license term.[438] Given the limited number of SDARS licensees, we will continue the current case-by-case approach to the length of license extensions for these satellites, rather than imposing the five-year cap. AT&T requests a similar exemption for GSO direct broadcast satellite (DBS) space stations that were initially authorized for a license term of ten years.[439] In a recent Report and Order, we updated the license term for DBS satellites operating on a non-broadcast basis from 10 years to 15 years, and concluded that the few existing non-broadcast DBS licensees that had not already had licenses extended may have their license extended to match a 15-year license term upon application to modify the license.[440] Licensees with an initial term of less than 15 years will also be treated on a case-by-case basis for subsequent extensions, rather than being subject to the five-year cap.[441]

127. *Other Issues.* In the *Notice*, the Commission also sought comment on whether there are types of GSO satellite anomalies that should trigger immediate reporting, and whether there were any types of satellite buses that warrant heightened scrutiny for purposes of assessing license extensions.[442] Those commenters addressing these issues disagreed with adoption of rules in either of these areas,[443] and we decline to adopt any new rules on these topics at this time because we think it is unnecessary to adopt specific requirements in this area and can continue to address these issues on a case-by-case basis.[444] With respect to GSO anomaly reporting, we observe that GSO operators typically already provide information informally to the Commission regarding anomalies, and the Further Notice seeks comment on incentives for GSO operators to maximize the probability of successful disposal. Additionally, regarding satellite design issues, we continue to expect that operators will disclose issues that may be systematic to a particular GSO satellite design as part of their license extension request—and note that the Commission may consider such systematic issues as they arise and when assessing requests for license extensions under its continued case-by-case approach.

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[436] *See* Sirius XM Comments at 2-3; Sirius XM Reply at 1-2.

[437] *See* Sirius XM Comments at 3; Sirius XM Reply at 2. Sirius XM requests that we adopt a first license extension of up to eight years for SDARS licensees and thereafter subject SDARS to the same license extension cap that applies to other satellite services. Sirius XM Comments at 3; Sirius XM Reply at 2.

[438] *Notice*, 33 FCC Rcd at 11375, para. 66.

[439] AT&T Comments at 5.

[440] *Amendment of the Commission's Policies and Rules for Processing Applications in the Direct Broadcast Satellite Service*, Report and Order, 33 FCC Rcd 9014, 9019, para. 16 (2019) (*DBS Modernization Order*).

[441] We observe that this would not necessarily result in a license term extension of more than five years.

[442] *Notice*, 33 FCC Rcd at 11375, para. 67.

[443] *See* Lockheed Martin Comments at 15-16 (disagreeing with adoption of rules related to either proposals); Intelsat Comments at 11 (disagreeing with adoption of a rule on anomaly reporting); Sirius XM Comments at 4 (disagreeing with adoption for rule identifying any particular satellite buses).

[444] Additionally, one commenter suggests that the GSO graveyard orbit be re-examined due to the potential that there are small debris from the graveyard orbit filtering down in the proximity of operational GSO satellites. McKnight Comments at 2. The Commission had not proposed to examine this issue in the *Notice*, and we decline to do so at this time, but could revisit in the future.

G. Casualty Risk Assessment

128. In the *Notice*, the Commission sought comment on two issues related to the human casualty risk assessment for space stations disposed of by re-entry into Earth's atmosphere. First, the Commission sought comment on whether to update our rules to specify that the human casualty risk assessment[445] must include all objects that would have an impacting kinetic energy of 15 joules, consistent with the NASA Standard.[446] Commenters generally supported including the 15 joule metric in the Commission's rule.[447] We adopt the proposal.

129. Second, the Commission proposed 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 assessment tool, the applicant must provide a statement indicating the calculated human casualty risk, as well as the input assumptions used in modeling re-entry.[448] The Commission further sought comment on whether to assess human casualty risk in the aggregate as well as on a per-satellite basis, and what metric should be used to evaluate such risk.[449] For the reasons explained below, we adopt a presumptively acceptable human casualty risk standard of zero, as calculated using the NASA Debris Assessment Software. Applicants may provide justification for a higher risk, which will be assessed on a case-by-case basis. The analysis must be conducted for a system as a whole, including an assessment of the total risk of human casualty presented by the estimated number of satellites, including replacement satellites, to be deployed.

130. The approach we adopt responds to comments requesting that the Commission specify presumptively acceptable risk and encourage "design for demise," i.e. designing spacecraft so that they burn up completely upon re-entry into the Earth's atmosphere,[450] but maintain the possibility for approval of systems that present casualty risk up to the 0.0001 (1 in 10,000) figure specified in the ODMSP.[451] We conclude that this approach will ensure that operators have considered design for demise or alternative methods of disposal, such as direct retrieval. The Commission has encouraged satellite designers to "design for demise" when choosing materials,[452] and as the number of Commission-authorized satellites

[445] Lockheed Martin argues that a disposal reliability metric is unnecessary given the casualty risk assessment requirement. Lockheed Martin Comments at 13. The disposal reliability metric does not replicate the casualty risk assessment, however. As explained below, it is design reliability that is implicated in casualty risk in cases where the planned disposal is by targeted re-entry, since an uncontrolled satellite can still be reliably disposed by atmospheric entry, but satellite control in order to conduct a targeted re-entry to minimize casualty risk is a design reliability issue.

[446] *Notice*, 33 FCC Rcd at 11373, para. 61.

[447] *See, e.g.*, CSSMA Comments at 17; Boeing Comments at 32; Boeing Reply at 38. This is also consistent with the ODMSP. *See* ODMSP, 4-1.a, b.

[448] *Notice*, 33 FCC Rcd at 11374, para. 62.

[449] *Id.*

[450] *See, e.g.*, Iridium Comments at 10; SpaceX Comments at 17; Aerospace Comments at 13; OneWeb Reply at 6. OneWeb states that controlled reentry should be an option assuming that the aggregate risk in the event of a satellite failure is below a certain threshold. OneWeb Comments at 17.

[451] *See, e.g.*, CSSMA Comments at 17; NASA Comments at 7; CSSMA Reply at 16. The adopted rule specifies that the risk is zero "as calculated," in recognition of the fact that it is possible to achieve a result of "zero" risk using the NASA Debris Assessment Software even where there is an extremely low non-zero risk. *See also* CSSMA Comments at 17.

[452] For example, in 2013, the International Bureau and Office of Engineering and Technology issued a public notice providing *Guidance on Obtaining License for Small Satellites* (*Small Satellite PN*), which stated that satellite designers are "urged and expected to follow a 'design to demise approach in choosing materials. *Guidance on Obtaining License for Small Satellites* Public Notice, 38 FCC Rcd 2555, 2558 (IB/OET 2013). The *Small Satellite PN* also stated that in the event an assessment of the spacecraft re-entry finds surviving materials presenting a

(continued….)

increases overall, the approach we adopt here ensures that systems that pose a risk of human casualty are not considered routine—particularly where there are multiple ways for operators to minimize their risk to an acceptable level. For this reason, we do not adopt the approach advocated by some commenters of routinely authorizing satellites that meet the 0.0001 (1 in 10,000) metric, and only requiring special justification for satellites that exceed that 1 in 10,000 metric.[453] We note that the revised ODMSP states that design-for-demise and other measures, including targeted reentry away from land masses, should be considered in order to further reduce reentry human casualty risk.[454]

131. Although some commenters raised concerns with consideration of casualty risk on an aggregate basis for systems that involve multiple satellites,[455] we do not think it is reasonable to ignore the potential for heightened human casualty risk resulting from such systems, simply because the risk from each individual satellite is relatively low.[456] It is clear that there is a corresponding benefit in safety that results from assessing and limiting casualty risk for systems as a whole, rather than solely on a per-satellite basis. As noted in the revised ODMSP, large constellations in particular should limit the cumulative reentry human casualty risk.[457] For NGSO systems, the licensing process considers whether to authorize a particular system as a whole, and accordingly, should consider reentry casualty risk as a whole. To provide guidance to applicants on preparing a casualty risk assessment, we specify that an application must include an estimate of the number of satellites that will be deployed over the course of the 15-year period for which licenses are typically issued, including any replacement satellites. This information will allow us to assess at the initial authorization stage the longer-term risks of systems that involve multiple satellites. We consider this approach preferable to the alternative suggested by several commenters that we consider a per-year or annualized rate approach, as the adopted approach elicits similar information in a manner that complements the established licensing process.[458]

132. Several commenters suggest that NASA's Debris Assessment Software does not account for some potential sources of casualty risk adequately.[459] NASA updates the Debris Assessment Software

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casualty risk other than zero, the applicant should provide in its application a detailed discussion of the need for use of high melting point materials, demonstrating that mission objectives cannot be met with an alternative spacecraft design. *Id.* at n.9.

[453] *See, e.g.*, Boeing Reply at 38-39.

[454] ODMSP at 4-1.a. Where applicants plan to meet casualty risk requirements through controlled re-entry, we expect that applicants will take into consideration whether satellite failures will prevent controlled re-entry. This is more of a concern for satellites with planned operations at lower altitudes, since in higher orbits, failed satellites are likely to remain on orbit for hundreds or thousands of years. *See also* Moran Express Comment (stating that controlled re-entry can become uncontrolled due to loss or failure of control during or prior to re-entry of the satellite).

[455] *See, e.g.*, Boeing Comments at 33; SpaceX Reply at 1; Boeing Reply at 38; Boeing *Ex Parte* at 11; Amazon Reply at 2-3 (arguing generally that standards and metrics should be applied on a per-satellite basis). *See also* NASA Comments at 7.

[456] ORBCOMM supports consideration of casualty risk on a cumulative basis, stating that NGSO systems are licensed as constellations, not single satellites. ORBCOMM Reply at 5. *See also* OneWeb Comments at 19.

[457] ODMSP, 5-1.b.

[458] *See* Iridium Comments at 10; OneWeb Reply at 6. We also note that this approach provides a method for casualty risk on an upfront basis at the application stage. The rule we adopt also addresses spare and replenishment satellites as part of the operator's initial estimate of number of satellites. *See* OneWeb Comments at 19. Additionally, it is not clear that a "per year" timeframe is appropriate for assessing casualty risk, since it could encourage operators to leave satellites in orbit to spread out the disposal period and achieve a lower "per year" casualty risk.

[459] SpaceX Comments at 18; CSSMA Reply at 17.

casualty risk assessment tool on an ongoing basis, including recently updating the reentry survivability model.[460] To the extent that an applicant believes that its satellite design will not be adequately assessed with the Debris Assessment Software tool, it should submit a higher fidelity analysis that provides an improved assessment.

H. Proximity Operations

133. In the *Notice*, the Commission noted the increasing number of commercial missions proposed involving proximity operations and rendezvous of spacecraft.[461] The Commission proposed that applicants be required to disclose whether the spacecraft is capable of, or will be, performing rendezvous or proximity operations.[462] The Commission also sought comment on whether the rules should include anything more specific regarding information sharing about proximity operations with the 18th Space Control Squadron or any successor civilian entity.[463]

134. We adopt a disclosure requirement that would identify situations where there are planned rendezvous and proximity operations and provide a vehicle for further review of those operations.[464] The disclosure requirement follows the general approach in the revised ODMSP of analyzing such operations within the framework of standard debris mitigation objectives—limiting debris release, preventing accidental explosions, and limiting collision risk.[465] Commenters generally supported this approach.[466] We note the evolving and developing nature of these operations, and accordingly find that more specific technical or operational requirements are premature at this time.[467]

I. Encryption and Security of Spacecraft Command

135. In the *Notice*, the Commission proposed a rule requiring that operators of space stations having onboard propulsion systems encrypt telemetry, tracking, and command communications with the space station.[468] The Commission noted concerns that a malevolent actor could take control of and command satellites.[469] A particular scenario of direct relevance to this proceeding is if the commandeered

[460] *See* NASA DAS 3.0 User's Guide at 1.2.1.

[461] *Notice*, 33 FCC Rcd at 11375-76, para. 68

[462] *Id.*

[463] *Id.*

[464] *See* Appendix A, Final Rules.

[465] ODMSP at 5-3.

[466] *See, e.g.*, Space Logistics Comments at 2, 6-7; Consortium for Execution of Rendezvous and Servicing Operations Comments at 2; Aerospace Comments at 18. Space Logistics states that disclosures regarding on-orbit servicing specifically should be provided in the context of a satellite license application or a modification application of an existing license to operate a "mission extension vehicle" with a different client vehicle. Space Logistics Comments at 6, n.13. As adopted, the disclosure regarding such operations would be an application requirement, and would also be required of any operators as part of a license modification, if the modification involved such operations.

[467] Several commenters note the work of the Consortium for Execution of Rendezvous and Servicing Operations in developing best practices. *See* Consortium for Execution of Rendezvous and Servicing Operations Comments at 1-2; Space Logistics Comments at 7; Secure World Foundation Comments at 6-7; Global NewSpace Operators Comments at 17; Intelsat Comments at 7.

[468] *Notice*, 33 FCC Rcd at 11377-78, paras. 74-75, Appendix A, Proposed Rules.

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

satellite has propulsion capabilities and can be used to introduce additional debris into the space environment and/or threaten damage to other spacecraft.[470] Commenters to the *Notice* express a variety of views on whether, and the extent to which, encryption should be undertaken to secure telemetry, tracking, and command links, both for spacecraft with propulsion and those without. While many recognize the need for securing commands, many also raise concerns about mandating the use of specific encryption standards.[471] Based on the record established in this proceeding, we adopt a clarifying update to our existing rule on control of transmitting stations and the security of command communications applicable to commercial systems.[472] We decline at this time to specifically include in our rules the more detailed and prescriptive security measures outlined in some comments, such as requiring use of a specific encryption standard.[473]

136. Several commenters point out that most satellites do not have sufficiently precise guidance and navigation capabilities to be used effectively by a malevolent actor to target and collide with other satellites, thereby causing debris.[474] At orbital velocities, the capabilities necessary to present a credible threat require advanced systems at a level of technical sophistication well beyond what is commonly deployed, particularly in typical low-cost small satellite missions. For this reason, we are not adopting the proposed rule focusing on those satellites with propulsion systems.

137. Many of the comments focus more generally on the issue of securing command communications. A number of commenters argue that the Commission should not impose detailed encryption requirements, particularly those tied to a single standard, because satellite operators already have sufficient incentives to protect their space assets through encryption and other methods for restricting access only to authorized users.[475] We agree that given the diversity of satellite operations, requiring the use of a one-size-fits-all encryption standard is not appropriate at this time,[476] and will

[470] *Notice*, 33 FCC Rcd 11378, paras. 74-75. *See* Global NewSpace Operators Comments at 18-19 (stating that the Commission should provide more specificity on the risk it seeks to mitigate and how the risk relates to orbital debris mitigation).

[471] *See, e.g.*, SiriusXM Comments at 8; ORBCOMM Comments at 13; CSSMA Comments at 19-20.

[472] Section 25.271 specifies requirements for "control of transmitting stations," including that the licensee ensure that the facilities are properly secured against unauthorized access or use whenever an operator is not present at the transmitter. 47 CFR § 25.271(d). We make a minor update to this rule to clarify that for space station operations, this includes securing satellite commands against unauthorized access and use. *See* Appendix A, Final Rules, 25.271(a). A number of commenters identify the importance of securing command communications specifically. *See, e.g.*, ViaSat Comments at 2; Eutelsat Comments at 6 (stating that if the Commission were to impose requirements, they should be limited to command signals only); *see also* Maxar Comments at 14 (supporting command and control encryption/authentication requirement); Tyvak Reply at 2 (supporting protection of command uplinks); AMSAT Comments at 7-8 (stating that in the amateur context, command, rather than telemetry or tracking communications, may be encrypted).

[473] *See, e.g.*, Providence Access Company Comments at 7, 10-11 (rec. April 4, 2019).

[474] *See* Aerospace Corp. Comments at 18 (estimating that it would extraordinarily difficult to commandeer a satellite and use it to intentionally harm another spacecraft if it were not designed to do so); CSSMA Comments at 19 (arguing that a malevolent actor taking control of an unsecured satellite is ultimately a very unrealistic scenario); Boeing Reply at 42-43 (agreeing with other parties that it would be extremely difficult for an authorized party to commandeer a satellite and cause it to harm any other space objects).

[475] *See, e.g.*, Boeing Comments at 36-37; AT&T Comments at 36-37; AT&T Reply at 11. *See also* Intelsat Comments at 11-12 (noting that operators are already subject to specific encryption obligations in certain situations, and encryption can result in extended service outages in the case of on-orbit anomalies with a TT&C system).

[476] Several commenters referenced the existing Federal cybersecurity policy that is applicable to commercial space systems supporting national security missions, the Committee on National Security Systems Policy 12 (CNSSP-12). Cybersecurity Policy for Space Systems Used to Support National Security Missions (February 2018), *available at* http://www.cnss.gov/cnss/issuances/Policies.cfm. *See* Charles Clancy and Jonathan Black Comments at 1-2 (rec.

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continue to address concerns related to securing facilities through existing high-level performance obligations identified in FCC rules.[477] As a matter of clarification, we are including specific language in the relevant part 25 rule to indicate that the rule applies to space stations.[478] We also encourage experimental and amateur licensees to continue to ensure that they are in full compliance with the Commission's existing rules applicable to experimental[479] and amateur licensees regarding control of transmitting stations.[480]

138. We recognize that the discussion regarding the security of TT&C communications is only one element of the broader topic of cybersecurity for satellite and ground station operations. There has been increasing discussion within the satellite industry regarding the importance of securing communications links.[481] Commenters suggest that there is need for additional guidance and best practices on cyber security or cyber resiliency for satellite systems.[482] Consideration of cybersecurity is an important part of their overall system development, and we encourage all operators to do so, including

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April 5, 2019) (Clancy and Black Comments); Providence Access Company Comments at 6-8. Commenters note, however, that it is not realistic to expect all licensees to demonstrate that they are using National Security Administration-approved means for securing command communications. *See, e.g.*, Clancy and Black Comments at 1-2.

[477] *See* 47 CFR § 25.271; *Notice*, 33 FCC Rcd at 11377, para.74, n.172.

[478] *See* Appendix A, Final Rules, § 25.271(d). Operators have flexibility to adopt security strategies, including encryption and other measures, to ensure that their system is secure.

[479] Section 5.107 of the Commission's rules requires, in part, that each experimental licensee "shall be responsible for maintaining control of the transmitter authorized under its station authorization, including the ability to terminate transmissions should interference occur[,]" and that for conventional experimental radio stations the licensee "shall ensure that transmissions are in conformance with the operating characteristics prescribed in the station authorization and that the station is operated only by persons duly authorized by the licensee." 47 CFR § 5.107.

[480] Section 97.5 of the Commission's rules requires, in part, that amateur station apparatus "must be under the physical control of a person named in an amateur station license grant on the [Universal Licensing System] consolidated license database or a person authorized . . . by § 97.107 . . . before the station may transmit on any amateur service frequency from any place that is . . . [w]ithin 50 km of the Earth's surface and at a place where the amateur service is regulated by the FCC[,] . . . or [m]ore than 50 km above the Earth's surface aboard any craft that is documented or registered in the United States." 47 CFR § 97.5. Section 97.109 of the Commission's rules also addresses station control, including provisions for remote control of stations, 47 CFR § 97.109. Specific to space stations, section 97.207(b) states that "[a] space station must be capable of effecting a cessation of transmissions by telecommand whenever such cessation is ordered by the FCC[,]" 47 CFR § 97.207(b), and section 97.211(b) states that a space telecommand station may transmit special codes intended to obscure the meaning of telecommand messages to the station in space operation[,]" 47 CFR § 97.211(b).

[481] For example, Global NewSpace Operators point out the satellite industry statement on cybersecurity jointly prepared by SIA and the Global VSAT forum, which broadly encourages industry participants to adopt industry and government cybersecurity best practices. Global NewSpace Operators Comments at 18 (citing SIA and Global VSAT Forum, *Joint Statement on the Satellite Industry's Commitment to Cybersecurity*, Nov. 2016, https://www.sia.org/wp-content/uploads/2016/11/SIA-GVF-Joint-Cybersecurity-Policy-Statement-FINAL-v.1-Nov-2016.pdf).

[482] *See* Clancy and Black Comments at 1-2 (suggesting a standing government working group charged with compiling a risk-based management framework for satellite cybersecurity); *see also* Maxar Comments at 14 (suggesting that the Commission should work with other federal agencies and industry stakeholders to ensure that any encryption requirements are technologically neutral); University Small-Satellite Researchers Reply at 14-15 (suggesting that instead of enacting TT&C encryption requirements at this time, the Commission could focus on encouraging best practices for satellite cybersecurity, and eventually consider conditioning authorizations on operators following cybersecurity best practices).

by following industry-developed best practices and government guidance, where applicable.[483]

J. Frequency Coordination for Orbit-Raising

139. The Commission considered in the *Notice* whether to modify its rule requiring authority for telemetry, tracking, and command functions to raise the satellite to its normal orbit following launch. Specifically, the rule limited such operations to a non-harmful interference, unprotected basis, and addressed only GSO operations. The rule made it clear that orbit-raising types of maneuvers in the pre-operational phase for GSO satellites are authorized operations, even though they may vary from the orbital parameters specified in the license. The Commission proposed to modify the rule such that satellite telemetry, tracking, and command communications for orbit raising must be coordinated between satellite operators for both GSO and NGSO satellites, rather than require those operations to be performed on a non-interference basis.[484] The Commission also proposed to extend the rule generally to NGSO satellites, so that orbit-raising maneuvers in the pre-operational phase for NGSO satellites would be considered authorized operations, even though they may vary from the orbital parameters specified in the license.[485] We address each of these proposals in turn.

140. *Coordination Among Operators of Frequency Use During Orbit Raising.* Most commenters agreed with the Commission revising its rules so that telemetry, tracking, and command operations would be entitled to interference protection if coordinated with potentially affected satellite networks.[486] Some commenters asked for clarification, or minor modifications, such as requiring informal, rather than formal coordination between operators.[487]

141. Under existing procedures, an operator is not strictly required to coordinate, but could simply accept interference from other operators. We find that this is not an ideal regime for telemetry, tracking, and command operations, and take this opportunity to clarify that operators should coordinate these operations to ensure that such operations are not subject to interference that could impact those critical communications links and affect physical space station operations.[488] This rule change is appropriate as part of this proceeding because it implicates communications related to the physical location of the space station.[489] This coordination should also ensure that satellites already in service are not subject to interference from satellites engaged in orbit-raising.[490] We further clarify that the "coordination" specified in the revised rule is informal operator-to-operator coordination, rather than, for

[483] Eutelsat argues that the Commission should modify provisions in rules on confidentiality to provide additional protection for information concerning telecommand frequencies. Eutelsat Comments at 8-9. The relevant rules are contained in part 0 of the Commission's rules and are beyond the scope of this proceeding.

[484] *Notice*, 33 FCC Rcd at 11376, para. 71.

[485] *Id.* at para. 70.

[486] *See, e.g.*, Boeing Comments at 36; Boeing Reply at 41; SES/O3b Reply at 5; ORBCOMM Comments at 9; Intelsat Comments at 4-5.

[487] *See, e.g.*, ViaSat Comments at 7; Eutelsat Reply at 2; SES/O3b Reply at 5; Sirius XM Reply at 2.

[488] We understand this is the current practice in many instances, and take the opportunity to clarify the Commission's rules. *See, e.g.* Lockheed Martin Comments at 16 (stating that coordination is effectively what would happen in most situations anyway); ViaSat Comments at 7-8 (same).

[489] *See* Global NewSpace Operators Comments at 17-18 (stating that the Commission should clarify the intent of this rule change as it relates to mitigating orbital debris).

[490] *See* SiriusXM Comments at 7. Boeing requests that we revise the language of section 25.282 to state that both in-service satellites and those engaged in orbit-raising must be operated on a co-equal basis following the completion of a sufficient coordination process to ensure that unacceptable interference does not result to either party. Boeing Reply at 41-42. We find that this level of specificity is overly complex and would potentially create an unnecessary new status in the frequency bands typically used for these operations—and therefore conclude that a general clarification that such operations should be coordinated is sufficient for purposes of this rule.

example, the formal procedures specified in the ITU regulations. Eutelsat points out that current practices involves discussion between operators to facilitate operations on a non-interference basis.[491] Sirius XM states that we should not modify this rule with respect to GSO operators, because operators have conducted orbit raising for GSO satellites on a non-harmful-interference, unprotected basis for decades without issue.[492] That may be the case, but we see no downside to clarifying that operators should be coordinating such operations. Sirius XM seems concerned that it would need to accept interference from satellites undertaking these operations,[493] but that is not the case—we are simply ensuring that such operations are coordinated between operators, which appears largely to be a continuation of existing practices. We expect that the practice of coordination between operators will continue and the goal of our rule revision is to encourage such discussions, rather than requiring that the operator conducting orbit-raising activities operate on a non-interference basis.[494] We decline to specify any particular requirements for the coordination process,[495] other than that operators undertake coordination in good faith, with the goal of facilitating orbit-raising operations and ensuring the availability of the telemetry, tracking, and command links, while not unduly disrupting other ongoing operations.

142. A few commenters raise other issues. Global NewSpace Operators suggests that the Commission consider the unique aspects of NGSO orbit raising, including that it is much faster and that a specific radiofrequency interference event may occur without impacting operations due to the short duration.[496] Regardless of the possibly short duration of a potential interference event, when it comes to frequency use for NGSO orbit raising, we maintain that it is in the public interest for space stations operators to coordinate those operations, even if the result is an agreed-upon short period of interference. Lockheed Martin supports the proposed change, but suggests an exemption for non-Earth orbit missions. The rule, as modified here, will continue to refer to "short-term, transitory maneuvers."[497] Rather than carve-out an exemption for non-Earth orbiting missions, we simply note that frequency use associated with longer-term transitory maneuvers can be addressed on a case-by-case basis, including as part of the space station authorizing conditions.

143. CSSMA comments specifically regarding systems operating in the Earth-Exploration Satellite Service, Meteorological-Satellite Service, and Space Operations Service, and states that since those operations are generally on a non-exclusive basis, CSSMA does not believe regulated radiofrequency coordination requirements are necessary in those bands.[498] We would not characterize our rule clarification here as "regulated radiofrequency coordination requirements," but simply a change that would ensure coordination specifically is completed to the extent necessary for telemetry, tracking, and command operations to be reliable and not impact other existing operations. If use of a particular frequency band is already shared through geographic separation of earth stations, for example, and the communications used for orbit-raising would be within the scope of that established sharing, then the operations would be considered "coordinated" and the operator would not need to undertake any additional coordination activities. There could be situations, however, where orbit-raising communications might be outside the scope of the established sharing regime for regular operations, and

[491] Eutelsat Reply at 2.

[492] Sirius XM Comments at 7.

[493] *See* Sirius XM Comments at 7.

[494] Our clarification that only informal coordination is required should address the concerns of Sirius XM as well about revisions to this rule. *See* Sirius XM Reply at 2-3.

[495] Eutelsat asks us, for example, to provide guidance on any specific requirements contemplated in the context of operator-to-operator discussions. Eutelsat Comments at 6; Eutelsat Reply at 2.

[496] Global NewSpace Operators Comments at 18.

[497] *See* Appendix A, Final Rules.

[498] CSSMA Comments at 18-19.

those orbit-raising communications would be coordinated. Thus, we decline to establish a carve-out for frequency bands that are used on a non-exclusive basis.

144. Intelsat asks that the rule be expanded to cover all orbit-raising operations, including Earth-to-space launch and early orbit phase (LEOP) operations conducted by earth stations, which are currently authorized pursuant to special temporary authority.[499] Since these radio frequency operations are authorized pursuant to special temporary authority, we declined to carve out an exception for earth station LEOP operations. We may revisit this issue in the future, however.

145. *Inclusion of Communications for Orbit-Raising in Authorization for NGSOs.* Although most commenters who address this issue agree with the proposal to extend authority to transmit to NGSO space stations during orbit-raising as part of a grant, without additional specific approval,[500] upon further consideration we decline to adopt this proposal. Instead we will continue the existing case-by-case practice of addressing these operations as part of the initial grant or through a license modification or special temporary authority. The change that the rule revision would have made would be to include such authority automatically in the original grant as we do for GSOs. After further consideration, we conclude that the explicit authorization process gives us the ability to examine the individual facts more closely, given the diversity of the types of operations present for NGSO orbit-raising. For NGSO satellites there is a broad range of potential operations that could be characterized as transmissions in connection with short-term, transitory maneuvers directly related to post-launch, orbit-raising maneuvers, and we conclude that it is in the public interest for those types of operations to be explicitly authorized, rather than automatically included in the grant. This will give other operators more information regarding the nature of such operations and facilitate coordination between operators as well as coordination with government operations in frequency bands shared with Federal operations. For the same reasons, we decline to extend the rule to operators supporting orbit-raising of MEO spacecraft at the end of the satellite's mission, as requested by SES/O3b.[501]

K. Liability Issues and Economic Incentives

1. Indemnification

146. In the *Notice*, the Commission sought 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.[502] The indemnification requirement was nearly universally opposed among those commenters addressing the proposal.[503] We address the concerns raised by commenters below, however, and conclude that it is in the public interest for licensees to indemnify the United States against costs associated with claims brought under international law, specifically the Outer Space Treaties. In the *Notice*, we proposed specific rule language regarding an indemnification agreement. We adopt an indemnification requirement slightly modified to reflect that the indemnification will be a license condition and affirmed as part of the application process rather than as a separate agreement following licensing.

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[499] Intelsat Comments at 5.

[500] *See, e.g.*, Intelsat Comments at 4; SES/O3b Reply at 5.

[501] *See* SES/O3b Comments at 4; SES/O3b Reply at 6.

[502] *Notice*, 33 FCC Rcd at 11378, para. 78.

[503] *See, e.g.*, SIA Comments at 8-10, AT&T Comments at 6; Boeing Comments at v, 37-38; CSSMA Comments at 20; EchoStar Comments at 7; Intelsat Comments at 12-15; LeoSat Comments at 9; Lockheed Martin Comments at 18-19; ORBCOMM Comments at 19; Sirius XM Comments at 9; Space Logistics Comments at 3, 13; Spaceflight Comments at 6; Telesat Comments at 11; ORBCOMM Reply at 3. Notably, one commenter, LeoSat, states that it "generally supports" the Commission's objective in this area, but states that it needs more information regarding the Commission's approach to indemnification agreements before LeoSat takes a firm position. LeoSat Comments at 9.

147. As the Commission specified in the *Notice* and previously explained in detail in the *2004 Orbital Debris Order*, under international law, the United States government could potentially be presented with a claim for damage resulting from private satellite operations.[504] Specifically, the United States is party to two international treaties addressing liability arising from activities in outer space[505]— the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty)[506] and the Convention on International Liability for Damage Caused by a Space Object (Liability Convention).[507] The Outer Space Treaty and Liability Convention, were signed by the United States and ratified by Congress, and thus have the force and effect of federal law. Article VI of the Outer Space Treaty states in part that, "State Parties to the Treaty shall bear international responsibility for national activities in outer space . . . whether such activities are carried on by governmental agencies or by non-governmental entities," and that, "[t]he activities of non-governmental entities in outer space . . . shall require authorization and continuing supervision by the appropriate State Party to the Treaty."[508] Under Article VII of the Outer Space Treaty, a State Party to the Treaty that "launches or procures the launching of an object into outer space . . . and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or its natural or juridical persons by such object or its component parts on the Earth, in air or in outer space[.]"[509] The Liability Convention specifies that liability rests with a "launching state," which is defined as either (1) a State which launches or procures the launching of a space object, or (2) a State from whose territory or facility a space object is launched.[510] The Liability Convention contains both strict liability (Article II) and fault-based liability (Article III) provisions.[511] The launching state is strictly liable for damage caused by its space object on the surface of the earth or to an aircraft in flight.[512] In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching state or to persons or property on board such a space object by a space object of another launching state, the launching state "shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible."[513] The treaty also provides for joint and several liability in certain circumstances, including where more than one State can be considered a "launching state."[514]

148. Regardless of whether a particular claim results in a payment of compensation, the United States would incur costs in addressing such claims, and those costs would be borne by U.S. taxpayers. Thus, there is a direct connection between the Commission's issuance of a license for satellite communications and exposure of the U.S. government to claims under international law, particularly

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[504] *Notice*, 33 FCC Rcd at11378, para. 77; *2004 Orbital Debris Order*, 19 FCC Rcd at 11613-14, paras. 109-113.

[505] Full text of these U.N. treaties is available at https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties.html.

[506] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, October 10, 1967 (Outer Space Treaty).

[507] Convention on International Liability for Damage Caused by Space Objects, September 1, 1972 (Liability Convention).

[508] Outer Space Treaty, Article VI.

[509] Outer Space Treaty, Article VII. As the Commission noted in the 2004 *Orbital Debris Order*, the definition of "space object" includes "component parts of a space object," which would arguably incorporate orbital debris resulting from satellite operations. *Orbital Debris Order*, 19 FCC Rcd at 11612-13, para. 109.

[510] Liability Convention, Article I.

[511] *See* Liability Convention, Art. II, III.

[512] Liability Convention, Article II.

[513] Liability Convention, Article III.

[514] *See* Liability Convention, Article V.

because the Commission is often the only agency reviewing an operator's plans for on-orbit operations and orbital debris mitigation, including on-orbit and post-mission disposal activities. Conditioning authorization on such indemnification requirements is therefore a reasonable step, given the absence of protections under international law otherwise applicable under U.S. law to the licensing authority's exercise of its discretionary functions.

149. Several commenters request that the Commission provide additional legal analysis regarding Commission authority for adopting an indemnification requirement, or otherwise question the Commission's jurisdiction in this area.[515] We have established above in our analysis that the Commission has authority, pursuant to the Communications Act, to review and assess orbital debris mitigation plans as part of its public interest analysis in issuing licenses for space station communications.[516] We consider an applicant's plan to mitigate orbital debris risks to be a relevant public interest factor in approving an applicant's space station operations, and requiring indemnification in the event that costs accrue as a result of those operations strengthens the incentives of applicants to mitigate risks.

150. In questioning the Commission's authority over this issue, several commenters argue that in other regulatory contexts, Congress has directly addressed the role of regulatory agencies with respect to liability and indemnification issues, but here, Congress has not provided the Commission with specific authority concerning indemnification.[517] In several examples cited by commenters, Congress provided for indemnification in specific instances, but in some instances, Congress has explicitly directed an agency to *accept* liability within certain ranges.[518] An example of this is the liability risk-sharing regime for commercial space transportation, addressed by statute and implemented by the FAA.[519] We observe that the FAA insurance requirements do not address post-launch issues arising from damages caused by a launch payload after a nominal launch is concluded.[520] Under the statute, launch or re-entry licensees obtain insurance to cover claims of third parties against launch or reentry participants, including the licensee, its customer, and the U.S. government and agencies and any contractors or subcontractors.[521] The FAA sets insurance requirements based upon the FAA's determination of the maximum probable

[515] *See* Intelsat Comments at 12; Space Logistics Comments at 13; Intelsat Comments at 12; Boeing Comments at 37-38; SIA Comments at 9; Telesat Comments at 11.

[516] Space Logistics Comments at 13. Since we conclude that the authority for the Commission to adopt an indemnification or insurance requirement derives from the same authority of the Commission to review debris mitigation plans, we do not address the additional argument of Space Logistics that the Commission cannot promulgate insurance or indemnification requirements under ancillary authority. *See id.* Intelsat similarly raises questions regarding the Commission's authority, but does not explain why the Commission's authority to adopt an indemnification requirement is more attenuated from the Commission's regulation of radiofrequency use than any requirements associated with orbital debris mitigation. *See* Intelsat Comments at 12.

[517] *See* SIA Comments at 9; Intelsat Comments at 13-14. *See also* Boeing Comments at 38-39.

[518] *See* Intelsat Comments at 13, n. 29. As one example from the statutes cited by Intelsat, the Nuclear Regulatory Commission has been given the authority to indemnify licensees from public liability arising from nuclear incidents which is in excess of the level of financial protection required of the licensee, 42 U.S.C. § 2210(c).

[519] Commercial Space Launch Act, 51 U.S.C. § 50901, *et seq.* (1994); 14 CFR part 440.

[520] Satellites would typically be considered part of the "launch payload." *See* 14 CFR § 401.5 (defining "payload" as an object that a person undertakes to place in outer space by means of a launch vehicle, including components of the vehicle specifically designed or adapted for that object). Title 14, part 440, subpart A of the FAA regulations establishes the financial responsibility and allocation of risk requirements for launch or reentry authorized by FAA license or permit under the regulations governing commercial space transportation. 14 CFR § 440.1. "Licensed activity" means the launch of a launch vehicle or the reentry of a reentry vehicle conducted under a license the FAA issues. 14 CFR § 440.3. "Permitted activity" means the launch or reentry of a reusable suborbital rocket conducted under a permit issued by the FAA. *Id.*

[521] *See* 51 U.S.C. § 50914.

loss that would result from the licensed launch or reentry activities, within statutory ceilings.[522] Subject to appropriations, the U.S. government may pay successful third-party liability claims in excess of the required maximum probable loss-based insurance, up to $1.5 billion (as adjusted for post-1989 inflation) above the amount of the maximum probable loss-based insurance.[523] Thus, the U.S. government, as established by statute, effectively indemnifies the licensee for that amount. For claims in excess of the maximum probable loss-based insurance plus government indemnification, the licensee or legally liable party is responsible.[524]

151. Should Congress directly address the issue of on-orbit or satellite disposal activities and require the Commission to accept liability for private activities, for example, we would be authorized to accept liability under those terms. Similarly, should Congress address the issue and direct the Commission to accept liability altogether, or direct another agency to do so with respect to on-orbit and disposal activities, we would not require indemnification. At this point, however, Congress has not required us to accept such liability or prohibited us from seeking indemnification from the private parties that engage in the activities that could give rise to such liability. Space Logistics claims that the fact that Congress did not establish a statutory liability framework for commercial space operations should not be interpreted as an invitation for FCC or other agency intervention.[525] The cases Space Logistics cites in support of this proposition are not relevant to the issue here, however, and the fact that Congress addressed third-party liability as it relates to launches authorized by the FAA does not imply that Congress explicitly or implicitly precluded the Commission from addressing liability issues related to completely separate Title III regulation of on-orbit and re-entry activities distinct from the launch activities addressed by the FAA.[526] As explained, the Commission has the authority under the Communications Act to grant applications consistent with the public interest, and ensuring that licensees understand their responsibilities when it comes to liability is consistent with the public interest.

152. Some commenters also argue that we should distinguish between different types of satellites for purposes of implementing this requirement, and not apply the requirement to GSO satellites, for example, because those operations allegedly present less risk.[527] The issue, however, is one of clarifying liability as a general matter. We are clarifying the responsibilities of operators for space operations when it comes to claims brought under the Outer Space treaties, and the risk profile of a

[522] *See id.*; 14 CFR § 440.9.

[523] *See* 51 U.S.C. 50915; 14 CFR § 440.19.

[524] *Id.*

[525] *Id.*

[526] *Rice v. Santa Fe Elevator Corp.* stands for the proposition that Congress has the power to pre-empt state law when Congress has legislated comprehensively, thus occupying an entire field of regulation and leaving no room for the States to supplement federal law. *See Rice v. Santa Fe Elevator Corp.*, 331 U.S. 218 (1947). Field preemption deals with preemption of State actions, not those of a Federal agency, and in any event, Space Logistics points to no Congressional act in support of the idea that Congress has "occupied the field" in this area. In *FDA v. Brown & Williamson Tobacco Corp.*, the U.S. Supreme Court concluded that Congress had clearly precluded the FDA from asserting jurisdiction over tobacco products because the FDA's assertion of jurisdiction was inconsistent with the intent that Congress had expressed in the Food, Drug, and Cosmetic Act's overall regulatory scheme and in subsequently enacted tobacco-specific legislation. *FDA v. Brown & Williamson Tobacco Corp.*, 529 U.S. 120, 160-61 (2001). Again, with respect to the action at issue here, no commenters point to any Congressional act that would cover or otherwise address the liability issues described here.

[527] *See, e.g.* Space Logistics Comments at 10 (arguing that the Commission should not impose indemnification requirements on GSO satellites because the primary liability risks are post-mission disposal through atmospheric reentry, which is not relevant for GSO satellites); AT&T Comments at 6 (arguing that the commission should apply any such requirement only to NGSO systems, which represent a substantially greater orbital debris risk than GSO space stations).

particular mission does not alter that responsibility.[528] For this same reason, we do not include a distinction in our rules between claims based on fault-based provisions and claims based on strict liability provisions.[529]

153. Intelsat asks that the Commission conduct an analysis of whether other governmental agencies would be better suited to decide whether to impose indemnification requirements on space station licensees in the first instance. Specifically, Intelsat requests that we conduct an analysis with respect to the Department of State.[530] Our actions here have been coordinated with other Federal agencies, which agree with the outcome here and either do not have regulatory functions or do not regulate with respect to the broad scope of activities that are covered by Commission licensing.[531]

154. EchoStar argues that since the Commission declined to impose indemnification requirements upon satellite licensees in 2004, it should not do so now, absent changed circumstances or statutory authority to adopt such requirements.[532] We observe that the Commission had previously sought comment on whether there were any circumstances in which requiring licensees to obtain insurance might protect the U.S. and its taxpayers from potential liability,[533] and while the Commission did not adopt a rule, since it had not proposed a specific indemnification requirement at that time, it concluded that "insurance and liability issues would continue to play a role in determining whether approval of a particular debris mitigation plan serves the public interest[.]"[534] Moreover, the Commission has gained experience in licensing over the last fifteen years and has concluded that a case-by-case approach to addressing liability is not sufficient in this area. As a practical matter, the issue of liability has not been systematically addressed and we believe that doing so here would serve the public interest by ensuring that licensees are incentivized to mitigate risks. Additionally, and as detailed above, circumstances have changed in the satellite industry in terms of the number of satellites being launched and the increase in orbital debris, including in heavily-used orbits.

155. Boeing argues that the Commission should refrain from adopting its indemnification proposal because the Commission has not referenced an example where the U.S. government has faced liability or incurred damages as a result of orbital debris from a commercial satellite system licensed by the Commission.[535] However, as the number of satellites in orbit and re-entering Earth's atmosphere

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[528] *See, e.g.*, Space Logistics Comments at 10; Sirius XM Comments at 10; AT&T Comments at 6. In the *Notice* we sought comment on whether we should exempt GSO space station licensees, for example, from an *insurance* requirement, but did not propose to exempt such licensees from an indemnification requirement. *Notice*, 33 FCC Rcd at 11379-80, para. 80.

[529] *See* SIA Comments at 9-10.

[530] Intelsat Comments at 14.

[531] We similarly reject Intelsat's claim that FAA liability insurance requirements in the launch and reentry context obviate the need for Commission action. Intelsat Comments at 14 (referencing the Commission's discussion of FAA authority in the *2004 Orbital Debris Order*). As noted above, FAA requirements, which generally address the launch vehicle activities, do not cover on-orbit activities or the types of satellite re-entry that would be the subject of review with respect to debris mitigation in the Commission's licensing process. The Commission's *2004 Orbital Debris Order* discussion of FAA requirements similarly does not indicate that FAA liability requirements would obviate the need for Commission action in this area. *See 2004 Orbital Debris Order*, 19 FCC Rcd at 11613, para. 110.

[532] EchoStar Comments at 7; *see also* AT&T Reply at 9.

[533] *Mitigation of Orbital Debris*, Notice of Proposed Rulemaking, 17 FCC Rcd at 5611, para. 6 (2002) *(2002 Orbital Debris Notice*).

[534] *2004 Orbital Debris Order*, 19 FCC Rcd at 11613-14, para. 111. The Commission noted that this was particularly true where such plans involve activities such as atmospheric re-entry, which may involve more immediate and substantial risks to persons and property on the surface of the Earth. *Id*.

[535] Boeing Comments at 37; Boeing Reply at 43; *see also* AT&T Reply at 9.

increases, potentially dramatically, and the number of countries with active satellites in outer space increases, it can be expected that the likelihood of a claim arising in international law will also increase. Therefore, it is necessary to revisit the topic of liability and provide clarity on the indemnification of the United States from costs associated with potential claims resulting from activities of the FCC-authorized satellites.

156. CSSMA argues that for non-catastrophic liability claims, the likelihood of a State-to-State claim is likely low given the political costs and efforts required to assert such a claim under the Liability Convention, but CSSMA provides no basis for this assumption.[536] CSSMA also states that for more serious circumstances, the loss would likely not be insurable and a licensee would not be able to pay even if it had agreed to indemnification.[537] We recognize that there may be situations where liability could be significant, and potentially more than a commercial enterprise could cover, that fact is a reality of dealing with liability in any area, and we do not find that is a reason to discount indemnification altogether.

157. Most of the commenters addressing this issue argue that the costs of the indemnification requirement to operators would outweigh any potential benefits.[538] Some commenters argue that such a requirement would be contrary to U.S. national interests in promoting innovation and competitiveness and ensuring that the Unites States is the jurisdiction of choice for space activities.[539] We also seek to foster innovation and to encourage the development of new services and technology, and believe that an indemnification requirement can be adopted that achieves the goal of limiting taxpayer liability while incurring relatively minimal costs for operators.[540] Further, by complying with the Commission's orbital debris regulations, including those regulations as amended in this proceeding, operators will most likely decrease the likelihood of incurring liability. Operators may choose to purchase insurance or not depending on their individualized needs. Several commenters specify practical difficulties with implementation, such as the possibility of obtaining insurance at reasonable rates.[541] We decline at this

[536] CSSMA Comments at 21.

[537] CSSMA Comments at 21. *See also* ORBCOMM Comments at 19 (arguing that without insurance to fund an indemnification liability, it is very likely that defaults on such obligations could occur, rendering such a requirement ineffective and unenforceable).

[538] AT&T Comments at 6 (arguing that an indemnification requirement would impose unnecessary burdens on operators while failing to meaningfully change licensee behavior); Space Logistics Comments at 9 (disagreeing specifically with indemnification proposal for GSO space stations); Boeing Comments at 38-39; Space Logistics Comments at 9-11; Lockheed Martin Comments at 18-19; *see also* AT&T Reply at 9; Sirius XM Reply at 4; Boeing Reply at 43.

[539] *See, e.g.*, CSSMA Comments at 20; Lockheed Martin Comments at 18-19 (stating that imposing "stringent" indemnification obligations on U.S. applicants and licensees could dissuade satellite applicants from seeking U.S. authorization); Spaceflight Comments at 6 (stating that adding new FCC indemnification and insurance requirements on top of the requirements already in place by the FAA, for example, could have a negative impact on the U.S. space market). *See also* OneWeb Comments at 30-31 (stating that this could discourage non-U.S.-licensees from seeking market access to provide services in the United States).

[540] SIA Comments at 9-10 (arguing that the Commission has not considered the potential for frivolous litigation). Space Logistics similarly argues that indemnification would increase litigation exposure for U.S. licensees both in terms of the direct assumption of liability and the potential that other parties could claim a right to sue the indemnifying party based on the indemnification requirement. Space Logistics Comments at 10. There are many different contexts in which a business may need to deal with costs associated with litigation, even if the business is ultimately found not to be liable. In other contexts, businesses address these issues by purchasing insurance, for example. There are always risks that an entity may be subject to a frivolous lawsuit, but those are part of the cost of doing business.

[541] *See, e.g.* SIA Comments at 9 (stating that the proposal is "vague and untenable"); Global NewSpace Operators Comments at 19 (stating that currently only 5% of LEO satellites are subject to on-orbit insurance, so the insurance industry would need to mature significantly to expand into this area); ORBCOMM Comments at 19 (raising

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time to impose an insurance requirement on licensees associated with the indemnification requirement. Commenters have not identified, and we are not aware of, any widespread practices that are likely to result in operators being subject to crippling liability—indeed, the entire point of requiring indemnification as well as disclosure of planned operations is to avoid creating any such liability in the first place.[542] We understand that operators are concerned with the possibility of incurring any liability for space activities based on international treaties, but there are risks associated with any operations in space, including for space stations operated by academic institutions, and start-up companies, and amateur operators.[543] The indemnification requirement would apply to experimental and amateur authorizations, as well as licenses issued under part 25.[544]

158. Boeing contends that an indemnification agreement is not necessary because the U.S. government could "easily initiate a civil action to secure recovery from the relevant operator."[545] Specifically, Boeing states that the U.S. could recover under a claim of contribution, claim of equitable tort indemnification, or claim of equitable apportionment.[546] Taking Boeing's contention at face value, it is unclear why, if recovery is relatively straightforward, an explicit indemnification would raise any significant concerns for operators. While we do not discount the potential avenues for securing recovery Boeing identifies, their applicability in the context of the possible treaty-based liability involved here has not been tested, and we therefore believe an explicit acknowledgement of indemnification would remove any uncertainties.

159. *Implementation.* In the *Notice*, the Commission sought comment on the means to execute the agreement, and proposed rule text implementing the requirement.[547] After consideration, we adopt an indemnification requirement that will be part of the license condition, rather than a separately executed agreement.[548] In order to ensure that applicants understand and agree to the indemnification obligation, we will also require that applicants include a signed statement regarding indemnification, which will be standardized, along with the other information provided in their application. We conclude, based on

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concerns about whether it will be possible for satellite system operators to obtain insurance at reasonable rates and about operators defaulting on obligations, rendering a requirement ineffective and unenforceable); Boeing Reply at 44 (unclear whether insurance for the entire life of the satellite could be obtained on reasonable terms).

[542] Intelsat, for example, argues that "limitless" indemnification could have crippling financial implications for a licensee in the event of a claim against the United States, regardless of fault. Intelsat Comments at 15.

[543] We recognize, for example, that by Commission rule, amateurs are duly authorized persons without pecuniary interest. 47 CFR § 97.3; *see* ARRL Comments at 4-5 (stating that an indemnification requirement could, as a practical matter, end the ability of amateur radio experimenters and their colleagues to launch and operate amateur satellites under U.S. auspices); Ray Soifer Reply; CSSMA Comments at 23 (stating that any form of indemnity insurance requirement imposed upon educational institutions, amateur satellite organizations, or other non-profit entities engaged in experimental activities would likely be an unbearable cost to these organizations). ARRL and AMSAT state that the imposition of an analogous requirement in the United Kingdom seriously hampered the amateur program in that country. ARRL Comments at 5; AMSAT Comments at 5-6. The operation of a space station, however, may present the same risks in terms of potential U.S. government liability whether the operator is an amateur or a commercial entity. AMSAT states that the proposed indemnification requirement would end the ability for organizations in the United States to launch and operate amateur satellites. AMSAT Comments at 6.

[544] *See* Appendix A, Final Rules.

[545] Boeing Comments at 37-39; Boeing Reply at 43.

[546] Boeing Comments at 37-39.

[547] *Notice*, 33 FCC Rcd 11379, para. 79.

[548] ORBCOMM, for example, expresses concern regarding a lack of uniformity for the indemnification agreement. ORBCOMM Comments at 19. Applying the indemnification requirement as a license condition will help to ensure uniformity.

further consideration that indemnification may be resolved at the application stage, rather than through a later agreement, since this would ensure that the indemnification is uniform for all applicants, and that it is agreed upon in advance of the issuance of the license. Requiring a statement regarding indemnification at the application stage ensures that agreement to indemnify can be one of the considerations underlying grant of the applicant's license request, whereas requiring agreement to indemnification after licensing would result in a more administratively complex process in which the license grant would remain contingent until the subsequent agreement to indemnify is completed. In describing the obligation of licensees in our application rules, we adopt language that is similar to what we proposed in the *Notice*, but modify it slightly to clarify that the indemnification obligation is associated with claims brought under the Outer Space Treaties.[549]

160. Several commenters express concern that it would create difficulties if the Commission implemented the indemnification requirement close to the application grant date.[550] LeoSat, for example, states that most new operators have not fully funded their proposed satellite systems prior to the Commission's grant of a license, and as a result, requiring operators to incur the costs to obtain the indemnification within 30 days of grant may not be realistic.[551] We note, however, that because we are not adopting an associated insurance requirement, there are not immediate costs associated with the indemnification, particularly if an entity is not yet operating. Accordingly, we adopt indemnification as an application requirement.

161. Taking into consideration concerns about timing, however, we will implement the indemnification requirement as an application requirement beginning two years following adoption of the rule, i.e., April 23, 2022. Therefore, any applicants whose applications for U.S. licenses are pending at that time would be required to file an amendment with the indemnification statement (along with any other updates to conform to our new rules).[552] Existing licensees would not be required to file the statement, unless they file a modification to their license. We note, however, that lack of a formal indemnification statement would not alter the liabilities of any existing operators for claims brought under international treaties. Additionally, as part of the public interest showing required for applications for assignments and transfers, applicants would also need to address transfer of indemnification. Specifically, the application will need to indicate that upon consummation of the transaction, the licensee or transferee will be bound by the terms of the indemnification arrangement.

162. *Market Access.* Additionally, we address the issue of indemnification by market access grantees, in other words, non-U.S.-licensed space stations granted access to the United States market. We make several initial observations. First, we again note that there can be multiple "launching states" for purposes of the Liability Convention. A "launching state" is broader and can include, among other things, a State which "launches or procures the launching of a space object," and is not necessarily limited to the State that has registered the satellite under the Convention on Registration of Objects Launched into Outer Space (Registration Convention) (although that State may be one of several 'launching states").[553] We expect that in most instances we would not require an indemnification agreement for a non-U.S.-licensed operator authorized for U.S. market access. In unusual situations, however, as assessed on a case-by-case basis, we would require a non-U.S.-licensed grantee to complete an indemnification

[549] *See* SIA Comments at 10 (suggesting that the *Notice* fails to address the potential for litigation that is frivolous or reflects anti-competitive intent).

[550] *See, e.g.,* LeoSat Comments at 9; Lockheed Martin Comments at 19; ORBCOMM Comments at 10; Sirius XM Comments at 9-10.

[551] LeoSat Comments at 9.

[552] This would also include market access applications to the extent that they fit the profile described below, where the United States would likely be considered a "launching state." The Commission will notify any market access applicants of the need to file an amendment, as necessary, at least 30 days prior to the effective date of the rule.

[553] *See* Liability Convention, Art. I.

agreement, particularly where, for purposes of determining a "launching state", there is no other administration with as clear of a connection to the space station and its operators as the United States.[554] One example might be where the space station has an ITU filing through a non-U.S. jurisdiction, but that jurisdiction has essentially no regulation of space activities, will not register the satellite with the United Nations, and the space station is operated by a U.S. company from a U.S. network control center, and launched from a U.S. launch site.

163. Telesat, CSSMA and others argue that when it comes to issues of economic liability for non-U.S.-licensed space stations, the Commission should defer to the national licensing agency, or other agency that has committed to registering the satellite with the United Nations as a space object.[555] However, this is not appropriate in all cases, as just illustrated. Commenters make a variety of arguments on this issue, but the main point is that the Commission would only require indemnification where a credible argument could be made that the United States is a launching state for the space station(s).[556] For example, OneWeb argues that for a satellite "licensed and launched" outside the United States, merely granting U.S. market access is unlikely to result in the United States incurring any "launching states" liability,[557] and therefore the imposition of an indemnification/insurance requirement lacks a sound jurisdictional basis, as non-U.S. licensees would be forced to financially account for claims that likely could not be successfully prosecuted against the United States.[558] OneWeb further contends that an indemnification/insurance requirement could have the effect of increasing claims against the United States because those financial commitments could be evidence of the United States' launching state status.[559] CSSMA argues that application to non-U.S. licensees would harm those operators, because foreign operators can be expected to have already paid similar, comparable expenses to their own respective foreign licensing authorities, and that a duplicate expense of this type, in addition to the bond requirements already applicable, could act to economically prohibit the entry of these operators into the U.S. market.[560] OneWeb suggests that such duplicative requirement could place non-U.S.-licensed operators at a disadvantage, potentially violating the U.S. market-opening commitments made in the WTO Agreement on Basic Telecommunications Services.[561] However, any operator that has incurred costs for indemnification or insurance through its national licensing entity would be clearly under the authority of that Administration and is not the "flag of convenience" operator that we would be concerned with in this context. Moreover, we would expect the United States vigorously to defend against any claims of liability based on unfounded assertions of its status as a "launching state." Thus, no operators

[554] *See* Appendix A, Final Rules (excepting applicants from the indemnification requirement where non-U.S.-licensed space stations are involved, except as determined by the Commission on a case-by-case basis).

[555] Telesat Comments at 12; CSSMA Comments at 24; OneWeb Comments at 30; Eutelsat Comments at 12; ViaSat Comments at 4.

[556] We note that this could also include an application filed by an earth station operator requesting communications with a non-U.S.-licensed satellite, either under parts 5 or 25. *See* Appendix A, Final Rules.

[557] Eutelsat takes this proposition a step further, and states that only satellites licensed or registered by the United States under the Convention on International Liability for Damage Caused by Space Objects of 1972 would implicate potential U.S. liability, but also acknowledges that the Commission can address on a case-by-case basis the unique circumstances where (i) the United State registers the satellite but is not the licensing administration; or (ii) does not register the satellite but is the licensing administration. Eutelsat Comments at 12 & n.15.

[558] OneWeb Comments at 31-32.

[559] OneWeb Comments at 32. We believe this is also the argument that Space Logistics makes in its comments regarding increasing litigation exposure for U.S. licensees. Space Logistics Comments at 10 (arguing that indemnification would increase litigation exposure and could also result in U.S. licensees having to obtain insurance for potential indemnification claims).

[560] CSSMA Comments at 24. *See also* Eutelsat Comments at 12; ViaSat Comments at 4.

[561] OneWeb Comments at 30.

would be incurring double indemnification or insurance costs because of a U.S. requirement, and therefore would not be at a disadvantage as compared to U.S.-licensed operators.

164. Relatedly, CSSMA argues that in some instances, an FCC space station licensee may not in fact have a sufficient legal nexus to the United States to imbue the status of "Launching State" upon the United States.[562] We find it very unlikely that a claimant would not identify the United States as the launching state or one of several "launching states" if the object in question is a Commission-licensed space station and U.S.-registered space object.

165. *Government Contracts.* We observe that in some instances the United States, through a government contract promulgated by an agency or other entity (e.g., NASA), may have agreed to indemnify an operator against certain claims. In these instances where an operator believes that the United States has indemnified the operator, the applicant should provide a demonstration of these circumstances, which would provide a basis for exempting the applicant from the indemnification requirement.

2. Other Economic Incentives

166. *Insurance.* We do not adopt an insurance requirement at this time associated with the indemnification requirement, although to the extent that they deem it important from a business perspective, we encourage licensees to obtain insurance that would cover the area in which licensees will indemnify the U.S. government. Separate from an indemnification requirement, the Commission had sought comment on the utility of insurance on its own as a means to incentivize operators to adhere to best practices in space.[563] Specifically, the ability to obtain lower insurance premiums could provide an economic incentive for operators to adopt debris mitigation strategies that reduce risk. A number of commenters suggest that insurance generally would not necessarily incentivize good behavior in space, and provide information concerning the functioning of insurance markets that suggest they do not by themselves provide adequate incentives for debris mitigation.[564] Given some of the limitations of insurance, we decline to adopt an insurance requirement on its own as a way of incentivizing "good behavior" in space. However, the rule adopted regarding indemnification will help to ensure that liability is considered as operators make decisions concerning satellite design and operation, and may thereby encourage operators to obtain insurance if possible to cover potential liabilities.[565]

167. *Other Incentives.* In the Further Notice below, we propose a performance bond for satellite disposal, which we tentatively believe would be in the public interest as an economic incentive. We decline, however, to adopt several of the other economic incentives proposed by commenters as ways to encourage best practices in orbital debris mitigation for Commission-authorized satellites and systems. None of the additional proposals have been developed sufficiently to demonstrate how they could be

[562] CSSMA Comments at 21.

[563] *Notice*, 33 FCC Rcd at para. 11379, para. 79.

[564] *See, e.g.*, Boeing Comments at 37-38; Sirius XM Comments at 10; Secure World Foundation Comments at 11; NewSpace Operators Comments at 19; CSSMA Comments at 21-22; CSSMA Reply at 19. CSSMA cites to Secure World Foundation paper on the topic of whether insurance can help incentivize the responsible use of space. *Id.* (citing Victoria A. Samson, et. al., *Can the Space Insurance Industry Help Incentivize the Responsible Use of Space?*, 69th Annual Astronautical Congress (October 2018), *available at* http://swfound.org/media/206275/iac-2018_manuscript_e342.pdf.). We refer to the views of the Secure World Foundation expressed on this topic in the record for this proceeding. *See* Secure World Foundation Comments at 8.

[565] If insurance does become viable in the future as a means to incentivize orbital debris mitigation strategies through premiums, Global NewSpace Operators states that a space sustainability rating could be valuable to insurers as a market standard to assess risks posed by the operator to the orbital environment. Global NewSpace Operators Comments at 20; *see also* D-Orbit Comments at 4 (suggesting some means of recognition that will incentivize best practices). As indicated earlier in the Order, we intend to follow these developments closely.

applied to the orbital debris mitigation context at this time.[566] We do not discount these possibilities altogether, however, and may revisit other economic incentives at some point in the future.

168. NYU and Duke Science Regulatory Lab, for example, recommend that the FCC carefully consider employing "market-based processes" that "harness the efficiencies of the market to achieve policy objectives" by exploring the use of government created rights—commonly referred to as "marketable permits." Examples of such marketable permits may include: "a cap and trade" system, auctioned launch permits, a "credit trading system,[567]" and a "priority review voucher."[568] Such marketable permits could create a limited right to place a designated mass object into orbit during a specific time frame and, as such, may be used to deter and mitigate orbital debris. As noted by various commenters, however, establishing any such marketable permit would be a substantial undertaking, given the complexities of defining, for example, an appropriate and tradeable "unit of exchange" or a quantifiable and verifiable monitoring process. Additionally, it is not clear how this type of system would fit within the Commission's satellite licensing structure.

169. NYU suggests the use of a regulatory fee to deter and mitigate orbital debris.[569] Such a regulatory fee, however, would require calibrating the dollar value of orbital debris; determining the amount of revenue that is required to achieve some orbital debris target, e.g., the projected cost for removal, mitigation or better design to minimize debris; and then deciding how to allocate fees across these differing objectives. The Commission also has limitations on its authority under the Communications Act to impose new regulatory fees—and indeed, we may not take into account risks of orbital debris creation under existing law.[570] These issues are compounded further by the fact that satellite operators are not homogenous and include large global satellite operators as well as smaller regional operators that supply services to distinct geographic regions thereby affecting differently scale economies and the intensity of competition. Accordingly, we do not adopt these models for reducing or mitigating orbital debris.

L. Scope of Rules

1. Amateur and Experimental Operations

170. The Commission proposed in the *Notice* to amend the rules governing experimental satellite and amateur satellite authorizations to maintain consistency with the proposed revisions to the orbital debris mitigation rules for commercial systems.[571] These authorized satellites have long been subject to orbital debris mitigation rules—as the Commission concluded in 2004 that it was in the public interest to require a description of the design and operational strategies used to mitigate orbital debris from applicants seeking to conduct experimental or amateur satellite operations.[572] In the *Notice*, the

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[566] *See also* Secure World Foundation Comments at 8 (stating its view that there are limits to the role that economic incentives can play in dealing with orbital debris challenges—and stating that the largest source of future debris is likely to be collisions between large spent rocket stages from government launches in decades past).

[567] NYU Reply at 10-11.

[568] Duke Science Regulatory Lab Comments at 20-24. *See also* D-Orbit Comments at 4 (proposing an "Ecotax" payable for every launch or for every year of satellite operations).

[569] NYU Reply at 13-14.

[570] *See* 47 U.S.C. § 159.

[571] *Notice*, 33 FCC Rcd at 11380, para. 82. The Commission noted that although it used the term "commercial" generally to refer to operations under part 25 of the Commission's rules, there is no requirement in part 25 that operations authorized under that part must be for an inherently commercial purpose. *Id.* at n.184.

[572] *2004 Orbital Debris Order*, 19 FCC Rcd at 11607-09, paras. 98-101, Appendix B. In the Order on Reconsideration issued by the Commission along with the *Notice* in this proceeding, the Commission denied a petition for reconsideration of the Commission's 2004 rules, in IB Docket No. 02-54, reiterating that it was in the public interest to apply orbital debris requirements to amateur radio service satellite operators. *See Mitigation of*

(continued….)

Commission stated that it continues to believe that it is appropriate for amateur licensees and experimental applicants to provide a similar amount of disclosure regarding debris mitigation plans as will be required of commercial satellites, and sought comment.[573] A number of commenters agreed that the amateur and experimental operations should be subject to the same orbital debris mitigation rules as commercial operations.[574] Commenters with interest in amateur operations generally request that we carefully consider the impact of any proposed regulations on amateur satellite organizations and others building and operating space stations in the amateur satellite service.[575]

171. In most instances, the issues relevant to amateur and experimental operations are discussed above in the context of specific rule changes.[576] We address a few additional issues below. As a general matter, the Secure World Foundation asks us to clarify the intent and actual impact of the proposed rule changes on the experimental and amateur satellite communities.[577] As part of our analysis on the specific rule changes above, we have taken into consideration any comments filed by parties with an interest in amateur satellites, or experimental satellite licensing, such as AMSAT and the University Small-Satellite Researchers. Where concerns have been raised about the application of rules to satellites and systems authorized under the experimental and amateur authorization processes, we have addressed those concerns. We note that, absent exceptions as noted in the discussion above, we will generally apply the same orbital debris mitigation rules to experimental and amateur-authorized stations because we conclude that these space stations can also pose risks to the on-orbit environment and to humans on the surface of the Earth, and so it is in the public interest to apply the same orbital debris requirements to satellites regardless of the type of authorization. We recognize as a general matter that amateur and experimental satellite operators may incur costs as a result of the revised orbital debris mitigation practices we adopt in this order. However, given the potentially significant risks associated with any space station, we believe these costs are outweighed by the benefits of having orbital debris mitigation rules that are generally-applicable to non-government satellites, and that do not favor one type of system over another based solely on whether the application is filed under part 5, part 25, or part 97.

172. Global NewSpace Operators suggests that an applicant should only be required to submit a collision analysis if it has the resources to do so, suggesting that some amateur or experimental space station operators may not.[578] Since compliance can be demonstrated through use of the NASA Debris Assessment Software, which is available at no-cost, and has been used by many experimental applicants and amateur space station operators, we do not see an issue with applying this requirement to those types of space stations.

173. We also recognize that in some instances, space stations, particularly amateur and experimental stations, are co-located on spacecraft with other space stations. AMSAT requests that we consider certain exemptions from orbital debris requirements in this scenario.[579] In instances where there

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Orbital Debris in the New Space Age; Mitigation of Orbital Debris, Notice of Proposed Rulemaking and Order on Reconsideration, 33 FCC Rcd at 11386-91, paras. 101-113 (2018).

[573] *Notice*, 33 FCC Rcd at 11380, para. 82.

[574] *See* NASA Comments at 7; Telesat Comments at 11; CSSMA Comments at 23; ORBCOMM Comments at 9; Global NewSpace Operators Comments at 20.

[575] AMSAT Reply at 3.

[576] For example, we discuss the applicability of rules related to the sharing of ephemeris data to amateur and experimental satellites. *See* SES/O3b Reply at 6-7. As another example, we address the application of the indemnification requirement to amateur and experimental satellite operators. *See, e.g.*, CSSMA Comments at 23.

[577] Secure World Foundation Comments at 9.

[578] Global NewSpace Operators Comments at 6.

[579] AMSAT Comments at 8. ARRL also supports this proposal. *See* ARRL Comments at 2.

are multiple space stations co-located on the same spacecraft, and information on orbital debris mitigation plans has been provided or will be provided by one or more of the space station applicants in conformance with the Commission's rules, applicants for other co-located space stations may satisfy the disclosure requirements through incorporation by reference.[580] In other words, there is no need for space station applicants to submit multiple copies of the same documentation to the Commission.[581] We decline to adopt a blanket exemption from orbital debris disclosures for space stations co-located with U.S. government space stations, but suggest that applicants for such space stations could seek a waiver of our orbital debris mitigation disclosure requirements on the basis that the plans are being evaluated by another U.S. government entity. In such instances, the Commission would request that the FCC applicant or operator specify the U.S. government agency and contact for officials who would be responsible for the orbital debris mitigation component of the spacecraft operations. This should be a relatively straightforward process in many cases—for example, there is no reason for the Commission to independently evaluate the orbital debris mitigation plan for an experimental space station planned to be co-located on the ISS. Applicants and operators should be aware however, that additional information may be necessary in certain factual scenarios—such as where the governmental space station operations will conclude before the Commission-authorized operations.[582]

174. AMSAT also seeks an exemption for Commission-authorized space stations co-located with government stations from any adopted indemnification requirement.[583] We generally agree, in cases where the U.S. government will have planned and developed the spacecraft at issue and will have accepted responsibility for the operations of the spacecraft. There could be some unique situations, however, so we decline to adopt a blanket exception, but instead we will assess these on a case-by-case basis through the waiver process.

2. Non-U.S.-Licensed Satellites

175. The Commission also proposed in the *Notice* that the new and amended rules adopted should be applicable to non-U.S.-licensed satellites seeking access to the U.S. market.[584] This approach is consistent with the Commission's current rules.[585] A number of commenters support the Commission's proposal to continue applying orbital debris mitigation requirements to non-U.S. licensed satellites seeking authority to access the U.S. market, and some commenters also support the existing approach of allowing non-U.S.-licensed satellite operators seeking U.S. market access to satisfy orbital debris mitigation requirements by demonstrating that their orbital debris mitigation efforts are subject to direct and effective regulatory oversight by another national licensing authority.[586] CSSMA suggests that

[580] Although AMSAT requests that we adopt language related specifically to the operations of amateur space stations authorized under Part 97, we see no reason not to extend this discussion to space stations authorized under Parts 5 and 25 as well.

[581] This would only apply where the orbital debris mitigation information submitted for one space station would cover the orbital debris mitigation requirements associated for the other space station. It would not apply, for example, where a space station is only temporarily located on another spacecraft. *See* CSSMA Reply at 3 (cautioning that any exemptions should not apply to satellites temporarily co-located on deployment vehicles).

[582] One example is the FalconSAT-3 spacecraft, which was made available for amateur radio service operations following conclusion of operations using NTIA-authorized frequencies. *See, e.g.*, U.S. Air Force Academy, "Astronautics Department to Retire 'Workhorse' Satellite," April 24, 2017, *available at* https://www.usafa.edu/news/astronautics-department-retire-workhorse-satellite/.

[583] AMSAT Comments at 8.

[584] *Notice*, 33 FCC Rcd at 11381, para. 85.

[585] *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).

[586] *See, e.g.*, ViaSat Comments at 2; Keplerian Tech Comments at 17; Secure World Foundation Comments at 9; Global NewSpace Operators Comments at 20; Eutelsat Comments at 12-13; CSSMA Comments at 23; OneWeb (continued….)

operators be permitted to demonstrate that their system's orbital debris mitigation plans are subject to direct and effective regulatory oversight by their foreign national licensing administration in cases where the operator does not have a substantial U.S. commercial presence, but is using U.S.-based activities for telemetry, tracking, and command.[587] Global NewSpace Operators, on the other hand, states that the degree of activity should not be a factor and that transmission and reception on a limited basis, such as telemetry, tracking, and command, still constitutes a commercial activity and those operators should be held to the same rules as a U.S.-licensed operator.[588] We agree with Global NewSpace Operators, and we do not think it is useful to make degree of activity the deciding factor for how to assess an applicant's orbital debris mitigation plans.

176. Regarding orbital debris mitigation plans specifically, the Commission previously concluded that the disclosure requirements could be satisfied by showing that the satellite system's debris mitigation plans are subject to the direct and effective oversight by a non-U.S.-satellite system's national licensing authority—which could include submitting an English language version of the debris mitigation rules or regulations of the authority and indicating the current status of the national licensing authority's review.[589] SpaceX asks that we extend this treatment to systems authorized by countries only with truly equivalent approaches to safe space.[590] We decline to set the exact parameters here for what constitutes "direct and effective oversight" in every instance, since foreign administrations may have different approaches which ultimately achieve the same result. We note, however, that transparency of the other administration's process is an important part of this assessment, particularly since the Commission's rules include a number of disclosures that are meant to inform not only the Commission, but also other operators so that those operators can plan accordingly.

M. Other Issues

1. Lunar/Other Orbits

177. Several commenters suggested that we adopt rules relating to the protection of lunar and other orbits.[591] We believe that regulations specific to lunar and other orbits is premature, and decline to establish any such rules at this time, particularly as they relate to satellite disposal. Operators will be required, however, to provide information in applications concerning limiting release of debris, limiting explosion risk, safe flight profiles, and plans for post-mission disposal, if any.

2. Probability of Accidental Explosions

178. In the *Notice*, we had not proposed to change our general application rule regarding minimizing debris generated by accidental explosions, which requires that applications provide a statement that the space station operator has assessed and limited the probability, during and after

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Comments at 32-34; OneWeb Reply at 1-2. CSSMA also notes its support for the Commission requiring information pertaining to the inclusion of applicants' systems in the United Nations Register of Objects Launched into Outer Space. CSSMA Comments at 23.

[587] CSSMA Comments at 24.

[588] Global NewSpace Operators Comments at 20.

[589] *2004 Orbital Debris Order*, 19 FCC Rcd at 11606, para. 95.

[590] SpaceX Reply at 8; *see also* EchoStar Comments.

[591] *See* CSSMA Comments at 4; Xplore Comments. CSSMA, for example, states that new rules should be developed for operations around other celestial bodies as needed, and that rules applicable to Earth-orbiting spacecraft should apply to these spacecraft when they are in Earth orbit after launch and on the way to deep space. *See also* Lockheed Martin Comments at 7 (stating that it is not clear how the term "operational orbit" would apply to future commercial space missions that are not Earth-centric or that are in Earth orbit for just a short time before leaving for other mission objectives).

completion of mission operations, of accidental explosions.[592] Boeing suggests that we adopt a specific acceptable threshold regarding the probability of accidental explosions, citing to the probability metric that is part of the revised ODMSP.[593] Specifically, Boeing asks that we specify that spacecraft operators demonstrate that the integrated probability of debris-generating explosions for each spacecraft (excluding small particle impacts) is less than 0.001 during deployment and mission operations.[594]

179. We decline to adopt this specific metric as part of our rules, both because we had not proposed this change in the *Notice* and since our experience has been that the information submitted by applicants is sufficient for us to make an informed assessment regarding whether the applicant has minimized the probability of accidental explosions, and that we have been sufficiently able to assess these demonstrations on a case-by-case basis. We note, however, that as a practical matter we would have concerns regarding any demonstration that would suggest that the probability of accidental explosions is greater than 0.001 for any spacecraft.

3. Implementation of the New Rules

180. Several commenters suggest that it is not practical to apply new debris mitigation requirements retroactively to operators already in-orbit.[595] CSSMA, for example, asks that we take into account that any changes to existing rules must be phased in over a period of several years so that the U.S. industry has time to evolve its technology and business plans.[596] We observe that most of the rules adopted in this proceeding are application rules. Except where otherwise specified in this Order (e.g., maneuverability for NGSO space stations above 400 km), the rules will apply to new applicants and not retroactively to existing applicants.

181. In some specific instances, applications have been granted in part on the condition that the applicant file a modification application for Commission review including updated information on their orbital debris mitigation plan. These modification applications must provide information that satisfies the new rules that we adopt here. Additionally, any other modifications filed by existing licensees or grantees seeking to modify their authorization as it relates to the orbital debris mitigation plan will be subject to these rules.

182. There is also one change to an operational rule regarding orbit-raising coordination. We do not anticipate that this will present any concerns to existing operators from a compliance perspective, since the record suggests that many operators already coordinate orbit-raising activities with other potentially affected operators. Therefore, we require operators to comply beginning on the effective date of the rule, or if compliance is not possible, seek waiver of the rule.

N. Additional Topics from the Regulatory Impact Analysis

183. In the *Notice*, as part of the Regulatory Impact Analysis, the Commission considered and sought comment on various regulatory alternatives to reducing debris in orbit.[597] Some of these approaches were related to other specific proposals in the *Notice* (e.g., changes in operations and disposal procedures). Other alternatives (e.g., fewer launches) were different from the proposals that the Commission otherwise proposed in the *Notice*. The Commission sought comment on six regulatory alternatives to address orbital debris: fewer launches, changes in satellite design, changes in operations and disposal procedures, use of economic incentives, active collision avoidance, and active debris

[592] 47 CFR § 25.114(d)(14)(ii).

[593] Boeing *Ex Parte* at 7-8.

[594] *Id.* at 7 (citing ODMSP 2-1).

[595] *See, e.g.*, Global NewSpace Operators Comments at 23; CSSMA Reply at 20-21.

[596] *Id.*

[597] *Notice*, 33 FCC Rcd at 11382-11386, paras. 88-100.

cleanup. The majority of these involve some type of regulatory activity. Based on the record and as discussed below, we conclude that as a general matter, operators would not necessarily be incentivized on their own to take action that is beneficial for the prevention and reduction of orbital debris in orbit absent regulatory action.

184. As an introduction to the Regulatory Impact Analysis, the Commission provided some high-level analysis on the benefits of mitigating orbital debris, and how debris can be characterized as a negative externality. That is, that while the debris problem is a significant consideration for the joint use of orbital resources, such considerations may not play a sufficient role in economic decision-making by operators individually. Reductions in the amount of debris created can help preserve orbital resources over the long-term. The costs and benefits are difficult to quantify—but in a worst-case scenario, certain valuable orbits could become useable only at an extremely high cost, rendering them unusable for most operators.[598] If there were large concentrations of debris in LEO, for example, certain areas could not be used to provide any satellite service. The same holds true for GEO, a particularly valuable orbit for satellite communications. These would be significant costs for the satellite industry overall, and may end up in the discontinuation of certain types of commercial satellites or systems, not to mention the potential impact on costs for U.S. government systems.[599] Moreover, there is a tendency of debris to generate yet more debris through collisions—resulting in an escalating debris situation, even if no new debris is added as a result of ongoing operations.[600] On the other hand, there are costs associated with practices such as collision avoidance and disposal—which we discuss in the context of each section above.

185. Additionally, there are considerations of how any U.S. regulations, specifically FCC regulations, can benefit the overall orbital debris environment, since the United States is only one among many spacefaring nations. Given the common pool nature of space, as previously explained, one country's decision to improve the efficiency with which space is used will convey a benefit to other countries that employ space even if that country does not employ such measures. That only the satellite operators of the country employing the measures designed to limit orbital debris are incurring the associated costs while the benefits are enjoyed by everyone, likely will create incentives for other countries to "free-ride" off of the efforts of the providers licensed by efficiency enhancing countries. In the *Notice* the Commission reiterated the Commission's 2004 statement 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."[601] Furthermore, as discussed above, we will apply the same orbital debris mitigation rules to non-U.S.-licensed satellites and systems seeking market access as we apply to U.S.-licensed systems, so that both types of satellites and systems will be subject to the same orbital debris regulation.

186. Some of the commenters in this proceeding responded to specific aspects of the Regulatory Impact Analysis, and in particular, disagreed with the options of limiting launches and regulating how satellites or satellite systems are designed.[602] For example, Eutelsat states, from the

[598] With increasing amounts of debris, operation in certain orbits becomes possible only through use of fuel resources for collision avoidance and increasing shielding, both of which can be significant expenses. Once costs become high enough, operators may decide to abandon operations in certain areas of space, even if operating in that area of space would generally be beneficial.

[599] If the government was able to continue operating its assets in areas of space crowded with debris, it would be only at a significant cost.

[600] *See Notice*, 33 FCC Rcd at 11383, para. 89-90. *See also* part II.

[601] *Notice*, 33 FCC Rcd at 11383, para. 90 (quoting *2004 Orbital Debris Order*, 19 FCC Rcd at 11607, para. 97).

[602] *See, e.g.*, Sirius XM Comments at 10-11; Boeing Comments at 39-40, Global NewSpace Operators Comments at 20-21. In addition to disagreeing with the approaches to limit launches and regulate satellite design, Boeing argues (continued….)

perspective of a GSO operator, that regulation of spacecraft design could inhibit innovation and competition by manufacturers regarding ways to limit orbital debris, improve satellite operations, and ensure reliable end-of-life operations.[603] Eutelsat further states that it may be difficult to identify a meaningful list of design elements that should be limited by rule and frequently updated to reflect technological progress.[604] Astranis also disagrees with the Commission regulating how satellites or satellite systems are designed, stating that in the case of GSO satellites, market forces (including manufacturer and operator commercial objectives) and well-settled international requirements are sufficient to drive reliable design elements.[605] Global NewSpace Operators states that while the government has a role to play in incentivizing industry, it does not recommend mandating specific satellite design concepts or active collision avoidance,[606] rather preferring that these elements emerge as industry best practices.[607] The Secure World Foundation states that changes in satellite design, operations and disposal and procedures, and economic incentives should all be considered as part of strengthening orbital debris mitigation requirements, and that ensuring better post-mission disposal through design and procedures represents the best opportunity for reducing the future growth of the space debris population from new launches.[608] The Secure World Foundation also notes that even with strong post-mission disposal, active debris removal or just-in-time collision avoidance of existing large debris objects will be required to prevent the collisions that will generate thousands of new pieces of debris.[609] According to the Secure World Foundation and Global NewSpace Operators, it is difficult to determine what the exact right mix of these components will be, and suggests that the U.S. government consider funding more public research and analysis of the orbital debris problem and holistic approaches to addressing space sustainability.[610] Many commenters also expressed views on the costs of certain rule revisions in the context of the discussion above, which we have considered as part of those analyses. Overall, we conclude that taking the action to adopt updates to our rules at this time balances the costs of requiring U.S. commercial and other non-governmental operators to address orbital debris mitigation as part of the current licensing process, with the benefit of limiting the increase in new debris in orbit.[611] At the same time, we recognize the need for continued research and development in this area,[612] and expect that given the pace of developments in the space industry and U.S. government, orbital debris regulation may

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that the Commission should not require satellite operators to engage in active debris cleanup. Boeing Comments at 40.

[603] Eutelsat Reply at 7; *see also* Astranis Reply at 3-4 (agreeing with Eutelsat). As Eutelsat notes, the Commission does review satellite designs to some extent in the context of review of applications and market access petitions. *Id.*

[604] Eutelsat Reply at 7.

[605] Astranis Reply at 3-4.

[606] *See also* D-Orbit Comments at 5 (discussing active debris cleanup in the context of the Regulatory Impact Analysis).

[607] Global NewSpace Operators Comments at 21.

[608] Secure World Foundation Comments at 10.

[609] *Id.*.

[610] *Id.; see* Global NewSpace Operators comments at 21.

[611] As discussed above, the Commission has required orbital debris mitigation plans since 2004, and the updated rules build on the Commission's existing framework, taking into consideration practices that have been common among applicants, such as using the NASA Debris Assessment Software tool, thus promoting regulatory certainty.

[612] The Secure World Foundation suggests that the Commission identify an agency responsible for coordinating scientific research on improving fundamental knowledge of the space environment, advancing the science and technology of critical space situational awareness inputs, and developing new hardware and software to support data processing and observations as outlined in SPD-3. Secure World Foundation Comments at 11. This recommendation goes beyond the scope of this proceeding.

become a more rapidly iterative process than it has been in the past. Given the record established both specific to the Regulatory Impact Analysis as well as specific to other topics in the proceeding, we agree with Global NewSpace Operators that the most practical, cost-neutral, and immediate regulatory actions can come from requiring changes in operations and disposal procedures.[613]

IV. FURTHER NOTICE OF PROPOSED RULEMAKING

187. In the *Notice*, the Commission had mentioned bonds as an example of an economic incentive, but had not made a specific proposal. In this Further Notice, we believe that a performance bond tied to successful post-mission disposal may be in the public interest, and propose to adopt such a bond applicable to space station licensees. We also seek comment on applying the performance bond for post-mission disposal to market access grantees. Essentially, we propose to adopt a requirement that space station licensees post a surety bond, similar to what they already do for spectrum utilization, that will be returned once the space stations authorized have successfully completed post-mission disposal. We propose to apply this requirement to all part 25 space stations—including both GSO and NGSO space stations, but also seek comment on whether there should be an exception for space stations authorized under the part 25 streamlined small satellite process.

188. In response to the mention of a post-mission disposal bond in the *Notice*, some commenters expressed disagreement with the idea.[614] According to Eutelsat, a performance bond requirement related to satellite end-of-life would cover what are typically unanticipated events that occur despite a proponent's best effort, and collection under a performance bond would not mitigate the result of such unanticipated events.[615] We believe this topic is worth further discussion, however, and tentatively conclude that there are benefits to a performance bond, despite the fact that even where the bond is forfeited the unsuccessful satellites would remain in orbit. Several commenters to the *Notice* suggest that there is difficulty in ensuring that entities follow through with their planned orbital debris mitigation plan. SpaceX, for example, states that once the government adopts verifiable requirements, the government should tie its rules to a rigorous enforcement framework that penalizes the generation of debris and reflects the seriousness of the harm such debris inflicts.[616] We observe, first, that while anomalous events are unanticipated, there are steps that an operator can take to reduce the probability of anomalous events, including testing, design redundancies, and second, with a bond in place tied to successful disposal, an operator may decide to begin end-of-life disposal procedures at an earlier stage if the satellite begins experiencing technical issues. Third, while this topic will need additional exploration outside the context of this proceeding,[617] developing a record in this proceeding could contribute to further conversations about how an end-of-life performance bond may serve as a way to fund future efforts toward active debris removal.[618] We also seek comment on any other ways in which a post-

[613] *See* Global NewSpace Operators Comments at 21.

[614] *See, e.g.*, ORBCOMM Comments at 19-20; Eutelsat Reply at 3-4. Eutelsat, for example, suggests that the costs for GSO satellites would outweigh the benefits. *Id.*

[615] Eutelsat Reply at 4; *see also* ORBCOMM Comments at 19-20.

[616] SpaceX Comments at 12.

[617] Further discussions outside of the context of this proceeding would be necessary to assess the viability of forfeited performance bonds as a source of funding for active cleanup of debris in orbit.

[618] *See, e.g.*, ORBCOMM Comments at 20 (stating that it is not clear if the Commission could ever establish a program to use forfeited de-orbit bonds to pay for the retrieval of spacecraft that were not successfully de-orbited); Sirius XM Comments at 10 (stating that fees obtained from penalizing rogue operators could be used to fund debris removal efforts); Satellite DFR Comments at 4 (the Commission or other regulatory entity should develop and fund a comprehensive program to begin removing debris from Earth orbit); Secure World Foundation Comments at 9 (stating that the removal of debris will need to be funded by governments—and stating that a government-supported technology development program, coupled with government purchase of service contracts, is the best way to develop this capability).

mission disposal bond could help to ensure that operators comply with orbital debris mitigation best practices.

189. We recognize that there are likely to be complexities in structuring a bond that would cover satellite end-of-life, and that maintaining a bond over a longer period of time than our current bond would potentially result in increased costs to operators. We do not think either of these issues are necessarily dispositive, however, and we seek comment on methods to structure the bond requirement that might reduce costs. Although a performance bond tailored to this scenario may not currently exist, a Commission rule could help to drive the market toward the creation of an appropriate bond instrument that would allow operators to satisfy this rule. We seek comment on this issue as well.

190. In addition to the orbital debris mitigation plan submitted by operators at the application-stage, there are a number of decisions by operators during and after the spacecraft mission which should be made in alignment with orbital debris mitigation best practices and culminate in successful disposal of the spacecraft. We tentatively conclude that application-stage requirements are not sufficient in all cases to incentivize operators to make decisions consistent with orbital debris mitigation best practices throughout the mission and post-mission lifetime of the spacecraft, and therefore to address this issue we tentatively conclude that a performance bond is in the public interest. Additionally, a performance bond can help to ensure post-mission disposal satellite reliability in instances where it may be difficult to assess, for example, where the operator's application-stage demonstration includes ensuring reliability through extensive testing of its satellites. A performance bond is another way to ensure the accuracy of the licensee's reliability estimate for post-mission disposal and to further discourage deployments that would potentially result in negative long-term impacts to the orbital environment. We seek comment on these tentative conclusions.

191. For implementation of a performance bond, the question of what constitutes a successful disposal must be addressed. We propose that the bond that would need to be forfeited by an NGSO satellite operator would be based upon any undisposed objects remaining in orbit and undisposed at the conclusion of the license term, beyond those accounted for in the licensee's calculation of the probability of successful disposal. The amount of the bond would also take into consideration the mass of the objects and the number of years that an individual undisposed satellite would remain in orbit longer than 25 years, up to a maximum of 200 years per object. We seek comment on these proposals generally, and welcome comment on any alternatives to the specifics of this proposal. For the actual forfeited bond calculation for NGSO licensees, we propose that the amount would be calculated as follows:

$$FA = ((M-EM) * ((Y-25)*(O-EO))$$

Where FA is the forfeited amount to be paid in dollars, M is the total undisposed mass in orbit in kilograms, EM is the expected undisposed mass in orbit in kilograms, and Y is the mean of the remaining years in orbit for any individual undisposed object, up to a maximum of 200 years per object, O is the total number of undisposed objects in orbit, and EO is the expected number of undisposed objects in orbit. The result would be rounded to the nearest $10,000. We observe that this formulation would result in a forfeited bond of zero for any space station or system deploying into an orbit in which, using conservative projections for solar activity, atmospheric drag will limit the spacecraft's time in orbit to 25 years or less. Licensees of space stations fitting this description would not be required to post a surety bond. We seek comment. In addition, we seek comment on whether we should provide an exemption from the requirement to post a bond where the maximum forfeited bond under this formula would be less than a certain amount, for example, $10,000. The bond, as formulated, would be most significant for those NGSO systems consisting of a large mass and which would have satellites remaining in orbit for a significant number of years beyond 25 years in the event of a failure. We also seek comment on whether we should incorporate the collision probability of the failed satellites over time, with a higher collision probability resulting in a higher forfeited bond.

192. We propose that the amount of the initial surety bond for NGSO licensees would be calculated as follows:

$$BA = (TM)*((Y-25)(TO))$$

Where BA is the amount of the bond in dollars, TM = the total mass of the satellite system, Y = number of years that an individual satellite will remain in orbit if it fails in the deployment orbit, and TO = total number of objects in orbit. The bond amount (BA) would be capped at a maximum of $100,000,000 for any system.

193. We seek comment on these proposals, including the potential monetary amounts and whether those amounts are sufficient to provide an economic incentive for operators. As a simpler alternative, default could be based upon the failure to dispose according to the expected disposal reliability, or failure to dispose according to the expected disposal reliability taking into consideration satellite mass. Under this alternative, a licensee would post a bond of $10,000,000, for example, and forfeit the bond if the disposal did not satisfy the disposal reliability metric stated in the application. The amount of the initial bond could vary depending on factors such as mass, number of spacecraft, and number of years in orbit. We seek comment on these various alternatives, and whether there is another approach that would incentivize NGSO operators to achieve high disposal reliability.

194. For GSO licensees, we propose that the question of successful disposal be based on whether the space station was disposed of in accordance with section 25.283(a) of the Commission's rules within six months following the conclusion of operations,[619] and seek comment on this issue. We propose that in the event of a failed disposal, the bond would be forfeited based upon the length of time the space station was in orbit before it was determined that disposal could not be successfully completed. Under this approach, the longer the space station is maintained on-orbit before the attempted disposal or anomaly causing inability to dispose of the spacecraft, the higher the amount of the bond forfeited. Generally speaking, the longer that a GSO space station operates, the more susceptible that space station is to malfunction that could put successful disposal at risk. One proposed approach that would take this into consideration follows. propose that the amount to be forfeited in the event of a failed disposal would be determined according to the following formula:

$$FA = \$5,000,000*(Y)$$

where A is the amount to be paid in dollars, and Y is calculated as follows: if the satellite operates for less than 15 years then Y=1; if the satellite operates between 15 and 20 years, then Y=2; and if the satellite operates for more than 20 years, then Y= two plus the total number of operational years, minus 20.

195. Initially we propose that a GSO licensee would have to post a surety bond of $5,000,000. For each license extension thereafter, the GSO licensee would need to increase the bond in an amount that would cover the additional five-year term, up to the maximum that would be forfeited if the satellite operates for that full five-year term.[620] In other words, if the operator seeks a five-year extension of the license, from 15 to 20 years, then the operator would need to increase the bond amount by an additional $5,000,000. We seek comment on this proposal. We seek comment on the monetary amounts involved and whether those amounts are sufficient to provide an economic incentive for operators. As a simpler alternative, default could be based on whether or not the GSO licensee successfully disposed of the space station, with a single bond amount, $10,000,000 dollars, for example, due if the space station is not disposed of in accordance with the Commission's rules. We seek comments on these various alternatives, on the appropriate bond amount, and whether there is another approach that would incentivize GSO

[619] Section 25.283(a) of the Commission's rules specifies a standard formula for GSO space stations to calculate the orbit to which the space stations must be located at the end of the space station's useful life. 47 CFR § 25.283(a).

[620] Different increases in the bond amount for license extensions shorter than five years could also be considered.

operators to achieve high disposal reliability.

196. We also seek comment on whether we should include any other analysis with respect to a failed disposal, such as failure to fully vent pressurized vessels, or failure to perform a targeted, controlled reentry into Earth's atmosphere. Additionally, similar to our surety bond rule currently, we seek comment on whether we should require that licensees post a surety bond for post-mission disposal within 30 days following grant of their license. Or, should we require the operators to post a surety bond closer to the date of launch, for example, 90 days prior to launch?

197. We propose that upon completion of disposal, operators would file a statement with the Commission specifying the details of the disposal, including those details relevant to determining whether the disposal was successful and to what extent. We propose that the Commission would then make a determination whether the licensee could release the bond or if the licensee would need to forfeit all or some of the bond amount. We seek comment on this approach and ask whether we should adopt an alternative method to determine when a bond may be released or a licensee must forfeit a certain amount.

198. Additionally, we seek comment on whether this bond should apply to grantees of U.S. market access. We observe that the post-mission disposal may be addressed in some instances by a different administration, and thus the post-mission disposal bond may overlap with existing requirements in this instance.

199. Under the approach stated above, referencing the specific formula, small-scale systems, including but not limited to those authorized under the experimental, amateur, or part 25 streamlined small satellite process are unlikely to need to post a bond since the amount of the forfeited bond for those small systems would be lower than $10,000 in all but the most unusual case. If we were to adopt this approach, we tentatively conclude that we would not apply the bond to NGSO systems authorized under either an experimental or amateur authorization, and that a categorical exemption would not be necessary for small systems licensed under part 25, such as under the NGSO streamlined small satellite process, since practically speaking those licensees would not be required to post a bond. We seek comment on this approach.

200. Alternatively, should we adopt an approach for NGSO systems that relies on the licensee meeting the disposal reliability metric indicated in the application, or another approach, we seek comment on the applicability of that approach to experimental, amateur, or small-scale systems such as those that would be authorized through the part 25 streamlined small satellite process.

V. PROCEDURAL MATTERS

201. *Ex Parte Procedures*. The proceeding this Further Notice initiates shall be treated as a "permit-but-disclose" proceeding in accordance with the Commission's *ex parte* rules.[621] 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 section 1.1206(b). In proceedings governed by section 1.49(f) or for which the Commission has made available a method of electronic filing, written *ex parte* presentations and

[621] 47 CFR §§ 1.1200 *et seq.*

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.

202. *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 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).

203. *Regulatory Flexibility Act.* Pursuant to the Regulatory Flexibility Act of 1980, as amended, 5 U.S.C. § 601 *et seq.* (RFA), the Commission's Final Regulatory Flexibility Analysis (FRFA) in this Report and Order is attached as Appendix B.

204. *Initial Regulatory Flexibility Analysis*. As required by the Regulatory Flexibility Act of 1980, as amended, the Commission has prepared an Initial Regulatory Flexibility Analysis (IRFA) for this Further 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 E. 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 Further Notice, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration.

205. *Paperwork Reduction Act.* This document contains modified information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. It will be

submitted to the Office of Management and Budget (OMB) for review under section 3507(d) of the PRA. OMB, other Federal agencies, and the general public are invited to comment on the modified information collection requirements contained in this document. In addition, we note that pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, see 44 U.S.C. 3506(c)(4), we previously sought specific comment on how the Commission might further reduce the information collection burden for small business concerns with fewer than 25 employees.

206. In this document, we have assessed the effects of adopting rule revisions related to the mitigation of orbital debris and find that doing so will serve the public interest and is unlikely to directly affect businesses with fewer than 25 employees.

207. In addition, this document contains proposed 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, Public Law 104-13. In addition, pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, see 44 U.S.C. 3506(c)(4)), we seek specific comment on how we might further reduce the information collection burden for small business concerns with fewer than 25 employees.

208. *Congressional Review Act.*— [The Commission will submit this draft Report and Order and Further Notice of Proposed Rulemaking to the Administrator of the Office of Information and Regulatory Affairs, Office of Management and Budget, for concurrence as to whether this rule is "major" or "non-major" under the Congressional Review Act, 5 U.S.C. § 804(2).] The Commission will send a copy of this Report and Order and Further Notice of Proposed Rulemaking to Congress and the Government Accountability Office pursuant to 5 U.S.C. § 801(a)(1)(A).

VI. ORDERING CLAUSES

209. 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, and 310, that this Report and Order IS ADOPTED, the policies, rules, and requirements discussed herein ARE ADOPTED, parts 5, 25, and 97 of the Commission's rules ARE AMENDED as set forth in Appendix A, and this Further Notice of Proposed Rulemaking IS ADOPTED.

210. IT IS FURTHER ORDERED that the amendments of the Commission's rules to sections 25.271(d) and 25.282, 47 CFR §§ 25.271(d), 25.282, set forth in Appendix A, ARE ADOPTED, effective thirty days from the date of publication in the Federal Register. The other amendments to the Commission's rules set forth in Appendix A contain new or modified information collection requirements that require review and approval by the Office of Management and Budget under the Paperwork Reduction Act, and WILL BECOME EFFECTIVE after the Commission publishes a notice in the Federal Register announcing such approval and the relevant effective date, except for the amendments to sections 5.64(c), 25.114(d)(14)(viii), and 97.207(h) of the Commission's rules, 47 CFR §§ 5.64(c), 25.114(d)(14)(viii), and 97.207(h), which WILL BECOME EFFECTIVE on April 23, 2022, provided that the amendments have been reviewed and approved by the Office of Management and Budget under the Paperwork Reduction Act.

211. IT IS FURTHER ORDERED that any space stations launched on or after April 23, 2022 must be compliant with the certification specified in either section 5.64(b)(4)(i)(D), 25.114(d)(14)(iv)(A)(4), or 97.207(g)(1)(iv)(A)(4) of the Commission's rules, 47 CFR §§ 5.64(b)(4)(i)(D), 25.114(d)(14)(iv)(A)(4), 97.207(g)(1)(iv)(A)(4) regarding maneuvering capabilities sufficient to perform collision avoidance throughout the period when the space stations are above 400 kilometers altitude. Operators planning to launch space stations on or after April 23, 2022 must submit a written certification to the Commission, as would be required under sections 5.64(b)(4)(i)(D), 25.114(d)(14)(iv)(A)(4), or 97.207(g)(1)(iv)(A)(4), either thirty days in advance of launch or by October 23, 2021, whichever is sooner.

212. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental

Affairs Bureau, Reference Information Center, SHALL SEND a copy of this Report and Order and Further Notice of Proposed Rulemaking, including the Initial and Final Regulatory Flexibility Analyses, to the Chief Counsel for Advocacy of the Small Business Administration.

213. IT IS FURTHER ORDERED that the Commission SHALL SEND a copy of this Report and Order in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act, *see* 5 U.S.C. § 801(a)(1)(A).

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

APPENDIX A

FINAL RULES

The Federal Communications Commission amends 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: 47 U.S.C. 154, 301, 302, 303, 307, 336.

2. Amend § 5.64, by revising paragraph (b), and adding paragraph (c), to read as follows:

§ 5.64 Special provisions for satellite systems.

* * * * *

(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, distinct from the space station launch vehicle, that may become a source of orbital debris;

(2) A statement indicating whether the space station operator has assessed and limited the probability 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 disposal. The statement must indicate whether this probability for an individual space station is 0.01 (1 in 100) or less, as calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool;

(3) A statement that the space station operator has assessed and limited the probability, during and after completion of mission operations, of accidental explosions or of release of liquids that will persist in droplet form. 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. 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 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 system:

(A) The statement must indicate whether the space station operator has assessed and limited the probability of a collision between any space station of the system and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the space station, including any de-orbit phases, to less than 0.001 (1

in 1,000). The probability shall be calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool. The statement must also provide the total probability of collision for the system as a whole, calculated as the sum of the probability of collision associated with each individual space station. Where the space station operator will rely on maneuverability to reduce total collision risk, the statement should provide a calculation of the total probability of collision taking into consideration both the expected failure rate of maneuver capability and an assumed 10% failure rate of the maneuver capability at an orbit that presents the worst case for collision risk. If the total probability of collision is greater than 0.001 (1 in 1,000), justification must be provided. The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects.

(B) The statement must identify characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, 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.

(C) If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, the statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft.

(D) 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 will not maintain orbital tolerances, *e.g.*, its propulsion system will not be used 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 design includes a propulsion system. For space stations deployed into the portion of the low-Earth orbit region above 400 km, the operator must certify that the space stations will be designed with the maneuvering capabilities sufficient to perform collision avoidance throughout the period when the space stations are above 400 km.

(E) The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.

(ii) Where a space station requests the assignment of a geostationary 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.

(5) A statement addressing the trackability of the space station(s). Space station(s) operating in low-Earth orbit will be presumed trackable if each individual space station is 10 cm or larger in its smallest dimension, exclusive of deployable components. Where the application is for an NGSO space station or system, the statement should also disclose the following:

(i) How the operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive;

(ii) Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity; and

(iii) The extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators.

(6) A statement disclosing planned proximity operations, if any, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks.

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

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

(ii) For space stations terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must disclose whether the spacecraft will be disposed of either through atmospheric re-entry, specifying if or by direct retrieval of the spacecraft will be used. The statement must also disclose the expected time in orbit for the space station following the completion of the mission and the steps taken to remove the space station(s) from orbit as soon as practicable..

(iii) For space stations not covered by either (i) or (ii), the statement must indicate whether disposal will involve use of a storage orbit or long-term atmospheric re-entry and rationale for the selected disposal plan.

(iv) For all NGSO space stations under (ii) or (iii), the following additional specific provisions apply:

(A) The statement must include a demonstration that the probability of success of the chosen disposal method will be 0.9 or greater for any individual space station. For space station systems consisting of multiple space stations, the demonstration should include additional information regarding efforts to achieve a higher probability of success, with a goal, for large systems, of a probability of success for any individual space station of 0.99 or better for large systems. For space stations under (B)that will be terminating operations in or passing through low-Earth orbit, successful disposal is defined as atmospheric re-entry of the spacecraft within 25 years or less following completion of the mission. For space stations under (iii), successful disposal is defined as atmospheric re-entry of the

spacecraft within 200 years or less following completion of the mission. will be assessed on a case-by-case basis.(B) If planned disposal is by atmospheric re-entry, the statement must also include:

1. A disclosure indicating whether the atmospheric re-entry will be an uncontrolled re-entry or a controlled targeted reentry.
2. A disclosure of the calculated casualty risk for an individual spacecraft using the NASA Debris Assessment Software or a higher fidelity assessment tool, and a description of input assumptions used in calculating such risk. The casualty risk assessment shall include an estimate as to whether any 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. For systems involving deployment of multiple space stations, the statement shall include an estimate of the total number of space stations to be deployed and the total casualty risk, calculated as the sum of the risk posed by each individual spacecraft re-entry. Where the calculated total risk of human casualty from surviving debris is greater than zero, the statement must include a justification specifying what measures have been taken to reduce the risk of human casualty from surviving debris, including the extent to which measures such as design-for-demise and targeted re-entry were considered.

(c) Applicants must submit a signed statement stating that upon issuance of a license by the Commission, the licensee will be responsible for indemnifying the United States against any costs associated with a claim brought under a provision of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies or Convention on International Liability for Damage Caused by Space Objects related to the facilities that are the subject of the license. This statement is not required for non-U.S.-licensed space stations as part of the initial application, but may be requested by the Commission from applicants on a case-by-case basis.

PART 25 – SATELLITE COMMUNICATIONS

1. 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.

2. Amend § 25.114 by revising paragraph (d)(14) by revising 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, distinct from the space station launch vehicle, that may become a source of orbital debris;

(ii) A statement indicating whether the space station operator has assessed and limited the probability 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 disposal. The statement must indicate whether this probability for an individual space station is 0.01 (1 in 100) or less, as calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool;

(iii) A statement that the space station operator has assessed and limited the probability, during and after completion of mission operations, of accidental explosions or of release of liquids that will persist in droplet form. 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. 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 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 system:

1. The statement must indicate whether the space station operator has assessed and limited the probability of a collision between any space station of the system and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the space station, including any de-orbit phases, to less than 0.001 (1 in 1,000). The probability shall be calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool. The statement must also provide the total probability of collision for the system as a whole, calculated as the sum of the probability of collision associated with each individual space station. The calculation must be performed for the estimated number of space stations to be deployed over a 15-year period, including replacement space stations. Where the space station operator will rely on maneuverability to reduce total collision risk, the statement should provide a calculation of the total probability of collision taking into consideration both the expected failure rate of the maneuver capability and an assumed 10% failure rate of the maneuver capability at an orbit that presents the worst case for collision risk. If the total probability of collision is greater than 0.001 (1 in 1,000), justification must be provided. The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects.

2. The statement must identify characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, 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.

3. If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, the statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft.

4. 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, *e.g.*, its propulsion system will not be used 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 design includes a propulsion system. For space stations deployed into the portion of the low-Earth orbit region above 400 km, the operator must certify that the space station(s) will be designed with the maneuvering capabilities sufficient to perform collision avoidance throughout the period when the space stations are above 400 km.

5. The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations. Where a space station requests the assignment of a geostationary 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 satellites and the measures that will be taken to prevent collisions;

(v) A statement addressing the trackability of the space station(s). Space station(s) operating in low-Earth orbit will be presumed trackable if each individual space station is 10 cm or larger in its smallest dimension, excluding deployable components. Where the application is for an NGSO space station or system, the statement shall also include the following:

(A) How the operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive;

(B) Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity; and

(C) The extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators.

(vi) A statement disclosing planned proximity operations, if any, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks.

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

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

(B) For space stations terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must disclose whether the spacecraft will be disposed of through atmospheric re-entry, specifying if direct retrieval of the spacecraft will be used. The statement must also disclose the expected time in orbit for the space station following the completion of the mission and the steps taken to remove the space station(s) from orbit as soon as practicable.

(C) For space stations not covered by either (i) or (ii), the statement must indicate whether disposal will involve use of a storage orbit or long-term atmospheric re-entry and rationale for the selected disposal plan.

(D) For all space stations under (B) or (C), the following additional specific provisions apply:

1. The statement must include a demonstration that the probability of success of the chosen disposal method will be 0.9 or greater for any individual space station. For space station systems consisting of multiple space stations, the demonstration should include additional information regarding efforts to achieve a higher probability of success, with a goal, for large systems, of a probability of success for any individual space station of 0.99 or better. For space stations under (B), successful disposal is defined as atmospheric re-entry of the spacecraft within 25 years or less following completion of the mission. For space stations under (C), successful disposal will be assessed on a case-by-case basis.

2. If planned disposal is by atmospheric re-entry, the statement must also include:

a. A disclosure indicating whether the atmospheric re-entry will be an uncontrolled re-entry or a controlled targeted reentry.

b. A disclosure of the calculated casualty risk for an individual spacecraft using the NASA Debris Assessment Software or a higher fidelity assessment tool, and a description of input assumptions used in calculating such risk. The casualty risk assessment shall include an estimate as to whether any 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. For systems involving deployment of multiple space stations, the statement shall include an estimate of the total number of space stations to be deployed over a 15 year period, including replacement space stations, and the total casualty risk, calculated as the sum of the risk posed by each individual spacecraft re-entry. Where the calculated total risk of human casualty from surviving debris is greater than zero, the statement must include a justification specifying what measures have been taken to reduce the risk of human casualty from surviving debris, including the extent to which measures such as design-for-demise and targeted re-entry were considered.

(E) 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.

* * *

(viii) Applicants for space stations must submit a signed statement stating that upon issuance of a license by the Commission, the licensee will be responsible for indemnifying the United States against any costs associated with a claim brought under a provision of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies or Convention on International Liability for Damage Caused by Space Objects related to the facilities that are the subject of the authorization. This statement is not required for non-U.S.-licensed space stations as part of the initial application, but may be requested by the Commission from applicants for U.S. market access on a case-by-case basis.

(ix) For non-U.S.-licensed space stations, the requirement to describe the design and operational strategies to minimize orbital debris risk can be satisfied either by submitting the information required of U.S.-licensed space stations, or 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.

3. Amend § 25.121 to add paragraph (f) as follows:

§25.121 License term and renewals.

* * * * *

(f) *Geostationary Satellite License Term Extensions.*

(1) For geostationary space stations issued an initial license term for a period of 15 years,

licensees may apply for a modification to extend the license term in increments of five years or less.

(2) Geostationary space station licensees seeking a license term extension through a license modification application must provide a statement that includes the following:

(i) The requested duration of the license extension;

(ii) The estimated total remaining space station lifetime;

(iii) A description of any single points of failure or other malfunctions, defects, or anomalies during the space station operation that could affect its ability to conduct end-of-life procedures as planned, and an assessment of the associated risk;

(iv) A certification that remaining fuel reserves are adequate to complete de-orbit as planned; and

(v) A certification that telemetry, tracking, and command links are fully functional.

4. Amend § 25.122 by revising paragraphs (c) and (d) to read as follows:

§ 25.122 Applications for streamlined small space station authorization.

* * * * *

(c) * * *

(3) The space station(s):

(i) Will be deployed at an orbital altitude of 400 km or below; or

* * *

* * *

(7) The total probability of a collision between the space station(s) and any other large object (10 cm or larger in diameter) during the orbital lifetime of the space station(s), including any de-orbit phases, is 0.001 (1 in 1,000) or less as assessed using the NASA Debris Assessment Software or a higher fidelity assessment tool. The total probability is calculated as the sum of the probability of collision associated with each individual space station.

(8) The probability that any individual space station will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal is 0.01 (1 in 100) or less.

* * *

(13) Upon receipt of a space situational awareness conjunction warning, the licensee or operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such

operator; and modifying space station attitude and/or operations. .

(d) * * *

(4) If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, a description of the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft shall be furnished at the time of application.

(5) A statement identifying characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, and indicating what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the licensee plans to use to avoid collision.

(6) A statement disclosing how the licensee or operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive, whether the space station(s) will be registered with the 18th Space Control Squadron or successor entity prior to deployment; and the extent to which the space station licensee or operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators.

(7) A description of the design and operation of maneuverability and deorbit systems, if any, and a description of the anticipated evolution over time of the orbit of the proposed satellite or satellites.

(8) If there are planned proximity operations, a statement disclosing those planned operations, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks.

(9) A demonstration that the probability of success of disposal is 0.9 or greater for any individual space station. Space stations deployed to orbits in which atmospheric drag will, in the event of a space station failure, limit the lifetime of the space station to less than 25 years do not need to provide this additional demonstration.

(10) Applicants for space stations must submit a signed statement stating that upon issuance of a license by the Commission, the licensee will be responsible for indemnifying the United States against any costs associated with a claim brought under a provision of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies or Convention on International Liability for Damage Caused by Space Objects related to the facilities that are the subject of the authorization. This statement is not required for non-U.S.-licensed space stations as part of the initial application, but may be requested by the Commission from applicants for U.S. market access on a case-by-case basis.

* * * * *

5. Amend § 25.123 by revising paragraph (b) to read as follows:

§ 25.123 Applications for streamlined small spacecraft authorization.

* * * * *

(b) * * *

(6) The total probability of a collision between the space station(s) and any other large object (10 cm or larger in diameter) during the orbital lifetime of the space station(s), including any de-orbit phases, is 0.001 (1 in 1,000) or less as assessed using the NASA Debris Assessment Software or a higher fidelity assessment tool. The total probability is calculated as the sum of the probability of collision associated with each individual space station.

* * *

(11) Upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.

* * * * *

6. Amend § 25.271 by revising paragraphs (d) to read as follows:

§ 25.271 Control of transmitting stations.

(d) The licensee shall ensure that the licensed facilities are properly secured against unauthorized access or use whenever an operator is not present at the transmitter. For space station operations, this includes securing satellite commands against unauthorized access and use.

7. Amend § 25.282 by modifying, by revising paragraph (b) to read as follows:

§ 25.282 Orbit raising maneuvers.

* * * * *

(b) The space station operator will coordinate on an operator-to-operator basis with any potentially affected satellite networks.

* * *

PART 97 – AMATEUR RADIO SERVICE

1. The authority citation for Part 97 continues to read as follows:

Authority: 47 U.S.C. 151-155, 301-609, unless otherwise noted.

2. Amend Section 97.207 by revising paragraph (g) and adding paragraph (h), to read as follows:

§ 97.207 Space station.

* * * * *

(g) * * *

(1) * * *

(iv) 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, distinct from the space station launch vehicle, that may become a source of orbital debris;

(ii) A statement indicating whether the space station operator has assessed and limited the probability 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 disposal. The statement must indicate whether this probability for an individual space station is 0.01 (1 in 100) or less, as calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool;

(iii) A statement that the space station operator has assessed and limited the probability, during and after completion of mission operations, of accidental explosions or of release of liquids that will persist in droplet form. 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. 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 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 system:

(1) The statement must indicate whether the space station operator has assessed and limited the probability of a collision between any space station of the system and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the space station, including any de-orbit phases, to less than 0.001 (1 in 1,000). The probability shall be calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool. The statement must also provide the total probability of collision for the system as a whole, calculated as the sum of the probability of collision associated with each individual space station. Where the space station operator will rely on maneuverability to reduce total collision risk, the statement should provide a calculation of the total probability of collision taking into consideration both the expected failure rate of the maneuver capability and an assumed 10% failure rate of the maneuver capability upon deployment. If the total probability of collision is greater than 0.001 (1 in 1,000), justification

must be provided. The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects.

(2) The statement must identify characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, 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.

(3) If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, the statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft.

(4) 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 be maintained to specific orbital tolerances, *e.g.*, its propulsion system will not be used 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 design includes a propulsion system. For space stations deployed into the portion of the low-Earth orbit region above 400 km, the operator must certify that the space stations will be designed with the maneuvering capabilities sufficient to perform collision avoidance throughout the period when the space stations are above 400 km.

(5) The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.

(B) Where a space station requests the assignment of a geostationary 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.

(v) A statement addressing the trackability of the space station(s). Space station(s) operating in low-Earth orbit will be presumed trackable if each individual space station is

10 cm or larger in its smallest dimension, exclusive of deployable components. Where the application is for an NGSO space station or system, the statement should also disclose the following:

(A) How the operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive;

(B) Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity; and

(C) The extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators.

(vi) A statement disclosing planned proximity operations, if any, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks.

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

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

(B) For space stations terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must disclose whether the spacecraft will be disposed of either through atmospheric re-entry, specifying if or by direct retrieval of the spacecraft will be used. The statement must also disclose the expected time in orbit for the space station following the completion of the mission and the steps taken to remove the space station(s) from orbit as soon as practicable.

(C) For space stations not covered by either (A) or (B), the statement must indicate whether disposal will involve use of a storage orbit or long-term atmospheric re-entry and rationale for the selected disposal plan.

(D) For all NGSO space stations under (B) or (C), the following additional specific provisions apply:

(1) The statement must include a demonstration that the probability of success of the chosen disposal method will be 0.9 or greater for any individual space station. For space station systems consisting of multiple space stations, the demonstration should include additional information regarding efforts to achieve a higher probability of success, with a goal, for large systems, of a probability of success for any individual space station of 0.99 or better for large systems. For space stations under (B) that will be terminating operations in or passing through low-Earth orbit, successful disposal is defined as atmospheric re-entry of the spacecraft within 25 years or less following completion of the mission. For space

stations under (C), successful disposal is defined as atmospheric re-entry of the spacecraft within 200 years or less following completion of the mission. will be assessed on a case-by-case basis.

(2) If planned disposal is by atmospheric re-entry, the statement must also include:

a. A disclosure indicating whether the atmospheric re-entry will be an uncontrolled re-entry or a controlled targeted reentry.

b. A disclosure of the calculated casualty risk for an individual spacecraft using the NASA Debris Assessment Software or a higher fidelity assessment tool, and a description of input assumptions used in calculating such risk. The casualty risk assessment shall include an estimate as to whether any 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. For systems involving deployment of multiple space stations, the statement shall include an estimate of the total number of space stations to be deployed and the total casualty risk, calculated as the sum of the risk posed by each individual spacecraft re-entry. Where the calculated total risk of human casualty from surviving debris is greater than zero, the statement must include a justification specifying what measures have been taken to reduce the risk of human casualty from surviving debris, including the extent to which measures such as design-for-demise and targeted re-entry were considered.

(viii) 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 a signed statement stating that the license grantee will be responsible for indemnifying the United States against any costs associated with a claim brought under a provision of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies or Convention on International Liability for Damage Caused by Space Objects related to the space station facilities.

APPENDIX B

Final Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[622] an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the Notice of Proposed Rulemaking, *Mitigation of Orbital Debris in the New Space Age* (*Notice*), released in November 2018 in this proceeding.[623] No comments were filed addressing the IRFA. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.[624]

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

This Order adopts updates to the Commission's rules relating to the mitigation of orbital debris. This represents the first comprehensive update to our rules on orbital debris mitigation since their adoption in 2004. These rule changes are informed by the Commission's experience gained in the licensing process and address updates in mitigation guidelines and practices as well as market developments. Adoption of these rule revisions will ensure that applicants for a Commission space station license or authorization, or grant of market access, provide a complete statement concerning plans for orbital debris mitigation enabling the Commission to fully evaluate whether the proposed operations are consistent with the public interest. Adoption of these rules will also provide specific guidance on evaluation criteria for orbital debris mitigation plans in a number of areas, for both non-geostationary orbit (NGSO) and geostationary-orbit (GSO) space stations. This action will help to ensure that Commission decisions are consistent with the public interest in space remaining viable for future satellites and systems and the many services that those systems provide to the public.

The Order adopts several changes to 47 CFR parts 5, 25, and 97. Principally, it:

1) Revises the Commission's application disclosure rules regarding mitigation of orbital debris to incorporate specific metrics for assessments of risk of collision with large objects, risk of collision with small objects, and re-entry casualty risk. Under the revised rules applicable to NGSO systems, risk of collision with large objects and re-entry casualty risk will also be assessed on a system-wide basis;

2) Adopts an applicant certification that NGSO space stations will have capability to perform collision avoidance maneuvers during any period when the space stations are located above 400 km in altitude;

3) Adopts application disclosures regarding protection of inhabitable spacecraft, trackability, space station identification, and sharing of information regarding initial space station deployment, ephemeris, and/or planned maneuvers;

4) Adopts a demonstration requirement for applicants for NGSO space stations that the probability of success of the chosen disposal method is 0.9 or greater for any individual space station, with the demonstration including efforts to achieve a higher probability of success for larger systems;

5) Codifies the current practice of requesting certain types of information from GSO licensees requesting license term extensions, and limits most GSO licensees to license extensions in increments of five years;

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[622] *See* 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601-612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996, (SBREFA) Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

[623] *Mitigation of Orbital Debris in the New Space Age,* Notice of Proposed Rulemaking, 33 FCC Rcd 11352 (2019).

[624] *See* 5 U.S.C. § 604.

6) Adopts a requirement that space station licensees indemnify the United States against any costs associated with a claim brought under a provision of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, or the Convention on International Liability for Damage Caused by Space Objects related to the facilities that are the subject of the license; and

7) Adopts other rules updates to address specific situations, including proximity operations, use of deployment devices, and certain types of plans for disposal of space stations.

B. Summary of Significant Issues Raised by Public Comments in Response to the IRFA

No comments were filed that specifically addressed the IRFA.

C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration

Pursuant to the Small Business Jobs Act of 2010, which amended the RFA, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration (SBA), and to provide a detailed statement of any change made to the proposed rules as a result of those comments.[625] The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

D. Description and Estimate of the Number of Small Entities To Which the Proposed Rules Will Apply

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 the proposed rules and policies, if adopted herein.[626] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[627] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[628] 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).[629] Below, we describe and estimate the number of small entities that may be affected by adoption of the final rules.

Satellite Telecommunications and All Other Telecommunications.

Satellite Telecommunications. This category comprises firms "primarily engaged in providing 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."[630] Satellite telecommunications service providers include satellite and earth station operators. The category has a small business size standard of $35 million or less in average

[625] 5 U.S.C. § 604(a)(3).

[626] *Id.*

[627] 5 U.S.C. § 601(6).

[628] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small-business concern" in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), 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."

[629] 15 U.S.C. § 632.

[630] U.S. Census Bureau, *2017 NAICS Definitions, "517410 Satellite Telecommunications";* https://www.census.gov/cgi-bin/sssd/naics/naicsrch?input=517410&search=2017+NAICS+Search&search=2017.

annual receipts, under SBA rules.[631] For this category, U.S. Census Bureau data for 2012 show that there were a total of 333 firms that operated for the entire year.[632] Of this total, 299 firms had annual receipts of less than $25 million.[633] Consequently, we estimate that the majority of satellite telecommunications providers are small entities

All Other Telecommunications. The **"**All Other Telecommunications" category is comprised of establishments primarily engaged in providing specialized telecommunications services, such as satellite tracking, communications telemetry, and radar station operation.[634] 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.[635] Establishments providing Internet services or voice over Internet protocol (VoIP) services via client-supplied telecommunications connections are also included in this industry.[636] The SBA has developed a small business size standard for "All Other Telecommunications", which consists of all such firms with annual receipts of $35 million or less.[637] For this category, U.S. Census Bureau data for 2012 show that there were 1,442 firms that operated for the entire year.[638] Of those firms, a total of 1,400 had annual receipts less than $25 million and 15 firms had annual receipts of $25 million to $49, 999,999.[639] Thus, the Commission estimates that the majority of "All Other Telecommunications" firms potentially affected by our action can be considered small.

These rule changes would also apply to experimental space station applicants under part 5 and amateur space station operators under part 97, and we estimate that in almost all cases these entities will qualify under the definition of small entities. Additionally, we estimate that some space station applicants applying under part 25 of the Commission's rules will qualify as small entities affected by these rule changes.

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

The Order amended those rules that are applicable to space station operators requesting a licensee or authorization from the Commission, or entities requesting that the Commission grant a request for U.S. market access. These applicants must submit a debris mitigation plan to the Commission as part of the application process, and the Order revised in part the information to be included in that debris mitigation plan. These revisions codified a number of informational requirements that applicants were providing under the existing rules, including providing some specific metrics for operators to reference in preparing orbital debris mitigation plans. The Order also adopts some additional disclosure requirements and

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[631] 13 CFR § 121.201, NAICS code 517410.

[632] U.S. Census Bureau, *2012 Economic Census of the United States*, Table EC1251SSSZ4, *Information: Subject Series - Estab and Firm Size: Receipts Size of Firms for the United States: 2012*, NAICS Code 517410, https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012_US/51SSSZ4//naics~517410.

[633] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard of annual receipts of $35 million or less.

[634] *See* U.S. Census Bureau, *2017 NAICS Definitions*, "*517919 All Other Telecommunications*", https://www.census.gov/cgi-bin/sssd/naics/naicsrch?input=517919&search=2017+NAICS+Search&search=2017.

[635] *Id.*

[636] *Id.*

[637] *See* 13 CFR § 121.201, NAICS Code 517919.

[638] U.S. Census Bureau, *2012 Economic Census of the United States*, Table EC1251SSSZ4, *Information: Subject Series - Estab and Firm Size: Receipts Size of Firms for the United States: 2012*, NAICS Code 517919, https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012_US/51SSSZ4//naics~517919.

[639] *Id.*

certifications related to orbital debris mitigation.

Applicants requesting authorization from the Commission must comply with existing technical disclosure requirements, including those related to orbital debris mitigation. Much of the information covered in the revised rules is information that applicants already provide or that the Commission would currently seek from the applicant under its existing general disclosure requirements. Most applicants already prepare orbital debris mitigation plans using the National Aeronautics and Space Administration (NASA) Debris Assessment Software identified in the revised rules as an acceptable assessment tool. This assessment tool is available at no cost and documentation on how to use the software is made available online by NASA. The additional disclosure and certification requirements adopted in the Report and Order are consistent with the types of legal and technical requirements already specified in the Commission's application rules, and therefore we expect that all parties, including small entities, will have the resources to prepare and disclose orbital debris mitigation plans in accordance with the revised rules.

In the IRFA, the Commission observed that most small entities do not launch and operate large satellite constellations and so proposals for operators to perform certain calculations in the aggregate were not likely to be burdensome. The rules adopted in the Order require a system-level assessment to be conducted in several areas (e.g., collision risk, re-entry casualty risk, and disposal reliability) for any systems consisting of more than one space station. Some small entities may apply for and operate multiple space stations, and thus this requirement would apply to some small entities as well. However, we believe conducting these assessments is not more significant than the type of technical analysis that an applicant will already be performing in preparing its application for Commission, and so should not be burdensome.

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

The RFA requires an agency to describe any significant alternatives that it has considered in developing its 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 rule 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."[640]

(1) *Differing compliance or reporting requirements or timetables*. The Order requires all space station applicants to disclose plans to mitigate orbital debris at the application stage, and thus applicants may prepare and submit the information according to their schedule, so long as the information is part of the application to the Commission, and there is enough time for the Commission to review and act on the application prior to launch. Applicants for GSO license extensions similarly may prepare information in support of their request for an extension in accordance with their preferred timetable. As noted, the revised requirements overall are consistent with the level of technical analysis that applicants currently provide in preparing an application for Commission review. We do make a timetable modification in the amateur space station rules to accommodate the notification process for Part 97 amateur authorizations.[641] Applicants for systems consisting of multiple space stations will need to provide some additional information at the application stage to assess risk on a system-wide basis, recognizing the impact of a system consisting of multiple satellites on the orbital debris environment. As noted above, operation of multiple space stations is not always correlated with larger entities, however, since small entities may also

[640] 5 U.S.C. § 603(c)(1)-(4).

[641] Amateur licensee grantees will provide information on orbital debris mitigation to the Commission as part of a pre-space notification no later than 90 days before integration of the space station into the launch vehicle. 47 CFR § 97.207.

plan to operate multiple space stations. As a general matter, we observe that space station operations by small entities can pose the same public interest concerns as those posed by large entities when it comes to contribution to the orbital debris environment, with the level of contribution to the debris environment being driven by factors other than the size of the entity.

(2) *Clarification, consolidation, or simplification of compliance or reporting requirements.* The Order clarifies a number of existing compliance requirements by providing specific metrics and guidance in a number of areas that inform an applicant's disclosures and certifications related to orbital debris mitigation. The Order also clarifies the authorization process by specifying additional disclosures in the rules, thereby providing applicants, including small entities, with a more complete view of the information that the Commission needs during a typical license or authorization process in order to adequately assess the applicant's orbital debris mitigation plan.

(3) *Use of performance, rather than design, standards.* The Order specifically addresses comments requesting the use of performance, rather than prescriptive, or design, standards.[642] We have endeavored throughout the Report and Order to adopt a performance-based approach where feasible.

(4) *Exemption from coverage of the rule, or any part thereof, for small entities.* Regarding the indemnification requirement adopted in the Order, we observe that the indemnification requirement is implemented to clarify liability generally, and since we cannot accept liability in any amount on behalf of the U.S. government for activities authorized by the Commission, we cannot distinguish between types of entities (e.g., small and large) for purposes of exempting certain entities from the indemnification requirement. With respect to other requirements, we reiterate our observation that as a general matter, space station operations by small entities can present the same public interest concerns as those posed by large entities when it comes to contribution to the orbital debris environment, with the level of contribution to the debris environment being driven by factors other than the size of the entity. Therefore, we do not adopt any other exemptions from coverage of a rule for small entities.

Report to Congress

The Commission will send a copy of the *Order*, including this FRFA, in a report to Congress pursuant to the Congressional Review Act.[643] In addition, the Commission will send a copy of the *Order*, including this FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the *Order* and FRFA (or summaries thereof) will also be published in the *Federal Register*.[644]

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[642] *Order* at para. 13.

[643] *See* 5 U.S.C. § 801(a)(1)(A).

[644] *See* 5 U.S.C. § 604(b).

APPENDIX C

List of Commenters to *Notice*

Comments

ARRL, The National Association for Amateur Radio
Association of Space Explorers
AT&T Services, Inc.
Catherine Doldirina, D-Orbit
Charles Clancy and Jonathan Black
Commercial Smallsat Spectrum Management Association
Darren Scott McKnight
Duke Science Regulation Lab
EchoStar Satellite Operating Corporation, Hughes Network Systems, LLC
Edward Lu, LeoLabs
European External Action Service
Eutelsat S.A.
Global NewSpace Operators
Horacio Gasquet
Institute for Policy Integrity, New York University School of Law
Intelsat License LLC
Iridium Communications Inc.
Josef Koller, The Aerospace Corporation
Keplerian Technologies Inc.
LeoSat MA, Inc.
Lockheed Martin Corporation
Maxar Technologies Inc.
Michael Maloney, Satellite Design for Recovery
Myles Patrick Moran
National Aeronautics and Space Administration
Nicholas John McCreight
ORBCOMM Inc.
Providence Access Company
Radio Amateur Satellite Corporation
Rev. Robert Bachelder, United Church of Christ
Satellite Industry Association
SES Americom Inc. and O3b Limited
Secure World Foundation
Sirius XM Radio Inc.
Space Exploration Technologies Corp.
Space Logistics, LLC
Spaceflight, Inc.
Telesat Canada
The Boeing Company
The Consortium for Execution of Rendezvous and Servicing Operations
University Small-Satellite Researchers, Samuelson-Glushko Technology Law & Policy Clinic
U.S. Department of Commerce
Viasat Inc.
WorldVu Satellites Limited
Xplore Inc.

Reply Comments

Amazon.com, Inc.
Astranis Space Technology Corp.
AT&T Services, Inc.
Commercial Smallsat Spectrum Management Association
Eutelsat S.A.
Institute for Policy Integrity, New York University School of Law
Nicholas Yu
ORBCOMM Inc.
Radio Amateur Satellite Corporation
Ray Soifer
Satellite Industry Association
SES Americom, Inc. and O3b Limited
Sirius XM Radio Inc.
Space Exploration Technologies Corp.
Swarm Technologies Inc.
The Boeing Company
Tyvak
University Small-Satellite Researchers, Samuelson-Glushko Technology Law & Policy Clinic
WorldVu Satellites Limited

***Ex Parte* Filers**

Astro Digital US, Inc.
AT&T Services, Inc.
Charity Weeden, Astroscale U.S.
David Goldman, Space Exploration Technologies Corp.
Josef Koller, The Aerospace Corporation
Keplerian Technologies, Inc.
Public Employees for Environmental Responsibility
Satellite Industry Association
Sirius XM Radio Inc.
Space Exploration Technologies Corp.
Telesat Canada
The Boeing Company
WorldVu Satellites Limited

APPENDIX D

PROPOSED RULES

The Federal Communications Commission amends title 47 of the Code of Federal Regulations, part 25, as follows:

PART 25 – SATELLITE COMMUNICATIONS

1. 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.

2. Add Section 25.166 to read as follows:

§ 25.166 Surety bonds for successful post-mission disposal.

(a) For all space stations licenses issued after [ ], the licensee must post a surety bond specific to successful post-mission disposal within 30 days of the grant of its license. Failure to post a bond will render the license null and void automatically.

(1) An NGSO licensee:

(A) Must have on file a surety bond requiring payment in the event of default as defined below in paragraph (B), determined according to the following formula: BA = (TM)*((Y-25)(TO)). BA is the amount of the bond in dollars, TM is the total mass of the satellite system, Y is the number of years that an individual satellite will remain in orbit if it fails in the deployment orbit, and TO is the total number of objects in orbit. The bond amount (BA) would be capped at a maximum of $100,000,000 for any system.

(B) Will be considered in default if any undisposed objects remain in orbit and undisposed at the conclusion of the license term, beyond those accounted for in the licensee's calculation of the probability of successful disposal. In the case of default, the NGSO licensee will be responsible for the amount determined according to the following formula, and rounded to the nearest $10,000. FA = ((M-EM) * ((Y-25)*(O-EO)). FA is the amount to be paid in dollars, M is the total undisposed mass in orbit in kilograms, EM is the expected undisposed mass in orbit in kilograms, Y is the mean of the remaining years in orbit for any individual undisposed object, up to a maximum of 200 years per object, and O is the total number of undisposed objects in orbit, and EO is the expected number of undisposed objects in orbit.

(2) A GSO licensee:

(A) Must have on file a surety bond requiring payment in the event of default as defined in paragraph (B) of this section in the amount of $5,000,000. If the licensee is granted a modification to extend the length of its license by up to five years, the surety bond on file must be increased by $5,000,000, and by an additional $5,000,000 for a subsequent extension of up to five years. For any additional years of license extension authorized by the Commission, the surety bond on file must be increased to an amount that would satisfy the formula in paragraph (B) of this section.

(B) Will be considered in default if the licensed space station is not disposed of in accordance with the statement specified in §§ 25.114(d)(14)(iv) and 25.283 within 6 months following conclusion of operations. In the case of default, the NGSO licensee will be responsible for the amount determined according to the following formula: FA = $5,000,000*(Y), where FA is the amount to be paid in dollars, and Y is calculated as follows: if the satellite operates for less than 15 years then Y=1; if the satellite operates between 15 and 20 years, then Y=2; and if the satellite operates for more than 20 years, then Y= two plus the total number of operational years, minus 20.

(b) The licensee must use a surety company deemed acceptable within the meaning of 31 U.S.C. 9304 et seq. (*See, e.g.*, Department of Treasury Fiscal Service, Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and As Acceptable Reinsurance Companies, 57 FR 29356, July 1, 1992.) The bond must name the U.S. Treasury as beneficiary in the event of the licensee's default. The licensee must provide the Commission with a copy of the performance bond, including all details and conditions.

APPENDIX E

Initial Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[645] 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 Further Notice of Proposed Rulemaking (Further Notice). 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 *Notice* for comments. The Commission will send a copy of this Further Notice, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration (SBA).[646] In addition, the Further Notic*e* and IRFA (or summaries thereof) will be published in the Federal Register.[647]

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

The Further Notice proposes to adopt a bond requirement for space station licensees under part 25 of the Commission rules, tied to successful disposal of the spacecraft following the end of the mission. This bond would be similar in some respects to the bond currently required of space station licensees and market access grantees under part 25 tied to the initial deployment and operations of their licensed space station or system. The goal of the bond requirement proposed in the Further Notice, however is to help to encourage operators to make decisions before and during the lifetime of the space station, that will ultimately lead to successful disposal of the spacecraft.

B. Legal Basis

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

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

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.[648] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[649] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[650] 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

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[645] *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).

[646] *See* 5 U.S.C. § 603(a).

[647] *Id.*

[648] 5 U.S.C. § 604(a)(3).

[649] 5 U.S.C. § 601(6).

[650] 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).

(SBA).[651] 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

Satellite Telecommunications. This category comprises firms "primarily engaged in providing 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."[652] Satellite telecommunications service providers include satellite and earth station operators. The category has a small business size standard of $35 million or less in average annual receipts, under SBA rules.[653] For this category, U.S. Census Bureau data for 2012 show that there were a total of 333 firms that operated for the entire year.[654] Of this total, 299 firms had annual receipts of less than $25 million.[655] Consequently, we estimate that the majority of satellite telecommunications providers are small entities.

All Other Telecommunications. The **"**All Other Telecommunications" category is comprised of establishments primarily engaged in providing specialized telecommunications services, such as satellite tracking, communications telemetry, and radar station operation.[656] 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.[657] Establishments providing Internet services or voice over Internet protocol (VoIP) services via client-supplied telecommunications connections are also included in this industry.[658] The SBA has developed a small business size standard for "All Other Telecommunications", which consists of all such firms with annual receipts of $35 million or less.[659] For this category, U.S. Census Bureau data for 2012 show that there were 1,442 firms that operated for the entire year.[660] Of those firms, a total of 1,400 had annual receipts less than $25 million and 15 firms had annual receipts of $25 million to $49, 999,999.[661] Thus, the Commission estimates that the majority of "All Other Telecommunications" firms potentially affected by our action can be considered small.

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

[652] U.S. Census Bureau, *2017 NAICS Definitions, "517410 Satellite Telecommunications";* https://www.census.gov/cgi-bin/sssd/naics/naicsrch?input=517410&search=2017+NAICS+Search&search=2017.

[653] 13 CFR § 121.201, NAICS code 517410.

[654] U.S. Census Bureau, *2012 Economic Census of the United States*, Table EC1251SSSZ4, *Information: Subject Series - Estab and Firm Size: Receipts Size of Firms for the United States: 2012*, NAICS Code 517410, https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012_US/51SSSZ4//naics~517410.

[655] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard of annual receipts of $35 million or less.

[656] *See* U.S. Census Bureau, *2017 NAICS Definitions*, "*517919 All Other Telecommunications*", https://www.census.gov/cgi-bin/sssd/naics/naicsrch?input=517919&search=2017+NAICS+Search&search=2017.

[657] *Id.*

[658] *Id.*

[659] *See* 13 CFR § 121.201, NAICS Code 517919.

[660] U.S. Census Bureau, *2012 Economic Census of the United States*, Table EC1251SSSZ4, *Information: Subject Series - Estab and Firm Size: Receipts Size of Firms for the United States: 2012*, NAICS Code 517919, https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012_US/51SSSZ4//naics~517919.

[661] *Id.*

We estimate, however, that some space station applicants applying under part 25 of the Commission's rules would qualify as small entities affected by these rule changes. If the Commission were to apply the bond requirement to amateur and experimental space station licensees, then additional small entities would be affected by the rule changes.

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

The bond requirement proposed in the Further Notice would require part 25 space station licensees to submit a demonstration to the Commission that they have posted a bond that meets the requirements specified in the Commission's rules. The space station licensee would then need to maintain the bond over the course of the license term, until the disposal of the spacecraft. The initial bond demonstration currently applies to part 25 space station licensees for the existing bond requirement and has proved workable. The Further Notice seeks comment, however, on methods to structure the bond requirement that may reduce costs.

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."[662]

In addition to seeking comment regarding the structure of the bond, the *Further Notice* seeks comment on the appropriate monetary amount for the bond, which could affect the extent of the impact on small entities. Additionally, for NGSO licensees, the Further Notice seeks comment on whether default should be tied to a certain number of undisposed space stations or undisposed mass in orbit. The resolution of this question could affect the extent of the impact of default on small entities, which may in some instances have fewer NGSO space stations in orbit than large entities.

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

None.

[662] 5 U.S.C. § 603(c)(1)-(4).