6712-01

FEDERAL COMMUNICATIONS COMMISSION

47 CFR Parts 5, 25, and 97

[IB Docket No. 18-313; FCC 18-159]

Mitigation of Orbital Debris in the New Space Age

AGENCY: Federal Communications Commission.

ACTION: Proposed rule.

SUMMARY: The Federal Communications Commission (FCC or Commission) proposes to amend its rules related to satellite orbital debris mitigation in order to improve and clarify those rules based on experience gained in the satellite licensing process and on improvements in mitigation guidelines and practices, and to address various market developments.

DATES: Comments are due **[INSERT DATE 45 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]**. Reply comments are due **[INSERT DATE 75 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]**.

ADDRESSES: You may submit comments, identified by IB Docket No. 18-313, by any of the following methods:

- Federal Communications Commission's Web Site: http://apps.fcc.gov/ecfs. Follow the instructions for submitting comments.
- People with Disabilities: Contact the FCC to request reasonable accommodations (accessible format documents, sign language interpreters, CART, etc.) by e-mail: FCC504@fcc.gov or phone: 202-418-0530 or TTY: 202-418-0432.

For detailed instructions for submitting comments and additional information on the rulemaking process, see the SUPPLEMENTARY INFORMATION section of this document.

FOR FURTHER INFORMATION CONTACT: Merissa Velez, 202-418-0751.

SUPPLEMENTARY INFORMATION: This is a summary of the Commission's Notice of Proposed Rulemaking (*NPRM*), FCC 18-159, adopted November 15, 2018, and released November 19, 2018. The full text of the NPRM is available at https://docs.fcc.gov/public/attachments/FCC-18-159A1.pdf. The NPRM is also available for inspection and copying during business hours in the FCC Reference Information Center, Portals II, 445 12th Street SW., Room CY-A257, Washington, DC 20554. To request materials in accessible formats for people with disabilities, send an email to FCC504@fcc.gov or call the Consumer & Governmental Affairs Bureau at 202-418-0530 (voice), 202-418-0432 (TTY).

Comment Filing Requirements

Interested parties may file comments and reply comments on or before the dates indicated in the DATES section above. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS).

- 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.

- Persons 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).

Ex Parte Presentations

The Commission will treat this proceeding as a "permit-but-disclose" proceeding in accordance with the Commission's *ex parte* rules. Persons making *ex parte* presentations must file a copy of any written presentation or a memorandum summarizing any oral presentation within two business days after the presentation (unless a different deadline applicable to the Sunshine period applies). Persons making oral *ex parte* presentations are reminded that memoranda summarizing the presentation must (1) list all persons attending or otherwise participating in the meeting at which the *ex parte* presentation was made, and (2) summarize all data presented and arguments made during the presentation. If the presentation consisted in whole or in part of the presentation of data or arguments already reflected in the presenter's written comments, memoranda or other filings in the proceeding, the presenter may provide

citations to such data or arguments in his or her prior comments, memoranda, or other filings (specifying the relevant page and/or paragraph numbers where such data or arguments can be found) in lieu of summarizing them in the memorandum. Documents shown or given to Commission staff during *ex parte* meetings are deemed to be written *ex parte* presentations and must be filed consistent with rule 1.1206(b). In proceedings governed by rule 1.49(f) or for which the Commission has made available a method of electronic filing, written *ex parte* presentations and memoranda summarizing oral *ex parte* presentations, and all attachments thereto, must be filed through the electronic comment filing system available for that proceeding, and must be filed in their native format (e.g., .doc, .xml, .ppt, searchable .pdf). Participants in this proceeding should familiarize themselves with the Commission's *ex parte* rules.

Paperwork Reduction Act

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

Synopsis

This Notice of Proposed Rulemaking (*NPRM*) represents the first comprehensive look at the Commission's orbital debris rules since their adoption in 2004. The proposed changes are designed to improve and clarify these rules based on experience gained in the satellite licensing process and on improvements in mitigation guidelines and practices, and to address the various market developments described above.

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

The Commission reviews these disclosures and determines, on a case-by-case basis, whether the public interest will be served by approval of the proposed operations. The rules adopted in 2004 provided some general guidance on the content of disclosures, but the Commission generally declined to adopt a particular methodology for the preparation and evaluation of an applicant's orbital debris mitigation plans. Both applicants and the Commission, however, have relied in a number of cases on standards and related assessment tools, such as the technical standards and related software tools developed by NASA for its space activities,[1] to, respectively, prepare such orbital debris plans and assess their adequacy.

Since the Commission's orbital debris rules were adopted in 2004, there have been a number of significant developments with respect to this topic. In addition, the number of debris objects capable of producing catastrophic damage to functional spacecraft has increased.

Proposed deployments of large satellite constellations in the intensely used LEO region, along with other satellites deployed in the LEO region, will have the potential to increase the risk of debris-generating events. New satellite and deployment technologies currently in use and

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

under development also may increase the number of potential debris-generating events, in the absence of improved debris mitigation practices.

Proposal Overview

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

The Commission seeks comment on the suitability of various orbital debris mitigation guidance and standards for application to non-Federal satellite systems.

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

The Commission seeks comment on whether there are any areas in which proposed requirements may overlap with requirements that are clearly within the authority of other agencies, so that we may seek to avoid duplicative activities. The Commission asks whether exceptions to applications of the Commission's rules as proposed or other exemptions may be appropriate in any particular circumstances.

Control of Debris Released During Normal Operations

In several recent instances, applicants have sought to deploy satellites using deployment mechanisms that detach from or are ejected from a launch vehicle upper stage and are designed solely as means of deploying a satellite or satellites, and not intended for other operations. Once these mechanisms have deployed the onboard satellite(s), they become orbital debris. As with other manmade objects in space, however, such deployment devices have the potential to collide with other objects and thereby create additional orbital debris. In some instances, the deployment device itself may not require an application for a license from the Commission for radio communications, if it does not have any radio frequency (RF) facilities.

In general, generation of operational debris, including from deployment devices, should be minimized. The Commission proposes to require disclosure by applicants if such devices are used to deploy their spacecraft, as well as a specific justification for their use. In addition, the Commission proposes that the disclosure include information regarding the planned orbital debris mitigation measures specific to the deployment device, including the probability of collision associated with the deployment device itself. Where appropriate, this description of orbital debris mitigation measures may be obtained from the operator of the deployment device. If the deployment device is itself the subject of a separate application for authorization by the Commission (e.g., SHERPA), then the entity seeking a license or a grant of U.S. market access for a satellite may satisfy this disclosure requirement by referencing the deployment device's

FCC application or grant. The Commission seeks comment on this proposed informational requirement. The Commission also seeks comment on how this proposal might overlap with informational requirements of other agencies and how we might streamline and minimize informational burden on applicants while mitigating space debris.[2]

Minimizing Debris Generated by Release of Persistent Liquids

Most conventional propellant and coolant chemicals evaporate or dissipate if released from a spacecraft. However, certain types of liquids, such as low vapor pressure ionic liquids, will, if released from a satellite, persist in the form of droplets. At orbital velocities, such droplets can cause substantial or catastrophic damage if they collide with other objects.[3] In the last several years, there has been increasing interest in the use by satellites (including small satellites) of alternative propellants and coolants, some of which would become persistent liquids when released by a deployed satellite.

The Commission proposes to include within the rules a requirement to identify any liquids that if released, either intentionally or unintentionally, will persist in a droplet form. The Commission also expects that the orbital debris mitigation plan for any system utilizing persistent liquids should address the measures taken, including design and testing, to eliminate the risk of release of liquids, and to minimize risk from any unplanned release of liquids, for example through a choice of orbit that will result in any released liquids having a very short orbital lifetime. The Commission seeks comment on this proposal.

Safe Flight Profiles

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

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

In an effort to ensure that the physical operations of both existing and planned systems do not contribute to the orbital debris environment, particularly in the heavily-used LEO region, the Commission proposes to update its rules.

Quantifying Collision Risk. The Commission proposes that applicants for NGSO satellites must demonstrate that the probability that their spacecraft will collide with a large object during the orbital lifetime[4] of the spacecraft will be no greater than 0.001.[5] The Commission seeks comment on whether, if a spacecraft's orbital debris mitigation plan includes maneuvering to avoid collisions, the Commission should, consistent with current licensing practice, consider this risk to be zero or near zero during the period of time in which the spacecraft is maneuverable, absent contrary information. The *NASA Standard* applies the 0.001 metric on a per-spacecraft basis. The Commission invites comment on whether this metric should also be applied on an aggregate, system-wide basis, *i.e.*, 0.001 for an entire constellation. If such a requirement is adopted on an aggregate basis, would it provide an incentive for evasion of the aggregate limit, for example, through a single controlling party applying for multiple satellite constellations, each of which meets the limit, but which collectively would not? Are existing procedures adequate to identify any such instances of evasion? The Commission also seeks comment on whether it should specify a size for what is considered a large object, or

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

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

whether it should continue its current case-by-case approach, which in practice typically results in consideration of catalogued objects.[6]

The Commission also seeks comment on whether it should adopt a specific metric for collision with small debris, that is, debris consisting of small meteoroids or other small (approximately < 10 cm) debris. The *NASA Standard* provides that for each spacecraft, the NASA program or project demonstrate that during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable post-mission disposal requirements is less than 0.01. The Commission seeks comment on whether it should incorporate the NASA probability metric into our rules, such that an applicant certify that for each spacecraft, the probability of accidental collision with small objects that would cause loss of control and prevent post-mission disposal is less than 0.01. In its Large Constellation Study, NASA indicated that the implementation of adequate impact protection from small debris can be an important factor in achieving high post-mission disposal reliability for large constellations. The Commission seeks comment on whether this metric should be applied on a per-spacecraft basis, or in the aggregate. Additionally, should the Commission limit this proposed requirement to operations in certain highly-populated orbits, or to large constellations with more than 100 satellites, for example?

The Commission also proposes other revisions to the NGSO-related provisions of the existing rule regarding collision risk. The existing rule states that where a satellite will be launched into a LEO region orbit that is identical, or very similar, to an orbit used by other satellites, the orbital debris mitigation statement must include analysis of potential risk of collision, disclosures regarding whether a satellite operator is relying on coordination with the

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

other system for collision avoidance, and what coordination measures have been or will be taken. First, the Commission proposes to revise the wording of the rule to require that, instead of identifying satellites with similar orbits, the orbital debris mitigation statement must identify the planned and/or operational satellites to which the applicant's satellite poses a collision risk, and indicate what steps have been taken or will be taken to coordinate with the other spacecraft or system and facilitate future coordination, or what other measures the operator may use to avoid collision. Second, the Commission proposes to extend this rule to all NGSO satellites, rather than only those that will be launched into the LEO region, since overlap in orbits among NGSO spacecraft in other regions could equally result in collision creating orbital debris. The Commission anticipates that in lightly-used orbits, the statement can simply indicate that there are no other planned or operational spacecraft posing a collision risk.

Orbit Selection. First, for any NGSO satellites planned for deployment above the International Space Station (ISS)[7] and that will transit through the ISS orbit either during or following the satellite operations, the Commission proposes that the applicant provide information about any operational constraints caused to the ISS or other inhabitable spacecraft and strategies used to avoid collision with manned spacecraft.[8] For example, will the normal operations of the ISS be significantly disrupted or otherwise constrained by the number of collision avoidance maneuvers that may be necessary as satellites in the constellation transit through the ISS orbit, such as during an uncontrolled de-orbit phase?[9]

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

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

[9] *See* NASA NGSO Constellation Comments at 2 (expressing concern about aspect of disposal plan for SpaceX LEO constellation and recommending that SpaceX "seek out creative ways to guarantee they can avoid the ISS and

Second, the Commission proposes that an applicant planning an NGSO constellation that will be deployed in the LEO region above 650 km altitude specify why it has chosen that particular orbit given the number of satellites planned and describe any other relevant characteristics of the orbit such as the presence of existing debris. Satellites deployed below 650 km will typically re-enter Earth's atmosphere within 25 years,[10] even absent any propulsive or other special de-orbit capabilities. Thus, the collision risks presented by such satellites are generally lower, even if the satellites fail on-orbit and are unable to perform any affirmative de-orbiting maneuvers.[11] Above this approximately 650 km threshold, a satellite that is not affirmatively de-orbited will remain in orbit for significantly longer periods of time. Accordingly, for NGSO deployments above the 650 km altitude, the Commission proposes that applicants provide a rationale for choosing a higher orbit, even if the satellites will have propulsive de-orbit capabilities.[12]

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other high value assets" for the entire deorbit phase of their planned spacecraft); Science Applications International Corporation, Orbital Traffic Management Study Final Report, Prepared for NASA Headquarters, at E-1-E-2 (Nov. 21, 2016) (SAIC Orbital Traffic Management Study) ("As debris populations grow in LEO, the odds of [micro-meteoroid or orbital debris] root cause events on ISS will become higher (i.e. worsen)[.]" "Recent analysis by the Aerospace Corporation suggests that the current large planned constellations could increase collision warnings with ISS six-fold, as the decommissioned spacecraft in those constellations decay through the ISS orbit.").

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

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

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

Third, the Commission seeks comment on whether we should also require a statement concerning the rationale for selecting an orbit from operators of satellites that will remain in orbit for a long period of time relative to the time needed to perform their mission. One example of an alternative guideline is that operators select orbits such that orbital lifetime exceed mission lifetime by no more than a factor of two. The Commission seeks comment on this metric, or alternative metrics that could be incorporated into our rules.

Fourth, certain areas of space are more populated with debris, such as that from the Cosmos 2251/Iridium 33 collision. It may be in the public interest for new constellations to avoid deployment in such areas to minimize risk, or, stated differently, to design constellations to operate in regions of space where the density of objects is lower, and consequently where the risk of collisions with debris objects is lower.[13] The Commission asks whether to require applicants to include an additional disclosure regarding orbit selection based on such risks, or to provide assurances on how the applicant plans to reduce these risks. The Commission also asks whether we should seek additional information or assurances from applicants in more narrow circumstances, for example, where they seek to deploy a large constellation in certain sun-synchronous orbits that have an increased likelihood of congestion.

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

Finally, the Commission asks whether we should adopt a maximum limit for variances in orbit for NGSO systems. That is, should the Commission limit the variance in altitude above or

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

below the operational orbit specified in an application for an NGSO system,[14] in order to enable more systems to co-exist in LEO without overlap in orbital altitude, and if so, how should an appropriate limit be set? If such a limit is adopted, should it apply only to near-circular obits, or also to elliptical orbits? The Commission seeks comment on these questions, as well as on any additional changes to our rules and policies that may help operators avoid collisions and ultimately reduce the risk of debris generation in heavily-used or otherwise critical orbits.

Tracking and Data Sharing. As an initial matter, the Commission proposes to require a statement from the applicant regarding the ability to track the proposed satellites using space situational awareness facilities, such as the U.S. Space Surveillance Network.[15] The Commission proposes that objects greater than 10 cm by 10 cm by 10 cm be presumed trackable for any altitude up to the geostationary region,[16] although the Commission seeks comment on whether a larger size should be presumed at higher altitudes given any tracking limitations at such altitudes. For objects with any dimension less than 10 cm, the Commission proposes that the applicant provide additional information concerning trackability, which will be reviewed on a case-by-case basis. The Commission also proposes that applicants for NGSO systems disclose, as part of their orbital debris mitigation plans, whether satellite tracking will be active and cooperative (that is, with participation of the operator by emitting signals via transponder or sharing data with other operators) or passive (that is, solely by ground-based radar or optical tracking of the object). The Commission also asks whether applications should certify that the satellite will include a unique telemetry marker allowing it to be readily distinguished from other satellites or space objects.

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

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

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

The Commission further seeks comment on whether there are hardware or information sharing requirements that might improve tracking capabilities, and whether such technologies are sufficiently developed that a requirement for their use would be efficient and effective.

The Commission seeks comment on whether we should adopt an operational rule requiring NGSO satellite operators to provide certain information to the 18th Space Control Squadron or any successor civilian entity,[17] including, for example information regarding initial deployment, ephemeris, and any planned maneuvers. As an example, communication with the Air Force's 18th Space Control Squadron may be particularly important in the case of a multi-satellite deployment, to assist in the identification of the satellite.[18]

The Commission also proposes that applicants for NGSO systems certify that, upon receipt of a conjunction warning, the operator of the satellite will take all possible steps to assess and, if necessary, to mitigate collision risk, including, but not limited to: contacting the operator of any active spacecraft involved in such warning; sharing ephemeris data and other appropriate operational information directly with any such operator; and modifying spacecraft attitude and/or operations. The Commission seeks comment on this approach as one designed to reduce collision risks and enhance certainty among operators and asks whether any different or additional requirements should be considered regarding the ability to track and identify satellites in NGSO or respond to conjunction warnings.

Maneuverability. The Commission also proposes that applicants for NGSO satellite authorizations describe the extent of any maneuverability. For example, the description could include an explanation of the number of collision avoidance maneuvers the satellite could be

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

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

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

Multi-Satellite Deployments. A single deployment of a number of satellites from a launch vehicle or free-flying deployment device could result in some heightened risk of collision between objects, or on a longer-term basis due to the similarity of orbits for the released objects. The Commission seeks comment on whether it should include in our rules any additional informational requirements regarding such launches.[19] Are there mitigation measures that are commonly employed that mitigate such risks, for example through use of powered flight during the deployment phase and/or through phasing of deployment, that the Commission should consider adopting as requirements under some circumstances? In seeking comment, the Commission recognizes that an applicant for a Commission license or authorization may not

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

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

Design Reliability. The Commission seeks comment on whether it would be appropriate to impose a design and fabrication reliability requirement, for example, 0.999 per spacecraft, if a NGSO satellite constellation involves a large number of satellites or will be initially deployed at higher altitudes in LEO. Deployment of large numbers of satellites increases the spatial density of objects in the region of space where the satellites are deployed, and provides an indicator of potential collision risk. The Commission considers a deployment of 100 satellites over a typical 15-year license term to be a deployment of a large number of satellites but seek comment on whether a different number may be appropriate. The Commission considers higher altitudes to be those with a perigee above 600-650 km.[20] From these orbits, spacecraft will typically remain in orbit for several decades to centuries, and present a long-term collision risk, unless active measures are taken to shorten orbital lifetimes. The Commission also seeks comment and suggestions on other possible metrics, and methods for verifying and assessing compliance with any such metric. Further, the Commission is cognizant that technology continues to develop rapidly in the satellite design arena and seek to avoid potential requirements that may wed designers to a current conception of technological limits that could be changed in the future.

Post-Mission Disposal

Probability of Success of Disposal Method

Incorporation of Disposal Reliability Metrics. The Commission proposes to require that applicants provide information concerning the expected reliability of disposal measures

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

involving atmospheric re-entry, and the method by which that expected reliability was derived. The Commission also seeks comment on the metric by which such information should be evaluated; for example, should the Commission specify a probability of success of no less than a set figure, such as 0.90?[21] The Commission also invitse comment as to whether, when assessing the reliability of disposal, it should do so on an aggregate, system-wide basis as well as on a per-satellite basis, and on whether, for large constellation deployments, where due to large numbers of spacecraft aggregate effects could be more damaging to the space environment, a more stringent metric should apply. A recent NASA study of large constellations concluded, for example, that a 0.99 spacecraft post-mission disposal reliability is needed to mitigate the serious long-term debris generation potential from large constellations.

Other Requirements for Satellites with Planned Operations in LEO. First, the Commission proposes that the applicant certify that all satellites that will operate at an altitude of 650 km or above will be initially deployed into orbit at an altitude below 650 km and then, once it is determined that the satellite has full functionality,[22] be maneuvered up to their planned operational altitude. This would help to ensure that if satellites are found to be non-functional immediately following deployment, such that they will be unable to perform any maneuvers, they will re-enter the atmosphere within 25 years and not persist in LEO for longer periods of time. The Commission posits here that the benefits of the continued viability of the LEO region may outweigh the costs of orbit-raising and seeks comment on the costs and benefits associated with this proposal. Relatedly, the Commission seeks comment on whether it should require that

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

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

applicants for large constellations test a certain number of satellites in a lower orbit for a certain number of years before deploying larger numbers, in order to resolve any unforeseen flaws in the design that could result in generation of debris.[23]

Second, the Commission proposes that applicants seeking to operate NGSO satellite systems provide a statement that spacecraft disposal will be automatically initiated in the event of loss of power or contact with the spacecraft, or describe other means to ensure that reliability of disposal will be achieved, such as internal redundancies, ongoing monitoring of the disposal function, or automatic initiation of disposal if communications with the spacecraft become limited.

The Commission recognizes that these design features have some associated costs. The Commission seeks comment on the costs and benefits associated with this proposed requirement. The Commission also asks whether it should simply require the design to include automatic disposal by a de-orbiting device in the event of loss of power, and on whether any such requirement would provide adequate flexibility for operators to react, for example, if the particular failure mode results in further propulsive maneuvers running a high risk of explosive fragmentation. Are there other technologies that can be used to ensure that satellite disposal is completed, even in the event of a major anomaly, and should the Commission require use of those technologies for satellites that will operate in particular regions? The Commission proposes that these two requirements would apply to satellites that will operate above 650 km and below 2,000 km, in other words, in the higher portion of LEO. The Commission also seeks comment on whether any requirements should only apply to LEO satellite constellations of a

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

certain size or greater or whether they should apply to all LEO satellites that will operate in the area described.

Means of LEO Spacecraft Disposal. Additionally, the Commission seeks comment on whether there are other rule changes it should consider related to the disposal of spacecraft from the LEO region. Should the Commission adopt a rule that disposal of spacecraft in the LEO region must be by either atmospheric re-entry or direct retrieval? In assessing whether a post-mission disposal plan is sufficiently reliable, what weight, if any, and under what circumstances, should the Commission give to proposals to directly retrieve the spacecraft from orbit at its end of life?[24] Should direct retrieval be considered as a valid debris mitigation strategy, for example, only if the retrieval spacecraft are presented for licensing as part of or contemporaneously with the constellation license?

At this time, there are a number of specific technologies under development for direct spacecraft retrieval, although generally these are nascent technologies and the Commission is not aware of any planned deployments for commercial applications thus far. Direct spacecraft retrieval involves rendezvous and proximity operations, but with potentially the additional challenge of a target spacecraft that is "non-cooperative," i.e., is spinning, is not providing any telemetry, etc. In the context of orbital debris mitigation, testing is ongoing for technologies such as nets and harpoons, and there are numerous other technologies under discussion such as robotic arms and magnetic capture mechanisms. The Commission seeks comment on the status of these and other technologies for spacecraft direct retrieval, including potential future commercial applications. Are there any aids to future use of direct retrieval, such as spacecraft reflective markers or attachment points, that could be adopted now or in the near future?

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

Disposal of NGSO Satellites In Orbits Above LEO. The Commission also seeks comment on whether to modify its existing rules regarding end-of-life disposal for satellites to include additional provisions concerning disposal of certain NGSO satellites operating in orbits above LEO. As a general matter, there appear to be two types of approaches to post-mission disposal above LEO. One approach is to remove a satellite from its operational orbit to another, relatively stable orbit that is sufficiently distinct from those orbits that are currently used or expected to be used for regular operations, so as to eliminate the risk of collisions with such operating satellites.[25] Another approach is to place a satellite into an unstable orbit, i.e., one in which gravitational forces and solar radiation pressure force a growth in the eccentricity of the orbit, ultimately resulting in lowering of the satellite's perigee and re-entry into the atmosphere.[26] The Commission seeks comment on whether these practices are sufficiently developed to formalize in our rules. The Commission also seeks comment on whether there are any specific guidelines we should include in our rules with respect to these approaches, or with respect to any particular type of orbit.[27]

Post-Mission Lifetime. The Commission asks whether the 25-year disposal guideline contained in the *NASA Standard* remains a relevant benchmark.[28] That is, does the guideline that

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

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

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

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

a spacecraft reenter the atmosphere no more than 25 years after the completion of the spacecraft's mission permit spacecraft designs that result in a longer disposal period than may be in the public interest for a particular satellite mission? Should the disposal guideline instead be proportional to mission lifetime, or specific to the orbital altitude where the spacecraft will be deployed? Solar activity can influence the re-entry periods of satellites in LEO,[29] and future solar activity may vary from predictions. In what manner, if any, should the Commission account for variations in solar activity in our rules and in crafting conditions on the grant of specific licenses? Should satellite operators planning disposal through atmospheric re-entry be required to continue obtaining spacecraft tracking information, for example by using radio facilities on the spacecraft, to the greatest extent possible following the conclusion of the primary mission? In addition to these questions, the Commission seeks comment generally on how to prevent satellites from becoming sources of orbital debris during the period following their mission lifetime and before disposal through atmospheric re-entry.

Casualty Risk Assessment. In order to assist in evaluating the spacecraft design with respect to human casualty risk, the Commission proposes two specific informational requirements for satellites with a planned post-mission disposal of uncontrolled atmospheric re-entry.[30]

First, the Commission proposes that the human casualty risk assessment include all objects that would have an impacting kinetic energy in excess of 15 joules. This is consistent

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

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

with the *NASA Standard*, wherein the potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules.[31]

Second, the Commission proposes that where the calculated risk of human casualty from surviving debris is determined to be greater than zero, as calculated using either the NASA Debris Assessment Software or a higher fidelity model,[32] the applicant must provide a statement indicating the actual calculated human casualty risk, as well as the input assumptions used in modelling re-entry. The Commission tentatively concludes that these additional specifications ill enable it to better evaluate whether the post-mission disposal plan is in the public interest and seek comment on this approach. The Commission further invites comment on whether, when assessing human casualty risk, it should do so on an aggregate, system-wide basis as well as on a per-satellite basis, and, if so, what metric should be used to evaluate aggregate risk.

Part 25 GSO Satellite License Term Extensions. Operators of GSO satellites routinely request that the Commission grant license modifications to extend their authorized satellite operations beyond the initial license terms.[33] The Commission proposes to codify our current practice of requesting certain types of information from GSO licensees requesting license term extensions. The rule would specify that applicants should state the duration of the requested

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[31] *Id*. The 15-joule limit has been determined to be the limit above which any strike on a person will require prompt medical attention. *NASA Standard*, at 45, Requirement 4.7.3.c. The 1:10,000 standard does not account for sheltering, as it is estimated that as much as 80% of the world's population is either unprotected or in lightly-sheltered structures for purposes of protecton from a falling object with a kilojoule-level kinetic energy. *NASA Standard*, at 45, Requirement 4.7.3.d.

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

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

license extension and the estimated total remaining satellite lifetime, certify that the satellite has no single point of failure or other malfunctions, defects, or anomalies during its operations that could affect its ability to conduct end-of life procedures as planned, that remaining fuel reserves are adequate to complete deorbit as planned, and that telemetry, tracking, and command links are fully functional. In the event that the applicant is unable to make any of the certifications, the Commission proposes that the applicant provide a narrative description justifying the extension. The Commission seeks comment on this approach.

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

The Commission further seeks comment on whether there are certain types of satellite buses[34] that may warrant heightened scrutiny for purposes of license extensions. In addition, the Commission seeks comment on whether, apart from the review undertaken when a license is extended, there are types or categories of anomalies that should trigger immediate reporting, in

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

order to assess whether reliability of post-mission disposal has been compromised to the point that immediate actions may be required.

Proximity Operations

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

Operational Rules

Orbit Raising. Because orbit-raising maneuvers are performed by satellites intended for non-geostationary orbits as well as for the geostationary orbit, and the number of satellites engaging in orbit-raising maneuvers may increase if other proposals in this *NPRM* are adopted, the Commission proposes and seeks comment on expanding the provision to include NGSO system operations.

In addition, similar to the provisions for maneuvering at the end-of-life for a GSO satellite,[35] the Commission proposes to require such telemetry, tracking, and command operations to be coordinated between satellite operators as necessary to avoid interference events, rather than require the operations to be performed on a non-interference basis. The Commission tentatively concludes that it is in the public interest that these types of telemetry, tracking and command communications, critical to effective spacecraft maneuvering, be coordinated as necessary to avoid interference, rather than being authorized only on an a non-harmful-interference, unprotected basis. The Commission seeks comment on revising its existing rule regarding orbit raising maneuvers to require coordination of such operations to avoid interference events and to extend the application of the rule to NGSO satellites as well as GSO satellites.

Maintaining Ephemeris Data. The Commission proposes that NGSO operators be required to maintain ephemeris data for each satellite they operate and share that data with operators of other systems operating in the same region of space, as well as with the U.S. governmental entity responsible for the civilian space object database and cataloging. Specifically, the Commission proposes to require that operators share ephemeris data with any other operator identified in its disclosure described above of any operational space stations that may pose a collision risk. The Commission believes this requirement will help to facilitate communications between operators, even before a potential conjunction warning is given. The Commission also proposes that the information be shared by means mutually acceptable to the parties involved, to allow for flexibility and efficiency in sharing of information. The Commission seeks comment on this proposed revision to include these proposed requirements

[35] 47 CFR 25.283(b) (providing for a space station to operate using its authorized tracking, telemetry, and control frequencies for the purpose of removing the satellite from the geostationary orbit at the end of its useful life, "on the condition that the space station's tracking, telemetry, and control transmissions are planned so as to avoid electrical interference to other space stations, and coordinated with any potentially affected satellite networks.").

regarding availability of NGSO satellite ephemeris data. The Commission also seeks comment on including similar requirements in the rules for experimental and amateur satellites.

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

Liability Issues and Economic Incentives

The Commission seeks comment on whether Commission space station licensees should indemnify the United States against any costs associated with a claim brought against the United States related to the authorized facilities. Given the potential risk of a claim being presented to the United States under international law, the Commission seeks comment on whether an indemnification by these U.S.-licensed private operators is appropriate. Such an indemnification could take the form of an indemnity agreement, for example, created in consultation with interagency partners, including the U.S. Department of State, to establish the parameters of such an agreement, including the scope of the indemnification and the means to execute the

agreement, including by an appropriate U.S. government agency. In the event that a requirement was established, what would be the appropriate form and content of such an agreement?

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

Related to liability, the Commission also seeks comment generally on the costs and benefits of insurance as an economic incentive for orbital debris mitigation. The Commission seeks comment on how insurance might serve as an economic incentive by incentivizing operators to adopt debris mitigation strategies that reduce risk and lower insurance premiums. How might this impact the amount of insurance that might be required? Could insurance requirements in fact encourage industry to be licensed by or launch from the United States rather than other countries? In the context of insurance, the Commission seeks comment on whether there are any distinctions that might be made between different types of operations that are higher or lower risk. The Commission also seeks comment on whether any distinctions could be

made between on-orbit liability and spacecraft re-entry liability, since on-orbit liability is addressed through a fault regime and re-entry liability is addressed through a strict liability regime under the Convention on International Liability for Damage Caused by Space Objects (Liability Convention). For example, should small satellites applying under the new streamlined process proposed in the *Small Satellite NPRM* be exempt from an insurance requirement, since space stations in that category would be relatively lower risk from an orbital debris perspective? As another example, the Commission asks whether GSO space station licensees should be exempt from an insurance requirement since they may present less risk in the post-mission disposal process since they do not typically re-enter Earth's atmosphere.

The Commission further invites comment generally 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. That is, recognizing debris creation as a negative externality, what approaches might induce private decisions on these design and launch choices to be consistent with the public interest in limiting the growth of orbital debris? Would, for example, a bond requirement, similar to the Commission's performance bond for satellite deployment but applied with respect to successful completion of end of life disposal, provide such an incentive?

Scope of Rules

Amateur and Experimental Operations. The Commission 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 under any of the changes to Part 25 discussed above that are adopted by the Commission. The Commission seeks comment on this proposal. The Commission also seeks comment on the

ephemeris data requirement and indemnification and insurance issues as they relate to experimental licensees and authorized amateur operators.

Non-U.S.-Licensed Satellites. The Commission generally proposes that the new and amended rules discussed in this *NPRM* should be applicable to non-U.S.-licensed satellites seeking access to the U.S. market. In other words, an entity seeking access to the U.S. market must continue to submit the same technical information concerning the satellite involved as is required to be submitted by U.S. satellite license applicants. The Commission seeks comment on this proposal.

In some instances, the Commission notes that applicants have sought approval to engage in very limited transmission and reception activities between non-U.S.-licensed space stations and earth stations in the United States, such as communications exclusively for telemetry, tracking, and command. Although applicants seeking approval for communications such as telemetry, tracking, and command only may have a limited commercial connection to the United States, there is nonetheless a commercial reason those applicants are seeking to transmit and/or receive from a U.S. earth station. Therefore, the Commission seeks comment on whether these applicants should be subject to the same public interest requirements as a U.S.-licensed satellite operating with a U.S. earth station.

The Commission further proposes that non-U.S.-licensed satellites may continue to satisfy the disclosure requirement by showing that the satellite system's debris mitigation plans are subject to direct and effective regulatory oversight by the satellite system's national licensing authority. Recognizing that in other countries authority over radiofrequency communications and authority over space operations are often addressed by different entities, in order to satisfy our orbital debris mitigation disclosure requirements, the Commission would expect information showing that the operator has received a license from the entity overseeing space operations, or

has initiated that process. This would include information about whether or not that administration is expected to register the space object with the United Nations Register of Objects Launched into Outer Space.[36] The Commission seeks comment on whether it is appropriate to continue assessing the direct and effective oversight of a foreign licensing authority on a case-by-case basis. Under this approach, approval of foreign oversight for a system design in one case will not necessarily imply similar approval for a different system design.

Regulatory Impact Analysis

In this section, the Commission seek comment on whether regulation of U.S. Commission-licensed space stations will help to limit such debris and result in a net benefit, even if it may give rise to some regulatory costs.

The Commission seeks comment on six approaches to reducing debris in orbit, which include the proposals discussed in the individual rule sections above:

Fewer Launches. One method of reducing orbital debris would be for the Commission to adopt rules that would have the effect of reducing the overall number of satellites launched.

Changes in Satellite Design. Another method of reducing orbital debris would be for the Commission to regulate how satellites or satellite system are designed.

Changes in operations and disposal procedures. This is the approach proposed in the individual rule sections above.

Use of Economic Incentives. In this NRPM, the Commission asks whether there are other economic incentives available that the Commission could offer that would help achieve the public interest in this area.

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

Active Collision Avoidance. The Commission could also potentially reduce orbital debris by requiring all operators to engage in active collision avoidance, which would involve coordination and maneuvering of spacecraft by operators to limit collisions with other objects in space.

Active Debris Cleanup. Another alternative to the rules proposed in this *NPRM* is for the Commission to consider requiring operators to engage in active debris removal. The Commission asks questions about this disposal method in this *NPRM*.

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

The Commission seeks comment on this proposed regulatory impact analysis. In connection with this analysis, it also seeks comment on the relative costs and benefits of performance-based regulation versus prescriptive regulation in the context of orbital debris mitigation.

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

Initial Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act of 1980, as amended (RFA), 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 *NPRM*. Written public comments are requested on this IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines specified in the *NPRM* for comments. The Commission will send a copy of this *NPRM*, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration (SBA). In addition, the *NPRM* and IRFA (or summaries thereof) will be published in the Federal Register.

Need for, and Objectives of, the Proposed Rules

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

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

1) Require satellite applicants to demonstrate compliance with certain metrics developed for assessing orbital debris mitigation plans by the National Aeronautics and Space Administration (NASA).
2) Require additional disclosures to the Commission regarding risk of collision, trackability, maneuverability, proximity operations, if any, choice of orbit, and impact on manned spacecraft, if any.
3) Require information regarding the probability of success for the chosen disposal method, where disposal is planned by atmospheric re-entry.
4) Require satellite applicants with planned operations in certain orbits to make certifications related deploying at a lower orbit and then raising the satellite(s) for operations.

Legal Basis

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

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. The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction." In addition, the term

"small business" has the same meaning as the term "small business concern" under the Small Business Act. 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). Below, we describe and estimate the number of small entity licensees that may be affected by adoption of the proposed rules.

Satellite Telecommunications and All Other Telecommunications

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

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

The second category of Other Telecommunications is comprised of entities "primarily engaged in providing specialized telecommunications services, such as satellite tracking, communications telemetry, and radar station operation. This industry also includes establishments primarily engaged in providing satellite terminal stations and associated facilities connected with one or more terrestrial systems and capable of transmitting telecommunications to, and receiving telecommunications from, satellite systems. Establishments providing Internet

services or voice over Internet protocol (VoIP) services via client-supplied telecommunications connections are also included in this industry." For this category, Census Bureau data for 2007 show that there were a total of 2,383 firms that operated for the entire year. Of this total, 2,346 firms had annual receipts of under $25 million.

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

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

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

The *NPRM* proposes to require several disclosures specifying compliance with several metrics established by NASA, such as probability of collision between the spacecraft and large objects. Many of the entities, for example, experimental licensees, that would be affected by these proposed rules already use a format for their orbital debris mitigation plans that is consistent with the NASA Orbital Debris Assessment Report (ODAR). The ODAR format includes several of the proposed NASA metrics that are incorporated into the proposed rules such as calculations related to re-entry casualty risk. Thus, to the extent that these entities already use the ODAR format, there would be no change to their existing recordkeeping and compliance requirements as a result of these proposed changes. For other entities that have not or would not use the ODAR format to report their orbital debris mitigation plans, some of these changes will involve some additional proposed calculations to provide the appropriate certifications, such as certifying that the probability of collision between a space station and another large object is less than 0.001 and that the probability of collision with small debris or meteoroids that would cause

loss of control and prevent post-mission disposal is less than 0.01.Given the engineering associated with development of a spacecraft, we expect that these calculations will be a natural outgrowth of work already being performed in designing and planning space station(s) operations. The *NPRM* also proposes to require that collision risk information be provided in the aggregate, that is, for the space station constellation as a whole. Since most small entities do not launch and operate large satellite constellations, we do not anticipate that this requirement to provide a collision risk assessment in the aggregate will be burdensome. In addition, we note the new requirement for demonstration that the probability of reliability for a particular disposal method is no less than 0.90, calculated on an aggregate basis. We anticipate that most small entities will be planning disposal of their spacecraft by atmospheric re-entry. So long as the spacecraft is deployed into a low altitude orbit, which most small entities' spacecraft are, atmospheric re-entry will be virtually guaranteed within a certain amount of time.

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

In addition, the *NPRM* proposes that operators of spacecraft make ephemeris data available to all operators of operational satellite systems identified as potentially raising a collision risk with its system. We anticipate that small entities will generally be operating only a

few spacecraft, and so will only need to address this ephemeris data requirement for a limited number of space stations.

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

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

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."[37]

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

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

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[37] 5 U.S.C. 603(c)(1)-(4).

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

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

None.

List of Subjects in 47 CFR Parts 5, 25, and 97

Reporting and recordkeeping requirements, Satellites

FEDERAL COMMUNICATIONS COMMISSION

Marlene Dortch,
Secretary.

Proposed Rules

For the reasons discussed in the preamble, the Federal Communications Commission proposes to amend 47 CFR 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)(1), redesignating paragraphs (b)(2) through (4) as (b)(3) through (5), adding new paragraph (b)(2), revising newly redesignated paragraphs (b)(3) through (b)(5) and adding (c), and (d), 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 not part of the space station launch that may become a source of orbital debris;

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

(3) A statement that the space station operator has assessed and limited the probability of accidental explosions or release of liquids that could become debris during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that

fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy and debris includes liquids that persist in droplet form. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application;

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

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

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

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

and operational strategies that will be used to avoid collision with manned spacecraft.

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

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

(ii) Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap

or touch. If so, the statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions; and

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

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

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

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

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

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

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

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

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

PART 25 – SATELLITE COMMUNICATIONS

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

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

4. Amend § 25.114 by:

a. Revising paragraph (d)(14)(i);

b. Redesignating paragraphs (d)(14)(ii) through (v) as paragraphs (iii) through (vi);

c. Adding new paragraph (d)(14)(ii); and

d. Revising newly redesignated paragraphs (d)(14)(iii) through (v).

The addition and revisions to read as follows.

§ 25.114 Applications for space station authorizations.

* * * * *

(d) * * *

(14) * * *

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

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

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

pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application;

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

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

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

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

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

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

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

statement as to the identities of those parties and the measures that will be taken to prevent collisions; and

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

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

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

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

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

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

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

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

* * * * *

5. Amend § 25.121 by adding paragraph (f) to read as follows:

§25.121 License term and renewals.

* * * * *

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

6. Amend § 25.161 by adding paragraph (e) to read as follows:

§25.161 Automatic termination of station authorization.

* * * * *

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

7. Add § 25.166 to read as follows:

§25.166 Indemnification.

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

8. Amend § 25.271 by revising paragraph (e) to read as follows:

§25.271 Control of Transmitting Stations.

* * * * *

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

* * * * *

9. Revise § 25.282 to read as follows:

§ 25.282 Orbit raising.

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

10. Add § 25.290 to read as follows:

§ 25.290 Telemetry, tracking, and command encryption.

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

PART 97 – AMATEUR RADIO SERVICE

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

AUTHORITY: 47 U.S.C. 151-155, 301-609, unless otherwise noted.

12. Amend § 97.207 by:

a. Revising paragraph (g)(1)(i),

b. Redesignating paragraphs (g)(1)(ii) through (v) as paragraphs (g)(1)(iii) through (vi)

c. Adding new paragraph (g)(1)(ii);

d. Revising newly redesignated paragraphs (g)(1)(iii) through (vi); and

e. Adding paragraphs (h) and (i).

The revisions and additions to read as follows:

§ 97.207 Space station.

* * * * *

(g) * * *

(1) * * *

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

(ii) A statement indicating whether the space station operator has assessed in the aggregate and limited the probability to 0.01 or less that the space station(s) will become

a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent post-mission disposal;

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

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

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

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

(*2*) The statement must identify any planned and/or operational space stations that may raise a collision risk, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or

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

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

(*4*) In addition, the statement must include a description of the means for tracking the spacecraft, including whether tracking will be active or passive. The space station licensee must certify that upon receipt of a space situational awareness conjunction warning, the licensee or

operator will review the warning and take all possible steps to assess and, if necessary, to mitigate collision risk, including, but not limited to: contacting the operator of any active spacecraft involved in such warning; sharing ephemeris data and other appropriate operational information with any such operator; modifying space station attitude and/or operations.

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

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

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

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

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

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

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

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

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

* * * * *

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

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

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