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

In the matter of	)	
	)	
Mitigation of Orbital Debris	)	IB Docket No. 02-54
	)	
	)	
	)	

NOTICE OF PROPOSED RULE MAKING

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By the Commission: Commissioner Copps issuing a statement

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I. INTRODUCTION

1. By this Notice, we propose to adopt rules for satellite services concerning orbital debris mitigation. Orbital debris consists of artificial objects orbiting the Earth that are not functional spacecraft. Since human activity in space began, there has been a steady growth in the number and total mass of orbital debris. Growth in the orbital debris population may limit the usefulness of space for communications and other uses in the future, by raising the costs and lowering the reliability of space based systems. There is an emerging consensus, however, that consideration of orbital debris issues as a part of spacecraft design and operation can play an important role in preserving access to space for the long term. Consideration of orbital debris issues also can minimize the risk of injury to humans from debris, both in space and on the surface of the Earth.

2. The Commission has either adopted or proposed to adopt requirements that satellite systems in three specific services describe debris mitigation plans when applying for a license.[1] The Commission has also consistently indicated that it would initiate a future rule making proceeding – this proceeding – to address debris mitigation issues involving all satellite systems. For these reasons, we believe this is an appropriate

[1] Policies and Service Rules for the Mobile Satellite Service in the 2 GHz Band, Report and Order, IB Docket No. 99-81, 15 FCC Rcd 16127, 16205 (2000) ("2 GHz MSS Order"); Establishment of Policies and Service Rules for Non-Geostationary Satellite Orbit, Fixed Satellite Service in Ku-Band, Notice of Proposed Rule Making, IB Docket No. 01-96, 16 FCC Rcd 9680, ¶¶ 66-67 (2001); Establishment of Policies and Service Rules for Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ka-Band, FCC 02-30, ¶43 (released February 6, 2002).

time to consider issues related to orbital debris mitigation, and commence this rule-making proceeding to consider the manner in which consideration of debris mitigation issues should be incorporated into our rules and licensing processes.

3. This Notice of Proposed Rule Making begins by providing a short discussion of the technical and scientific aspects of orbital debris. We next provide a brief outline of the development of U.S. policies and regulations concerning orbital debris, as well as the international context in which those policies have developed. We then turn to our substantive proposals, which involve adopting a requirement that satellite systems licensed by the FCC must disclose in their requests for authorization their debris-mitigation plans, and several other specific rule changes to address debris mitigation. We also seek comment on a number of issues concerning mitigation, and on whether our rules should be modified to address those issues.

II. BACKGROUND

A. Technical and Scientific Aspects of Orbital Debris

4. The orbital debris population consists of a wide range of objects. The smallest and most numerous objects (in excess of a million), consist of a large number of paint flakes, solid rocket motor slag,[2] and break-up debris (from the explosion of space objects). Larger objects include operational debris (bolts, lens caps, etc), break-up debris, solid rocket motor slag, and reactor coolant. The least numerous objects, but the ones making up the largest percentage of mass in orbit, are spacecraft, rocket bodies, and the largest pieces of break-up debris from exploded spacecraft and rocket bodies.[3]

5. Absent other influences, objects placed in orbit around the Earth will continue in orbit indefinitely, as the momentum of the object causes it to orbit the Earth along a trajectory determined by the Earth's gravitation. For objects orbiting the Earth, the point in orbit that the object is farthest from the Earth is known as its "apogee." The point in orbit that the object is closest to the Earth is known as the object's "perigee."

6. An object's orbit around the Earth can be affected by a number of additional factors. Objects in Low-Earth orbit (LEO), i.e., with a perigee relatively close to the Earth, will experience drag from collisions with molecules of gas from the upper reaches of the Earth's atmosphere. Atmospheric drag results in orbital decay, i.e., a

[2] The term "slag" is used here to refer to material, often aluminum oxide, ejected from solid rocket motors as a by-product of the burning of solid rocket propellants.

[3] Nicholas L. Johnson "Overview of NASA Orbital Debris Program," slides presented 27 January 1998 at the U.S. Government Orbital Debris Workshop for Industry (available in the docket file of this proceeding). National Research Council Committee on Space Debris, Aeronautics and Engineering Board, Commission on Engineering and Technical Systems, Orbital Debris: A Technical Assessment (National Academy Press, Washington, D.C. 1995), p. 199 ("Orbital Debris: A Technical Assessment"). Available online at http://sn-callisto.jsc.nasa.gov.

gradual lowering of the object's orbit. Eventually, orbital decay will result in the object reentering the Earth's atmosphere.

7. Atmospheric drag on orbiting objects decreases dramatically as the orbital altitude of the object increases. For example, from an altitude of 250 kilometers, a typical spacecraft in a circular orbit will reenter the Earth's atmosphere within approximately two months, and from an altitude of 600 kilometers, it will reenter within approximately 15 years. On the other hand, orbits with a perigee above 850 kilometers suggest an orbital lifetime typically exceeding 500 years.[4] At the Geostationary Earth orbit[5] (GEO), the effects of atmospheric drag are essentially non-existent.[6] Objects in orbit are also affected by gravitational forces other than the Earth's (especially lunar and solar forces), and by solar pressure.[7] These forces can be of particular significance for objects in and around GEO.

8. Objects reentering the Earth's atmosphere typically burn up from the heat generated during reentry. However, larger or particularly heat-resistant objects may survive reentry and reach the surface of the Earth. Approximately 75 percent of the mass launched into orbit since the beginning of human activity in space has reentered the Earth's atmosphere.[8] However, because a significant number of objects remain in orbit indefinitely, and with continuing activity to place new objects in orbit, there has been long-term growth in the mass and number of orbital debris.[9]

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[4] These figures derive from the National Aeronautics and Space Administration's Debris assessment software, available at http://sn-callisto.jsc.nasa.gov/mitigate/mitigation.html. They are based on an assumed spacecraft area to mass ratio of .01 m^2/kg. There are substantial variations in the amount of drag at any given altitude due to variations in solar activity. As solar activity increases through the 11 year sun spot cycle, the Earth's atmosphere is heated, and it expands, thus increasing the density of drag-producing gases at any given altitude.

[5] The geostationary earth orbit is a circular orbit at an altitude of approximately 35,786 kilometers (km). A spacecraft in a geostationary earth orbit is maintained at a constant longitudinal position relative to the Earth, thus allowing the satellite to be "seen" continuously from a fixed point on the Earth's surface. For a detailed description of the geostationary orbit, *see* Physical Nature and Technical Attributes of the Geostationary Orbit, Study Prepared by the Secretariat, United Nations Committee on the Peaceful Uses of Outer Space, UN Document A/AC.105/404 (13 January 1988) (Copy available in the docket file of this proceeding). GEO is also sometimes referred to as the geosynchronous satellite orbit, or "GSO." Examples of GEO satellite systems licensed by the FCC include the Panamsat and Intelsat satellite systems.

[6] American Institute of Aeronautics and Astronautics, 6th International Space Cooperation Workshop Report (March 2001) at 14. (Copy available in the docket file).

[7] The absorption and re-radiation by a spacecraft of the sun's radiation creates a small amount of momentum. Solar pressure is the momentum created thereby. Solar pressure tends to render more elliptical the typically or nearly circular orbits of objects in the vicinity of the GEO.

[8] *See* Nicholas L. Johnson, "Overview of NASA Orbital Debris Program," slides presented 27 January 1998 at the U.S. Government Orbital Debris Workshop for Industry (available in the docket file of this proceeding).

[9] *Id. See also*, Scientific and Technical Subcommittee of the United Nations Committee on Peaceful Uses of Outer Space, Technical Report on Space Debris, Figure II (1999)("*STSC Technical Report on Space Debris*"); National Research Council, Orbital Debris: A Technical Assessment, Figure 1-2 (1995); White

9. In space, because of the high relative velocities involved, even some of the smaller objects, particularly those greater than 0.1mm in diameter, are capable of producing significant impact damage. For debris objects larger than 1 mm in diameter. impact damage can include significant structural damage to a satellite. Objects larger than approximately 1 cm in diameter can produce catastrophic damage to other space objects.[10]

B. Development of U.S. Policy and Regulations Concerning Orbital Debris

10. U.S. policy on orbital debris is the product of considerable work over the years to assess the risks posed by orbital debris, and to develop methods for mitigating those risks.[11] This work has included two U.S. government reports, the first in February 1989,[12] and the second in November 1995.[13] The *1995 Interagency Report* recommended that the National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD) jointly develop draft design guidelines that could serve as a baseline for agency requirements for future spacecraft. The *1995 Interagency Report* recommended that interested U.S. agencies then consult with the private sector to develop government/industry design guidelines. It also recommended that such guidelines could be used by both government and industry in the design and development of future satellite systems.[14] At a 1998 U.S. government workshop for industry, draft U.S. Government guidelines were presented to industry. The practices listed in the guidelines were control of orbital debris released during normal operations, minimization of debris generated by accidental explosions, selection of a safe flight profile and operational configuration, and post-mission disposal of space structures. Those practices have now been adopted, with some modifications, and are applied in U.S. government missions. A copy of these practices is attached for information as Appendix A.[15]

House Office of Science and Technology Policy, Interagency Report on Orbital Debris, Figure 7 (1995) ("*1995 Interagency Report*").

[10] *1995 Interagency Report* at 8.

[11] For a detailed chronology focusing on U.S. efforts to address orbital debris issues, see David S.F. Portree and Joseph P. Loftus, Jr., Orbital Debris: A Chronology, NASA/TP-1999-208856 (January 1999)(available through www.sti.nasa.gov).

[12] Report on Orbital Debris for the National Security Council (1989).

[13] *1995 Interagency Report.*

[14] Shortly thereafter, the President adopted a National Space Policy calling for, among other things, measures seeking to "minimize the creation of space debris." Available online at http://www.ostp.gov/NSTC/html/fs/fs-5.html. The 1996 National Space Policy continued a national policy, first stated in 1998, favoring U.S. actions to minimize the creation of space debris, and encourage other spacefaring nations to adopt policies and practices aimed at debris minimization. Presidential Directive on National Space Policy, February 11, 1988. Excerpts available at http://www.hq.nasa.gov/office/pao/History/policy88.html.

[15] Also available at http://sn-callisto.jsc.nasa.gov

11. Under the U.S. Government Standard Practices, the first objective – controlling debris released during normal operations – is addressed by minimizing the amount of debris released in a planned manner during normal operations. The second objective – minimizing debris generated by accidental explosions – is addressed by limiting the risk to other space systems from accidental explosions both during mission operations and after completion of mission operations. For mission operations, this is accomplished by analyzing credible failure modes and developing methods to limit the probability they will occur. Post-mission, this is accomplished by depleting all sources of stored energy on board the spacecraft when they are no longer required for mission operations or post-mission disposal. The third objective – selecting a safe flight profile and operational configuration – is addressed through estimating and limiting the probability of collision with large objects during orbital lifetime, and the probability of disabling collisions with small debris during mission operations.

12. The fourth objective – providing for post-mission disposal of space structures – is met by planning for disposal of a spacecraft at the end of mission life to minimize impact on future space operations. This is accomplished through one of two options relevant here.[16] The first option is atmospheric reentry, *i.e.*, leaving the structure in an orbit in which it will remain in orbit for no longer than 25 years after mission completion. Under this option, it is also necessary to address the expected human casualty risk from any portions of the spacecraft that may survive atmospheric reentry. The second option is maneuvering to a storage orbit. There are three suggested storage orbits. The first is between low and medium Earth orbit, *i.e.*, satellite perigee altitude above 2,000 kilometers and apogee altitude below 19,700 kilometers. The second is between medium and geosynchronous Earth orbit, *i.e.*, perigee altitude above 20,700 kilometers and apogee altitude below 35,300 kilometers. The third is above geosynchronous Earth orbit, *i.e.*, perigee altitude above 36,100 kilometers (or approximately 300 kilometers above geosynchronous altitude).

13. The Government Standard Practices apply to missions operated or procured by the U.S. government agencies. By their terms, the Government Standard Practices require that "programs and projects will assess and limit" events that could produce debris and "will plan for" post-mission disposal.[17] Government agencies retain the ability to deviate from specific practices if necessary to address considerations of cost or mission effectiveness. The Government Standard Practices are not directly applicable to non-Government missions.

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[16] A third option, direct retrieval of the spacecraft, appears to have limited relevance. We are not aware of any instance in which a commercial communications mission has been designed for end of life disposal using direct retrieval.

[17] See Appendix A. See also the 1996 National Space Policy ("NASA, the Intelligence community, and the DoD, in cooperation with the private sector, will develop design guidelines for future government procurements of spacecraft, launch vehicles, and services. The design and operation of space tests, experiments and systems, will minimize or reduce accumulation of space debris consistent with mission requirements and cost effectiveness.").

14. Licensing authority for non-government space activities rests with three agencies: the Department of Transportation Federal Aviation Administration (FAA); the Department of Commerce National Oceanic and Atmospheric Administration (NOAA); and the FCC. The FAA is the U.S. licensing authority for commercial launches, pursuant to the Commercial Space Launch Act of 1984, as amended. [18] The FAA regulates launches from U.S. territory and launch activities by U.S. nationals outside the United States. FAA regulations[19] provide detailed launch safety and liability insurance requirements. FAA regulations specifically indicate that the FAA does not review "payloads"[20] that are subject to regulation by the FCC or NOAA.[21] Under the Land Remote Sensing Policy Act of 1992,[22] NOAA is the U.S. licensing authority for commercial remote sensing systems. The Remote Sensing Act and NOAA's implementing regulations[23] address national security, foreign policy and science policy issues, other than radiocommunication matters.[24] The Land Remote Sensing Policy Act requires that a licensee, "upon termination of operations under the license, make disposition of any satellites in space in a manner satisfactory to the President."[25] The Remote Sensing Act did not alter the authority of the FCC concerning licensing of satellites transmitting radio communications.[26] Thus, because they use radio frequencies to transmit data collected in space back to the Earth, commercial U.S. remote sensing satellites typically must obtain a license from both NOAA and the FCC. Both the FAA and NOAA have issued regulations concerning mitigation of orbital debris. In several respects those regulations require non-governmental space missions to adopt practices consistent with the Government Standard Practices.

15. Specifically, the FAA has adopted regulations concerning commercial space launches. Those regulations include a requirement that an applicant for a commercial launch license must demonstrate that for all launch vehicle stages or

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[18] 49 U.S.C. § 70101 et. seq.

[19] 14 C.F.R. § 400 et. seq. The FAA is the U.S. licensing authority for commercial launches, pursuant to the Commercial Space Launch Act of 1984, as amended, 49 U.S.C. § 70101 et. seq.

[20] 14 C.F.R. § 415.39 (2001). A "payload" is defined as "an object that a person undertakes to place in outer space by means of a launch vehicle, including components of the vehicle specifically designed or adapted for that object." 14 C.F.R. § 401.5 (2001).

[21] 14 C.F.R. §§ 415.7, 415.53.

[22] 15 U.S.C. § 5601 et. seq. ("Remote Sensing Act").

[23] Licensing of Private Land Remote-Sensing Space Systems, (Interim Final Rule) 65 Fed.Reg. 46822 (July 31, 2000).

[24] 15 U.S.C. §§ 5625(e), 5656.

[25] 15 U.S.C. § 5622(b)(4).

[26] 15 U.S.C. § 5625(e).

components which reach Earth orbit, there will be no unintended physical contact of the vehicle or its components with its payload after payload separation.[27] In addition, the FAA requires measures that prevent the conversion of energy sources into energy[28] that fragments a vehicle or its components.[29] As part of the licensing process, the FAA also examines other safety matters concerning launch vehicles, such as safe flight profiles and assessment of associated risks.[30] This assessment includes the assessment of risk in the event a portion of a launch vehicle will reenter the Earth's atmosphere after attaining orbit. In addition, the FAA undertakes a safety review of payloads, unless the payload is owned or operated by the U.S.Government, or subject to regulation by the FCC or NOAA.

16. The FCC has addressed issues regarding orbital debris and satellite systems on a case-by-case and service-by-service basis, under authority granted by the Communications Act.[31] Until recently, the Commission's rules did not require submission of information regarding plans for orbital debris mitigation. However, in adopting rules for the mobile satellite service at 2 GHz, the Commission required systems to "describe the design and operational strategies that they will use, if any, to mitigate orbital debris."[32] This rule also requires 2 GHz MSS system proponents to "submit a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the spacecraft."[33] The FCC has proposed to adopt similar rules for the Ku-Band non-geostationary orbit satellites and for Ka-Band non-geostationary orbit satellites.[34] The Commission has also consistently indicated in these proceedings that it would initiate a future rule making proceeding – this proceeding – to address debris mitigation issues involving all satellite systems.[35] The number of commercial satellites on orbit or planned

[27] 14 C.F.R. § 415.39 (2001).

[28] One example of such a conversion would be the explosion of residual propellants.

[29] *Id.*

[30] 14 C.F.R. § 415.35 (acceptable flight risk). *See also* 14 C.F.R. § 431.43(c)(1) (200 kilometer separation from inhabitable orbiting objects during launch and reentry); Licensing and Safety Requirements for Launch (Notice of Proposed Rule Making), 65 Fed.Reg.63922, 63951 (October 25, 2000).

[31] The Communications Act of 1934, as amended, 47 U.S.C. § 151 et. seq. ; 2 GHz MSS Order, 15 FCC Rcd 16127, 16198 (adopting 2 GHz service rules pursuant to, inter alia, 47 U.S.C. §§ 154(i) and 303(r)); In re Applications of Space System Licensee, et.al., Memorandum Opinion, Order and Authorization, DA 02-307, ¶ 56 (released February 8, 2002)(reviewing and approving satellite end of life plan and approving transfer of control, based on, inter alia, 47 U.S.C. §§ 154(i), 309, and 310(d)).

[32] 47 C.F.R. § 25.143(b)(1), as amended by 2 GHz MSS Order, 15 FCC Rcd 16127, 16205 (2000).

[33] 47 C.F.R. § 25.143(b)(1), as amended by the 2 GHz MSS Order, 15 FCC Rcd at 16205.

[34] Establishment of Policies and Service Rules for Non-Geostationary Satellite Orbit, Fixed Satellite Service in Ku-Band, Notice of Proposed Rule Making, IB Docket No. 01-96, 16 FCC Rcd 9680, ¶¶ 66-67 (2001); Establishment of Policies and Service Rules for Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ka-Band, FCC 02-30, ¶43 (released February 6, 2002).

[35] *Id.*; 2 GHz MSS Order, 15 FCC Rcd at 16188 ¶ 138.

for launch has increased dramatically over the last decade, particularly as new orbits, such as LEO, and new frequency bands have been incorporated into commercial satellite system designs.

17. Issues related to orbital debris have arisen in several cases. In some cases, parties have raised questions concerning potential collisions between satellites.[36] The Commission has also sought and received advice from NASA concerning technical issues, particularly those relating to end-of-life disposal.[37] Based on technical analyses by NASA, and following coordination with a wide range of Executive Branch agencies, the FCC's International Bureau recently authorized the Iridium system to perform end-of-life maneuvers, when those maneuvers become necessary in the future.[38]

C. International Aspects

18. Both the 1995 Interagency Report and the 1996 National Space Policy[39] recognized that there are important international aspects of the debris mitigation policy. The 1995 Interagency Report noted the need for a coordinated U.S. international strategy to encourage other nations to adopt debris policies and practices. The National Space Policy indicates that it is in the interest of the U.S. Government to ensure that space debris minimization practices are applied by other spacefaring nations. The National Space Policy also states that the U.S. Government will take a leadership role in international fora to adopt policies and practices aimed at debris minimization and will cooperate internationally in the exchange of information on debris research and the identification of debris mitigation options." Thus, the international aspects of debris mitigation include both measures adopted by individual countries to govern their national activities involving the use of space, and cooperation among nations in development of debris mitigation options and practices. In this section, we briefly examine both international aspects. We first provide some background concerning international treaties having some relevance to debris mitigation issues, and associated with the international organizations in which there have been cooperative efforts to develop debris mitigation options and practices. We then describe development of mitigation guidelines by national authorities in other countries, and ongoing work in international fora to address space debris issues.

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[36] *See, e.g.*, File No. 194-SAT-ML-97 (potential collisions between satellites in the Orbcomm and Iridium constellations; subsequently resolved through coordination between the system operators).

[37] *See, e.g.*, Letter dated February 11, 1998, from Daniel S. Goldin, Administrator, NASA, to William Kennard, Chairman, FCC (addressing technical cooperation between NASA and the FCC on orbital debris matters); *see also* Letter dated March 4, 1998, from Nicholas L. Johnson, NASA Chief Scientist for Orbital Debris, to Karl Kensinger, FCC International Bureau (addressing projected orbital lifetimes of satellites in the Orbcomm system) (both letters available in the docket file of this proceeding).

[38] In re Applications of Space System Licensee, et.al., Memorandum Opinion, Order and Authorization, DA 02-307 (released February 8, 2002).

[39] *See supra*, n. 13.

19. The United States is party to four treaties concerning activities involving outer space, concluded under the auspices of the United Nations Committee on Peaceful Uses of Outer Space ("UNCOPUOS"). These treaties are: (1) the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, which entered into force October 10, 1967 ("the Outer Space Treaty"); (2) the Convention on International Liability for Damage Caused by Space Objects, which entered into force September 1, 1972 ("the Liability Convention"); (3) the Convention on Registration of Objects Launched into Outer Space, which entered into force September 15, 1976 ("the Registration Convention"); and (4) the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, which entered into force December 1968 ("the Rescue Agreement").[40]

20. The Outer Space Treaty provides the basic framework on international space law. It provides that outer space is not subject to national appropriation by claim of sovereignty or other means,[41] and that outer space may be used by all states for peaceful purposes, and that use of outer space shall be carried out for the benefit and in the interests of all countries.[42] The Outer Space Treaty also requires that States, i.e., nations that are parties to the treaty, be responsible for national space activities whether carried out by governmental agencies or non-governmental entities, and that activities by non-governmental entities require authorization and continuing supervision by States that are parties to the treaty.[43] Under the Outer Space Treaty, a State is internationally liable for damage caused by its space objects,[44] and States must avoid harmful contamination of space and celestial bodies.[45]

21. The Liability Convention elaborates on Article 7 of the Outer Space Treaty. It provides that a launching State[46] shall be absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth or to aircraft,[47] and liable under a fault standard for damage in space.[48] The Liability Convention also

[40] Full texts of the treaties are available on-line at http://www.oosa.unvienna.org/SpaceLaw/treaties.html.

[41] Outer Space Treaty, Article II.

[42] Outer Space Treaty, Articles I, III, and IV.

[43] Outer Space Treaty, Article VI.

[44] Outer Space Treaty, Article VII.

[45] Outer Space Treaty, Article IX.

[46] A "launching state" is defined in Article I of the Liability Convention as "(i) A State which launches or procures the launching of a space object; (ii) A State from whose territory or facility a space object is launched."

[47] Liability Convention, Article II.

[48] Liability Convention, Article III.

provides procedures for the settlement of claims for damages.[49] The Registration Convention provides that States should maintain a national registry of objects launched into Earth orbit or beyond, and transmit information from that registry to a registry maintained by the United Nations.[50] The Rescue Agreement elaborates on elements of articles 5 and 8 of the Outer Space Treaty. It provides, among other things, that States shall, upon request, provide assistance to launching States in recovering space objects that return to Earth outside the territory of the Launching State.[51]

22. These obligations have been implemented through national legislation in a number of countries.[52] In the United States, the Commercial Space Launch Act of 1984, as amended,[53] contains the principal statutory provisions addressing the United States' obligations under the Outer Space Treaty to supervise activities by non-government entities. The FAA has adopted implementing regulations for that statute.[54] The Department of State maintains the U.S. Registry of Space Objects required under the Registration Convention.[55]

23. The United States is also a Member State of the International Telecommunication Union ("ITU"), a specialized agency of the United Nations. The U.S. is a party to the ITU Constitution, Convention, and Radio Regulations. The FCC serves as the principal point of contact with the ITU Radiocommunication Bureau and with other ITU Member States for purposes of coordinating U.S. commercial satellite networks with networks of other countries. Such coordination is designed to avoid harmful radiofrequency interference.

24. The ITU Radiocommunication Assembly (ITU-R) adopted an orbital debris mitgation recommendation in 1993. ITU-R recommended, among other measures, that as little debris as possible be released into GSO, and that a GSO satellite at the end of

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[49] Liability Convention, Articles IX-XX.

[50] Registration Convention, Articles II-IV.

[51] Rescue Treaty, Article V.

[52] For English language texts of national legislation from a number of countries, *see* http://www.oosa.unvienna.org/SpaceLaw/national/index.html. For an overview of national legislation, *see* Review of existing national space legislation illustrating how States are implementing, as appropriate, their responsibilities to authorize and provide continuing supervision of non-governmental entities in outer space, Note by the Secretariat, UN Committee on Peaceful Uses of Outer Space, Document Number A/AC.105/C.2/L.224 (22 January 2001).

[53] 49 U.S.C. § 70101 et. seq.

[54] 14 C.F.R. § 400.1 et. seq.

[55] *See* http://www.state.gov/g/oes/sat/.

its life be transferred, before the complete exhaustion of its propellant, to a storage orbit that does not intersect with GSO.[56]

25. Consistent with this international framework, more detailed technical and policy means for mitigation of orbital debris have been largely addressed at the national level. In addition to the United States, Japan, Russia, the Ukraine, France, and India have developed or are developing debris mitigation standards or practices.[57] The European Space Agency (ESA) has also developed mitigation standards.

26. Additionally, there is significant and ongoing international consultation and technical study of orbital debris. Much progress in this area has been facilitated by the Inter-Agency Space Debris Coordination Committee (IADC). The IADC's members include the space agencies of Europe, France, Germany, India, Italy, Japan, the People's Republic of China, Russia, Ukraine, the United Kingdom, and the United States. The IADC developed to enable space agencies to exchange information on space debris research activities, to review the progress of ongoing cooperative activities, to facilitate opportunities for cooperation in space debris research, and to identify debris mitigation options.[58]

27. Orbital debris has also been studied by the Scientific and Technical Subcommittee of UNCOPUOS (STSC). The STSC adopted a comprehensive report on orbital debris in 1999.[59] One conclusion of this report was that: "In most cases, man-made space debris today poses little risk to the successful operation of approximately 600 active spacecraft now in Earth orbit. However, the known and assessed population of debris is growing, and the probabilities of potentially damaging collisions will consequently increase. Because of the difficulty of improving the space environment with existing technologies, the implementation of some debris mitigation measures today is a prudent step towards preserving space for future generations." [60] The STSC report

[56] *See* Rec. ITU-R S.1003, "Environmental Protection of the Geostationary –Satellite Orbit," ITU-R Recommendations, 1994 S Series Volume: Fixed Satellite Service, International Telecommunication Union, Geneva, Switzerland, 1994 pp. 364-367. The recommendation suggests, in pertinent part, that a geostationary satellite at the end of its life should be transferred before complete exhaustion of its propellant, to a "supersynchronous graveyard orbit that does not intersect the GSO," with GSO defined as the mean earth radius of 42,164 kilometers plus or minus 300 kilometers. The recommendation also notes that what constitutes "an effective graveyard orbit" requires further studies. In this regard, we note that orbital perturbations due to solar and lunar gravitation, solar pressure, or other sources, may, over time, result in an inactive satellite's orbit intersecting the GSO, as defined by the ITU recommendation, even if the initial disposal altitude does not intersect the GSO.

[57] Nicholas Johnson, Trends and Options in the Disposal of Launch Vehicle Orbital Stages, 52nd International Astronautical Congress (Toulouse, France 2001).

[58] *See* www.iadc-online.org.

[59] UN Technical Report on Space Debris. *See also* Disposal of satellites in geosynchronous orbit, Report by the Secretariat, UN COPUOS, document No. A/AC.105/734 (17 December 1999).

[60] *STSC Technical Report on Space Debris*, p. 42.

also states that "[i]n some cases, technical work remains to be done to determine the most effective and cost-efficient solutions."[61] As a result, the STSC has developed a multi-year work plan that contemplates the IADC submitting a consensus set of guidelines concerning space debris mitigation to the STSC, in 2003.[62]

III. DISCUSSION

28. Based on developments in United States policy and the scientific understanding of techniques for orbital debris mitigation, and in light of our statutory responsibilities, we conclude that now is an appropriate time to consider adoption of rules concerning orbital debris mitigation by FCC licensees. We seek comment on a range of options for addressing these issues. As a general matter, we propose to require, as part of the licensing process, disclosure of orbital debris mitigation plans for all types of satellite systems licensed by the FCC.[63] We also seek comment on whether we should specify in greater detail in our rules the content of such showings, and whether each of the debris mitigation practices discussed below are now sufficiently mature to warrant adoption of a rule requiring use of the practice.

29. The discussion that follows first addresses our statutory authority concerning orbital debris mitigation matters. We then turn to a discussion of the individual elements of debris mitigation. That discussion largely tracks the organization of the U.S. Government Standard Practices, focusing first on release of debris during normal operations, then on minimizing debris caused by accidental explosions, then on the selection of safe flight profiles, and finally on post-mission disposal of spacecraft.

A. FCC Statutory Authority Concerning Orbital Debris

30. Although the Communications Act of 1934 predated the advent of satellite communications, the FCC has concluded that the Communications Act provides authority for licensing radio frequency uses by satellite, even though the satellite is located in space.[64] Since the first rules concerning satellites were adopted, the FCC satellite licensing process has addressed aspects of the physical design and location of satellites.[65] The Commission has addressed orbital debris issues in several cases,[66]

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[61] *Id.*

[62] Report of the Scientific and Technical Subcommittee on its thirty-eighth session (2001) UN Document No. A/AC.105/761, at pages 21-22.

[63] We propose, however, to waive this requirement with respect to disclosure of post-mission spacecraft disposal plans for remote sensing systems licensed by NOAA.

[64] Establishment of Domestic Communication-Satellite Facilities by Nongovernmental Entities, 22 FCC 2d 86, Appendix C-Memorandum on Legal Issues (1970).

[65] *Id.*, at Appendix D-Technical Appendix (requiring an approximately geostationary orbit, outlining required separations between satellites, and requiring that satellites be capable of reasonable shifts in orbital longitude).

[66] *See,* The Boeing Company, DA 01-1631 (Int'l Bur., rel. July 17, 2001); Celsat America, Inc., DA 01-1632 (Int'l Bur., rel. July 17, 2001); Constellation Communications Holdings, Inc., DA 01-1633 (Int'l

and debris-related issues have been raised in several other cases. To date, however, the Commission has not formally addressed the scope and nature of its authority concerning orbital debris.[67] The Communications Act[68] provides the Commission with broad authority with respect to radio communications involving the United States, except for communications involving U.S. Government radio stations.[69] The Communications Act charges the FCC with encouraging "the larger and more effective use of radio in the public interest,"[70] and provides for licensing of radio communications,[71] upon a finding that the "public convenience, interest, or necessity will be served thereby."[72] Orbital debris and related mitigation measures could affect the cost, reliability, and safety of satellite operations. Thus, orbital debris issues could affect the "larger and more effective use of radio in the public interest." Furthermore, any debris generated as a result of FCC-licensed activities could conceivably effect other activities in space, including manned space flight, as well as the safety of individuals on the surface of the earth. In addition, orbital debris can effect the integrity and capability of new satellite systems that we will wish to license in the future, pursuant to our existing authority. Thus, orbital debris issues may be relevant in determining whether the public interest would be served by any particular satellite system, or by any particular practice or operating procedure of satellite systems. In addition, because robotic spacecraft are typically controlled through radiocommunication links, there would appear to be a nexus between the radiocommunication function of FCC licensed space stations[73] and their physical operations. We seek comment on these issues and this analysis.

31. We also specifically seek comment on the scope and nature of the Commission's authority with respect to non-U.S. licensed space stations[74] that seek to

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Bur./OET, rel. July 17, 2001); Globalstar, L.P., DA 01-1634 (Int'l Bur./OET, rel. July 17, 2001); ICO Services Limited, DA 01-1635 (Int'l Bur./OET, rel. July 17, 2001); Iridium LLC, DA 01-1636 (Int'l Bur., rel. July 17, 2001); Mobile Communications Holdings, Inc., DA 01-1637 (Int'l Bur./OET, rel. July 17, 2001); TMI Communications and Company, DA 01-1638 (Int'l Bur., rel. July 17, 2001); . Space System Licensee, et. al., DA 02-307 (released February 8, 2002).

[67] For a discussion of the FCC and other governmental agencies' legal authority concerning orbital debris, *see* MEO/LEO Constellations: U.S.Laws, Policies, and Regulations on Orbital Debris Mitigation, American Institute of Aeronautics and Astronautics Special Project No. SP-016-2-1999 (1999).

[68] The Communications Act of 1934, as amended, 47 U.S.C. § 151 et. seq.

[69] The Communications Act provides that "radio stations belonging to and operated by the United States" are not subject to licensing by the FCC. 47 U.S.C. § 305(a). The Commerce Department's National Telecommunication and Information Administration is responsible for assignment of frequencies for use by such government stations.

[70] 47 U.S.C. § 303(g).

[71] 47 U.S.C. § 301.

[72] 47 U.S.C. § 307(a).

[73] As used in this Notice of Proposed Rule Making, the term "space station" has the meaning given in the ITU Radio Regulations, i.e., one or more transmitters or receivers or a combination of transmitters and receivers necessary for carrying on a radiocommunication service, and located on an object which is beyond, is intended to go beyond, or has been beyond, the major portion of the Earth's atmosphere. *See* ITU Radio Regulations S1.61 and S1.64.

[74] We use the term "non-U.S. licensed space station" to refer to a space station that is authorized by a country other than the United States, and for which the United States is not the administration that has

operate using earth stations licensed by the FCC.[75] With respect to earth stations communicating with non-U.S. licensed space stations, we believe some consideration of whether the space station will employ reasonable debris mitigation measures is appropriate in order to ensure that the satellite communications activity we authorize does not involve substantial safety concerns or activities that may be detrimental to space operations. We note that, for non-U.S. licensed space stations, the radiocommunications necessary to control the spacecraft may be performed from a non-U.S. earth station, and thus the communications activity the FCC authorizes would not directly involve the licensing of radiocommunication used for controlling the spacecraft.

32. We also seek comment on whether there are any matters involving launch vehicles that we have authority to consider. To date, the FCC has not required license applicants to submit information regarding debris mitigation plans for the launch vehicle that will be used to launch a satellite, nor have we reviewed that information even if it is submitted.[76] We are not proposing to change that practice, and the proposals in this notice address only spacecraft, and not launch vehicles. We observe that matters addressed under the Commercial Space Launch Legislation and its implementing regulations are most appropriately addressed by the FAA. Because Congress has specifically established a statutory regime governing such matters we believe it would be generally inappropriate to address such issues in the FCC licensing process, unless requested to do so by the FAA. We seek comment, however, on whether the FCC would have authority to consider launch-related matters that appear to be outside the scope of the Commercial Space Launch Legislation and its implementing regulations. For example, if a company is seeking an FCC license and procuring its launch from a foreign country, could the FCC consider orbital debris issues involving that launch, if asked to do so?

33. We also seek comment on whether the Commission would have authority to either adopt a rule, or, in an individual case, to impose a license condition, that would require licensees to obtain insurance to address debris mitigation or related issues.[77]

34. We also observe that, because NOAA has explicit statutory authority to address post mission disposal of remote sensing systems, we do not anticipate addressing in the FCC licensing process matters involving post-mission disposal of NOAA-licensed satellites.

B. Elements of Orbital Debris Mitigation

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assumed responsibility for notification, coordination, and other relevant matters under the ITU Radio Regulations.

[75] *See, infra Section III.D.*

[76] *See, e.g.* The Boeing Company, DA 01-1631, at ¶33 (July 17, 2001).

[77] *See,* Section III.D., *infra.* (Liability Issues and Insurance).

35. The U.S. Government standard practices identify four broad objectives and a number of practices designed to achieve those objectives. We ask a number of specific questions concerning these practices below. In addition, we seek comment generally on the relationship between economic incentives and the likelihood that FCC-licensed satellite systems will adopt and carry out debris mitigation measures voluntarily. What impact do either normal business pressures, such as market incentives for profit maximization, or more extraordinary pressures, such as insolvency, have on incentives to adopt debris mitigation measures, or on related issues?[78] We seek comment on these issues.

1. Control of Debris Released During Normal Operations; Selection of a Safe Operational Configuration

36. The U.S. Government standard practices include two provisions that speak directly to the hardware design of spacecraft. First, the U.S. Government standard practices provide that programs will assess and limit the amount of debris released in a planned manner during normal operations. The communications payloads licensed by the FCC have not typically involved the planned release of any operational debris following the launch phase of operations. While we believe it is appropriate for applicants to confirm in any orbital debris mitigation showing that this is the case, we do not anticipate that addressing this guideline presents any significant issues for typical communications missions. We seek comment on this conclusion.

37. Second, the U.S. Government standard practices also provide that programs and projects will select a safe operational configuration, i.e. the project must assess and limit the probability that an operating spacecraft will become a source of debris through collisions with man-made objects or meteors. Particularly for collisions with smaller objects, this practice involves consideration of spacecraft shielding, placement of components, and use of redundant systems such that a collision will not cause a loss of spacecraft control that would prevent post-mission disposal. We propose to require an applicant to confirm in its orbital debris mitigation showing that it has made such an assessment. We anticipate that for communications missions, the operator's economic interest in ensuring reliability will generally provide ample incentive for designing each spacecraft as robustly as possible, since the systems used to control the spacecraft for end-of-life disposal are typically the same as those used in normal operations. We seek comment on this proposal.

38. We also seek comment on whether there are emerging satellite system designs that might call into question the adequacy of economic incentives alone. In particular, we note that there is substantial interest in satellite system designs that involve large numbers of small spacecraft. Among the potential benefits of such spacecraft often cited are their low cost, and the ability to enhance reliability by using multiple satellites, thus minimizing the impact of the loss of any individual satellite. While the redundancy afforded by the use of large numbers of small satellites may adequately address operator's concerns with the potential for economic losses, the U.S. Government standard

[78] *See, e.g.*, Section III.D., *infra.* (Liability Issues and Insurance).

practices focus on ensuring the ability to perform post-mission disposal. Thus, for purposes of addressing this guideline, the use of multiple spacecraft would not appear to be an adequate substitute for the more traditional method of hardening individual spacecraft.

2. Minimizing Debris Generated By Accidental Explosions

39. The U.S. Government standard practices provide that programs and projects will assess and limit the probability of accidental explosion during and after completion of mission operations. This is perhaps the single most important debris mitigation measure regarding potential damage to space assets. When an object explodes in space, it can produce a large number of debris objects, and the objects produced typically disperse over a much wider range of orbits than the orbit of the object that exploded.[79] The U.S. government standard practices provide that programs will assess possible failure modes that could result in explosions, and adopt operational procedures to limit the probability they will occur. In addition, the U.S. government standard practices provide that all sources of stored energy on-board a spacecraft "should be depleted or safed" when they are no longer required for mission operations or post-mission disposal.

40. We propose to require an applicant to confirm in its orbital debris mitigation showing that it has made such an assessment. We anticipate that for typical communications missions, the operator's economic interest in ensuring reliability will provide ample incentive for designing a spacecraft that does not experience accidental explosions during its useful life. We seek comment on this proposal. With respect to procedures at or near the end of a spacecraft's life, similar incentives may not apply, and, in fact, the operator may have economic incentives to continue potentially income-producing activities even as a spacecraft's systems degrade, potentially to the point where the reliability of energy depleting measures is compromised. We seek comment on this conclusion. We also note that the FAA has adopted a rule implementing this guideline for launch vehicle upper stages.[80] We propose to adopt a similar rule for space stations licensed by the FCC.[81] We note, however, that, once a launch vehicle upper stage delivers a payload to orbit, there is typically little or no economic value that can be derived from delaying energy depleting measures. On the other hand, end-of-life measures for a communication satellite are taken at the expense of income-producing activity. Therefore, we seek comment on whether additional measures, such as requiring

[79] For a more detailed discussion of explosions and other satellite fragmentation events, *see* History of On-Orbit Satellite Fragmentations, available on-line at http://sn-callisto.jsc.nasa.gov/measure/sat_frag_update.html#new.

[80] 14 C.F.R. § 415.39.

[81] *See* Appendix B.

reporting concerning availability of fuel adequate to execute planned end-of-life maneuvers, might be appropriate in connection with communications satellites.[82]

3. Safe Flight Profiles

41. The U.S. Government guidelines provide that programs and projects will assess and limit the probability of operating space systems becoming a source of debris by collisions with man-made objects or meteoroids. Thus, the guidelines provide that, when developing the design and mission profile for a spacecraft, a program will estimate and limit the probability of collision with known large objects during orbital lifetime. The development of safe flight profiles for FCC-licensed satellite systems presents a number of issues. While current FCC rules and international regulations have several provisions that impact the selection of the flight profile for a satellite, these rules were developed primarily to address radio frequency interference concerns. Thus, these rules may not by themselves adequately address situations where functioning satellites operate in different frequency bands, but are located in similar orbits, such as the same GEO satellite orbit location. However, an applicant's disclosure in the licensing process of, for example, the parameters of orbits its system would use, may assist third parties in identifying potential problems that may be caused by the proposed operations. In the most heavily used orbits or in orbits with particular sensitive operations, such as orbits used for manned space flight, additional measures may be warranted to avoid collision, such as coordination among the operators, or assignment of orbital locations designed to ensure adequate physical separation between operational satellites.

42. In the following paragraphs, we outline current rules and licensing practices that have some bearing on limiting the probability of collisions with large known objects, and we seek comment on whether it is necessary to change these rules and practices.

43. *Application Filing Requirements.* Section 25.114 of the Commission's rules establishes the information that an applicant must submit in an application for a space station authorization.[83] Section 25.114 (c)(12) requires the applicant to submit information regarding the physical characteristics of the space station. Section 25.114 (c)(6) requires applicants for GSO satellites to specify the satellite's orbital location, and discussion of factors relevant to selection of orbital location. Section 25.114 (c)(9) also requires applicants for GSO satellites to specify the accuracy with which the satellite's orbital inclination[84] and longitudinal drift[85] will be maintained. For non-

[82] *See, infra,* ¶ 52.

[83] *See* 47 C.F.R. § 25.114 (2001).

[84] Without so-called "north-south" station-keeping, the inclination of a GEO satellite will gradually increase, from zero degrees (equatorial orbit) to a maximum of approximately 14.6 degrees.

geostationary satellite systems, Section 25.114 (c)(6) requires applicants to specify the number of space stations, the number and inclination of orbital planes, orbital period, apogee, perigee, the argument(s) of perigee, and right ascension of the ascending node(s).

44. We note that a common FCC practice in authorizing space stations is to condition authorization on operations consistent with the technical specifications set forth in the application. Thus, upon authorization, this information becomes a material term of the license. We seek comment on whether the information typically provided in an application, particularly with respect to orbital parameters, provides an adequate basis for potentially affected parties to evaluate proposed systems with respect to collision avoidance and safe flight profiles. We also seek comment on whether it would be appropriate to require non-geostationary satellite systems to disclose the accuracy with which they will maintain orbital parameters such as apogee, perigee, period, and inclination.

45. *Rules and Practices for the Pre-operational Phase.* Following separation from a launch vehicle, but prior to commencing full commercial operations, there may be a substantial period of deployment and testing in which a satellite does not operate in its assigned orbit. To date, we have reviewed such operations on a case-by-case basis. To the extent an applicant seeks authority to transmit in connection with deployment and testing as part of its application for authority for "full" operations, we address that request in connection with licensing the satellite or satellite constellation as a whole.[86] In a number of cases, however, we have addressed this pre-operational phase by issuing a special temporary authority. For example, we have in a number of instances granted special temporary authority for the testing of geostationary satellites at orbital locations other than those specified in their licenses.[87]

46. We propose to continue these general practices. We believe it is beneficial to maintain regulatory flexibility in addressing the deployment and testing phase of satellite operations. We seek comment on this proposal. We also seek comment on the level of specificity of disclosure, regarding such "pre-operational" operations, that we should require in the licensing process. Most such operations are highly transitory in nature, often involving a series of spacecraft maneuvers, and, therefore, it may be difficult to specify precise orbital parameters for the operations. If, on the other hand, the operations involve the use of a particular orbit for an extended

[85] Because of small variations in the Earth's gravitation, a geostationary satellite, unless located at one of two "gravity wells" on the geostationary arc, will in the absence of station-keeping maneuvers drift east or west from its assigned orbital longitude.

[86] *See, e.g.,* 2 GHz MSS Order, 15 FCC Rcd 16127, 16176 (2000) (FCC may authorize pre-operational testing in connection with a license grant, if such authority is requested in the application).

[87] *See, e.g.,* File No. SAT-STA-20010612-00061 (granting Intelsat 901 authority for in orbit testing, following completion of coordination to prevent harmful radiofrequency interference); *see also* Public Notice, SAT-00078 (August 7, 2001) (accepting application for authority for temporary deployment of Intelsat 901).

period of time, such as a geostationary satellite orbital location used for in-orbit testing, or, for a non-geostationary satellite, use of an "engineering" orbit in which satellites are tested and maintained prior to deployment in "mission" orbits, we would generally expect licensees to specify precise orbital parameters. The parameters specified should be consistent with the requirements for disclosure in connection with normal operations.[88] We seek comment on this, or alternate, approaches.

47. *On-orbit Operations.* Section 25.210(j) of the Commission's rules specifies station-keeping requirements for fixed satellite service satellites in the geostationary satellite orbit. The rule requires that such satellites must be designed with the capability of being maintained in orbit within 0.05° of their assigned orbital longitude, and must be maintained in orbit at their assigned orbital longitude within the longitudinal tolerance specified by the Commission.[89] The FCC rule parallels, but is generally more stringent than, the requirement in the ITU Radio Regulations.[90] Because a geostationary satellite in the process of removal from orbit at the end of its mission would not comply with this rule, we propose to modify the rule to provide an explicit exception for such operations. In addition, we also propose changes to shorten and simplify the text of the rule, so that it simply indicates that GSO satellites must be maintained within .05 degrees of their assigned orbital longitude, unless otherwise authorized by the Commission.[91]

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[88] *See supra* ¶40.

[89] 47 C.F.R. § 25.210(j). The rule also provides that the Commission may authorize operations at assigned orbital longitudes offset by 0.05° or multiples thereof from the nominal orbital location specified in the station authorization. *Id.* While the FCC rules for the Direct Broadcast Satellite service, contained in 47 C.F.R. Part 100 do not directly address station-keeping requirements for Direct Broadcast Satellites, the FCC has proposed to consolidate its Part 100 DBS rules with its Part 25 rules. *See* Policies for the Direct Broadcast Satellite Service, Notice of Proposed Rule Making, IB Docket No. 98-21, 13 FCC Rcd 6907 (1998). *See also* ITU Radio Regulations, APS30, Annex 5, Section 3.11 (Space stations in the broadcasting-satellite service at 11.7-12.7 GHz must be maintained in position with an accuracy equal to or better than ±0.1° in the E-W directions), APS30, Annex 3, Section 4.13, and Annex 7, Section B (describing the grouping of the space stations in nominal orbital positions of +0.2° and –0.2° from the center of a cluster of orbital positions, one position for right-hand polarized channels and the other position for left-hand polarized channels).

[90] The ITU Radio Regulations provide as follows:

S22.6 1) Space stations on board geostationary satellites which use any frequency band allocated to the fixed-satellite service or the broadcasting-satellite service[7]:

S22.7 *a)* shall have the capability of maintaining their positions within ± 0.1° of the longitude of their nominal positions;

S22.8 *b)* shall maintain their positions within ± 0.1° of longitude of their nominal positions; *but*

S22.9 *c)* experimental stations on board geostationary satellites need not comply with No. **S22.7** nor No. **S22.8**, but shall maintain their positions within ± 0.5° of longitude of their nominal positions;

S22.10 *d)* however, space stations need not comply with No. **S22.8** nor No. **S22.9** as appropriate as long as the satellite network to which the space station belongs does not cause unacceptable interference to any other satellite network whose space station complies with the limits given in Nos. **S22.8** and **S22.9**.

[91] *See* Appendix B (Proposed Rules).

We seek comment on whether these rules, adopted for the purpose of avoiding harmful radio interference, are nonetheless useful as basic "rules of the road" for the purpose of limiting the probability of collision with other large objects, particularly with respect to potential collisions between functional spacecraft at geostationary orbit. As a related question, we seek comment on whether the longitudinal tolerance applicable to the fixed satellite service should be applied to space stations in other services, such as the mobile satellite service or remote sensing satellites.[92]

48. The FCC Rules also provide for operation of GSO satellites in inclined orbit, i.e., without the so-called "north-south" station-keeping maneuvers that correct for solar and lunar gravitational forces.[93] This rule provides authority for such operations, provided that the Commission is notified, and subject to conditions designed to avoid radio frequency interference to other satellites. We propose several changes to this rule to clarify the date by which the notification required by the rule must occur, and to address post-mission disposal issues.[94]

49. For non-geostationary satellites, neither the FCC's rules nor the ITU Radio Regulations specify a tolerance within which orbital parameters must be maintained. We tentatively conclude that non-geostationary satellite systems should disclose in license applications the tolerances within which orbital parameters would be maintained, so that potentially affected third parties can evaluate any collision risk.[95] We also seek comment on whether it is appropriate to specify a required tolerance within which orbital parameters must be established and maintained, or whether, alternatively, tolerances should be addressed on a case-by-case basis.

50. We also seek comment on limiting the probability of collisions through selection of an operating orbit, such that the operating orbit does not coincide too frequently with the orbit or orbits of other large known objects.[96] Given the currently extremely low spatial density of and risk of collision with large debris objects, this guideline would appear to be readily attainable, almost by definition, for virtually all missions. In specific cases, however, more detailed discussion of potential collisions

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[92] For remote sensing and mobile satellite systems at GEO, the tolerance within which a satellite's orbital position is maintained tends to have much less significance with respect to radio-frequency interference.

[93] 47 C.F.R. § 25.280 (2001). Without north-south station-keeping, the inclination of a GEO satellite will gradually increase, from zero degrees (equatorial orbit) to a maximum of approximately 14.6 degrees.

[94] *See* Appendix B (Proposed Rule Changes).

[95] In addition, we note that such disclosure may facilitate analysis of potential radio frequency interference.

[96] In the only known instance in which two "catalogued objects" (objects large enough to be regularly tracked by the United States Space Command), one controlled and the other uncontrolled, have accidentally collided, the French Cerise satellite and a piece of an exploded Ariane upper stage collided, severing the stabilizing boom of the Cerise satellite. *See* History of On Orbit Fragmentations, at 316. The two objects were in very similar, near-polar orbits.

may be warranted. For example, if two operators are proposing to launch a large number of LEO satellites into identical or very similar orbits, such as circular orbits at the same altitude, the risk of collision may be sufficiently large that adjustments to the operations of the two systems, or coordination of operations, would be appropriate. We propose, however, to make no change in our general policy of leaving the choice of orbital regime (LEO, MEO, GEO), or of the specific orbital parameters for any particular system, to the discretion of the operator, in the absence of conflicting requests. We seek comment on this proposal.

51. *Coordination of Maneuvers.* As a final matter concerning limiting the probability of collisions and safe flight profiles, we seek comment on what, if any, notification requirements we should adopt concerning maneuvers by FCC-licensed satellite systems. Such notifications may be particularly important in connection with certain types of space assets, such as manned spacecraft.[97] Space objects that are not maneuvering may be more predictable in their behavior, and it may be more technically feasible to assess potential collision risks based on their orbits. Maneuvering spacecraft, on the other hand, are not similarly predictable. We are aware of a number of U.S. space operators that have exchanged information related to maneuvers with United States Space Command in appropriate circumstances and encourage operators to continue doing so. Although United States Space Command neither approves nor directs the actions of these operators, the exchange of information regarding the location of space objects can mitigate the risk associated with the maneuvers. We also anticipate that operators informally coordinate maneuvers with each other on an as-needed basis. We seek comment on whether, in fact, such coordination is common. We also seek comment on whether, with increases in space activity by an increasing number of operators, it is appropriate to consider a more formal requirement. If so, what is the appropriate scope of such a requirement? Should it include all maneuvers, or only those that involve particularly critical orbits? If the latter, what criteria should be used to determine whether an orbit is particularly critical? If applied at the geostationary orbit, should this requirement apply only to maneuvers outside a station's current location and station keeping tolerance? We also seek comment on the parties that should receive any such notification, and on the form of the notification. Should other operators receive notification of planned maneuvers? Would posting of those plans on a web site or an electronic bulletin board provide a means for operators to adequately notify each other of planned maneuvers, such that any potential collision concerns could be identified and addressed? Are there currently mechanisms in place as a result of operators' informal coordinations that may be instructive as to how a more formal requirement might work?

4. Post-Mission Disposal

52. The U.S. Government guidelines provide for post-mission disposal of space structures, bearing in mind considerations of cost-effectiveness. Programs and projects must plan for disposal of a spacecraft at the end of mission life to minimize impact on future space operations. This is accomplished through one of three options. The first option is atmospheric reentry. This can be accomplished either by using the

[97] *Cf.* 14 C.F.R. § 431.43(c)(1)(required separation from inhabitable objects).

spacecraft's propulsion system (if it is capable of doing so) to propel the spacecraft out of orbit and into the Earth's atmosphere, or by leaving the spacecraft in an orbit from which it will remain in orbit for no longer than 25 years after mission completion. Under this option, it is also necessary to address the human casualty risk from any portions of the spacecraft that may survive atmospheric reentry. The second option is direct retrieval of the spacecraft from orbit. Direct retrieval and atmospheric reentry are the most effective methods of ensuring that an object will not, through collisions with other objects, become a source of a large number of orbital debris in the future. Direct retrieval can be expensive, however, and unless the retrieval is performed using a reusable launch vehicle, the retrieval process has the potential to place additional mass, such as launch vehicle upper stages, into orbit. Thus, direct retrieval has generally not be considered a cost-effective option unless the object being retrieved has substantial economic or scientific value.

53. The third post-mission disposal option is maneuvering to a storage orbit. There are four storage orbits suggested in the U.S. Government Standard Practices. The first is between low and medium Earth orbit, *i.e.*, satellite perigee altitude above 2,000 kilometers and apogee altitude below 19,700 kilometers (i.e. approximately 500 kilometers below semi-synchronous altitude).[98] The second storage orbit is between medium and geosynchronous Earth orbit, *i.e.*, perigee altitude above 20,700 kilometers and apogee altitude below 35,300 kilometers (i.e., approximately 500 kilometers below the GSO altitude). The third storage orbit is above geosynchronous Earth orbit, *i.e.*, perigee altitude above 36,100 kilometers (or approximately 300 kilometers above geosynchronous altitude). The fourth suggested storage orbit is to maneuver the spacecraft to remove it from Earth orbit, into a heliocentric orbit, i.e., an orbit around the sun. The three "protected" regions -- LEO, the semi-synchronous orbit, and GEO -- were chosen because, according to the NASA safety standard, they are "high value regions of space."[99] The U.S. Government standard practices also provide that, because of fuel gauging uncertainties near the end of mission, a program should use a maneuver strategy that reduces the risk of leaving the structure near an operational orbit regime. While the use of a storage orbit leaves the space object in orbit indefinitely, and, thus, is a less effective mitigation method than removal of the object from orbit, the use of a storage orbit may mitigate the effects of growth in the debris population by preserving specific regions of space for future use. The storage orbit option is important for a number of orbits, such as GEO, where removal of the space object entirely from orbit is impracticable.

54. We seek comment on whether it would be appropriate to adopt the post-mission disposal guideline, or portions of the guideline, as FCC rules. With respect to GEO, we note that the ITU has adopted a disposal recommendation, which, like the U.S. Government Standard Practices, specifies a disposal orbit with a perigee of 300

[98] A semi-synchronous orbit is one with an orbital period of 12 hours. A semi-synchronous satellite with a circular orbit will operate at an altitude of approximately 20,200 km.

[99] *See* Guidelines and Assessment Procedures for Limiting Orbital Debris, NSS 1740.14 (August 1995), at 6-1.

kilometers above GEO altitude. The IADC has recently developed a more detailed formula for deriving an appropriate storage orbit above GEO; that formula takes into account spacecraft characteristics that may affect the longer-term stability of the end-of-life orbit. We propose to use the IADC formula for purposes of evaluating end-of-life plans for GEO systems, although we seek comment on whether the ITU recommendation, or some other guideline for end-of-life disposal at GEO, may be preferable. We also specifically propose to amend our rules to provide GEO licensees with authority, as part of their licenses, to dispose of space stations at end-of-life, without the need for specific Commission authorization, provided the disposal plan comports with the IADC recommendation. We seek comment on this proposal.

55. In addition, we seek comment on whether an FCC rule is necessary concerning fuel gauging or other matters that may affect the ability of a spacecraft to execute end-of-life procedures reliably. We note that one group of experts has recommended the adoption of reporting requirements for satellites reaching end-of-life, concerning fuel reserves and end-of-life plans.[100] We also seek comment on technological developments that may affect end-of-life procedures, including development of alternative thruster technologies, such as ion propulsion. For such technologies, is availability of adequate fuel the primary constraint on the performance of end-of-life maneuvers, or do other factors, such as the reliability of other satellite subsystems, take on increased significance?

56. With respect to LEO end-of-life procedures, we seek comment on whether we should adopt the U.S. Government standard practices as rules applicable to new systems and to replacement satellites for existing systems. We note that the U.S. government guidelines, if strictly applied, could have a significant impact on the deployment of systems in LEO, particularly for certain orbital regimes or types of technologies. For example, spacecraft operating with circular orbits in the region between approximately 1,000 and 1,600 kilometers would be required to budget a substantial amount of fuel in order to achieve the guidelines' objective of either lowering the spacecraft's perigee to an altitude (of roughly 600 kilometers, depending on the characteristics of the spacecraft) from which it would reenter the Earth's atmosphere in 25 years, or boosting the spacecraft's perigee to an altitude above 2,000 kilometers. To cite another example, many small satellite systems are currently deployed with only minimal on-board maneuvering capabilities. Adoption of the guideline as a rule may effectively preclude operations of such spacecraft at higher orbital altitudes in the LEO region.

57. These concerns are in part based on the limits of the technology currently used for commercial space operations. We seek comment on whether technological developments, such as more advanced propulsion systems, may render these concerns less substantial. We also seek comment on whether the use of orbits or technical capabilities that would facilitate meeting the U.S. Government guidelines' objectives would necessarily hamper a system's ability to provide service. Finally, we seek

[100] American Institute of Aeronautics and Astronautics, International Activities Committee, 6th International Space Cooperation Workshop Report, at 12 (March 2001).

comment on the public interest benefits of adopting a rule, as opposed to addressing end-of-life disposal on case-by-case basis.

58. We also seek comment concerning the end-of-life disposal of a spacecraft involving atmospheric reentry. Such a disposal method may present special safety considerations, particularly if, due to the size of the spacecraft or the materials used in its construction, there is a possibility that portions of the spacecraft may survive the substantial friction generated during reentry, and reach the surface of the Earth. The U.S. Government standard practices provide that, if a space structure is to be disposed of by reentry into the Earth's atmosphere, the risk of human casualty will be less than 1 in 10,000.[101] We have recently begun to apply this guideline in our case-by-case licensing decisions.[102] We propose to continue doing so. We seek comment on this proposal.

59. *Methodology for Analysis and Criteria for Evaluation of Showings.* We also seek comment on whether we should establish more detailed methodologies for preparation of showings submitted in the FCC authorization process. We note that the U.S. Government practices are modeled in part on a NASA safety standard that provides a handbook for debris mitigation analysis and activities.[103] We seek comment on whether the methodologies outlined in that standard may provide satellite systems with greater certainty in planning their activities. On the other hand, we do not wish to preclude the use of other methodologies that may be equally or more suitable to address debris mitigation by FCC licensees. We also seek comment as to whether there are any criteria for the evaluation of those showings submitted that should be included in our rules, such that they would become a threshold qualification requirement.

D. Liability Issues and Insurance

60. As discussed above,[104] the Liability Convention imposes liability on the United States and other States that are parties to the treaty for damage caused by its space objects. For such damage caused on the surface of the Earth there is strict liability. For damage in space, liability is based on fault. Thus, the activities of private space station operators could result in liability for the United States government, as a launching state, if the operator's space station causes damage to another country. For U.S. launches, the U.S. Congress has adopted a comprehensive statutory regime to address liability issues.[105] Under that statute, the FAA requires its launch licensees to obtain insurance for potential losses caused by launch mishaps. Those insurance requirements do not, however, address post-launch issues arising from damages caused by a payload.

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[101] *See also* NASA Safety Standard NSS 1740.14, providing detailed guidance on methods for computing casualty risk.

[102] *Iridium LLC*, DA 01-1636 (released July 17, 2001).

[103] NSS 1740.14.

[104] *See, supra,* section II.C.

[105] Commercial Space Launch Act of 1984, as amended, 49 U.S.C. § 70101 et. seq.

61. We seek comment on the role that liability considerations and insurance should play in our decisions concerning debris mitigation measures.[106] For example, we seek comment on whether, assuming that the FCC has authority to require insurance,[107] there are any circumstances in which requiring an FCC licensed space station to obtain insurance might protect the United States and its taxpayers from exposure to potential liability, or provide economic incentives for operators to adopt debris mitigation strategies that reduce risk and lower insurance premiums. We specifically seek comment on whether different types of risks may differ with respect to whether they can be appropriately addressed through insurance. For example, it may be difficult or impossible to obtain insurance for damages that may arise long after a spacecraft has reached its end-of-life. We seek comment on these issues.

E. Scope of the Proposals

62. Space stations licensed by Administrations other than the United States can provide service to earth stations located in the United States through the processes outlined in Section 25.137 of our rules.[108] Under that rule, a party seeking approval for the provision of such service must submit information concerning the space station involved. Our proposed rules would require such parties to submit information regarding orbital debris mitigation plans for such space stations. We believe it is reasonable to examine debris mitigation plans for space stations serving the United States, regardless of the Administration that licensed the space station. Some consideration of whether the space station will employ reasonable debris mitigation measures is appropriate in order to ensure that the satellite communications activity we authorize does not involve substantial safety concerns or activities that may be detrimental to space operations. We seek comment on this proposal. We note, however, that this type of review generally provides the FCC with an opportunity to review the broad outlines of a space station's mitigation plans prior to issuance of an earth station authorization, and that the earth station authorization may be issued to a party unaffiliated, except as a customer, with the operator of the space station involved. Thus, by undertaking such a review the FCC may gain no ability to take direct enforcement action concerning a non-U.S. licensed space station that, for example, subsequently altered its operations or mitigation plans, other than through denial or revocation of a license issued to a potentially unaffiliated party. We note that orbital debris mitigation plans are not unique in this regard, but are like a number of technical policy areas, such as compliance with FCC two degree spacing policies, in which we seek technical information relevant to the authorization of earth station operations in the United States. We also seek comment on whether it should be

[106] To date, the FCC has not required that any licensee obtain insurance. In one case, the FCC's International Bureau noted the existence of insurance policies designed to address debris risks as a relevant factor in approving an applicant's end-of-life disposal plans. Space System Licensee, et. al., DA 02-307 (released February 8, 2002).

[107] *See supra*, ¶ 34.

[108] 47 C.F.R. § 25.137 (b).

deemed sufficient for parties utilizing the processes in Section 25.137 of our rules to submit evidence that the satellite system's debris mitigation plans are subject to direct and effective regulatory oversight by the satellite system's national licensing authority, and on the proper scope of any such showing.

63. We are also proposing to amend Parts 5 and 97 of our rules, concerning experimental satellite and amateur satellite authorizations, so that licensees under those Parts are subject to the same disclosure requirements as licensees under Part 25 [and 100] of our rules. Operations pursuant to Parts 5 and 97 can present the same public interest concerns as operations under other rule parts, and therefore we believe it is appropriate to provide a similar amount of disclosure regarding debris mitigation plans for such systems. We seek comment on this proposal.[109]

IV. CONCLUSION

64. We propose to amend our rules to address orbital debris mitigation, and seek comment on a number of issues. While the immediate risk presented by orbital debris is minimal, prudent measures adopted now are important to ensure continued affordable access to space, the continued provision of reliable space based communications services, and the continued safety of persons and property on the surface of the Earth. Orbital debris mitigation measures are therefore an important part of operations in the public interest by FCC licensees.

V. ADMINISTRATIVE MATTERS

A. *Ex Parte* Rules – Permit-But-Disclose Proceeding

65. This is a permit-but-disclose notice and comment rule making proceeding. *Ex parte* presentations are permitted, except during the Sunshine Agenda period, provided they are disclosed as provided in Commission rules.[110]

B. Initial Regulatory Flexibility Analysis

66. As required by the Regulatory Flexibility Act, *see* 5 U.S.C. § 603, the Commission has prepared an Initial Regulatory Flexibility Analysis (IRFA) of the possible impact on small entities of the proposals in the Notice of Proposed Rulemaking. The IRFA is set forth in Appendix C. Written public comments are requested on the IRFA. These comments must be filed in accordance with the same filing deadlines for comments on the Notice of Proposed Rulemaking, and they must have a separate and distinct heading designating them as responses to the Initial Regulatory Flexibility Analysis. The Commission's Consumer Information Bureau, Reference Information

[109] *See* Appendix B. With respect to Part 97 of the Rules, we also propose to update references to ITU documents contained in the current rules concerning space station notifications, so that those references reflect current ITU documents.

[110] *See generally* 47 C.F.R. §§ 1.1202, 1.1203, and 1.1206.

Center, will send a copy of this Notice of Proposed Rulemaking, including the Initial Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration, in accordance with the Regulatory Flexibility Act.[111]

C. Initial Paperwork Reduction Act of 1995 Analysis

67. This NPRM seeks comment on a proposed information collection. As part of the Commission's continuing effort to reduce paperwork burdens, we invite the general public and the Office of Management and Budget (OMB) to take this opportunity to comment on the information collections contained in this NPRM, as required by the Paperwork Reduction Act of 1995, Public Law 104-13. Public and agency comments are due at the same time as other comments on this NPRM and must have a separate heading designating them as responses to the Initial Paperwork Reduction Analysis (IPRA). OMB comments are due 60 days from date of publication of this NPRM in the Federal Register. Comments should address: (a) whether the proposed collection of information is necessary for the proper performance of the functions of the Commission, including whether the information shall have practical utility; (b) the accuracy of the Commission's burden estimates; (c) ways to enhance the quality, utility, and clarity of the information collected; and (d) ways to minimize the burden of the collection of information on the respondents, including the use of automated collection techniques or other forms of information technology. In addition to filing comments with the Secretary, a copy of any comments on the information collection(s) contained herein should be submitted to Judy Boley, Federal Communications Commission, Room 1-C804, 445 12th Street, S.W., Washington, D.C. 20554, or via the Internet to <jboley@fcc.gov> and to Edward Springer, OMB Desk Officer, Room 10236 NEOB, 725 17th Street, N.W., Washington, D.C. 20503, or via the Internet to <edward.springer@omb.eop.gov>.

D. Comment Dates

68. Pursuant to applicable procedures set forth in Sections 1.415 and 1.419 of the Commission's Rules,[112] interested parties may file comments on or before [75 days after publication in the Federal Register] and reply comments on or before [105 days after publication in the Federal Register]. Comments and reply comments should be filed in IB Docket No. 02-54. All relevant and timely comments will be considered by the Commission before final action is taken in this proceeding. To file formally in this proceeding, interested parties must file an original and four copies of all comments, reply comments, and supporting comments. If interested parties want each Commissioner to receive a personal copy of their comments, they must file an original plus nine copies. Interested parties should send comments and reply comments to the Office of the Secretary, Federal Communications Commission, Room TW-A325, 445 Twelfth Street, S.W., Washington, D.C. 20554, with a copy to Stephen Duall, 445 Twelfth Street, S.W., Washington, D.C. 20554.

69. Comments may also be filed using the Commission's Electronic Comment

[111] *See* 5 U.S.C. § 603(a).
[112] 47 C.F.R. §§ 1.415, 1.419.

Filing System (ECFS).[113] Comments filed through the ECFS can be sent as an electronic file via the Internet to <http://www.fcc.gov/e-file/ecfs.html>. Generally, only one copy of an electronic submission must be filed. In completing the transmittal screen, commenters should include their full name, Postal Service mailing address, and the applicable docket or rulemaking number. Parties may also submit an electronic comment by Internet E-Mail. To obtain filing instructions for E-Mail comments, commenters should send an e-mail to ecfs@fcc.gov, and should include the following words in the body of the message: "get form <your E-Mail address>." A sample form and directions will be sent in reply.

70. Comments and reply comments will be available for public inspection during regular business hours at the FCC Reference Center, Room CY-A257, at the Federal Communications Commission, 445 Twelfth Street, S.W., Washington, D.C. 20554. Copies of comments and reply comments are available through the Commission's duplicating contractor: International Transcription Service, Inc. (ITS, Inc.), 1231 20th Street, N.W., Washington, D.C. 20037, (202) 857-3800.

E. Ordering Clauses

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

72. IT IS FURTHER ORDERED that the Commission's Consumer Information Bureau, Reference Information Center, SHALL SEND a copy of the Notice of Proposed Rulemaking, including the Initial Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

FEDERAL COMMUNICATIONS COMMISSION

William F. Caton

William Caton
Acting Secretary

[113] *See* Electronic Filing of Documents in Rulemaking Proceedings, 63 Fed. Reg. 24,121 (1998).

Appendix A

US Government Orbital Debris Mitigation Standard Practices

OBJECTIVE

1. CONTROL OF DEBRIS RELEASED DURING NORMAL OPERATIONS

Programs and projects will assess and limit the amount of debris released in a planned manner during normal operations.

MITIGATION STANDARD PRACTICES

1-1. *In all operational orbit regimes:* Spacecraft and upper stages should be designed to eliminate or minimize debris released during normal operations. Each instance of planned release of debris larger than 5 mm in any dimension that remains on orbit for more than 25 years should be evaluated and justified on the basis of cost effectiveness and mission requirements.

OBJECTIVE

2. MINIMIZING DEBRIS GENERATED BY ACCIDENTAL EXPLOSIONS

Programs and projects will assess and limit the probability of accidental explosion during and after completion of mission operations.

MITIGATION STANDARD PRACTICES

2-1. *Limiting the risk to other space systems from accidental explosions during mission operations:* In developing the design of a spacecraft or upper stage, each program, via failure mode and effects analyses or equivalent analyses, should demonstrate either that there is no credible failure mode for accidental explosion, or, if such credible failure modes exist, design or operational procedures will limit the probability of the occurrence of such failure modes.

2-2. *Limiting the risk to other space systems from accidental explosions after completion of mission operations:* All on-board sources of stored energy of a spacecraft or upper stage should be depleted or safed when they are no longer required for mission operations or postmission disposal. Depletion should occur as soon as such an operation does not pose an unacceptable risk to the payload. Propellant depletion burns and compressed gas releases should be designed to minimize the probability of subsequent accidental collision and to minimize the impact of a subsequent accidental explosion.

OBJECTIVE

3. SELECTION OF SAFE FLIGHT PROFILE AND OPERATIONAL CONFIGURATION

Programs and projects will assess and limit the probability of operating space systems becoming a source of debris by collisions with man-made objects or meteoroids.

MITIGATION STANDARD PRACTICES

3-1. *Collision with large objects during orbital lifetime:* In developing the design and mission profile for a spacecraft or upper stage, a program will estimate and limit the probability of collision with known objects during orbital lifetime.

3-2. *Collision with small debris during mission operations:* Spacecraft design will consider and, consistent with cost effectiveness, limit the probability that collisions with debris smaller than 1 cm diameter will cause loss of control to prevent post-mission disposal.

3-3. *Tether systems* will be uniquely analyzed for both intact and severed conditions.

OBJECTIVE

4. POSTMISSION DISPOSAL OF SPACE STRUCTURES

Programs and projects will plan for, consistent with mission requirements, cost effective disposal procedures for launch vehicle components, upper stages, spacecraft, and other payloads at the end of mission life to minimize impact on future space operations.

MITIGATION STANDARD PRACTICES

4-1. *Disposal for final mission orbits:* A spacecraft or upper stage may be disposed of by one of three methods:

a. Atmospheric reentry option: Leave the structure in an orbit in which, using conservative projections for solar activity, atmospheric drag will limit the lifetime to no longer than 25 years after completion of mission. If drag enhancement devices are to be used to reduce the orbit lifetime, it should be demonstrated that such devices will significantly reduce the area-time product of the system or will not cause spacecraft or large debris to fragment if a collision occurs while the system is decaying from orbit. If a space structure is to be disposed of by reentry into the Earth's atmosphere, the risk of human casualty will be less than 1 in 10,000.

b. Maneuvering to a storage orbit: At end of life the structure may be relocated to one of the following storage regimes:

I. Between LEO and MEO: Maneuver to an orbit with perigee altitude above 2000 km and apogee altitude below 19,700 km (500 km below semi-synchronous altitude

II. Between MEO and GEO: Maneuver to an orbit with perigee altitude above 20,700 km and apogee altitude below 35,300 km (approximately 500 km above semi-synchronous altitude and 500 km below synchronous altitude.)

III. Above GEO: Maneuver to an orbit with perigee altitude above 36,100 km (approximately 300 km above synchronous altitude)

IV. Heliocentric, Earth-escape: Maneuver to remove the structure from Earth orbit, into a heliocentric orbit.

Because of fuel gauging uncertainties near the end of mission, a program should use a maneuver strategy that reduces the risk of leaving the structure near an operational orbit regime.

c. Direct retrieval: Retrieve the structure and remove it from orbit as soon as practical after completion of mission.

4-2. *Tether systems* will be uniquely analyzed for both intact and severed conditions when performing trade-offs between alternative disposal strategies.

APPENDIX B: Proposed Rule Changes

Proposed Rule Changes to 47 C.F.R. Part 25

1. Section 25.114 is proposed to be amended by adding new paragraphs (xx) and (xx2) to read as follows:

25.114 Applications for Space Station Authorizations

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(xx) A description of the design and operational strategies that will be used to mitigate orbital debris, including a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the spacecraft.

(xx2) A demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. This demonstration should address whether stored energy will be removed at the spacecraft's end-of-life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application.

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2. Section 25.143 is proposed to be amended by revising paragraph (b) as follows:

25.143 Licensing Provisions for the 1.6/2.4 GHz mobile-satellite service and 2 GHz mobile-satellite service.

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(b) *Qualification Requirements.*
(1) *General Requirements:* Each application for a space station system authorization in the 1.6/2.4 GHz Mobile-Satellite Service or 2 GHz Mobile-Satellite Service shall describe in detail the proposed satellite system, setting forth all pertinent technical and operational aspects of the system, and the technical, legal, and financial qualifications of the applicant. In particular, each application shall include the information specified in Section 25.114 . Non-U.S. licensed systems shall comply with the provisions of Sec. 25.137.

(2) ***

***

3. Section 25.210 is proposed to be amended by revising paragraph (j) as follows:

25.210 Technical requirements for space stations in the Fixed-Satellite Service.

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(j) Space stations operated in the geostationary satellite orbit must be maintained within 0.05° of their assigned orbital longitude in the east/west direction, unless specifically authorized by the Commission to operate with a different longitudinal tolerance, and except as provided in Section 25.282 (End-of-life disposal).

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4. Section 25.280 is proposed to be amended in its entirety, as follows:

§ 25.280 Inclined Orbit Operations

(a) Satellite operators may commence operation in inclined orbit mode without obtaining prior Commission authorization provided that the Commission is notified by letter within 30 days after the last north-south station keeping maneuver. The notification shall include:
(1) The operator's name;
(2) The date of commencement of inclined orbit operation;
(3) The initial inclination;
(4) The rate of change in inclination per year; and
(5) The expected end-of-life of the satellite accounting for inclined orbit operation, and the maneuvers specified under Section 25.282 of the rules.
(b) Licensees operating in inclined-orbit are required to:
(1) Periodically correct the satellite attitude to achieve a stationary spacecraft antenna pattern on the surface of the Earth and centered on the satellite's designated service area;
(2) Control all electrical interference to adjacent satellites, as a result of operating in an inclined orbit, to levels not to exceed that which would be caused by the satellite operating without an inclined orbit;
(3) Not claim protection in excess of the protection that would be received by the satellite network operating without an inclined orbit; and
(4) Continue to maintain the space station at the authorized longitude orbital location in the geostationary satellite arc with the appropriate east-west station-keeping tolerance.

5. A new section 25.282 is proposed to be added, as follows:

§ 25.282 End-of-Life Disposal

(a) A space station authorized to operate in the geostationary satellite orbit under this Part may operate using its authorized tracking, telemetry and control frequencies, and outside of its assigned orbital location, for the purpose of removing the satellite from the

geostationary satellite orbit at the end of its useful life, provided that the following conditions are met:

(i) the satellite is capable of being removed to, and the operations at variance from the assigned orbital location are designed to maneuver the satellite to, an orbit with a perigee with an altitude of no less than:

$$36{,}021 \text{ km} + (1000 \cdot C_R \cdot A/m)$$

where C_R is the solar pressure radiation coefficient of the spacecraft, and A/m is the Area to mass ratio, in square meters per kilogram, of the spacecraft.

(ii) all stored energy sources on board the satellite are discharged, by venting excess propellant, discharging batteries, relieving pressure vessels, and other appropriate measures.

(iii) tracking, telemetry and control transmissions are planned so as to avoid electrical interference to other satellites, and coordinated with any potentially affected satellite networks.

Proposed Rule Change to 47 C.F.R. Part 5:

1. Section 5.63 is proposed to be amended by adding a new paragraph (e) to read as follows:

§ 5.63 Supplementary statements required.

*****

(e) Except where the satellite system has already been authorized by the FCC, applicants for an experimental authorization involving a satellite system must submit a description of the design and operational strategies the satellite system will use to mitigate orbital debris, including a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the spacecraft. The applicant must also submit a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. This demonstration should address whether stored energy will be removed at the spacecraft's end-of-life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy. Other equivalent procedures may be approved in the course of the licensing process.

Proposed Rule Change to 47 C.F.R. Part 97 :

1. Section 97.207 is proposed to be amended by modifying paragraph (g) as follows:

§ 97.207 Space station

*****

(g) The license grantee of each space station must make two written pre-space station notifications to the International Bureau, FCC, Washington DC 20554. Each notification must be in accord with the provisions of Articles S9 and S11 of the ITU Radio Regulations.

(1) The first notification is required no less than 27 months prior to initiating space station transmissions and must specify the information required by Appendix S4 and Resolution No. 642 of the International Telecommunication Union Radio Regulations. The first notification shall also include a description of the design and operational strategies the space station will use to mitigate orbital debris, including a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the spacecraft. The notification must also include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. This demonstration should address whether stored energy will be removed at the spacecraft's end-of-life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures.

(2) The second notification is required no less than 5 months prior to initiating space station transmissions and must specify the information required by Appendix S4 and Resolution No. 642 of the Radio Regulations.

APPENDIX C: Initial Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[1] the Commission has prepared this present Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on small entities by the policies and rules proposed in this Notice of Proposed Rulemaking. Written public comments are requested on this IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines for comments on the Notice of Proposed Rulemaking provided above in Section V. The Commission will send a copy of the Notice of Proposed Rulemaking, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration. *See* 5 U.S.C. § 603(a). In addition, the Notice of Proposed Rulemaking and IRFA (or summaries thereof) will be published in the Federal Register. *See id.*

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

Orbital debris consists of artificial objects orbiting the Earth that are not functional spacecraft. Since human activity in space began, there has been a steady growth in the number and total mass of orbital debris. The risks presented by orbital debris consist primarily of the risk of collisions between orbital debris and functional spacecraft, and the risk of damage to persons and property on the surface of the Earth in cases where an object survives reentry into the Earth's atmosphere. While these risks are small and are likely to remain so for the near term, continued and unmitigated growth in the orbital debris population may limit the usefulness of space for communications and other uses in the future, by raising the costs and lowering the reliability of space-based systems.

U.S. policy on orbital debris is the product of considerable work over the years to assess the risks posed by orbital debris, and to develop methods for mitigating those risks. Since 1988, mitigation of orbital debris has been a formal goal of national space policy. In 1995, an Interagency Report drafted under the direction of the White House Office of Science and Technology Policy recommended that the National Aeronautics and Space Administration (NASA) and the Department of Defense jointly develop draft design guidelines that could serve as a baseline for agency requirements for future spacecraft. The Interagency Report recommended that the guidelines could be used by both government and industry in the design and development of future satellite systems. In January 1998, draft U.S. Government Standard Practices were issued for consideration by agencies and industry. The practices listed were control of orbital debris released during normal operations, minimization of debris generated by accidental explosions, selection of a safe flight profile and operational configuration, and post-mission disposal of space structures. Those practices have now been adopted, with some modifications, and are applied in U.S. government missions. Some of those practices are also applied by the Federal Aviation Administration for licensing of launch vehicles, and the National Oceanic and Atmospheric Administration for licensing of remote sensing satellites. In

[1] *See* 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601-612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, 110 Stat. 857 (1996).

addition, other space-faring nations are either considering or have adopted standards or practices concerning debris mitigation.

The Notice of Proposed Rule Making proposes to adopt a requirement that satellite systems seeking an FCC license, including experimental and amateur satellite systems, must provide a statement concerning the measures the system will take to mitigate orbital debris. In addition, the NPRM seeks comment on whether portions of the U.S. Government Standard Practices should be incorporated into the FCC's rules. Alternatively, the NPRM seeks comment on whether the Commission should evaluate such showings on a case-by-case basis, and poses a number of questions concerning how to address such showings. The NPRM also proposes several rule changes concerning disposal of geostationary spacecraft.

B. Legal Basis

The proposed action is supported by Sections 4(i), 7(a), 303(c), 303(f), 303(g), and 303(r) of the Communications Act of 1934, as amended, 47 U.S.C. §§ 154(i), 157(a), 303(c), 303(f), 303(g), 303(r).

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

The RFA directs agencies to provide a description of, and, where feasible, an estimate of, the number of small entities that may be affected by the proposed rules, if adopted.[2] The RFA generally defines the term "small entity " as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[3] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[4] 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).[5] A small organization is generally "any not-for-profit enterprise which is independently owned and operated and is not dominant in its field."[6]

[2] 5 U.S.C. § 603(b)(3).

[3] *Id.* § 601(6).

[4] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small business concern" in 15 U.S.C. § 632). Pursuant to the RFA, the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register." 5 U.S.C. § 601(3).

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

[6] 5 U.S.C. § 601(4).

Nationwide, as of 1992, there were approximately 275,801 small organizations.[7] "Small governmental jurisdiction" generally means "governments of cities, counties, towns, townships, villages, school districts, or special districts, with a population of less than 50,000."[8] As of 1992, there were approximately 85,006 such jurisdictions in the United States.[9] This number includes 38,978 counties, cities, and towns; of these, 37,566, or 96 percent, have populations of fewer than 50,000.[10] The Census Bureau estimates that this ratio is approximately accurate for all governmental entities. Thus, of the 85,006 governmental entities, we estimate that 81,600 (91 percent) are small entities. Below, we further describe and estimate the number of small entity licensees that may be affected by the proposed rules, if adopted.

The rules proposed in this Notice of Proposed Rulemaking would affect satellite operators, if adopted. The Commission has not developed a definition of small entities applicable to satellite operators. Therefore, the applicable definition of small entity is generally the definition under the SBA rules applicable to Satellite Telecommunications.[11] This definition provides that a small entity is expressed as one with $11.0 million or less in annual receipts.[12] 1997 Census Bureau data indicate that, for 1997, 273 satellite communication firms had annual receipts of under $10 million. In addition, 24 firms had receipts for that year of $10 million to $24,999,990.[13]

In addition, Commission records reveal that there are approximately 240 space station operators licensed by this Commission. We do not request or collect annual revenue information, and thus are unable to estimate of the number of licensees that would constitute a small business under the SBA definition. Small businesses may not have the financial ability to become space station licensees because of the high implementation costs associated with satellite systems and services.

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

[7] 1992 Economic Census, U.S. Bureau of the Census, Table 6 (special tabulation of data under contract to Office of Advocacy of the U.S. Small Business Administration).

[8] 5 U.S.C. § 601(5).

[9] U.S. Dept. of Commerce, Bureau of the Census, "1992 Census of Governments."

[10] *Id.*

[11] "This industry 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." Small Business Administration, 1997 NAICS Definitions, NAICS 513340.

[12] 13 C.F.R. § 120.121, NAICS code 513340.

[13] U.S. Census Bureau, 1997 Economic Census, Subject Service: Information, "Establishment and Firm Size," Table 4, NAICS 513340 (Issued Oct. 2000).

The proposed rule would require disclosure in an application for an FCC authorization of a satellite system's orbital debris mitigation plans. The Notice of Proposed Rule Making seeks comment on the degree of specificity that should be required in such reports, and on possible methodologies for developing such reports.

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

The RFA requires an agency to describe any significant 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 or reporting requirements under the rule for 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 small entities. 5 U.S.C. § 603(c).

The NPRM identifies several alternatives designed to minimize any significant economic impact on all entities, including small entities.

First, although the NPRM seeks comment on requiring debris mitigation practices by rule, it proposes as an alternative that the FCC proceed on a case-by-case basis in analyzing debris mitigation plans. Under a case-by-case method, the Commission could consider exemptions or other methods for minimizing any impact on small entities.

Second, the NPRM also seeks comment on whether to require that an applicant for an earth station license, to be used for communications with a non-U.S. licensed satellite, should submit information concerning debris mitigation plans for the satellite system. As an alternative, the NPRM seeks comment on whether a showing concerning direct and effective regulation by a foreign administration should be considered.

Third, the NPRM seeks comment on post-mission disposal of spacecraft from low Earth orbit, and on alternatives to using orbits that may experience a substantial economic impact under the U.S. Government Recommended Practices. Those alternatives could include use of different portions of low Earth orbit.

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

Remote sensing satellite systems are licensed by both the FCC and the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce. The NPRM proposes to waive disclosure requirements concerning post-mission disposal of spacecraft for remote sensing satellites licensed by NOAA.

SEPARATE STATEMENT OF COMMISSIONER MICHAEL J. COPPS

RE: Mitigation of Orbital Debris, Notice of Proposed Rulemaking

I want to commend the International Bureau for its hard work on this item, and Chairman Powell and International Bureau Chief Don Abelson for issuing such a forward-looking item.

It is important as the United States' expert agency in communications that we sometimes look over the horizon and try to head off problems before they occur, rather than waiting for the problems find us unprepared. An ounce of prevention is worth a pound of cure, and if we come up with the right orbital debris mitigation rules now, we can head off a potentially very costly problem with far less costly precautions.

While our satellite communications system is not immediately threatened by orbital debris, if we don't act I believe that the threat will become real. Other government agencies are moving ahead with regard to government systems. Given the long planning and construction periods for satellite fleets, the rules we set in place now will affect satellites that will not be deployed for years to come. So moving ahead expeditiously is a prudent course.