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

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

SECOND REPORT AND ORDER

Adopted: June 9, 2004 **Released: June 21, 2004**

By the Commission:

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I. INTRODUCTION

1. In this Second Report and Order, we amend Parts 5, 25, and 97 of the Commission's rules by adopting new rules concerning mitigation of orbital debris.[1] Adoption of these rules will help preserve the United States' continued affordable access to space, the continued provision of reliable U.S. space-based services – including communications and remote sensing satellite services for U.S. commercial, government, and homeland security purposes – as well as the continued safety of persons and property in space and on the surface of the Earth. Under the rules as amended today, a satellite system operator requesting FCC space station authorization, or an entity requesting a Commission ruling for access to a non-U.S.-licensed space station under our satellite market access procedures, must submit an orbital debris mitigation plan to the Commission regarding spacecraft design and operation in connection with its request. This Second Report and Order provides guidance for the preparation of such plans. We also adopt requirements concerning the post-mission disposal of Commission-licensed space stations[2] operating in or near the two most heavily used orbital regimes, low-Earth orbit (LEO),[3] and geostationary-Earth orbit (GEO).[4] Adoption of these rules will further the domestic policy objective of

[1] 47 C.F.R. Parts 5 [Experimental Radio Service], 25 [Satellite Communications], and 97 [Amateur Radio Service] (2002).

[2] As used in this Second Report and Order, the term "space station" has the meaning given in the International Telecommunication Union (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.

[3] For purposes of this Second Report and Order, the term LEO is used to refer to the orbits at altitudes below 2,000 kilometers.

[4] GEO is a circular orbit along the plane of the Earth's equator at an altitude of approximately 35,786 kilometers. A spacecraft in geostationary-Earth orbit can be maintained at a constant longitudinal position relative to the Earth, thus allowing the satellite to be "seen" continuously from, and at a fixed orientation to, any given point on the Earth's surface. *See* Physical Nature and Technical Attributes of the Geostationary Orbit, Study Prepared by the (continued....)

the United States to minimize the creation of orbital debris and is consistent with international policies and initiatives to achieve this goal.[5]

II. BACKGROUND

A. Nature of Orbital Debris

2. As explained in detail in the Notice of Proposed Rulemaking in this proceeding (*Orbital Debris Notice* or *Notice*),[6] orbital debris consists of artificial objects orbiting the Earth that are not functional spacecraft. It consists of a wide range of non-functioning man-made objects that have been placed into the Earth's orbit, both accidentally and on purpose. Orbital debris ranges in size from small objects, such as paint flakes, solid rocket motor slag, and break-up debris, to larger objects, such as discarded lens caps or ejected bolts.[7] The largest items, in terms of mass, include spacecraft, rocket bodies, and the largest pieces of debris from exploded spacecraft and rocket bodies.[8] The U.S. Department of Defense's Space Surveillance Network (SSN) has catalogued approximately 9,000 individual orbital debris objects currently in orbit and routinely tracks over 11,000 objects in orbit sized 10 centimeters or greater.[9] Furthermore, it is estimated that there are currently in orbit more than one hundred thousand objects between 1.0 and 10 centimeters and several million objects between 0.1 and 1 centimeters.[10]

3. The majority of space operations take place in a limited number of orbital regimes. The first of these regimes is low-Earth orbit. LEO is used by a number of Earth observation satellites, as well as by global mobile-satellite telephony services such as Iridium and Globalstar. LEO is also used for manned spaceflight, such as the Space Shuttle and the International Space Station. The second regime is geostationary-Earth orbit. GEO is used for the majority of satellite video, voice, and data services, as well as for direct-to-home and direct broadcast satellite services. Because of its ability to allow a spacecraft to appear "fixed" relative to the Earth, GEO is a unique and limited natural resource. In addition to LEO and GEO, there are other orbital regimes. Medium-Earth orbit (MEO) utilizes altitudes between LEO and GEO, typically around 20,200 kilometers, to provide a range of communications and navigational services.[11] Space operations may also utilize highly elliptical orbits (HEO). HEO spacecraft

(...continued from previous page)
Secretariat, United Nations Committee on the Peaceful Uses of Outer Space, UN Document A/AC.105/404 (January 13, 1988). (Copy available in the docket file of this proceeding).

[5] For further discussion of U.S. and international policies regarding orbital debris, see Section II.B., *infra*.

[6] *Mitigation of Orbital Debris*, Notice of Proposed Rulemaking, IB Docket No. 02-34, FCC 02-80, 17 FCC Rcd 5586 (2002).

[7] *Id.* at 5588. 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.

[8] Nicholas L. Johnson "Overview of NASA Orbital Debris Program," slides presented 27 January 1998 at the U.S. Government Orbital Debris Workshop for Industry. (Copy 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) at 199 (Orbital Debris: A Technical Assessment). Available online via www.orbitaldebris.jsc.nasa.gov.

[9] United States Space Command website, available on-line at http://www.spacecom.mil/factsheetshtml/reentryassessment.htm.

[10] *See* White House Office of Science and Technology Policy, Interagency Report on Orbital Debris (1995) (*1995 Interagency Report*) at 6, Table 2.

[11] For example, the U.S. Global Positioning System (GPS) operates at altitudes of approximately 20,000 kilometers, and the Russian Global Navigation Satellite System (GLONASS) operates at altitudes around 19,000 kilometers.

typically have perigees (*i.e.*, the point of orbit closest to the Earth) at LEO or MEO altitudes and have apogees (*i.e.*, the point farthest from the Earth) ranging from altitudes in the vicinity of MEO, to altitudes above the GEO altitude.[12]

4. As experts have recognized for many years, orbital debris poses a potential risk to the continued reliable use of these orbital regimes for space-based services and operations, as well as to the continued safety of persons and property in space and on the surface of the Earth. The effects of collisions involving orbital debris can be severe. Objects in orbit move at a very high velocity.[13] Because of the high relative velocities involved, collisions involving even very small debris objects are capable of producing significant impact damage.[14] Even debris as small as one millimeter in diameter can cause significant structural damage to a functional spacecraft; for objects larger than one centimeter in diameter, the damage caused to functional spacecraft can be catastrophic.[15] Furthermore, such collisions can produce a large amount of additional debris, which can be dispersed over a wide orbital area.[16]

5. In addition, the orbital lifetime of debris can be extremely long. Once debris is created, it remains in orbit indefinitely, absent other forces.[17] Although atmospheric drag[18] will result in debris being removed from orbit at low altitudes, the effect of atmospheric drag decreases dramatically as the orbital altitude of an object increases. For example, while atmospheric drag will cause an object with a perigee altitude of 250 kilometers to re-enter the Earth atmosphere within approximately two months, the same object will remain in orbit typically in excess of 500 years at orbits with perigees above 850 kilometers.[19] At GEO, where the effects of atmospheric drag are virtually non-existent, objects can

[12] Use of HEO spacecraft was pioneered by the Soviet "Molniya" communications satellites, and as a result HEO is sometimes colloquially referred to as a "Molniya" orbit. *See 1995 Interagency Report* at 4. Sirius Satellite Radio, a licensee in the Satellite Digital Audio Radio Service, is an example of a Commission-licensed satellite system utilizing highly elliptical orbits with perigee altitudes of a little less than 24,500 kilometers and apogee altitudes of about 47,000 kilometers. *See* Satellite CD Radio, Inc., Application to Modify Authorization, File No. SAT-MOD-19981211-00099 (filed December 11, 1998).

[13] Orbital velocities are directly related to altitude; that is, objects in lower orbits travel faster than objects in higher orbits. Objects in LEO orbits have orbital velocities in the range of 7-8 kilometers per second (km/s). For objects in GEO, the orbital velocity is about 3 km/s. The velocity of objects in HEO varies throughout their orbits, with perigee velocities greater than objects in circular LEO orbits and with apogee velocities slower than objects in circular GEO orbits. Impact velocities for objects in circular orbits range from 0 km/s for objects colliding in virtually the same orbit, to twice the orbital velocity for head-on collisions. *See* Orbital Debris: A Technical Assessment at 89.

[14] For purposes of illustration, it is estimated that a one centimeter aluminum sphere with a mass of about 1.4 grams moving at 13 km/s would have a kinetic energy equivalent to 56 grams of TNT; a ten centimeter aluminum sphere moving at the same speed would have the equivalent of 56 kilograms of TNT. *See* Orbital Debris: A Technical Assessment at 93.

[15] *1995 Interagency Report* at 8.

[16] Fragments resulting from a collision will be dispersed at a wide range of velocities, which will place them into a range of new orbits. *See* Orbital Debris: A Technical Assessment at 92.

[17] *Orbital Debris Notice*, 17 FCC Rcd at 5588.

[18] Atmospheric drag is produced when molecules of gas from the Earth's atmosphere collide with the surface of the orbiting object, causing the object to lose velocity and eventually re-enter the Earth's atmosphere. *See id.* at 5588.

[19] *Orbital Debris Notice*, 17 FCC Rcd at 5589. These figures were derived using NASA's debris assessment software, which is available on-line at www.orbitaldebris.jsc.nasa.gov/mitigate/das/das.html. They were based on an assumed spacecraft area to mass ration of .01 m^2/kg. *See id.* at 5589 n.4.

remain in orbit in excess of a million years.[20] Although the natural "cleansing" of atmospheric drag results in the removal of some low-altitude debris, the overall trend is one of an increasing orbital debris population that will increase the potential for future collisions.[21]

6. Objects in orbit that re-enter the Earth's atmosphere are slowed by drag as they enter the atmosphere. As a result of drag, many objects break up and/or burn up. Objects that are particularly resistant to heat and the forces experienced during re-entry may survive re-entry and reach the surface of the Earth. Although the velocity of these objects, compared to objects in orbit, is very low, the kinetic energy of such objects is sufficient to cause damage or injury at the surface of the Earth. To date, however, there has never been a confirmed incident of injury to a human being as a result of orbital debris re-entering the Earth's atmosphere.

B. Prior Commission Actions Concerning Orbital Debris

7. The Commission has historically addressed issues regarding orbital debris and satellite systems on a case-by-case and service-by-service basis. In recent years, the Commission has adopted orbital debris mitigation disclosure obligations as part of the service rules for certain classes of satellite systems. For example, in 2000 the Commission adopted orbital debris mitigation rules for licensees in the 2 GHz mobile-satellite service (MSS),[22] and in 2002 and 2003 the Commission adopted such rules for the Ku- and Ka-band non-geostationary orbit (NGSO) fixed-satellite service (FSS).[23] Under these rules, applicants must disclose, as part of their license applications, "the design and operational strategies that they will use, if any, to mitigate orbital debris."[24] Applicants in these services are also required to submit a "casualty risk assessment" that evaluates the probability of risk of human injury on the Earth from orbital debris if the operator plans to dispose of its spacecraft at end of life through one of the available disposal methods, atmospheric re-entry.[25] In each of these instances, the Commission stressed that it would continue to evaluate an applicant's orbital debris disclosure on a case-by-case basis, but stated that it would initiate a separate rulemaking proceeding to consider the adoption of orbital debris disclosure requirements for all FCC-licensed satellite services, as well as other measures to mitigate orbital debris.[26]

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[20] *1995 Interagency Report* at 8; American Institute of Aeronautics and Astronautics, 6th International Space Cooperation Workshop (March 2001) (*AIAA 2001 Report*) at 14. (Copy available in the docket file of this proceeding).

[21] *See* Orbital Debris: A Technical Assessment at 20, Figure 1-2; Scientific and Technical Subcommittee of the United Nations Committee on Peaceful Uses of Outer Space, Technical Report on Space Debris, UN Document A/AC.105/720 (1999) (*STSC Technical Report on Space Debris*) at 14, Figure II; *1995 Interagency Report on Orbital Debris* at 18, Figure 11.

[22] 47 C.F.R. § 25.143(b).

[23] 47 C.F.R. §§ 25.145(c)(3) and 25.146(i)(4).

[24] *The Establishment of Policies and Service Rules for the Mobile Satellite Service in the 2 GHz Band*, Report and Order, IB Docket No. 99-81, FCC 00-302, 15 FCC Rcd 16127, 16188 (2000) (*2 GHz MSS Order*); *The Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-band*, Report and Order and Further Notice of Proposed Rulemaking, IB Docket No. 01-96, FCC 02-123, 17 FCC Rcd 7841, 7865-66 (para. 81) (2002) (*NGSO FSS Ku-Band Order*); *The Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ka-Band*, IB Docket No. 02-19, FCC 03-137, 18 FCC Rcd 14708, 14725-26 (para. 55) (2003) (*NGSO FSS Ka-Band Order*).

[25] *See, e.g., 2 GHz MSS Order*, 15 FCC Rcd at 16188.

[26] *2 GHz MSS Order*, 15 FCC Rcd at 16188 (para. 138); *NGSO FSS Ku-Band Order*, 17 FCC Rcd at 7866 (para. 81); *NGSO FSS Ka-Band Order*, 18 FCC Rcd at 14725-26 (para. 55).

8. The Commission initiated this rulemaking proceeding in March, 2002.[27] The *Orbital Debris Notice* sought comment on a wide range of proposals concerning ways to mitigate orbital debris arising from Commission-authorized space activities. Principally, the *Notice* proposed to adopt debris mitigation disclosure requirements for all types of satellite systems licensed by the Commission.[28] The *Notice* also sought comment on the content of such debris mitigation disclosures, and whether there are debris mitigation practices that are sufficiently developed to warrant adopting these practices as Commission rules.[29] In addition, the *Notice* sought comment regarding the Commission's statutory authority to adopt debris mitigation rules, the proper scope of such rules, and liability and insurance matters arising from orbital debris issues.

9. Since the release of the *Orbital Debris Notice*, the FCC has addressed orbital debris issues in a number of proceedings. Most significantly, the Commission adopted disclosure requirements concerning orbital debris mitigation measures as part of its efforts to streamline the Commission's space station licensing procedures.[30] Specifically, the Commission adopted a *First Report and Order* in this docket, in which it established default rules for all satellite systems that required certain classes of applicants to submit, as part of their license application, a narrative statement describing the design and operational strategies that they will use to mitigate orbital debris, as well as a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the spacecraft.[31] In addition, the International Bureau has addressed orbital debris mitigation issues in a number of other proceedings.[32] In the absence of comprehensive orbital debris mitigation rules, each of these instances was addressed on a case-by-case basis.

10. With regards to the adoption of specific debris mitigation practices, the *Notice* based its proposals on the debris mitigation practices embodied in the U.S. Government Orbital Debris Mitigation Standard Practices (U.S. Government Standard Practices).[33] These practices were adopted by the U.S.

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[27] *See generally Orbital Debris Notice*.

[28] *Orbital Debris Notice*, 17 FCC Rcd at 5598.

[29] *Id*.

[30] *Amendment of the Commission's Space Station Licensing Rules and Policies, Mitigation of Orbital Debris*, First Report and Order and Further Notice of Proposed Rulemaking in IB Docket No. 02-34, First Report and Order in IB Docket No. 02-54, FCC 03-102, 18 FCC Rcd 10760 (2003) (*First Report and Order*).

[31] The default service rules, including the default orbital debris mitigation requirements, apply only to applications in service bands for which the Commission has not adopted service-specific service rules. *See id.* at 10784-85 (para. 53)(NGSO-like systems) and 10808 (para. 120)(GEO-like systems). This step was taken because, as part of the streamlining actions taken in our Space Station Licensing Reform proceeding, we will now approve non-GEO space stations prior to adoption of service rules. Therefore, we sought to ensure that basic information concerning debris mitigation measures is provided prior to any such approval.

[32] *See, e.g., EchoStar Satellite Corp.*, Order and Authorization, DA 03-2559, 18 FCC Rcd 15862 (Int'l Bur. 2003)(addressing EchoStar's compliance with any FCC orbital debris mitigation requirements as part of its request to modify its Ka-band license to include a C-band payload authorized by a foreign administration); *Applications of The Boeing Company*, Order and Authorization, DA 03-2073, 18 FCC Rcd 12317 (Int'l Bur. 2003)(reviewing Boeing's proposed orbital debris mitigation plans as part of its request for modification of its 2 GHz MSS license); *Orbital Communications Corp.*, Order and Authorization, DA 02-772, 17 FCC Rcd 6337 (Int'l Bur. 2002)(conditioning grant of licensee's request to increase the orbital altitude of a portion of its satellite constellation upon the licensee taking steps to reduce the orbital lifetime of those satellites to no more than 25 years after end of life). *See also* PanAmSat Corporation, Special Temporary Authorization for the Galaxy IIIR Satellite, File No. SAT-STA-20030324-00039 (authorization conditioned on maintaining a satellite's capability to de-orbit to an altitude no less than 300 kilometers above GEO) (*Galaxy IIIR STA Grant*).

[33] A copy of the U.S. Government Standard Practices is attached as Appendix A to the *Orbital Debris Notice*.

Government in 2000 and apply to missions operated or procured by U.S. government agencies.[34] The U.S. Government Standard Practices seek to control the creation of orbital debris by means of four practices: (1) control of debris during normal operations; (2) minimizing debris generated by accidental explosions; (3) selection of a safe flight profile and operational configuration; and (4) post-mission disposal of space structures. The *Orbital Debris Notice* examined the specifics of these practices and sought comment on whether each of these practices should be incorporated as a requirement for space station operators seeking Commission authorization for their space activities.[35]

11. The *Orbital Debris Notice* also observed that orbital debris mitigation measures have been addressed internationally. For example, in 1993 the Radiocommunication Assembly of the International Telecommunication Union (ITU-R)[36] adopted a debris mitigation recommendation concerning the region of space in the vicinity of GEO.[37] The ITU-R recommended, among other things, that as little debris as possible be released into the geostationary Earth orbit, and that a GEO satellite at the end of its life be transferred, before the complete exhaustion of its propellant, to a storage orbit at least 300 kilometers above GEO altitude. Furthermore, the Scientific and Technical Subcommittee (STSC) of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS)[38] adopted a comprehensive report on orbital debris in 1999.[39] The STSC established a multi-year work plan, to be completed in 2005, to consider orbital debris and called for the Inter-Agency Space Debris Coordination Committee (IADC)[40] to submit consensus debris mitigation guidelines that could be implemented by countries on a voluntary basis.[41] The IADC presented its consensus guidelines to the STSC in February 2003. The IADC guidelines recognize LEO and GEO as unique orbital regions that must be protected from generation of

[34] The U.S. Government Standard Practices were adopted in response to an interagency U.S. Government report published in November 1995. *See generally 1995 Interagency Report*. The *1995 Interagency Report* recommended that that 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. It also recommended that interested U.S. agencies then consult with the private sector to develop government/industry design guidelines. A draft of the U.S. Government Standard Practices was presented to industry at a 1998 U.S. government workshop for industry. *See Orbital Debris Notice*, 17 FCC Rcd at 5590.

[35] *Id.* at 5601-10. A list of parties filing pleadings in response to the *Notice* is provided as Appendix A.

[36] The ITU is a specialized agency of the United Nations. The United States is a Member State of the ITU and is a party to the ITU Constitution, Convention, and Radio Regulations.

[37] 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 at pp. 364-367.

[38] UNCOPUOS was established pursuant to the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (The Outer Space Treaty), which entered into force October 10, 1967. The United States is a party to the Outer Space Treaty. Over 98 countries have ratified the treaty as of January, 2003. A full text of the Outer Space Treaty is available on-line at http://www.oosa.unvienna.org/SpaceLaw/treaties.html.

[39] *See generally STSC Technical Report on Space Debris*.

[40] The IADC is an inter-governmental committee developed to enable spacefaring nations to exchange information on orbital debris research activities, to review the progress of ongoing cooperative activities, to facilitate opportunities for cooperation in orbital debris research, and to identify debris mitigation options. Members of the IADC includes 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. *See* IADC website, available at http://www.iadc-online.org.

[41] Report of the Scientific and Technical Subcommittee on its thirty-eighth session, UN Document A/AC.105/761 (2001) at para. 130.

orbital debris in order to ensure their future safe and sustainable use. The IADC guidelines propose specific practices to protect these regions and to mitigate orbital debris in general. The STSC is reviewing the guidelines and discussing means of endorsing their utilization.[42] Subsequent to the release of the *Orbital Debris Notice*, the ITU revised its 1993 recommendation and adopted a formula for the post-mission disposal of GEO satellites that follows the proposal of the IADC guidelines.[43] In addition, individual nations, such as Japan, Russia, the Ukraine, France, Germany and India, have developed, or are in the process of developing, debris mitigation standards and practices at the national level.[44]

III. DISCUSSION

A. FCC Statutory Authority Regarding Orbital Debris

12. *Background*. In the *Notice*, comment was sought on the basis of the Commission's statutory authority to adopt rules regarding orbital debris.[45] The *Notice* observed that the Commission has addressed orbital debris issues in several cases,[46] but has not, to date, formally addressed the scope and nature of its authority concerning orbital debris. The *Notice* analyzed the statutory responsibilities and obligations of the Commission under the Communications Act of 1934 (Communications Act or Act)[47] and how these responsibilities were related to the consideration of orbital debris. The *Notice* sought comment on this analysis.

13. *Discussion.* We conclude that adoption of the debris mitigation measures in this Second Report and Order is consistent with our authority and public interest obligations under the Communications Act. Only one commenter questions the Commission's authority to adopt debris mitigation rules.[48] That commenter does not provide any legal analysis to support its position and does not address any of the analysis provided in the *Notice*. To the contrary, we find that orbital debris mitigation issues are a valid public interest consideration in the Commission's licensing process.

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[42] Report of the Scientific and Technical Subcommittee on its fortieth session, Committee on the Peaceful Uses of Outer Space, UN Document A/AC.105/804 (March 5, 2003).

[43] *See* ITU Recommendation S.1003, Environmental Protection of the Geostationary-satellite Orbit (revised Jan. 2004), available at www.itu.org.

[44] Nicholas Johnson, Trends and Options in the Disposal of Launch Vehicle Orbital Stages, 52nd International Astronautical Congress (Toulouse, France 2001). *See also* National research on space debris, safety of space objects with nuclear power sources on board and problems relating to their collision with space debris, Addendum to Note by the Secretariat, United Nations Committee on the Peaceful Uses of Outer Space, UN Document A/AC.105/789/Add.1 (March 17, 2003) (presenting Germany's "Space debris end-to-end service" project).

[45] *Orbital Debris Notice*, 17 FCC Rcd at 5598-99.

[46] *Id.* at 5598 (citing *The Boeing Company*, Order and Authorization, DA 01-1631 16 FCC Rcd 13691 (Int'l Bur. 2001); *Celsat America, Inc.*, Order and Authorization, DA 01-1632, 16 FCC Rcd 13712 (Int'l Bur. 2001); *Constellation Communications Holdings, Inc*., Order and Authorization, DA 01-1633, 16 FCC Rcd 13724 (Int'l Bur./OET 2001); *Globalstar, L.P.*, Order and Authorization, DA 01-1634, 16 FCC Rcd 13739 (Int'l Bur./OET 2001); *ICO Services Ltd.*, Order and Authorization, DA 01-1635, 16 FCC Rcd 13762 (Int'l Bur./OET 2001); *Iridium LLC*, Order and Authorization, DA 01-1636, 16 FCC Rcd 13778 (Int'l Bur. 2001); *Mobile Communications Holdings, Inc.*, Order and Authorization, DA 01-1637, 16 FCC Rcd 13794 (Int'l Bur./OET 2001); *TMI Communications and Co.*, Order and Authorization, DA 01-1638, 16 FCC Rcd 13808 (Int'l Bur. 2001); *Space System Licensee, et al.*, Memorandum Opinion, Order and Authorization, DA 02-307, 17 FCC Rcd 2271 (Int'l Bur. 2002)).

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

[48] Ecliptic Comments at 4 (stating that it would be a "far reach" to relate orbital debris mitigation measures to the Commission's mandate under the Communications Act).

14. As discussed in the *Orbital Debris Notice*,[49] the Communications Act provides the Commission with broad authority with respect to radio communications involving the United States, except for communications involving U.S. Government radio stations.[50] The Act charges the FCC with encouraging "the larger and more effective use of radio in the public interest,"[51] and provides for licensing of radio communications,[52] upon a finding that the "public convenience, interest, or necessity will be served thereby."[53] Satellite communications are an important component of the national and world-wide radio communications infrastructure.[54] Because orbital debris could affect the cost, reliability, continuity, and safety of satellite operations, orbital debris issues have a bearing upon the "larger and more effective use of radio in the public interest." In addition, orbital debris can negatively affect the availability, integrity, and capability of new satellite systems and valuable services to the public. Thus, orbital debris and related mitigation issues are relevant in determining whether the public interest would be served by authorization of any particular satellite system, or by any particular practice or operating procedure of satellite systems.[55] Furthermore, debris prospectively generated from satellites licensed by, or authorized by, the FCC could affect the public interest in protecting the safety of manned space flight, as well as the safety of persons and property on the surface of the Earth. Because robotic spacecraft are typically controlled through radiocommunications links, there is a direct connection between the radiocommunications functions we are charged with licensing under the Communications Act and the physical operations of spacecraft. Accordingly, we conclude that the actions taken in this Second Report and Order are within the scope of our authority under the Communications Act.[56]

B. Disclosure of Orbital Debris Mitigation Plans

15. *Background.* In the *Orbital Debris Notice*, the Commission proposed to require, as part of the licensing process, disclosure of orbital debris mitigation plans for all types of satellite systems licensed by the FCC.[57] Specifically, the *Notice* proposed to adopt an orbital debris mitigation disclosure as part of the technical information that must be supplied pursuant to Section 25.114 of the Commission's rules.[58] The *Notice* also sought comment on whether we should establish more detailed methodologies

[49] *Orbital Debris Notice*, 17 FCC Rcd at 5598-99.

[50] 47 U.S.C. § 305(a). The Commerce Department's National Telecommunication and Information Administration is responsible for assignment of frequencies for use by U.S. Government stations.

[51] 47 U.S.C. § 303(g).

[52] 47 U.S.C. § 301.

[53] 47 U.S.C. § 307(a).

[54] *First Report and Order*, 18 FCC Rcd at 10764 (para. 2)(observing that the satellite industry is a "crucial component of the global communications marketplace").

[55] Courts have held that the Commission may consider public safety factors as part of its licensing procedures. *See Simmons v. FCC*, 145 F.2d 578, 579 (D.C. Cir. 1944)(finding that the "public interest, convenience and necessity clearly require the Commission to deny applications for construction which would menace air navigation"); *Deep South Broadcasting Co. v. FCC*, 278 F.2d 264, 267 (D.C. Cir. 1960)(confirming FCC authority to consider structural aspects of a radio tower as a "clearly relevant public interest consideration"). For a discussion of the FCC's legal authority concerning orbital debris, *see also* 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).

[56] We address questions raised in the *Notice* concerning the scope of our authority with respect to launch activities, satellites licensed by the National Oceanic and Atmospheric Administration (NOAA), and non-U.S. licensed satellites in Section III.D., *infra*.

[57] *Orbital Debris Notice*, 17 FCC Rcd at 5598.

[58] *Id* at 5611.

for the preparation and evaluation of the debris mitigation plans submitted in the FCC authorization process.[59]

16. *Discussion.* We adopt the proposal of the *Notice* and amend our rules to require disclosure of orbital debris mitigation plans as part of the technical information submitted pursuant to Section 25.114 of the Commission's rules.[60] Disclosure of debris mitigation plans will allow the Commission and potentially affected third parties to evaluate debris mitigation plans prior to issuance of an FCC approval for communications activities in space. Disclosure may also aid in the wider dissemination of information concerning debris mitigation techniques and may provide a base-line of information that will aid in analyzing and refining those techniques. Without such disclosure, the Commission would be denied any opportunity to ascertain whether operators are in fact considering and adopting reasonable debris mitigation practices.

17. Although we expect that operators in many instances have in the past, and will in the future, practice debris mitigation out of economic self-interest,[61] especially when such practices increase the reliability of revenue-producing operations, these economic incentives alone may not be sufficient where debris mitigation measures either do not affect the revenue-producing operations or, in fact, limit such operations. We also note that economic incentives alone may not sufficiently motivate operators to address effects that, although resulting from their current operations, may manifest themselves decades or centuries later. By that time, the satellite's operator may be out of business or may have no economic incentive to preserve the utility of the orbital regime. Disclosure of an applicant's debris mitigation plans as part of the technical information required by Section 25.114 will allow the Commission to examine whether a space station operator has taken orbital debris mitigation into consideration, even when economic incentives may be absent. In addition, for the reasons explained throughout this Second Report and Order, mitigation of orbital debris is important for several public interest reasons, including U.S. homeland security and continued reliability of satellite radio communications.

18. A disclosure requirement should entail minimal costs for entities requesting FCC authorization. To the extent that satellite operators already take measures to consider debris mitigation, as comments by satellite operators indicate, the additional cost of disclosing these measures should not be significant. This conclusion is expressly supported by comments, which state that a disclosure requirement would not be onerous and could be met by operators.[62] In addition, the costs of disclosure are not unduly burdensome when balanced against the public interest benefits of preserving safe and affordable access to space.

19. We also believe that disclosure of debris mitigation plans is useful, even though in some instances work is ongoing to develop or refine desired mitigation strategies.[63] In this regard, we note that we are amending our rules as part of this proceeding in order to provide more concrete requirements for

[59] *Id.* at 5610.

[60] Pursuant to Section 25.137 of the Commission's rules, the same technical information required by Section 25.114 for U.S.-licensed space stations must also be submitted by entities requesting to operate with a non-U.S.-licensed space station to serve the United States. *See* 47 C.F.R. § 25.137. For a more detailed discussion of the scope of our orbital debris mitigation rules and non-U.S.-licensed space stations, see Section III.D.1., *infra*.

[61] SIA Comments at 3-5; PanAmSat Comments at 2; SES Americom Reply at 2-4.

[62] Telesat Comments at 4, 6; AMSAT Comments at 10.

[63] Some commenters argue that the lack of "precise standards" or "clear parameters" for assessing a debris mitigation plan could lead to arbitrary application of our rules or the reduction of the plan to "just an administrative burden" on the operator. *See* Orbcomm Comments at 3; SIA Comments at 7.

orbital debris mitigation in certain cases, such as in the disposal of space stations at the end of life.[64] Where more concrete requirements are established, such as for the end-of-life disposal of GEO space stations, they will provide a basis for reviewing the sufficiency of an applicant's debris mitigation disclosure. We will continue to analyze other issues on a case-by-case basis under the public interest standard of the Communications Act. Disclosure is still useful in those situations in order to verify that operators, in fact, are considering debris mitigation issues and bringing the latest in debris mitigation techniques to bear on satellite design and operations. Disclosure will also provide flexibility to address new developments in space station design and allows the Commission to retain its discretion to grant, condition, or deny an authorization in a manner consistent with the Communications Act.

20. Accordingly, we amend our rules to require a disclosure of debris mitigation plans as part of the technical information required pursuant to Section 25.114 of the Commission's rules. We will also make conforming editorial changes to specific service rules governing the 2 GHz MSS service,[65] the Ku-band NGSO service,[66] the Ka-band NGSO service,[67] and our default service rules for space stations under our streamlined space station licensing procedures.[68] Since systems seeking FCC approvals in these services must submit the information specified in Section 25.114 of our rules, there is no longer a need to include a separate disclosure requirement for these services in the individual rule sections that establish service-by-service requirements. Parties that have requests for approval of space stations pending before the Commission shall have 30 days following publication of this Second Report and Order in the Federal Register in which to amend their requests by filing a disclosure of debris mitigation plans in a manner consistent with this Second Report and Order.

21. We decline to adopt a particular methodology for the preparation and evaluation of an applicant's orbital debris mitigation plans, except as specifically indicated in this Second Report and Order for individual debris mitigation practices, such as in the case of post-mission disposal of certain Commission-licensed space stations. Commenters did not propose the use of any specific methodology. As we observed in the *Orbital Debris Notice*,[69] NASA has adopted a safety standard that provides a handbook for debris mitigation analysis and activities, which is available to the public.[70] Unless otherwise noted in this Second Report and Order,[71] applicants are encouraged, but not required, to use the NASA safety standard when assessing their debris mitigation plans and preparing these plans for submission to the Commission. Although we do not adopt a particular methodology for preparing debris mitigation plans, an applicant's debris mitigation plans – like all other elements of applications for space station authorization – must constitute a concrete proposal for Commission evaluation.[72] The plan must identify particular methods by which a proposed satellite system will mitigate orbital debris, rather than presenting a generalized commitment to address debris mitigation at a future date or a catalogue of

[64] *See* Section III.C. *infra.*

[65] 47 C.F.R. § 25.143(b).

[66] 47 C.F.R. § 25.146(i)(4).

[67] 47 C.F.R. § 25.145(c)(3).

[68] 47 C.F.R. § 25.217(d). *See also supra*, note 31.

[69] *Orbital Debris Notice*, 17 FCC Rcd at 5610.

[70] NASA Safety Standard, Guidelines and Assessment Procedures for Limiting Orbital Debris, NSS 1740.14 (August 1995). (Copy available at http://www.orbitaldebris.jsc.nas.gov.).

[71] For example, applicants are required to use the standards established by the NASA guidelines when performing a casualty-risk assessment for the re-entry of space craft into the Earth's atmosphere at the end of life. *See* Section III.C.4.b., *infra*.

[72] 47 C.F.R. § 25.114(b).

potential options. If an applicant's debris mitigation plans change after authorization, the changes must be submitted to the Commission by means of a request to modify the space station authorization.[73]

C. Specific Elements of Orbital Debris Mitigation

22. In addition to extending the debris mitigation disclosure requirement to all satellite systems authorized by the Commission, the *Orbital Debris Notice* identified specific elements of orbital debris mitigation and sought comment on issues arising under each element. It also sought comment on whether any measures identified in the U.S. Government Standard Practices are sufficiently mature to warrant adoption of rules requiring their use.[74] We address each of the specific elements of orbital debris mitigation below.

1. Spacecraft Hardware Design: Control of Debris Released During Normal Operations; Selection of a Safe Operational Configuration; Collisions with Small Debris

23. *Background.* In the *Orbital Debris Notice,* the Commission observed that 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 require that programs assess and limit the amount of orbital debris released in a planned manner during normal operations.[75] Concerning this element of debris mitigation, the *Notice* observed that communications payloads approved by the FCC do not typically involve the planned release of any operational debris during normal operations.[76] As a result, the *Notice* proposed that parties submitting an orbital debris mitigation showing simply confirm that there will not be any planned release of operational debris during normal operations of the space station.[77] Second, the U.S. Government Standard Practices require that programs select a safe operational configuration. In order to address this element of debris mitigation, a program must assess and limit the probability that an operating space station will become a source of orbital debris through collisions with debris smaller than one centimeter in diameter that will cause loss of control and prevent post-mission disposal. This element of debris mitigation practices implicates hardware design insofar as it involves shielding of spacecraft components, placement of components, and the use of redundant systems. The *Notice* suggested that to address this element of debris mitigation, applicants could simply confirm that they have assessed the possibility of such collisions and have taken steps to limit their effects.[78]

24. *Discussion.* We adopt the proposals of the *Orbital Debris Notice* regarding disclosure of debris released during normal operations and efforts made to limit the probability that an operating space station will become a source of orbital debris through collisions with small debris that cause loss of control and prevent post-mission disposal. First, the record supports the observation that communications space stations do not typically involve the planned release of orbital debris. Comments confirm that very little, if any, orbital debris is produced by communication satellites as part of normal operations.[79] SIA states that upon the successful separation of the spacecraft from the launch vehicle and deployment, the spacecraft stays in one piece throughout its useful life and disposal process, absent a catastrophic event

[73] 47 C.F.R. § 25.117.

[74] *Orbital Debris Notice*, 17 FCC Rcd at 5598.

[75] *Id.* at 5601.

[76] *Id*.

[77] *Id*.

[78] *Id*.

[79] SIA Comments at 6; Telesat Comments at 4.

such as a collision with a man-made object or meteor.[80] We conclude that a statement confirming that no debris will be released by the space station during normal operations will be sufficient to meet disclosure obligations. In any instances where release of operational debris is planned, we will examine such plans on a case-by-case basis and retain the discretion to seek additional information or to take action, through conditioning or denying approval, in the event that we find that such release will not serve the public interest.

25. We also conclude that confirmation as part of a debris mitigation disclosure that the satellite system operator has considered possible collisions with small debris and taken steps to limit the effects of such collisions, such as through shielding, the placement of components, and the use of redundant systems, will generally be considered sufficient, in the absence of specific facts suggesting the contrary, to satisfy disclosure obligations. We do not anticipate that this disclosure requirement will prove burdensome for the majority of systems, since satellite operators assert that they already assess the probability of such collisions in orbit and take steps to limit the effects of such collisions.[81] For example, Telesat confirms that it requires system redundancy as part of its satellite procurement process and that it requires that single point failures within a satellite to be minimized or eliminated, so that the adverse impact of such failures can be minimized to the maximum extent possible.[82]

26. We are not persuaded by comments that argue either for more detailed Commission regulation regarding the operational configuration of space stations or for no Commission regulation whatsoever. UM Space Law Center argues that space station operators may have an economic incentive to omit hardening or shielding of a satellite structure due to the additional cost of such efforts and because the resulting "weight penalty" could reduce the amount of on-board revenue-generating payload.[83] Accordingly, UM Space Law Center urges us to adopt guidelines for space station design and to require operators to submit a cost-benefit analysis that weighs the benefits of various forms of debris mitigation that can be incorporated in a satellite design versus the costs related to each of those forms.[84] By contrast, SIA claims that it is not useful to have any confirmation that an operator has assessed the probability a spacecraft would become a source of orbital debris through collisions, since the Commission does not propose to set standards for the evaluation of such assessments and because the Commission has traditionally left space station design issues to the operator.[85]

27. We agree with commenters that it is unlikely that a satellite operator would trim satellite construction costs by electing to omit hardening or shielding of a spacecraft, when such an action would expose the operator to significant risk of loss of the entire revenue-producing payload of that satellite.[86] Given the economic self-interest of satellite operators in protecting revenue-producing operations from damage through in-orbit collisions, and given our understanding that the systems used in a typical communications satellite for mission operations are the same as those used for end-of-life disposal, we believe more detailed disclosure requirements are unlikely to yield any significant benefit to the regulatory process. However, if the spacecraft design involves use of a sub-system or set of sub-systems,

[80] SIA Comments at 6.

[81] SIA Comments at 6; Telesat Comments at 4.

[82] Telesat Comments at 3-4.

[83] UM Space Law Center Comments at 2.

[84] *Id*.

[85] SIA Comments at 6-7 (citing *Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile-Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands*, Notice of Proposed Rulemaking, 9 FCC Rcd 1094 (1994))(*Big LEO NPRM*)). *See also* SES Americom Reply at 4.

[86] Telesat Reply at 4*;* SES Americom Reply at 4.

distinct from systems used in connection with the primary communications mission, in order to accomplish end-of-life disposal, an applicant's disclosure should address in greater detail the measures taken specifically to analyze the susceptibility of that sub-system to collisions with small debris.

28. We disagree, however, that requiring confirmation that a space station operator has assessed and limited the probability that its spacecraft would be unable to perform end-of-life maneuvers as a result of collisions with small debris serves no useful purpose unless the Commission adopts set standards for the review of such assessments. Although we anticipate that the majority of satellite operators have an economic incentive to design their spacecraft as robustly as possible in order to protect revenue-producing operations, this may not always be true. For example, the record indicates that satellite system designs are emerging that involve large constellations of ultra-small satellites in which the redundancy permitted by a large number of satellites permits the reliability of any individual satellite in the constellation to be low without impacting the reliability of the constellation as a whole.[87] By requiring confirmation that a space station operator has taken measures to ensure a safe operational configuration of its satellite system through hardware design, we preserve the ability to take action, through conditioning an authorization or denying an application in those instances where economic incentives may not be sufficient by themselves to ensure that the applicant has adequately taken debris mitigation into account during the design of its spacecraft. Although our preference is to leave spacecraft design decisions to space station operators, this preference does not foreclose the Commission from considering design issues insofar as they may impact the public interest.

2. Minimizing Debris Generated by Accidental Explosions

29. *Background.* The prevention of accidental explosions during and after completion of mission operations constitutes perhaps the single most important debris mitigation measure in preventing potential damage to space assets.[88] Explosions in space can produce a large number of debris fragments dispersed over a much wider range of orbits than the orbit of the exploded object.[89] Indeed, it is estimated that fragmentation debris accounts for more than 40 percent of the catalogued orbital debris population, and that the vast majority of this fragmentation debris has been created by the explosive breakups of spacecraft and rocket bodies.[90]

30. For these reasons, the *Orbital Debris Notice* proposed to require confirmation in orbital debris mitigation disclosures that space station operators have assessed and limited the probability of accidental explosions during and after completion of mission operations. The *Notice* proposed specifically that applicants demonstrate that "debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft," and that such a demonstration should specifically address measures taken at the spacecraft's end of life.[91] These requirements are similar to a rule adopted by the Federal Aviation Administration (FAA) for launch vehicle upper stages.[92] The *Notice* tentatively concluded that satellite operators' self-interest in ensuring

[87] *See* Ecliptic Comments at 7.

[88] *Orbital Debris Notice*, 17 FCC Rcd at 5602.

[89] For a more detailed discussion of explosions and other satellite fragmentation events, see History of On-Orbit Satellite Fragmentations, available on-line at http://www.orbitaldebris.jsc.nasa.gov.

[90] Orbital Debris: A Technical Assessment at 138; *STSC Technical Report on Orbital Debris* at 32 (para. 98).

[91] *Orbital Debris Notice*, 17 FCC Rcd at 5602.

[92] *Id.* at 5602-03. The FAA regulation, codified at 14 C.F.R. § 415.39, reads:

> To obtain safety approval, an applicant must demonstrate for any proposed launch that for all launch vehicle stages or components that reach earth orbit –

(continued....)

spacecraft reliability provides incentive to design a spacecraft that does not experience accidental explosions during its useful life, but questioned whether operators have similar incentive at or near the end of a spacecraft's life, since an operator may have the economic incentive to continue income-producing activities even as a spacecraft's systems degrade.[93]

31. *Discussion.* We adopt the proposal of the *Orbital Debris Notice* to require confirmation in orbital debris mitigation disclosures that space station operators have assessed and limited the probability of accidental explosions during and after completion of mission operations. Because of the particular danger that accidental explosions pose to safe and reliable operations, we conclude that requiring confirmation that space station operators have assessed and limited the risk of accidental explosions serves the public interest.

32. Such a disclosure requirement should be sufficient in most cases to serve the public interest. Comments support the tentative conclusion of the *Notice* that satellite operators' self-interest provides adequate incentive for the majority of operators to design spacecraft that do not experience accidental explosions during useful life.[94] Although we agree that many satellite operators address the risk of accidental explosions throughout the life span of the satellite, it does not follow, as some commenters suggest,[95] that disclosure of such assessment to the Commission is not useful. Given the significance of this issue for growth of the debris population, we think the limited disclosure we are seeking is justified. In addition, there may be situations where economic incentives, by themselves, are insufficient to ensure that the risk of accidental explosions is adequately addressed. For example, it may be the case that non-commercial operators do not have the same economic incentives to ensure reliability as commercial operators, since the financing of their activities may have little to do with the ability of the spacecraft to continue revenue-producing activity. Thus, given the serious consequences of accidental explosions of spacecraft in orbit, we believe that the public interest would be served by ensuring space station applicants have assessed and limited the probability of such explosions.

33. Such disclosure should not be burdensome. Comments indicate that satellite operators already consider the possibility of accidental explosions and should not experience difficulty in confirming that they have assessed and limited the probability of accidental explosions as part of their

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(a) There will be no unplanned physical contact between the vehicle or its components and the payload after payload separation;

(b) Debris generation will not result from the conversion of energy sources into energy that fragments the vehicle or its components. Energy sources include chemical, pressure, and kinetic energy; and

(c) Stored energy will be removed 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.

[93] *Id.* at 5602.

[94] SIA states that operators already routinely conduct a failure mode verification analysis (FMVA) as part of the satellite design review to ensure that failure of a component aboard the satellite does not lead to an accidental explosion. *See* SIA Comments at 9. Furthermore, Telesat claims that satellite operators have economic incentive to design spacecraft that do not experience accidental explosions during or after mission operations so that the spacecraft does not threaten the ability of the operator to operate a replacement satellite at the same orbital position, or to use an aging satellite as an on-orbit spare or to lease the satellite to a third-party near the end of life. *See* Telesat Comments at 5.

[95] SIA Comments at 9.

orbital debris mitigation disclosure.[96] Indeed, one operator expressly states that it would not be onerous to require operators to confirm expressly in their debris mitigation disclosures that they have assessed and limited the risk of accidental explosions.[97] Accordingly, we amend our rules as proposed in the *Notice* to require a statement, as part of the debris mitigation disclosure, that a space station operator has assessed and limited the probability of accidental explosions during and after mission operations.[98] In the event that a showing suggests that further review may be warranted, we retain the discretion to seek additional information from the applicant and preserve the ability to take action, through conditioning an authorization or denying an application in those instances where economic incentives may not be sufficient by themselves to ensure that the applicant has adequately assessed and limited the risk of accidental explosions.

3. Safe Flight Profiles: Collisions With Large Objects

34. The U.S. Government Standard Practices provide that programs and projects will select safe flight profiles by assessing and limiting the probability of operating space systems becoming the source of debris by collisions with man-made objects or meteoroids.[99] More specifically, 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 *Notice* observed that while current Commission rules and international regulations have several provisions that impact the selection of the flight profile for a satellite, those rules and regulations were developed primarily to address radiofrequency interference concerns. Thus, for example such 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. The *Notice* observed, however, that an applicant's disclosure in the licensing process of, for example, the parameters of the orbits its system would use, may assist third parties in identifying potential problems that may be caused by the proposed operations. It noted that in the most heavily used orbits, or in orbits with particularly 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.[100] It also inquired whether any changes were needed to our existing rules and practices in light of these considerations. We discuss below our existing rules and changes proposed by commenters as they relate to four phases of space station authorization and operations: the application filing; pre-operational phase; on-orbit operations; and coordination of maneuvers.

a. Application Information Requirements

35. *Background*. Applicants seeking a space station authorization must submit technical information regarding the proposed space station as set forth in Section 25.114 of the Commission's

[96] SIA Comments at 9; Telesat Comments at 5.

[97] Telesat Comments at 6.

[98] SIA states that satellite operators and manufacturers treat their failure mode verification analyses as confidential business information, and implies that our disclosure requirement threatens the confidentiality of such analyses. *See* SIA Comments at 9. Since we do not anticipate requiring applicants to submit those analyses in the ordinary course, but rather simply to confirm that that such an analysis has been undertaken, we do not anticipate that this will be a routine issue. In the event such a submission is required, our rules provide protections for any documents that warrant confidential treatment. *See* 47 C.F.R. § 0.459.

[99] *Orbital Debris Notice*, 17 FCC Rcd at 5603.

[100] *Id*.

rules.[101] This information includes the physical characteristics of the space station,[102] the satellite's orbital location and the factors that went into selection of that location,[103] the accuracy with which a GEO satellite's orbital inclination and longitudinal drift will be maintained,[104] and, for non-GEO satellite systems, the number of space stations in the system, the inclination of the orbital plane(s), orbital period, apogee, perigee, the argument(s) of perigee, active service arc(s), and right ascension of the ascending node(s).[105] The *Notice* inquired whether the information required to be submitted under Section 25.114 provides an adequate basis for potentially affected parties to evaluate proposed systems with respect to collision avoidance and safe flight profiles.[106] Furthermore, it sought comment on whether Section 25.114 should be amended to require non-geostationary satellites systems to disclose the accuracy with which they will maintain orbital parameters such as apogee, perigee, period, and inclination.[107]

36. *Discussion.* We conclude that the information requirements of Section 25.114, as amended today, are sufficient with respect to collision avoidance and safe flight profiles and to identify any potential issues with a proposed system that might require further evaluation or action. Comments broadly support this conclusion.[108] We conclude that other alternatives proposed by commenters would not necessarily meet the same goals.[109]

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[101] 47 C.F.R. § 25.114. Subsequent to the release of the *Orbital Debris Notice*, Section 25.114 was substantially amended as a result of our adoption of a standardized form for space station license applications. *See Amendment of the Commission's Space Station Licensing Rules and Policies, 2000 Biennial Regulatory Review – Streamlining and Other Revisions of Part 25 of the Commission's Rules Governing the Licensing of, and Spectrum Usage by, Satellite Network Earth Stations and Space Stations*, Third Report and Order and Second Further Notice of Proposed Rulemaking, IB Docket Nos. 02-34 and 00-248, FCC 03-154, 18 FCC Rcd 13486 (2003) (*Space Station Licensing Third Report and Order*). As a result, the subsection numbers referenced in this Second Report and Order may differ from the numbers referenced in the *Notice*.

[102] 47 C.F.R. § 25.114(c)(10).

[103] 47 C.F.R. § 25.114(c)(5).

[104] 47 C.F.R. § 25.114(c)(5)(iii) and (5)(iv). As noted in the *Orbital Debris Notice*, 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. *See Orbital Debris Notice*, 17 FCC Rcd at 5603 n.84. In addition to maintaining the accuracy of its inclination, a GEO satellite must execute station-keeping maneuvers to maintain longitudinal accuracy in order to prevent a naturally occurring drift to the east or to the west due to small variations in the Earth's gravity, unless the spacecraft is located at one of the two "gravity wells" on the geostationary arc. *See id.* at 5604 n.85.

[105] 47 C.F.R. § 25.114(c)(6).

[106] *Orbital Debris Notice*, 17 FCC Rcd at 5604.

[107] *Id*.

[108] SIA Comments at 10 (current information is sufficient to enable operators to evaluate the potential for collisions and safe-flight profiles); Ecliptic Comments at 7-8 (FCC rules requiring applicants to provide orbital information are generally helpful in minimizing the probability of collisions).

[109] SIA refers to a proposal raised in another FCC rulemaking proceeding, in which it proposed that we amend our licensing rules to require applicants to submit only the technical information required by ITU Appendix 4, which sets forth the technical characteristics of a satellite network that must be submitted to the ITU for advance publication and the initiating of coordination of satellite networks. *See* SIA Comments at 10. SIA argues that this information would also be sufficient to determine safe-flight profiles because the technical information submitted pursuant to Appendix 4 includes, among other things, the orbital characteristics of the satellite network. We have, however, already considered and rejected SIA's proposal in our Space Station Licensing Rules and Policies proceeding. *See Space Station Licensing Third Report and Order*, 18 FCC Rcd at 13491 (observing that reliance on ITU submissions alone does not serve the public interest, because the Commission's technical and regulatory (continued....)

37. We also find that the public interest would be served by requiring NGSO systems to disclose, as part of an orbital debris mitigation statement, the accuracy with which orbital parameters will be maintained. This information is already required for GEO systems under Section 25.114(c)(7) of our rules, and we expect that disclosure of this information for NGSO systems will help interested third parties evaluate proposed systems with respect to collision avoidance and safe-flight profiles. In the event that an NGSO system is not able to maintain orbital tolerances, *i.e.*, it lacks a propulsion system for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites, in order to permit third parties to evaluate the system with respect to collision avoidance and safe flight profiles.

b. Pre-Operational Phase

38. *Background.* As observed in the *Orbital Debris Notice*,[110] there may be a substantial period of deployment and testing after a satellite separates from a launch vehicle, but before it commences full commercial operations. During this time, the satellite may operate at a location other than its permanently assigned orbit. The Commission has historically reviewed such operations on a case-by-case basis, either through a request for deployment and testing as part of an applicant's application for authority for "full" operations, or through a request for special temporary authority (STA) filed closer to the time of launch of the satellite system.[111] The *Notice* proposed to continue this general practice, noting that this approach gave the Commission regulatory flexibility in addressing the deployment and testing phase of satellite operations. It observed that many activities in the pre-operational phase are highly transitory in nature, often involving a series of spacecraft maneuvers, and, therefore, it may be difficult to specify precise orbital parameters for those operations. It indicated, however, that when pre-operational activities involve the use of a particular orbit for an extended period of time, the Commission would generally expect licensees to specify precise orbital parameters in their requests for authorization, in a manner consistent with the disclosure requirements in connection with "normal" operations.[112]

39. *Discussion.* We will continue our practice of reviewing pre-operational activities on a case-by-case basis, either through a request for deployment and testing as part of an applicant's application for authority for "full" operations, or through a STA request filed closer to the time of launch of the satellite system. Comments support this proposal,[113] and we believe that this practice provides regulatory flexibility to operators without compromising the Commission's ability to examine whether the public interest is served by the grant of an authorization. Applicants must specify, in a manner consistent with the disclosure requirements of a normal application, the precise parameters of any pre-operational orbits that are intended to be used for an extended period.[114] Applicants must also, wherever possible, include any such orbits in their applications for full operational authority, in order to ensure that any issues concerning the pre-operational phase can be identified at an early stage. We believe this may be of

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requirements are not the same as the ITU requirements and because there is no guarantee that ITU rules will be adequate for U.S. operations). As a result, SIA's proposal is moot and need not be considered here.

[110] *Orbital Debris Notice*, 17 FCC Rcd at 5604.

[111] *Id*.

[112] *Id*.

[113] SIA Comments at 10.

[114] Examples of extended pre-operational activities include the use of a geostationary satellite orbital location for in-orbit testing that is different from the one authorized for use by the satellite operator, or the use of an "engineering" orbit by an NGSO satellite in which satellites are tested and maintained prior to deployment in "mission" orbits. *See Orbital Debris Notice*, 17 FCC Rcd at 5605.

particular importance for NGSO systems that will seek to use "engineering" or "parking" orbits for satellites not involved in full system operations.

40. With respect to the types of transitory operations involved in "orbit-raising"[115] and similar maneuvers in the pre-operational phase, we are adopting a new rule, Section 25.282, to make clear that, although such operations are of necessity at variance with the orbital parameters specified in the license for "full" operations, they are nonetheless authorized operations, provided they meet certain conditions designed to avoid radio-frequency interference.[116]

c. On-Orbit Operations

41. *Background.* Currently, very few Commission rules exist that govern the physical aspects of the on-orbit operations of space stations. Furthermore, existing rules were designed with radiofrequency interference in mind, rather than debris mitigation. The *Orbital Debris Notice* examined the Commission's existing rules, proposed several amendments and additions, and sought comment on several additional issues that might require rule changes. We discuss each of these matters below.

42. *Discussion.* First, the *Notice* observed that Section 25.210(j) of the Commission's rules specifies that fixed-satellite service satellites in geostationary orbit 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 with the longitudinal tolerance specified by the Commission.[117] As noted in the *Notice*, this rule parallels, but is generally more stringent than, the requirement in the ITU Radio Regulations, which requires geostationary FSS and broadcast satellite service (BSS) satellites to maintain their positions within 0.1° of their assigned positions.[118] Because a geostationary satellite in the process of removal from orbit at the end of its mission would not comply with this rule, we proposed to amend the language of Section 25.210(j) to provide an explicit exception for such operations. In addition, we proposed to shorten and simplify the text of the rule and sought comment whether to apply the ±0.05° longitudinal tolerance applicable to fixed-satellite service space stations to space stations in other services.[119] In this regard, we noted that longitudinal tolerance is much less important to radio-frequency interference for remote sensing and mobile-satellite systems at GEO than for fixed-satellite services.[120]

43. We adopt the changes to the text of Section 25.210(j) that were proposed in the *Notice* to shorten and simply the text of the rule and to provide an explicit exception for certain end-of-life operations. Comments received in response to these proposals generally support these suggested changes. SIA favors the simplification of the text of Section 25.210(j) and welcomes the explicit exception to the ±0.05° longitudinal tolerance requirement in the case of post-mission disposal operations.[121] SIA also

[115] As used in this Second Report and Order, "orbit raising" refers to the process by which a satellite is maneuvered after launch typically from a lower initial orbit into a higher permanent operational orbit.

[116] *See* Appendix B.

[117] 47 C.F.R. § 25.210(j).

[118] *Orbital Debris Notice*, 17 FCC Rcd at 5605.

[119] *Id.* (seeking comment on applicability of FSS longitudinal tolerance to other services, such as mobile-satellite service or remote sensing satellites); *see id.* at n.89 (noting that the rules for DBS, which at the time of the release of the *Orbital Debris Notice* were contained in Part 100 of the Commission's rules, were in the process of being consolidated into Part 25). Since release of the *Notice*, the rules for DBS have been consolidated into Part 25. *See Policies and Rules for the Direct Broadcast Satellite Service*, Report and Order, IB Docket No. 98-21, FCC 02-110, 17 FCC Rcd 11331 (2002).

[120] *Orbital Debris Notice*, 17 FCC Rcd at 5606 n.92.

[121] SIA Comments at 11.

indicates that satellite operators would be able to comply with the simplified text of Section 25.210(j), since it claims that it is already industry practice to maintain GEO satellites within ±0.05° of their assigned orbital longitude, unless otherwise authorized by the Commission.[122] Other comments state that GEO satellite operators are generally conscientious about staying within their assigned longitudinal bands, although errors can inadvertently occur from time to time due to faulty calibration of the transponder ranging data that is used to determine the orbits and longitude of the satellite.[123]

44. We decline, at this time, to adopt changes to Section 25.210(j) to specify a longitudinal tolerance of ±0.05° for all space stations, including MSS and remote sensing space stations. Although one commenter observes that precise station-keeping requirements are important so that adjacent or co-located satellite operators know that neighboring satellites have control requirements and will not encroach into an adjoining station-keeping box, this commenter does not necessarily support adopting a ±0.05° longitudinal tolerance requirement for all GEO space stations.[124] Other parties, chiefly proponents of MSS systems, argue that a ±0.05° longitudinal tolerance is unnecessary and economically burdensome for MSS systems, particularly those operating in highly inclined orbits.[125] In addition, FSS operators observe that MSS spacecraft frequently use FSS frequency bands for feeder links and for tracking, telemetry, and control operations and express concern that, if MSS satellites are allowed a larger station keeping tolerance than the ±0.05° tolerance required for FSS systems, the MSS operations could cause operational restrictions or radiofrequency interference to adjacent or co-located FSS spacecraft.[126] We conclude that the record in this proceeding is not sufficiently developed at this time to adopt a change in our rules with respect to non-FSS space stations, and that the radiofrequency interference concerns specified by the FSS operators raise issues that need additional exploration in a further notice of proposed rulemaking in this proceeding. Accordingly, we defer this issue to a further notice of proposed rulemaking to be initiated at a later date. Our action today does not, however, alter in any way the obligation of space stations in the Fixed-Satellite Service to comply with the ±0.05° longitudinal tolerance requirements of Section 25.210(j), as amended herein.

45. The second change proposed in the *Orbital Debris Notice* involved amending the text of Section 25.280 of the Commission's rules.[127] Section 25.280 permits satellite operators in

[122] SIA Comments at 11.

[123] MIT Lincoln Laboratories Comments at 2.

[124] Telesat Comments at 7.

[125] *See, e.g.,* Letter from Bruce Olcott, Counsel for The Boeing Company, to Marlene Dortch, Secretary, FCC, dated December 23, 2003; Letter from Alexander Hoehn-Saric, Counsel for Inmarsat Ventures Ltd., to Marlene Dortch, Secretary, FCC, dated December 23, 2003; Letter from John Janka, Counsel for Inmarsat Ventures Ltd., to Marlene Dortch, Secretary, FCC, dated January 9, 2004; Letter from John Janka, Counsel for Inmarsat Ventures Ltd., to Marlene Dortch, Secretary, FCC, dated January 16, 2004; Letter from Christian Pietrowski, VP – Telecommunications Marketing & Sales, EADS Astrium, to Marlene Dortch, Secretary, FCC, dated March 8, 2004.

[126] *See* Letter from Kalpak Gude, Vice President of Government and Regulatory Affairs and Associate General Counsel, PanAmSat Corp., *et al.* to the Hon. Michael Powell, Chairman, FCC, dated January 13, 2004 (FSS Operators January 13 Ex Parte) at 1. In reply, Boeing asserts that MSS spacecraft are unlikely to cause radiofrequency interference to FSS systems, arguing that co-located FSS and MSS systems are generally not authorized to operate in the same frequency bands and, in any event, that the relatively low transmit power and large gateway earth stations used by MSS systems makes it unlikely that MSS transmissions would interfere with FSS operations. *See* Letter from Bruce Olcott, Counsel for The Boeing Company, to Marlene Dortch, Secretary, FCC, dated January 22, 2004 at 2.

[127] *Orbital Debris Notice*, 17 FCC Rcd at 5606.

geosynchronous orbits to operate in inclined orbits[128] without prior Commission authorization, subject to certain conditions, including notification to the Commission of such operations.[129] The *Notice* proposed to amend the text of this rule by specifying that notification to the Commission must occur within 30 days after the last north-south station-keeping maneuver, and by requiring that this notification include a description of the post-mission disposal plans for the spacecraft.[130] SIA supports our proposal as a welcome clarification of the rule's notification obligation.[131] Accordingly, we adopt the proposed changes to Section 25.280.

46. The *Notice* also sought comment on whether to specify a required tolerance, akin to the GEO station-keeping rule, concerning maintenance of orbits for non-geostationary satellite systems, or whether the public interest would be better served by addressing tolerances for NGSO systems on a case-by-case basis.[132] Although we believe a disclosure requirement concerning the tolerance within which an NGSO orbit will be maintained is warranted, we decline to specify at this time any tolerances that NGSO satellite systems must meet as a precondition to licensing. We agree with commenters who observe that the additional number of orbital parameters that NGSO satellite systems have to work with as compared to GEO space stations makes such a tolerance requirement unnecessary,[133] and, as a result, NGSO systems that are not currently equipped with propulsion systems would suffer economic harm out of proportion to the public benefit gained by such a tolerance requirement.[134]

47. Nonetheless, we believe that disclosure of the tolerance to which proposed NGSO systems will maintain their orbits will provide useful information concerning such systems. In the absence of such information, potentially affected parties may find it difficult to evaluate proposed systems and to identify potential issues. For example, the number of parties potentially affected by a proposed system, and the nature of potential concerns, are quite different if a satellite proposed for a "nominal" circular orbit with an altitude of 800 kilometers will be maintained to within 10 kilometers of that orbit, or within 200 kilometers. We retain discretion in any specific case, based upon any concerns arising in the licensing process, to include any needed conditions concerning the tolerance within which an NGSO spacecraft maintains its orbit.

48. The *Notice* also sought 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.[135] Although the *Notice* anticipated that this objective would be readily attainable for the majority of applicants, due to the currently extremely low spatial density of and risk of collision with large debris objects, it sought comment on whether more detailed discussion of potential

[128] That is, the space station will operate without "north-south" station-keeping maneuvers that correct for solar and lunar gravitational forces. Absent such maneuvers, the inclination of a GEO satellite will gradually increase from zero degrees (equatorial orbit) to a maximum of approximately 14.6 degrees.

[129] 47 C.F.R. § 25.280. These conditions are intended to ensure that a satellite operating in an inclined orbit causes no more radio frequency interference to adjacent satellites than would be the case of a satellite operating without an inclined orbit.

[130] *Orbital Debris Notice*, 17 FCC Rcd at 5606 and Appendix B (Proposed Rule Changes).

[131] SIA Comments at 11.

[132] *Orbital Debris Notice*, 17 FCC Rcd at 5606.

[133] SIA Comments at 12 (observing that, unlike GEO space stations that are separated only by longitudinal separation, NGSO satellite systems are separated by multiple orbital parameters, such as orbital altitude, period, and inclination).

[134] Ecliptic Comments at 9; Leggett Comments at 4; AMSAT Comments at 8.

[135] *Orbital Debris Notice*, 17 FCC Rcd at 5606.

collisions may be warranted in specific cases, such as multiple LEO operators seeking to use identical or very similar orbits at the same altitude.[136] The *Notice* proposed, however, to maintain the general policy of leaving the choice of orbital regime and of the specific orbital parameters for any particular system to the discretion of the operator, absent conflicting requests.

49. We continue to believe that, as regards to potential collisions with large objects, the choice of orbit regime and specific orbital parameters is best left to the discretion of the operator in the majority of cases. We conclude that in the majority of instances operators will be able to achieve the objective of selecting an operating orbit that does not coincide too frequently with the orbit or orbits of other large known objects. SIA states that satellite operators already evaluate collision possibilities as part of their due diligence prior to seeking a license or launching a satellite.[137] Satellite operators indicate that, once a satellite is launched, they use the services of entities that can warn geostationary satellite operators of orbital debris and other objects that may enter the orbit of the spacecraft.[138]

50. We conclude, however, that in some instances the public interest would be served by a more detailed discussion of how an operator will avoid potential collisions. The first of these instances, as described in the *Notice*, is where a system will be launched into a low-Earth orbit that is identical, or very similar, to an orbit used by other systems.[139] In such an instance we believe that the operator should submit, as part of its debris mitigation disclosure, an analysis of the potential risk of collision between the LEO systems and a description of what measures the operator plans to take to avoid in-orbit collisions. If the operator is relying on coordination with another system, the operator should indicate what steps have been taken to contact, and to ascertain the likelihood of successful coordination of physical operations with, the other system.

51. The second instance involves proposals to co-locate multiple satellites at a single GEO orbital location. Any entity requesting an assignment of a GEO orbital location must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location such that the station keeping volumes of the respective satellites might overlap. If so, the entity's orbital debris mitigation statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions.[140] We observe that there are a number of cases in which operators have successfully located multiple satellites at a single location, and within the same station-keeping volume. These arrangements require real-time coordination. Where the satellites are not operated by a single company, such coordination may present logistical or cost considerations that render it undesirable as a first choice for preventing collisions. Furthermore, in cases where operators coordinate operations, it is particularly important that they use common methods of calibrating measurement of satellite positions, or rely on a third party to provide that service. In general, we will require entities that indicate that they plan to rely on coordination with other operators at the same orbital location to disclose the manner in which that coordination will be effected.

[136] *Id.* at 5606-07.

[137] SIA Comments at 12.

[138] SIA Comments at 12-13; Telesat Comments at 14.

[139] *Orbital Debris Notice*, 17 FCC Rcd at 5607.

[140] This statement should address any licensed FCC systems, or any systems applied for and under consideration. The statement need not address every filing with the ITU that meets these criteria. The operator should, however, assess and address any systems reflected in ITU filings that are in operation or that it believes may be progressing toward launch, for example, by the appearance of the system on a launch vehicle manifest.

d. Coordination of Maneuvers

52. *Background.* The *Orbital Debris Notice* sought comment on what, if any, notification requirements should be adopted concerning maneuvers by FCC-licensed satellite systems.[141] The *Notice* observed that coordination of such maneuvers may be especially important in connection with certain types of space assets, such as manned spacecraft, and that space objects that are maneuvering may be less predictable in their behavior, which may increase the difficulty in assessing the potential collision risk. The *Notice* observed that the Commission currently does not have a formal coordination or notification process for such maneuvers, but that a number of U.S.-licensed space station operators have in the past exchanged information related to maneuvers informally with potentially affected operators and the U.S. Strategic Command.[142] It sought comment on whether such informal coordination was common and whether, with increases in space activities by an increasing number of operators, a more formal requirement is necessary. It also sought comment on the scope of such a coordination requirement, the parties that should be included in the notification, and the form of the notification.[143]

53. *Discussion.* Based on our experience and the comments in response to the *Notice*, we conclude that existing informal notification procedures have been generally effective so far for avoiding radiofrequency interference involving maneuvering space stations. Satellite operators indicate that informal coordination of maneuvers between operators is common[144] and that this coordination includes coordination with U.S. Strategic Command when appropriate.[145] SIA states that, although the number of operating satellites has increased during recent years, the total number of satellite operators remains relatively small.[146] Accordingly, SIA argues that existing, informal coordination of maneuvers among satellite operators is sufficient and there is no need for additional regulation in this regard.[147] Telesat agrees that it is normal for satellite operators to coordinate informally whenever a GEO space station is maneuvered from its assigned orbital position.[148] Given operators' past practice in coordinating informally during space station maneuvers in order to avoid radiofrequency interference, we conclude that informal coordination can also prove to be effective in minimizing the risks of on-orbit collisions during such maneuvers. Accordingly, we do not adopt formal coordination requirements at this time.

54. We encourage space station operators, however, to engage in coordination discussions with other potentially affected operators whenever they engage in maneuvers that cause a spacecraft to move from an orbit used during normal operations. Absent such discussions, there is an increased risk that a space craft could physically interfere with another space station and contribute additional objects to the debris population.

55. We decline to adopt specific formats for such coordination. In order to ensure that all

[141] *Orbital Debris Notice*, 17 FCC Rcd at 5607.

[142] *Id*.

[143] *Id*.

[144] SIA Comments at 13; Telesat Comments at 7; SES Americom Reply at 4.

[145] SIA Comments at 13; Telesat Comments at 7.

[146] SIA Comments at 13.

[147] *Id*.

[148] Telesat Comments at 7. Telesat indicates that its current practice is to routinely transmit current orbital elements for each of the satellites that it operates to the United States Strategic Command, and, when performing a relocation, to inform all "in-band" operators over the orbital arc in question, and provide those operators with frequency plans and power levels, points of contact, and a summary of the relocation plan.

relevant parties are able to participate in coordination, Telesat proposes the creation of a centralized database of proposed maneuvers, which would be managed by the ITU or some other international agency or group.[149] SES Americom opposes the creation of a centralized database since it believes that existing informal coordination procedures are sufficient without the need for additional regulation.[150] In any event, we are not in a position to consider Telesat's proposal, since it would necessitate action by entities other than the Commission and is beyond our ability to adopt in this proceeding.

56. We decline to adopt a specific rule setting a minimum separation from inhabitable orbiting objects. Although the *Notice* observed that notification of space station maneuvers may be important in connection with certain types of space assets, such as manned spacecraft,[151] the record does not include sufficient information to determine an appropriate minimum separation from inhabitable objects for FCC licensed spacecraft. Entities seeking approval for LEO operations should, however, address such matters in their disclosure statements, including the full range of measures, such as maintaining a minimum distance separation and coordination that will be undertaken to address risks to inhabitable orbiting objects.

57. We also decline to adopt Ecliptic's proposal to require Commission space station licensees to provide to the public the full, classical, Keplerian orbital elements of their spacecraft following launch, and periodically thereafter, in an easily usable format via the FCC website.[152] We find that additional Commission action in this regard is unnecessary. Our existing rules already require NGSO applicants[153] to submit information about their orbits that provides substantially the same information as full, classical Keplerian orbital elements, except for certain information that provides a temporal time frame of reference for the satellite's position in orbit.[154] We do not believe that requiring the submission of more detailed information would, in general, substantially improve the usefulness of data available from the Commission, since an operator undertaking planning requiring such additional information would be well-advised to coordinate directly with any potentially affected satellite systems. In addition, we note

[149] Telesat Comments at 7-8.

[150] SES Americom Reply at 5.

[151] *Orbital Debris Notice*, 17 FCC Rcd at 5607 n.97 (noting FAA regulations, 14 C.F.R. § 431.43(c), which requires a collision avoidance analysis for reusable launch vehicles in order to maintain at least a 200 kilometer separation from any inhabitable orbiting object).

[152] Ecliptic Comments at 7-8. *See also* AMSAT Comments at 7-8.

[153] For GEO satellites, the assignment of an orbital location and the station-keeping requirements in our rules necessarily imply a range of Keplerian elements. Thus, Ecliptic's proposal to require periodic reports of this information is not warranted with respect to GEO satellite licensees.

[154] 47 C.F.R. § 25.114(c)(6)(requiring satellites in non-geostationary orbits to file applicable information relating to the number of orbital planes, the inclination of the orbital plane(s), the orbital period, the apogee, the perigee, the argument(s) of perigee, active service arc(s), and right ascension of the ascending node(s)). Classical Keplerian elements include a few elements that are not expressly required by Section 25.114(c): epoch, eccentricity, mean motion, and mean anomaly. Eccentricity can be calculated from the information supplied about the perigee and apogee of the orbit. Likewise, the orbital period can be used to calculate the mean motion, since the period is simply the reciprocal of mean motion. While epoch and mean anomaly require information about the satellite within a frame of reference which is only available after the satellite has been tracked, we note that Schedule S, adopted in the *Space Station Licensing Third Report and Order*, requires NGSO applicants to specify an "orbit epoch date," at the time they file their application. *See Space Station Licensing Third Report and Order*, 18 FCC Rcd at 13542. We recognize that this information does not represent the true epoch; however, the use of a nominal epoch with respect to which satellites in a constellation are referenced facilitates modeling the constellation for radiofrequency and debris mitigation purposes.

that there are a number of public and private sources for such data.[155] Given the availability of this data from other sources, we conclude that it is not necessary to require satellite operators to provide additional information about their orbital parameters other than that already required by our existing rules.

4. Post-Mission Disposal

58. Post-mission disposal consists of measures taken at the end of a spacecraft's useful life that result in removal of the spacecraft from the Earth's orbit or relocation of the spacecraft to a long-term orbit that reduces the risk of interference with operational spacecraft. Effective disposal of non-functional spacecraft not only provides an immediate benefit by protecting operational spacecraft from accidental collisions with orbital debris, but can also have the long-term benefit of reducing the probability of non-functioning objects colliding with one another and creating additional debris in orbits used by functional spacecraft.[156] Although non-functioning rocket bodies and spacecraft comprise only a small fraction of the total orbital debris population, they constitute the majority of its total mass and cross-sectional area. The sizeable cross-sectional area of non-functioning spacecraft presents a large "target area" for orbital debris strikes, and the relatively large mass of these objects could fragment into a large number of smaller debris pieces upon impact with another object.[157] This fragmentation debris could be spread over a large area and could result in a significant increase in the overall orbital debris population.[158]

59. The *Orbital Debris Notice* inquired whether it would be appropriate at this time to adopt post-mission disposal requirements for Commission-licensed spacecraft.[159] The *Notice* observed that the U.S. Government Standard Practices provides for the disposal of spacecraft after completion of mission, subject to considerations of cost-effectiveness, by means of three alternative methods: (1) direct retrieval; (2); atmospheric re-entry; and (3) maneuvering into a storage orbit.[160] We discuss each of these methods in turn.

60. *Direct Retrieval.* The first method of post-mission disposal is direct retrieval of the spacecraft from orbit. Although direct retrieval ensures that an object will not become a source of a large amount of orbital debris in the future, it can be expensive and has generally not been considered to be a cost-effective option of debris mitigation. Furthermore, direct retrieval has only been attempted at low-Earth orbits. The *Notice* noted that direct retrieval currently has limited relevance for post-mission disposal of Commission-licensed space stations.[161]

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[155] For example, NASA's Orbital Information Group (OIG) makes available unclassified satellite orbital data that has been received from U.S. Government sources. *See* OIG website, available at http://oig1.gsfc.nasa.gov/. In addition, we observe that there are numerous private companies that provide databases of the orbital parameters of objects in Earth orbit.

[156] Orbital Debris: A Technical Assessment at 167.

[157] *Id*.

[158] *Id.* at 161.

[159] *Orbital Debris Notice*, 17 FCC Rcd at 5608.

[160] *Id.* at 5607-08.

[161] *Id.* at 5591 n.16. One commenter argues that we should not dismiss direct retrieval as a long-term possibility for post-mission disposal and proposes that we promote an economic incentive in direct retrieval by adopting a rule that allows the salvage of non-functioning U.S.-licensed spacecraft by U.S. nationals. *See* UM Space Law Center Comments at 3. We stress that we did not intend to dismiss or in any way foreclose direct retrieval. If direct retrieval is implemented in the future, we will have the opportunity to revisit this issue at that time. Any such commercial mission would require radio-frequency authorization, and, in connection with any such FCC authorization we will, as a result of the rules adopted in this proceeding, have an opportunity to evaluate public (continued....)

61. *Atmospheric Re-entry*. Atmospheric re-entry is a disposal process by which a spacecraft is brought into the Earth's atmosphere to disintegrate as a result of friction with the atmosphere. Atmospheric re-entry is typically achieved by one of two procedures. The first entails using the spacecraft's propulsion system (if it is capable of doing so) to propel the spacecraft out of orbit into the Earth's atmosphere. The second is achieved by leaving a spacecraft in an orbit from which the natural phenomenon of atmospheric drag will eventually cause the spacecraft to re-enter the Earth's atmosphere without the use of propulsion systems. If a program or project selects to leave the spacecraft in an orbit from which it will re-enter the Earth's atmosphere without the use of propulsion, the U.S. Government Standard Practices call for the selection of an orbit from which the spacecraft will remain in orbit no longer than 25 years after mission completion.[162] Under the U.S. Government Standard Practices, programs using either procedure must address the human casualty risk from any portions of the spacecraft that may survive atmospheric re-entry.[163] Because of the prohibitively large amounts of fuel that would be required to be stored and expended to lower the spacecraft's altitude into a re-entry orbit, atmospheric re-entry currently is not a feasible alternative for disposal of spacecraft in higher orbits, such as GEO.

62. *Storage Orbit.* A third method of post-mission disposal is maneuvering a spacecraft to a storage or disposal orbit where the spacecraft is unlikely to pose a risk to operational spacecraft in high value orbits.[164] The use of a storage orbit leaves an object in Earth orbit, but removes it from regions where it would pose a direct collision hazard to functional spacecraft.[165] The U.S. Government Standard Practices suggest four potential storage orbits: (1) between low-earth and medium-earth orbit, *i.e.*, satellite perigee altitude above 2000 km and apogee altitude below 19,700 km; (2) between medium-earth orbit and geosynchronous orbit, *i.e.*, perigee altitude above 20,700 km and apogee altitude below 35,300 km (500 km below geosynchronous orbit); (3) above geosynchronous orbit, *i.e.*, a perigee altitude above 36,100 km (300 km above geosynchronous orbit); and (4) removal from Earth orbit into a heliocentric orbit, *i.e.*, the spacecraft is removed to an orbit around the sun.[166]

63. As detailed more fully below, the *Orbital Debris Notice* sought comment on whether to adopt these three methods as requirements for the post-mission disposal of Commission-licensed spacecraft.[167] The *Notice* specifically sought comment on the application of these disposal methods to geostationary and non-geostationary spacecraft. It also sought comment on whether a Commission rule is necessary to ensure that spacecraft reserve adequate fuel to execute post-mission disposal maneuvers, as well as on any other matters that may affect the ability of a spacecraft to execute end-of-life maneuvers reliably.[168] We address each of these issues below.

(...continued from previous page)
interest considerations, including the benefits of removing debris, as well as any possible debris generation, that may result from a direct retrieval mission. Any issues related to salvage that are within the scope of our authority can be addressed at that time.

[162] *Orbital Debris Notice*, 17 FCC Rcd at 5608.

[163] *Id*.

[164] *Id*.

[165] Orbital Debris: A Technical Assessment at 148.

[166] *Orbital Debris Notice*, 17 FCC Rcd at 5608.

[167] *Id*.

[168] *Id.* at 5609.

a. GEO Space Stations

64. *Background.* The *Orbital Debris Notice* described developments in recommendations concerning GEO disposal. The ITU adopted a recommendation in 1993, ITU Recommendation S.1003, which recommends that GEO spacecraft be removed at end of life to a disposal orbit with a minimum perigee of 300 kilometers above GEO.[169] The U.S. Government Standard Practices also adopted this standard for disposal of GEO spacecraft. In addition, the *Notice* indicated that the IADC had developed a recommendation concerning GEO satellite disposal. That recommendation provides a formula for calculating a minimum disposal altitude above GEO that takes into account the major physical forces that act upon a spacecraft after the end of its useful life, and the fact that the effect of those forces may vary based on characteristics of the spacecraft. Since the release of the *Notice*, the ITU has revised Recommendation S.1003 to endorse use of the IADC formula for calculating minimum disposal altitudes for GEO spacecraft.[170]

65. The *Orbital Debris Notice* proposed to amend the Commission's rules to provide GEO space station licensees with authority to dispose of space stations at the end of life, without the need for a case-by-case authorization, provided that the disposal plan meets specified criteria.[171] One criterion is that the licensee maneuvers its spacecraft at the end-of-life into a disposal orbit calculated using the IADC formula. This formula is reproduced below:

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

where C_R is the solar radiation pressure coefficient of the spacecraft, and A/m is the Area to mass ratio, in square meters per kilogram, of the spacecraft. This formula is based on a GEO altitude of 35,786 kilometers and establishes a "protected region" of 200 kilometers around GEO, plus 35 kilometers to account for the maximum descent of a re-orbited spacecraft due to lunar, solar, and geopotential perturbations. The formula then provides an additional term to take into account the solar radiation pressure on a particular spacecraft.[172] The effects of solar radiation pressure vary, based on the mass of the spacecraft, but generally render the spacecraft's orbit more elliptical. As a result, unless this effect is taken into account in selecting a disposal altitude, it is possible for a spacecraft to drift back into the GEO protected region, or, in some cases, into GEO itself.

66. *Discussion.* We conclude that the public interest would be served by adopting rules for the post-mission disposal of Commission-licensed GEO space stations. Unless GEO spacecraft are disposed of at end of life in an effective manner, decommissioned spacecraft pose a risk to the continued reliable and affordable use of GEO. If disposed of at or near GEO, a decommissioned spacecraft could physically interfere with a functional spacecraft that is being controlled at its assigned longitudinal location at GEO. Even if removed from GEO, a decommissioned spacecraft can present a collision risk to functional

[169] *Id.* at 5608-09. The recommendation suggests, in pertinent part, that a GEO 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 [GEO]," with GEO 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 radiation pressure, or other sources, may, over time, result in an inactive satellite's orbit intersecting the GEO, as defined by the ITU recommendation, even if the initial disposal altitude does not intersect the GEO.

[170] See *supra* note 43 and accompanying text.

[171] *Orbital Debris Notice*, 17 FCC Rcd at 5609.

[172] Solar radiation pressure is momentum imparted to the spacecraft by the absorption and re-radiation of the sun's radiation.

spacecraft operating in orbits above GEO as part of a transfer maneuver to change the longitudinal location of that spacecraft.[173] A collision involving a decommissioned satellite, or its fragments, is likely to lead to a degradation or total loss of the telecommunications capabilities of an operational spacecraft and the creation of additional debris fragments. Debris from such a collision will remain on orbit virtually forever. The wide-spread distribution of debris across GEO could result in the degradation of the reliability of GEO satellite communications for the foreseeable future. Even absent such collisions, the increased presence of debris in heavily-used orbits could force operators to incur additional expenses to increase the survivability of their spacecraft through additional shielding or through other measures designed to avoid collision. Such measures to avert the damage caused by collision would add to the cost of spacecraft operations.

67. Although it is difficult to estimate the risk of collision of objects in the geostationary region with any degree of precision,[174] the current risk of collision is considered to be very low due to the relatively low spatial density of debris in the GEO region. For example, a report by the United Nations released in 1999 estimates the annual risk of collision for an average operational satellite with other objects greater than one meter in diameter is 10^{-5}.[175] It is reasonable to assume, however, that the risk of collision will increase in the future. First, we do not anticipate that the population of active spacecraft in GEO is likely to decrease, but rather is likely to remain stable or grow moderately as operators replace decommissioned space stations and launch additional space stations to increase capacity. Second, there is no natural removal mechanism for spacecraft at higher orbital altitudes, and absent disposal maneuvers, objects will remain indefinitely at these altitudes once placed into orbit. As a result, debris will continue to accumulate, and the risk of collision will increase as more functional and non-functional objects are placed in or near GEO. Given the importance of GEO and the serious and potentially irreversible effects that the presence of orbital debris can have in the GEO region, we do not believe the public interest would be served by waiting until the risk to operations in this orbit becomes unacceptably high before taking action.

68. Accordingly, we adopt the proposal of the *Orbital Debris Notice* to evaluate end-of-life plans for GEO space stations according to the formula developed by the IADC for determining the storage altitude for GEO spacecraft at the end of life.[176] We believe that application of this formula provides the best long-term protection to operational GEO spacecraft from orbital debris. Unlike the disposal practices for GEO spacecraft set forth by the U.S. Government Standard Practices, the IADC formula takes into account the specific characteristics of individual spacecraft, such as its susceptibility to the effects of solar radiation pressure, which may cause a spacecraft eventually to drift back into GEO. Furthermore, use of the IADC formula establishes a 200-kilometer "protected region" around GEO that

[173] By increasing altitude, a spacecraft decreases its velocity relative to the Earth and the GEO arc, which results in a change of location of the spacecraft on the GEO arc. Generally speaking, the greater the increase in altitude, the faster this change of location will occur. For example, a transfer of one degree per day requires an orbital increase of approximately 78 kilometers above GEO. For a transfer of two degrees per day requires an increase of double this amount, or roughly 156 kilometers above GEO.

[174] This difficulty is due to existing limitations in assessing the debris population at these altitudes. Currently, only objects with a diameter of one meter or greater are routinely catalogued at GEO.

[175] *STSC Technical Report on Space Debris* at 28. The report cautions, however, that additional orbital debris measurements in GEO are needed before more accurate risk assessments can be performed. *See id.* Other studies indicate that the annual risk of collision may be significantly greater. *See, e.g.,* Leclair and Sridharan, MIT Lincoln Laboratory, "Probability of Collision in the Geostationary Orbit," in the Proceedings of the Third European Conference on Space Debris (October 2001) (estimating the annual risk of collision for an average operational satellite with other objects greater than one meter in diameter at 2.0×10^{-4}).

[176] *Orbital Debris Notice*, 17 FCC Rcd at 5609.

provides protection to spacecraft that are operating above GEO either during normal station keeping operations or during transfer maneuvers. For example, Telesat states that it routinely uses orbits that are 100 kilometers above or below GEO for moving satellites from one orbital location to another, and that other operators follow similar practices.[177] The IADC formula also represents an internationally developed consensus for disposal of GEO spacecraft, which has already been adopted into the revised ITU GEO disposal recommendation.

69. We are also adopting the proposal in the *Notice* to provide GEO space station licensees with authority to dispose of space stations at the end of life without the need for a case-by-case authorization from the Commission, provided that the disposal is consistent with the IADC disposal recommendation for GEO spacecraft.[178] No commenters oppose this proposal and its adoption will promote administrative efficiency.

70. Commenters have sought clarification of certain terms of the IADC formula. For example, SIA seeks clarification that the "Area" of the satellite for purposes of calculating the "Area to mass ratio" is calculated on a deployed and on-station basis.[179] Slabinski also agrees that the definition of "Area" in the IADC formula needs clarification and offers suggestions on how to determine this value.[180] We confirm that the area of the satellite should be calculated using a method that reflects its deployed and on-station configuration. The IADC formula is designed to account for the physical characteristics of a spacecraft at the time of disposal. To the extent that antenna and solar panels remain deployed upon disposal, calculations under the IADC formula should account for this fact. The area to be calculated is the average aspect area. We will not specify a detailed methodology for calculating area. However, NASA Safety Standard NSS 1740.14 may prove instructive to licensees in this regard. We note that it would be entirely reasonable for parties to make simplifying assumptions in assessing aspect area, provided that such assumptions bear in mind the objective of ensuring that objects placed into a storage orbit do not re-enter the GEO protected region. Thus, we expect satellite operators to use assumptions which would lead to a disposal orbit in excess of one calculated using higher fidelity methods.

71. We conclude that the use of the IADC formula for evaluating the post-mission disposal plans of GEO space stations is superior to other methods suggested by commenters. Some commenters propose to allow operators the choice of using disposal orbits with an altitude calculated by the IADC formula or 300 kilometers above GEO, whichever is lower.[181] We decline to adopt such a rule, since it would permit space stations that are particularly susceptible to solar radiation pressure to be placed in a disposal altitude of 300 kilometers above GEO, even though this altitude may not be sufficient to prevent such spacecraft from re-entering into the GEO protected region according to the IADC formula. Furthermore, we disagree with commenters that suggest that requiring Commission-licensed space stations to be placed into a disposal orbit constitutes an appropriation of space in violation of the Outer Space Treaty.[182] Just as an initial assignment of an orbital location is not an appropriation of outer space, neither is the use of a storage orbit at end of life, and authorization of a space station to use a storage orbit is consistent with provisions under the Outer Space Treaty that require authorization and continuing

[177] Telesat Comments at 7.

[178] *See* Appendix B.

[179] SIA Comments at 14.

[180] Slabinski Reply at 2-3.

[181] SIA Comments at 14; PanAmSat Comments at 5; SES Americom Reply at 6.

[182] UM Space Law Center Comments at 4 (suggesting that formalizing the routine use of a storage orbit in national legislation and regulations could be construed as appropriating space by use or occupation through the means of national legislation in violation of Article II of the Outer Space Treaty).

supervision of the activities of non-governmental entities in outer space.[183] We observe that no U.S. Government agency in charge of implementing the Outer Space Treaty has asserted that use of storage orbits is inconsistent with Article II.

72. We also decline to rely solely on industry practices, as proposed by the majority of commercial satellite operators. We agree with commenters that operators have an economic incentive to maintain a safe environment for their revenue-producing spacecraft,[184] and that this incentive extends to preserving a safe environment for replacement satellites.[185] These economic incentives, however, may be countered by a more immediate incentive to obtain the most revenue from an operational satellite before decommissioning. Maneuvering a spacecraft to a disposal orbit imposes costs on a satellite operator by requiring fuel to be reserved and expended on re-orbiting maneuvers that otherwise could be used to prolong the revenue-producing operations of the spacecraft.[186] Because the last few months of a satellite's operational life can be worth millions of dollars, operators have an economic incentive to extend the operational life of their space stations as long as possible. Furthermore, operators may respond to other short-term pressures, such as the need to bring into use an orbital location specified in an ITU filing, in order to preserve date priority in the ITU process.

73. It is also not clear that the economic effects of failure to dispose of GEO spacecraft at the end of life will be felt by, or limited to, the satellite operator disposing of the spacecraft. Although the economic incentive to maximize revenue-producing activities is immediate, and the consequences of failing to properly dispose of spacecraft at the end of life are not similarly perceived as such, serious ramifications exist for future space station operations that could have repercussions for centuries, if steps are not taken now to address orbital debris. This is true because of the long orbital lifetimes of objects at high altitudes that continue after disposal of the spacecraft. In addition, the consequences of an ineffective disposal may not be felt by the operator performing the disposal. A spacecraft raised to a disposal orbit will have an initial westward drift rate of 1.28° per day for each 100 kilometers in initial elevation above GEO, and thus the eventual effects of an inadequate disposal altitude, as the initial disposal orbit is lowered by physical forces, may be on a location well-removed from the location at which the satellite originated.[187] As a result, operators may react by using disposal orbits that are not adequate for the long-term protection of GEO, but that nonetheless will provide minimal risk to the operator during the timeframe of its planned business activities.

74. The record also indicates that operators follow a wide variety of practices. Some operators voluntarily dispose of their GEO satellites at end of life in accordance with the recommendations of the

[183] Outer Space Treaty, Article VI.

[184] SIA Comments at 2; PanAmSat Comments at 3; SES Americom Reply at 2; Telesat Reply at 4.

[185] PanAmSat Comments at 3; SIA Comments at 3; SES Americom Reply at 2. Commenters point to the Commission's general policy of granting applications for replacement satellites at the same orbital location so long as the applicant remains qualified to operate its proposed satellite. *See, e.g.*, SIA Comments at 3 (citing *Licensing Space Stations in the Domestic Fixed-Satellite Service*, Report and Order, FCC 85-395, 58 Rad. Reg. 2d. 1267, 1277-79 (1985); *Assignment of Orbital Locations to Space Stations in the Domestic Fixed-Satellite Service*, Report and Order, FCC 88-373, 3 FCC Rcd 6972 n.31 (1988)).

[186] The fuel requirement to re-orbit a GEO satellite 100 kilometers above GEO is estimated at 1.69 kilograms of propellant per 1000 kilograms of mass of the spacecraft. *See 1995 Interagency Report* at 36. It has been estimated that the amount of fuel required to maneuver a spacecraft to 300 kilometers above GEO is comparable to three months of lost revenue-producing operations. *See id.*

[187] 1993 ITU Recommendation S.1003 at 3.

ITU and the IADC. Others do not.[188] Further, the record shows that there is substantial variation in the stated practices of operators concerning the minimum altitude above GEO at which disposal is planned, ranging from 100 kilometers above GEO[189] to 192 kilometers above GEO.[190] Although operators claim that such minimum disposal altitudes are sufficient to protect GEO, the target orbits, particularly those in the lower end of this range, could, in fact, result in decommissioned spacecraft drifting back into altitudes at which active GEO communications spacecraft operate.[191]

75. We do not expect that use of the IADC formula as implemented in this decision will be unduly burdensome to space station operators. For GEO spacecraft, the selection of a disposal orbit is primarily an economic, rather than a technical issue. Because the industry practice for GEO spacecraft is generally to use the same propulsion system for end-of-life maneuvers as is used for operational station-keeping, GEO satellites are equipped with the technical means to execute post-mission disposal maneuvers. It is simply a question of how much fuel is budgeted for such maneuvers. To the extent that operators plan to dispose of their spacecraft to an altitude of 300 kilometers above GEO, as recommended by the ITU in 1993, we do not anticipate that the costs of maneuvering a spacecraft to a storage orbit calculated using the IADC formula will be significantly greater for the majority of space stations in the planning stage. In a number of cases, the costs may be less if the space station is not particularly susceptible to solar radiation pressure and the calculated orbit is less than 300 kilometers above GEO.[192] In some instances, there will be additional costs involved with complying with the IADC formula for disposal of GEO spacecraft as compared to the costs that would be incurred under the 1993 ITU recommendation, but we believe that these costs are justified when balanced against potential risk posed in these instances to the continued safe and reliable use of GEO. In these cases, the higher minimum storage altitude is directly related to the increased susceptibility of the spacecraft to solar radiation pressure, which requires that the spacecraft be placed into a higher storage orbit in order to reduce the probability that the spacecraft will re-enter GEO region and interfere with functional space stations. Accordingly, we believe that the additional costs are warranted in these instances in order to achieve the

[188] For example, of the thirteen GEO spacecraft that reached end of life in 2002, only five were disposed of following the IADC formula; the remaining eight spacecraft were re-orbited in a manner that will probably interfere with GEO in the future, or were otherwise disposed of in a manner inconsistent with the IADC formula. *See* C. Hernández and R. Jehn, *Classification of Geosynchronous Objects*, Issue 5, European Space Agency, European Space Operations Centre, Darmstadt, Germany (2003) at 102-103. Of the five U.S.-licensed satellites that reached end of life in 2002, only two were re-orbited according to the IADC formula. *See id.* In 2001, only two of fourteen GEO spacecraft that reached the end of life were disposed of following the IADC formula. *See id.*, Issue 4 (2002) at 98-99. Only one of four U.S.-licensed GEO spacecraft that reached end of life during 2001 was disposed of following the IADC formula. *See id.* This has led the authors of these reports to conclude that "the reorbiting recommendations which are issued by many national and international organizations since many years are widely ignored" and that a "more rigorous control of the reorbiting practices in GEO is required to protect this unique resource." *See i*d.

[189] Telesat Comments at 8.

[190] Inmarsat December 23, 2003, Ex Parte at 1.

[191] As indicated by the IADC guideline, orbital perturbations due to gravitational effects and solar radiation pressure can, depending upon a spacecraft's physical characteristics, result in changes of satellite orbits by as much as 235 kilometers, although such changes for communications satellites typically range from 60 to 90 kilometers. Communications spacecraft typically operate, with normal station-keeping parameters, at altitudes up to 25 kilometers above GEO. Thus, a spacecraft disposed to 100 kilometers above GEO could re-enter the region in which operational GEO spacecraft reside.

[192] For example, an analysis of a typical Boeing 601 spacecraft, with solar panel fully deployed, results in an area-to-mass ratio of approximately $0.0166 m^2/kg$ (average aspect area, $41 m^2$, and dry mass, 2477kg). Using the IADC formula with an assumed spacecraft solar radiation pressure coefficient of 1.5 kg/m (value ranges from 1 to 2), the post-mission disposal altitude for this spacecraft is approximately 260 km above GEO.

public interest in minimizing the hazard posed by orbital debris to the continued safe and reliable use of GEO.

76. Accordingly, we will require entities seeking an FCC license to operate a GEO space station, or requesting authorization from the Commission to operate with a non-U.S.-licensed space stations to serve the U.S. market under our foreign entry provisions, to demonstrate as part of its orbital debris mitigation disclosure that the operator will be capable of maneuvering its spacecraft at end of life to a disposal altitude with a perigee calculated by use of the IADC formula. As part of this demonstration, entities should provide the calculations that were used in deriving the disposal altitude. As discussed above, simplifying assumptions may be made when applying the IADC formula, provided that such assumptions lead to a disposal orbit in excess of one calculated using higher fidelity methods. Entities who plan to operate or communicate with a GEO spacecraft that will be disposed of at end of life in a manner inconsistent with IADC formula must seek a waiver of our rules as part of their application for Commission authorization.

(i) Grandfathering

77. Many commercial operators of GEO satellites urge the Commission to apply GEO disposal rules only prospectively and to exempt, or "grandfather," all satellites that are currently on-orbit or under physical construction.[193] In support of this position, these operators assert that application of the IADC formula to satellites already in orbit would constitute an impermissibly retroactive application of a new rule. In addition, they claim that application of the IADC formula to spacecraft currently on-orbit would impose large additional costs on operators that are not balanced by a corresponding benefit to the public.

78. As an initial point, we stress that application of the IADC formula to existing spacecraft would not be impermissible under either the Administrative Procedure Act or Commission precedent, as purported by some space station operators. Operators cite to *Bowen*[194]and its progeny in support of this argument.[195] Courts have clarified, however, that *Bowen* is limited to situations in which an agency "alter[s] the *past* legal consequences of past actions" (emphasis in original).[196] Accordingly, application of an agency's rule is impermissibly retroactive when it "would impair rights a party possessed when he acted, increase a party's liability for past conduct, or impose new duties with respect to transactions already completed."[197] This type of "primary" retroactivity is not at issue here. Application of the IADC formula would extend only to disposals that will occur in the future and would not alter the consequences or liability for disposals already completed. Furthermore, application of the IADC formula would not alter any right operators currently possess. Authorization from the Commission has always been required for radiocommunications involving FCC-licensed space stations, including those used to command

[193] *See* SIA Comments at 15 (disposal rules should not apply to satellites in orbit at the time the rule is adopted); PanAmSat Comments at 6 (disposal rules should not apply to any satellite that is already in orbit); SES Americom Reply Comments at 6 (new regulations should only apply prospectively); EchoStar January 30, 2004 Ex Parte at 2 (Commission should grandfather satellites in orbit as of the effective date of disposal rule); Inmarsat February 4, 2004 Ex Parte at 2 (rules should not apply to spacecraft that are in-orbit or currently under physical construction).

[194] *Bowen v. Georgetown University Hospital*, 488 U.S. 204 (1988).

[195] *See* PanAmSat Comments at 6 (citing *Bowen* and *National Mining Assoc. v. United States Dept. of Interior*, 177 F.3d 1 (D.C. Cir. 1999)); EchoStar January 30, 2004 Ex Parte at 2.

[196] *See Celotronix Telemetry, Inc. v. FCC*, 272 F.3d 585, 588 (D.C. Cir. 2001) (*Celotronix*) (citing *Bowen*, 488 U.S. at 219 (Scalia, J., concurring)).

[197] *Celotronix*, 272 F.3d at 588 (citing *Landgraf v. USI Film Products*, 511 U.S. 244, 280 (1994)).

disposal maneuvers.[198] Our rules to date have not vested any right for operators to dispose of their spacecraft in a particular manner. We are also unaware of any authorization for a GEO space station currently on orbit that provides a licensee with authority for post-mission disposal and the maneuvers and radio transmissions necessary to effectuate it. Instead, we have always reviewed applications for post-mission disposal of FCC-licensed space stations on a case-by-case basis.[199] Thus, evaluating the post-mission disposal plans of spacecraft already on orbit consistent with the IADC formula would not alter any existing right of operators to dispose of their spacecraft in a particular manner.[200]

79. Nonetheless, we agree that, in light of the potentially significant financial impact of this new requirement, a transition period sufficient to permit operators to adjust their projections and operations is in the public interest. Based on comments and *ex parte* presentations, it appears that a number of operators currently plan for disposal of their GEO spacecraft at minimum perigee altitudes of 100-150 kilometers above GEO, which is significantly lower than the minimum perigee altitudes calculated by use of the IADC formula.[201] Operators state that the additional fuel required to dispose of currently operational spacecraft at altitudes higher than those for which disposal of these satellites are planned would shorten the spacecraft's expected operational lifetimes by an average of one to three months compared to the use of a lower disposal altitude of, for example, 150 kilometers.[202] Three months represents a reduction of somewhat less than two percent of the mission life of a satellite with a 15-year operational lifetime. Operators also indicate that as a result of lost operational lifetime, the overall cost of using the IADC formula to dispose of on orbit spacecraft could amount to hundreds of millions of dollars

[198] 47 U.S.C. § 301. Furthermore, an FCC-licensed GEO space station license requires a licensee to operate within certain station keeping parameters. Operations outside of these parameters, such as during maneuvers to a storage orbit at end of life, are not typically included in an operator's space station license and require specific additional authorization from the Commission to effectuate.

[199] *See* Section II.B, *infra*. In a number of cases, staff has, particularly in recent years as information has become available concerning variations in disposal practices of GEO spacecraft, included conditions in authorizations requiring disposal of GEO spacecraft consistent with the ITU recommendation, or requiring that licensees maintain the capability to dispose of their spacecraft consistent with the ITU recommendation. *See, e.g., PanAmSat Licensee Corp.*, File No. SAT-STA-20030805-00141 (filed August 18, 2003); *Galaxy IIR STA Grant* (conditioning grant of special temporary authority on licensee maintaining the capability to dispose of spacecraft at an altitude with a perigee of no less than 300 kilometers above GEO).

[200] Even if adoption of a post-mission disposal requirement alters the expectations of space station operators, the Commission has held that licensees have no vested right to an unchanged regulatory scheme throughout their license term. *See* Amendment of Part 1 of the Commission's Rules – Competitive Bidding Procedures, *Order on Reconsideration*, FCC 00-274, 15 FCC Rcd 15293, 15396 (2000), *pet. for recon. denied*, 18 FCC Rcd 10180 (2003). Furthermore, it is undisputed that the Commission has the power to alter existing licenses by a rulemaking procedure such as this. *See Celotronix*, 272 F.3d at 589 (citing *United States v. Storer Broadcasting Co.*, 351 U.S. 192, 205 (1956); *National Broadcasting Co. v. United States*, 319 U.S. 190, 225 (1943); *Committee for Effective Cellular Rules v. FCC*, 53 F.3d 1309, 1319-20 (D.C. Cir. 1995); *WBEN, Inc. v. FCC*, 396 F.2d 601, 617-18 (2d Cir. 1968)).

[201] *See* Telesat Comments at 8; Echostar January 30, 2004, Ex Parte at 1; SES Americom January 14, 2004, Ex Parte at 3; PanAmSat January 8, 2004, Ex Parte at 2.

[202] *See* SES Americom January 15 Ex Parte at 3. Other filings in the record support this conclusion. Telesat states that about one month of operational lifetime is lost in order to maneuver to a storage altitude 100-150 kilometers above GEO and that "two to three times" as much fuel is necessary to maneuver to 300 kilometers above GEO. *See* Telesat Comments at 8. EchoStar states that approximately four months of service life is lost by maneuvering to 300 kilometers above GEO. *See* EchoStar January 30 Ex Parte at 2.

in lost revenue to the industry.[203] While it is impossible to state the precise loss of operator revenue that would result from requiring on-orbit spacecraft to maneuver existing on-orbit spacecraft at end of life to disposal orbits calculated by use of the IADC formula, we accept that this loss of revenue could be significant and must be balanced against the public benefits of application of the IADC formula to all spacecraft, including those already on orbit.

80. We conclude that the risks resulting from grandfathering, such as increased risks of collision or risks associated with other fragmentation events occurring in the GEO region, currently are not sufficient to outweigh the potential financial hardships involved in applying the IADC formula to all GEO spacecraft currently on orbit. The record does not demonstrate the amount of increased risk that would result from a finite number of existing on-orbit spacecraft being disposed of at altitudes below those calculated by use of the IADC formula, but at an altitude from which the disposed spacecraft would not pose a risk to normally station-kept satellites.[204] Given the existing low spatial density of the GEO regions, there is insufficient evidence on the record at this time to conclude that this increase in risk would be significant.

81. Accordingly, we will grandfather all on orbit GEO spacecraft that were launched as of the release of the *Notice* in this proceeding.[205] We will not, however, grandfather all GEO spacecraft currently on-orbit or under construction as of the release of this Second Report and Order, as urged by some commenters. Operators generally agree that notice of our intent to implement the IADC formula was provided by the release of the *Orbital Debris Notice*.[206] Thus, equity concerns that support the exemption of satellites launched prior to the release of the *Notice* are not present with those satellites launched after the release when operators were on notice of the possible use of the IADC formula to evaluate the post-mission disposal of GEO spacecraft.[207] Operators that launched satellites after the release of the *Notice* were on notice of our intent to use the IADC formula. Furthermore, the long expected lifetimes of satellites launched since the release of the *Orbital Debris Notice* should allow operators reasonable time to take the IADC formula into account when planning for the disposal of their spacecraft.

82. Finally, we will not specify a minimum altitude for disposal of grandfathered satellites. The stated current practice of several U.S. operators is, barring catastrophic hardware failures, to execute end-of-life maneuvers that result in a disposal altitude no less than 150 kilometers above GEO.[208] Some non-

[203] SIA February 4 Ex Parte at 1. *See also* SES Americom January 14 Ex Parte at 6 (claiming $77 million in lost revenue from application of the IADC disposal formula to its existing on-orbit GEO fleet); PanAmSat January Ex Parte at 2 (claiming $140 million in lost revenue).

[204] We estimate that there are approximately 80 or fewer FCC-licensed GEO spacecraft that would be eligible for grandfathering.

[205] The *Orbital Debris Notice* was released on March 18, 2002.

[206] *See* SES Americom January 14 Ex Parte at 3 (stating that release of the *Notice* "marks the first time the Commission indicated that it would replace industry self-regulation with new rules"). *See also* SIA February 4, 2004 Ex Parte at 2 (stating that, "At a minimum, spacecraft launched prior to the release of the [*Notice*] should be grandfathered.").

[207] EchoStar argues that release of the *Notice* did not provide sufficient notice to justify "retroactive" application of disposal rules. *See* EchoStar January 30 Ex Parte at 2. EchoStar's argument, however, is based on the premise that application of rules to future disposal is contrary to the APA and Supreme Court's decision in *Bowen*. Since that is not the case, as discussed above, EchoStar's argument is not persuasive.

[208] A number of operators have exceeded this minimum, *see, e.g.,* Letter from Karis A. Hastings, Counsel for SES Americom, to Marlene H. Dortch, Secretary, FCC, dated February 12, 2004 (reporting the deorbit of the GSTAR4 satellite to an altitude more than 300 kilometers above GEO), and at least one U.S. licensed operator (Intelsat) has, (continued....)

U.S. operators have indicated a disposal perigee altitude range of 100-192 kilometers above GEO.[209] We urge operators to continue to evaluate the safety of any such practice in light of developing knowledge about risks in GEO and the surrounding region, and in light of the conditions of any particular spacecraft.[210] We also urge operators to exercise the highest standards, and applaud those who have voluntarily adopted practices, involving substantial margins of safety, designed to protect the unique and important geostationary-Earth orbit resource.[211]

b. NGSO Space Stations

83. *Background.* The *Orbital Debris Notice* sought comment on whether to adopt the U.S. Government Standard Practices as rules applicable to the post-mission disposal of new low-Earth orbit systems and to replacement satellites for such existing systems.[212] In particular, it noted that the U.S. Government Standard Practices calls for the disposal of LEO satellites at end of life either through immediate atmospheric re-entry or through the placement of a spacecraft into an orbit from which it will re-enter the Earth's atmosphere within 25 years. The *Notice* observed that the U.S. Government Standard Practices, if strictly applied, could have a significant impact on the deployment of spacecraft in certain orbital regimes or using certain types of technologies. Specifically, the *Notice* noted that spacecraft operating with circular orbits in the region of approximately 1000 to 1600 kilometers would be required to budget a substantial amount of fuel in order to either lower the spacecraft's perigee orbit to an altitude from within which it would re-enter the Earth's atmosphere within 25 years, or to boost the spacecraft into a storage orbit between low-Earth orbit and medium earth orbit.[213] In addition, it noted that many small satellite systems are currently deployed with only minimal on-board maneuvering capabilities. Thus, the *Notice* indicated that adoption of the U.S. Government Standard Practices into the Commission's rules could effectively preclude operations of such spacecraft at higher orbital altitudes. Finally, the *Notice* sought comment concerning the end-of-life disposal of spacecraft involving atmospheric re-entry.[214]

84. *Discussion.* As a result of the disclosure requirements we are adopting, we will receive information concerning end-of-life disposal for NGSO satellites. We intend to examine such disclosures on a case-by-case basis in light of the U.S. Government Standard Practices and the IADC Guidelines. In particular, we intend to examine such disclosures to determine, for spacecraft with orbits either wholly within, or passing through, the LEO region, whether the spacecraft will be disposed of at end of life either

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barring catastrophic failure, retired spacecraft consistent with the IADC recommendation in recent years. *See* C. Hernández and R. Jehn, *Classification of Geosynchronous Objects*, Issue 6, European Space Agency, European Space Operations Centre, Darmstadt, Germany (2004) at 109.

[209] Telesat Comments at 8; Inmarsat Dec. 23, 2003, Ex Parte at 1.

[210] For example, it may be preferable to dispose of a spacecraft in the GEO region, if that spacecraft faces a known and high risk of explosion in connection with thruster firings, because the consequences of an explosive fragmentation of the spacecraft considerably outweigh the future collision risk associated with disposal in GEO of an intact spacecraft.

[211] Note that our grandfathering action is not intended to address any issues of liability that may arise as a result of grandfathered spacecraft. *See The T.J. Hooper et.al. v. Northern Barge Corporation, et.al.,* 60 F.2d 737 (2nd Cir., 1932) (adoption by some ships of a practice of carrying radio sets to receive weather reports, even though not required by statute, considered relevant in assessing liability).

[212] *Orbital Debris Notice*, 17 FCC Rcd at 5609.

[213] *Id*.

[214] *Id*.

through immediate atmospheric re-entry, through the placement of a spacecraft into an orbit from which it will re-enter the Earth's atmosphere within 25 years, or through boosting the spacecraft into an orbit with a perigee above the LEO region.[215] As a general matter, these methods of post-mission disposal suggest that the space station will operate consistent with the public interest. We have already been evaluating the post-mission disposal plans of Commission-licensed LEO space stations based on this practice on a case-by-case basis.[216] If a disclosure indicates that a space station will not use one of these methods, the Commission may be required to seek further information, or ultimately to condition or withhold approval for the space station.

85. We recognize that changes in the design and operation of certain types of LEO spacecraft may be necessary in order to follow these practices and may limit an operator's ability to deploy spacecraft in certain orbital regimes or use certain spacecraft designs. On balance, however, we believe closer adherence to these practices is warranted in order to limit the growth of orbital debris in LEO. Without such disposal practices, objects could remain in low-Earth orbit for decades or centuries after the end of their useful lives and could become the source of collisions that produce additional debris spread over a wide area. By requiring LEO space stations to be removed from orbit within 25 years of the completion of their mission, the probability that such spacecraft will contribute to the creation of additional orbital debris is greatly diminished. The IADC Guidelines specifically note that an IADC study examined the effect of post-mission orbital lifetime limitations on collision rates and debris population growth and found 25 years to be a reasonable and appropriate lifetime limit.[217] None of the commenters raising concerns about adherence to LEO end-of-life practices takes issue with the general desirability of limiting debris growth. While closer adherence to these practices may require changes in spacecraft design, choice of a different orbit, or other changes, it appears that such changes would serve the public interest, and would help to ensure long-term, affordable access to space, as well as the continued availability, reliability, and continuity of space-based services for U.S. consumers.

86. We decline to adopt as rules the stricter disposal requirements for certain classes of LEO space stations, as recommended by some commenters in this proceeding. For example, Ecliptic proposes that large microsat constellations, consisting of 100 or more spacecraft, be limited to orbital altitudes from which they will re-enter the Earth's atmosphere within five years of mission completion, due to their lack of propulsion systems and low rate of reliability of individual spacecraft.[218] Ecliptic also recommends that all microsats, regardless of constellation size, be limited to altitudes of no higher than 625 kilometers at perigee.[219] L'Garde also suggests placing limits on the altitudes at which microsats can operate.[220] Both Ecliptic and L'Garde suggest that microsats, and other NGSO satellites lacking propulsion, be required to incorporate methods, such as the use of inflatable devices, to decrease their orbital lifetimes by

[215] The IADC Guidelines, unlike the U.S. Government Standard Practices, do not explicitly provide for the "boost" method of end-of-life disposal. However, because this method would remove the spacecraft from the LEO region, it would meet the primary goal of protecting this highly utilized region. Any such disposal plan should address, and will be analyzed, consistent our discussion, *infra*, concerning MEO disposal, to determine whether the disposal orbits chosen would be sufficiently stable to remain out of LEO and GEO, and to avoid physical interference with highly utilized MEO orbits.

[216] *See, e.g., Orbital Communications Corp.*, Order and Authorization, DA 02-772, 17 FCC Rcd 6337 (2002) (conditioning approval of an increase in the proposed orbital altitude of a licensee's Little LEO satellite constellation on measures being taken to reduce the orbital lifetime of the satellites).

[217] IADC Guidelines at Section 5.3.2.

[218] Ecliptic Comments at 7.

[219] *Id*.

[220] L'Garde Comments at 5.

means of atmospheric drag.[221] Although we agree that each of the measures proposed would appear to be a reasonable means by which a space station operator could mitigate debris under the circumstances presented by the commenters, we do not believe that adopting detailed rules of this type is appropriate at this time. We anticipate that as experience with debris mitigation measures grows, it may be possible to provide more detailed guidelines of this type. For now, however, we believe it is appropriate to address cases involving NGSO disposal as they arise. In light of concerns raised about the low rate of reliability of individual spacecraft, however, we note that it may be appropriate in some instances to address this issue as part of a debris mitigation showing, particularly with respect to satellite designs having known and significant failure rates, or where a satellite has been designed with an acceptable failure rate well below commercial industry norms. Reliability may be relevant to both assessment of whether the satellite will meet end-of-life goals, and to assessment of whether the public interest benefits arising from the satellite's activities will, in fact, be provided.

87. We will also continue to evaluate post-mission disposal plans for space stations in orbits that do not pass through LEO or GEO, such as highly elliptical or medium Earth orbits, on a case-by-case basis. The IADC Guidelines call for the end-of-life maneuvering of space stations that are using orbits other than LEO or GEO in order to reduce their orbital lifetimes to the 25 year timeframe for post-mission disposal of LEO spacecraft, or for relocation of such space stations into storage orbits if they cause interference with highly utilized orbit regions.[222] The IADC Guidelines do not, however, provide detailed recommendations for accomplishing these objectives. We note that technical studies are on-going to evaluate the long-term stability of disposal orbits in MEO.[223] Entities relying on such orbits should indicate with specificity what orbit will be used for disposal, and whether that orbit has been analyzed to determine its long-term stability.

88. Finally, the *Orbital Debris Notice* proposed to continue to require applicants proposing to dispose of spacecraft by means of atmospheric re-entry to provide an assessment of the risk of human casualty from such atmospheric re-entry. The *Notice* observed that the U.S. Government Standard Practices provide that any such disposal of a spacecraft should present a risk of human casualty of no more than 1 in 10,000.[224] The *Notice* observed that this assessment has been required in previous Commission case-by-case licensing decisions and is based on standards established by NASA Safety Standard NSS 1740.14 for debris re-entry and incorporated in the U.S. Government Standard Practices.[225] We will continue to require entities proposing to dispose of spacecraft by means of atmospheric re-entry to assess the risk of human casualty from such atmospheric re-entry and will review these assessments on a case-by-case basis.[226] No party to this proceeding opposed the continued evaluation of the human casualty risk assessment according to the standards of the NASA and U.S. Government Standard Practices. Entities may wish to look to the U.S. Government Standard Practices and NASA Safety Standard NSS 1740.14 (and any revisions to that standard) as a guide when preparing their assessment

[221] Ecliptic Comments at 7; L'Garde at 6.

[222] IADC Guidelines at Section 5.3.3.

[223] *See, e.g.,* C.C. Chao and R.A. Gick, "Long-Term Evolution of Navigation Satellite Orbits: PS/GLONASS/GALILEO" (COSPAR02-A-02858)(PEDAS1-B1.4-0051-02).

[224] *Orbital Debris Notice*, 17 FCC Rcd at 5610.

[225] *Id*.

[226] In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry and reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty.

and certification.[227]

c. Fuel Matters

89. *Background.* The *Orbital Debris Notice* sought comment whether an FCC rule is necessary to ensure that spacecraft reserve adequate fuel supplies at the end of useful life to execute post-mission disposal maneuvers, such as de-orbiting or removal to storage orbits.[228] The *Notice* noted that the reservation and expenditure of fuel for post-mission disposal maneuvers comes at the expense of income-producing activities, and sought comment whether measures might be necessary to ensure that spacecraft maintain adequate fuel at end of life, such as requiring operators to report the availability of fuel adequate to execute planned disposal maneuvers.[229] In this regard, it observed 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.[230] The *Notice* also sought comment on any other matters, including any technological developments, which might affect end-of-life procedures.

90. *Discussion.* We agree with commenters that it is unnecessary at this time for the Commission to mandate specific fuel levels for post-mission disposal maneuvers.[231] In the case of GEO spacecraft, we have specified that the IADC formula should be used to calculate the minimum perigee for an appropriate storage orbit for satellites launched subsequent to the release of the *Notice*. Satellite operators are in the best position to apply the IADC formula and determine the corresponding amount of fuel that must be reserved for a particular spacecraft in order to achieve the corresponding minimum perigee altitude. Likewise, operators of NGSO systems are also in the best position to determine how they will dispose of their spacecraft at the end of life and the corresponding amount of fuel to reserve to achieve disposal, if in fact the spacecraft plans to use propulsion as a means of disposal. We believe that operators have adequate incentive to reserve adequate fuel supplies to comply with our post-mission disposal requirement without the need for additional Commission mandates regarding fuel supplies.[232]

91. We conclude, however, that the public interest would be served by having space station operators disclose, as part of applications for Commission authorizations, the quantity of fuel – if any – they intend to reserve for post-mission disposal of their spacecraft, as well as the methodology used to derive that quantity, including the methods used to determine and address fuel gauging uncertainty. We conclude that such a requirement serves the public interest by demonstrating, prior to receiving Commission authority, that the space station operator has adequately planned for the post-mission disposal of its spacecraft. While this disclosure requirement does not eliminate the possibility of inadequate disposal as the result of operator error or unforeseen emergencies, as noted by one commenter,[233] it does provide reasonable assurance that an operator has addressed post-mission disposal

[227] These documents and software tools that may prove useful in completing debris mitigation statements, including any casualty risk assessment, can be found at the NASA orbital debris website, www.orbitaldebris.jsc.nasa.gov.

[228] *Id.* at 5609.

[229] *Id.* at 5602-03.

[230] *Id.* at 5609 (citing *AIAA 2001 Report* at 12).

[231] SIA Comments at 9-10, 16.

[232] In this respect, we agree with comments that argue that fuel gauging requirements are unnecessary if there are adequate penalties for non-compliance with disposal requirements. *See* MIT Lincoln Laboratories Comments at 3. We acknowledge that fuel gauging is "not an exact science," *see* SIA Comments at 10, and do not anticipate taking action against improper disposal of Commission-licensed space stations that result from fuel levels calculations that prove to be erroneous, but that are nonetheless made in good faith.

[233] Slabinski Comments at 1.

as part of its operational plans.

D. Scope of Rules

1. Non-U.S.-Licensed Space Stations

92. *Background*. The FCC has adopted procedures to facilitate provision of satellite services in the United States using space stations licensed by Administrations other than the United States pursuant to the commitments of the United States under the World Trade Organization (WTO) Agreement on Basic Telecommunications Services (WTO Telecom Agreement) and the General Agreement on Trade in Services (GATS).[234] Such non-U.S.-licensed space stations[235] can provide service to earth stations located in the United States through the provisions outlined in Section 25.137 of the Commission's rules.[236] A party following this procedure must submit the same technical information concerning the space station involved as is required to be submitted by U.S. space station license applicants.[237] The *Orbital Debris Notice* proposed to require submission of debris mitigation plans as part of such submissions of technical information.[238] In addition, the *Notice* sought comment on whether it should be deemed sufficient for non-U.S.-licensed space station operators 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.[239]

93. *Discussion.* We conclude that the public interest is served by requiring entities that request a Commission ruling for access to a non-U.S.-licensed space station to serve the U.S. market to submit the same information concerning the orbital debris mitigation plans of the non-U.S-licensed space station as that submitted by U.S.-licensed space stations. As we observed in the *Orbital Debris Notice*, some consideration of whether a space station serving the United States will employ reasonable debris

[234] The WTO came into being on January 1, 1995, pursuant to the Marrakesh Agreement Establishing the World Trade Organization (the Marrakesh Agreement). 33 I.L.M. 1125 (1994). The Marrakesh Agreement includes multilateral agreements on trade in goods, services, intellectual property, and dispute settlement. The GATS is Annex 1B of the Marrkesh Agreement. 33 I.L.M. 1167 (1994). The WTO Telecom Agreement was incorporated into the GATS by the Fourth Protocol to the GATS (April 30, 1996). 36 I.L.M. 354 (1997).

[235] The term "non-U.S.-licensed space station" refers 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 assumed responsibility for notification, coordination, and other relevant matters under the ITU Radio Regulations. *See Orbital Debris Notice*, 17 FCC Rcd at 5599 n.74.

[236] 47 C.F.R. § 25.137. The Commission's foreign entry framework was adopted in the *DISCO II* proceeding. *See Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Satellites Providing Domestic and International Service in the United States*, Report and Order, IB Docket No. 96-111, FCC 97-399, 12 FCC Rcd 24094 (1997) (*DISCO II Order* or *DISCO II*), *recon.* 15 FCC Rcd 7207 (1999) (*DISCO II First Reconsideration Order*), *recon. denied* 16 FCC Rcd 19794 (2001) (*DISCO II Second Reconsideration Order*). For a detailed summary of the *DISCO II* framework, we refer the reader to the *DISCO II First Reconsideration Order*, 15 FCC Rcd at 7209-10 (paras. 4-5).

[237] Until recently, operators of non-U.S.-licensed space stations were not required to submit certain technical information concerning the satellite if they had completed international coordination. *See DISCO II Order*, 12 FCC Rcd at 24175 (para. 189). As part of our Space Station Licensing Reform proceeding, however, we concluded that, in order to better determine whether a non-U.S.-licensed space station meets the Commission's technical requirements, non-U.S.-licensed space station operators seeking access to the U.S. market must provide the same information as U.S. satellite license applicants, regardless of whether they have completed international coordination. *See First Report and Order*, 18 FCC Rcd at 10872 (para. 300).

[238] *Orbital Debris Notice*, 17 FCC Rcd at 5611.

[239] *Id.* at 5611-12.

mitigation measures is appropriate, regardless of the licensing Administration, in order to ensure that the satellite communications activity that we authorize does not involve substantial safety concerns or activities that may be detrimental to space operations.[240] Most importantly, a categorical exemption for any class of satellites serving the United States would undermine the legitimate public policy objective of mitigating orbital debris, and thereby promoting continued affordable access to space, continued provision of reliable space-based services, and the safety of persons and property in space and on the surface of the Earth.

94. By requiring entities that request Commission approval to access the U.S. market via non-U.S.-licensed space stations to submit technical information concerning orbital debris mitigation, we are simply ensuring that foreign operators that seek access to the U.S. market for commercial reasons meet the same public interest requirements as U.S.-licensed operators. As comments point out,[241] this approach comports with our policy of requiring non-U.S. satellite operators to submit the same type of technical information that we require of U.S. space station licensees.[242] We observe that orbital debris mitigation plans are not unique in this regard, but are like a number of technical regulatory policy areas, such as compliance with FCC two-degree spacing policies, in which we seek technical information about non-U.S.-licensed space station systems relevant to the authorization of earth station operations in the United States.[243] Our review of the debris mitigation plans of all systems, whether involving U.S.-licensed or non-U.S.-licensed space stations, will be based on objective and transparent criteria set forth in this proceeding that have been designed to be no more burdensome than necessary to protect the public interest in mitigating orbital debris. Furthermore, these criteria have been developed in a manner consistent with the recommendations of international organizations, such as the ITU, which has recommended orbital debris mitigation measures since at least 1993.[244] Accordingly, we have no reason to believe that non-U.S.-licensed space stations will have any greater difficulty complying with our debris mitigation disclosure requirements than U.S.-licensed space stations.

95. Regarding the nature of the proposed debris mitigation showing by non-U.S.-licensed space stations, we conclude that the disclosure requirement can be satisfied by showing that the satellite system's debris mitigation plans are subject to direct and effective regulatory oversight by the satellite system's national licensing authority. This conclusion is supported by those parties that submitted comments on this question.[245] One method of making this showing is to submit an English language version of the debris mitigation rules or regulations of the national licensing authority and to indicate the current status of the national licensing authority's review of its debris mitigation plans.

96. We do not agree with comments that claim that requiring a non-U.S.-licensed space station to submit its orbital debris mitigation plan constitutes a "unilateral" or "extraterritorial" imposition of Commission rules.[246] Our review of orbital debris mitigation plans of non-U.S.-licensed space stations

[240] *Id.* at 5600, 5611.

[241] SIA Comments at 18; SES Americom Reply at 7.

[242] We note that the Commission has previously found that requiring prospective foreign entrants to meet the same qualification requirements, including technical requirements, that apply to U.S. applicants is consistent with the United States' obligations under the GATS. *See DISCO II Order*, 12 FCC Rcd at 24163.

[243] *See Orbital Debris Notice*, 17 FCC Rcd at 5611.

[244] As noted previously, the ITU, a specialized agency of the United Nations, has adopted a recommendation for the disposal of GEO space stations and has revised this recommendation to closely comport with the disposal guidelines proposed by the IADC. *See supra*, note 43.

[245] SIA Comments at 18; UM Space Law Center Comments at 4.

[246] Telesat Comments at 9.

applies only to those non-U.S. space station operators that for commercial reasons request to provide service to the U.S. market. As observed in the *Notice*,[247] this review does not give the Commission any ability to take direct enforcement action concerning a non-U.S. licensed space station; rather, Commission actions are limited to withholding or withdrawal of authority of U.S.-licensed earth stations to communicate with non-U.S.-licensed space stations. Thus, our review of debris mitigation plans as part of requests for Commission authorization in no way expands our existing authority regarding the ability of non-U.S.-licensed space stations to serve the U.S. market.

97. To the extent that our policy leads other countries to adopt orbital debris mitigation requirements of their own, as Telesat suggests,[248] we believe such a development would be desirable and fully consistent with our overall goal of mitigating orbital debris.[249] Because the debris mitigation rules that we adopt herein are consistent with the consensus recommendations of international institutions and the leading space-faring nations,[250] we anticipate that measures for mitigating orbital debris that may be adopted by other countries are likely to be consistent with those measures we adopt today.[251] Furthermore, although Telesat suggests that other nations may use orbital debris mitigation rules as a means to prevent entry of foreign satellite service providers,[252] we do not believe that the theoretical possibility that other countries could take ill-considered actions, at variance with international norms, in any way should prevent the Commission from adopting objective and transparent measures concerning orbital debris mitigation that serve that public interest.

2. Amateur and Experimental Licensees

98. *Background.* The Commission's rules include provisions in Parts 97 (amateur) and 5 (experimental) concerning satellites. The *Orbital Debris Notice* observed that amateur and experimental spacecraft can present the same public interest concerns as operations under other rule parts.[253] As a result, the *Notice* proposed to amend Parts 5 and 97 to require amateur and experimental space station licensees to submit the same disclosure regarding orbital debris mitigation plans as that submitted by operators subject to Part 25.[254] Specifically, the *Orbital Debris Notice* proposed to amend the texts of Sections 5.63 and 97.207(g) of the Commission's rules to require experimental and amateur satellite licensees to submit 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 a spacecraft – and to demonstrate that debris generation will not result from the

[247] *Orbital Debris Notice*, 17 FCC Rcd at 5611.

[248] Telesat Comments at 9.

[249] To the extent that our actions provide incentive for other spacefaring nations to adopt comparable orbital debris mitigation measures for their commercial satellite operators, our actions are consistent with the policy expressed in the 1996 National Space Policy, which states that it is in the interests of the U.S. Government to ensure orbital debris mitigation practices are applied by other spacefaring nations and international organizations.

[250] In this respect, Telesat's desire that we rely on debris mitigation measures developed through an international process appears to have been addressed.

[251] Furthermore, as the Commission has previously found, the chance that other countries may adopt licensing requirements for U.S. satellite operators seeking to provide service in that country is, on balance, a minimal burden when compared to the possibility that unrestricted entry by foreign-licensed satellites would vitiate our orbit efficiency policies. *See DISCO II Order*, 12 FCC Rcd at 24163.

[252] Telesat Comments at 9.

[253] *Orbital Debris Notice*, 17 FCC Rcd at 5612.

[254] *Id*. We also proposed to update references in the current rules to ITU documents concerning space station notifications, so that those references reflect current ITU documents. *See id.* at n.109.

conversion of energy sources on board the spacecraft into energy that fragments the spacecraft.[255]

99. *Discussion.* No comments oppose requiring amateur service and experimental radio service licensees to disclose their orbital debris mitigation plans as part of their applications for Commission authorization. We also note that AMSAT states that a disclosure requirement can be met by builders of amateur radio satellites.[256] For these reasons, we adopt our proposal to amend Sections 5.63 and 97.207(g) of the Commission's rules to require amateur service and experimental satellite licensees to submit a description of the design and operational strategies that will be used to mitigate orbital debris as part of their applications for Commission authorization. We will review the debris mitigation disclosures of amateur service and experimental space station licensees on a case-by-case basis to determine whether the licensee's proposed system will be consistent with requirements and policies adopted in this Second Report and Order, including measures for the post mission disposal of spacecraft. To the extent the information disclosed raises operational or orbital debris mitigation concerns, the Commission may seek further information, condition the authorization, or withhold approval, as necessary.

100. Some comments argue that either a temporary or permanent exception is warranted for amateur service space stations because of the allegedly high cost of compliance with mitigation requirements and the limited resources of amateur radio operators.[257] Other comments indicate that amateur service space station licensees should be exempt from such requirements because the amateur service has played an important role in the development and use of satellite technologies.[258] We decline to exempt amateur service space stations categorically from any need to address orbital debris mitigation because some amateur service space stations in low Earth orbit have expected post-mission orbital lifetimes that exceed the 25 year time period recommended by the U.S. Government Standard Practices and the IADC guidelines[259] and because the long orbital lifetimes of such amateur service satellites increases the probability that collisions between objects will occur thereby resulting in more orbital debris. For these reasons, we believe amateur service space stations pose the same public interest concerns with regard to orbital debris as space stations subject to other parts of our rules. We recognize that because most amateur service space craft are LEO spacecraft, post-mission disposal requirements may necessitate modifications in the current design and operation, either through the addition of propulsion systems or other strategies to cause a spacecraft to re-enter the Earth's atmosphere within 25 years of end of life, or by foregoing operations at higher orbital altitudes where the effects of atmospheric drag are not sufficiently strong by themselves to remove the space station from orbit within this 25-year time period. We believe, however, that the costs involved with these modifications are justified when

[255] *Id.*, Appendix B [Proposed Rule Changes].

[256] AMSAT Comments at 10.

[257] Leggett Comments at 2-3; Ecliptic Comments at 11-12 (stating that amateur and experimental licensees are the "most cost constrained" class of licensees); AMSAT Comments at 6-8; AMSAT Reply at 5 (stating that compliance with debris mitigation rules could impose costs on amateur satellite operations, either through the additional cost of adding propulsion systems to amateur space stations or through a reduction of the visible "footprint" of a propulsion-less satellite by restricting its operations to lower altitudes from which it will re-enter the Earth's within 25 years).

[258] Ecliptic Comments at 12-13.

[259] For example, the "Quakesat" microsatellite that was launched in June 2003 is expected to have an orbital lifetime of more than 41 years. This lifetime is derived using the NASA Orbital Debris Assessment Software (DAS version 1.5), which is available at http://www.orbitaldebris.jsc.nasa.gov. It is based on an orbit with apogee of 833 kilometers and perigee of 817 kilometers and on an area-to-mass ratio of 0.0542 m^2/kg (0.1626 m^2/3kg). The orbital characteristics of the Quakesat are published in NASA Satellite Situation Report, Volume 44, Number 9 (September 30, 2003). The nominal operational lifetime for Quakesat has been estimated at one year. *See* Quakesat website, which is available at http://www.quakefinder.com/quakesat.

balanced against the public interest in mitigating orbital debris.

101. Recently, AMSAT filed a proposal to modify the notification procedures for the licensing of amateur service satellites.[260] Our licensing rules for amateur service satellites currently require a license grantee of an amateur service space station to make written notifications of its proposed operations to the International Bureau prior to commencing operations. The first of these written notices is required no less than 27 months prior to initiating space station transmissions and must provide the technical characteristics of the space station required by Appendix 4 and Resolution No. 642 of the ITU Radio Regulations.[261] The second notice is required no less than five months prior to the initiation of space station transmissions and must provide the information regarding spurious emissions required by Appendix 3 and Resolution No. 642 of the ITU Radio Regulations.[262] AMSAT proposes to change the written notification requirements to provide for shorter notification periods and more streamlined information requirements.[263] The current notification periods, if followed by amateur applicants,[264] should generally provide sufficient time for Commission staff to review the orbital debris mitigation plans of amateur space stations prior to their launch and operation and should provide adequate time for applicants to correct any deficiencies revealed as a result of this review. We have recently commenced a rulemaking proceeding to consider proposals to shorten or otherwise alter the licensing process for amateur space stations.[265] As part of this rulemaking, we have sought comment on what actions the Commission should take if it is presented with an orbital debris mitigation plan that raises concerns as to the debris mitigation practices of an amateur service space station, as well as on any alternative licensing processes that may help us to evaluate whether the launch and operation of particular amateur space stations are consistent with the public interest.[266]

3. NOAA-Licensed Space Stations

102. *Background.* As described in the *Orbital Debris Notice*,[267] commercial remote sensing satellites are subject to regulation by both National Oceanic and Atmospheric Administration (NOAA) and the FCC. The Land Remote Sensing Policy Act of 1992 (Remote Sensing Act)[268] designated the Secretary of Commerce as the U.S. licensing authority for commercial remote sensing systems. Because

[260] *See* Radio Amateur Satellite Corporation Petition For Rule Making (filed December 2, 2002) (AMSAT Petition). The petition was placed on public notice on December 18, 2002. *See Public Notice*, Report No. 2589 (rel. Dec. 18, 2002).

[261] 47 C.F.R. § 97.207(g)(1).

[262] 47 C.F.R. § 97.207(g)(2).

[263] AMSAT Petition at 2 (proposing amending section 97.202(g) to provide for a single notification to the International Bureau 30 days after the amateur licensee obtains a launch commitment for the satellite and to limit the information provided to that described in Appendix 4 of the ITU Radio Regulations).

[264] We note that it is our experience that amateur space station licensees have not consistently submitted notifications to the Commission in the timely manner set out by Section 97.207(g).

[265] *Amendment of Part 97 of the Commission's Rules Governing the Amateur Radio Services*, Notice of Proposed Rulemaking, WT Docket No. 04-140, FCC 04-79, 19 FCC Rcd 7293 (paras. 73-77) (2004) (proposing, among other things, to require that pre-space notification be submitted within 30 days after the launch vehicle used to launch the amateur space station is determined, but no later than 90 days before the space station is integrated into the launch vehicle).

[266] *See id.* at para. 77.

[267] *Orbital Debris Notice*, 17 FCC Rcd at 5592.

[268] 15 U.S.C. § 5601 *et seq*.

commercial remote sensing satellites use radio frequencies to transmit data collected in space back to Earth, commercial remote sensing satellites typically must also obtain a separate license from the FCC pursuant to the Communications Act for the spectrum usage.[269] Thus, commercial remote sensing satellites hold NOAA licenses regarding the operation of the satellite, such as provisions regarding the resolution of the imagery, as well as from the FCC regarding spectrum use.

103. The Remote Sensing 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."[270] NOAA has interpreted this requirement to mean that a licensee shall assess and minimize the amount of orbital debris released during the post-mission disposal of its satellite.[271] Accordingly, NOAA requires applicants subject to its jurisdiction to provide, at the time of application for NOAA authorization, a plan for the post-mission disposal of remote sensing satellites, which is reviewed on a case-by-case basis.[272] Because NOAA already examines the post-mission disposal of remote sensing satellites, the *Orbital Debris Notice* tentatively concluded not to address matters involving post-mission disposal of NOAA-licensed satellites as part of its examination of the debris mitigation disclosures of remote sensing satellites.[273]

104. *Discussion.* We adopt the proposal of the *Notice*. There is no additional benefit to reviewing the post-mission disposal plans of commercial remote sensing satellite applicants when such plans are already subject to effective regulatory review by NOAA. Accordingly, to the extent that a remote sensing satellite applicant has submitted its post-mission disposal plans to NOAA for review and approval, we will not require submission of such information. Nonetheless, with respect to elements of debris mitigation other than post-mission disposal, and for which NOAA has not received information necessary for review and approval, we will require FCC remote sensing satellite applicants to submit such information as part of an application for Commission authority, and will review any such aspects of a remote sensing applicant's debris mitigation plans that are outside the scope of NOAA review.[274]

4. Launch Vehicles

105. *Background.* In the *Orbital Debris Notice*, the Commission sought comment on whether there are any matters involving launch vehicles that the FCC has authority to consider as part of its review of an orbital debris mitigation disclosure.[275] The *Notice* observed that Congress appointed the Department of Transportation to be the U.S. licensing authority for commercial launch operators pursuant to the Commercial Space Launch Act of 1984, as amended,[276] and that the Department of Transportation,

[269] 15 U.S.C. § 5625(e) (stating that Remote Sensing Act does not affect the authority of the FCC concerning the licensing of satellites transmitting radio communications).

[270] 15 U.S.C. § 5622(b)(4).

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

[272] *Id.*

[273] 15 U.S.C. § 5601 *et seq*. 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." *See id.* § 5622(b)(4).

[274] Should NOAA elect to receive and approve the orbital debris mitigation plans of remote sensing satellite applicants beyond post-mission disposal, we would consider waiver of our review of those elements already approved by NOAA.

[275] *Orbital Debris Notice,* 17 FCC Rcd at 5600.

[276] 49 U.S.C. § 70101 *et seq.*

through a delegation of authority to the Federal Aviation Administration, has already adopted detailed launch safety requirements that include measures to mitigate orbital debris and regulations requiring launch liability insurance.[277] The Commission has not required applicants for FCC space station licenses to submit information regarding debris mitigation plans for the launch vehicle that will be used to launch the space station, nor have we reviewed this information even if it is submitted.[278] The *Notice* did not propose to change this practice, but rather observed that matters addressed under the Commercial Space Launch Act and its implementing regulations are most appropriately addressed by the FAA.[279]

106. The *Orbital Debris Notice* inquired, however, whether the Commission would have the authority to consider launch-related matters that appear to be outside the scope of the Commercial Space Launch Act and FAA jurisdiction. For example, although FAA authorization is required for all launches from U.S. territory and for launches by U.S. citizens outside the United States,[280] the FAA does not regulate launches by non-U.S. citizens outside the United States. In the case where a company is seeking a FCC license and procuring its launch from a launch provider that is not subject to FAA jurisdiction, we sought comment on whether the Commission could consider orbital debris issues involving the launch vehicle used to launch the satellite system, if asked to do so.[281]

107. *Discussion.* Arianespace, a non-U.S. provider of launch services, opposes any consideration of launch vehicles as part of the Commission's licensing process. It asserts that the Commission lacks statutory authority under either the Commercial Space Launch Act or the Communications Act to consider matters relating to launch vehicles.[282] Arianespace also claims that FCC consideration of matters related to non-U.S. launch vehicles would constitute an extraterritorial and unilateral extension of FCC authority, which would undermine negotiations conducted by U.S. Executive branch agencies in multilateral bodies, such as the IADC and UNCOPOUS.[283] Finally, Arianespace argues that submitting non-U.S. launch vehicles to the Commission's debris mitigation requirements would subject non-U.S. launch providers to duplicative and dual regulation, since Arianespace claims that it will be subject to the debris mitigation regulations of France and the European Space Agency.[284] Even if the Commission adopts orbital debris mitigation rules similar to those imposed by other nations, Arianespace asserts that a non-U.S. launch provider would still incur additional costs by having to participate in the Commission licensing process on behalf of its customer and would face the market uncertainty of whether its orbital debris mitigation plans are acceptable to the Commission.[285]

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[277] *Orbital Debris Notice*, 17 FCC Rcd at 5592-93. The FAA's implementing regulations are codified at 14 C.F.R. Ch. III, § 400 *et seq*. The FAA's authority over payloads does not extend to payloads subject to regulation by the FCC or NOAA, and the FAA's authority does not cover space activities conducted by and for the U.S. Government. *See* 49 U.S.C. § 70117(b) and (g).

[278] *Orbital Debris Notice*, 17 FCC Rcd at 5600 (citing *The Boeing Company*, Order and Authorization, DA 01-1631, 16 FCC Rcd 13691, 13704(para. 33) (2001)).

[279] *Id*.

[280] 49 U.S.C. §§ 70102 and 70104. Section 70102(1) of the Commercial Space Launch Act defines "citizen of the United States" to mean: "(A) an individual who is a citizen of the United States; (B) an entity organized or existing under the laws of the United States; or (C) an entity organized or existing under the laws of a foreign country if the controlling interest…is held by an individual or entity described in subclause (A) or (B). . . ."

[281] *Orbital Debris Notice*, 17 FCC Rcd at 5600.

[282] Arianespace Comments at 3.

[283] *Id.* at 4-5.

[284] *Id.* at 6.

[285] *Id.* at 7-8.

108. We see no reason to alter our current practice of not requiring information about the launch vehicle used to launch a Commission-authorized space station into orbit. We agree with Arianespace that it is highly unlikely that there would be any significant public interest concerns regarding orbital debris that would arise from the use of a particular launch vehicle due to the highly regulated nature of the launch industry, both within the United States and abroad,[286] and the active participation of the launch vehicle industry in the formulation of debris mitigation measures. We disagree with Arianespace, however, that the Commission lacks the authority to address these concerns, insofar as they involve a non-U.S. licensed launch provider, should they be brought to our attention in a specific space station licensing case. The Communications Act requires the Commission to ascertain that the grant of an authorization to construct, launch and implement a space station serves the public interest and makes no exemption or distinction for public interest concerns related to the launch vehicle used as part of the launch of that space station. While we do not anticipate that we will need to consider such concerns due to the commitment of the launch industry, and of a wide range of responsible authorities in the major space-faring nations, to mitigate orbital debris, we retain the discretion to consider such concerns in the event that they are brought to our attention as part of a request for Commission authorization of a particular space station. For example, commenters observe that upper stages of launch vehicles sometimes carry secondary payloads and experiments that are designed not to separate from the upper stage, including amateur radio satellites.[287] In such a case, the upper stage of the launch vehicle effectively becomes part of the space station that is seeking Commission authorization to operate. To the extent that the debris mitigation disclosure certifies that the debris mitigation plans of the launch vehicle upper stage have been, or will be, reviewed by the FAA, no further FCC examination of the debris mitigation plans of the upper stage will be required. We anticipate that the same deference will be extended to entities who demonstrate that the debris mitigation plans of the utilized upper stage are subject to direct and effective regulatory control by another national regulatory agency and the entity certifies that the upper stage will conform to the orbital debris mitigation practices adopted by the national regulatory agency.

E. Liability Issues and Insurance

109. *Background.* The *Orbital Debris Notice* sought comment on the role that liability considerations and insurance should play in decisions regarding debris mitigation measures. As observed in the *Notice*,[288] the United States is party to two international treaties that address liability arising from activities in outer space.[289] The Outer Space Treaty requires that State Parties bear international responsibility for national activities in space, whether carried out by governmental agencies or non-governmental entities.[290] Article VII of the Outer Space Treaty provides that, "Each State Party to the Treaty that launches or procures the launching of an object into outer space … is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies."[291] The definition of "space object" includes "component parts of a space object" and thus may, at least arguably, incorporate orbital debris resulting from satellite operations. The Convention on International Liability for Damage Caused by Space Objects (Liability Convention) elaborates on Article

[286] *Id.* at 7 (observing that Arianespace launch vehicles are subject to debris mitigation guidelines promulgated by France's Centre National des Études Spatiales (CNES) and the European Space Agency (ESA)).

[287] AMSAT Comments at 5.

[288] *Orbital Debris Notice*, 17 FCC Rcd at 5595.

[289] Full text of the U.N. treaties are available on-line at http://www.oosa.unvienna.org/SpaceLaw/treaties.html.

[290] Outer Space Treaty, Article VI.

[291] Outer Space Treaty, Article VII.

VII of the Outer Space Treaty and provides that a "launching state shall be absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth or to aircraft flight."[292] In the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the Liability Convention states that the launching state "shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible."[293] A "launching state" is defined as either (1) a State which launches or procures the launching of a space object, or (2) a State from whose territory or facility a space object is launched.[294]

110. Accordingly, under international law, the United States government could potentially be presented with a claim under the Liability Convention for certain damage that may result from private space station operations, including disposal, maneuvering, and the generation of orbital debris. Congress has adopted a comprehensive statutory regime to address liability issues arising from the launch of spacecraft by private entities.[295] Under that statute, the FAA requires its launch licensees to obtain insurance for potential liability to third parties resulting from launch mishaps.[296] These insurance requirements do not, however, address post-launch issues arising from damages caused by a space station payload after a nominal launch is concluded.[297] The *Notice* sought comment on whether there are circumstances in which Commission-licensed space stations should be required to obtain insurance in order to protect the United States and its taxpayers from exposure to third-party liability arising from orbital debris, or in order to provide economic incentives for operators to adopt debris mitigation strategies that reduce risk and lower insurance premiums.[298] The *Notice* also sought comment on whether different types of risk may differ with respect to whether they can be appropriately addressed through insurance, as well as the Commission's authority to require such insurance.[299]

111. *Discussion.* We agree with comments that state that there may be cases where requiring operators to obtain insurance would not be unreasonable given the potential risk assumed by the U.S. government under international law, and that insurance can, in some instances, provide an economic incentive for operators to undertake debris mitigation measures.[300] We have found in the past that the existence of insurance policies to address orbital debris risks was a relevant public interest factor in approving an applicant's plans to dispose of its space stations at the end of life by means of atmospheric re-entry.[301] SIA agrees that insurance requirements may be necessary with respect to satellites that will be disposed of through atmospheric re-entry, since there is a potential risk of damage and insurance has proven to be available in the past for such disposal.[302] We anticipate that insurance and liability issues

[292] Liability Convention, Article I.

[293] Liability Convention, Article II.

[294] Liability Convention, Article I.

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

[296] 14 C.F.R. § 440.1 *et seq.*

[297] Under FAA regulations, third-party liability insurance is required to remain in effect only for 30 days after the later of vehicle ignition or payload separation. *See* 14 C.F.R. § 440.11.

[298] *Orbital Debris Notice*, 17 FCC Rcd at 5611.

[299] *Id*.

[300] UM Space Law Center Comments at 5.

[301] *See Space System Licensee, et al.*, Memorandum Opinion, Order and Authorization, DA 02-307, 17 FCC Rcd 2271 (Int'l Bur. 2002).

[302] SIA Comments at 17.

will continue to play a role in the determination of whether approval of a particular debris mitigation plan serves the public interest, particularly when the plan involve activities such as atmospheric re-entry, which may involve more immediate and substantial risks to persons and property on the surface of the Earth.

112. With respect to other potential activities that might be the subject of any insurance requirement, we indicated in the *Notice* that debris objects have potentially very long orbital lifetimes.[303] Those lifetimes may range into the hundreds or thousands of years. Thus, the period for insurance coverage against damage caused by orbital debris may exceed the period of time typically covered by commercially available insurance policies. We conclude that such risks are not ones that may be addressed through insurance requirements. As for risks that occur during the normal operation of the space station, comments indicate that many operators already obtain insurance for such operations.[304] We decline to adopt a specific requirement with regards to insurance for such normal operations, but note that in specific cases the existence of, or availability of, insurance may be considered as a factor in our public interest determinations.

113. With respect to liability issues, we stress that our examination of debris mitigation and post-mission disposal plans is restricted to an inquiry as to whether a space station operator has taken debris mitigation measures into account during the design and operation of its spacecraft and as to whether such designs and operations might raise obvious public interest concerns. Our review of an applicant's debris mitigation plan, or a grant of authority to dispose of a space station at the end of life, does not address, nor is it intended to alter, any liability of the space station applicant or any other private company in connection with the commissioning, operation, or de-commissioning of its satellite system.[305]

F. Other Matters

114. *Background.* In response to the *Orbital Debris Notice*, certain proposals were made in addition to those raised by the *Notice*. In particular, Slabinski proposes that space station licensees in the geostationary-Earth orbit be required to post a one-million dollar bond per space station to the FCC or some other agency before launch, which would be refunded only after the space station is disposed at end of life to a proper disposal orbit.[306] The bond amount would be forfeited if the space station is not properly disposed of at end of life, or the amount would be returned on a pro-rated basis if the actual disposal orbit was raised only part way to the minimum required disposal orbit.[307] Slabinski argues that the posting of such a bond would provide additional economic incentive to space station licensees to ensure that their space stations are properly disposed of at the end of life. In addition, Slabinski urges adoption of a requirement that all space station licensees should procure and maintain comprehensive, up-to-date and readily available documentation that explains the spacecraft idiosyncrasies and end-of-life maneuver procedures.[308] This documentation would include reports of all operational anomalies.[309] Although Slabinski does not expressly state the purpose of this documentation, it can be inferred that it

[303] *Orbital Debris Notice*, 17 FCC Rcd at 5611.

[304] AON Space Comments at 4-5.

[305] *See Space System Licensee, et al.*, 17 FCC Rcd at 2291 n.132.

[306] Slabinski Comments at 1.

[307] *Id*.

[308] *Id.* at 3.

[309] *Id*. Slabinski also urges that this documentation be maintained in paper form, given that technology is likely to change over the 15 years or more of a space station's functional lifetime, and electronic copies of documentation may not be readable by the end of a space station's life.

would be to preserve a record for the decisions made with regard to the post-mission disposal of a space station, which could occur a decade or more after launch.

115. *Discussion.* We decline at this time to impose a bond requirement for post-mission disposal of geostationary-Earth orbit satellites. Although we recently adopted a milestone performance bond requirement as part of the recent reform of our space station licensing procedures,[310] we do not find that a similar bond requirement is appropriate at this time with regard to post-mission disposal of GEO space stations. The rules that we adopt regarding post-mission disposal of Commission-licensed space stations should provide incentive for operators to dispose of their spacecraft at the end of life in a manner consistent with orbital debris mitigation objectives. Although we disagree with commenters that it would be prohibitively difficult to administer such a bond requirement,[311] we do not believe that the public interest would be served by requiring Commission licensees to post a bond which would not be returnable to the licensee for fifteen years or more, based on the current operational lifetimes of GEO communications satellites.[312] To the extent that Slablinski's proposal is intended to ensure that operators exercise their best efforts to properly perform end-of-life measures, we note that, if an operator fails to meet goals for proper end-of-life measures, the Commission has the authority to investigate the reasons for that failure, and take further regulatory measures, including enforcement action in appropriate cases.

116. We also decline to adopt additional document maintenance requirements for Commission space station licensees, as suggested by Slabinski. Slabinski has not provided any evidence to support the contention that space station licensees are not adequately maintaining records concerning their spacecraft, or that record maintenance is a direct influence on orbital debris creation or mitigation. Accordingly, we do not perceive any public interest benefit in adopting requirements regarding record retention and format of spacecraft documentation.

IV. CONCLUSION

117. Orbital debris mitigation measures are an important part of satellite operations in the public interest. Accordingly, we amend our rules to require disclosure of orbital debris mitigation plans as part of the technical information submitted pursuant to Section 25.114 of the Commission's rules. Specifically, a satellite system operator requesting FCC space station authorization, or an entity requesting a Commission ruling for access to a non-U.S.-licensed space station under our satellite market access procedures, must submit an orbital debris mitigation plan to the Commission regarding spacecraft design and operation in connection with its request. In addition, we provide guidance on the preparation of these plans and adopt post-mission disposal requirements for certain Commission-licensed space stations in the GEO and LEO orbital regimes. We will also initiate a further notice of proposed rulemaking to consider amending Section 25.210(j) to provide an explicit extension of an ±0.05° longitudinal tolerance to all Commission space stations, including MSS and remote sensing space stations. The actions that we take today will help ensure the continued affordable access to space, the continued provisions of reliable space-based communications services, and the continued safety of persons and property on the surface of the Earth.

[310] *First Report and Order*, 18 FCC Rcd at 10825 (para. 167).

[311] SES Americom Reply at 5 (arguing that a bond requirement raises numerous questions about the proper amount of any bond and how the Commission would determine whether the bond conditions have been satisfied).

[312] By contrast, the bond requirement adopted as part of our space station licensing reform is extent only for the relatively short period of time between licensing of the space station and the commencement of service via the licensed system. *See First Report & Order*, 18 FCC Rcd at 10825 (para. 167).

V. PROCEDURAL MATTERS

A. Final Regulatory Flexibility Act Analysis

118. As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[313] an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Orbital Debris Notice*.[314] The Commission sought written public comment on the proposals in the *Orbital Debris Notice*, including comment on the IRFA. The comments received are discussed below. Pursuant to the RFA, [315] a Final Regulatory Flexibility Analysis (FRFA) is contained in Appendix C.[316]

B. Final Paperwork Reduction Act of 1995 Analysis

119. This document does not contain new or modified information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. The Commission obtained OMB approval for the information collection requirements specified in the Second Report and Order. The OMB Control Number for the approved information collection is 3060-1013.

120. The Commission will send a copy of the Second Report and Order in a report to be sent to Congress and the General Accounting Office (GAO) pursuant to the Congressional Review Act, see 5 U.S.C. 801(a)(1)(A).

VI. ORDERING CLAUSES

121. Accordingly, IT IS ORDERED, pursuant to Sections 1, 4(i), 301, 303, 308, 309 and 310 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 151, 154(i), 301, 303, 308, 309 and 310, that this Second Report and Order in IB Docket No. 02-54 is hereby ADOPTED.

122. IT IS FURTHER ORDERED that Parts 5, 25 and 97 of the Commission's rules ARE AMENDED as set forth in Appendix B.

123. IT IS FURTHER ORDERED that the Consumer Information Bureau, Reference Information Center, SHALL SEND a copy of this Second Report and Order, including the Final Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

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

[314] *See Mitigation of Orbital Debris*, Notice of Proposed Rulemaking, IB Docket No. 02-54, FCC 02-80, 17 FCC Rcd 5586, 5613 (2002).

[315] *See* 5 U.S.C. § 604.

[316] *See* 5 U.S.C. § 604.

APPENDIX A – Parties Filing Pleadings

Comments

AON Space, Inc.
Arianespace Inc.
Ecliptic Enterprises Corp.
L'Garde, Inc.
Nickolaus E. Leggett
Orbcomm LLC
PanAmSat Corp.
Radio Amateur Satellite Corp. (AMSAT)
Satellite Industry Association (SIA)
Telesat Canada
University of Mississippi School of Law National Remote Sensing and Space Law Center (UM Space Law Center)
Victor J. Slabinski

Reply Comments

Radio Amateur Satellite Corp.
SES Americom, Inc.
Telesat Canada
Victor J. Slabinski

Late-Filed Comments & Ex Parte Communications

Boeing Company
EADS Astrium
EchoStar Satellite LLC
Inmarsat Ventures Ltd.
Intelsat Global Services Corp.
Iridium Satellite LLC
Massachusetts Institute of Technology Lincoln Laboratory (MIT Lincoln Labs)
PanAmSat Corp.
Satellite Industry Association
SES Americom, Inc.
Telesat Canada

APPENDIX B – Rule Revisions

For the reasons discuss above, the Federal Communications Commission amends title 47 of the Code of Federal Regulations, parts 5, 25, and 97, as follows:

PART 5 -- EXPERIMENTAL RADIO SERVICE (OTHER THAN BROADCAST)

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

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

2. Add new paragraph (e) to § 5.63 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 the following information:

(1) A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal;

(2) A statement that the space station operator has assessed and limited the probability of accidental explosions during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. 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;

(3) A statement that the space station operator has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Where a space station will be launched into a low-Earth orbit that is identical, or very similar, to an orbit used by other space stations, the statement must include an analysis of the potential risk of collision and a description of what measures the space station operator plans to take to avoid in-orbit collisions. If the space station operator is relying on coordination with another system, the statement must indicate what steps have been taken to contact, and ascertain the likelihood of successful coordination of physical operations with, the other system. The statement must disclose the accuracy – if any – with which orbital parameters of non-geostationary satellite orbit space stations will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances, *i.e.*, it lacks a propulsion system for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites

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

(4) A statement detailing the post-mission disposal plans for the space station at end of life, including the quantity of fuel – if any – that will be reserved for post-mission disposal maneuvers. For geostationary-Earth orbit space stations, the statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude. The statement must also include a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the space station. In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry and reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty.

PART 25 -- SATELLITE COMMUNICATIONS

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

Authority: 47 U.S.C. 701-744. Interprets or applies Sections 4, 301, 302, 303, 307, 309 and 332 of the Communications Act, as amended, 47 U.S.C. Sections 154, 301, 302, 303, 307, 309 and 332, unless otherwise noted.

4. Add new paragraph (d)(14) to § 25.114 to read as follows:

§ 25.114 Applications for Space Station Authorizations.

* * * * *

(d) * * *

(14) A description of the design and operational strategies that will be used to mitigate orbital debris, including the following information:

(i) A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal;

(ii) A statement that the space station operator has assessed and limited the probability of accidental explosions during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. 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;

(iii) A statement that the space station operator has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Where a space station will be launched into a low-Earth orbit that is identical, or very similar, to an orbit used by other space stations, the statement must include an analysis of the potential risk of collision and a description of what measures the space station operator plans to take to avoid in-orbit collisions. If the space station operator is relying on coordination with another system, the statement must indicate what steps have been taken to contact, and ascertain the likelihood of successful coordination of physical operations with, the other system. The statement must disclose the accuracy – if any – with which orbital parameters of non-geostationary satellite orbit space stations will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a

system is not able to maintain orbital tolerances, *i.e.*, it lacks a propulsion system for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap. If so, the statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions;

(iv) A statement detailing the post-mission disposal plans for the space station at end of life, including the quantity of fuel – if any – that will be reserved for post-mission disposal maneuvers. For geostationary-Earth orbit space stations, the statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude. The statement must also include a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the space station. In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry and reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty.

* * * * *

5. Revise § 25.143(b)(1) to read as follows:

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

* * * * *

(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 and legal qualifications of the applicant. In particular, each application shall include the information specified in § 25.114. Non-U.S. licensed systems shall comply with the provisions of § 25.137.

* * * * *

6. Remove and reserve § 25.145(c)(3) to read as follows:

§ 25.145 Licensing conditions for the Fixed-Satellite Service in the 20/30 GHz bands.

* * * * *

(c) * * *

(3) [reserved.]

* * * * *

7. Remove and reserve § 25.146(i)(4) to read as follows:

§ 25.146 Licensing and operating authorization provisions for the non-geostationary satellite orbit fixed-satellite service (NGSO FSS) in the bands 10.7 GHz to 14.5 GHz.

* * * * *

(i) * * *

(4) [reserved.]

* * * * *

8. Revise § 25.210(j) to read as follows:

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

* * * * *

(j) Space stations operated in the geostationary satellite orbit must be maintained within 0.05^{o} 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 25.283(b) (End-of-life Disposal).

* * * * *

9. Remove and reserve § 25.217 (d) to read as follows:

§ 25.217 Default Service Rules.

* * * * *

(d) [reserved.]

* * * * *

10. Revise § 25.280 to read 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 25.283 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.

11. Add § 25.282 to subpart D to read as follows:

§ 25.282 Orbit Raising Maneuvers.

(a) A space station authorized to operate in the geostationary satellite orbit under this Part is also authorized to transmit in connection with short-term, transitory maneuvers directly related to post-launch, orbit-raising maneuvers, provided that the following conditions are met:

(1) Authority is limited to those tracking, telemetry, and control frequencies in which the space station is authorized to operate once it reaches its assigned geostationary orbital location;

(2) In the event that any unacceptable interference does occur, the space station licensee shall cease operations until the issue is rectified;

(3) The space station licensee is required to accept interference from any lawfully operating satellite network or radio communication system.

12. Add § 25.283 to subpart D to read as follows:

§ 25.283 End-of-Life Disposal.

(a) *Geostationary orbit space stations.* Unless otherwise explicitly specified in an authorization, a space station authorized to operate in the geostationary satellite orbit under this Part shall be relocated, at the end of its useful life, barring catastrophic failure of satellite components, 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.

(b) 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 conditions of subsection (a) are met, and on the condition that the space station's tracking, telemetry and control transmissions are planned so as to avoid electrical interference to other space stations, and coordinated with any potentially affected satellite networks.

(c) *All space stations.* Upon completion of any relocation authorized by subsection (b), or any relocation at end-of-life specified in an authorization, or upon a spacecraft otherwise completing its authorized mission, a space station licensee shall ensure, unless prevented by technical failures beyond its control, that all stored energy sources on board the satellite are discharged, by venting excess propellant, discharging batteries, relieving pressure vessels, and other appropriate measures.

(d) The minimum perigee requirement of subsection (a) shall not apply to space stations launched prior to March 18, 2002.

PART 97 -- AMATEUR RADIO SERVICE

13. The authority citation for Part 97 continues to read as follows:

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

14. Revise § 97.207(g) to read 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 the following information:

(i) A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal;

(ii) A statement that the space station operator has assessed and limited the probability of accidental explosions during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. 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;

(iii) A statement that the space station operator has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Where a space station will be launched into a low-Earth orbit that is identical, or very similar, to an orbit used by other space stations, the statement must include an analysis of the potential risk of collision and a description of what measures the space station operator plans to take to avoid in-orbit collisions. If the space station operator is relying on coordination with another system, the statement must indicate what steps have been taken to contact, and ascertain the likelihood of successful coordination of physical operations with, the other system. The statement must disclose the accuracy – if any – with which orbital parameters of non-geostationary satellite orbit space stations will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances, *i.e.*, it lacks a propulsion system for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites

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

(iv) A statement detailing the post-mission disposal plans for the space station at end of life, including the quantity of fuel – if any – that will be reserved for post-mission disposal maneuvers. For geostationary-Earth orbit space stations, the statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude. The statement must also include a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the space station. In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry and reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty.

(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 – Final Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[317] an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the Notice of Proposed Rulemaking in the Matter of Mitigation of Orbital Debris (*Orbital Debris Notice*).[318] The Commission sought written public comment on the proposals in the *Orbital Debris Notice*, including comment on the IRFA. The comments received are discussed below. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.[319]

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 a debris 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 – particularly high-value orbits such as low-Earth orbit (LEO)[320] and geostationary-Earth orbit (GEO)[321] – for communications and other uses in the future, by raising the costs and lowering the reliability of space-based systems.

This Second Report and Order adopts rules to minimize the creation of orbital debris by FCC-authorized satellites. Minimizing the creation of orbital debris will help to ensure continued affordable access to space by the United States, the continued provision of U.S. space-based communications, and the continued safety of persons and property in space and on the surface of the Earth. In addition, the adoption of orbital debris mitigation rules by the FCC furthers the long-standing policy of the United States to minimize the creation of orbital debris, and is consistent with international policies and initiatives to mitigate orbital debris.

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

[318] *See Mitigation of Orbital Debris*, Notice of Proposed Rulemaking, IB Docket No. 02-54, FCC 02-80, 17 FCC Rcd 5586, 5613 (2002).

[319] *See* 5 U.S.C. § 604.

[320] For purposes of the Second Report and Order, the term LEO is used to refer to the orbits at altitudes below 2,000 kilometers.

[321] GEO is a circular orbit along the plane of the Earth's equator at an altitude of approximately 35,786 kilometers. A spacecraft in geostationary-Earth orbit can be maintained at a constant longitudinal position relative to the Earth, thus allowing the satellite to be "seen" continuously from, and at a fixed orientation to, any given point on the Earth's surface.

B. Summary of Significant Issues Raised by Public Comments in Response to the IRFA

Two parties submitted comments that specifically responded to the IRFA. The Radio Amateur Satellite Corporation (AMSAT)[322] contends that it and its constituent members qualify as "small entities" that must be considered in the Commission's formulation of any new rules that may be applicable to the amateur-satellite service. In addition, the University of Mississippi National Remote Sensing and Space Law Center (UM Space Law Center)[323] proposes that, although threshold requirements for orbital debris mitigation should be set by the FCC, the orbital debris mitigation plans of small entities should be reviewed on a case-by-case basis and that small entities should be able to seek exemptions from orbital debris mitigation reporting or compliance requirements if specific reasons for the exemption can be shown.

There is no significant economic impact on AMSAT or its constituent members under the RFA. AMSAT is a non-profit scientific and educational organization that represents individuals who hold amateur radio licenses under Part 97 of the FCC rules, 47 C.F.R. § 97, and who operate or communicate with amateur space stations. Because only individuals may hold amateur licenses and amateur licensees are precluded from operating for commercial purposes, neither AMSAT nor individual amateur licensees fit the definition of small entity, as defined by the SBA.[324] Nonetheless, the Second Report and Order has addressed the proposal of AMSAT and other commenters to exempt categorically amateur space stations from orbital debris mitigation requirements and found such proposals to be inconsistent with the purpose and object of such requirements.[325]

Furthermore, the rules adopted in the Second Report and Order are consistent with the proposals of the UM Space Law Center. Under the new rules, the elements of the orbital debris mitigation plans of all parties – not just small entities – are reviewed on a case-by-case basis in the majority of instances. Where the rules adopt rules in lieu of case-by-case review, such as for the post-mission disposal of GEO satellites, parties are permitted under existing FCC rules to seek waivers of such requirements for specific good cause shown.[326] In addition, the Second Report and Order exempts, or "grandfathers," in-orbit GEO satellites that were launched prior to the release of the *Orbital Debris Notice* on March 18, 2002 from the minimum post-mission disposal altitude requirement that are adopted by the Commission.[327] Comments indicated that the financial impact of the post-mission disposal rules for GEO spacecraft would be greatest for this class of satellites, including any that may be operated by small entities.

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.[328] The RFA generally

[322] Comments of the Radio Amateur Satellite Corporation Regarding Initial Regulatory Flexibility Analysis, IB Docket No. 02-54 (filed July 17, 2002).

[323] Response of the University of Mississippi National Remote Sensing and Space Law Center to Initial Regulatory Flexibility Analysis, IB Docket No. 02-54 (filed July 16, 2002).

[324] *See* 5 U.S.C. § 601(6) ("small entity" has same meaning as "small business" under RFA).

[325] *See Second Report and Order* at paras. 89-92.

[326] *See* 47 C.F.R. § 1.3.

[327] *See Second Report and Order* at Section III.D.4.i.

[328] 5 U.S.C. § 603(b)(3).

defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[329] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[330] 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).[331] A small organization is generally "any not-for-profit enterprise which is independently owned and operated and is not dominant in its field."[332] Nationwide, as of 1992, there were approximately 275,801 small organizations.[333] "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."[334] As of 1992, there were approximately 85,006 such jurisdictions in the United States.[335] This number includes 38,978 counties, cities, and towns; of these, 37,566, or 96 percent, have populations of fewer than 50,000.[336] 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 Second Report and Order 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.[337] The SBA has developed a small business size standard for Satellite Telecommunications, which consists of all such firms having $12.5 million or less in annual receipts.[338] According to Census Bureau data for 1997, in this category there was a total of 324 firms that operated for the entire year.[339] Of this total, 273 firms had annual receipts of under $10 million, and an additional twenty-four firms had receipts of $10 million to $24,999,999.[340] Thus, under this size standard, the majority of firms can be considered small.

[329] *Id*. § 601(6).

[330] 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).

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

[332] 5 U.S.C. § 601(4).

[333] 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).

[334] 5 U.S.C. § 601(5).

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

[336] *Id*.

[337] "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.

[338] 13 C.F.R. § 121.201, NAIC code 517410 (changed from 513340 in October 2002).

[339] U.S. Census Bureau, 1997 Economic Census, Subject Series: Information, "Establishment and Firm Size (Including Legal Form of Organization)," Table 4, NAICS code 513340 (issued October 2000).

[340] *Id.*

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

Under the rules as amended by the Second Report and Order, a satellite system operator requesting FCC space station authorization, or an entity requesting a Commission ruling for access to a non-U.S.-licensed space station under the FCC's satellite market access procedures, must submit an orbital debris mitigation plan to the Commission regarding spacecraft design and operation in connection with its request. The Second Report and Order provides guidance for the preparation of such plans. The Second Report and Order also adopt requirements concerning the post-mission disposal of Commission-licensed space stations operating in or near the two most heavily used orbital regimes, low-Earth orbit and geostationary-Earth orbit.

As discussed below in Section E, all parties requesting Commission authorization to operate a space station or a ruling for access to a non-U.S.-licensed space station must already demonstrate under existing FCC rules that they have the technical and legal ability to conduct such operations as a prerequisite to grant of an FCC authorization.[341] Because the preparation and disclosure of orbital debris mitigation plans utilizes the same engineering and legal resources as those used for space station operations, it is expected that all parties – including small entities – will have the resources to prepare and disclose orbital debris mitigation plans.

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

The RFA requires an agency to describe any significant alternatives that it has considered in 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.[342] Each is discussed in turn below.

(1) *Differing compliance or reporting requirements*. The Second Report and Order requires all satellite operators to disclose plans to mitigate orbital debris as part of their requests for Commission authorization. The timetable for the disclosure of orbital debris mitigation plans is tied to submission of a request for Commission licensing or authorization, the timing of which is subject to the control of the applicant. As a result, the timetable for the disclosure can be adjusted by any applicant – including small entities – without the need for specific exemptions in the Commission's rules. In addition, differing compliance requirements for small entities are unnecessary because all parties requesting Commission authorization to operate a space station or a ruling for access to a non-U.S.-licensed space station must

[341] 47 C.F.R. § 25.140-146 (requiring applicants in various satellite services to demonstrate technical qualifications as a prerequisite to receiving Commission authorization for space station operations).

[342] 5 U.S.C. § 603(c)(1) – (c)(4).

already demonstrate under existing FCC rules that they have the technical and legal ability to conduct such operations as a prerequisite to grant of an FCC authorization.[343] Because the preparation and disclosure of orbital debris mitigation plans utilizes the same engineering and legal resources as those used for space station operations, it is expected that all parties – including small entities – will have the resources to prepare and disclose orbital debris mitigation plans. Furthermore, authorizing space station operations by small entities, which pose the same public interest concerns as those posed by large entities, without any consideration of whether the proposed space station operations will contribute unreasonably to the creation of orbital debris would undermine the policy object of the Commission and the United States Government in mitigating orbital debris.

(2) *Clarification, consolidation, or simplification of compliance or reporting requirements*. The Second Report and Order clarifies, consolidates, and/or simplifies several existing compliance or reporting requirements regarding the operation of FCC-licensed space stations that will benefit all authorized space station operators, including small entities.

(3) *Use of performance, rather than design, standards*. The Second Report and Order establishes its debris mitigation requirements in terms of performance standards and does not adopt design standards for any class of entities, including small entities.

(4) *Exemption from coverage of the rule, or any part thereof, for small entities*. Authorizing space station operations by small entities, which pose the same public interest concerns as those posed by large entities, without any consideration of whether the proposed space station operations will contribute to the creation of orbital debris would undermine the policy object of the Commission and the United States Government in mitigating orbital debris. A categorical exemption from debris mitigation rules was considered in the context of amateur space station licenses – even though amateur space station licensees are not small entities as defined by the RFA – and was rejected as inconsistent with the underlying purpose of the rules.[344] In addition, any operator – including a small entity – is permitted under existing FCC rules to seek waivers of debris mitigation requirements for specific good cause shown.[345] In addition, the Second Report and Order exempts, or "grandfathers," all in-orbit GEO satellites that were launched prior to the release of the *Orbital Debris Notice* on March 18, 2002 from the minimum post-mission disposal altitude requirement that are adopted by the Commission.[346] Comments indicated that the financial impact of the post-mission disposal rules for GEO spacecraft could be significant for this class of satellites in the absence of grandfathering.

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 Second Report and Order waives disclosure requirements concerning post-mission disposal of spacecraft for remote sensing satellites when those disposal plans have been reviewed and approved by NOAA as part of its licensing process.

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[343] 47 C.F.R. § 25.140-146 (requiring applicants in various satellite services to demonstrate technical qualifications as a prerequisite to receiving Commission authorization for space station operations).

[344] *See Second Report and Order* at para. 91.

[345] *See* 47 C.F.R. § 1.3.

[346] *See Second Report and Order* at Section III.D.4.i.

G. Report to Congress

The Commission will send a copy of the Second Report and Order, including this FRFA, in a report to be sent to Congress pursuant to the Congressional Review Act.[347] In addition, the Commission will send a copy of the Second Report and Order, including this FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the Second Report and Order and FRFA (or summaries thereof) will also be published in the Federal Register.[348]

[347] *See* 5 U.S.C. § 801(a)(1)(A).

[348] *See* 5 U.S.C. § 604(b).