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FEDERAL COMMUNICATIONS COMMISSION

47 CFR Parts 5, 25, and 97

[IB Docket No. 18-313; FCC 20-54; FRS 16850]

Mitigation of Orbital Debris in the New Space Age

AGENCY: Federal Communications Commission.

ACTION: Final rule.

SUMMARY: In this document, the Commission adopts amendments to its rules related to satellite orbital debris mitigation, to reflect the Report and Order adopted on April 23, 2020. A proposed rule document for the Further Notice of Proposed Rulemaking (*FNPRM* or *Further Notice*) related to this Final rule document is published elsewhere in this issue of the *Federal Register*.

DATES: The amendments to §§ 25.271 and 25.282 are effective [**30 DAYS AFTER PUBLICATION IN THE FEDERAL REGISTER].** The other rule amendments contain information collection requirements that are not effective until approved by the Office of Management and Budget. The Commission will publish a document in the *Federal Register* announcing the effective date for those amendments.

FOR FURTHER INFORMATION CONTACT: Merissa Velez, International Bureau, Satellite Division, at (202) 418-0751. For information regarding the PRA information collection requirements contained in the PRA, contact Cathy Williams, Office of Managing Director, at (202) 418-2918 or Cathy.Williams@fcc.gov.

SUPPLEMENTARY INFORMATION: This is a summary of the Commission's *Report and Order* (Order), IB Docket No. 18-313, FCC 20-54, adopted on April 23, 2020, and released on

April 24, 2020. The full text of this document is available on the Commission's website at https://docs.fcc.gov/public/attachments/FCC-20-54A1.pdf. To request materials in accessible formats for people with disabilities, send an email to FCC504@fcc.gov or call the Consumer & Governmental Affairs Bureau at 202-418-0530 (voice), 202-418-0432 (TTY).

Supplemental Final Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act of 1980 (RFA), the Commission has prepared a Final Regulatory Flexibility Analysis (FRFA) of the possible significant economic impact on small entities of the policies and rules adopted in the Order.

Congressional Review Act

The Commission will send a copy of this *Order* in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act (CRA), see 5 U.S.C. 801(a)(1)(A).

Synopsis

I. INTRODUCTION

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

Commission decisions are consistent with the public interest in space remaining viable for future satellites and systems and the many services that those systems provide to the public.

The Report and Order (Order) comprehensively updates the Commission's existing rules regarding orbital debris mitigation, which were adopted in 2004. Our goal is to provide the clearest possible regulatory framework for applicants for non-Federal satellite communications. We also seek comment in a Further Notice of Proposed Rulemaking (Further Notice) on probability of accidental explosions, collision risk for multi-satellite systems, maneuverability requirements, casualty risk, indemnification, and performance bonds tied to successful spacecraft disposal.

II. BACKGROUND

There are a variety of predictions for how the space economy and space environment will evolve in the coming New Space Age, but one clear indicator of the changes to come is the unprecedented number of non-geostationary orbit (NGSO) space stations[1] for which applications have been submitted at the FCC. Some of the systems have begun preliminary operations, and we expect these activities to accelerate in the coming years. These new large constellations, many of which are designed to provide global broadband services, are likely to bring thousands of new satellites to low-Earth orbit (LEO). At the same time, there are a number of commercial systems with more than a hundred satellites that are already fully operational and providing commercial imaging and other Earth-exploration services. Additional satellite constellations,

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

again in potentially large numbers, will be coming online to provide other innovative services such as "Internet of Things." Moreover, the last decade has seen an exponential increase in the number of operations by small satellites with short duration missions for academic and research purposes, as the miniaturization of electronic components along with increased "rideshare" launch opportunities has led to the flourishing of "CubeSat" spacecraft missions, including launches with unprecedented numbers of satellites on board. In the meantime, operators continue to launch new, technologically-advanced communications satellites into the geostationary orbit (GSO), providing critical services across the globe.

At the same time, studies indicate that already in some regions of LEO, the number of new objects and fragments generated from collisions exceeds those removed by natural atmospheric drag. Other regions have sufficient densities of orbital debris to lead some analysts to conclude that they are close to or have already reached a "runaway" status, where the debris population will grow indefinitely due to collisions between debris objects. The predicted increase in the number of satellites in orbit requires that orbital debris mitigation be taken seriously by all operators in order to ensure the continued safe and reliable use of space for satellite communications and other activities. The number of U.S. commercial satellites in space exceeds the number of U.S. government satellites, and the actions taken by operators today have the potential to impact the orbital environment for hundreds or thousands of years.

The Commission first adopted comprehensive rules on orbital debris mitigation in 2004 in its Mitigation of Orbital Debris Second Report and Order. The rules require disclosure of an applicant's debris mitigation plans as part of the technical information submitted to the Commission. The Commission reasoned that the disclosures would allow the Commission to examine whether a space station operator has taken orbital debris into consideration, while

finding that the costs associated with disclosure would not be unduly burdensome when balanced against the public interest benefits of preserving safe and affordable access to space, and disclosure would provide flexibility for the Commission to address new developments in space station design and permit discretion when granting conditioning, or denying an authorization. As part of its 2004 Orbital Debris Order, the Commission also explained how its orbital debris rules related to certain regulations of the National Oceanic and Atmospheric Administration (NOAA) and regulations of the Department of Transportation, Federal Aviation Administration (FAA). Additionally, the Commission applied the new rules to amateur and experimental space stations, authorized under parts 97 and 5 of the Commission's rules, respectively, and considered liability issues and insurance as they related to Commission-authorized space stations.

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

In the United States, Space Policy Directive-3 (SPD-3), titled "National Space Traffic Management Policy," recognized the growing threat to space activities from orbital debris, and directs the Administrator of the National Aeronautics and Space Administration (NASA), in coordination with the Secretaries of State, Defense, Commerce, and Transportation, and the Director of National Intelligence, and in consultation with the Chairman of the Commission, to lead efforts to update the U.S. Government Orbital Debris Mitigation Standard Practices (ODMSP) and establish new guidelines for satellite design and operation. The ODMSP apply to missions operated or procured by U.S. government agencies, and "provides a reference for to promote efficient and effective space safety practices for other domestic and international

operators." SPD-3 stated that the United States should eventually incorporate appropriate standards and best practices, derived in part from the ODMSP, into Federal law and regulation through appropriate rulemaking or licensing actions, and that such guidelines should encompass protocols for all stages of satellite operation from design through end-of-life. This rulemaking is one such activity.

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

At the U.S. government agency level, the NASA Technical Standard (NASA Standard) and other NASA documents contain additional detail informing orbital debris mitigation measures when it comes to the development of NASA programs and projects. The NASA Standard provides specific technical requirements for limiting orbital debris generation consistent with NASA policies, and has been updated regularly, with the most recent update on April 25, 2019. The NASA Orbital Debris Program Office also develops and maintains a number of software modelling tools designed to assist with current orbital debris mitigation analysis and help better understand the evolution of the orbital environment. Several of these are available at no cost to the public. The software modeling tool that has been used by many

Commission applicants is the NASA Debris Assessment Software, which provides a means of calculating, during the planning and design phase, various metrics-related debris mitigation practices such as assessing collision risk and casualty risk, which are relevant to some, but not all, of the Commission's requirements. The FAA (for launch vehicles and intact re-entry) and NOAA (for commercial remote sensing satellites) both have orbital debris-related regulations which apply to non-government (in most cases commercial) operators licensed by those agencies. Both agencies are currently considering updates to their rules, including some rules relevant to orbital debris mitigation.

Internationally, there have been a number of significant developments relevant to the mitigation of orbital debris. The Inter-Agency Space Debris Coordination Committee (IADC), an international forum of government bodies that includes NASA and other space agencies, "for the coordination of activities related to the issues of man-made and natural debris in space[,]" issued an updated set of consensus guidelines for debris mitigation in 2007. The IADC Guidelines cover a wide range of topics including limitation of debris released during normal operations, minimization of the potential for on-orbit break-ups, post-mission disposal, and prevention of on-orbit collisions. Work by the IADC also helped to inform the development of the Space Debris Mitigation Guidelines of the United Nations (UN) Committee on the Peaceful Uses of Outer Space, which were endorsed by the UN General Assembly in 2007. As with the IADC Guidelines, the UN Guidelines established voluntary, non-binding consensus principles and guidelines for space debris mitigation. More recent developments include the IADC issuance in 2017 of a "Statement on Large Constellations of Satellites in Low Earth Orbit," as well as the adoption by the Committee on the Peaceful Uses of Outer Space of a preamble and 21 consensus guidelines for the "Long-Term Sustainability of Space Activities." Additionally, there

are international standards-setting organizations, such as the International Standards Organization that have issued standards for space activities, including orbital debris mitigation.

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

The Commission adopted a Notice of Proposed Rulemaking (NPRM) on November 15, 2018 (84 FR 4742 (February 19, 2019)) seeking comment on a comprehensive update to its rules relating to orbital debris mitigation. It sought comment on issues ranging from minor updates codifying established metrics into existing rules to how to assess the risks posed by constellations of thousands of satellites, as well as topics such as economic incentives for

operators that would align with orbital debris mitigation best practices.

Comments on the NPRM were due April 5, 2019, and reply comments were due May 6, 2019. We received 45 comments and 19 reply comments. A list of commenters, reply commenters, and other filers is contained in Appendix C of the Report and Order.

III. DISCUSSION

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

A. Regulatory Approach to Mitigation of Orbital Debris

1. FCC Statutory Authority Regarding Orbital Debris

The Commission licenses radio frequency uses by satellites under the authority of the Communications Act of 1934, as amended (the Act). When the Commission adopted debris mitigation rules applying to satellites across all service types, the Commission concluded that its authority to review orbital debris mitigation plans fell within its responsibilities and obligations under the Act, derived from its authority with respect to authorizing radio communications. As the Commission then noted, the Act charges the FCC with encouraging "the larger and more effective use of radio in the public interest." Additionally, the Act provides for the licensing of radio communications, including satellite communications, only upon a finding that the "public convenience, interest, or necessity will be served thereby." These provisions of the Act have

remained unchanged since the Commission's previous analysis of its authority in this area, in which it concluded that orbital debris and related mitigation issues are relevant in determining whether the public interest would be served by authorization of any particular satellite-based communications system, or by any particular practice or operating procedure of such satellite systems. The analysis undertaken by the Commission is designed to ensure that the space systems reviewed by the Commission have sufficient plans to mitigate orbital debris, consistent with the public interest. As the Commission also previously concluded, to the extent that spacecraft are controlled through radiocommunications links, there is a direct connection between the radiocommunications functions we are charged with licensing under the Act and the physical operations of the spacecraft. Rules that limit the generation of orbital debris are intended to minimize the orbital debris that would negatively affect the cost, reliability, continuity and safety of all commercial, experimental and amateur satellite operations licensed or authorized by the Commission. Orbital debris also negatively affects the availability, integrity, and capability of both incumbent and newly-authorized satellite systems, thereby raising the potential for impairing the ability of such systems to use the spectrum to the full extent that the Commission authorized.

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

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

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

A few commenters correctly observe that some of the Commission's NPRM proposals go beyond a narrower focus on debris mitigation, such as in the ODMSP, and also relate in part to other functional areas often referred to as space situational awareness or space traffic

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

2. Relationship with Other U.S. Government Activities

The Commission recognized the importance of a coordinated, effective regulatory environment that meets the dual goals of orbital debris mitigation and furthering U.S. space commerce. Specifically, in the NPRM, the Commission sought comment on whether there are any areas in which the proposed requirements overlap with requirements clearly within the authority of other agencies, in order to avoid duplicative activities, and whether there are any exceptions to applications of our rules that would be appropriate in specific circumstances. The NRPM also highlighted the ongoing activities of various executive branch agencies of the U.S.

government related to the Space Policy Directive-3 (SPD-3), including the now-completed updating of the ODMSP. In accordance with its consultatory role described in SPD-3, the Commission has been engaged with those ongoing activities. The Commission additionally sought comment on the suitability of various orbital debris mitigation guidance and standards.

Commenters addressing these topics universally supported interagency coordination, and many mentioned the sharing of expertise regarding space operations. Commenters also generally supported application of consistent principles as well as elimination of regulatory duplication. The Commerce Department provided informative comments describing in detail many of the Commerce Department and interagency initiatives currently underway as a result of the Space Policy Directives. At this time, we are pleased to highlight the recent completion of the revisions to the ODMSP, and look forward to further work with the Commerce Department and other agencies on an evolving "whole of government" approach to space activities. Given the pace that the industry is evolving, and our responsibility to continue licensing satellites and systems on a day-to-day basis, we find that it would not be beneficial at this time to delay our rule updates. We expect that regulation of orbital debris will be an iterative process as new research becomes available and new policies are developed, and as discussions continue concerning approaches to improving the organization of the regulation of space activities. If it becomes clear through a change to the governing law that an activity the Commission is currently undertaking is instead one that another agency is charged with performing, we will modify our process and regulations accordingly.

We continue to carefully follow the rulemaking developments of other agencies, in particular those of the FAA and NOAA, as those agencies look to update their rules related to authorization of commercial space activities. The NPRM did not propose any change to the

specific conclusions drawn by the Commission in 2004 with respect to the role of the Commission vis-à-vis other agencies such as the FAA and NOAA. We will continue to coordinate closely with other agencies in any cases where it appears that the other agency may have relevant expertise or in cases that present unique scenarios that implicate overlap with that agency's responsibilities.

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

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

3. Economic Considerations

In addition to regulatory requirements to control or mitigate orbital debris, certain commenters argue that developing mechanisms and processes that harness market forces can

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

In the NPRM, the Commission included a regulatory impact analysis designed to assess various approaches to reducing debris in orbit from an economic perspective. Many of these approaches were consistent with the rule revisions proposed by the Commission in the NPRM, and others represented different means of reducing debris. To the extent that the comments directed to this section overlapped with other topics in the NPRM, we discuss those comments in the various sections below. Commenters generally disagreed with the additional approaches discussed as part of the regulatory impact analysis, such as limiting launches, and as addressed below, we decline to further address those approaches at this time. Several commenters presented views on novel approaches, at least in the space debris context, for incentivizing

particular activities. For example, the New York University School of Law Institute for Policy Integrity proposed that the Commission broadly consider market-based alternatives such as different liability rules, marketable permits or offsets, and regulatory fees. Although we ultimately conclude that these approaches are not sufficiently robust on their own to address the problem of orbital debris, and thus regulation in this area is necessary, we address these and other approaches below.

Given the nature of space, some commenters raise the point that the Commission's actions in this area may be limited in value since they cannot account for activities of actors that are not subject to U.S. law and regulations. Although we address the application of our rules to non-U.S.-licensed satellites in more detail below, as an introductory matter it is worth pointing out that we have been applying, and will continue to apply, our rules on orbital debris mitigation to those operators of existing or planned non-U.S.-licensed satellites seeking access to the United States market. This means that any non-Federal satellite communicating with an earth station in the United States will be subject to an orbital debris assessment under the Commission's rules.[2] Given the interest by many satellite operators in serving the U.S. market, this provides means for our regulations to have a broader reach than if the regulations were just to apply to operators seeking a U.S. license, and helps to ensure that non-U.S. licensees do not gain competitive advantage by following less rigorous debris mitigation practices than U.S.-licensed satellites.

4. Other Introductory Matters

A number of commenters state that the Commission should focus its efforts on performance-based regulation, rather than prescriptive regulation (e.g., regulation of satellite performance rather than regulation of design). We have endeavored throughout this Order to

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

adopt a performance-based approach where feasible. We agree with those commenters who argue, for example, that performance metrics can enable operators to develop innovative and cost-effective solutions in many instances.

Several commenters also request that rules be based on specific metrics to ensure regulatory transparency, and that the Commission provide clear guidance on how to achieve certain metrics. In many areas we are providing metrics and identifying methodology, typically using publicly-available NASA assessment tools, which are already used by many satellite applicants.[3] In these cases, applicants may look to detailed guidance published by NASA in preparing orbital debris mitigation plans. There will continue to be some areas, such as those in which the U.S. Government Orbital Debris Mitigation Standard Practices express qualitative objectives or aspirational goals, without a quantitative metric, where for now we will assess issues on a case-by-case basis. We also seek comment on adopting more quantitative rules in certain areas in the Further Notice of Proposed Rule Making. Finally, we note that a number of commenters (generally those operators planning large NGSO constellations), expressed concern as a general matter about metrics being applied on an aggregate basis to a constellation of NGSO satellites. We address these concerns in connection with individual rules, including whether in particular cases the Commission needs to consider the full factual scenario relevant to a licensing decision, including understanding of the complete scope of the risk involved with the proposed operations.

In our recent order adopting elective streamlined licensing procedures for qualifying

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

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

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

B. Safe Flight Profiles

Our existing orbital debris rules include several disclosure requirements designed to ensure that operators are addressing the issue of potential collisions with debris or other objects. We update our rules on safe flight profiles to specify metrics that NASA applies to its missions, and adopt additional disclosures relating to orbital characteristics and maneuverability. We also seek comment on some additional issues as part of the Further Notice.

1. Collisions with Large Objects

In the NPRM, the Commission proposed that applicants for NGSO satellites must state

whether the probability that their spacecraft will collide with a large object during the orbital lifetime of the spacecraft will be less than 0.001 (1 in 1,000). The current NASA Standard defines a "large object" as an object larger than 10 cm in diameter. To date, many applicants have used NASA's Debris Assessment Software to conduct the analysis for LEO spacecraft.

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

In the NPRM, the Commission also sought comment on whether, for purposes of conducting the analysis, and absent evidence to the contrary, the collision risk with large objects should be assumed zero or near zero during the period of the time when the space station is able to conduct collision avoidance maneuvers. Several commenters agreed with this approach. A number of commenters pointed out that this requires an assumption that maneuvering systems are 100% reliable, and some suggested instead incorporating the probability thresholds at which operators undertake collision avoidance maneuvers into the overall assessment of collision risk. Those thresholds vary among operators, but are typically at lower probabilities than the 0.001 metric as applied through the NASA Debris Assessment Software. As a simplifying assumption, we believe the alternative assumption of zero is warranted. However, in individual cases, to the extent there is evidence that a particular system or operator is unable to effectively maneuver or is maneuvering only at risk thresholds that raise reasonable questions about its ability to meet the

0.001 collision risk metric even with some degree of maneuverability, this assumption will not be applied.

Systems with Multiple Space Stations. In the NPRM, the Commission also sought comment on the assessment of the collision risk presented by a system as a whole, i.e., in the aggregate. Commenters expressed a variety of views on assessing probability of collision with large objects on a system-wide basis, including on what specific metrics, if any, should apply. Additionally, subsequent to the Notice, the revised ODMSP was issued, which includes a section discussing "large constellations," and states that "in determining the successful post-mission disposal threshold [for large constellations], factors such as mass, collision probability, orbital location and other relevant parameters should be considered." As described in the Further Notice, we seek to develop the record further on this issue and how to address multi-satellite systems, including large constellations.

GSO Satellites. The Aerospace Corporation (Aerospace) suggests that we apply the requirement to GSO satellites as well as NGSO satellites, because GSO satellites can also be involved in collisions that would generate large amounts of un-trackable, long-term debris in the geostationary orbit (GEO) region. In the NPRM, the Commission proposed inclusion of the metric into the disclosure specifically for NGSO satellites. The NASA Standard formulation discussed in the Notice applies to "each spacecraft and launch vehicle orbital stage in or passing through LEO."[4] Currently, all space station applicants, including applicants for GSO space stations, must provide a statement that the space station operator has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or

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

other operational space stations. We believe that continuing to apply this disclosure approach to applicants for GSO systems is sufficient, without needing to adopt a specific metric at the current time. We encourage GSO operators to provide quantitative collision risk information, but believe that requiring such analysis as part of the initial application materials is unnecessary,[5] given that GSO operators are assigned to particular orbital locations, including a specific "station keeping box," and must comply with certain well-established disposal procedures.

2. Collisions with Small Objects

In the NPRM, the Commission sought comment on adding a quantifiable metric to our existing rules regarding the probability of a space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal. The NPRM referenced the NASA Standard, which states that for each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable post-mission disposal maneuver requirements does not exceed 0.01 (1 in 100). The revised ODMSP includes a similar provision.[6] Our current rules require a statement that operators (both GSO and NGSO) have assessed and limited the probability of the satellite becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control or prevent post-mission disposal. Generally, operators have provided information regarding spacecraft shielding, redundant systems, or other designs that would enable the spacecraft systems to survive a collision with small debris. Some operators have been

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

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

providing the information specified in the NASA Standard, calculated using the NASA Debris Assessment Software.

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

We conclude that applicants for GSO space station will also be required to include a disclosure related to this metric. In the NPRM, the Commission had proposed to add this metric to our rules for both NGSO and GSO space stations, but we received several comments suggesting that inclusion of this metric into our rules for GSO space stations would be of limited utility. One of the commenters, Boeing, seems to have changed its view on this point in

supplemental comments. Additionally, while Eutelsat suggests that the risks posed to GSO satellites in this area are materially lower than the risks posed to NGSO satellites, we do not see this as a reason not to apply the metric in our rules for GSO spacecraft, since it should be easier for those spacecraft to satisfy the rule. Accordingly, we adopt our proposal.

3. Disclosures Regarding Planned Orbit(s)

Identification of Other Relevant Satellites and Systems. In the NPRM, the Commission sought comment on revising the wording of its rule regarding identifying other space stations that are operating in similar or identical orbits in low-Earth orbit. The Commission proposed revising the rule to require that, instead of identifying satellites with similar or identical orbits, the statement must identify planned and/or operational satellites with which the applicant's satellite poses a collision risk, and indicate what steps have been taken to coordinate with the other spacecraft system and facilitate future coordination, or what other measures the operator may use to avoid collisions. The Commission also proposed to extend this rule to all NGSO satellites, rather than just those that will be launched into the LEO region, since overlap in orbits among NGSO spacecraft in other regions may also result in collisions. Several commenters supported these revisions, and we adopt them.[7] As part of the public record, this disclosure can also help to inform other operators that may be operating or plan to operate in the same region of space. Since this wording is similar to the previous rule, we find that there are unlikely to be significant additional costs from compliance with this disclosure requirement, but to the extent there are any additional costs in research and assessment of the environment in which the spacecraft will be located, we conclude they are warranted in the interest of ensuring that operators take into consideration other relevant space stations and systems when preparing

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

orbital debris mitigation plans, and coordinate with those operators when necessary.

CSSMA and LeoSat oppose a requirement that the collision analysis include analysis with respect to planned systems, arguing that planned systems change frequently and not all systems are known. We clarify that the rule will require a disclosure identifying potential systems of concern, but does not require that the applicant's calculated collision risk include such systems (which would go beyond what can be assessed using the NASA Debris Assessment Software). It is important, however, that applicants assess planned systems, what impact such systems may have on their operations, and what coordination can be completed with the operators of such systems. While not all planned systems may come to fruition and there may be systems that would be unknown to applicants, such as foreign or government systems, we expect applicants to make best efforts to analyze the environment in which their satellites will be operating[8] and specify how they plan to coordinate, to the extent possible, with other operators to ensure safe operations. Boeing asks that we clarify that the disclosure must specify only those other NGSO satellite systems "the normal operation of which" pose a risk of collision. We concur with Boeing's clarification of the rule, but decline to change the rule language since we believe that it is self-evident that an operator can only take into consideration the planned or normal operations of another operator's system.

Orbit Selection and Other Orbital Characteristics. In the NPRM, the Commission also proposed that any applicants planning an NGSO constellation that would be deployed in the LEO region above 650 km in altitude specify why the applicant had chosen the particular orbit and describe other relevant characteristics of the orbit. The Commission reasoned that missions deploying above 650 km altitude may represent a greater risk from a long-term orbital debris

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

perspective, since satellites that fail above that altitude will generally not re-enter Earth's atmosphere within 25 years, and depending on the deployment altitude, may be in orbit for centuries or longer. The Commission also sought comment on whether it should require a statement concerning the rationale for selecting an orbit from operators of satellites that will remain in orbit for a long period of time relative to the time needed to perform their mission.

After review of the record, we decline to adopt these proposals. We conclude after further consideration that the long-term risks associated with deployments above 650 km are sufficiently addressed through our other rules, such as collision risk assessment, and reliability of post-mission disposal and that therefore the additional statement is not necessary. Indeed, application of the Commission's other orbital debris mitigation rules may in some instances result in an operator deciding to deploy below 650 km. While SpaceX, for example, supported the proposed disclosure regarding rationale for selecting a particular orbit, we conclude that concerns the Commission may have about risks associated with operations in a particular orbit can be adequately addressed through other measures addressed in this proceeding.

We do adopt our proposal, however, that NGSO systems disclose information regarding other relevant characteristics of the chosen deployment orbit not already covered, such as the presence of a large concentration of existing debris in a particular orbit. Boeing states that the Commission should not adopt regulation in this area, because operators are adequately incentivized to select initial orbits that are sufficiently free of hazards, or invest in other measures to facilitate the safety of their satellites. We find that this disclosure will help to ensure that operators have considered all the characteristics of the deployment and operational orbits, and are fully aware of the risks associated with operations in the particular orbit. This may not always be the case, particularly with smaller operators or operators who use a rideshare launch.

If an orbit is particularly congested with debris, for example, an operator may want to consider modifying its operations slightly to avoid having to perform a large number of collision avoidance maneuvers.

4. Orbit Variance and Orbit Selection for Large NGSO Systems

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

The question of whether two satellite systems can coexist in a given region of space, such as a circular LEO orbit, depends on multiple factors, including the number and size of satellites, the capabilities of the satellites such as maneuverability, costs of maneuvering (such as interruption of service), availability and timeliness of data on satellite parameters (both from telemetry and from radar or optical observations), planning cycles for maneuvers, and the time required to coordinate operations between systems, etc. Larger deployments of satellites into circular LEO orbits have been into separate orbital "shells." As a practical matter, in cases where two planned systems propose use of the same shell, coordination typically results in one or both systems adjusting planned orbital altitudes, so that the constellations are separated, rather than in the operators coordinating their operations at the same or overlapping altitude ranges.

While some commenters urge that we adopt specific requirements for separation of orbits, others argue that coordination, data sharing, and collision avoidance practices should be sufficient to avoid collisions, or that limits are not practicable for the regions in which some operators operate, particularly small satellite operators. ORBCOMM states that the operational availability of NGSO orbits appears likely to become an increasingly scarce resource, but states that it is premature to try and set rules on maximum altitude variance and orbit selections. Other commenters argue, particularly with respect to systems proposing large orbital variances, that the Commission must consider the impact of such systems on the rational, efficient, and economic use of orbital resources. At this time, we decline to adopt a maximum orbital variance for NGSO systems and decline to adopt a required separation between orbital locations, and will instead continue to address these issues case-by-case. There are a wide range of considerations in such cases, and while we are concerned about the risk of collisions between the space stations of NGSO systems operating at similar orbital altitudes, as the Commission has previously stated, we think that these concerns are best addressed in the first instance through inter-operator coordination.

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

5. Protection of Inhabitable Spacecraft

The Commission proposed in the NPRM that for any NGSO space station deployed above the International Space Station (ISS) and that will transit through the ISS orbit either during or following the space station's operations, the applicant provide information about any operational constraints caused to the ISS or other inhabitable spacecraft[9] and strategies used to avoid collision with such spacecraft. The Commission explained that normal operations of the ISS could be disrupted or constrained by collision avoidance maneuvers that the ISS would need to perform to avoid satellites transiting through the ISS orbit.

We conclude that it is in the public interest to adopt the proposed disclosure requirement.[10] The statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and enable the operator to avoid posing any undue operational constraints to the inhabitable spacecraft. Commenters agree that special protections should be afforded to inhabitable spacecraft. We find that requiring this information will help to ensure that the applicant has taken into consideration the inhabitable spacecraft, and will provide information in the public record to help the Commission and other interested parties, such as NASA, determine if there are any potential issues with the applicant's operations vis-à-vis the ISS or other inhabitable spacecraft. NASA states that disruption to ISS operations may be lessened if a spacecraft in the process of disposal through atmospheric reentry remains active and able to maneuver until the apogee is below ISS altitude. We conclude that the benefits in assuring the safety of human life in space and minimizing disruption to the operations of

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

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

inhabitable spacecraft outweighs any additional cost to applicants in preparing such a disclosure.

6. Maneuverability

Disclosure. Maneuverability can be an important component of space debris mitigation, both by enabling space stations to engage in collision avoidance and by facilitating spacecraft disposal. The Commission proposed in the NPRM that applicants disclose the extent of maneuverability of the planned space stations. The Commission noted this could include an explanation of the number of collision avoidance maneuvers the satellite could be expected to make, and/or any other means the satellite may have to avoid conjunction events, including the period both during the satellite's operational lifetime and during the remainder of its time in space prior to disposal. The Commission tentatively concluded that this information could assist in the Commission's public interest determination, particularly regarding any burden that other operators would have to bear in order to avoid collisions and false conjunction warnings. Most commenters addressing this topic agree with the maneuverability disclosure, and we adopt this disclosure.

LeoSat disagrees with the proposal, arguing that specific information related to satellite maneuverability is proprietary and competitive in nature, that public disclosure of this information as part of an application could prompt a "race to the bottom" among satellite operators, and that any information initially disclosed in an application will become stale and inaccurate as the operator's satellites age and their propulsion capacity is consumed. It does not appear that LeoSat has support among fellow satellite operators for its proposition that satellite maneuverability information is proprietary and competitive. Further, even if such information has some potential "competitive" value, such information would likely need to be shared with another operator in the event of a potential conjunction, and all operators will be better able to

make informed decisions if they have a baseline understanding of the maneuvering potential of other satellites in orbit. Moreover, it is not clear to us how disclosure would cause a "race to the bottom," and even if information became outdated as some spacecraft were no longer able to maneuver, having initial information on what capabilities the satellites were designed with could still assist the Commission in its review of the system and also assist other operators. We find that the benefits of having information regarding maneuverability as part of the record outweigh these commenters' generalized competitive concerns. Boeing also disagrees in some respects with the proposed disclosure on the basis that the Commission has not provided guidance on the number of avoidance maneuvers that would be presumptively deemed acceptable. We plan to consider the maneuverability disclosure as factual information, and at this time do not establish a presumptive number of avoidance maneuvers that would trigger concern. We believe that on balance, this area is an appropriate one for a disclosure and provides useful information, including to other operators. We encourage operators to submit as much information as they reasonably can regarding maneuverability, ideally providing the type of information mentioned by NASA in its comments, including maneuver methods and capabilities, as well as any other mechanisms to mitigate conjunction likelihood (e.g., cross-sectional area modulation). This would also include information regarding the propulsive technology itself (i.e., ion thrusters, traditional chemical thrusters, etc.), thrust level, and a description of the guidance and operations scheme for determining maneuvers, where applicable. Generally speaking, operators should submit a written description of the space stations' expected capabilities, including, if possible, the expected time it would take the space station to modify its orbital location by a certain distance to avoid a collision.

Propulsion or Maneuverability Above a Certain Altitude. The Commission also sought

comment in the NPRM on whether it should require all NGSO satellites planning to operate above a particular altitude to have propulsion capabilities reserved for station-keeping and to enable collision avoidance maneuvers, regardless of whether propulsion is necessary to de-orbit within 25 years, and if so, what altitude should be adopted. A number of commenters supported some requirement along these lines, with some identifying 400 km as an altitude above which propulsion or other maneuvering capabilities should be required, generally based on the approximate operational altitude of the ISS. Other commenters disagreed with this suggestion. We seek to expand the record on this potential requirement in the Further Notice.

C. Tracking and Data Sharing

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

We also received several comments addressing improvements to the U.S. space

situational awareness and space traffic management functions more generally. In this proceeding, the Commission has not considered other activities related to space situational awareness and space traffic management, such as maintaining a comprehensive catalog of space objects or providing conjunction warnings. These functions as a general matter are well beyond the type of analysis that we have historically addressed through our rules and licensing process, but we suggest that these comments be filed for consideration in the proceeding currently underway in the Commerce Department, if they have not been already, so that the comments can be taken into consideration in that context.

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

1. Trackability and Satellite Identification

Trackability. The Commission proposed in the NPRM to require a statement from an applicant regarding the ability to track the proposed satellites using space situational awareness facilities, such as the U.S. Space Surveillance Network. The Commission also proposed that objects greater than 10 cm by 10 cm by 10 cm in size be presumed trackable for LEO. For objects with any dimension less than 10 cm, the Commission proposed that the applicant provide

additional information concerning trackability, which will be reviewed on a case-by-case basis.

Commenters generally support the proposed approach to size as it relates to trackability. NASA recommends that the term "satellite trackability" be interpreted to mean that an object is trackable if, through the regular operation of space situational awareness assets, it can be tracked and maintained so as to be re-acquirable at will, and that the object's orbital data is sufficient for conjunction assessments. According to NASA, this will typically mean that the object possesses trackability traits (e.g., sufficient size and radar/optical cross-section) to allow it to be acquired routinely by multiple space situational awareness assets in their regular modes of operation. Several commenters agree that in LEO, a 10 x 10 x 10 cm cube should meet this standard. We agree, and adopt the proposed rule stating that space stations of this size in LEO are deemed presumptively trackable, modified slightly to cover space stations that are 10 cm or larger in their smallest dimension.[11] We clarify that this presumption covers those space stations that are 10 cm or larger in their smallest dimension excluding deployable components.[12]

CSSMA proposes that the Commission require applicants to simply certify that they can be tracked reliably by widely available tracking technology. Swarm similarly suggests that the rules permit smaller satellite form factors pursuant to an affirmative demonstration that such spacecraft can be accurately tracked, and that size should be merely one factor in assessing trackability. Although there may be future improvements in standard space situational awareness tracking facilities, at this time we believe it is in the public interest to adopt the presumed trackable approach for space stations in LEO larger than 10 cm in the smallest dimension, and for other cases, including where a satellite is planning to use deployable devices

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

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

to increase the surface area, we conclude that operators should provide more information to support their conclusion that the space station will be reliably trackable. For a spacecraft smaller than 10 cm x 10 cm x 10 cm, for example, some of the standard space situational awareness tracking facilities may no longer be able to track the satellite. In these instances, part of a demonstration supporting a finding of trackability may be a showing that the operator has taken on the cost of bringing the trackability back up to the level it would be for a larger spacecraft, perhaps by enlisting a commercial space situational awareness provider. CSSMA and others argue that the Commission should permit operators flexibility to choose appropriate solutions, and that ground-based space situational awareness capabilities may improve significantly in the future. We find that our approach provides operators with flexibility to satisfy the Commission's rule, because it permits a case-by-case assessment of trackability where the space station is smaller than 10 cm in the smallest diameter. Global NewSpace Operators argues that we should provide further detail on what information we are looking for in the disclosure, for example, to what accuracy and how often should tracking occur, and whether we will ask for verification from the space situational awareness provider that they can indeed track the proposed satellites. We decline to provide additional detailed guidance in our rules on this topic, as an acceptable disclosure could vary significantly depending on the trackability solution that will be used by the applicant. We expect, however, that applicants will specify the tracking solution and provide some indication of prior successful demonstrated use of the technology or service, either as part of a commercial or government venture. This would include addressing reliability of deployment of any deployable spacecraft parts that are being relied on for tracking. Tracking solutions that have not been well-established or previously demonstrated will be subject to additional scrutiny, and applicants may need to consider a back-up solution in those instances.

In addition, our rule provides flexibility for trackability demonstrations above LEO, where Aerospace states that it is not clear that a 10 cm x 10 cm x 10 cm object could be reliably tracked. Aerospace states that the assumed size for reliable tracking in the GEO region by the current Space Surveillance Network is one meter, done primarily with optical sensors. The Commission will address the trackability demonstration on a case-by-case basis for satellites that would operate above the LEO region, including in the GEO region, and we do not see the need at this time to include a specific size value in our rules for those space stations.

In the NPRM, the Commission inquired whether there were hardware or information sharing requirements that might improve tracking capabilities, and whether such technologies are sufficiently developed that a requirement for their use would be efficient and effective. Aerospace suggests that hardware such as transponders or other signature enhancements and data sharing would benefit trackability, but it is not clear that any commercial transponder hardware or comprehensive data sharing methods currently exist. Aerospace states that a potential rule could drive development in this area, and consider enhancements such as radar reflectors for small objects in orbits well above LEO. NASA cautions against relying on active tracking assistance that would no longer occur once the spacecraft is unpowered, and observes that at the present time, on-board tracking improvement methods such as beacons or corner cube reflectors are not sufficiently supported by space situational awareness assets to enable significant and reliable tracking improvements. Keplerian Tech suggests that the Commission should mandate the use of an independent transponder solution, such as the space beacon that it has developed. Swarm suggests that trackability can be improved through the use of active or passive signature enhancements, such as the passive radar retro reflectors that would be used by Swarm's proposed satellites. CSSMA opposes a specification of any particular type of tracking technology, and

suggests that mandating use of an independent tracking solution would impose unnecessary costs on operators. According to CSSMA, the level of trackability needed to maintain a safe orbital environment can already be attained by well-established active or passive tracking methods.

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

We do adopt the disclosure proposed in the NPRM that applicants specify whether space station tracking will be active (that is, with participation of the operator by emitting signals via transponder or sharing data with other operators) or passive (that is, solely by ground based radar or optical tracking of the object. This disclosure, in connection with the other descriptive disclosures discussed in this section, will provide a way for the Commission and any interested parties to understand the extent to which the operator is able to obtain satellite positioning information separately from information provided by the 18th Space Control Squadron or other space situational awareness facilities. We believe this requirement presents minimal costs, since an operator will readily have access to this information based on the basic characteristics of its

spacecraft (for example, will it be transmitting its Global Positioning System location information via transponder?). Operators are likely to select either active or passive means of tracking depending on the mission specifications, but it is useful for the Commission to understand as part of its holistic review of the application, the overall trackability and ability to identify the satellite.

Relatedly, we also adopt the NPRM proposal that operators certify that their space station will have a unique telemetry marker allowing it to be distinguished from other satellites or space objects. This is the same as the certification we have previously adopted for small satellites applying under the streamlined process, and is unlikely to pose any additional costs for most operators, since the vast majority of operators already distinguish their satellite's signal from other signals through use of unique signal characteristics. Few commenters addressed this issue, and some expressed support or sought clarification. As we clarified in the Small Satellite Order, we expect that when a spacecraft transmits telemetry data to the ground it will include in that transmission some marker that allows the spacecraft to be differentiated from other spacecraft. This signal-based identification marker, which should be different from those of other objects on a particular launch, can assist with identification of a satellite for space situational awareness purposes. Boeing argues that the Commission does not need to verify whether an active telemetry marker will be unique since satellite operators have adequate incentives to distinguish their own telemetry beacons from those of other satellites, but we disagree, because smaller-scale operators may not have these incentives or know that they should implement this type telemetry marker to help identify their satellite.

Identification. Additionally, the Commission sought comment on whether applicants should be required by rule to provide information about the initial deployment to the 18th Space

Control Squadron or any successor civilian entity. We noted that, as an example, communications with the 18th Space Control Squadron may be particularly important in the case of a multi-satellite deployment to assist in the identification of a particular satellite. We adopt a rule requiring that applicants disclose how the operator plans to identify the space station(s) following deployment, for example, how the operator plans to obtain initial telemetry.[13] We expect that for most operators this disclosure will be fairly straightforward, but requesting this information, alongside the other information requested on satellite trackability, will help the Commission and any other interested parties to understand whether the satellite poses a risk of being misidentified following deployment, for example, in the case of a multi-satellite deployment. As Global NewSpace Operators suggests, we will consider favorably in an application the use of radiofrequency transponder tags or other unique telemetry markers that can support the identification of objects once in orbit. Overall, we want to emphasize the importance of operators planning for satellite identification in advance so that they are able to troubleshoot potential issues, particularly for multi-satellite deployments. Also, as the Secure World Foundation suggests, we encourage additional research in this area on how identification aids may help distinguish one satellite from another early after payload separation.

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

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

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

2. Ongoing Space Situational Awareness

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

Most commenters agreed with the goals of the proposed requirements. Some

commenters argue that data sharing exchanges should respect owner/operator intellectual property and proprietary information and should be limited to only the information necessary to describe explicit maneuvers, initial deployment, or conjunction avoidance. Several commenters also seek flexibility to share maneuverability and status data using any reasonable method identified by the providing operator. After consideration of the record on this issue, we adopt a disclosure requirement regarding sharing of ephemeris and other data. Specifically, we adopt a rule stating that applicants must disclose the extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, or other entities that engage in space situational awareness or space traffic management functions, and/or other operators. This also includes disclosure of risk thresholds for when an operator will deem it appropriate to conduct a collision avoidance maneuver. This disclosure provides an opportunity for the Commission to assess the extent to which the operator is actively engaging with space situational awareness facilities, keeping in mind that the need for such engagement may vary depending on the scale of the system.[14] We observe that for certain types of systems, for example, those using electric propulsion, sharing of ephemeris data is particularly critical in preventing collisions, and so we would look for a detailed description of those plans when assessing the application for those systems. The disclosure will also assist other operators in understanding how they may be able to best coordinate with the applicants' system and provide flexibility for operators to demonstrate how their plans for sharing information will facilitate space safety. As one example, a particular operator may decide to share ephemeris information with the private Space Data Association, which would be indicated in its disclosure. This also addresses any operator's

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

concerns regarding proprietary information and security, since operators concerned with these issues could take them into consideration as part of their plan for how to share ephemeris[15]

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

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

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

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

requirement regarding sharing of information with the 18th Space Control Squadron or other operators whose systems may pose a collision risk. We conclude that requirement is unnecessary given the application disclosure requirement we adopt here as well as the separate certification that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary—and that the assessment and potential mitigation should include, as appropriate, sharing ephemeris data and other relevant operational information.

Conjunction Warnings. The Commission proposed that applicants for NGSO space stations certify that, upon receipt of a conjunction warning, the operator of the satellite will take all possible steps to assess and, if necessary, to mitigate collision risk, including, but not limited to: contacting the operator of any active spacecraft involved in such warning; sharing ephemeris data and other appropriate operational information directly with any such operator; and modifying spacecraft attitude and/or operations. The Commission also sought comment on whether any different or additional requirements should be considered regarding the ability to track and identify satellites in NGSO or respond to conjunction warnings.

As discussed below, based on the record, we adopt the proposal from the NPRM. We believe this certification will enhance certainty among operators, and thereby help to reduce collision risk. Most commenters addressing this issue agreed generally with the Commission's proposal, although some commenters had varying views on implementation of the proposed requirement. NASA and Aerospace recommend that applicants submit information outlining plans that they intend to follow operationally in order to minimize collision risk. Global NewSpace Operators suggests that the Commission simply require the applicant to have an operational procedure and process for a conjunction warning, rather than a certification. We see

the potential benefits of having applicants outline operational steps to minimize collision risk, but we believe that the information that would be included in this type of submission is already addressed by other aspects of the rules. As described above, we will request information on maneuverability of the satellites, and applicants will be required to disclose how they have coordinated or plan to coordinate with other operators whose satellites may pose a collision risk, as well as disclose how they plan to share ephemeris and other information during the course of the spacecraft operations.

Other commenters suggest modifications to the language of the proposed rule to provide operators with some additional flexibility when responding to conjunction warnings. The Commission's proposed rule stated that the space station operator "must certify that upon receipt of a space situational awareness conjunction warning, the operator will review the warning and take all possible steps to assess and, if necessary, to mitigate collision risk, including, but not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; modifying space station attitude and/or operations." Several commenters, including SIA, Telesat, and others, were concerned that the use of the term "all possible steps" would not give operators enough flexibility to decide how to respond, and proposed the language "appropriate steps" instead. Taking into consideration the concerns expressed in the record, we adopt a slightly different formulation of the certification. Specifically, the rule we adopt states that the space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft

involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations. We believe that the terms "if necessary" and "as appropriate" provide sufficient flexibility for operators to determine what is appropriate in individual cases. Finally, Boeing suggests that this requirement may be unnecessary, because operators already have sufficient incentives to avoid collision risks. We conclude, however, that this certification is useful in ensuring that all space actors, in particular new space actors, are aware of and have planned responses to conjunction warnings, consistent with responsible space operations.

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

D. Topics Related to Creation of Debris During Operations

The Commission's existing orbital debris rules require disclosure of debris released during normal operations. This has been a longstanding requirement, and is consistent with the revised U.S. Government Standard Practices objective regarding "Control of Debris Released During Normal Operations." The Commission observed in 2004 that communications space stations do not typically involve the release of planned debris. Although there are some unique experiments on space stations today that do potentially involve the planned release of debris, we observe that most communications space stations still do not typically release debris absent some

type of anomaly. Where there is a planned release of debris, however, we examine such plans on a case-by-case basis. Accordingly, the Commission did not propose to update our general rule in this area, as it has functioned well for the past 15 years. In the Notice, the Commission did propose to update its rules, however, in two specific areas related to the release of debris, discussed below, which reflect evolving satellite and launch technologies.

1. Deployment Devices

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

The Commission proposed in the NPRM to require disclosure by applicants if "free-

flying" deployment devices are used to deploy their spacecraft, as well as requiring a specific justification for their use. We adopt our proposal, and require that applicants for a Commission license disclose whether they plan to have their spacecraft deployed using a deployment device. This includes disclosure of all devices, defined as separate deployment devices, distinct from the space station launch vehicle, regardless of whether they will be authorized by the Commission.[16] Although in some instances it is difficult to draw a clear line between a launch vehicle and deployment device, for purposes of this rule, as explained below, we consider a deployment device to be a device not permanently physically attached to or otherwise controlled as part of the launch vehicle. For purposes of this discussion, we distinguish between consideration of orbital debris mitigation issues involving such free-flying deployment devices and consideration of orbital debris mitigation issues involving multi-satellite deployments generally, including use of deployment devices that are part of or remain attached to the launch vehicle.

We have considered the arguments of Eutelsat, University Small-Satellite Researchers, and Boeing, who suggest that it would be burdensome for space station applicants to disclose information regarding free-flying or uncoupled deployment devices. Eutelsat states that satellite operators are not responsible for launch procedure and do not choose the specific deployment device used for launch of their satellite, which may not be determined until after the space station application is submitted. Some commenters suggest that information regarding a free-flying deployment device should be outside the scope of the Commission's purview, either for jurisdictional or practical reasons. We disagree with these points. It is reasonable to consider objects with limited purpose, other than launch vehicles, as part of the deployment or operations

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

of a Commission-licensed spacecraft. Free-flying deployment devices are, in terms of their effect on the orbital debris environment, indistinguishable from lens covers, tie-down cables, and other similar devices, in that they fulfill a limited function and then become debris. In some instances, the required disclosure may be as straightforward as incorporating by reference the information contained in a separate Commission application that has been submitted by the operator of the deployment device. In other instances, the space station operator will need to obtain the information regarding the deployment device from the operator and/or manufacturer of that device. The space station operator will be able to obtain this information, since the space station will be using the deployment device. Second, our experience has been that FAA launch-related analyses do not include consideration of free-flying or separated deployment devices, since such devices are not considered part of the launch vehicle. In this sense, depending on the factual scenario, the devices can be considered either "spacecraft" or "operational debris" related to the authorized space stations.[17] Our goal is to avoid a regulatory gap in which the orbital debris issues associated with a particular deployment device are not under review by any government entity. We will continue to coordinate with the FAA as needed, and in any case where an applicant believes that the deployment device would be under the FAA's authority, the applicant should make us aware so we can coordinate with the FAA in the particular case and avoid overlapping review. Eutelsat points out that in some instances the launching entity may not even be within U.S. jurisdiction or regulatory authority. In these instances, the operator should still provide information regarding use of any free-flying or separated deployment devices, consistent with our policy to require same information related to orbital debris

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

mitigation from market access applicants as from U.S. license applicants. For example, it would not be in the public interest for us to authorize market access for a non-U.S.-licensed satellite where the satellite meets our orbital debris mitigation requirements, but will be deployed by a free-flying device that has a 200-year on-orbit lifetime and presents a significant collision risk. Although, as Eutelsat states, market access may be requested long after the satellite is launched, that fact has not prevented us from applying our orbital debris regulations to such satellites in the past.

We will continue to largely assess these on a case-by-case basis at this time, since the individual facts can vary widely and so it is difficult to assess specific disclosure rules for each different type of device that may be used.[18] Consistent with the NPRM proposal, we will require that applicants disclosing the use of a deployment device also provide an orbital debris mitigation disclosure for any separate deployment devices. The information provided by applicants should address basic orbital debris principles, such as the orbital lifetime of the device, and collision risk associated with the device itself. Where applicable, the information should also address the method, sequencing, and timing by which the spacecraft be deployed into orbit. Boeing opposes the adoption of an information disclosure requirement absent "clear and objective criteria articulating when the use of such devices is permissible." There are a variety of facts to assess in connection with use of deployment device and potential for contribution to

[18] In *ex parte* filings, SIA expresses concern with the Commission's review of deployment devices on a case-by-case basis without identifying any criteria for their permissible use, such as required number of years for disposal. *See* Letter from Tom Stroup, President, Satellite Industry Association, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 18-313, Attach. at 4 (email to Tom Sullivan, Chief of the International Bureau, FCC) (filed April 15, 2020) (SIA Apr. 15, 2020 *Ex Parte*). We would have concerns regarding use of a deployment device if the device constitutes a debris object that exceeds 25 years on orbit in the LEO region, or exceeds the 0.001 collision risk probability that would be assessed if it were an otherwise functional spacecraft, for example, as indicia associated with negatively contributing to the debris environment. *See also* Letter from Bruce A. Olcott, Counsel to the Boeing Company, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 18-313, at 3 (filed April 16, 2020) (Boeing Apr. 16, 2020 *Ex Parte*). Boeing argues that deployment devices should be addressed in the Further Notice, *see id.*, but we find that the disclosure-based approach adopted here is appropriate for the limited number of cases and variety of factual scenarios involved.

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

We also received a number of comments related to the best means in which to evaluate collision risk specifically associated with the deployment of multiple satellites from a deployment device (e.g., re-contact analysis). We expect that recontact analysis will be conducted by operators, and that information will be provided to the Commission, but we do not adopt specific rules in this Order on how to conduct a re-contact analysis in the instance where a deployment device is deploying multiple satellites. Free-flying deployers releasing multiple satellites are still relatively new, and there is not consensus on what constitutes an adequate analysis of re-contact risk, and the extent to which re-contact risk is different from typical collision risk in terms of likelihood of creating debris. Accordingly, we will continue to assess

this issue on a case-by-case basis in the context of a particular mission profile. In addition to compiling information regarding collision risk, however, we encourage operators of free-flying deployment devices to adopt practices that will help reduce risks associated with multi-satellite deployments—including formulating a deployment sequence that minimizes re-contact risks and making other operators with satellites nearby aware and updated on the scope of the deployment.[19]

Additionally, we do not adopt rules in this Order related to multi-satellite launches more generally, i.e. multi-satellite launches not involving separate, free-flying deployment devices. In the Notice, the Commission also sought comment on whether we should include in our rules any additional information requirements for satellite applicants that will be part of a multi-satellite launch. A number of commenters suggested that these issues should be handled by the launch licensing authority and/or that there would be other difficulties involved in requiring additional information regarding launch and deployment from an FCC applicant. We observe that there are a number of established practices for multi-satellite deployment that are associated with low risk of re-contact, or otherwise a low risk of debris creation since any recontact would occur at low velocities. While we decline to adopt any rules related to this topic at this time, we may revisit this issue in the future.

2. Minimizing Debris Generated by Release of Persistent Liquids

In the NPRM, the Commission proposed to update the rules to cover the release of liquids that, while not presenting an explosion risk, could nonetheless, if released into space, cause damage to other satellites due to collisions. Specifically, the Commission proposed to include a requirement to identify any liquids that if released, either intentionally or unintentionally, will

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

persist in droplet form. The Commission observed that there has been increasing interest in use by satellites (including small satellites) of alternative propellants and coolants, some of which would become persistent liquids when released by a deployed satellite. The NPRM also stated our expectation that the orbital debris mitigation plan for any system using persistent liquids should address the measures taken, including design and testing, to eliminate the risk of release of liquids and to minimize risk from any unplanned release of liquids.

Some commenters addressing this issue disagreed with the Commission adopting a rule to address this issue, with most expressing concern that there was not sufficient evidence that release of certain propellants, for example, would result in persistent droplets or create any additional risk in the orbital environment. Along these lines, Aerospace states that it is important to distinguish between releases that could result in droplets or solids that could be a collision threat and those that dissipate or are too small to cause damage on impact. Aerospace points out, for example, that there are a number of beneficial operations including venting or using excess propellant and oxidizer that constitute release of liquids that are less likely to cause impact damage. Aerospace recommends that the Commission's proposed rule be clarified to explicitly permit the venting of volatile liquids and pressurants that could create future risk of fragmenting the spacecraft if not released, but will not form hazardous droplets. We agree that it is important to distinguish between those releases that could result in a long-term risk to the orbital environment and those that are unlikely to create any significant additional risks, such as release of volatile propellants that are soon dispersed through natural processes. Additionally, we have long recognized the importance of operators limiting the risk of accidental explosions, including by venting pressurized systems at a spacecraft's end of life.[20]

[20] *See also* 47 CFR 25.114(d)(14)(ii); *2004 Orbital Debris Order*, 19 FCC Rcd at 11580-82, paras. 29-33. Boeing asks that we update our rules regarding removal of stored energy at the spacecraft's end-of-life to acknowledge that

We adopt our proposed disclosure requirement, but clarified to require that applicants must specify only the release of those liquids that may in fact persist in the environment and pose a risk.[21] Thus, the applicant will determine whether any liquids have a chemical composition that is conducive to the formation of persistent droplets. If so, then the applicant will disclose that fact to the Commission.[22] The main consideration in making this determination is whether the liquid, if released into space, will disperse through evaporation, or remain in droplet form, as is typical of some ionic liquids, such as NaK droplets. If the applicant determines that released liquids will not persist due to evaporation or chemical breakdown, for example, then the applicant need not address the release of such liquids.[23] We conclude that asking applicants—

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stored energy sources can be "safed." Boeing Feb. 14, 2020 *Ex Parte* at 7-8. It is unclear exactly what Boeing requests, but to the extent that Boeing is concerned that the existing rule does not adequately address removal of stored energy, we note that our existing rules leaves various options for stored energy to be discharged or removed, including by indicating that "other equivalent procedures" or "other appropriate measures" may be used in addition to the enumerated examples provided in §§ 25.114(d)(14)(ii) and 25.283(c) of the Commission's rules, respectively. 47 CFR 25.114(d)(14)(ii), 25.283(c). We view our provisions on this topic as consistent with the ODMSP. Should an applicant seek to use measures not specifically listed in §§ 25.114(d)(14)(ii) and 25.283(c), we would expect that the applicants would provide documentation regarding the chosen method, consistent with the types of documentation that listed in the NASA Standard regarding eliminating stored energy sources. *See* NASA Standard 4.4.4.2.

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

[22] Boeing states that the Commission should provide clear and objective guidance regarding when the use of such liquids would be permitted. Boeing Comments at 9; Boeing Feb. 14, 2020 *Ex Parte* at 13. SIA similarly expresses concern with a case-by-case approach for reviewing these matters. SIA Apr. 15, 2020 *Ex Parte* Letter, Attach. at 4-5. Here, we believe a disclosure requirement should entail minimal costs for most operators and will provide flexibility to address new developments in space station design. As Boeing points out, there may be tradeoffs associated with use of certain new types of propellants in terms of orbital debris mitigation, and we believe these tradeoffs are best addressed on a case-by-case basis. *See* Boeing Comments at 10. Relevant considerations in cases involving use of persistent liquids may include, for example, design and testing of methods for containment of the liquid and prevention of release in space in droplet form. In a later *ex parte* filing, Boeing asks that we consider these issues in the Further Notice. *See* Boeing Apr. 16, 2020 *Ex Parte* at 3. For the reasons specified here, however, we believe that a case-by-case approach is sufficient at this time to address this relatively unique issue.

[23] Boeing asks that we state that the use of liquids that would result in persistent droplets if released is presumptively appropriate if reasonable measures are taken to prevent their release. Boeing Comments at 10. If the operator discloses that such liquids would present a risk to the orbital environment if accidentally released, then we would ask operators to describe the measures that are taken to prevent such accidental release. If unintentional release of the liquids would present a significantly greater risk to the orbital environment that would be otherwise posed by an

who have the most information regarding the operational profile of the mission and characteristics of the potentially released substances—to assess the risk will address the commenters' concerns that such a requirement may be overinclusive or premature. We clarify that this rule would apply to any liquids, not just propellants. In addition, we clarify that this rule will apply equally to release of liquids throughout the orbital lifetime. We further conclude that the benefit of identifying potential risks associated with use of certain liquids, if such liquids could become long-term debris objects, outweighs any costs to operators in assessing the chemical composition of any liquids to determine the physical properties of such liquids following release into the orbital environment.

E. Post-Mission Disposal

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

The orbital lifetime of a particular space station affects the collision risk it presents and reduction in post-mission orbital lifetime reduces collision risk. Spacecraft that are unable to complete post-mission disposal, particularly when left at higher altitudes where they may persist

accidental explosion of the spacecraft (not taking into account release of the liquids), for example, then the operator should expect to provide additional information to the Commission regarding measures taken to prevent release as well as potential alternatives.

indefinitely, will contribute to increased congestion in the space environment over the long-term and increase risks to future space operations.

1. Post-Mission Orbital Lifetime

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

As a practical matter, space stations that conduct collision avoidance maneuvers would achieve the main goal of limitations on orbital lifetime—avoiding collisions with large objects. Even with no maneuver capability, spacecraft deployed to and operating below 400 km generally re-enter Earth's atmosphere as a result of atmospheric drag within, at most, several years. For such satellites, when functioning normally, specification of a maximum post-mission orbital lifetime may be unnecessary. We examine in the Further Notice a maneuverability requirement for satellites operating above 400 km. Given the practical reality that satellites with maneuvering capabilities are likely to meet the objectives of limitations on post-mission orbital lifetime, the need to incorporate a separate provision into our rules regarding post-mission orbital lifetime will depend on whether we adopt a maneuverability requirement, and therefore will be addressed

in the Further Notice.

At this time, we will require that applicants planning disposal by atmospheric re-entry specify the planned time period for post-mission disposal as part of the description of disposal plans for the space station. We maintain the Commission's existing rule requiring a statement detailing post-mission disposal plans for the space station at end of life. The Commission also sought comment on whether we should account for solar activity in our rules or grant conditions. We note that the NASA Debris Assessment Software takes into consideration solar flux that may affect atmospheric drag, among other environmental factors. To the extent that the operator plans to rely on atmospheric drag for re-entry, reliance on NASA Debris Assessment Software or a higher fidelity assessment tool will meet the requirement on specifying the time period for post-mission disposal.

The Commission also sought comment on whether operators planning disposal through atmospheric re-entry should be required to continue obtaining spacecraft tracking information, for example by using radio facilities on the spacecraft to the greatest extent possible following the conclusion of the primary mission. Boeing argues that satellite operators should not be required to maintain communication links and active tracking with the satellite following the end of the missions unless they had initially indicated in the application that active tracking, rather than passive tracking, would be used to monitor the location of the spacecraft. Boeing also states that satellite operators should be required to continue to obtain spacecraft tracking information for retired satellites only if the satellite operator's original calculations regarding acceptable collision risk as the satellite's orbit decays depend upon the operator's ability to conduct collision avoidance. Iridium, on the other hand, suggests that satellites should be controlled all the way through atmospheric re-entry. We do not adopt a specific regulation specifying the

extent to which an operator should be required to maintain communications links or otherwise obtain spacecraft tracking information following the conclusion of the satellite's main mission at this time, since absent any particular requirements to maintain maneuvering capabilities, for example, operators are likely to have a wide range of capabilities in this area such that it would not be reasonable to adopt a "one-size-fits all" rule absent other requirements such as requiring active tracking capabilities, which we decline to adopt above. We do, however, encourage all operators to maintain communications links for tracking, control, and collision avoidance purposes for as long as possible following the conclusion of the spacecraft's primary operations, even below 400 km, and to continue to provide location information to the 18th Space Control Squadron and other operators for as long as possible, in accordance with the operators' plan for sharing ephemeris.

2. Reliability and Post-Mission Disposal

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

spacecraft should have a probability of successful post-mission disposal at a level greater than 0.9 with a goal of 0.99 or better.

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

We conclude that a baseline post-mission disposal reliability of 0.90 is appropriate for individual NGSO space stations, and that larger systems will be evaluated on a case-by-case basis for whether a higher per-spacecraft disposal reliability standard is necessary to avoid significant long-term impacts to the orbital environment. The rule adopted specifies that NGSO applicants provide a demonstration that the probability of successful post-mission disposal is 0.9 or greater for any individual space station.[24] Consistent with the general approach taken in the revised ODMSP, the rule further states that for space systems consisting of multiple space

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

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

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

For purposes of calculating the probability of successful post-mission disposal, we define successful post-mission disposal for spacecraft in LEO as re-entry into the Earth's atmosphere within 25 years or less following completion of the spacecraft mission. We recognize that consistent with the discussion above on post-mission lifetime, 25 years will in almost all instances be a longer period than the planned post-mission lifetime of the spacecraft.[25] We believe this is an appropriate balance, however, by giving operators options to meet a performance-based post-mission disposal reliability standard while mitigating the long-term impact of spacecraft failures on the orbital environment. Absent unusual circumstances, this

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

would allow spacecraft and systems deployed at low altitudes to achieve a 100% probability of successful post-mission disposal even if the satellites themselves fail immediately upon deployment. We observe that at lower deployment altitude, however, a high percentage of failed satellites could result in a high collision risk for a system as a whole.

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

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

Operators of large constellations replenishing on a regular basis or otherwise deploying a system through multiple launches should strive to improve reliability with each successive deployment, since it appears such improvements may have significant impact on the longer-term debris environment. Related to this point, Iridium suggests the Commission require all operators of space stations above 400 km to notify the Commission of any on-orbit satellite failures, whether such failures occur before or during operations. According to Iridium, once an operator makes such a notification, the Commission should require the operator to identify and correct the

root causes of failure on the ground prior to launching any additional satellites. Other commenters similarly request the Commission address how it will verify compliance with operator disclosures on post-mission reliability and other issues. In instances where an applicant for a system consisting of multiple satellites submits information that the expected total probability of collision, post-mission disposal reliability, or casualty risk is close to the acceptable threshold, the Commission will require, as an initial condition of the license, that, in case a rate of failure that would result in values above the risk threshold(s) described in the application is observed, such occurrence be reported to the Commission. The Commission could also require reporting as a result of information that comes to the attention of the Commission during the licensee's operations. In appropriate circumstances, the Commission could subsequently modify the license in accordance with section 316 of the Communications Act to address a rate of failure that departs materially from the expected reliability level, since that departure would affect the public interest assessment underlying grant of the license.

a. Deployment Orbit

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

Commenters addressing this issue generally disagree with the NPRM proposal. NASA recommends that a post-mission disposal reliability metric be adopted rather than requiring an

initial deployment altitude below 650 km, stating that the lower deployment would add to the complexity of the deployment of spacecraft and not significantly reduce risk. Other commenters suggested that this would create additional difficulties in development of a constellation and meeting of milestones, without significant benefits, and that the goal of reducing dead-on-arrival satellites could be met by other means. We decline to adopt a uniform requirement that NGSO satellites deploy first to 650 km and then raise their orbits to deployment altitude. We conclude that reliability of post-mission disposal and collision risk standards we adopt here more effectively address the same underlying issues regarding the long-term impact of non-functional satellites on the orbital environment. It should be noted, however, that in order to achieve post-mission disposal reliability objectives, the use of this strategy may be necessary, particularly for deployments involving larger numbers of satellites.

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

of satellites. OneWeb contends that required testing could impact an operator's ability to comply with the Commission's NGSO milestone rules.

We observe that there are tradeoffs with different testing modalities, and we expect that there will be some systems that will undergo a rapidly iterative development process following initial deployments. In such cases, those operators should consider deploying at lower altitudes and with smaller numbers of satellites, to ensure minimal impact on the orbital debris environment. We agree with those commenters suggesting that it may be difficult to fully determine on the ground how a satellite will perform in the space environment. As Boeing points out, several operators of planned NGSO systems have launched test satellites, usually consisting of just a few satellites, prior to any larger deployment. We believe the economic incentives are aligned to a certain extent to encourage such testing by operators of larger systems, given the costs involved in launching satellites. We may also revisit the basis for an applicant's license grant should it become evident that the licensee's satellite performance with respect to orbital debris mitigation is not consistent with what was specified in the application. In appropriate circumstances, the Commission could subsequently modify the license in accordance with section 316 of the Communications Act to address risks that depart materially from the expected level of risk or reliability, since that departure would affect the public interest assessment underlying grant of the license. We therefore at this time do not see the need for a regulatory specification regarding how much testing should be done before a certain level of constellation deployment. As discussed above, we expect that operators will be testing systems related to satellite disposal as well, and, if the operators conclude after deployment of a few satellites that they are not able to meet the reliability for post-mission disposal specified in their application, the operators will make changes to these systems to ensure that the required

reliability is achieved.

b. Automatic Initiation of Disposal

In the NPRM, the Commission proposed that applicants seeking to operate NGSO space stations should provide a statement that the spacecraft disposal will be automatically initiated in the event of loss of power or contact with the spacecraft, or describe other means to ensure that reliability of disposal will be achieved, such as internal redundancies, ongoing monitoring of the disposal function, or automatic initiation of disposal if communications become limited. The Commission also sought comment on the costs and benefits associated with these design features. After review of the record, we decline to adopt any regulations at this time with respect to automatic de-orbit.

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

development of robustly reliable autonomous systems could help to establish a high-level of reliability for post-mission disposal, but we will consider such technologies on a case-by-case basis.

c. Direct Spacecraft Retrieval

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

We generally agree with those commenters stating that it would be premature to establish more detailed regulations in this area. To the extent that any applicants seek to rely on direct retrieval as a means to dispose of their spacecraft, the plan may be considered on a case-by-case basis, keeping in mind that the technology would need to be sufficiently developed at the time of the application for the Commission to be able to assess the reliability of the disposal method. Although the technology for direct retrieval is not sufficiently developed for commercial applications at the moment, in the future this type of technology may enable some missions that would not otherwise be possible currently.

3. MEO Disposal

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

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

F. GSO License Extensions and Related Issues

Assessment of Request for Extension. In the NPRM, the Commission proposed to codify the current practice of requesting certain types of information from GSO licensees requesting license term extensions. The Commission proposed that the rule would specify that the applicants should state the duration of the requested license extension and the total remaining satellite lifetime, certify that the satellite has no single point of failure that could affect its ability to conduct end-of-life procedures as planned, that remaining fuel reserves are adequate to complete deorbit as planned, and that telemetry, tracking, and command links are fully functional. The Commission noted that in the event that an applicant is unable to make any of the certifications, the applicant could provide a narrative description justifying the extension. We adopt the proposed rule, modified to address commenter's concerns with the proposed certification concerning single point failures, as described below.

Commenters are concerned that the proposed certification that the satellite has "no single point of failure or other malfunctions, defects, or anomalies during its operations that could affect its ability to conduct end-of-life procedures" could unduly restrict the ability of operators to obtain extensions for satellites with years of useful life remaining and suggest a more flexible, case-by-case approach, as is currently followed. We modify our proposed rule on single points of failure or other malfunctions, defects, or anomalies to accommodate a description rather than a certification. An operator could specify, for example, that despite a single point of failure, the reliability of post mission disposal remains within acceptable levels. We will continue our case-by-case approach to assessing requests for license extensions, and the descriptive nature of this disclosure will enable an operator to provide additional information about potential risk and disposal reliability. Additionally, Space Logistics requests that the Commission adopt rules that

would permit a GSO space station licensee to extend its satellite license term by the length of any mission extension service in lieu of such certifications. We would also address this under our case-by-case approach.

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

A number of commenters, primarily operators or manufacturers of existing GSO satellites, oppose a cap on how many years may be requested at a time through an extension request. Telesat, for example, states the Commission should continue its current flexible approach because it minimizes regulatory proceedings and costs for the Commission and licensees. Although the limitation of a single license term extension to five years could potentially result in more modification requests being filed with the Commission as operators seek multiple license extensions, we conclude that the additional costs of preparing an application and paying a modification application fee are outweighed by the benefits of revisiting license extensions within five years—namely, ensuring that the extension continues to be consistent with the public interest by reevaluating the satellite health and functionality information that provides a basis for extending the license term. Lockheed Martin contends that it is not appropriate to limit extensions to five years if a longer term is justifiable based on a review of the provided specifics. Similarly, SIA argues that a five-year limit would significantly

constrict the ability of GSO operators to leverage the full value of their in-orbit assets. According to SIA, the Commission should continue to permit GSO operators to demonstrate, through the modification application process, that the satellite is capable of continuing to serve the public interest for an appropriate additional term. We fully recognize that there are satellites capable of providing service well beyond the initial 15-year license term, and in appropriate cases will license those satellites for additional license extensions. Under the approach we adopt here, GSO satellite licenses may be extended for more than five years in total, but the extensions will be granted in increments of five years, at most, through applications for modification. While GSO space station licensees understandably want to provide service for as long as possible using their existing space station(s), they are not necessarily incentivized to make conservative estimates when requesting license term extensions. The five-year limit per extension will allow for reassessment of satellite health on a regularized basis even for those satellites with longer lifetimes, which serves the public interest.

Intelsat argues the Commission should not limit the duration of license extension requests because in some countries, such as Brazil, landing rights are granted for the term specified in the original U.S. license and only one renewal is permitted, and so the landing rights are limited to the duration of the initial U.S. license term plus the length of the extension. Therefore, Intelsat argues, the Commission's five-year cap on an individual license term extension would limit the maximum period for landing rights in other countries. While we appreciate that operators are navigating regulatory processes in other nations as well as the United States, we cannot be responsible for the approach that other countries take with respect to landing rights—and have no control over whether and when another administration attaches significance to Commission decisions. We find that this rule change is in the public interest for the reasons discussed above,

and if operators have concerns regarding the approaches of other administrations, they should address those issues with the relevant administration(s).

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

Other Issues. In the NPRM, the Commission also sought comment on whether there are types of GSO satellite anomalies that should trigger immediate reporting, and whether there were any types of satellite buses that warrant heightened scrutiny for purposes of assessing license extensions. Those commenters addressing these issues disagreed with adoption of rules in either of these areas, and we decline to adopt any new rules on these topics at this time because we think it is unnecessary to adopt specific requirements in this area and can continue to address these issues on a case-by-case basis. With respect to GSO anomaly reporting, we observe that

GSO operators typically already provide information informally to the Commission regarding anomalies, and the Further Notice seeks comment on incentives for GSO operators to maximize the probability of successful disposal. Additionally, regarding satellite design issues, we continue to expect that operators will disclose issues that may be systematic to a particular GSO satellite design as part of their license extension request—and note that the Commission may consider such systematic issues as they arise and when assessing requests for license extensions under its continued case-by-case approach.

G. Casualty Risk Assessment

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

Second, the Commission proposed that where the calculated risk of human casualty from surviving debris is determined to be greater than zero, as calculated using either the NASA Debris Assessment Software or a higher fidelity assessment tool, the applicant must provide a statement indicating the calculated human casualty risk, as well as the input assumptions used in modeling re-entry. The Commission further sought comment on whether to assess human casualty risk in the aggregate as well as on a per-satellite basis, and what metric should be used to evaluate such risk.

The revised ODMSP states that for those satellites disposed of by reentry into Earth's atmosphere, "the risk of human casualty from surviving components with impact kinetic energies

greater than 15 joules should be less than 0.0001 (1 in 10,000)." The ODMSP also states that "[d]esign-for-demise and other measures, including . . . targeted reentry away from landmasses, to further reduce reentry human casualty risk should be considered." With respect to "large constellations," the ODMSP states that, "[i]n developing the mission profile, the program should limit the cumulative reentry human casualty risk from the constellation."

At this time, we adopt the approach advocated by some commenters and incorporate the 0.0001 (1 in 10,000) or less human casualty risk metric into our rules for those satellites that would be disposed of by atmospheric re-entry. This continues the approach followed in licensing since the adoption in 2004 of debris mitigation rules, and will provide in the codified rules an explicit reference point for applicants, consistent with the ODMSP and NASA Standard. In the Further Notice we seek additional comment on how the additional ODMSP guidance related to design-for-demise and other measures such as targeted reentry to further reduce human casualty risk should be addressed in our rules, as well as the guidance for large constellations that such constellations limit cumulative reentry human casualty risk. Thus, to the extent that some commenters suggest that we should apply a more stringent standard than 1 in 10,000 and consider total casualty risk on a system-wide basis, we address those topics in the Further Notice.

Several commenters suggest that NASA's Debris Assessment Software does not account for some potential sources of casualty risk adequately. NASA updates the Debris Assessment Software casualty risk assessment tool on an ongoing basis, including recently updating the reentry survivability model. To the extent that an applicant believes that its satellite design will not be adequately assessed with the Debris Assessment Software tool, it should submit a higher fidelity analysis that provides an improved assessment, and the rule revisions we adopt here are consistent with this approach.

H. Proximity Operations

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

We adopt a disclosure requirement that would identify situations where there are planned rendezvous and proximity operations and provide a vehicle for further review of those operations. The disclosure requirement follows the general approach in the revised ODMSP of analyzing such operations within the framework of standard debris mitigation objectives—limiting debris release, preventing accidental explosions, and limiting collision risk.[26] Commenters generally supported this approach. We note the evolving and developing nature of these operations, and accordingly find that more specific technical or operational requirements are premature at this time.

I. Encryption and Security of Spacecraft Command

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

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

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

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

Many of the comments focus more generally on the issue of securing command communications. A number of commenters argue that the Commission should not impose detailed encryption requirements, particularly those tied to a single standard, because satellite operators already have sufficient incentives to protect their space assets through encryption and other methods for restricting access only to authorized users. We agree that given the diversity

of satellite operations, requiring the use of a one-size-fits-all encryption standard is not appropriate at this time, and will continue to address concerns related to securing facilities through existing high-level performance obligations identified in FCC rules. As a matter of clarification, we are including specific language in the relevant part 25 rule to indicate that the rule applies to space stations.[27] We also encourage experimental and amateur licensees to continue to ensure that they are in full compliance with the Commission's existing rules applicable to experimental[28] and amateur licensees regarding control of transmitting stations.[29]

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

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

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

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

J. Frequency Coordination for Orbit-Raising

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

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

Under existing procedures, an operator is not strictly required to coordinate, but could simply accept interference from other operators. We find that this is not an ideal regime for telemetry, tracking, and command operations, and take this opportunity to clarify that operators should coordinate these operations to ensure that such operations are not subject to interference

that could impact those critical communications links and affect physical space station operations. This rule change is appropriate as part of this proceeding because it implicates communications related to the physical location of the space station. This coordination should also ensure that satellites already in service are not subject to interference from satellites engaged in orbit-raising. We further clarify that the "coordination" specified in the revised rule is informal operator-to-operator coordination, rather than, for example, the formal procedures specified in the ITU regulations. Eutelsat points out that current practices involves discussion between operators to facilitate operations on a non-interference basis. Sirius XM states that we should not modify this rule with respect to GSO operators, because operators have conducted orbit raising for GSO satellites on a non-harmful-interference, unprotected basis for decades without issue. That may be the case, but we see no downside to clarifying that operators should be coordinating such operations. Sirius XM seems concerned that it would need to accept interference from satellites undertaking these operations, but that is not the case—we are simply ensuring that such operations are coordinated between operators, which appears largely to be a continuation of existing practices. We expect that the practice of coordination between operators will continue and the goal of our rule revision is to encourage such discussions, rather than requiring that the operator conducting orbit-raising activities operate on a non-interference basis. We decline to specify any particular requirements for the coordination process, other than that operators undertake coordination in good faith, with the goal of facilitating orbit-raising operations and ensuring the availability of the telemetry, tracking, and command links, while not unduly disrupting other ongoing operations.

A few commenters raise other issues. Global NewSpace Operators suggests that the Commission consider the unique aspects of NGSO orbit raising, including that it is much faster

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

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

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

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

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

coordination with government operations in frequency bands shared with Federal operations. For the same reasons, we decline to extend the rule to operators supporting orbit-raising of MEO spacecraft at the end of the satellite's mission, as requested by SES/O3b.

K. Liability Issues and Economic Incentives

1. Indemnification

In the NPRM, the Commission sought comment on whether Commission space station licensees should indemnify the United States against any costs associated with a claim brought against the United States related to the authorized facilities under international law, specifically the Outer Space Treaties. Almost all commenters addressing the proposed indemnification requirement raised concerns, and several argued the proposal should be examined further before it is adopted. We conclude that further development of the record on this topic is warranted and we address this topic in the Further Notice.

2. Other Economic Incentives

Insurance. Separate from an indemnification requirement, the Commission had sought comment on the utility of insurance on its own as a means to incentivize operators to adhere to best practices in space. Specifically, the ability to obtain lower insurance premiums could provide an economic incentive for operators to adopt debris mitigation strategies that reduce risk. A number of commenters suggest that insurance generally would not necessarily incentivize good behavior in space, and provide information concerning the functioning of insurance markets that suggest they do not by themselves provide adequate incentives for debris mitigation. Given some of the limitations of insurance, we decline to adopt an insurance requirement on its own as a way of incentivizing "good behavior" in space. However, we seek comment in the Further Notice on whether a rule regarding indemnification will help to ensure that liability is

considered as operators make decisions concerning satellite design and operation.

Other Incentives. In the Further Notice, we propose a performance bond for satellite disposal, which we tentatively believe would be in the public interest as an economic incentive. We decline, however, to adopt several of the other economic incentives proposed by commenters as ways to encourage best practices in orbital debris mitigation for Commission-authorized satellites and systems. None of the additional proposals have been developed sufficiently to demonstrate how they could be applied to the orbital debris mitigation context at this time. We do not discount these possibilities altogether, however, and may revisit other economic incentives at some point in the future.

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

NYU suggests the use of a regulatory fee to deter and mitigate orbital debris. Such a regulatory fee, however, would require calibrating the dollar value of orbital debris; determining

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

L. Scope of Rules

1. Amateur and Experimental Operations

The Commission proposed in the NPRM to amend the rules governing experimental satellite and amateur satellite authorizations to maintain consistency with the proposed revisions to the orbital debris mitigation rules for commercial systems.[30] These authorized satellites have long been subject to orbital debris mitigation rules—as the Commission concluded in 2004 that it was in the public interest to require a description of the design and operational strategies used to mitigate orbital debris from applicants seeking to conduct experimental or amateur satellite operations. In the NPRM, the Commission stated that it continues to believe that it is appropriate for amateur licensees and experimental applicants to provide a similar amount of disclosure regarding debris mitigation plans as will be required of commercial satellites, and sought comment. A number of commenters agreed that the amateur and experimental operations should

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

be subject to the same orbital debris mitigation rules as commercial operations. Commenters with interest in amateur operations generally request that we carefully consider the impact of any proposed regulations on amateur satellite organizations and others building and operating space stations in the amateur satellite service.

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

filed under part 5, part 25, or part 97.

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

We also recognize that in some instances, space stations, particularly amateur and experimental stations, are co-located on spacecraft with other space stations. AMSAT requests that we consider certain exemptions from orbital debris requirements in this scenario. In instances where there are multiple space stations co-located on the same spacecraft, and information on orbital debris mitigation plans has been provided or will be provided by one or more of the space station applicants in conformance with the Commission's rules, applicants for other co-located space stations may satisfy the disclosure requirements through incorporation by reference. In other words, there is no need for space station applicants to submit multiple copies of the same documentation to the Commission.[31] We decline to adopt a blanket exemption from orbital debris disclosures for space stations co-located with U.S. government space stations, but suggest that applicants for such space stations could seek a waiver of our orbital debris mitigation disclosure requirements on the basis that the plans are being evaluated by another U.S. government entity. In such instances, the Commission would request that the FCC applicant or operator specify the U.S. government agency and contact for officials who would be responsible

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

for the orbital debris mitigation component of the spacecraft operations. This should be a relatively straightforward process in many cases—for example, there is no reason for the Commission to independently evaluate the orbital debris mitigation plan for an experimental space station planned to be co-located on the ISS. Applicants and operators should be aware however, that additional information may be necessary in certain factual scenarios—such as where the governmental space station operations will conclude before the Commission-authorized operations.

2. Non-U.S.-Licensed Satellites

The Commission also proposed in the NPRM that the new and amended rules adopted should be applicable to non-U.S.-licensed satellites seeking access to the U.S. market. This approach is consistent with the Commission's current rules. A number of commenters support the Commission's proposal to continue applying orbital debris mitigation requirements to non-U.S. licensed satellites seeking authority to access the U.S. market, and some commenters also support the existing approach of allowing non-U.S.-licensed satellite operators seeking U.S. market access to satisfy orbital debris mitigation requirements by demonstrating that their orbital debris mitigation efforts are subject to direct and effective regulatory oversight by another national licensing authority. CSSMA suggests that operators be permitted to demonstrate that their system's orbital debris mitigation plans are subject to direct and effective regulatory oversight by their foreign national licensing administration in cases where the operator does not have a substantial U.S. commercial presence, but is using U.S.-based activities for telemetry, tracking, and command. Global NewSpace Operators, on the other hand, states that the degree of activity should not be a factor and that transmission and reception on a limited basis, such as telemetry, tracking, and command, still constitutes a commercial activity and those operators

should be held to the same rules as a U.S.-licensed operator. We agree with Global NewSpace Operators, and we do not think it is useful to make degree of activity the deciding factor for how to assess an applicant's orbital debris mitigation plans.

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

M. Other Issues

1. Lunar/Other Orbits

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

if any.

2. Implementation of the New Rules

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

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

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

N. Additional Topics from the Regulatory Impact Analysis

In the NPRM, as part of the Regulatory Impact Analysis, the Commission considered and sought comment on various regulatory alternatives to reducing debris in orbit. Some of these approaches were related to other specific proposals in the NPRM (e.g., changes in operations and disposal procedures). Other alternatives (e.g., fewer launches) were different from the proposals that the Commission otherwise proposed in the Notice. The Commission sought comment on six regulatory alternatives to address orbital debris: fewer launches, changes in satellite design, changes in operations and disposal procedures, use of economic incentives, active collision avoidance, and active debris cleanup. The majority of these involve some type of regulatory activity. Based on the record and as discussed below, we conclude that as a general matter, operators would not necessarily be incentivized on their own to take action that is beneficial for the prevention and reduction of orbital debris in orbit absent regulatory action.

As an introduction to the Regulatory Impact Analysis, the Commission provided some high-level analysis on the benefits of mitigating orbital debris, and how debris can be characterized as a negative externality. That is, that while the debris problem is a significant consideration for the joint use of orbital resources, such considerations may not play a sufficient role in economic decision-making by operators individually. Reductions in the amount of debris created can help preserve orbital resources over the long-term. The costs and benefits are difficult to quantify—but in a worst-case scenario, certain valuable orbits could become useable only at an extremely high cost, rendering them unusable for most operators. If there were large concentrations of debris in LEO, for example, certain areas could not be used to provide any satellite service. The same holds true for GEO, a particularly valuable orbit for satellite communications. These would be significant costs for the satellite industry overall, and may end up in the discontinuation of certain types of commercial satellites or systems, not to mention the

potential impact on costs for U.S. government systems. Moreover, there is a tendency of debris to generate yet more debris through collisions—resulting in an escalating debris situation, even if no new debris is added as a result of ongoing operations. On the other hand, there are costs associated with practices such as collision avoidance and disposal—which we discuss in the context of each section above.

Additionally, there are considerations of how any U.S. regulations, specifically FCC regulations, can benefit the overall orbital debris environment, since the United States is only one among many spacefaring nations. Given the common pool nature of space, as previously explained, one country's decision to improve the efficiency with which space is used will convey a benefit to other countries that employ space even if that country does not employ such measures. That only the satellite operators of the country employing the measures designed to limit orbital debris are incurring the associated costs while the benefits are enjoyed by everyone, likely will create incentives for other countries to "free-ride" off of the efforts of the providers licensed by efficiency enhancing countries. In the Notice the Commission reiterated the Commission's 2004 statement that: "we do not believe that the theoretical possibility that other countries could take ill-considered actions, at variance with international norms, in any way should prevent the Commission from adopting objective and transparent measures concerning orbital debris mitigation that serve the public interest." Furthermore, as discussed above, we will apply the same orbital debris mitigation rules to non-U.S.-licensed satellites and systems seeking market access as we apply to U.S.-licensed systems, so that both types of satellites and systems will be subject to the same orbital debris regulation.

Some of the commenters in this proceeding responded to specific aspects of the Regulatory Impact Analysis, and in particular, disagreed with the options of limiting launches

and regulating how satellites or satellite systems are designed. For example, Eutelsat states, from the perspective of a GSO operator, that regulation of spacecraft design could inhibit innovation and competition by manufacturers regarding ways to limit orbital debris, improve satellite operations, and ensure reliable end-of-life operations. Eutelsat further states that it may be difficult to identify a meaningful list of design elements that should be limited by rule and frequently updated to reflect technological progress. Astranis also disagrees with the Commission regulating how satellites or satellite systems are designed, stating that in the case of GSO satellites, market forces (including manufacturer and operator commercial objectives) and well-settled international requirements are sufficient to drive reliable design elements. Global NewSpace Operators states that while the government has a role to play in incentivizing industry, it does not recommend mandating specific satellite design concepts or active collision avoidance, rather preferring that these elements emerge as industry best practices. The Secure World Foundation states that changes in satellite design, operations and disposal and procedures, and economic incentives should all be considered as part of strengthening orbital debris mitigation requirements, and that ensuring better post-mission disposal through design and procedures represents the best opportunity for reducing the future growth of the space debris population from new launches. The Secure World Foundation also notes that even with strong post-mission disposal, active debris removal or just-in-time collision avoidance of existing large debris objects will be required to prevent the collisions that will generate thousands of new pieces of debris. According to the Secure World Foundation and Global NewSpace Operators, it is difficult to determine what the exact right mix of these components will be, and suggests that the U.S. government consider funding more public research and analysis of the orbital debris problem and holistic approaches to addressing space sustainability. Many commenters also

expressed views on the costs of certain rule revisions in the context of the discussion above, which we have considered as part of those analyses. Overall, we conclude that taking the action to adopt updates to our rules at this time balances the costs of requiring U.S. commercial and other non-governmental operators to address orbital debris mitigation as part of the current licensing process, with the benefit of limiting the increase in new debris in orbit. At the same time, we recognize the need for continued research and development in this area, and expect that given the pace of developments in the space industry and U.S. government, orbital debris regulation may become a more rapidly iterative process than it has been in the past. Given the record established both specific to the Regulatory Impact Analysis as well as specific to other topics in the proceeding, we agree with Global NewSpace Operators that the most practical, cost-neutral, and immediate regulatory actions can come from requiring changes in operations and disposal procedures.

ORDERING CLAUSES

IT IS ORDERED, pursuant to sections 1, 4(i), 301, 303, 307, 308, 309, and 310 of the Communications Act of 1934, as amended, 47 U.S.C. 151, 154(i), 301, 303, 307, 308, 309, and 310, that this Report and Order IS ADOPTED, the policies, rules, and requirements discussed herein ARE ADOPTED, and parts 5, 25, and 97 of the Commission's rules ARE AMENDED as set forth in Appendix A of the Report and Order.

IT IS FURTHER ORDERED that the amendments of the Commission's rules to §§ 25.271(d) and 25.282, 47 CFR 25.271(d), 25.282, set forth in Appendix A of the Report and Order, ARE ADOPTED, effective thirty days from the date of publication in the *Federal Register*. The other amendments to the Commission's rules set forth in Appendix A of this Order contain new or modified information collection requirements that require review and

approval by the Office of Management and Budget under the Paperwork Reduction Act, and WILL BECOME EFFECTIVE after the Commission publishes a notice in the *Federal Register* announcing such approval and the relevant effective date.

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

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

Final Regulatory Flexibility Analysis

As required by the Regulatory Flexibility Act of 1980, as amended (RFA), an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the Notice of Proposed Rulemaking, Mitigation of Orbital Debris in the New Space Age (Notice), released in November 2018 in this proceeding. No comments were filed addressing the IRFA. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.

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

This Order adopts updates to the Commission's rules relating to the mitigation of orbital debris. This represents the first comprehensive update to our rules on orbital debris mitigation since their adoption in 2004. These rule changes are informed by the Commission's experience gained in the licensing process and address updates in mitigation guidelines and practices as well as market developments. Adoption of these rule revisions will ensure that applicants for a Commission space station license or authorization, or grant of market access, provide a complete

statement concerning plans for orbital debris mitigation enabling the Commission to fully evaluate whether the proposed operations are consistent with the public interest. Adoption of these rules will also provide specific guidance on evaluation criteria for orbital debris mitigation plans in a number of areas, for both non-geostationary orbit (NGSO) and geostationary-orbit (GSO) space stations. This action will help to ensure that Commission decisions are consistent with the public interest in space remaining viable for future satellites and systems and the many services that those systems provide to the public.

The Order adopts several changes to 47 CFR parts 5, 25, and 97. Principally, it:

1) Revises the Commission's application disclosure rules regarding mitigation of orbital debris to incorporate specific metrics for assessments of risk of collision with large objects, risk of collision with small objects, and re-entry casualty risk;

2) Adopts application disclosures regarding protection of inhabitable spacecraft, maneuverability trackability, space station identification, and sharing of information regarding initial space station deployment, ephemeris, and/or planned maneuvers;

3) Adopts a demonstration requirement for applicants for NGSO space stations that the probability of success of the chosen disposal method is 0.9 or greater for any individual space station, with the demonstration including efforts to achieve a higher probability of success for larger systems;

4) Codifies the current practice of requesting certain types of information from GSO licensees requesting license term extensions, and limits most GSO licensees to license extensions in increments of five years; and

5) Adopts other rules updates to address specific situations, including proximity operations, use of deployment devices, and certain types of plans for disposal of space

stations.

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

No comments were filed that specifically addressed the IRFA.

C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration

Pursuant to the Small Business Jobs Act of 2010, which amended the RFA, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration (SBA), and to provide a detailed statement of any change made to the proposed rules as a result of those comments. The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

D. Description and Estimate of the Number of Small Entities To Which the Proposed Rules Will Apply

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

Satellite Telecommunications and All Other Telecommunications.

Satellite Telecommunications. This category comprises firms "primarily engaged in providing telecommunications services to other establishments in the telecommunications and broadcasting industries by forwarding and receiving communications signals via a system of satellites or reselling satellite telecommunications." Satellite telecommunications service providers include satellite and earth station operators. The category has a small business size standard of $35 million or less in average annual receipts, under SBA rules. For this category, U.S. Census Bureau data for 2012 show that there were a total of 333 firms that operated for the entire year. Of this total, 299 firms had annual receipts of less than $25 million. Consequently, we estimate that the majority of satellite telecommunications providers are small entities

All Other Telecommunications. The "All Other Telecommunications" category is comprised of establishments primarily engaged in providing specialized telecommunications services, such as satellite tracking, communications telemetry, and radar station operation. This industry also includes establishments primarily engaged in providing satellite terminal stations and associated facilities connected with one or more terrestrial systems and capable of transmitting telecommunications to, and receiving telecommunications from, satellite systems. Establishments providing Internet services or voice over Internet protocol (VoIP) services via client-supplied telecommunications connections are also included in this industry. The SBA has developed a small business size standard for "All Other Telecommunications", which consists of all such firms with annual receipts of $35 million or less. For this category, U.S. Census Bureau data for 2012 show that there were 1,442 firms that operated for the entire year. Of those firms, a total of 1,400 had annual receipts less than $25 million and 15 firms had annual receipts of $25 million to $49, 999,999. Thus, the Commission estimates that the majority of "All Other Telecommunications" firms potentially affected by our action can be considered small.

These rule changes would also apply to experimental space station applicants under part 5 and amateur space station operators under part 97, and we estimate that in almost all cases these entities will qualify under the definition of small entities. Additionally, we estimate that some space station applicants applying under part 25 of the Commission's rules will qualify as small entities affected by these rule changes.

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

The Order amended those rules that are applicable to space station operators requesting a licensee or authorization from the Commission, or entities requesting that the Commission grant a request for U.S. market access. These applicants must submit a debris mitigation plan to the Commission as part of the application process, and the Order revised in part the information to be included in that debris mitigation plan. These revisions codified a number of informational requirements that applicants were providing under the existing rules, including providing some specific metrics for operators to reference in preparing orbital debris mitigation plans. The Order also adopts some additional disclosure requirements related to orbital debris mitigation. Applicants requesting authorization from the Commission must comply with existing technical disclosure requirements, including those related to orbital debris mitigation. Much of the information covered in the revised rules is information that applicants already provide or that the Commission would currently seek from the applicant under its existing general disclosure requirements. Most applicants already prepare orbital debris mitigation plans using the National Aeronautics and Space Administration (NASA) Debris Assessment Software identified in the revised rules as an acceptable assessment tool. This assessment tool is available at no cost and documentation on how to use the software is made available online by NASA. The additional

disclosure and certification requirements adopted in the Report and Order are consistent with the types of legal and technical requirements already specified in the Commission's application rules, and therefore we expect that all parties, including small entities, will have the resources to prepare and disclose orbital debris mitigation plans in accordance with the revised rules.

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

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

(1) Differing compliance or reporting requirements or timetables. The Order requires all space station applicants to disclose plans to mitigate orbital debris at the application stage, and thus applicants may prepare and submit the information according to their schedule, so long as the information is part of the application to the Commission, and there is enough time for the Commission to review and act on the application prior to launch. Applicants for GSO license extensions similarly may prepare information in support of their request for an extension in accordance with their preferred timetable. As noted, the revised requirements overall are consistent with the level of technical analysis that applicants currently provide in preparing an application for Commission review. We do make a timetable modification in the amateur space station rules to accommodate the notification process for Part 97 amateur authorizations.

Applicants for systems consisting of multiple space stations will need to provide some additional information at the application stage, recognizing the impact of a system consisting of multiple satellites on the orbital debris environment. As noted above, operation of multiple space stations is not always correlated with larger entities, however, since small entities may also plan to operate multiple space stations. As a general matter, we observe that space station operations by small entities can pose the same public interest concerns as those posed by large entities when it comes to contribution to the orbital debris environment, with the level of contribution to the debris environment being driven by factors other than the size of the entity.

(2) Clarification, consolidation, or simplification of compliance or reporting requirements. The Order clarifies a number of existing compliance requirements by providing specific metrics and guidance in a number of areas that inform an applicant's disclosures and certifications related to orbital debris mitigation. The Order also clarifies the authorization process by specifying additional disclosures in the rules, thereby providing applicants, including small entities, with a more complete view of the information that the Commission needs during a typical license or authorization process in order to adequately assess the applicant's orbital debris mitigation plan.

(3) Use of performance, rather than design, standards. The Order specifically addresses comments requesting the use of performance, rather than prescriptive, or design, standards. We have endeavored throughout the Report and Order to adopt a performance-based approach where feasible.

(4) Exemption from coverage of the rule, or any part thereof, for small entities. With respect to exemptions, we reiterate our observation that as a general matter, space station operations by small entities can present the same public interest concerns as those posed by large

entities when it comes to contribution to the orbital debris environment, with the level of contribution to the debris environment being driven by factors other than the size of the entity. Therefore, we do not adopt exemptions from coverage of a rule for small entities.

Report to Congress

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

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

Reporting and recordkeeping requirements, Satellites.

Federal Communications Commission.

Marlene Dortch,
Secretary.

Final Rules

For the reasons discussed in the preamble, the Federal Communications Commission amends title 47 of the CFR, parts 5, 25, and 97 as follows:

PART 5 – EXPERIMENTAL RADIO SERVICE

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

Authority: 47 U.S.C. 154, 301, 302, 303, 307, 336.

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

§ 5.64 Special provisions for satellite systems.

* * * * *

(b) 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. Where applicable, this statement must include an orbital debris mitigation disclosure for any separate deployment devices, distinct from the space station launch vehicle, that may become a source of orbital debris;

(2) A statement indicating whether the space station operator has assessed and limited the probability that the space station(s) will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal. The statement must indicate whether this probability for an individual space station is 0.01 (1 in 100) or less, as calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool;

(3) A statement that the space station operator has assessed and limited the probability,

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

(4) A statement that the space station operator has assessed and limited the probability of the space station(s) becoming a source of debris by collisions with large debris or other operational space stations.

(i) Where the application is for an NGSO space station or system, the following information must also be included:

(A) A demonstration that the space station operator has assessed and limited the probability of collision between any space station of the system and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the space station, including any de-orbit phases, to less than 0.001 (1 in 1,000). The probability shall be calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool. The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects.

(B) The statement must identify characteristics of the space station(s)'

orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision.

(C) If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, the statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft.

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

(E) The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should

include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.

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

(5) A statement addressing the trackability of the space station(s). Space station(s) operating in low-Earth orbit will be presumed trackable if each individual space station is 10 cm or larger in its smallest dimension, exclusive of deployable components. Where the application is for an NGSO space station or system, the statement shall also disclose the following:

(i) How the operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive;

(ii) Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity; and

(iii) The extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators.

(6) A statement disclosing planned proximity operations, if any, and addressing debris

generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks.

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

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

(ii) For space stations terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must disclose whether the spacecraft will be disposed of either through atmospheric re-entry, specifying if direct retrieval of the spacecraft will be used. The statement must also disclose the expected time in orbit for the space station following the completion of the mission.

(iii) For space stations not covered by either paragraph (b)(7)(i) or (ii) of this section, the statement must indicate whether disposal will involve use of a storage orbit or long-term atmospheric re-entry and rationale for the selected disposal plan.

(iv) For all NGSO space stations under paragraph (b)(7)(ii) or (iii) of this section, the following additional specific provisions apply:

(A) The statement must include a demonstration that the probability of success of the chosen disposal method will be 0.9 or greater for any individual space station. For space station systems consisting of multiple space stations, the demonstration should include additional information regarding efforts to achieve

a higher probability of success, with a goal, for large systems, of a probability of success for any individual space station of 0.99 or better. For space stations under paragraph (b)(7)(ii) of this section that will be terminating operations in or passing through low-Earth orbit, successful disposal is defined as atmospheric re-entry of the spacecraft within 25 years or less following completion of the mission. For space stations under paragraph (b)(7) (iii) of this section, successful disposal will be assessed on a case-by-case basis.

(B) If planned disposal is by atmospheric re-entry, the statement must also include:

(*1*) A disclosure indicating whether the atmospheric re-entry will be an uncontrolled re-entry or a controlled targeted reentry.

(*2*) An assessment as to whether portions of any individual spacecraft will survive atmospheric re-entry and impact the surface of the Earth with a kinetic energy in excess of 15 joules, and demonstration that the calculated casualty risk for an individual spacecraft using the NASA Debris Assessment Software or a higher fidelity assessment tool is less than 0.0001 (1 in 10,000).

PART 25 – SATELLITE COMMUNICATIONS

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

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

4. Amend § 25.114 by revising paragraph (d)(14) 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. Where applicable, this statement must include an orbital debris mitigation disclosure for any separate deployment devices, distinct from the space station launch vehicle, that may become a source of orbital debris;

(ii) A statement indicating whether the space station operator has assessed and limited the probability that the space station(s) will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal. The statement must indicate whether this probability for an individual space station is 0.01 (1 in 100) or less, as calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool;

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

of stored energy, or through other equivalent procedures specifically disclosed in the application;

(iv) A statement that the space station operator has assessed and limited the probability of the space station(s) becoming a source of debris by collisions with large debris or other operational space stations.

(A) Where the application is for an NGSO space station or system, the following information must also be included:

(*1*) A demonstration that the space station operator has assessed and limited the probability of collision between any space station of the system and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the space station, including any de-orbit phases, to less than 0.001 (1 in 1,000). The probability shall be calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool. The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects.

(*2*) The statement must identify characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision.

(*3*) If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any

inhabitable spacecraft, including the International Space Station, the statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft.

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

(*5*) The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.

(B) Where a space station requests the assignment of a geostationary orbit

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

(v) A statement addressing the trackability of the space station(s). Space station(s) operating in low-Earth orbit will be presumed trackable if each individual space station is 10 cm or larger in its smallest dimension, excluding deployable components. Where the application is for an NGSO space station or system, the statement shall also disclose the following:

(A) How the operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive;

(B) Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity; and

(C) The extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators.

(vi) A statement disclosing planned proximity operations, if any, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental

collision, and measures taken to mitigate those risks.

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

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

(B) For space stations terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must disclose whether the spacecraft will be disposed of through atmospheric re-entry, specifying if direct retrieval of the spacecraft will be used. The statement must also disclose the expected time in orbit for the space station following the completion of the mission.

(C) For space stations not covered by either paragraph (d)(14)(vii)(A) or (B) of this section, the statement must indicate whether disposal will involve use of a storage orbit or long-term atmospheric re-entry and rationale for the selected disposal plan.

(D) For all space stations under paragraph (d)(14)(vii) (B) or (C) of this section, the following additional specific provisions apply:

(*1*) The statement must include a demonstration that the probability of success of the chosen disposal method will be 0.9 or greater for any individual space station. For space station systems consisting of multiple space stations, the demonstration should include additional information

regarding efforts to achieve a higher probability of success, with a goal, for large systems, of a probability of success for any individual space station of 0.99 or better. For space stations under paragraph (d)(14)(vii)(B) of this section, successful disposal is defined as atmospheric re-entry of the spacecraft within 25 years or less following completion of the mission. For space stations under paragraph (d)(14)(vii)(C) of this section, successful disposal will be assessed on a case-by-case basis.

(*2*) If planned disposal is by atmospheric re-entry, the statement must also include:

(*i*) A disclosure indicating whether the atmospheric re-entry will be an uncontrolled re-entry or a controlled targeted reentry.

(*ii*) An assessment as to whether portions of any individual spacecraft will survive atmospheric re-entry and impact the surface of the Earth with a kinetic energy in excess of 15 joules, and demonstration that the calculated casualty risk for an individual spacecraft using the NASA Debris Assessment Software or a higher fidelity assessment tool is less than 0.0001 (1 in 10,000).

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

(viii) For non-U.S.-licensed space stations, the requirement to describe the design

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

* * * * *

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

§ 25.121 License term and renewals.

* * * * *

(f) *Geostationary Satellite License Term Extensions*. (1) For geostationary space stations issued an initial license term for a period of 15 years, licensees may apply for a modification to extend the license term in increments of five years or less.

(2) Geostationary space station licensees seeking a license term extension through a license modification application must provide a statement that includes the following:

(i) The requested duration of the license extension;

(ii) The estimated total remaining space station lifetime;

(iii) A description of any single points of failure or other malfunctions, defects, or anomalies during the space station operation that could affect its ability to conduct end-of-life procedures as planned, and an assessment of the associated risk;

(iv) A certification that remaining fuel reserves are adequate to complete de-orbit as planned; and

(v) A certification that telemetry, tracking, and command links are fully functional.

6. Amend § 25.122 by revising paragraphs (c) and (d) to read as follows:

§ 25.122 Applications for streamlined small space station authorization.

* * * * *

(c) Applicants filing for authorization under the streamlined procedure described in this section must include with their applications certifications that the following criteria will be met for all space stations to be operated under the license:

(1) The space station(s) will operate only in non-geostationary orbit;

(2) The total in-orbit lifetime for any individual space station will be six years or less;

(3) The space station(s):

(i) Will be deployed at an orbital altitude of 600 km or below; or

(ii) Will maintain a propulsion system and have the ability to make collision avoidance and deorbit maneuvers using propulsion;

(4) Each space station will be identifiable by a unique signal-based telemetry marker distinguishing it from other space stations or space objects;

(5) The space station(s) will release no operational debris;

(6) The space station operator has assessed and limited the probability of accidental explosions, including those resulting from the conversion of energy sources on board the space station(s) into energy that fragments the spacecraft;

(7) The probability of a collision between each space station and any other large object (10 centimeters or larger) during the orbital lifetime of the space station is 0.001 or less as calculated using current National Aeronautics and Space Administration (NASA) software or other higher fidelity model;

(8) The space station(s) will be disposed of post-mission through atmospheric re-

entry. The probability of human casualty from portions of the spacecraft surviving re-entry and reaching the surface of the Earth is zero as calculated using current NASA software or higher fidelity models;

(9) Operation of the space station(s) will be compatible with existing operations in the authorized frequency band(s). Operations will not materially constrain future space station entrants from using the authorized frequency band(s);

(10) The space station(s) can be commanded by command originating from the ground to immediately cease transmissions and the licensee will have the capability to eliminate harmful interference when required under the terms of the license or other applicable regulations;

(11) Each space station is 10 cm or larger in its smallest dimension;

(12) Each space station will have a mass of 180 kg or less, including any propellant;

(13) The probability that any individual space station will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal is 0.01 (1 in 100) or less; and

(14) Upon receipt of a space situational awareness conjunction warning, the licensee or operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.

(d) The following information in narrative form shall be contained in each application:

(1) An overall description of system facilities, operations, and services and an explanation of how uplink frequency bands would be connected to downlink frequency bands;

(2) Public interest considerations in support of grant;

(3) A description of means by which requested spectrum could be shared with both current and future operators, (e.g., how ephemeris data will be shared, antenna design, earth station geographic locations) thereby not materially constraining other operations in the requested frequency band(s);

(4) If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, a description of the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft shall be furnished at the time of application;

(5) A statement identifying characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, and indicating what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the licensee plans to use to avoid collision;

(6) A statement disclosing how the licensee or operator plans to identify the space station(s) following deployment and whether space station tracking will be active or passive; whether the space station(s) will be registered with the 18th Space Control Squadron or successor entity prior to deployment; and the extent to which the space station licensee or operator plans to share information regarding initial deployment,

ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators;

(7) A description of the design and operation of maneuverability and deorbit systems, if any, and a description of the anticipated evolution over time of the orbit of the proposed satellite or satellites;

(8) If there are planned proximity operations, a statement disclosing those planned operations, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks;

(9) A demonstration that the probability of success of disposal is 0.9 or greater for any individual space station. Space stations deployed to orbits in which atmospheric drag will, in the event of a space station failure, limit the lifetime of the space station to less than 25 years do not need to provide this additional demonstration; and

(10) A list of the FCC file numbers or call signs for any known applications or Commission grants related to the proposed operations (e.g., experimental license grants, other space station or earth station applications or grants).

7. Amend § 25.123 by adding paragraph (b)(11) to read as follows:

§ 25.123 Applications for streamlined small spacecraft authorization.

* * * * *

(b) * * *

(11) Upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk

if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.

* * * * *

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

§ 25.271 Control of transmitting stations.

* * * * *

(d) The licensee shall ensure that the licensed facilities are properly secured against unauthorized access or use whenever an operator is not present at the transmitter. For space station operations, this includes securing satellite commands against unauthorized access and use.

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9. Amend § 25.282 by revising paragraph (b) as follows:

§ 25.282 Orbit raising maneuvers.

* * * * *

(b) The space station operator will coordinate on an operator-to-operator basis with any potentially affected satellite networks.

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PART 97 – AMATEUR RADIO SERVICE

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

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

11. Amend § 97.207 by revising paragraph (g)(1) to read as follows:

§ 97.207 Space station.

* * * * *

(g) * * *

(1) A pre-space notification within 30 days after the date of launch vehicle determination, but no later than 90 days before integration of the space station into the launch vehicle. The notification must be in accordance with the provisions of Articles 9 and 11 of the International Telecommunication Union (ITU) Radio Regulations and must specify the information required by Appendix 4 and Resolution No. 642 of the ITU Radio Regulations. The notification must also include a description of the design and operational strategies that 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. Where applicable, this statement must include an orbital debris mitigation disclosure for any separate deployment devices, distinct from the space station launch vehicle, that may become a source of orbital debris;

(ii) A statement indicating whether the space station operator has assessed and limited the probability that the space station(s) will become a source of debris by collision with small debris or meteoroids that would cause loss of control and prevent disposal. The statement must indicate whether this probability for an individual space station is 0.01 (1 in 100) or less, as calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool;

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

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

(iv) A statement that the space station operator has assessed and limited the probability of the space station(s) becoming a source of debris by collisions with large debris or other operational space stations.

(A) Where the application is for an NGSO space station or system, the following information must also be included:

(*1*) A demonstration that the space station operator has assessed and limited the probability of collision between any space station of the system and other large objects (10 cm or larger in diameter) during the total orbital lifetime of the space station, including any de-orbit phases, to less than 0.001 (1 in 1,000). The probability shall be calculated using the NASA Debris Assessment Software or a higher fidelity assessment tool. The collision risk may be assumed zero for a space station during any period in which the space station will be maneuvered effectively to avoid colliding with large objects.

(*2*) The statement must identify characteristics of the space station(s)' orbits that may present a collision risk, including any planned and/or operational space stations in those orbits, and indicate what steps, if any, have been taken to coordinate with the other spacecraft or system, or what other measures the operator plans to use to avoid collision.

(*3*) If at any time during the space station(s)' mission or de-orbit phase the space station(s) will transit through the orbits used by any inhabitable spacecraft, including the International Space Station, the statement must describe the design and operational strategies, if any, that will be used to minimize the risk of collision and avoid posing any operational constraints to the inhabitable spacecraft.

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

propulsion system.

(*5*) The space station operator must certify that upon receipt of a space situational awareness conjunction warning, the operator will review and take all possible steps to assess the collision risk, and will mitigate the collision risk if necessary. As appropriate, steps to assess and mitigate the collision risk should include, but are not limited to: contacting the operator of any active spacecraft involved in such a warning; sharing ephemeris data and other appropriate operational information with any such operator; and modifying space station attitude and/or operations.

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

(v) A statement addressing the trackability of the space station(s). Space station(s) operating in low-Earth orbit will be presumed trackable if each individual space station is 10 cm or larger in its smallest dimension, exclusive of deployable components. Where the application is for an NGSO space station or system, the statement shall also disclose the following:

(A) How the operator plans to identify the space station(s)

following deployment and whether space station tracking will be active or passive;

(B) Whether, prior to deployment, the space station(s) will be registered with the 18th Space Control Squadron or successor entity; and

(C) The extent to which the space station operator plans to share information regarding initial deployment, ephemeris, and/or planned maneuvers with the 18th Space Control Squadron or successor entity, other entities that engage in space situational awareness or space traffic management functions, and/or other operators.

(vi) A statement disclosing planned proximity operations, if any, and addressing debris generation that will or may result from the proposed operations, including any planned release of debris, the risk of accidental explosions, the risk of accidental collision, and measures taken to mitigate those risks.

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

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

(B) For space stations terminating operations in an orbit in or passing through the low-Earth orbit region below 2,000 km altitude, the statement must disclose whether the spacecraft will be disposed of either through atmospheric re-entry, specifying if direct retrieval of the

spacecraft will be used. The statement must also disclose the expected time in orbit for the space station following the completion of the mission.

(C) For space stations not covered by either paragraph (g)(1)(vii)(A) or (B) of this section, the statement must indicate whether disposal will involve use of a storage orbit or long-term atmospheric re-entry and rationale for the selected disposal plan.

(D) For all NGSO space stations under paragraph (g)(1)(vii)(B) or (C) of this section, the following additional specific provisions apply:

(*1*) The statement must include a demonstration that the probability of success of the chosen disposal method will be 0.9 or greater for any individual space station. For space station systems consisting of multiple space stations, the demonstration should include additional information regarding efforts to achieve a higher probability of success, with a goal, for large systems, of a probability of success for any individual space station of 0.99 or better. For space stations under paragraph (g)(1)(vii)(B) of this section that will be terminating operations in or passing through low-Earth orbit, successful disposal is defined as atmospheric re-entry of the spacecraft within 25 years or less following completion of the mission. For space stations under paragraph (g)(1)(vii)(C) of this section, successful disposal will be assessed on a case-by-case basis.

(*2*) If planned disposal is by atmospheric re-entry, the

statement must also include:

(*i*) A disclosure indicating whether the atmospheric re-entry will be an uncontrolled re-entry or a controlled targeted reentry.

(*ii*) An assessment as to whether portions of any individual spacecraft will survive atmospheric re-entry and impact the surface of the Earth with a kinetic energy in excess of 15 joules, and demonstration that the calculated casualty risk for an individual spacecraft using the NASA Debris Assessment Software or a higher fidelity assessment tool is less than 0.0001 (1 in 10,000).

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

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