

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

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

**COMMENTS OF
THE BOEING COMPANY**

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SUMMARY

The Commission should further update its orbital debris mitigation rules by continuing to adopt requirements that are objective and transparent; align closely with the standards maintained by other expert federal agencies; and do not excessively encumber the growth and development of the U.S. space industry. Both the Commission and the Satellite Industry Association have expressed support for these goals, which can be implemented in a manner that promotes space safety and sustainability while facilitating the ongoing growth of the satellite industry.

Consistent with these objectives, the Commission should require satellite operators to demonstrate that the probability of debris-generating explosions is less than 0.001 per satellite during deployment and mission life. This is the standard that is included in the Orbital Debris Mitigation Standard Practices (“*ODMSP*”), it is supported by SIA and is appropriate for use in the Commission’s rules. The Commission should permit satellite applicants to demonstrate compliance using commonly accepted engineering and probability assessment methods.

The Commission should also work with expert U.S. agencies and the satellite industry to develop a probability standard for collisions with large objects involving large low Earth orbit (“LEO”) satellite systems. Boeing acknowledges that the current metric of 0.001 is inadequate to address LEO constellations with more than 100 satellites. At the same time, applying the 0.001 probability metric to entire satellite systems would be inappropriate because such a requirement would often be impossible to achieve on an economically reasonable basis. Boeing is encouraged by efforts to develop a new metric, such as the undisposed mass per year (“*UMPY*”) approach, but thus far no proposal is sufficiently developed for use as a new standard to regulate large LEO constellations.

Boeing also supports a requirement that all satellites that are launched above a certain altitude must be designed so they have the ability to effectively maneuver regardless of the technology employed. In applying this requirement, effective maneuverability should constitute the ability to increase a miss distance by at least five kilometers over a 48 hour period following the receipt of a conjunction warning. Boeing recognizes that a major reason why a significant miss distance is needed is because of inaccuracies that exist in the tracking of certain objects in space, particularly satellites during orbit raising. Therefore, the minimum level of maneuverability that is needed is likely to decrease over time as the tracking of space objects continues to improve.

Boeing also supports a requirement that the vast majority of satellites that are injected into orbit between 400 and 600 kilometers have the capability to effectively maneuver. Exceptions should exist, however, for small experimental spacecraft as long as they do not exceed 180 kilograms per satellite and 1800 kilograms per system.

Boeing agrees with the Commission and with most parties that have filed comments in this proceeding that the 25 year rule needs to be replaced with a shorter metric with respect to LEO satellites that employ atmospheric reentry. It would be Boeing's preference for the Commission to adopt a new standard for LEO satellites that is developed through the interagency process for inclusion in the *ODMSP*. To the extent that the Commission adopts a new standard in advance of interagency action, Boeing would support an interim post-mission threshold of five years to complete atmospheric reentry.

It is premature, however, for the Commission to impose a requirement that satellite operators achieve a zero risk of human casualties. The NASA threshold of limiting the risk of human casualty from a single space object to 1 in 10,000 is an internationally accepted standard

that has ensured that no individual has ever been harmed by a reentering space object. A zero risk requirement is premature because some materials that remain optimal for use in satellite manufacturing are susceptible to surviving atmospheric reentry. The satellite industry continues to identify economically viable alternatives to such materials, but this transition is far from complete.

The Commission should also refrain from adopting an indemnification requirement for satellite operators. The U.S. government has never faced a liability claim resulting from an accident involving a space object authorized by the United States. If such an accident did occur, the U.S. government already has adequate civil recourse to secure reimbursement from satellite operators without the imposition of a burdensome and administratively complex indemnification obligation.

Finally, the Commission should not adopt a post-mission disposal bond for satellite licensees. Satellite operators already have adequate incentive to ensure that their retired satellites are disposed of appropriately, in part to ensure that the orbital resources in question can be used by a subsequent generation of replacement satellites. A bond requirement would also be ineffective in ensuring the success of post-mission disposal activities because most recent satellite failures during the final years of operation have resulted from circumstances that were beyond the operator's control. The Commission's existing satellite manufacturing bond requirement appropriately includes an exception for circumstances that are beyond the satellite licensee's control. The implementation of such an exception for post-mission disposal bonds, however, would be excessively difficult to enforce in an objective manner. Therefore, the Commission should refrain from adopting a disposal bond requirement.

TABLE OF CONTENTS

I.	THE COMMISSION SHOULD ADOPT RULES THAT ARE OBJECTIVE, TRANSPARENT, CONSISTENT WITH EXPERT FEDERAL AGENCIES, AND ARE NOT EXCESSIVELY BURDENSOME.....	2
II.	THE COMMISSION SHOULD ADOPT THE OBJECTIVE <i>ODMSP</i> STANDARD FOR ACCIDENTAL EXPLOSIONS WITHOUT MODIFICATION	6
III.	THE COMMISSION SHOULD SUPPORT EFFORTS TO IDENTIFY AN APPROPRIATE METRIC TO ADDRESS COLLISIONS WITH LARGE OBJECTS INVOLVING LARGE LEO SATELLITE SYSTEMS	8
IV.	THE COMMISSION SHOULD REQUIRE SATELLITES TO EMPLOY EFFECTIVE MANEUVERABILITY ABOVE A CERTAIN LEO ALTITUDE	13
V.	ABSENT FURTHER INTER-AGENCY GUIDANCE, A POST-MISSION DISPOSAL LIFETIME OF FIVE YEARS MAY BE APPROPRIATE FOR MOST SATELLITES	14
VI.	IT IS PREMATURE FOR THE COMMISSION TO ADOPT A ZERO RISK REQUIREMENT FOR HUMAN CASUALTY.....	16
VII.	NO BENEFIT WOULD RESULT FROM IMPOSING AN INDEMNIFICATION OBLIGATION ON SATELLITE OPERATORS.....	18
VIII.	IMPOSING PERFORMANCE BOND REQUIREMENTS WOULD HAVE PUNITIVE IMPACTS ON THE U.S. SPACE INDUSTRY	21
	A. Satellite Operators Already Have Sufficient Economic Incentives to Dispose of Satellites in a Safe and Effective Manner.....	21
	B. The Commission’s Bond Proposal Disregards that Most Late-Mission Satellite Failures Result From Circumstances Beyond the Operator’s Control	23
IX.	CONCLUSION.....	25

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Throughout this proceeding, The Boeing Company (“Boeing”) has supported the adoption of significant changes in the Commission’s rules to address the mitigation of orbital debris.¹ The increasingly high rate of launches by commercial satellite operators, combined with a disproportionate increase in failure rates, necessitates changes to the Commission’s orbital debris rules to ensure that space resources are managed in a safe and sustainable manner and remain accessible for the U.S. and international space industry.

Although Boeing continues to support changes to the Commission’s orbital debris rules, Boeing has not wavered in its position that the Commission’s orbital debris requirements must be objective and transparent; align closely with the standards maintained by other expert federal

¹ See, e.g., Comments of The Boeing Company, IB Docket No. 18-313, at ii (April 5, 2019). Boeing opened its initial comments by observing:

The commercial space industry is experiencing a period of tremendous growth and innovation, with U.S. companies in leadership roles in many of these initiatives and American citizens ultimately receiving the benefits of the services they make possible. To maintain this growth and leadership, steps must be taken by industry participants and government to ensure that orbital debris does not inhibit the progress of commercial enterprises in space.

Id.

agencies; and do not excessively encumber the growth and development of the U.S. space industry. The Commission and the Satellite Industry Association have expressed support for each of these goals and Boeing urges adherence to these principles in the Commission’s consideration of its Further Notice of Proposed Rulemaking (“*Further Notice*”).²

I. THE COMMISSION SHOULD ADOPT RULES THAT ARE OBJECTIVE, TRANSPARENT, CONSISTENT WITH EXPERT FEDERAL AGENCIES, AND ARE NOT EXCESSIVELY BURDENSOME

In considering improvements to its orbital debris rules, the Commission has consistently recognized the importance of adopting requirements that are objective and transparent, explaining that “[o]ur goal is to provide the clearest possible regulatory framework for applicants for non-Federal satellite communications”³ so that “operators can plan accordingly” in developing U.S.-authorized satellite systems.⁴ The adoption of objective and transparent regulations necessitates that all rules addressing orbital debris are coupled with guidance provided by the Commission identifying the minimum operational or performance requirements that must be demonstrated by an applicant to warrant the grant of a satellite system authorization.

The use of objective and transparent rules does not mean the Commission should refrain from waiving its requirements in appropriate circumstances to accommodate new and unique satellite system proposals that are presented for licensing. The Commission should continue to

² See Mitigation of Orbital Debris in the New Space Age, IB Docket No. 18-313, *Report and Order and Further Notice of Proposed Rulemaking*, FCC 20-54 (April 24, 2020) (“*Order*” or “*Further Notice*”).

³ *Order*, ¶ 2.

⁴ *Id.*, ¶ 145.

further the public interest by granting waivers of its rules “for good cause shown,”⁵ but the starting point in this process should be the adoption of regulations that are objective and transparent in order to clearly disclose to satellite applicants the baseline performance requirements that are expected of all users of public orbital resources.

The Commission should also adopt rules that align as much as possible with the standards established by other expert federal agencies. The use of consensus-based standards will ensure the Commission’s orbital debris rules are both effective and not overly burdensome to the U.S. commercial space industry. Adherence to a “whole of government” approach would also be consistent with Space Policy Directive-3 (“SPD-3”), which specifically instructed the Commission to incorporate updates to the Orbital Debris Mitigation Standard Practices (“*ODMSP*”) into its “licensing processes, as appropriate and consistent with applicable law.”⁶

Although the existing inter-agency process should continue to take the lead in the development of orbital debris standards and requirements, Boeing acknowledges that certain changes to the Commission’s orbital debris rules merit consideration and approval in the near term. Boeing is encouraged by efforts within the inter-agency process to work with the Commission and the U.S. satellite industry to explore these issues on an expedited basis. The most recent updates to the *ODMSP* were adopted within the inter-agency process in November 2019,⁷ only eleven months following the SPD-3 directive that “[t]hese standard practices should be updated to address

⁵ 47 C.F.R. § 1.3.

⁶ Presidential Memorandum, *Space Policy Directive-3, National Space Traffic Management Policy*, § 6(b)(ii) (June 18, 2018) (“*SPD-3*”).

⁷ See U.S. Government, *Orbital Debris Mitigation Standard Practices*, Nov. 2019 Update (“*ODMSP*”) available at: https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf (last visited Oct. 2, 2020).

current and future space operating environments.”⁸ Boeing anticipates that the inter-agency process can identify additional updates to the *ODMSP* even more rapidly. For example, the inter-agency meeting that was held on August 28 with participation by U.S. industry representatives was productive and warrants a recurring schedule.

Although the Commission should continue to defer to the inter-agency process to take the lead in identifying updates to orbital debris mitigation requirements, Boeing recognizes that an industry-led process may also be suitable to identify changes to the Commission’s rules that are both effective and reasonable regardless of whether they have received inter-agency endorsement. Discussions of this nature are being held within the Satellite Industry Association (“SIA”) and in technical discussions between companies, and Boeing is engaged as an active participant. The initial results of these discussions are already reflected by Boeing in these comments and will likely be reflected in the comments and reply comments of other parties, including SIA.

In considering industry-based mitigation proposals, however, the Commission must exercise extreme caution in ensuring that the rules that are proposed do not inappropriately harm segments of the U.S. space industry or excessively increase barriers to entry by new (or existing) industry participants through competitive inequality. Instead, to the extent that the Commission considers the adoption of new rules that have not yet been endorsed within the inter-agency process, those proposed rules should reflect wide support within the U.S. space industry and should be subject to revision if more appropriate and less burdensome approaches are subsequently identified through further updates and supplements to the *ODMSP*.

The final goal is to ensure that the Commission’s orbital debris mitigation rules are not excessively burdensome to the U.S. space industry. Chairman Pai acknowledged the importance

⁸ *SPD-3*, § 5(a)(iii).

of “a balanced approach: mitigating the risk posed by orbital debris, while at the same time continuing to light a regulatory path for space-based innovation.”⁹ Each of the Commissioners expressed a consistent view, observing that “we are not the only ones looking to the skies for innovation and economic growth”¹⁰ and “[i]f the U.S. wants to be the leader in the current space race, our regulatory processes cannot be more expensive and burdensome than those of other nations.”¹¹ To this end, all five Commissioners have sought to “spur American leadership in this promising industry while still promoting space safety.”¹²

Some of the most important tools to ensure that orbital debris rules are not excessively burdensome are already discussed above in these comments. The Commission’s rules need to be objective, transparent, and align as much as possible with standards adopted by other expert U.S. agencies. The Commission should also ensure that the rules are competitively neutral and do not disfavor certain technologies or business approaches. In furtherance of competitive neutrality, the Commission should give further consideration to applying its orbital debris rules to all participants in the U.S. satellite market, regardless of whether they request an FCC license or a grant of market access. Finally, the Commission should refrain from adopting new information disclosure requirements unless those rules are directly associated with clear and easily discernable standards regarding the extent of the Commission’s use of such information and the threshold requirements that must be identified in the disclosed information to merit the grant of a Commission authorization.

⁹ *Order*, Separate Statement of Chairman Ajit Pai.

¹⁰ *Id.*, Separate Statement of Commissioner Jessica Rosenworcel.

¹¹ *Id.*, Separate Statement of Commissioner Michael O’Rielly.

¹² *Id.*, Separate Statement of Commissioner Geoffrey Starks.

Based on the governing principles identified in this opening section of these comments, Boeing provides the following views on the specific proposals identified in the *Further Notice*.

II. THE COMMISSION SHOULD ADOPT THE OBJECTIVE *ODMSP* STANDARD FOR ACCIDENTAL EXPLOSIONS WITHOUT MODIFICATION

As noted above, the Commission should adopt orbital debris mitigation standards that are transparent and objective so that the commercial satellite industry can understand how to meet any licensing criteria or regulatory requirements imposed. The Commission should also align its orbital debris mitigation rules as much as possible with the standards of other expert U.S. agencies.

Consistent with this, Boeing observed in its supplemental comments that the Commission has never adopted objective guidance regarding the measures that it requires of satellite applicants to limit the probability of accidental explosions during and after completion of mission operations.¹³ Instead, the Commission's rules simply require that satellite license applicants explain in their applications that they have assessed and limited the probability of accidental explosion without specifying in the rules the outcome of such assessments that may be deemed acceptable by Commission staff.

In contrast, the updated *ODMSP* includes an objective standard to address this issue, requiring spacecraft operators to demonstrate that the integrated probability of debris-generating explosions for each spacecraft (excluding small particle impacts) is less than 0.001 during deployment and mission operations.¹⁴ Boeing recommended that the Commission promote

¹³ See Supplemental Comments of The Boeing Company, IB Docket No. 18-313 at 7 (Feb. 14, 2020).

¹⁴ See *ODMSP*, § 2-1.

business certainty and space safety by incorporating this objective standard into the Commission's rules. SIA also expressed support for this position.¹⁵

The *Further Notice* embraces this proposal and requests comment on its implementation.¹⁶ Specifically, the *Further Notice* acknowledges that the *ODMSP* instructs that compliance demonstrations for this requirement should be developed using “commonly accepted engineering and probability assessment.”¹⁷ The *Further Notice* requests comment on how the Commission should assess such demonstrations. The Commission's space station rules, of course, already include numerous instances where applicants for satellite authorizations are required to “demonstrate” compliance with various technical rules. These technical demonstrations are already subject to Section 1.17 of the rules, which requires that all filings by license applicants be both truthful and accurate.¹⁸ Therefore, the Commission should continue its customary practice of reviewing such showings for accuracy and to verify the use of commonly accepted engineering practices and probability assessment. If this review raises significant questions with the Commission staff, it should also continue the usual practice of sending a written inquiry to the applicant seeking additional information. In all other events, however, the technical demonstrations that are filed by satellite system applicants should be accepted as accurate and should justify the grant of an application as long as they indicate compliance with the less than 0.001 probability requirement.

¹⁵ See *Ex Parte Notice of the Satellite Industry Association*, IB Docket No. 18-313, Attachment 1 at 4 (April 15, 2020) (“*SIA Ex Parte Presentation*”) (arguing that the 0.001 threshold for accidental explosions would provide an “objective and transparent” ceiling).

¹⁶ *Further Notice*, ¶ 154.

¹⁷ *Id.*

¹⁸ 47 C.F.R. § 1.17.

III. THE COMMISSION SHOULD SUPPORT EFFORTS TO IDENTIFY AN APPROPRIATE METRIC TO ADDRESS COLLISIONS WITH LARGE OBJECTS INVOLVING LARGE LEO SATELLITE SYSTEMS

Based on wide support within the satellite industry, including support from Boeing, the Commission adopted a requirement that each satellite should be designed and operated in a manner that the probable risk of a collision with a large object should not exceed 0.001.¹⁹ This metric has long been the standard recommended by NASA;²⁰ it is incorporated into the revised *ODMSP*,²¹ and it is appropriate for the Commission’s regulatory purposes.

The *Further Notice* seeks comment on how to apply this standard to large non-geostationary satellite orbit (“NGSO”) systems,²² which Boeing continues to assume includes all NGSO systems involving 100 or more satellites in simultaneous operation.²³ Boeing acknowledges that the 0.001 standard is inappropriate to address the collision risk for large NGSO constellations operating in LEO altitude.²⁴ The application of the 0.001 standard on a per-satellite basis is not sufficiently stringent to prevent an intolerable probability of collisions with large objects over the life of a large NGSO system. At the same time, the application of the 0.001

¹⁹ *Order*, ¶ 34.

²⁰ See NASA Technical Standard, *Process for Limiting Orbital Debris*, NASA-STD-8719.14A (with Change 1) (May 25, 2012), available at <https://standards.nasa.gov/file/2707/download?token=jFflsudM> (last visited April 2, 2019) (“*NASA Standard*”).

²¹ See *ODMSP* at 4, § 3-1.

²² See *Further Notice*, ¶ 155.

²³ See, e.g., *id.*, ¶ 166 (using 100 or more satellites as an example of a large constellation); *ODMSP*, § 5-1 (defining large constellations as “consisting of 100 or more operational spacecraft”).

²⁴ Boeing defines LEO for purposes of these comments as 1,400 kilometers and below. As discussed below, Boeing continues to believe that the 0.001 metric does remain appropriate to address the probability of collisions with large objects involving large constellations of satellites in MEO orbit.

standard to an entire LEO constellation in the aggregate would also be inappropriate because it would be impossible to achieve this level of compliance on an economically reasonable basis for large (or very large) constellations. Therefore, a new metric is needed to address the probability of collisions with large objects involving large LEO systems.

Boeing has not identified an appropriate metric to regulate the risk of collisions with large objects involving large LEO constellations. Boeing is encouraged, however, by research being conducted by various industry participants. For example, The Aerospace Corporation developed a metric based on undisposed mass per year (“UMPY”) in order to model the long term effects of space debris.²⁵ The UMPY approach forecasts different levels of debris generation and space sustainability based on the total mass of objects that are projected to be launched into LEO and the proportion of that mass that does not complete disposal. The UMPY approach would permit prospective system operators to easily calculate the permissible undisposed mass for their satellites and scale that allocation based on the size of the constellation. It would permit a direct allocation of scarce orbital resources so that the space industry could theoretically achieve space sustainability by allocating a proportion of the future permissible undisposed mass to each satellite system operator.

Although the UMPY approach is intriguing, it is not sufficient for use as a metric to regulate large LEO constellations and their potential for collisions with large objects. First, the UMPY approach was designed for a different purpose, the identification of threshold requirements for post-mission disposal. The probability of collision with large objects is one of the data points

²⁵ See *Parameterizing Large Constellation Post-Mission Disposal Success to Predict the Impact to Future Space Environment*, G. A. Henning et al., 1st International Orbital Debris Conference, Sugar Land, Texas, 2019, available at <https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6037.pdf> (last visited Sept. 30, 2020).

used in the simulation that determines the appropriate global UMPY metric (along with other data points such as the probability of accidental explosion), although the inclusion of a collision-based data input necessitates an assumption regarding the probability of collisions that will be achieved.

Second, the UMPY approach is dependent on agreement regarding the total mass of objects that will be launched into space each year. The authors used space station applications filed with the FCC to compute the anticipated total mass, while acknowledging that FCC filings are not a reliable indicator of the number or mass of satellites that will ultimately be launched.²⁶ Third, the UMPY metric is currently determined using a 200-year simulation that may not properly reflect the severity of the near-term growth in debris below 850 kilometers, since this debris completes atmospheric reentry well before the end of the 200-year period. Fourth, and most important, the UMPY approach requires an allocation of permissible undisposed mass to each satellite operator. Absent the adoption of a strict percentage (*i.e.*, undisposed mass in LEO cannot exceed “x” percent of launched mass), the apportionment of this mass to different operators (and to different licensing Administrations) could result in a subjective and difficult to manage process.

Boeing continues to study the research of various parties in determining an appropriate metric to address the potential for collisions with large objects involving large LEO constellations. Until consensus is reached on an appropriate approach, the Commission should not arbitrarily implement a placeholder requirement, even as a safe harbor.²⁷ As Boeing and SIA have argued extensively in this proceeding, the Commission’s orbital debris rules should be objective and

²⁶ See *Further Notice*, ¶ 156.

²⁷ See *id.*, ¶ 159 (seeking comment on employing the 0.001 probability of collision metric to entire constellations as a safe harbor “to identify those systems that would require additional review”).

transparent.²⁸ The use of a safe harbor that lacks a clear, objective and well-supported basis would likely result in subjective and nontransparent decision making.

The *Further Notice* raises additional questions about the probability of collisions with large objects, such as the factors to be considered in calculating the appropriate risk.²⁹ As the *Further Notice* correctly observes, the number of launched satellites is only one relevant factor.³⁰ Other considerations include the area-to-mass ratio and the operational orbit, both of which are already considered by the NASA Debris Assessment Software.³¹ Consideration is also necessary regarding the quantity and schedule for deploying replenishment satellites.³²

The *Further Notice* also seeks comment on assumptions regarding maneuverability and its relationship to collision risk.³³ Boeing agrees with the Commission's previous conclusion that a satellite with effective maneuverability (the definition of which is discussed in a later section) should be deemed to have a zero risk of collision with large objects.³⁴ At the same time, Boeing acknowledges that the calculated risk of collisions with large objects cannot assume that all satellites in a large LEO constellation will retain the ability to maneuver throughout their lives. Instead, Boeing agrees that the probability of collision should be calculated using an assumption

²⁸ See, e.g., *SIA Ex Parte Presentation*, Attachment 1 at 1.

²⁹ See *Further Notice*, ¶ 158.

³⁰ See *id.*, ¶¶ 156 and 158.

³¹ See *id.*, ¶ 158.

³² See *id.*

³³ See *id.*, ¶ 160.

³⁴ See *Order*, ¶ 35.

of a certain failure rate in maneuvering capabilities.³⁵ The failure rate that should be used in this calculation likely should be 10 percent absent a demonstration by an operator that its system is likely to achieve a lower failure rate in maneuvering capability, in which case, the lower predicted failure rate should be used.³⁶

Finally, Boeing seeks to distinguish its views with respect to the probability of collision involving large LEO versus large MEO constellations. Thus far, the majority of large constellations have been proposed for LEO rather than MEO. This is likely because of efforts to achieve very low latency in two-way communications and very high resolution in Earth imaging. LEO satellites also have greatly reduced coverage footprints, necessitating much larger constellations to provide global coverage. In contrast, MEO satellites enjoy much larger coverage footprints of the Earth and a far greater range of available orbital altitudes (*i.e.*, anything above 1,400 kilometers). Therefore, the long term potential for debris generation in MEO is much lower than in LEO, greatly reducing the need to adopt aggressive regulations restricting the design and operation of MEO satellites, including their probability of collision with large objects. Therefore, once the Commission identifies an appropriate metric for large NGSO constellations addressing the risk of collision with large objects, the Commission should apply this more stringent metric only to large LEO constellations. In contrast, the Commission should continue to apply the existing 0.001 probability threshold for collisions with large objects on a per-satellite basis to MEO constellations.

³⁵ See *Further Notice*, ¶ 160.

³⁶ See *id.*, ¶ 161.

IV. THE COMMISSION SHOULD REQUIRE SATELLITES TO EMPLOY EFFECTIVE MANEUVERABILITY ABOVE A CERTAIN LEO ALTITUDE

Boeing supports a requirement that all satellites that are launched above a certain altitude must be designed so that they have the ability to effectively maneuver.³⁷ The Commission, however, should not specify particular types of maneuverability (*i.e.*, propulsion-based) mandating instead a minimum maneuvering capability regardless of the technology used.³⁸

With respect to the extent of the maneuvering capability, Boeing supports a requirement that all satellites must be capable of increasing the miss distance by at least five kilometers over a 48-hour period following the receipt of a conjunction warning. Boeing is concerned about proposals to permit smaller adjustments in the forward direction because the current ability to track smaller debris and satellites involved in orbit raising leaves a one-to-two kilometer variance in predicted location that needs to be taken into account to avoid a conjunction. A five-kilometer change in forward track incorporates this variance and provides a comfortable margin for additional error.

Boeing recognizes, however, that the need for such a significant margin results in part from the accuracy (or lack thereof) of the tracking of objects in space. Therefore, the minimum level of maneuverability that is needed is likely to decrease over time as the tracking of space objects continues to improve. Boeing is uncertain, however, how to objectively capture such ongoing improvements in the Commission's rules and Boeing will review the comments of other parties to see how this issue is addressed.

³⁷ See *id.*, ¶ 164.

³⁸ See *id.*, ¶ 167.

With respect to the altitude above which maneuverability should be required, Boeing acknowledges that most satellites above 400 kilometers should have the capability to effectively maneuver.³⁹ Exceptions should exist in the rules for small experimental spacecraft that are injected into orbit between 400 and 600 kilometers for research and educational purposes. The Commission could restrict such satellites to less than 180 kilograms per satellite and less than 1800 kilograms per system. Although these experimental satellites should not be required to demonstrate effective maneuverability, they should be required to complete atmospheric reentry within a reasonable time, as discussed in the following section.

V. ABSENT FURTHER INTER-AGENCY GUIDANCE, A POST-MISSION DISPOSAL LIFETIME OF FIVE YEARS MAY BE APPROPRIATE FOR MOST SATELLITES

Boeing agrees with the Commission and with most parties that have filed comments in this proceeding that the 25-year rule is no longer a practical standard with respect to satellites that employ atmospheric reentry for their disposal.⁴⁰ Given the significant number of satellites that are being launched into LEO orbits, the 25-year rule permits satellites to remain in decaying orbits for excessive periods.

Although the 25-year standard may no longer be practical, it is also unclear whether it remains very relevant. As the *Further Notice* observes, nearly all satellites launched above 600 kilometers include propulsion capabilities that can ensure their prompt post-mission disposal absent a failure.⁴¹ The Commission is poised to impose maneuverability requirements on nearly

³⁹ See *id.*, ¶ 165.

⁴⁰ See *id.*, ¶ 169.

⁴¹ See *id.*, ¶ 170.

all satellites injected into orbit above 400 kilometers.⁴² Satellites launched below 400 kilometers likely will complete their reentry into the Earth's atmosphere well in advance of 25 years regardless of their propulsion capabilities. This leaves a small subset of satellites launched between 400 and 600 kilometers for which the 25-year rule remains potentially relevant. Some of these satellites are increasingly employing passive drag techniques to hasten their atmospheric reentry, thereby reducing the pool of satellites with prolonged atmospheric re-entry periods even further.

In Boeing's experience, the vast majority of the remaining satellites (those launched between 400 and 600 kilometers and lacking active or passive reentry technologies) involve small experimental spacecraft launched for research and educational purposes, often in cooperation with government research organizations such as NASA. Given this fact, the views of other federal agencies, such as NASA, seem particularly relevant with respect to the disposition of the 25-year threshold. Fortunately, based on the substance of a recent interagency meeting on orbital debris that was held on August 28, 2020, it is apparent that the future of the 25-year rule is a central focus of discussion by experts within the U.S. government.

Given this focus, it appears likely that further updates or supplements to the *ODMSP* addressing the 25-year rule can be expected in the near future. Therefore, the Commission should continue to participate in the interagency process and, once a new standard to replace the 25-year rule has been adopted in that process, those proposed changes should be placed on public notice by the Commission as a part of a proposal to incorporate them into the Commission's rules.

In the interim, if the Commission believes that an immediate replacement for the 25-year rule is needed, Boeing would support the adoption of a five-year post-mission limit on orbital life

⁴² See *id.*, ¶ 165.

absent a failure of the satellite. Satellite license applicants should be permitted to demonstrate compliance with a five-year deorbit life based on a certification that the satellite was designed to complete atmospheric reentry within five years using reasonable assumptions about the altitude of its orbit injection. For example, if a satellite operator is using a rideshare approach to launch, the operator should be able to assume that its target orbit will be achieved regardless of whether the satellite is ultimately placed in that orbit. Satellite license applicants, particularly those requesting experimental authority, should also be permitted to secure longer reentry periods for good cause, such as to accommodate unique experimental payloads.

VI. IT IS PREMATURE FOR THE COMMISSION TO ADOPT A ZERO RISK REQUIREMENT FOR HUMAN CASUALTY

Boeing works with its satellite customers on a continuous basis to design satellite and space systems using materials and components that substantially demise if subject to atmospheric reentry. As a result of these ongoing efforts, satellites manufactured by Boeing consistently achieve the internationally-accepted standard that their uncontrolled reentry would not pose a probability risk of a world-wide human casualty in excess of 1 in 10,000. Many satellites designed by Boeing achieve risk levels that are substantially less than the 1 in 10,000 ceiling. In each case, Boeing works with its customers to balance the use of demisable materials with their mission objective, weight tolerances, the reliability requirements for the spacecraft (certain demisable materials are less reliable in a space environment), and economic constraints.

Although Boeing and other manufacturers continue to make progress in identifying and implementing materials and components that are minimally susceptible to surviving atmospheric reentry, the transition to fully demisable spacecraft has not yet been achieved on an economically reasonable and sufficiently reliable basis. Therefore, the Commission should refrain from mandating a design for demise requirement by reducing the internationally-accepted standard for

human casualty risk to zero. Such a requirement would be excessively burdensome on the U.S. space industry without resulting in any actual benefits. Thus far, no individual has been harmed by the atmospheric reentry of a manmade space object. Therefore, the costly implementation of even tighter standards is unnecessary. It would be particularly inappropriate to impose the zero risk requirement (or even the existing 1 in 10,000 standard) to entire fleets of NGSO satellites. Practically speaking, the application of the 1 in 10,000 standard to NGSO constellations would effectively equate to a zero risk requirement per-satellite for any large constellation, *i.e.*, those in excess of 100 satellites. This is because the fraction of the 0.0001 standard that would be available to each satellite would be incredibly small.

Boeing has worked with SIA to document technical details regarding the need to maintain the existing risk standard. Certain materials and components that remain optimal for use in spacecraft manufacturing remain susceptible to surviving atmospheric reentry. Boeing is already implementing the use of certain substitute materials — such as carbon wrapped pressure vessels — but the immediate transition to sufficiently demisable materials and components would result in less reliable spacecraft and, correspondingly, an increase in the generation of orbital debris.

It would also be inappropriate to require applicants that do comply with the 1 in 10,000 requirement, but not with a zero risk requirement, to provide additional information to the Commission, such as “a detailed discussion of the need for use of high melting point material” and a “demonstration that mission objectives cannot be met with an alternative spacecraft design.”⁴³ The satellite design process is highly complex involving intricate trade studies and technical analysis involving a satellite operator’s technical experts and Boeing’s design engineers. No appropriate opportunity exists for Commission staff to inject themselves in these commercially

⁴³ *Id.*, ¶ 173, n.583.

sensitive and technically complex discussions. Instead, consistent with U.S. and international standards, the FCC should continue to adhere to the 1 in 10,000 risk threshold, which has remained successful in ensuring that no individual has ever been harmed by the atmospheric reentry of a manmade space object.

The *Further Notice* also raises questions about the use of targeted re-entry to ensure that satellite debris lands in uninhabited areas, quoting the *ODMSP* guidance that targeted reentry “should be considered.”⁴⁴ Although such measures can be considered and encouraged, they should not be required by the Commission because they may not be technically neutral and are not yet economically achievable on a sufficiently reliable basis using existing technologies. Instead, the Commission should incorporate the NASA recommendation of 1 in 10,000 per satellite into its rules and continue to permit satellite operators to decide on their own how they will comply with this already stringent standard.

VII. NO BENEFIT WOULD RESULT FROM IMPOSING AN INDEMNIFICATION OBLIGATION ON SATELLITE OPERATORS

The Commission was correct in acknowledging in the *Further Notice* that an “indemnification requirement may be an unnecessary formal step to acknowledge an existing legal obligation of licensees engaged in space activities.”⁴⁵ Indemnification is unnecessary because, as Boeing explained in its comments, the U.S. government has more than adequate authority to

⁴⁴ See *id.*, ¶ 174 (quoting *ODMSP*, § 4-1.a.).

⁴⁵ *Id.*, ¶ 179.

seek reimbursement from a satellite operator for liability resulting from a space-related accident using existing legal doctrines.⁴⁶

The *Further Notice* acknowledges these legal options, but raises a question about their application to liability claims resulting from treaty obligations entered into by the U.S. government, such as the Outer Space Treaties.⁴⁷ As SIA explains in its comments, no cases have been identified imposing civil liability on the U.S. government as a result of the Outer Space Treaties. However, general case law, a major treatise, and at least one case involving a bi-lateral treaty agreement between the U.S. and Canada supports the conclusion that the U.S. government has the authority to seek contribution, recovery or apportionment from liable private parties.⁴⁸ The threshold requirement for the U.S. government to make such a civil claim is the government's willingness to be sued based on the treaty in question through its waiver of sovereign immunity. The Outer Space Treaties, which were ratified by Congress, clearly address the liability of signatory countries for space-related accidents.⁴⁹ Therefore, the U.S. government has the underlying authority to seek contribution from third parties to recover payments for such claims.

⁴⁶ See Comments of The Boeing Company, IB Docket No 18-313, at 37-38 (Apr. 5, 2019) (citing relevant case law).

⁴⁷ *Further Notice*, ¶ 179 (referencing Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, October 10, 1967, and Convention on International Liability for Damage Caused by Space Objects, September 1, 1972 (hereinafter the “Outer Space Treaties”)).

⁴⁸ See Comments of the Satellite Industry Association, IB Docket No. 18-313, at 10-11 (Oct. 9, 2020).

⁴⁹ Outer Space Treaty, Article VI. (explaining that “State Parties to the Treaty shall bear international responsibility for national activities in outer space . . . whether such activities are carried on by governmental agencies or by non-governmental entities”).

Given these legal conclusions, it is apparent that the imposition of a duplicative indemnification requirement would do nothing to strengthen the incentives for satellite operators to mitigate risks.⁵⁰ An indemnification requirement would also be unnecessary to ensure that U.S. taxpayers do not have to cover the liabilities from space-related accidents. Satellite operators already have sufficient incentive to adopt satellite design and operational procedures that reduce the risk of creating orbital debris to the extent economically practical. And the U.S. government is fully capable of securing recovery from U.S.-authorized satellite operators using existing civil procedures. Therefore, the option of an indemnification requirement would not advance the public interest and should be abandoned.

If the Commission did attempt to implement an indemnification requirement, significant complexities would exist regarding its implementation. In most contractual indemnification agreements, the indemnifying party has the right to assume control of the defense of the underlying litigation since they are the party that would ultimately be at risk. It remains far from obvious whether the U.S. government would be willing or able to defer to a satellite operator as a private party in the defense of a claim under the Outer Space Treaties. Questions also exist regarding the right to choose counsel, to challenge the judicial forum, and to negotiate a settlement. In contractual indemnifications, control of these issues falls primarily to the indemnifying party, an approach that the U.S. government would need to consider. The *Further Notice*, however, fails to address these critical legal issues and therefore the adoption of an indemnification requirement is not only unnecessary, but would clearly be premature based on the record that is likely to result

⁵⁰ *Further Notice*, ¶ 180 (seeking comment on the potential incentives resulting from an indemnification requirement).

from the questions raised in the *Further Notice*. Therefore, the Commission should best serve the interests of the U.S. space industry by discarding its proposed indemnification requirement.

VIII. IMPOSING PERFORMANCE BOND REQUIREMENTS WOULD HAVE PUNITIVE IMPACTS ON THE U.S. SPACE INDUSTRY

Imposing a disposal bond obligation would harm the U.S. space industry by significantly increasing costs for satellite operators without resulting in the manufacture or launch of more reliable satellites. A bond requirement would have little impact on the reliability of satellites for two reasons. First, satellite operators already have adequate incentive to design and manufacture highly reliable satellites. Second, most mishaps resulting in the loss of a satellite during the later years of its mission life result from circumstances that are outside the control of the satellite operator or its manufacturer. Therefore, a bond requirement would not prevent such loss.

A. Satellite Operators Already Have Sufficient Economic Incentives to Dispose of Satellites in a Safe and Effective Manner

When considering the existing incentives of satellite operators to avoid satellite failures, separate consideration is needed with respect to the two major phases of a satellite's life: its operational phase and its late-mission disposal phase. With respect to the operational phase of a satellite, the operator has an inherently strong economic self-interest to ensure that the satellite operates successfully. Most satellites do not carry in-orbit insurance, so any loss of a satellite during its useful life will cause direct economic harm to the satellite operator. This economic self-interest is greatest immediately after the launch of the satellite, when the spacecraft's value as an ongoing source of revenue is just beginning.⁵¹ Coincidentally, it is this period immediately

⁵¹ Further, this strong incentive flows from one generation of satellites to the next. Thus, an operator that experiences anomalies involving a current generation of satellites clearly has

following launch when the potential for a satellite failure resulting from a manufacturing flaw or launch error is the greatest. Given this high correlation between early mission risk of loss and economic harm to the satellite operator, it is evident that no additional economic incentive is needed to encourage satellite operators to employ reasonably adequate measures to ensure that their satellites operate successfully during the early operational phase of their missions.

With respect to the late-mission disposal phase of a satellite's life, Boeing acknowledges that a satellite operator's economic incentive to ensure compliant decommissioning and disposal of a satellite is less prevalent. Nevertheless, satellite operators still have significant incentive to ensure that older satellites are decommissioned and disposed of in a compliant manner. First, most satellite operators (including both geostationary ("GSO") and NGSO system operators) seek to launch replacement satellites to the same orbital location as a retired satellite. This may be impossible, however, if the previous satellite was not disposed of properly. Second, failure to dispose an aging satellite in accordance with the Commission's rules could result in enforcement action, including the imposition of fines, and could result in the Commission's imposition of additional operating conditions on future satellites. Both of these threats provide substantial incentive for satellite operators to ensure the proper disposal of retired spacecraft.

The *Further Notice*, however, suggests the possible creation of collateral incentives, theorizing that a disposal bond requirement may convince satellite operators "to begin end-of-life disposal procedures at an earlier stage if the satellite begins experiencing technical issues."⁵² Certainly, it is important for satellite operators to appropriately assess the remaining useful life of

incentives to eliminate those anomalies in subsequent generations of satellites in order to preserve the revenue stream from those spacecraft.

⁵² *Further Notice*, ¶ 194.

a satellite and begin deorbit procedures when it becomes apparent that the ongoing control of the spacecraft is uncertain. At the same time, satellites are designed with significant redundancy in critical systems. Thus, a failure of one system does not mean that the spacecraft can no longer be used in a safe and reliable manner for additional years. Further, the preservation of a safe and sustainable space environment necessitates leaving functional satellites in operation for as long as it is reasonably feasible in order to minimize unnecessary replacement launches. The Commission should therefore refrain from adopting rules that encourage operators to remove satellites from service while they are still able to function in a safe and reliable manner. Thus far, the U.S. satellite industry has shown strong judgment in balancing between its interests in keeping operational satellites in space and ensuring their disposal while they remain under operational control. The Commission should not adopt a potentially burdensome bond requirement that may force satellite operators to displace prudent technical judgments with a regulatory mandate.

B. The Commission’s Bond Proposal Disregards that Most Late-Mission Satellite Failures Result From Circumstances Beyond the Operator’s Control

The sufficiency of the incentives for satellite operators to launch reliable satellites and dispose of them properly is just one of the two issues that must be considered with respect to a bond requirement. The second issue is the ability of a satellite operator (and its manufacturer) to control a satellite’s reliability and ultimate disposal. As historic evidence indicates, during the past 10 to 15 years, most U.S. communications satellites that failed following their initial deployment and test phase (*i.e.*, several years after launch) resulted from circumstances that were beyond the control of the operator or its manufacturer, such as solar storms, magnetic activity, micrometeoroid strikes, or collisions with existing space debris.

In contrast, surety bonds are usually imposed to incentivize parties to complete actions that are within their control, such as the construction of a building or, in the FCC’s case, the timely

manufacture and launch of a satellite. The Commission's rules recognize this by permitting extensions of build out milestones (and the bonds associated with them) due to delays that are beyond a satellite licensee's control.⁵³ The *Further Notice* makes no suggestion of providing equivalent leniency with respect to its proposed disposal bond requirement. Given the highly complex issues that are often involved with respect to determining the cause of a failed satellite (absent an obvious impact by a space borne object), it would be very impractical to attempt to enforce a disposal bond requirement solely with respect to failures to dispose of satellites that were clearly within the operator's control. At the same time, forfeiting a bond regardless of fault will increase costs for satellite operators through expensive bond obligations without increasing incentives for their safe design, operation and disposal.

Given the fact that a disposal bond obligation would not result in the manufacture and launch of more reliable satellites, it would clearly be harmful to the U.S. space industry to impose such a financially burdensome requirement. Particularly for smaller operators, the cost of securing a surety bond can be very high, reflecting the risk involved in effectively insuring the reliability of a very long term asset. As the *Further Notice* acknowledges, such bonds would have to be maintained for lengthy periods, including 15 years or more for a single GSO satellite or indefinitely for multiple generations of NGSO satellites. Such costs will increase the already substantial economic barriers to entry for startup companies in the U.S. space industry and encourage some operators to base their activities overseas. Given these high costs, and the

⁵³ See 47 CFR §§ 25.117(e)(1) (permitting modifications of space station licenses to extend milestone requirements due to “unforeseeable circumstances beyond the applicant’s control”); see also Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters, IB Docket No. 16-408, *Notice of Proposed Rulemaking*, FCC 16-170, ¶ 32 n.80 (Dec. 15, 2016) (explaining that “a licensee failing to meet its milestone deadline may avoid the automatic termination provision by demonstrating that the failure was caused by circumstances beyond the licensee’s control”).

questionable efficacy of a disposal bond requirement, the Commission should refrain from adopting its disposal bond proposal.

IX. CONCLUSION

The Commission should continue to support the safe and effective use of space for commercial purposes by adopting the further updates to its orbital debris mitigation rules that are identified in these comments. The proposals discussed herein are objective and transparent; align closely with the standards maintained by other expert federal agencies; do not excessively encumber the growth and development of the U.S. space industry; and will advance the goals of ensuring that space resources are safe, sustainable and available for space research and commerce.

Respectfully submitted,

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