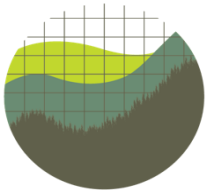

Institute *for*
Policy Integrity
NEW YORK UNIVERSITY SCHOOL OF LAW

December 26, 2023

To: Federal Aviation Administration, U.S. Department of Transportation

Re: Mitigation Methods for Launch Vehicle Upper Stages on the Creation of Orbital Debris, 88 Fed. Reg. 65,835 (proposed Sept. 26, 2023)

The Institute for Policy Integrity at New York University School of Law (Policy Integrity)[1] respectfully submits this comment letter to the Federal Aviation Administration (FAA) regarding its proposal to require commercial space launch operators to limit or dispose of orbital debris within 25 years (Proposed Rule).[2] Policy Integrity is a non-partisan think tank dedicated to improving the quality of government decision-making through advocacy and scholarship in the fields of administrative law, economics, and public policy.

We offer the following recommendations:

- **FAA should reconsider its proposed decision not to adopt more stringent standards.** In rejecting such standards, FAA fails to account for uncertainty in operators' debris mitigation plans, unmitigated damage caused by debris objects smaller than 5 millimeters (mm), and the additional benefits that more stringent standards would offer. Its justifications are largely based on harmonization with international or U.S. government standards, but such harmonization, while important, should not be treated as determinative. Instead, in line with longstanding executive orders, FAA should more robustly assess whether the additional benefits of more stringent standards—such as requiring mitigation more quickly than 25 years, allowing fewer than 100 object-years of debris per launch, or requiring mitigation of more than the debris expected from a particular launch—might justify their higher costs.
- While FAA's conclusion that the Proposed Rule's benefits likely justify its costs is well grounded, **FAA should conduct a more robust benefits analysis**. Specifically, FAA should conduct a breakeven analysis and should include a more detailed description of its unquantified benefits. FAA should also include more discussion of the Proposed Rule's potential to (i) encourage international reciprocity, (ii) provide benefits worldwide, and (iii) promote national security.
- **FAA should analyze the Proposed Rule's likely effects on competition.**

Background

On September 26, 2023, FAA published the Proposed Rule, which seeks to preserve the continued usefulness of Earth's orbits and prevent serious hazards posed to on-orbit missions by requiring commercial space operators to mitigate their contributions to the growing problem of orbital debris.[3] Under the Commercial Space Launch Act of 1984, as amended,[4] the Secretary of Transportation (though FAA) is responsible for issuing licenses for commercial space launch and reentry activities as conducted

[1] This document does not purport to represent the views, if any, of New York University School of Law.
[2] Mitigation Methods for Launch Vehicle Upper Stages on the Creation of Orbital Debris, 88 Fed. Reg. 65,835 (Sept. 26, 2023) [hereinafter Proposed Rule].
[3] *Id*. at 65,836.
[4] 51 U.S.C. §§ 50901–23.

by U.S. entities or within the United States.[5] As a condition of such a license, FAA "may prescribe . . . any requirement necessary to protect the public health and safety, safety of property, national security interests, and foreign policy interests of the United States."[6]

Promulgated under this authority, the Proposed Rule requires licensed commercial operators to demonstrate to FAA that upper stages[7] and other components will not generate orbital debris that will remain in orbit for more than 25 years after launch.[8] Specifically, commercial operators must select one of five methods to dispose of "all launch vehicle stages or jettisoned components": (1) controlled atmospheric disposal, (2) heliocentric, Earth-escape disposal, (3) direct retrieval, (4) uncontrolled atmospheric disposal, or (5) maneuver to a disposal orbit.[9] Each disposal method carries additional requirements.[10] Further, in addition to the 25-year limit for individual debris objects, the Proposed Rule would limit operators to a total of 100 object-years for all debris object they release into low Earth orbit (LEO).[11]

In a regulatory impact analysis (RIA), FAA estimates that the Proposed Rule will cost $2.6 million annually at a 3% discount rate.[12] FAA also describes the Proposed Rule's benefits, including preventing 427 vehicle upper stages from becoming orbital debris over 15 years, avoided long-term remediation costs, mitigating risks to space assets, internalizing orbital-debris-related externalities, encouraging reciprocal foreign action, and preventing collisions.[13] FAA concludes that, in the absence of the Proposed Rule, "the [commercial space] industry's desired path for growth and expansion is unlikely to be achieved."[14] The agency does not, however, monetize any benefits in its main analysis. FAA provides a sensitivity analysis in its RIA's Appendix monetizing some benefits.

I. FAA Should Reconsider Its Proposed Decision to Reject More Stringent Regulatory Alternatives

FAA reasonably describes some of the risks that orbital debris poses and determines that the Proposed Rule would mitigate many of those risks. But the particular standards it sets merit reconsideration. Specifically, FAA's reasons for rejecting more stringent alternatives to its proposed 25-year and 100-object-year limits are not persuasive. FAA does not address important reasons why more stringent standards may be appropriate—in particular, the uncertainty in operators' debris mitigation plans, the option value of keeping orbits clearer, the unmitigated damage caused by debris objects smaller than 5 mm, and the possibility that more stringent standards may carry higher net benefits. Instead, it focuses

[5] Proposed Rule, 88 Fed. Reg. at 65,836.
[6] 51 U.S.C. § 50905(b)(2)(B).
[7] FAA defines an upper stage as "a segment of a launch vehicle that reaches orbit." Proposed Rule, 88 Fed. Reg. at 65,836.
[8] *Id*. at 65,836, 65,845.
[9] *Id*. at 65,847.
[10] *See id.*
[11] *Id*. at 65,845.
[12] FAA, Preliminary Regulatory Impact Analysis, Mitigation Methods for Launch Vehicle Upper Stages on the Creation of Orbital Debris 2 (Aug. 2023) [hereinafter RIA]. Although FAA also analyzed costs under a 7% discount rate, a 3% discount rate is used throughout for both ease of illustration and because the updated version of Circular A-4 recommends against using a capital-based discount rate (like the previously recommended 7% rate). OFF. OF MGMT. & BUDGET, CIRCULAR A-4: REGULATORY ANALYSIS 77–80 (Nov. 9, 2023), https://www.whitehouse.gov/wp-content/uploads/2023/11/CircularA-4.pdf [hereinafter UPDATED CIRCULAR A-4].
[13] RIA, *supra* note 12, at 21–26.
[14] *Id*. at 26.

solely on harmonizing its requirements with external standards. FAA should determine whether more stringent standards better serve its statutory objectives or offer higher net benefits, in accordance with longstanding executive orders.

A. FAA Fails to Account for Uncertainty in Operators' Debris Mitigation Plans and Option Value

The Proposed Rule would require commercial space operators to demonstrate only a 90% probability of successfully executing one of FAA's identified disposal methods.[15] FAA should consider increasing the stringency of its proposed standard to compensate for its permitted risk of unsuccessful disposal.

In particular, if FAA allows operators to show a 90% chance of success, it necessarily allows them to show a 10% chance of failing to mitigate debris in accordance with FAA's requirements. If FAA wants benefits commensurate with commercial operators mitigating their newly generated debris within 25 years (with a 100 object-year backstop requirement), but its requirements allow failures 10% of the time, those requirements must be made more stringent to account for expected failures.

Moreover, while the 2003 version of Circular A-4 (Prior Circular A-4) recommends that agencies generally treat society as "risk neutral," it notes that this general approach may not always be appropriate.[16] The recently updated Circular A-4 (Updated Circular A-4) elaborates that there are many contexts in which agencies should consider "risk aversion" as the appropriate societal risk preference.[17] If FAA assumes a societal preference for risk aversion—i.e., an overall preference among all relevant stakeholders for a lower degree of variability and uncertainty regarding operators' successful debris mitigation—then that lowers the expected value of uncertain mitigation disposal methods. Thus, if FAA decides to maintain a threshold of 90% probability of success,[18] it should reconsider its preference for less-stringent standards.

Furthermore, Updated Circular A-4 highlights the importance of "real options" analyses, "particularly where irreversibility is material to your analysis."[19] Such analyses assess "the benefits and costs of changing the timing of regulatory effects in light of the value of information about potential states of the world that can be learned over time."[20] As an example, "a regulation that preserves a natural resource today may preserve option value associated with future uses of that resource.[21]" Prior Circular A-4 similarly discusses such analyses.[22]

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[15] Proposed Rule, 88 Fed. Reg. at 65,848–49, 65,851–52.

[16] OFF. OF MGMT. & BUDGET, CIRCULAR A-4: REGULATORY ANALYSIS 42 (2003) [hereinafter PRIOR CIRCULAR A-4].

[17] UPDATED CIRCULAR A-4, *supra* note 12, at 47. OMB recommends following this updated guidance before its effective date "[t]o the extent feasible and appropriate." *Id.* at 93. Here, it is feasible to follow this recommendation as it imposes no extra analytical burdens beyond acknowledging general risk aversion. And it is appropriate given that this guidance reflects more up-to-date economic knowledge. However, as noted, even if FAA were to follow Prior Circular A-4 strictly, even that version acknowledges that risk neutrality is not always the appropriate assumption.

[18] While this 90% threshold is consistent with common international standards and criteria for U.S. government launches, Proposed Rule, 88 Fed. Reg. at 65,848, Section I.C *infra* details why FAA should not treat harmonization with other standards as dispositive.

[19] UPDATED CIRCULAR A-4, *supra* note 12, at 69.

[20] *Id.*

[21] *Id.*

[22] *See* PRIOR CIRCULAR A-4, *supra* note 16, at 39.

Here, because orbital debris remediation efforts are in nascent stages,[23] and because unmitigated orbital debris would remain in space until such efforts bear fruit, generating orbital debris is at least partially irreversible. Usable orbits are therefore analogous to a largely nonrenewable natural resource. That means that "preserv[ing] a natural resource [i.e., usable orbits] today may preserve option value associated with future uses of that resource."[24] Moreover, the degree of irreversibility depends in part on the Proposed Rule: insofar as the Proposed Rule incentivizes cheaper mitigation and even remediation technologies and methods, it creates even more option value by opening up more possibilities for efficiently clearing out orbits in the future. More stringent standards would therefore increase option value even more, providing another factor supporting more stringent standards.

B. FAA Fails to Account for Unmitigated Damage Caused by Debris Objects Smaller Than 5 Millimeters

Adopting more stringent regulatory alternatives may also be an appropriate means of offsetting the effects of smaller, yet still harmful, debris that FAA does not regulate. In describing the problem FAA seeks to address, the agency describes the serious risks generated by orbital debris smaller than 5 mm in diameter. Specifically, FAA explains that, because of the hypervelocities at which objects travel in space, smaller objects can have performance-degrading impacts on satellites and other spacecraft.[25] Nonetheless, FAA defines "orbital debris" subject to regulation to include only those objects greater than 5 mm in diameter, concluding that it is not technologically feasible to track and mitigate objects smaller than 5 mm.[26] As a result, operators would not be responsible for the negative externalities imposed by any debris they generate that is smaller than 5 mm. Even if FAA does not regulate smaller orbital debris itself because of technological limitations, FAA could alter other aspects of its Proposed Rule to account for the harms posed by smaller orbital debris that the rule does not currently mitigate. For instance, it could make its proposed 25-year and 100-object-year standards more stringent. Doing so would help FAA more fully mitigate the expected debris-related harms of a launch, given that even this small debris poses risks to safety, property, and U.S. national security and foreign policy interests.[27]

C. Rather than Treating Harmonization with Other Standards or Higher Costs as Dispositive, FAA Should Assess Whether More Stringent Standards Would Better Serve Its Statutory Goals or Maximize Net Benefits

The Commercial Space Launch Act highlights the importance of considering "public health and safety, safety of property, national security interests, and foreign policy interests of the United States" when setting standards.[28] Moreover, longstanding executive orders and guidance instruct agencies "choosing among alternative regulatory approaches" to "select those approaches that maximize net benefits

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[23] *See* Proposed Rule, 88 Fed. Reg. at 65,847 (noting that dedicated debris-remediation missions are "forecasted to be expensive and ha[ve] not yet been shown to be a viable operation").
[24] UPDATED CIRCULAR A-4, *supra* note 12, at 69.
[25] FAA suggests that such debris can "degrade performance, pit or crack windows, mar surfaces of solar panels, damage optics and degrade surface coatings." Proposed Rule, 88 Fed. Reg. at 65,838. For example, in 1984, a fleck of paint, originally about 0.2 mm wide, formed a 4 mm crater that damaged the windshield of the Space Shuttle Challenger, as it was traveling 3–6 kilometers per second. *Id.* at 65,838.
[26] *Id*. at 65,844–45.
[27] 51 U.S.C. § 50905(b)(2)(B).
[28] *Id.*

(including . . . distributive impacts[] and equity)," to the extent permitted by law.[29] Consistent with these guidelines, FAA should consider regulatory alternatives that would better promote its statutory goals or yield higher net benefits.

Instead, FAA largely rejects more stringent standards because they differ from standards set by the international community and other U.S. agencies—specifically, the Inter-Agency Space Debris Coordination Committee's (IADC's)[30] recommendations and the U.S. Government Orbital Debris Mitigation Standard Practices (USGODMSP).[31] FAA also rejects these more stringent standards because they carry higher costs. While harmonization and cost are important considerations, FAA should not treat them as dispositive in its analysis.

Harmonization. FAA bases its proposed 25-year requirement on harmonization with standards from IADC and other U.S. government agencies that apply to other launches.[32] It explicitly rejects an alternative 5-year limit because it would be inconsistent with these external standards.[33] So too with the proposed 100-object-year standard, which FAA defends as consistent with USGODMSP.[34]

But, while the Commercial Space Launch Act requires FAA to *consider* other standards,[35] it does not require the agency to *match* such standards. FAA may reasonably determine, for example, that more stringent alternatives would better protect public safety and property.[36] Moreover, relying on potentially outdated standards that apply to foreign and U.S. government launches may fail to account for the recent growth in U.S. commercial space activity and the accompanying contributions to orbital debris. Indeed, in a recent report to Congress, FAA acknowledged criticism of the IADC's standards, as the IADC did not anticipate the scale of space traffic existing today,[37] and the even greater scale that will exist in the near

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[29] Exec. Order No. 12,866 § 1(a), 58 Fed. Reg. 51,735, 51,735 (Oct. 4, 1993); *see also* Exec. Order No. 14,094 § 1, 88 Fed. Reg. 21,879, 21,879 (Apr. 11, 2023) (reaffirming the principles of Executive Order 12,866); PRIOR CIRCULAR A-4, *supra* note 16, at 2; UPDATED CIRCULAR A-4, *supra* note 12, at 2–3.

[30] The IADC describes itself as "an international forum of space agencies, authorized governmental or inter-governmental entities for the coordination of activities related to the issues of human-made and natural debris in space." IADC STEERING GROUP AND WORKING GROUP 4, IADC SPACE DEBRIS MITIGATION GUIDELINES, IADC–02–0, REVISION 2, 4 (Mar. 2020), https://orbitaldebris.jsc.nasa.gov/library/iadc-space-debris-guidelines-revision-2.pdf [https://perma.cc/KGT3-RSHV]. NASA belongs to the IADC, as do analogous representatives from Asia and Europe, including China National Space Administration and Russia's State Space Corporation. *Id.*

[31] U.S. GOVERNMENT ORBITAL DEBRIS MITIGATION STANDARD PRACTICES, NOVEMBER 2019 UPDATE 2, https://orbitaldebris.jsc.nasa.gov/library/usg_orbital_debris_mitigation_standard_practices_november_2019.pdf [https://perma.cc/WX76-9RUM]. Elsewhere in the Proposed Rule, FAA explains that its efforts to conform aspects of the Proposed Rule with such "common standards" is in keeping with U.S. Space Transportation Policy which requires FAA to act "consisent[ly] with existing statutes and executive orders[] to address orbital debris mitigation practices for U.S.-licensed commercial launches . . . ." Proposed Rule, 88 Fed. Reg. at 65,844 n.48. But this directive does not appear to mandate conformity with USGODMSP, as FAA's statutory standards and other longstanding regulatory standards, like those from Executive Order 12,866, should also factor in.

[32] Proposed Rule, 88 Fed. Reg. at 65,845–46, 65,849–50.

[33] RIA, *supra* note 12, at 45.

[34] Proposed Rule, 88 Fed. Reg. at 65,845–46.

[35] 51 U.S.C. § 59019(e).

[36] *Id.* § 50905(b)(2)(B).

[37] FED. AVIATION ADMIN., REPORT TO CONGRESS: RISK ASSOCIATED WITH REENTRY DISPOSAL OF SATELLITES FROM PROPOSED LARGE CONSTELLATIONS IN LOW EARTH ORBIT 13 (2023), https://www.faa.gov/sites/faa.gov/files/Report_to_Congress_Reentry_Disposal_of_Satellites.pdf [https://perma.cc/VZ9D-2KRX].

future.[38] Moreover, better preserving the viability of useful orbits may advance FAA's statutory obligation to enable, encourage, and promote commercial space activity.[39] FAA should address whether these and similar considerations suggest that more stringent alternatives would best promote FAA's statutory objectives or maximize net benefits, even at the cost of harmonization. If FAA retains its heavy reliance on harmonization as a justification, it should discuss more precisely why harmonization creates benefits, so those benefits can be more easily compared to its calculated costs.

Indeed, FAA's own reasoning and analysis indicates that a 5-year alternative may be more net beneficial than the proposed 25-year standard. With respect to the timeframe imposed on the orbital lifetime of debris, FAA states that "increases in the numbers and kinds of activities in Earth orbit may render the 25-year timeframe inadequate to prevent the growth of orbital debris."[40] Later, in discussing the 25-year standard for the uncontrolled atmospheric disposal, FAA acknowledges that "a shorter deadline of 5 years that removes the highest-mass objects from orbit would vastly reduce the risk of creating more debris and would make U.S. commercial space a leader in orbital debris mitigation."[41] In the RIA, FAA further suggests that a 5-year requirement would carry minimal additional costs.[42] Putting this all together, FAA seems to suggest that the 5-year alternative would carry higher benefits without much higher costs, so it could plausibly carry higher net benefits. If FAA indeed finds that a 5-year requirement maximizes net benefits—or that another requirement between 5 and 25 years does—then the FAA should reconsider its preference for 25 years.

Cost. FAA proposes not to require operators to remediate debris they have already created because remediation efforts are "forecasted to be expensive and ha[ve] not yet been shown to be a viable operation."[43] However, noting that remediation's marginal costs are currently high ignores whether its marginal benefits may be even higher. As FAA concedes, not only are the costs of remediation likely to precipitously decline in the future, "[i]t should not be concluded that orbital debris mitigation *and remediation* should be delayed or avoided now because of the falling costs due to space technological advancement."[44]

Consistent with executive orders and guidance, FAA should not foreclose requiring more stringent alternatives on the basis of their higher costs without assessing whether additional benefits may justify

[38] Private-sector operations comprise the fastest-growing source of space launches. Chris Daehnick et al., *Space Launch: Are We Heading for Oversupply or a Shortfall?*, MCKINSEY (Apr. 17, 2023), https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/space-launch-are-we-heading-for-oversupply-or-a-shortfall ("While government (military and civil) space activity remains a significant and growing source of launch demand, the private sector is the fastest-growing segment . . . ."). Further, as of 2018, the Congressional Research Service found that a majority of U.S. satellites were commercially owned. CONG. RSCH. SERV., COMMERCIAL SPACE: FEDERAL REGULATION, OVERSIGHT, AND UTILIZATION 1 (Nov. 29, 2018), https://www.everycrsreport.com/files/20181129_R45416_448ecfba931aa7974dcb1c200f4d2a603ea42f0e.pdf [https://perma.cc/TKT5-JGKU].

[39] 51 U.S.C. § 50903(b)(1).

[40] Proposed Rule, 88 Fed. Reg. at 65,846.

[41] *Id*. at 65,850.

[42] RIA, *supra* note 12, at 45.

[43] Proposed Rule, 88 Fed. Reg. at 65,847.

[44] RIA, *supra* note 12, at 57 (emphasis added).

those costs.[45] The RIA describes several benefits of reducing orbital debris,[46] Section I.A. above adds risk reduction and option value, and Section II.B. below suggests still others. The importance of continuing to promote private space exploration and the catastrophic nature of some orbital-debris-related risks provide reason to expect that remediation's higher benefits may plausibly justify its higher costs. Put differently, instead of stopping its analysis after concluding that remediation is costly, FAA should consider whether the costs of forgoing remediation are even higher.

II. FAA Should More Robustly Analyze Benefits

In the RIA, FAA identifies six benefits of the Proposed Rule:

1. Preventing 427 vehicle upper stages from becoming debris in 15 years;
2. Avoiding long-term remediation costs;
3. Mitigating risks to space assets;
4. Internalizing the externality of space debris;
5. Encouraging reciprocal regulations from foreign countries; and
6. Preventing collisions and protecting humans in space.[47]

In its primary analysis, FAA reasonably relies on a purely qualitative discussion of these benefits to justify its conclusion the Proposed Rule's benefits justify the costs. Both the Prior and Updated Circular A-4 versions are clear that unquantified benefits can support a conclusion that benefits justify costs.[48]

Furthermore, in the RIA's appendix, FAA supplements its qualitative assessment with a quantification of potential cost savings resulting from the Proposed Rule. Specifically, FAA estimates cost savings stemming from the fact that near-term mitigation will avoid the need for costlier longer-term remediation to keep the relevant orbits usable. The agency uses a Monte Carlo simulation to account for uncertain input parameters.[49] Following its economist's own research,[50] FAA should go one small step further and compare those estimated cost savings (i.e., benefits) to costs of mitigation to show that the former likely outweigh the latter. To enable an apples-to-apples comparison, FAA should present costs and benefits over the same analytical time horizon, whether 15 or 25 years.[51] And, given the importance of comparing

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[45] *See* Exec. Order No. 12,866 § 1(a), 58 Fed. Reg. 51,735, 51,735 (Oct. 4, 1993) ("[I]n choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits . . . , unless a statute requires another regulatory approach."); Exec. Order No. 14,094 § 1, 88 Fed. Reg. 21,879, 21,879 (Apr. 11, 2023) (reaffirming the same); PRIOR CIRCULAR A-4, *supra* note 16, at 10 ("The size of net benefits, the absolute difference between the projected benefits and costs, indicates whether one policy is more efficient than another."); UPDATED CIRCULAR A-4, *supra* note 12, at 3 ("When all benefits and costs . . . can be quantified and expressed in monetary units, regulatory alternatives' monetized net benefits—the difference between the monetized benefits and the monetized costs—are an indication of the alternative . . . that generates the largest welfare improvement to society.").

[46] *See* RIA, *supra* note 12, at 20–26.

[47] *Id.*

[48] PRIOR CIRCULAR A-4, *supra* note 16, at 2 ("[T]he most efficient alternative will not necessarily be the one with the largest quantified and monetized net-benefit estimate. In such cases, you should exercise professional judgment in determining how important the non-quantified benefits or costs may be in the context of the overall analysis."); UPDATED CIRCULAR A-4, *supra* note 12, at 3 (similar).

[49] RIA, *supra* note 12, at 47–58.

[50] *See* Martin K. Zhu, *A Break-Even Analysis of Orbital Debris and Space Preservation Through Monetization*, 9 J. SPACE SAFETY ENG'G 600 (2022).

[51] *Compare* RIA, *supra* note 12, at 44 tbl.6 (reporting costs over 15 years), *with id.* at 50 ("[F]or purposes of this sensitivity analysis, the FAA is using 25 years from launch for the time frame . . . .").

benefits and costs, FAA should elevate this monetized benefits analysis to the RIA's main text and the rule preamble rather than featuring it only in an appendix. Because the estimated cost savings greatly exceed estimated costs,[52] this comparison would bolster FAA's conclusion that benefits justify costs.

FAA should take other reasonable steps to reinforce this conclusion even more. Specifically, FAA should follow Circular A-4's recommendation for a breakeven analysis to support its determination that benefits justify costs. FAA should also add or bolster discussions of international reciprocity, global impacts, and national security.

A. FAA Should Explicitly Conduct a Breakeven Analysis to Bolster Its Conclusion that Benefits Justify Costs

A breakeven analysis could bolster FAA's comparison of benefits and costs, showing that FAA's conclusion that benefits justify costs need not turn on the monetized cost savings discussed above. Prior Circular A-4 notes that, "[i]f the non-quantified benefits and costs are likely to be important, you should carry out a threshold analysis to evaluate their significance."[53] Updated Circular A-4 also stresses the importance of breakeven analysis when dealing with non-monetized effects: "[B]reak-even analysis asks what magnitude non-monetized benefits and costs would need to have for the regulation at issue to yield positive net benefits or to change which regulatory alternative is most net beneficial."[54]

The Updated Circular notes that breakeven analyses are particularly useful when trying to estimate how a regulation affects the probability of catastrophic events: "Your break-even analysis could demonstrate how much a regulatory alternative would need to reduce the probability of a catastrophic event occurring in order to yield positive net benefits or change which regulatory alternative is most net beneficial."[55] This guidance again applies to the Proposed Rule given that much of its benefits stem from avoiding disastrous collisions between space assets (including manned spacecraft) and orbital debris.

A variety of inputs are available for conducting a breakeven analysis for the Proposed Rule. Using data from a 2023 study by the National Aeronautics and Space Agency's (NASA's) Office of Technology, Policy, and Strategy that analyzes the costs and benefits of debris remediation efforts,[56] a cursory breakeven analysis is presented below. The results of this analysis, which is conservative as it only considers the benefits to the value of space equipment and operations, show that benefits of the Proposed Rule likely break even with costs, even without considering the cost savings or other benefits described above.

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[52] *Compare id.* at 45 tbl.8 (reporting $5 million in annualized costs under the least conservative "High Case" using a 3% discount rate), with *id.* at 56 tbl.A-4 (reporting present values for cost savings in particular years totaling hundreds of millions of dollars using a 3% discount rate). While these time horizons are not consistent, the fact that benefits exceed costs by two orders of magnitude suggests that the overall conclusion that benefits exceed costs is very likely robust.

[53] PRIOR CIRCULAR A-4, *supra* note 16, at 2.

[54] UPDATED CIRCULAR A-4, *supra* note 12, at 47.

[55] *Id.*

[56] NAT'L AERONAUTICS & SPACE ADMIN., COST AND BENEFIT ANALYSIS OF ORBITAL DEBRIS REMEDIATION (Mar. 10, 2023), https://www.nasa.gov/wp-content/uploads/2023/03/otps_-_cost_and_benefit_analysis_of_orbital_debris_remediation_-_final.pdf [hereinafter NASA Study]. FAA's RIA briefly mentions this study. RIA, *supra* note 12, at 57.

The NASA report groups U.S. satellites into various categories based on features such as the spacecraft's orbits and operators (e.g., civilian, commercial, or military).[57] The study estimates many of these spacecraft's equipment and operational values.[58] Table 1 below presents a breakeven analysis using these values for a variety of categories (using FAA's annual cost estimate of $2.6 million at a 3% discount rate). It also estimates the weighted-average value from all included categories.

Table 1: Breakeven Analysis for FAA's Proposed Rule, by Satellite Category[59]

Satellite Category	**Value of one space asset in this category ($ million)**	**Number of catastrophic collisions with space assets needed to be prevented per year to break even (two significant figures)[60]**
Commercial Large Constellation	1.7	1.5
Commercial Medium Constellation	43	0.060
Commercial Small Constellation	6	0.43
Weighted-value category in 2023[61]	29.9	0.087

Thus, at a 3% discount rate, the Proposed Rule would break even if it mitigated roughly 0.087 catastrophic collisions per year, or one every 11.5 years, when using the weighted-average value of these spacecraft. Again, this estimate is conservative since it considers only the equipment and operational

[57] NASA Study, *supra* note 56, at 71.

[58] *Id.* at 53. Note that the report does not give lost operations value or lost vehicle value for every category. For instance, there is no lost operational value estimated for commercial or military assets.

[59] Commercial Large Constellations are "emerging communications constellations containing hundreds to thousands of spacecraft" with a value of $1.7 million per satellite. NASA Study, *supra* note 56, at 94. Commercial Medium Constellations "contain[] 20–100 satellites each" and have a value of $43 million per satellite. *Id.* at 92. Commercial Small Constellations are "commercial constellations of roughly identical spacecraft containing less than twenty satellites each" and have a value of $6 million per satellite. *Id.* at 89. To determine the value of these spacecraft, the report looks to available data from individual space operators on the value of their spacecraft, and then averages them to determine the categorical value. For instance, for the Commercial Medium Constellation category, there are an estimated 105 satellites. Per Table 24, NASA averages 32 Globalstar spacecraft worth $29 million per asset with 73 Iridium NEXT satellites worth $49 million each to arrive at the value of $43 million for the category. *Id.* at 92.

[60] Under the central case with a 3% discount rate, annualized costs are $2.6 million. Proposed Rule, 88 Fed. Reg. at 65,856. The values in this column equal that value, $2.6 million, divided by the value of one space asset in each category.

[61] This value was determined by taking the weighted average value of all the categories of space assets listed in the NASA Report. Table 5 of the report lists estimates for 10 categories. It estimates the values of the categories of spacecraft by assuming that collisions happen at the midway point of the spacecraft's lifecycle. The number of space assets per category is noted in Table 13 and in Appendix A of the report. Thus, using the value of the spacecraft (including operational value if given) denoted in Table 5 and the number of spacecraft in each category per Table 13 and Appendix A, a weighted-average value of $29.9 million per spacecraft was determined. NASA Study, *supra* note 56. This value derives from the number of assets in each category in 2023, but that value will differ in other years.

values of the spacecraft listed in the report, excluding the value of other spacecraft and the other benefits FAA lists. (FAA should re-run this and all relevant analyses at a 2% discount rate, consistent with Updated Circular A-4.[62])

In performing this analysis, FAA should detail why it anticipates the breakeven level of benefits to be plausible. This analysis should discuss why FAA believes both the number of collisions prevented and the economic value of such prevented collisions are realistic. Modeling described in the Proposed Rule gives reason to expect that it will prevent many collisions, and FAA should elaborate on this analysis in the final rule to show that the regulation would likely break even. Figure 5 of the Proposed Rule predicts the number of collisions in the LEO under both a non-mitigation scenario and under post-mission-disposal scenario.[63] For instance, by 2070, it is estimated that four collisions would be avoided in total if 90% of worldwide launches follow the proposed regulations.[64] However, this figure does not take into account the rapid growth in the number of launches of large constellations,[65] which will likely increase the Proposed Rule's benefits. FAA's Figure 6 shows the expected number of collisions given the rapid growth of this market but does not show a non-mitigation scenario for comparison.[66] FAA can likely use similar methods that these studies employed to show that it is plausible the Proposed Rule will break even by determining the number of collisions that it would prevent.

Moreover, FAA can show an even higher likelihood of breaking even by appealing explicitly to catastrophic tipping points. As FAA notes, even if no future space launches occurred, collisions among *existing* space objects "will eventually become the major source of debris."[67] FAA further explains that, if the current amount of debris remains in orbit, Kessler Syndrome may pose catastrophic threats to spacecraft.[68] Given the nontrivial possibility of catastrophic "collisional cascading,"[69] adopting even more

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[62] *See* UPDATED CIRCULAR A-4, *supra* note 12, at 77. While the updates do not formally apply to final rules until January 2025, it advises agencies to apply its guidance immediately "[t]o the extent feasible and appropriate." *Id.* at 93. It is "appropriate" here for FAA to apply a 2% discount rate given the extensive economic support for lower discount rates. *See, e.g.*, Peter Howard & Jason A. Schwartz, *Valuing the Future: Legal and Economic Considerations for Updating Discount Rates*, 39 YALE J. ON REGUL. 595, 599 (2022) (detailing "the compelling economic evidence for further lowering the current default [discount] rates for regulatory analyses"). Doing so is also "feasible" given that the discount rate parameter is easily adjustable. If necessary, this analysis could be conducted as a separate or sensitivity analysis, alongside analyses using other rates.

[63] Proposed Rule, 88 Fed. Reg. at 65,841. Figure 5 was taken from a publication by NASA's Orbital Debris Publication Office, which notes that "[a]pproximately 50% of the predicted collisions are catastrophic collisions." NASA, *An Updated Assessment of the Orbital Debris Environment in LEO*, 14 ORBITAL DEBRIS Q. NEWS 1, 8 (2010).

[64] Proposed Rule, 88 Fed. Reg. at 65,840–41 (showing seventeen expected collisions by 2070 without any mitigation, compared to thirteen if 90% of worldwide launches comply with the Proposed Rule). While the Proposed Rule would formally only apply to commercial launches within FAA's jurisdiction, as detailed in Section II.B below, the Proposed Rule may inspire reciprocal international action, making this 90% threshold more plausible. If, however, FAA determines that this figure is not plausible, it could conduct multiple analyses under varying assumptions of the extent of international reciprocity. For instance, analyses could show the number of collisions averted with 50% and 90% of foreign launches adhering to the Proposed Rule's standards.

[65] *Id.*

[66] *Id.* at 65,841 fig. 6.

[67] *Id.* at 65,836.

[68] *Id.* at 65,840. Kessler Syndrome describes the phenomenon of debris colliding with other debris, thereby creating more debris, which in turn collides more, and so on.

[69] NAT'L AERONAUTICS & SPACE ADMIN., COST AND BENEFIT ANALYSIS OF ORBITAL DEBRIS REMEDIATION 14 (Jan. 27, 2021), https://oig.nasa.gov/docs/IG-21-011.pdf [https://perma.cc/NEG7-DXQF].

stringent standards may be critical to ensuring that the use of outer space remains viable for future generations.[70] The costs of orbital debris would become non-linear upon reaching these catastrophic breaking points, meaning mitigation now could prevent nonlinear cost increases in the future. Society's general risk aversion and the special costs of irreversible harms—discussed in Section I.A. above—render these "fat-tail" catastrophic possibilities especially harmful.

While quantifying the value of reducing orbital debris is complex given the uncertainty of the benefits and the likely lack of standardized procedures to perform such calculations, FAA should prioritize future research. Specifically, the Agency should describe the necessary data to quantify the Proposed Rule's effects, to help the agency or academic community prioritize collecting it. As Updated Circular A-4 notes, "it is helpful to outline the data collection or analysis that would enable quantification or monetization, even if doing such data collection or analysis is currently infeasible. Doing so may encourage research by external entities that would allow for such effects to be quantified or monetized in future regulations."[71] FAA should build on the aforementioned NASA study. It can also glean information from an FAA report to Congress from earlier this year, in which FAA estimated that one person would be struck by space debris every two years given current growth rates of orbital debris.[72] FAA could monetize expected fatal debris strikes using the value of a statistical life,[73] which it could then compare to its monetized costs, presenting yet another potential means to conclude that the Proposed Rule's benefits plausibly justify its costs.

B. FAA Should Include More Discussion of Additional Benefits from the Proposed Rule

As discussed above, FAA's existing discussion provides good reason to conclude that the Proposed Rule's benefits likely justify its costs. Still, FAA should consider supplementing its benefits discussion. Specifically, it should further discuss the Proposed Rule's likely benefits to (1) international reciprocity, (2) countries outside the United States, and (3) national security.

International Reciprocity. As noted in a prior Policy Integrity comment letter on the Federal Communications Commission's proposed rule on orbital debris, orbital debris constitutes a classic "tragedy of the commons" problem.[74] This problem refers to the category of situations where parties can benefit from a resource without having to internalize all associated costs that can limit the resource's

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[70] *See* UPDATED CIRCULAR A-4, *supra* note 12, at 10 n.16 ("[W]hen assessing the benefits of a regulation that could prevent a catastrophic event with some probability, it may be appropriate for you to consider not only the near-term effects of averting the catastrophic event on those who would be immediately affected, but also the long-run effects on others—including future generations—who would be affected by the catastrophic event.").

[71] UPDATED CIRCULAR A-4, *supra* note 12, at 45.

[72] FED. AVIATION ADMIN., REPORT TO CONGRESS: RISK ASSOCIATED WITH REENTRY DISPOSAL OF SATELLITES FROM PROPOSED LARGE CONSTELLATIONS IN LOW EARTH ORBIT (2023), https://www.faa.gov/sites/faa.gov/files/Report_to_Congress_Reentry_Disposal_of_Satellites.pdf [https://perma.cc/GG99-VN3N]. Additional sources of data on the costs of collisions could come from insurance companies which are increasingly involved in the space industry market. *See* Micah Nguyen Worthy, *Your Chance of Getting Hit by Space Junk Is Extremely Low… but Not Zero!*, CRANFILL SUMNER, https://www.cshlaw.com/resources/the-current-universe-of-space-insurance/ [https://perma.cc/ET9X-F3FT].

[73] *See* U.S. Dep't of Transp., *Departmental Guidance on Valuation of a Statistical Life in Economic Analysis* (2021), https://www.transportation.gov/office-policy/transportation-policy/revised-departmental-guidance-on-valuation-of-a-statistical-life-in-economic-analysis [https://perma.cc/49R6-FUC4].

[74] *See* Inst. For Pol'y Integrity, Comment Letter on Mitigation of Orbital Debris in the New Space Age (May 6, 2019), https://policyintegrity.org/documents/DOC_Orbital_Debris_Comments_2019.5_.9_.pdf.

value.[75] Thus, countries are able to reap the benefits of launching space assets into outer space individually while spreading the costs of orbital debris to all other countries. Unregulated commons produce inefficient outcomes for all parties involved, which stresses the importance of international reciprocity potentially resulting from the Proposed Rule. FAA should discuss how the problem of orbital debris constitutes a global tragedy of the commons that inspires the need for regulation; such discussion can supplement FAA's "Background" section of the preamble where the overall problem of orbital debris is described.

International reciprocity by other spacefaring nations will lead to important benefits for the United States. First, international regulations would help stem the rapid growth rate of orbital debris.[76] This will help mitigate the cost of operations to U.S. actors.[77] Additionally, international requirements that limit orbital debris growth will particularly benefit American companies that "dominate[] the commercial share in manufacturing and satellite launch services"[78] by reducing the likelihood of collisions with American spacecraft. While the Proposed Rule focuses on mitigation efforts, FAA notes that remediation operations might be necessary in the future.[79] International technological demonstrations of direct remediation efforts are ongoing.[80] FAA issuing mitigation regulations may encourage more technological investments on these sorts of efforts, thereby lowering costs for American and other operators needing to engage in direct removal in the future.

Global Benefits. Neither the RIA's discussion of benefits nor its Appendix's monetized cost savings explicitly mentions any benefits to non-American entities. Given the inherently global nature of the problem of orbital debris, FAA should explicitly consider the Proposed Rule's global costs and benefits. Prior Circular A-4 notes that, when regulations have impacts "beyond the borders of the United States," agencies should report them.[81] Updated Circular A-4 goes further, noting that, in "certain contexts, it may be particularly appropriate to include effects experienced by noncitizens residing abroad in your primary analysis," such as when "regulating an externality on the basis of its global effects supports a cooperative international approach."[82] Given that all countries pay the cost from any one country producing orbital debris, and that all countries benefit from one country mitigating orbital debris, the Proposed Rule is a particularly clear case in which global impacts merit consideration.

Federal agencies already acknowledge global impacts and the strategic benefits for the United States from taking mitigation actions. In its recently finalized social cost of greenhouse gases estimates, EPA takes into account global effects, noting that climate change is a global problem requiring international

[75] *See* Elinor Ostrom, *Tragedy of the Commons*, *in* THE NEW PALGRAVE DICTIONARY OF ECONOMICS (Steven N. Durlauf & Lawrence E. Blume eds., 2008).
[76] Proposed Rule, 88 Fed. Reg. at 65,839.
[77] *See* RIA, *supra* note 12, at 25 ("As orbital debris increases, the cost of mission operations rises.").
[78] *Id.* at 24.
[79] Proposed Rule, 88 Fed. Reg. at 65,856 (noting that a benefit of the Proposed Rule is reducing future remediation costs).
[80] *See* Proposed Rule, 88 Fed. Reg. at 65,849 n.57 ("On August 25, 2021, a Japanese spacecraft successfully captured a simulated piece of space debris as a first step to demonstrate technology to remove orbital debris.").
[81] PRIOR CIRCULAR A-4, *supra* note 16, at 15.
[82] UPDATED CIRCULAR A-4, *supra* note 12, at 8.

cooperation.[83] The government-wide estimates endorsed in 2021 took a similar approach.[84] Growth of orbital debris falls into this same category: a global common good and a stock pollutant. Furthermore, the United States considering the global effects of its regulations may encourage other countries to do similarly.[85] As foreign countries also account for the global effects of orbital debris, the global commons of outer space will be better protected, with spillover benefits for American space operations.

National Security Risks. Orbital debris poses risks to military satellites. While monetized estimates of these satellites' equipment and operational value are unavailable because such estimates "are highly sensitive,"[86] there is some reason to expect that their value—and that of similar government assets in space—are high. Damaging an American military satellite may impact military operations—at worst, endangering national security. Damaging another country's satellite carries a variety of risks—at worst, risking accidental war, even nuclear war, if the damage is misinterpreted as a hostile act.[87]

While these outcomes are unlikely, Updated Circular A-4 emphasizes that "low-probability but high-impact effects may be important to assess (whether or not those effects can be quantified or monetized)."[88] The Circular further encourages agencies that are "assessing the benefits of a regulation that could prevent a catastrophic event with some probability" to count both "the near-term effects of averting the catastrophic event on those who would be immediately affected" and "the long-run effects on others—including future generations—who would be affected."[89] To provide a fuller picture of orbital debris mitigation's potential benefits, FAA should discuss these risks.

III. FAA Should Discuss the Proposed Rule's Effects on Competition

In accordance with recent guidance from OMB, FAA should also further elaborate on the Proposed Rule's potential effects on competition.[90] This guidance notes that "encouraging competitive markets is

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[83] *See* ENV'T PROT. AGENCY, EPA REPORT ON THE SOCIAL COST OF GREENHOUSE GASES: ESTIMATES INCORPORATING RECENT SCIENTIFIC ADVANCES 12–19 (2023), https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf [https://perma.cc/98CM-2VKZ]. As EPA notes, "Unlike many environmental problems where the causes and impacts are distributed more locally, GHG emissions are a global externality making climate change a true global challenge. GHG emissions contribute to damages around the world regardless of where they are emitted. The global nature of GHG pollution and its impacts means that U.S. interests are affected by climate change impacts through a multitude of pathways, and these need to be considered when evaluating the benefits of GHG mitigation to the U.S. population." *Id.* at 14.

[84] INTERAGENCY WORKING GRP. ON THE SOC. COST OF GREENHOUSE GASES, TECHNICAL SUPPORT DOCUMENT: SOCIAL COST OF CARBON, METHANE, AND NITROUS OXIDE – INTERIM ESTIMATES UNDER EXECUTIVE ORDER 13,990 at 14–16 (2021), https://whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf [https://perma.cc/V5YP-CU8U].

[85] *See* Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42(S) COLUM. J. ENV'T L 203, 221 (2017).

[86] NASA Study, *supra* note 56, at 85.

[87] *See* Anelí Bongers & José L. Torres, *Star Wars: Anti-Satellite Weapons and Orbital Debris*, DEFENCE & PEACE ECON. 1 (2023) (detailing security risks stemming from, and contributing to, orbital debris); *see also* Seth Baum, *Uncertain Human Consequences in Asteroid Risk Analysis and the Global Catastrophe Threshold*, 94 NAT. HAZARDS 759, 763–64 (2018) (documenting how similar risks from asteroids could lead to nuclear war).

[88] UPDATED CIRCULAR A-4, *supra* note 12, at 28.

[89] *Id.* at 10 n.16.

[90] OFF. OF MGMT. & BUDGET, GUIDANCE ON ACCOUNTING FOR COMPETITION EFFECTS WHEN DEVELOPING AND ANALYZING REGULATORY ACTIONS (2023), https://www.whitehouse.gov/wp-content/uploads/2023/10/RegulatoryCompetitionGuidance.pdf [https://perma.cc/UT36-VURR] [hereinafter COMPETITION GUIDANCE].

an important policy goal" since competitive markets lead to, among other benefits, "more innovative products and services, more business formation, and greater resilience to unexpected events."[91] These three byproducts of competition are particularly important to the space industry. As an emerging market, technological innovations are essential for the space industry to continue its rapid growth in a scientifically and economically complex area. Relatively few commercial operators are active in the space industry,[92] so ensuring competition is important to allow for new entrants to the market. Lastly, the commercial space market is one defined by significant risks, like rocket explosions,[93] that can have severe economic and fatal impacts. Resiliency to these unexpected events can help ensure the market continues to grow.

Given these important considerations, FAA should analyze the Proposed Rule's likely effects on competition. On one hand, the Proposed Rule may tend to promote competition by lowering costs to enter the market. A study by the Organisation for Economic Co-operation and Development estimates that space debris adds significant costs to missions through efforts such as satellite protection and debris surveillance.[94] These costs are estimated to be between 5 and 10% of total mission costs for launches into the Geostationary Earth Orbit, and even higher for LEO launches.[95] As the growth of orbital debris slows, these costs to avoid and protect against debris will be lowered, in turn lowering barriers to entry into the market and allowing for a more competitive and innovative marketplace. As the competition guidance notes, "[l]ow barriers to entry may also encourage innovation and improved quality, as firms can more easily introduce new and better types of products to compete against existing offerings or develop new production technologies so that they can produce similar products at a lower cost."[96]

On the other hand, requirements to mitigate orbital debris do impose added costs on operators and make launches more expensive due to disposal efforts and reporting costs.[97] Such added costs may make it more difficult for new firms to enter the space market. Thus, the Proposed Rule's impacts on competition are not overtly clear. FAA should nevertheless follow this guidance and discuss the competitive impacts of the regulation, as the impacted market is unique given the relatively few market actors and rapid recent growth. This analysis need not be quantitative or resource-intensive,[98] but FAA focusing on competitive impacts may "provide insights critical to crafting policy."[99]

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[91] *Id.* at 4.

[92] *Commercial Space Data*, FAA, https://www.faa.gov/data_research/commercial_space_data (last visited Nov. 20, 2023). Operators include Northrop Grumman, SpaceX, Blue Origin, and Rocket Lab, among others. *Id.*

[93] *See, e.g.*, Joe Pappalardo, *Second SpaceX Megarocket Launch Ends with Another Explosion. What Happens Next?*, NAT'L GEOGRAPHIC (Nov. 18, 2023), https://www.nationalgeographic.com/science/article/spacex-starship-rocket-reaches-key-milestone-then-explodes [https://perma.cc/EK4F-75ST].

[94] *See* ORG. FOR ECON. COOP. & DEV., SPACE SUSTAINABILITY: THE ECONOMICS OF SPACE DEBRIS IN PERSPECTIVE 7 (2020), https://read.oecd-ilibrary.org/science-and-technology/space-sustainability_a339de43-en [https://perma.cc/V3UZ-QBHG].

[95] *Id*.

[96] *See* COMPETITION GUIDANCE, *supra* note 90, at 23.

[97] RIA, *supra* note 12, at 44.

[98] *See* COMPETITION GUIDANCE, *supra* note 90, at 2 ("Even when a regulatory analysis cannot estimate important competition effects quantitatively, it should describe any such effects qualitatively.").

[99] *Id.*

Respectfully,

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