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Reply Comments of University Small-Satellite Researchers

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Summary

The record in this proceeding, while filled with diverse and valuable approaches to mitigating orbital debris, overwhelmingly suggests that the Commission should take balanced steps toward ensuring orbital sustainability while urging caution against unnecessarily burdensome and heavy-handed regulation. Most commenters acknowledge a role for the Commission in establishing debris mitigation best practices but assert that that the Commission should regulate within a larger framework of coordinated agency and international actions concerning space traffic management.

Based on the record, the Commission should undertake debris mitigation efforts that account for the diversity of actors utilizing space in order to promulgate reasonable and practical rules that advance U.S. space leadership while reducing the likelihood of catastrophic events in orbit. Among other goals, **the Commission should ensure that any rules it adopts do not unduly burden or preclude university research missions from operating in orbit** because of the vital role they serve in fostering such leadership through cutting edge research as well as scientific training.

First, the Commission should avoid imposing maneuverability or propulsion requirements as much as possible, especially at altitudes below 600 km. Second, clear guidance on compliance methods is needed whenever the Commission adopts quantitative informational disclosure requirements. Third, the Commission should focus on mitigating debris risk by guaranteeing disposal efficacy, including by possibly updating the 25-year disposal timeline. Finally, we identify the support on the record for the Commission's proposed data sharing and trackability requirements and the opposition to blanket data encryption requirements.

Ultimately, the Commission should heed the record by adopting light-handed regulatory approaches. In the event that more heavy-handed regulation is deemed appropriate in certain areas to mitigate harm from increasing launches, the Commission should exempt university researchers as good-faith actors who are responsible only for negligible debris population.

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Discussion

I. The Commission should refrain from imposing propulsion or maneuverability requirements, especially below 600 km and to university research missions.

The *Orbital Debris NPRM* proposes a number of possible propulsion or maneuverability requirements as a means to reduce collision risk and orbital debris accumulation, including informational disclosures related to quantifying collision risk, justifying orbit selection, and describing the extent of a given operation's maneuverability capabilities.[1] The Commission has also asked whether it should require all NGSO satellites that operate above a certain altitude to require propulsion for station-keeping and collision avoidance maneuvers in lieu of requiring collision risk and orbital justification disclosures.[2]

We agree with other commenters that the Commission should not adopt blanket propulsion requirements in lieu of informational disclosures.[3] The record reflects that altitude-triggered blanket propulsion requirements are not necessary for mitigating collision risk and if enacted, would make university missions effectively incapable of operating above those threshold altitudes. Even highly-sophisticated university missions may only have design-to-demise budgets of $300,000, and propulsion technologies—which are still in nascent stages for incorporation on small satellites—may cost upwards of $200,000.[4] Moreover, the volume and power required by propulsion systems reduce capacity to include other elements, all else held constant, potentially rendering a university satellite unable to host a reasonable research payload.

In short, the Commission's proposed informational disclosures are better adapted to mitigating debris risk than blanket propulsion requirements. We agree with Boeing, which "opposes the adoption of a blanket rule that all NGSO satellites that would operate above a certain altitude must have propulsion capabilities," noting that "other techniques have been used (and more are being

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[1] *Orbital Debris NPRM* ¶¶ 26-35, 39.
[2] *Id.* at ¶ 34.
[3] Global New Space Operators Comments at 8; NASA Comments at 3-4.
[4] *See* Researcher Comments at 10.

developed) to permit small satellites to proactively maneuver without the use of propulsion and thus enable collision avoidance."[5]

We also agree that a key method for mitigating collision risks for altitudes above the ISS should focus on functional collision avoidance.[6] As The Aerospace Corporation explains, "a new system should demonstrate that it can avoid a collision as it transits a manned object's altitude without requiring that system to maneuver. If this can be accomplished via drag modification or some similar approach, propulsion may not be necessary."[7] University small satellite missions are increasingly investigating the employment of drag devices as means of collision avoidance, maneuverability, and facilitating deorbit.

Finally, we agree with NASA that propulsion requirements should only be driven with an eye toward meeting the 0.001 lifetime collision risk.[8] Missions that can demonstrate a < 0.001 lifetime collision risk for a given altitude through non-propulsive means should not be required to have propulsion capabilities.[9]

Some commenters have encouraged the Commission to adopt blanket propulsion requirements for altitudes as low as 400 km.[10] We understand these commenters' arguments that uniform propulsion may reduce debris risk, but strongly urge the Commission not to enact any such propulsion requirements. It would be prohibitively expensive for university researchers to comply with such rigid design requirements when informational requirements can also be used to accomplish the same objectives by less restrictive means. Moreover, because emerging technology

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[5] Boeing Comments at 19.
[6] The Aerospace Corporation Comments at 10; WorldVu Comments at 10.
[7] *Id.*
[8] NASA Comments at 4.
[9] *See* NASA Comments at 6; *Orbital Debris NPRM* at ¶ 26; *see also* The Aerospace Corporation Comments at 10 (making a parallel argument to NASA's that the "essence" of propulsion requirements could be backdoored through requiring demonstration of a 0.001 collision risk, which would "place the burden for collision avoidance on systems with large numbers of satellites . . . and for systems in more populated orbits.").
[10] *See* Iridium Comments at 6-7; WorldVu Comments at 14.

may soon render this point moot, and because it may be more hazardous than not to have a large number of Cubesat-class systems with propulsion capabilities in LEO, the Commission should refrain from imposing maneuverability requirements at this time.

Because many university small satellite missions operate at altitudes between 400-600 km, mandating propulsion would effectively preclude these missions from launching. Halting university small satellite missions would cause immense negative consequences for space technology innovation, the future of U.S. space leadership, and the cultivation of the next generation of U.S. space scientists.[11]

Accordingly, should the Commission adopt any altitude-triggered propulsion requirements, it should not do so for altitudes lower than 600 km. Alternatively, the Commission should exempt academic missions from propulsion requirements imposed at altitudes below 600 km. Doing so would be in the public interest, allowing universities to continue innovating with low risk, small budget missions while still mitigating potential debris from higher-risk deployments such as large constellations.

We agree with commenters that the Commission's proposal to require applicants for NGSO satellite authorizations to describe the extent of any maneuverability[12] should exist only as an informational requirement, whereby applicants disclose their systems capabilities pre-license.[13] The Commission should not use this informational requirement as a backdoor for imposing operational requirements like propulsion; that is, maneuverability information should only be used holistically to make sure granting an authorization is in the public interest, and no maneuverability disclosure content, or lack thereof, should be dispositive of authorization. Commenters share our concerns relating to how maneuverability disclosures might be used,[14] but disclosures of a spacecraft's maneuverability capabilities are only problematic if used as a factor for denying authorization to

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[11] *See* Researcher Comments at 10.
[12] *See Orbital Debris NPRM* ¶ 39.
[13] *See* CONFERS Comments at 2.
[14] *See e.g.,* Global New Space Operators Comments at 10; *See* LeoSat Comments at 5.

otherwise safe mission profiles, which instead, should be assessed based on compliance with the 0.001 collision risk rule.[15]

II. The Commission should provide clear guidance on acceptable analytical methods that may be utilized to obtain quantitative informational requirements.

In our initial comments, we stressed that in each case where the Commission requires satellite operators to complete quantitative informational disclosures as part of the application process (e.g., applicants demonstrating probability of collision during lifetime as less than 0.001),[16] it should provide a safe harbor method of compliance.[17] A lack of clear guidance for quantitative informational disclosures creates uncertainty for applicants who cannot be sure that their choice of analytical method will be accepted by the Commission.

The record supports adopting such safe harbors.[18] For example, Boeing stresses that "in each case in which the Commission adopts a new information disclosure requirement, the Commission should concurrently provide guidance regarding its presumptive expectations with respect to the required substance of a disclosure and what would presumptively be acceptable."[19] We discuss several specific instances of proposed informational requirements and their needs for transparent compliance mechanisms below.

A. The Commission should explicitly incorporate the NASA Standard as a safe harbor for calculating collision risk.

The record overwhelmingly supports incorporating clear guidance on acceptable methods of collision risk assessment analysis, specifically supporting directly incorporating the NASA Standard[20]

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[15] *See* NASA Comments at 5-6.
[16] *Orbital Debris NPRM* ¶ 26.
[17] *See* Researchers Comments at 14.
[18] *See* Intelsat Comments at 8-9; *See* Boeing Comments at 7.
[19] *See* Boeing Comments at 7.
[20] *See* NASA Technical Standard, Process for Limiting Orbital Debris, NASA-STD-8719.14A (with Change 1) (May 25, 2012) (*NASA Standard*), http://www.hq.nasa.gov/office/codeq/doctree/871914.pdf.

into the Commission's rules.[21] By providing clear guidance on the analytical methods that will be accepted under any collision risk assessment requirements, the Commission can ensure that operators are being evaluated based on similar criteria, thereby ensuring fair processing and effective debris mitigation analysis.

The record further indicates that if the Commission requires collision risk assessments, it should do so on an individual satellite basis rather than in the aggregate.[22] Specifically, NASA does not recommend applying collision risk assessment in an aggregate manner for constellations.[23] In contrast, it is clear that powerful industry actors, planning large constellations of their own, do not want to take the extra time and care to conduct risk assessments on each satellite that they launch on an individual basis.[24] The Commission should favor the practical orbital sustainability benefits of individual satellite risk assessments over commercial convenience.

Moreover, there is ample support on the record in favor of the Commission deferring multi-satellite deployment risk assessments to multi-satellite consolidators or the proper regulatory agency—in this case, the FAA—as the appropriate entities to conduct/requires such analysis.[25]

B. The Commission should consistently establish clear guidance on quantitative information requirements, including design reliability.

There is nearly unanimous consensus on the record opposing strict design reliability requirements because such requirements would be "difficult to implement in practice" and nearly impossible to enforce.[26] Commenters suggest having applicants describe their overall approach to achieving reliability by providing technical and design information instead of imposing quantitative

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[21] *See* ORBCOMM Comments at 7; LeoSat Comments at 3; *See* NASA Comments at 3; *See* Intelsat Comments at 8-9.
[22] *See* NASA Comments at 7; LeoSat Comments at 3.
[23] *See* NASA Comments at 7.
[24] *See* SpaceX Comments at 15-16*;* WorldVu Comments at 16-17.
[25] *See* ORBCOMM Comments at 15-16; *See* Global New Space Operators Comments at 10-11.
[26] *See* WorldVu Comments at 9-10; SpaceX Comments at 10; SeriusXM Comments at 5; AMSAT Comments at 3; *See* ORBCOMM Comments at 17; NASA Comments at 6; *See* Iridium Comments at 4-5; *ee* Global New Space Operators Comments at 12; LeoSat Comments at 5.

requirements.[27] University researchers support this approach and echo SpaceX's request that any requirements remain technologically neutral to promote innovation and investment.[28]

C. The Commission should not impose quantitative informational requirements related to disposal reliability until the record can support them.

Similar to collision risk and design reliability, commenters consistently urge the Commission not to adopt any stringent requirements with quantitative metrics without providing clear guidance on how to achieve them.[29] However, the record does support adopting requirements for disposal reliability that have "sufficient foundation" to support them.[30] We support this approach, but neither the record nor the NPRM propose any method of determining disposal reliability. Therefore, the Commission should defer action on establishing quantitative informational requirements for disposal reliability until a further proceeding can generate a record sufficient to support such requirements.

III. The Commission should adopt disposal and end of life requirements that mitigate orbital debris while maintaining operational flexibility.

We agree with many commenters that the Commission should emphasize debris mitigation efforts that look to guaranteeing disposal efficacy.[31] Satellite operators should engineer their systems with the expectation that re-entry will be the only appropriate means of disposal and the Commission should regulate in a way that encourages and facilitates efficient, safe, and effective disposal. The record supports a number of Commission initiatives for guaranteeing effective

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[27] *See* Iridium Comments at 4-5; Global New Space Operators Comments at 12.
[28] *See* SpaceX Comments at 10.
[29] *See* ORBCOMM Comments at 17-18; Lockheed Martin Comments at 14-15; *See* NASA Comments at 6; *See* Global New Space Operators Comments at 11-12.
[30] *See* ORBCOMM Comments at 17-18.
[31] *See* CSSMA comments at 2; The Aerospace Corporation Comments at 13 ("[T]he probability of success for the disposal of an object at the end of its orbital life is the most critical aspect that should be considered in a rulemaking to prevent space debris. Implementing such a rule would, particularly for large constellations, accomplish the intent of many of the additional rules being proposed.").

disposal. These include requiring re-entry for all satellites (disallowing "junk" or "parking orbits),[32] having applicants demonstrate the probability of success of disposal method (with established and transparent mechanisms for compliance),[33] and having the Commission further investigate whether modernizing the 25-year disposal guideline (without requiring propulsion) will promote debris mitigation and encourage space sustainability.[34] However, in its efforts to facilitate effective post-mission disposals, the record indicates that the Commission should refrain from requiring automated disposals in the event of power or contact loss.[35]

A. It may be time to update the 25-year disposal requirement, but the record does not contain clear analysis identifying the risks of the current requirement.

The record suggests that the current 25-year disposal requirement should be updated given the volume of launches occurring in the New Space Age. However, it provides no clear analysis supporting specific revisions to the requirement or demonstrating that the existing requirement should not remain intact.

The Commission should regulate disposal requirements in a way that facilitates active removal of spacecraft from orbit at the end of their useful lives, and in accordance, should conduct a detailed analysis of whether the 25-year disposal timeline should be modernized. Without specific justification, it is irresponsible in today's space environment for short-lived satellite operations to remain in orbit for decades.

However, it would be equally irresponsible for the Commission to modify existing disposal timelines without clearly identifying the current 25-year framework's shortcomings and targeting appropriate solutions. While all satellite operators should have an onus to deorbit in as short a timeline as is reasonably feasible, the Commission should tailor future updates to its disposal

[32] *See Orbital Debris NPRM* ¶ 52.
[33] *See Orbital Debris NPRM* ¶ 46.
[34] *See Orbital Debris NPRM* ¶ 58-59.
[35] *Id.* at ¶ 49.

timeline requirements based on the unique risks posed by disparate mission types, altitudes, and other orbital characteristics.

In response to the Commission's request for comment on whether the 25-year disposal guideline contained in the NASA Standard remains a relevant benchmark,[36] commenters have suggested a large variety of possible updates.[37] Among these, the record points substantially in the direction of the Commission modernizing its 25-year one-size-fits-all benchmark, recognizing the impetus for more efficient disposal as a key factor in mitigating debris risk in the New Space Age.

While we originally suggested the Commission might adopt a disposal timeline proportional to mission life, leaving the constant of proportionality unspecified,[38] we do not believe that a proportional disposal timeline is the best or only option for updating the 25-year benchmark. The Commission should use its expertise in selecting a new set of disposal timeline rules that encourages reliable, safe, and efficient disposals, while not unduly restricting operator flexibility. To strike this balance, the Commission should first conduct rigorous analyses of the risks associated with upholding the 25-year disposal requirement. Then, if the Commission clearly identifies shortcomings with the existing 25-year framework, it should identify methods of modernizing disposal timelines that effectively facilitate removal from orbit while avoiding unnecessary regulatory burdens or costs to operators.

To illustrate this approach, if the Commission were to adopt stricter disposal timelines without analytical justification—for example, a proportional disposal timeline capped at twice the mission

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[36] *See Orbital Debris NPRM* ¶ 58-59.

[37] *See* WorldVu Comments at 21-22 (generally supporting a proportional disposal timeline where disposal occurs within 2x the operating mission life); SpaceX Comments at 6 (disposal time allowance is mission lifetime + 5 years); Maxar Comments at 13 (supports requiring disposal within 5 years of completion of mission life); Iridium Comments at 8-9 (disposal timeline "measured as a function of the design life of the licensed satellite system"); Boeing Comments at 17 (25-year disposal period remains for satellites operating below ISS altitudes, satellites operating above ISS presumed to require deorbits within 15 years post-mission absent justification).

[38] *See* Researchers Comments at 12-13.

life[39]—it could unduly burden academic small satellites and other operators with short mission lives to no practical advantage. Such disposal guidelines should be based on the results of clear analysis with sensitivity studies, and to the extent possible, accompanied with exemptions for academic research missions in LEO—usually below 600 km—to allow university satellites sufficient time to naturally or passively deorbit.[40]

Some commenters do not see a need to update the 25-year benchmark.[41] We agree with these comments to the extent that updates are not based on the clear results of rigorous analysis indicating that such updates necessary and appropriate measures for addressing specific risks. For instance, CSSMA opposes updating disposal timelines, concerned that compliance pressures could hurt businesses who have designed their systems in accordance with the 25-year requirement.[42] We recognize this concern and encourage the Commission, should it update its disposal guidelines, to allow operators to flexibly comply in the short term. However, keeping the 25-year period stagnant may not contribute toward mitigating debris risk and may actually under-incentivize operators from designing for more efficient deorbits.

We support CSSMA's ideas for assuaging any compliance pressures relating to future change in disposal guidelines. For example, upon the issuance of new disposal guidelines, existing systems could be grandfathered under the 25-year benchmark.[43] Moreover, new disposal requirements would not have to take effect immediately. A delay in implementing new disposal requirements for a period of years post-R&O could allow operators sufficient time to design newly-launched systems for expedited disposals. A series of selective waivers could also ease transition difficulties for businesses.

Still, it is not clear from the record whether and how the Commission should update the 25-year disposal requirement at this time. Thus, we urge the Commission to conduct more rigorous analysis of the risks factors present in maintaining the 25 year disposal requirement and to move forward

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[39] *See Orbital Debris NPRM* ¶ 32; WorldVu Comments at 21-22; IntelSat Comments at 6.
[40] *See* Researchers Comments at 13.
[41] *See* ORBCOMM Comments at 12-13; *see* NASA Comments at 4; CSSMA Comments at 16-17.
[42] CSSMA Comments at 16-17.
[43] *Id.*

with proposals that specifically address these risks without unduly imposing unnecessary burdens on the entire satellite community.

B. The record supports the Commission requiring post-mission disposal through atmospheric re-entry alone.

The record supports the Commission requiring post-mission disposal to be accomplished through atmospheric re-entry alone. Even for missions above LEO, as SatDFR notes, "[i]t is becoming increasingly clear that there are no safe disposal orbits. They are only temporary solutions to the overall debris problem."[44] All missions, even those at high altitudes, should eventually be disposed of through reentry. [45] The Commission should investigate how to safely facilitate deorbits of high-altitude missions, possibly by requiring propulsion capabilities for missions above LEO, and by further identifying low-risk options for "unstable orbits" that can take advantage of gravitational or solar force to prompt eventual reentry.[46]

Additionally, while operators can and should be encouraged to design their satellites to facilitate direct retrieval, retrieval is not currently economical and "operators should not be permitted to substitute retrieval in lieu of an effective PMD [post-mission disposal] plan using the satellite's onboard systems."[47] However, commenters do note that while direct retrieval is not currently feasible, it may be in the near future.[48] Some operators are already making express efforts by designing their systems to facilitate direct retrieval.[49] There are clearly major advances being made in direct retrieval technologies and the Commission should keep these in mind in promulgating future rules. However, until direct retrieval becomes an efficient and safe disposal method on par with

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[44] SatDFR Comments at 3.
[45] *See Orbital Debris NPRM* ¶ 56.
[46] *Id.*
[47] SatDFR Comments at 2.
[48] Telesat Canada Comments at 7.
[49] WorldVu Comments at 27 (For instance, OneWeb intends to include "grappling fixture and fiducial" on every NGSO spacecraft "to facilitate capture.").

atmospheric reentry, the record supports the Commission conditioning authorization on reliable reentry plans from operators.

C. The record does not support requiring automatic de-orbit as a result of power loss.

The record strongly rejects imposing automatically initiated disposal as a result of power failure at this time.[50] Although many commenters urge the Commission not to adopt such disposal requirements at all, we agree with ORBCOMM and Lockheed Martin that the current record is merely insufficient to support such specific hard requirements.[51] As WorldVu acknowledges, requiring automatic de-orbit of certain non-operational satellites may even increase collision risks.[52] Although such regulation may prove effective and warranted sometime in the future, it is not clear that requiring the ability to automatically de-orbit will provide practical benefits to a degree that sufficiently warrants shutting operators such as university researchers out of orbit because they are unable to integrate maneuverability systems into their spacecraft.

We are not necessarily opposed to automatic de-orbit requirements if the Commission can show sufficient need for the requirement and rigorous analysis of externalities, showing that the benefits outweigh the costs—or develops a record on the availability of novel disposal systems. Because the Commission and the record here have not demonstrated this, the issue of automatic de-orbit should be addressed in further proceedings. Should the Commission make the above showing in the future, we urge it to ensure that any requirements are technology neutral and allow for enough flexibility for university researchers to comply, such as allowing drag systems over mandating propulsion systems as the de-orbit mechanism.

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[50] *See* ORBCOMM comments at 17-18; *see* Lockheed Martin comments at 14; *see* Global New Space Operators comments at 6-8 & 13; *see* WolrdVu comments at 20-21.
[51] *See id.*
[52] *See* WorldVu at 20-21.

IV. The record supports the Commission mitigating debris risk through the use of data sharing and functional trackability requirements.

The Commission has proposed a number of data sharing requirements as debris mitigation tools. Among these, the Commission proposes requiring NGSO operators to disclose information to the Air Force 18th Space Control Squadron,[53] that operators coordinate in the event of conjunction warnings,[54] and that NGSO ephemeris data be maintained and shared with operators of nearby systems.[55] The record indicates, and we agree, that these data sharing initiatives are useful tools for mitigating debris and collision risks.

We agree with commenters that ephemeris data and other information should be provided to the Air Force 18th Space Control Squadron.[56] We also agree with numerous commenters on the record that the Commission could require ephemeris data sharing between nearby operators.[57] We do note, however, that ephemeris data sharing, both to the government and to nearby operators that may pose collision risks, is often an industry and business best practice,[58] and that voluntary sharing between operators may be effective in the absence of regulatory mandates.[59] We agree with commenters who support requiring NGSO operator coordination upon issuance of conjunction warnings.[60]

We also agree with the record, which indicates that the Commission should use satellite trackability as a debris mitigation tool, but that it should do so by imposing technology-neutral and functional requirements. In our original comments, we noted that the Commission's proposal of requiring a "unique telemetry marker"[61] was underspecified and unclear.[62] Given the "number of

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[53] *See Orbital Debris NPRM* ¶ 37.
[54] *Id.* at ¶ 38.
[55] *Id.* at ¶ 73.
[56] *See e.g.,* WorldVu Comments at 7; *See* LeoSat Comments at 9.
[57] *See e.g.,* ORBCOMM Comments at 8; IntelSat Comments at 6.
[58] *See* CSSMA comments at 11.
[59] *See* Lockheed Martin Comments at 10-11.
[60] *See e.g.,* Boeing Comments at 22; LeoSat Comments at 4.
[61] *See Orbital Debris NPRM* at ¶ 36.
[62] *See* "Researchers Comments" at 11.

variables and the changing tracking capabilities" dependent on tracking technology utilized and the size of satellite tracked, the Commission should adopt a general functional requirement that satellites be trackable rather than imposing mandates requiring uniform installation of certain hardware.[63] We concur with the Secure World Foundation, which notes that no tracking or identification aids have "reached the level of technological maturity or cost effectiveness to warrant widespread standardization."[64] Finally, we agree with commenters who support the presumption that satellites 10 cm x 10 cm x 10 cm or larger are trackable.[65]

V. The record does not support requiring encrypted TT&C links for non-propulsed satellites.

The Commission asks whether it should require encryption for telemetry, tracking, and command communications for satellites with propulsion capabilities, or if it should impose a blanket encryption requirement on all satellites.[66] While we recognize the potential risks associated with lack of TT&C encryption (even for non-propulsed satellites[67]), we agree with the record that should the Commission adopt encryption requirements at all, it should only do so by targeting propulsed missions, which pose greater risks to the space environment if hijacked. However, as the Commission already recognizes, "most satellites do operate with secure encrypted communications links, and all operators have an interest in securing against unauthorized actors interfering."[68]

Boeing notes that Commission encryption requirements would be duplicative of industry norms, best practices, and market pressures, arguing "the Commission should conclude that satellite

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[63] *See* The Aerospace Corporation Comments at 11.
[64] *See* Secure World Foundation Comments at 4.
[65] *See Orbital Debris NPRM* ¶ 36. *See, e.g.,* NASA Comments at 5; Iridium Comments at 7.
[66] *See Orbital Debris NPRM* ¶ 75.
[67] Hijacking efforts by bad actors would be particularly concerning in cases where a satellite can be actively maneuvered. However, we recognize the potential for harm even for non-propulsed satellites, such as university CubeSats. A hijacked CubeSat might still cause damage using atmospheric drag and a loss of operator control could damage or redner unusable government sponsored university research projects.
[68] *Orbital Debris NPRM* ¶ 74.

operators have adequate incentive to encrypt their control communications."[69] While other commenters are opposed to any federal encryption requirements,[70] many commenters who do support encryption requirements only do so for narrowly-tailored contexts.[71]

Furthermore, many commenters on the record note that flexibility of encryption (or non-encryption) should be allowed for certain classes of operators. We agree with Lockheed Martin, which suggests limiting TT&C encryption requirements to propulsed missions, in order "to avoid unduly limiting university-sponsored and similar projects involving cubesats."[72] The Commission notes that for cubesats or other small satellites (particularly those "operated for academic purposes"), developers "may have concluded that the costs or time associated with implementing encryption of [TT&C] outweigh the potential risks."[73] Similarly, the ARRL strongly urges the Commission to only apply encryption requirements to propulsed systems.[74] They note that "[T]he amateur satellite service has historically relied upon broad-based reporting of its onboard telemetry for both operational and educational purposes," and that freely "decoding the satellite telemetry signals has been an important component of educational programs that use AMSAT's satellites for teaching purposes."[75]

Instead of enacting TT&C encryption requirements at this time, the Commission could focus on encouraging best practices for satellite cybersecurity, and eventually consider conditioning

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[69] Boeing Comments at 37.
[70] *See, e.g.,* Intelsat Comments at 11.
[71] *See* Viasat Comments at 6 (encryption requirements must be "narrowly tailored to target risks relating to orbital debris"); LeoSat Comments at 8 (supports encryption requirements only for propulsed satellites); Eutelsat Comments at 7-11 (Encryption requirements should only codify best practices, be limited to command signals only, and should not apply to satellites already in orbit, under construction, or even at the design procurement stage).
[72] Lockheed Martin Comments at 17.
[73] *Orbital Debris NPRM* ¶ 74.
[74] ARRL Comments at 5.
[75] *Id.*

authorizations on operators following cybersecurity best practices.[76] However, should the Commission choose to enact TT&C encryption rules at this time, the record suggests that it should narrowly tailor these requirements to high-risk systems, such as those with propulsive capabilities.

[76] *See* Comments of Charles Clancy and Jonathan Black at 2. Clancy and Black recommend the creation of a federally-funded standing group composed of academic and corporate stakeholders. This group would "analyze, evaluate, establish, publish, and refine best-practices" for satellite cybersecurity, with different best-practices established for different "spacecraft stakeholder communities." The commenters suggest that "The Commission should tie spectrum licenses for satellites to submission and approval of cybersecurity management plans consistent with the established best practices."