Federal Communications Commission

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Comments of the Secure World Foundation

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Statement of Interest

The mission of the Secure World Foundation is to work with academia, governments, industry, international organizations, and civil society to develop and promote ideas and actions to achieve the secure, sustainable, and peaceful uses of outer space benefiting Earth and all its peoples.

As the only organization devoted entirely to space sustainability, the Secure World Foundation strives to be a trusted and objective source of leadership and information on space security, sustainability, and the use of space for benefits on Earth. We use a global and pragmatic lens to study and evaluate proposed solutions to improve the governance of outer space. While recognizing the complexities of the international political environment, SWF works to encourage and build relationships with all willing stakeholders in space activities, including government, commercial, military, civil society, and academic actors. Central to this approach is increasing knowledge about the space environment and the need to maintain its stability, promoting international cooperation and dialogue, and helping all space actors realize the benefits that space technologies and capabilities can provide.

We are very pleased to see the FCC provide such a thorough analysis of the Commission's existing orbital debris mitigation framework and concrete proposals for improving the situation. Orbital debris mitigation is a critical part of space sustainability, and we have been working on various aspects of it for nearly a decade. We have organized many panel discussions and workshops to discuss best practices for orbital debris mitigation during all phases of spaceflight, as well as improving data sharing for space situational awareness (SSA). We have also conducted and published research on the legal, policy, and economic aspects of debris mitigation and active debris removal (ADR) and potential future regimes for space traffic management (STM). Our work has involved stakeholders from the United States and other governments around the world, as well as academia and industry.

Based on this work, we offer the following public comments on selected items from the NPRM, organized by paragraph.

Comments on Specific Items

Para 17: "We do seek comment, however, on whether there are any areas in which proposed requirements may overlap with requirements that are clearly within the authority of other agencies, so that we may seek to avoid duplicative activities."

We believe strongly that the United States should set the example as a global leader in implementing orbital debris mitigation practices in its national licensing and oversight of commercial space activities. We feel that at the moment it is appropriate for the FCC to continue to include orbital debris mitigation requirements in its licensing of satellite systems as it has the broadest reach of any of the existing U.S. regulatory agencies for space. Without the FCC playing this role there would likely be multiple U.S. private sector entities conducting space activities that are not adequately covered by other U.S. regulatory authorities. That could result in a situation where U.S. private sector entities are conducting space activities without proper oversight or those private sector activities never happen because there is no enabling regulatory authority. The FCC also plays a strong role in ensuring foreign satellite operators who seek U.S. market access must abide by orbital debris mitigation practices, even if their home country does not have the same enforcement criteria.

Looking forward, we do think the U.S. government should re-examine the existing authorities for implementing orbital debris mitigation to improve their consistency, efficiency, and efficacy. It would likely be beneficial to centralize the authority for implementing orbital debris mitigation requirements in one agency. However, we feel that it would be best if such authority was given to an agency that also gains authority and responsibility for the civil space situational awareness (SSA) mission as the two missions areas are complementary. Having greater institutional insight into the space environment and activities in space will inform how said agency approaches the development of orbital debris mitigation requirements and allow for enforcement of any licensing requirements.

We also believe that the same agency should be given authority and mission to manage the physical space environment (radiofrequency management should remain within the purview of FCC). This would not only reinforce the orbital debris mitigation and civil SSA responsibilities, but also enable that agency to take a leadership role in developing (or encouraging development of) and possibly implementing active debris removal (ADR) technologies which the United States has so far largely neglected.

Para 30: "...we propose that the applicant provide information about any operational constraints caused to the ISS or other inhabitable spacecraft and strategies used to avoid collision with manned spacecraft"

We note that in the near future it is very likely that the International Space Station will not be the only human-occupied spacecraft on orbit. The People's Republic of China is planning on launching their Tiangong-3 space station in the next few years, and there are multiple U.S. commercial entities that are planning to develop private or government-funded space stations within the next decade.

Regardless of whether, or when, all these plans come to fruition, orbital debris mitigation requirements and standards as a whole need to be reshaped to take these developments into account. That should include dealing with multiple space stations that are at different altitudes, have different processes and practices for emergency maneuvering, are each independently launching their own cubesats, and have different levels of protection against orbital debris hazards.

Para 37: "We seek comment on whether we should adopt an operational rule requiring NGSO satellite operators to provide certain information to the 18th Space Control Squadron or any successor civilian entity, including, for example information regarding initial deployment, ephemeris, and any planned maneuvers."

While we applaud the U.S. military's role since the 2009 Iridium-Cosmos collision in helping prevent additional on-orbit collisions, they are not the only entity that provides such a service. Other countries have, or are developing, their own capabilities, and there are private sector organizations such as the Space Data Association that augment government SSA services.

We do think that there should be a requirement for NGSO satellite operators to provide basic information on initial deployment, ephemeris, and any planned maneuvers to a SSA entity but believe there should be more flexibility in who that entity is, or entities are. Recent launches such as that of SSO-A have shown a need for greater data sharing and collaboration between satellite operators, launch operators, and SSA operators to help identify and catalog small satellites that are launched in significant numbers.

Related to this, we also believe there needs to be a more orchestrated effort for research and development of tracking and identification aids for satellites. Of these, identification aids that help distinguish one satellite from another, particularly early after payload separation and when multiple small payloads are released on the same launch, are the most important to prioritize. Several proposals and technologies exist, but none have reached the level of technological maturity or cost effectiveness to warrant widespread use and standardization. In addition, there needs to be input from the civil SSA and regulatory agencies on what types of tracking and identification aids would be most beneficial in enhancing safety of spaceflight.

Para 54: "We seek comment on the status of these and other technologies for spacecraft direct retrieval, including potential future commercial applications. Are there any aids to future use of direct retrieval, such as spacecraft reflective markers or attachment points, that could be adopted now or in the near future?"

Direct spacecraft retrieval concepts are closely related to a larger set of nascent capabilities more commonly referred to as active debris removal (ADR). Although the 2010 National Space Policy directed the Department of Defense and National Aeronautics and Space Administration to jointly develop ADR technology, very little has been done by either organization in the years since. We believe this is primarily due to neither organization having management of the space environment in their mission statement, and

thus a lack of incentive to prioritize it relative to their other activities.[1] We would urge the U.S. government to remedy this situation by assigning such responsibility to one agency, ideally in conjunction with responsibility for orbital debris mitigation and civil SSA.

We believe that a program modeled after NASA's very successful Commercial Cargo and Crew Program would be the best way to incentivize development of ADR capabilities. The program would involve a government agency holding a phased competition for multiple commercial entities to develop ADR capabilities, which the U.S. government or other entities would then purchase as a service.

In addition, we believe that the biggest hurdle to developing ADR capabilities is not the technology, but rather the legal and policy questions. Significant work needs to be put into answering legal questions related to jurisdiction and control of un-identified space debris objects, liability, and export control. The U.S. government should develop a positive licensing framework for enabling commercial ADR and satellite servicing activities and work with industry to develop transparency mechanisms to be able to distinguish these commercial activities from similar military or national security space activities.

We also note that there are early stage efforts underway within industry groups (e.g. CONFERS - see comments under Para 68, below) to develop standards and best practices related to rendezvous and proximity operations, satellite end-of-life services, and ADR. Any regulatory efforts related to these technical areas should be designed to consider the role of industry standards.

Para 59: "Consistent with these shorter mission lifetimes, as well as the number of satellites planned for deployment, we ask whether the 25-year disposal guideline contained in the NASA Standard remains a relevant benchmark. That is, does the guideline that a spacecraft reenter the atmosphere no more than 25 years after the completion of the spacecraft's mission permit spacecraft designs that result in a longer disposal period than may be in the public interest for a particular satellite mission?"

Our engagement and discussions with the scientific community studying orbital debris indicate there's a general consensus that the 25-year rule is no longer adequate, but no consensus exists on how it should be changed. We believe that, in general, a "one size fits all" approach is not appropriate. It is likely that the re-entry requirements should be modified to take into account both the designed lifetime of the satellite and the orbital regime it will be in. For example, it does not make sense for a cubesat with a six-month expected lifespan to remain on orbit for 25 years. Similarly, large payloads placed into highly-congested Sun-synchronous or geostationary Earth orbits should be removed from those regions as soon as possible after end-of-life.

[1] Weeden, B., "The Evolution of U.S. National Policy for Addressing the Threat of Space Debris," 67th International Astronautical Congress, Guadalajara, Mexico, September 2016, https://swfound.org/media/205624/iac-16a683-weeden_evolution_us_space-debris_policy-paper.pdf.

While it is important for the United States to work with the international community in developing and promoting orbital debris mitigation standards, we do not believe the U.S. should wait for there to be international consensus on a new standard before changing the U.S. national requirements.

An important part of revamping the 25-year rule is developing the means to verify compliance with the requirement. Compliance with the existing 25-year rule is estimated to be around 40-60%, depending on the type of object and orbital region.[2] Meanwhile, studies on the potential impact of new large satellite constellations show that 100% compliance will be necessary to avoid significant future growth in the orbital debris population.[3]

Another critical part of limiting orbital lifetimes or requiring post-mission disposal is the ability to monitor whether or not a licensee has complied with those requirements. SSA provides critical data and analytical tools to do this monitoring, but currently those capabilities are housed in the U.S. military, which does not have any regulatory authority over private sector space activities, and the agencies with regulatory authority don't have easy access to the SSA data. Thus, we believe that it is important to combine regulatory authority for orbital debris mitigation with civil SSA authority and capabilities to enable the monitoring of private sector end-of-life practices and ensure compliance with any license requirement.

Para 68: "We propose that applicants be required to disclose whether the spacecraft is capable of, or will be, performing any space rendezvous or proximity operations. The statement would indicate whether the satellite will be intentionally located or maneuvering near another spacecraft or other large object in space. We also seek comment on whether the proposed notification requirement regarding maneuvers, described above, is sufficient in the context of proximity operations, or whether the rules should include anything more specific regarding information sharing about proximity operations with the Air Force's 18th Space Control Squadron or any successor civilian entity."

SWF is part of the Secretariat for the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), an industry-led initiative with initial seed funding provided by the Defense Advanced Research Projects Agency (DARPA) that aims to leverage best practices from government and industry to research, develop, and publish non-binding, consensus-derived technical and operations standards for on-orbit servicing (OOS) and rendezvous and proximity operations (RPO).

[2] European Space Agency Space Debris Office, "ESA's Annual Space Environment Report," Darmstadt, Germany, May 2018, https://www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf.
[3] Virgili et al., "Risk to space sustainability from large constellations of satellites," *Acta Astronautica*, vol. 126, 2016, pp. 154-162. *Science Direct*, https://doi.org/10.1016/j.actaastro.2016.03.034.

While we do not speak for our Consortium members, we would point out that CONFERS has recently published a set of Guiding Principles for Commercial RPO and OOS[4] and Recommended Design and Operating Practices.[5] The principles highlight the importance of transparency and state the following:

- In keeping with Article XI of the OST, the parties conducting the servicing operation will notify the relevant State(s) of the general nature, conduct, locations, and results of servicing operations.
- In keeping with Article IX and Article XI of the OST, the parties conducting the servicing operation will ensure sufficient communication and coordination with entities that could reasonably be affected by the servicing operation to support safety and avoid harmful interference.
- The parties conducting the servicing operation will develop and implement a protocol that provides timely public notification of anomalies or mishaps that could have an adverse impact on other entities or the space environment.
- Parties conducting servicing operations will look for opportunities to share lessons learned from operational successes and anomalies while protecting intellectual property and competition-sensitive information, and complying with export control regulations.

The practices further state that entities conducting commercial satellite servicing activities should notify affected third parties in advance of any close approaches and exchange information to support safety of spaceflight (e.g. operator points-of-contact, ephemerides, ability to maneuver, and maneuver plans) while respecting owner/operator intellectual property and proprietary information.

Para 75: "We seek comment on whether to include any provisions in our rules concerning encryption for telemetry, tracking, and command communications for satellites with propulsion capabilities, and propose to add a requirement to our operational rules."

It is extremely unlikely a satellite could be hijacked and commanded to collide with another satellite. Unless a satellite is equipped with on-board rendezvous and proximity operations sensors and capabilities, it is almost impossible to deliberately engineer a collision using third-party SSA tracking data. It is more likely an attacker would try and hijack command and control of a satellite to interfere with or damage its operational capability, such as by attempting to point optics into the Sun.

Thus, it is prudent to encourage satellite operators to consider encryption and authentication, which are two distinct and important requirements, of all command and control channels to forestall such attempts.

[4] Consortium for Execution of Rendezvous and Servicing Operations, "Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS)," November 2018, https://www.satelliteconfers.org/wp-content/uploads/2018/11/CONFERS-Guiding-Principles_7Nov18.pdf.
[5] Consortium for Execution of Rendezvous and Servicing Operations, "CONFERS Recommended Design and Operational Practices," February 2019, https://www.satelliteconfers.org/wp-content/uploads/2019/02/CONFERS-Operating-Practices-Approved-1-Feb-2019-003.pdf.

Para 80: "Related to liability, we also seek comment generally on the costs and benefits of insurance as an economic incentive for orbital debris mitigation... We seek comment on how insurance might serve as an economic incentive by incentivizing operators to adopt debris mitigation strategies that reduce risk and lower insurance premiums. How might this impact the amount of insurance that might be required? Could insurance requirements in fact encourage industry to be licensed by or launch from the United States rather than other countries?"

Our work in this area suggests that insurance is unlikely to play a strong role in incentivizing behavior at this time. In January 2018, SWF organized a workshop with the Stimson Center to explore this question of insurance incentivizing good behavior among satellite operators. Approximately 30 participants from space insurers, underwriters, satellite operators, and other related industries participated in this not-for-attribution event.[6] Among the findings of the event was that competition among space insurers is very fierce and can lead to price undercutting. In this competitive environment, rewarding good behavior, or penalizing bad behavior, with differentiated pricing is impossible due to the "race to the bottom" in pricing of insurance. Essentially, there is too much supply and not enough demand for insurers. In the future, with more companies operating more satellites, this dynamic may shift, but for now, insurance pricing is not a good motivator of behavior. Furthermore, a relatively low share of U.S. operators currently purchase on-orbit liability insurance.

In addition, insurance tends to be a lagging indicator that responds to historical trends and risks rather than anticipating future risks. With the high degree of change in the space domain, it is unlikely that historical risks will remain the same in the future, but it is even more unlikely those future risks can be predicted with enough accuracy to warrant changes in insurance pricing.

Para 81: "We further invite comment generally on what economic approaches might be feasible and effective in creating incentives such that appropriate launch vehicle and satellite design choices are made, and appropriate decisions regarding the number of satellites launched are made as well. That is, recognizing debris creation as a negative externality, what approaches might induce private decisions on these design and launch choices to be consistent with the public interest in limiting the growth of orbital debris? Would, for example, a bond requirement, similar to our performance bond for satellite deployment but applied with respect to successful completion of end of life disposal, provide such an incentive?"

While we believe market forces and incentives should play a significant role in public policy, we believe there are limits to the role that economic incentives can play in dealing with the orbital debris challenge. The vast majority of existing orbital debris was created by governments over the last several decades, not private sector entities, and the most highly-congested region of orbit (700 to 900 kilometers) is still primarily used by governments for public services such as weather forecasting, environmental monitoring, and national security. The largest source of future debris is likely to be collisions between large spent rocket stages from government launches in decades past. It is thus unlikely that economic incentives will have a major impact on orbital debris in that region for the foreseeable future.

[6] Secure World Foundation, "Insurance and Responsible Behavior in Space Event Report," Washington, DC, USA, January 2018, https://swfound.org/media/206112/2018_stimson_swf_insurance_event_report.pdf.

Economic incentives are likely a useful tool for encouraging responsible private sector behavior in the future, and thus reducing the creation of or motivating the removal of future orbital debris, but are unlikely to be a useful tool to fund cleanup of existing orbital debris. We believe that removal of the existing orbital debris will need to be funded by governments as they are the primary source of current orbital debris. We believe a government-supported technology development program, coupled with government purchase of service contracts, is the best way to develop this capability.

Para 82. "We are also proposing to amend our rules governing experimental satellite and amateur satellite authorizations to maintain consistency with the proposed revisions to the orbital debris mitigation plan application requirements in our commercials rules."

In addition to the 2013 FCC document *Guidance on Obtaining Licences for Small Satellites*, the Commission has done much to encourage the development of what is often referred to as the CubeSat Revolution. Yet, as was seen in the process of the 2018 NPRM on *Streamlining Licensing Procedures for Small Satellites*, there was also significant confusion within the university CubeSat community about the repercussions of that NPRM. News reports[7] and formal comments to the Commission[8] belied a misconception that the Commission was seeking to extract rents from the experimental and amateur satellite authorizations. In light of those previous challenges, we exhort the Commission to further clarify the intent and actual impact this proposed rule change on the experimental and amateur satellite communities.

Para 85: "We generally propose that the new and amended rules discussed in this NPRM should be applicable to non-U.S.-licensed satellites seeking access to the U.S. market. In other words, an entity seeking access to the U.S. market must continue to submit the same technical information concerning the satellite involved as is required to be submitted by U.S. satellite license applicants. We seek comment on this proposal. Relating to the above discussion regarding liability, we seek comment on these issues with respect to non-U.S. licensees, for example, where the applicant is substantially U.S.-based and the foreign licensing administration has not committed to registering the satellite with the United Nations as that administration's space object."

We strongly agree that non-U.S. licensed satellites seeking access to the U.S. market should be required to comply with the same orbital debris mitigation requirements as U.S.-licensed satellites. We believe this is an important mechanism for U.S. leadership in promulgation of orbital debris mitigation standards and encouraging responsible behavior in space. Moreover, it will help offset the potential incentives for companies to base their operations in foreign countries to take advantage of more lax orbital debris requirements or oversight.

[7] Straub, J., " New federal policy would hike student spacecraft costs, threatening technology education," *The Conversation*, May 2018, https://theconversation.com/new-federal-policy-would-hike-student-spacecraft-costs-threatening-technology-education-96388.

[8] Reid, B., "Comments of University Small-Satellite Researchers," https://www.fcc.gov/ecfs/filing/107091398724499.

Para 91: "We seek comment on six approaches to reducing debris in orbit, which include the proposals discussed in the individual rule sections above (fewer launches, changes in satellite design, changes in operations and disposal procedures, use of economic incentives, active collision avoidance, and active debris removal)."

We believe that addressing orbital debris and the long-term sustainability of space will require a basket of multiple approaches. There is no silver-bullet solution. Changes in satellite design, operations and disposal procedures, and economic incentives should all be considered as part of strengthening orbital debris mitigation requirements and enforcement to mitigate the generation of future debris from human space activities. Additionally, ensuring better post-mission disposal (PMD) through design and procedures represents the best opportunity for reducing the future growth of the space debris population from new launches. But even with strong PMD, active debris removal or just-in-time collision avoidance of existing large debris objects will be required to prevent debris-on-debris collisions that will generate thousands of new pieces of debris. Active collision avoidance, as part of an overall space traffic management system, will be necessary to mitigate the impact of orbital debris to satellite operations.

However, it is difficult at this point to say what exactly the right mix of these components will be and the specifics of each. Currently, we are not aware of any significant, publicly-accessible research being done by the U.S. government on these issues or this problem writ large. The only serious research on these issues we are aware of is being funded by the European Union and conducted by the European Space Agency under their Clean Space Programme.

We suggest the U.S. government should consider funding more public research and analysis of the orbital debris problem and holistic approaches to addressing space sustainability to ensure that the U.S. government takes other steps to promote wider discussion within the space community.

Para 98 - More broadly, we seek comment on the appropriate role of the Commission given the various stakeholder agencies and other entities. As discussed above, there are a number of agencies and entities with expertise and interest in mitigating the growth of orbital debris. With various entities playing a role, how do we ensure an appropriate, coordinated approach that avoids duplication of efforts? How can we ensure clarity regarding the roles that various entities can or should play? What agency or entity has the greatest expertise when it comes to the technical, engineering, mathematic, and scientific expertise needed to address orbital debris? Additionally, we provide opportunity for comment on the impact of any potential legislation or other developments related to the Commission's role, that may arise during the pendency of this proceeding.

As mentioned earlier, we believe the U.S. government should re-examine the existing authorities for implementing orbital debris mitigation to improve their consistency, efficiency, and efficacy. It would likely be beneficial to centralize the authority for implementing orbital debris mitigation requirements in one agency. However, we feel that it would be best if such authority was given to an agency that also gains authority and responsibility for the civil space situational awareness (SSA) mission as the two missions areas are complementary. Having greater institutional insight into the space environment and activities in space will inform how said agency approaches the development of orbital debris mitigation requirements and allow for enforcement of any licensing requirements.

We also believe that the same agency should be given authority and mission to manage the space environment and orbital debris. This would not only reinforce the orbital debris mitigation and civil SSA responsibilities but also enable that agency to take a leadership role in developing, and possibly implementing, active debris removal (ADR) technologies, which the United States has so far largely neglected.

In addition, we believe there should be an agency responsible for coordinating scientific research on improving fundamental knowledge of the space environment, advancing the science and technology of critical SSA inputs such as observational data, algorithms, and models necessary to improve SSA capabilities, and developing new hardware and software to support data processing and observations as outlined in Space Policy Directive-3. NASA seems to be the likely candidate for such coordination responsibility, which would require additional budgetary resources, although some of the R&D efforts will likely be funded by other agencies such as the Department of Commerce, Department of Transportation, and the Department of Defense.

Within this updated oversight framework, we believe the appropriate role of the Commission is to maintain its purview over the licensing of radio communications as pursuant to the Commission's responsibilities and obligations under the Communications Act of 1934. If such an update occurs, with another agency appropriately authorized and funded to take the lead on the implementation of orbital debris mitigation requirements, then the Commission's role concerning the enforcement of orbital debris mitigation will be subsumed. Until that time, however, we believe the Commission should still play a substantial role in implementing orbital debris mitigation.