February 20, 2019

By electronic filing

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street S.W.
Washington, D.C. 20554

Re: Written Comment: IB Docket No. 18-313

Dear Ms. Dortch,

Satellite Design for Recovery (DFR) is a space debris mitigation advocacy group focused on enabling cost-effective debris remediation missions through changes to current satellite designs that will accommodate future active debris removal (ADR) missions.

Our objective is:

> *All objects launched into Earth orbit must be built to facilitate rendezvous, capture, and disposal operations.*

The Commission is rightfully concerned, as represented in this Notice, that a business-as-usual approach to the use of Earth orbit will no longer work going forward. We agree and believe it immaterial whether or not the FCC is the right agency to consider such matters due to the pressing need for this discussion and resulting rules changes.

It's been 40 years since Kessler, et al. wrote in the *Journal of Geophysical Research*, June 1978: *"Only a few 'sinks', or removal mechanisms, exist for earth-orbiting satellites. They are basically only retrieval and atmospheric reentry."* Because we failed to plan for it, forty years later our best plans for retrieving intact objects include nets and harpoons; this must change immediately.

Numerous studies have clearly shown that only via remediation will we ensure sustainable use of space. Several companies have developed and demonstrated the technology for removing debris from orbit; going forward we need to ensure that the objects we launch today are designed to enable safe, effective removal.

Active removal of large objects must begin now to limit future debris. As “an ounce of prevention is worth a pound of cure” so, today’s satellites and launch vehicles must be designed and built with features that enable these future missions – a gram of DFR is worth a kilogram of ADR.

I welcome the opportunity to provide the following comments to the Draft Notice, as provided in Attachment 1 to this letter, and look forward to the opportunity to discuss and clarify these comments as needed.

Sincerely yours,

Michael W. Maloney
Founder
Satellite Design for Recovery
www.satdfr.org

Attachment 1. Satellite Design for Recovery Comments to IB Docket 18-313

General Comments

Design to Demise – Years ago, NASA instituted a philosophy of 'Design to Demise' that helped reduce the threat of pieces of spacecraft surviving atmospheric reentry. This philosophy has applied mostly to objects launched into low earth orbit (LEO), but it needs to be extended to anything that will remain in earth orbit, regardless of altitude. As Kessler pointed out, objects will either reenter the atmosphere or be retrieved. However, even those that are retrieved will likely be deorbited to destructive reentry since that is currently our most cost-effective disposal method.

Design for Recovery – Operators and manufacturers should be required to address the future recovery and disposal of their objects. Design features should include hard points or grappling fixtures to facilitate safe rendezvous and capture. Additional features could include external passivation by a recovery satellite, or retraction of deployed appendages to reduce its collision cross section.

Design Documentation – Operators and manufacturers of space objects should be required to archive detailed design information about their satellite design for future use by those who plan future ADR operations. These archives will become crucial to recovering components and materials for recycling.

25-Year Rule – The 25-year rule should be replaced with a risk-based rule that takes into account orbital altitude, collision cross-section, and operating lifetime. Additionally, a requirement to provide accurate ephemeris on all their objects for their entire time on orbit (see Location Reporting comment below) would motivate operators to more quickly remove their objects from orbit. Ultimately, a move to an active-payloads only orbit regime is needed – no more rocket bodies or launch-related debris should remain in orbit.

Safe Reentry – Considering that it cannot be guaranteed which objects in the future will ultimately be deorbited to reentry, all designs, regardless of purpose or operating altitude, should undergo a review against NASA's re-entry analysis tools: DAS (Debris Assessment Software); and ORSAT (Object Re-entry Survival Analysis Tool). Or the ESA tools: SCARAB (Spacecraft Atmospheric Re-entry and Aero-thermal Breakup); and SESAM (Spacecraft Entry Survival Analysis Module).

Most objects will likely be destroyed at some point by destructive reentry. At that point, a top-level declaration whether or not the object requires a controlled reentry or not will be necessary. This simple analysis is better done by the original manufacturer's design team rather than later, when design details may have been lost. This requirement places only a minor burden on today's launch vehicle providers and satellite operators.

Location Reporting – Starting as soon as practicable, satellite operators and launch vehicle providers must be required to provide accurate ephemeris data on all their objects in orbit for their entire time in orbit. The past practice of "we launch it, you find it" needs to end. Additionally, this information needs to be shared openly with the space community, and should include advanced notice of planned maneuvers, or any changes to orbits as they occur. The costs of space situational awareness (SSA) should be fairly allocated to those that create the greater burden on the space surveillance network (SSN).

Space Environmental Effects – In addition to location data, operators should be encouraged to collect and share data on the space environment their satellites experience. Data provided could include: disturbance torques; micrometeoroid or debris impacts; and, changes in drag experienced. This information will assist in a more accurate estimation of the space environment and its effect on debris orbits.

Specific Comments

Paragraph 9 – The definition of 'end-of-life' needs to be made clear. This should change to 'end-of-orbital-life' for the purposes of mitigating debris. From a debris perspective, responsibility for an object on orbit doesn't end simply because it has stopped operating.

Paragraphs 13, 14 – While spectrum coordination is vitally important to avoid interference, so too is orbital coordination to avoid collisions. Therefore, a launch license for all objects should be required, whether or not any RF facilities are included, and regardless of whose jurisdiction the RF facilities will be used. Alternatively, inclusion of an RF transmitter could be required on all objects to aid with identification and tracking.

Paragraphs 28, 29, 30 – The current system for SSA is outdated. Operators know, or should know, where their satellites are. They should be required to provide all relevant orbital information to the Air Force and other operators for the entire on-orbit-lifetime of their satellites in orbit. Operators can access the catalog, or other available databases, and run their own conjunction assessments. This puts the responsibility for collision avoidance where it belongs; and legally resides in any case – with the owners of those objects. This should also apply to launch vehicle components that remain in orbit.

Paragraph 44 – Absent reliable and mature ADR, disposal of LEO spacecraft should not include raising their orbits above LEO. Satellites in LEO should only be disposed of by destructive reentry.

Paragraph 45 – The retrieval of a satellite, properly designed for recovery, is feasible, albeit not economical. Operators should be required to design their satellites for recovery, including documentation for retrieving those that fail to deorbit as planned. Absent a solid demonstration of successful retrievals, operators should not be permitted to substitute retrieval in lieu of an effective PMD plan using the satellite's onboard systems.

Paragraphs 46, 47, 48 – It is becoming increasingly clear that there are no safe disposal orbits. They are only temporary solutions to the overall debris problem. Remediation of earth orbit must begin soon. Operators should be immediately required to address disposal to destructive reentry or retrieval of their satellites or rocket bodies from any orbit used. To advance the development of global ADR, the IADC should remove remediation from Working Group 4 and form a fifth working group dedicated to remediation.

Paragraphs 51, 52, 53 – The casualty risk assessment should be run on all objects launched into earth orbit, regardless of altitude and proposed disposal method. This should be done by the manufacturer and submitted as part of the licensing process. This will provide a permanent and easily accessible certification of whether an object requires a controlled reentry or not, and any risk therefrom.

Paragraph 56 – Operators have a strong financial incentive to keep satellites in GSO orbital slots as long as possible, including selling the satellites to others in order to retain rights to orbital slots not yet occupied. The reverse isn't true, there are little to no costs to an operator for an on-orbit failure. A simple narrative description isn't sufficient to permit an objective evaluation of a successful deorbit probability. Operators could be permitted to post a bond or buy insurance in lieu of certifications to cover the liability for any subsequent failure of that satellite to be deorbited.

Paragraph 59 – Transparency is key to allaying concerns of other space actors of the motivations of those conducting such operations; these disclosures should be required. Due to the risky nature of such operations, the required disclosures should include sufficient detail, including contingency plans for adverse outcomes, to evaluate this risk.

Paragraphs 61, 62 – Coordination between space operators to avoid interference events should be required.

Paragraphs 63, 64 – The owners/operators of all objects launched into orbit should be required to provide accurate ephemeris during their entire time on orbit, whether operating or not. Space situational awareness (SSA) is not a service, it's the responsibility of all space actors. The space surveillance network (SSN) cannot scale to accommodate the proposed use of near-earth orbit. Therefore, space actors must carry their share of the cost of SSA.

Paragraphs 65, 66 – Considering that some non-maneuverable satellites can alter their orbits by changing their orientation to the velocity vector, command encryption should also be required on these missions.

Paragraph 85 – The growth of debris is proceeding apace with Kessler's prediction. ADR will be required to ensure continued access to certain orbits. To ensure safe and effective future disposal missions, today's satellite designs must ensure successful rendezvous and capture. Satellite and launch vehicle manufacturers and operators should be required to include

design features that facilitate recovery. These design features do not need to be mandated, or standardized; standards groups such as DARPA's CONFERS should be encouraged. Licensees should be required to document these attributes in a disposal plan that is archived to be made available when needed.

Paragraph 88 – Unless and until operators are held accountable for their contribution to the debris environment, there will be no basis for a cost-benefit analysis to determine whether one mitigation approach or another is preferred. While the responsibility and authority for maneuvering lies with the operator, putting the collision prediction calculation in the hands of a government agency only clouds the issue of responsibility for any subsequent debris event. The better approach provides the catalog of debris to all operators and requires them to perform their own conjunction assessments and coordinate amongst themselves to resolve conflicts where applicable.

Paragraph 89 – ADR is for the foreseeable future beyond the ability of any single operator. The Commission should require operators to include design features anticipating future debris removal operations. The Commission, or whatever entity assumes this regulatory role, should immediately develop and fund a comprehensive program to begin removing debris from Earth orbit. Until we hold ourselves accountable for our contribution to the debris problem, we will be unable to hold others accountable for theirs.