FEDERAL COMMUNICATIONS COMMISSION
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[IB Docket No. 18-313; FCC 20-54; FRS 16848]

Mitigation of Orbital Debris in the New Space Age

FURTHER NOTICE OF PROPOSED RULEMAKING

Comments Provided By

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INTRODUCTION

The Association of Space Explorers (ASE) is an international nonprofit professional and educational organization of over 400 flown astronauts and cosmonauts from 38 nations. Membership in ASE is open to individuals who have completed at least one orbit of the Earth in a spacecraft.

ASE member countries include Afghanistan, Austria, Belgium, Brazil, Bulgaria, Canada, China, Costa Rica, Cuba, Czech Republic, Denmark, France, Germany, Hungary, India, Israel, Italy, Japan, Kazakhstan, Malaysia, Mexico, Mongolia, Netherlands, Poland, Romania, Russia, Saudi Arabia, Slovakia, South Africa, South Korea, Spain, Sweden, Switzerland, Syria, Ukraine, United Kingdom, United States, and Vietnam.

ASE fully supports activities aimed at making operations in earth orbit safe, efficient, and collegial, and is often asked for "the astronaut's/cosmonaut's perspective" on subjects that fall under these headings. Space Traffic Management and Orbital Debris (STM&OD) are two such topics where ASE sees the need for a coordinated, international effort to insure safe and efficient operations in earth orbit. In July 2020 ASE published **Space Traffic Management and Orbital Debris: A Position Paper** to clearly express our opinion regarding what a comprehensive STM&OD Program should look like.

OVERVIEW OF COMMENTS

For those currently operating spacecraft in earth orbit, the need for reducing orbital debris and Space Traffic Management is a foregone conclusion. Earth orbit is a busy place! Since the late 50's when one satellite was lifted into orbit on one booster, now over a hundred satellites ride the same rocket to space. Once a primary payload is typically deployed, the other riders are ejected from "corncob launchers" as the booster continues on its path. The number of active satellites is quickly approaching 3,000 with many commercial companies planning constellations that will easily double that figure. Unfortunately, the number of pieces of debris has steadily increased as well. Where the debris catalog included around 27,000 separate pieces measuring 10 centimeters or larger, that number is in the process of being revised. Recent studies have shown that a piece of debris measuring only a few millimeters in size can be potentially lethal to an active satellite. Estimates suggest the true debris catalog of lethal objects would number near 500,000.

Even a modest number of satellites and pieces of debris represents a significant computational challenge to avoid collisions. Because there are simply not enough frequent observations of everything in earth orbit, the uncertainty of positions and orbits results in large error ellipsoids around the expected positions of each object. When calculations are performed looking for potential conjunctions (intersecting error ellipsoids) so many "potential" collisions are identified that they are routinely ignored. It is vital that this situation be remedied before a major accident occurs.

What is needed is more accurate and frequent tracking observations of the hundreds of thousands of potentially hazardous objects in orbit. More accurate monitoring will not only result in more reliable conjunction warnings to be issued, but also motivate space operators to adopt sustainable practices and to comply with guidelines to avoid liability issues.

Avoiding an incident requires one or both parties to maneuver to change their orbits, if possible, to remove any possibility of a collision. Just as with ships at sea and aircraft in flight, rules are required for either a Central Controlling Authority to direct a maneuver be made or for one to be made without direction in accordance with the rules. Further, these rules must have applicability long before satellites

arrive in orbit. Policies and procedures must be in place to support mission planning, launch, post insertion, on orbit operations, and retirement/deorbit.

ASE applauds the FCC in taking a leadership role in addressing both orbital debris and Space Traffic Management. Addressing these challenges will require a well thought out and structured program. ASE believes the FCC is in a position through its licensing authority to put many of the needed policies, procedures, and rules in place, and to coordinate needed functionality and support from other federal agencies. Further, ASE sees this as an opportunity for the USA through the FCC to develop a template for a larger international undertaking to address orbital debris and Space Traffic Management as was done years ago for aviation.

STRUCTURE OF ASE COMMENTS

ASE is providing comments as requested in response to this FNPRM. After each of the FNPRM sections where ASE has a comment, selected requests by the Commission will be shown in italics followed by ASE's response. Please see "**Space Traffic Management and Orbital Debris: A Position Paper**" published in July 2020 for additional details.

FNPRM TEXT WITH ASE COMMENTS

IV. FURTHER NOTICE OF PROPOSED RULEMAKING

B. Total Probability of Collisions with Large Objects

157. First, we ask how the Commission should consider the collision risks associated with a system in its entirety as part of the licensing process. Is assessing the total probability of collision on a system-wide basis consistent with the public interest?

158. We seek comment on the factors that could be relevant both in establishing a threshold or bright-line rule, and in assessing a system on a more detailed basis, for example, if the system risk exceeds a particular safe harbor. We seek comment on consideration of factors including per-satellite collision risk, maneuverability, number of satellites (potentially including constellation replenishment rate and replacement satellites), orbital lifetime, and/or size for NGSO satellites. Are there any other factors that could or should be considered?[537]

159. To the extent that we consider a particular threshold or safe harbor that would be applicable to multi-satellite NGSO systems, we seek comment on using total collision risk, i.e., in the aggregate, as calculated as the sum of the probability of collision associated with each individual satellite in the system. Should we ask that applicants take into consideration replacement/replenishment satellites as part of this calculation, and if so, over what period of time?[541]

ASE Comment #1: Constellations The questions being asked here are fundamental to deciding how a comprehensive STM&OD program should be structured. First, each satellite or piece of debris must be considered as a unique object. Frankly, it's irrelevant if the satellite is part of a constellation in respect to how it may represent a hazard to another satellite in orbit.

Second, as much as we'd like to believe otherwise, there is a great deal of unpredictability in this business. Our industry has already demonstrated that between normal performance variations and system failures satellites don't always end up in the orbits to which they were intended nor follow their "orbital plan" for their lifetimes. Any STM&OD program plan needs to be able to be able to manage the entire constellation of objects through all flight phases with variations.

ASE Comment #2: Conjunction Assessments Like it or not, the correct answer is to continuously perform conjunction assessments of each satellite and object in earth orbit to identify potential conflicts. Where in the past such a computational challenge would have been considered beyond our collective capabilities, that is no longer the case. Private companies and universities (LeoLabs and Texas A&M) have already shown that both tracking the entire catalog is doable as is running conjunction analyses on a near continuous basis.

ASE Comment #3: Lethal Debris Fundamental to this discussion is what should be included in the catalog. Obviously, all satellites, recognizing that an active satellite may become passive debris due to failures or at the end of its planned operational lifetime, but also debris that is large enough to be considered potentially "lethal" to operational satellites. Where 10 cm was the rule of thumb for the catalog, it is now time to push technology to capture all of the objects that NASA would gauge as potentially lethal. Studies have shown that objects 2 cm or larger pose a direct threat to the ISS where objects as small as 1-2 mm may carry enough kinetic energy to cause serious damage to a commercial satellite. The object catalog and tracking technologies should be pushed to include all of the objects that NASA would consider potentially lethal.

ASE Comment #4: Operational Flight Rules (Code of Conduct)
There will be a need to notify parties when a potential conjunction has been identified and some schema for determining who should maneuver out of the way. This is what drove ASE to recommend the establishment of different classes of satellites and a code of conduct (operational flight rules) to guide decision making. Further, the idea of a voluntary system where operators are "expected" to provide orbital data on all of their satellites and cooperate in deciding who will maneuver out of the way is still considered idealistic. Since a "voluntary" system never worked with ships and planes, there is no reason to think it would work with space objects. Imagine getting on an airliner knowing that participation in air traffic control was voluntary. This, of course, brings one back to the need for a Centralized Coordinating Body to manage the airspace and enforce the rules.

C. Maneuverability Above a Certain Altitude in LEO

164. Would requiring maneuverability above a particular altitude help to ensure that the burden for conducting collision avoidance maneuvers is more evenly distributed among operators, since all Commission authorized satellites would have some collision avoidance capability when operating in the upper part of the LEO region? To what extent would such a requirement enhance space safety in the LEO region?

165. We recognize that the costs and benefits of this type of approach are likely to be contingent to some extent on the altitude selected as the cut-off for maneuvering capabilities. While the majority of commenters who agreed that a requirement was necessary suggested 400 km as an appropriate cut-off, some parties suggested alternative altitudes, such as 600 or 650 kilometers.[556] We seek comment on these various options. If we were to adopt a requirement tied to the operations of the ISS, we seek comment on requiring maneuverability during any period when satellites are "located in the LEO region in an orbit with an apogee above 400 km,"[561] for example, or whether there would be an alternative way to specify a cut-off orbital altitude, for spacecraft located above 400 km with the potential impact to certain categories of satellite missions.

ASE Comment #5: Maneuverability The primary goal of this idea is to protect the ISS by making sure anyone operating near that orbit would be able to maneuver out of the way if needed. The reality is that there are going to be many crewed spacecraft operating in earth orbit to include more space stations at unpredictable orbital altitudes and inclinations. A better approach is to manage all the different classes of satellites with systematic observations, conjunction analyses, warnings, maneuvering rules, and verification.

F. Indemnification

176. In the Notice, we sought comment on the adoption of an indemnification requirement as part of a broader discussion of liability issues and economic incentives.[588] In response to concerns and questions expressed by various commenters, we seek additional comments on this issue in order to obtain a fuller record. We also seek comment on whether any indemnification requirement should be addressed as a license condition and affirmed as part of the application process rather than as a separate agreement following licensing in order to address concerns raised by some commenters concerning the details of implementation.[589]

178. Regardless of whether a particular claim results in a payment of compensation, the United States would incur costs in addressing such claims, and those costs would be borne by U.S. taxpayers. Thus, there is a connection between the Commission's issuance of a license for satellite communications and exposure of the U.S. government to claims under international law, particularly because the Commission is often the only agency reviewing an operator's plans for on-orbit operations and orbital debris mitigation, including post-mission disposal activities. Under these circumstances, conditioning Commission authorization on indemnification of the U.S. government may be a reasonable step, given the absence of protections under international law of the protection from liability under U.S. law related to a licensing authority's exercise of its discretionary functions. We seek comment on these considerations.

ASE Comment #6: Indemnification ASE supports the combination insurance/bond concept to cover damages resulting from conjunctions/collisions/interference that would currently be paid by the USA. ASE, however, thinks it's time to move away from states/countries being liable for damages resulting from satellites launched from their soil and instead shift the burden of responsibility to the owners of the spacecraft/debris themselves. The establishment of a Code of Conduct (flight rules) lays the foundation for this transfer of liability to the owners.

SUMMARY: ASE is still of the opinion that any comprehensive STM&OD program will need to include the following elements:

- A Centralized Coordinating Body
- Tracking Devices for Satellites and Boosters
- Spacecraft and Object Categorization
- Assignment of Spacecraft Ownership
- Flight Rules (Operational Rules)
- Conjunction Analyses: Mission Planning
- Conjunction Analyses: Launch
- Conjunction Analyses: On Orbit

- Conjunction Analyses: Vehicle Retirement/Deorbit
- Assignment of Liability
- Debris Ownership
- Observational Frequency
- Communication Protocols
- Periodic Conjunction Studies
- Management Oversight
- Space Traffic Management Domain
- Financial Impacts Resulting from Liability
- International Applicability
- Licensing
- Issuance of Conjunction Warnings
- Data Collection, Verification, and Integration

One of the lessons of history, in this case from aviation, teaches that instead of a voluntary program based on cooperation by the airspace users a formal program was needed with government oversight, tracking, clear flight rules, flight following, monitoring, and enforcement. As much as we would like to believe that a cooperative association for space data could be successful in providing a comprehensive catalog, timely conjunction studies, warnings, and mutual collision avoidance maneuvering, we are skeptical.

We encourage the FCC to assume the role of Centralized Coordination and Management Body and to provide the community with a robust program including all of the elements listed above.