Paper ID: 64399
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19th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Modeling and Risk Analysis (2)

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THE EFFICACY OF MANAGING SPACE ENVIRONMENTAL RISK BY REGULATING PROBABILITY OF COLLISION WITH LARGE OBJECTS

Abstract

As more large constellations are deployed, it becomes increasingly important to quantify, understand, and limit the risk of creating a Low Earth Orbit (LEO) region which cannot sustain safe operations for human or robotic missions due to space debris. A significant contributor to this risk comprises debris which is energetic enough to cause catastrophic fragmentation upon collision with other spacecraft, small enough to be difficult to track, and prohibitively expensive to remediate due to quantity and distribution. Currently, the most effective way to reduce the long term risk of such debris is to prevent its creation in the first place, which is why certain administrations require as part of their license application processes compliance with regulations designed to limit the likelihood of events which could generate space debris.

One such regulation used by the United States Federal Communications Commission (FCC) is the limitation of the probability of collision with large objects. In this instance, a "large object" is any object larger than 10 cm in diameter, and the enforced probabilistic maximum is 0.001 per satellite. To show compliance with this regulation, operators commonly use the Debris Assessment Software (DAS) tool, developed and maintained by NASA. Historically, DAS has provided adequate means for assessing collision risk for single-satellite missions operating in LEO, but given the rapidly changing environment and large numbers of spacecraft that were not envisioned in the drafting of corresponding regulations, let alone DAS itself, it becomes necessary to review the appropriateness using of such an approach for all space missions, and especially large constellations.

This paper will analyze the efficacy of using DAS to comply with current regulations and the efficacy of the regulations themselves in limiting catastrophic fragmentations. It will also identify potential shortcomings and oversights resulting from current approaches that may further endanger the sustainability of LEO if not addressed. The discussion includes quantifying the effects of omitting collision risk involving large operational constellations, omitting collision risk involving debris objects with diameters between 5-10 cm, computing risk by integrating over variable lifetimes as opposed to fixed reference time frames, and omitting risk aggregation from having more than one satellite licensed within the same application process. These effects likely have significant impacts in how space traffic and debris risk is managed and must be taken into consideration by current regulations as part of ensuring a safe and sustainable space environment for future generations.