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CORRELATING LEO SUSTAINABILITY TO TARGETED DEBRIS MITIGATION METHODS USING A SIMPLE METRIC

Abstract

Low Earth Orbit (LEO) traffic has increased dramatically in recent years and that trend is very likely to continue or increase. Compliance with international orbital debris mitigation policy has always been the best way to control the proliferation of debris in LEO. Existing guidelines are based on historic space traffic levels, which have increased significantly since the guidelines were last formulated. Analysis shows that existing guidelines will not be sufficient to maintain a reasonable LEO environment with significant increases in space traffic. New approaches will be needed to structure standards and best practices to deal with higher traffic levels and the wide size ranges of space systems, with a focus on Large LEO Constellations (LEO) occupying numerous orbit shells across many altitudes.

This study models the effects of various debris mitigation methods on long-term space debris environment outcomes, using the simple Undisposed Mass Per Year (UMPY) metric to correlate these methods to their effects. Methods such as improved post-mission disposal (PMD) success, extended individual satellite operational lifetime, control-to-reentry (C2R), etc., applied to individual satellites or constellations directly modify the UMPY value for those objects. UMPY correlates well to operations and environmental effects metrics like future object count, cumulative catastrophic collisions, and conjunction frequency. By assessing the expected effect on such metrics by reducing UMPY by a specific amount, targeted debris mitigation methods can be applied to specific operators to achieve that desired UMPY and therefor environmental outcome. These expected effects are then compared with the effects as found using direct modeling and analysis.

The modeling and analysis in this study was performed using the Aerospace Debris Environment Projection Tool (ADEPT), which models the long-term space environment, subject to varying initial conditions and future space traffic scenarios. The results of hundreds of cases were used to check the correlation between UMPY values and environment and operations effects. The results of ADEPT analyses have been used to inform U.S. and International Space Traffic Management (STM) and debris mitigation policy, as well as for numerous studies of the effects that current and future activity will have on the sustainability of the space environment.

Further study on the effects of targeted mitigation methods can help policymakers decide the best path forward for ensuring a sustainable space environment for all future operators.