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DISPOSAL AND FLIGHT SAFETY IN CISLUNAR SPACE: SHORTFALLS IN CURRENT GUIDELINES AND A WAY FORWARD

Abstract

The population of space missions beyond geosynchronous orbit (GEO) is growing rapidly, but disposal and flight-safety requirements have not kept up to accommodate operations in the cislunar and lunar regimes. Irrespective of their destination, all space missions must comply with flight-safety and disposal requirements. These requirements are derived from guiding documents such as the Orbital Debris Mitigation Standard Practices (ODMSP) in the United States, the IADC Space Debris Mitigation Guidelines, and the COPUOS Guidelines on the Long-Term Sustainability of Outer Space Activities. However, none of these guidelines apply to flight beyond GEO, and many aspects of operating in the cislunar regime are incompatible with them. This paper reports on a requirement-by-requirement analysis of these guiding documents (primarily the ODMSP) for archetypal cislunar missions. The study uncovered both policy shortfalls, where new guidelines must be added to accommodate unique cislunar concerns, and capability shortfalls, where the guidelines may be adequate per se, but the community lacks quantitative insight or the tools to perform verification of compliance in cislunar space. In the case of US space missions, more than half of the requirements necessary for flight had unaccommodated cislunar implications. For example, in the case of disposal, the technical definition of "heliocentric escape" does not readily translate to multi-body dynamics, and a "storage above GEO" disposal option has no upper limit to protect regions of interest in cislunar space or at the Moon. Furthermore, verifying disposal compliance requires orbital propagations on decades- or centuries-long timescales, but there is no community consensus on a robust methodology to propagate cislunar dynamics that long. Three areas were identified where action is urgently needed: 1) lunar impact as a disposal option, 2) cislunar collision risk assessment and collision avoidance, and 3) long-term cislunar disposal. We will show the analysis outcomes and breakdowns when applying the current guidelines to cislunar missions, provide a detailed review of the policy and capability shortfalls that we uncovered, and develop recommendations for the community that correspond to the three areas of urgent action. Accompanying the recommendations is a detailed analysis portfolio, which will require investment from the entire community to properly inform the composition of new cislunar-relevant guidelines. Without a global effort to extend sustainability guidelines to the Moon and beyond, the community runs the risk of setting bad precedents with a patchwork of exceptions, waivers, and idiosyncratic interpretations of rules that will imperil the long-term sustainability of space beyond GEO.