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MULTI-PERSPECTIVE ANALYSIS OF SUSTAINABILITY METRICS CHARACTERISING THE
DEBRIS ENVIRONMENT

Abstract

To assess the effectiveness of mitigation measures, long-term simulations of the debris environment are often analysed and evaluated using simple metrics such as the total number of objects or the frequency of fragmentation events. In addition, more complex criticality metrics have been developed in the past to rank objects according to their environmental impact and evaluate the overall state of the debris environment. In this context, three different perspectives are particularly worth highlighting: Object-specific metrics that characterise the criticality of individual objects and orbits, spatial metrics that can be used to identify particularly vulnerable orbital regions and global metrics which describe the sustainability of the environment as a whole. Typically, the criticality metrics are specific to one of the respective perspectives, but unification across and convertibility between perspectives would allow for a more comprehensive assessment of sustainability. In this context, a methodology is developed to transform object-specific and spatial metrics into one another. The conversion concept enables a comparison of two structurally different metrics from their respective initial object-specific and spatial domain. Furthermore, the third perspective is taken into account by using different aggregation methods to retrieve a global metric from the initial object-specific and spatial descriptions. The three perspectives then are compared by conducting environment evolution simulations for various baseline scenarios using a common space debris population in low Earth orbit. The comparative analysis identifies commonalities and differences of the chosen metrics in the three different perspectives and how the conversion between them affects their quantification of sustainability. The multi-perspective convertibility and aggregation of single-perspective metrics represents a contribution to the generalisation of sustainability metrics for different scopes of application.