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A SPACE ENVIRONMENT INDEX BASED ON MINIMUM ORBITAL INTERSECTION DISTANCE——MBSI

Abstract

Abstract: Space Environment Index (SEI) serves as a quantitative assessment metric for delineating the long-term impacts of space debris on the space environment. This index facilitates comparative analysis to ascertain whether the orbital operation of a particular space object poses significant threats to other objects or the overall environment. This paper conducts an in-depth analysis and comparison of the constituent features of typical SEIs, culminating in the formulation of a general paradigm for SEI construction. This paradigm emphasizes the necessity for SEIs to comprehensively integrate key factors such as the effective cross-sectional area, mass, longevity, and collision risk of space objects. Addressing deficiencies in past Space Environment Index models, particularly concerning the calculation of average collision risk, a novel SEI model termed MBSI (MOID-based Space Index) is proposed. The index is based on the Minimum Orbit Intersection Distance (MOID) between objects and background debris. It couples the proportion of time spent in close proximity encounters with the size of space objects to characterize collision risks among objects. Additionally, it estimates the likelihood of collision events occurring among space objects over a future time period. In this study, the MBSI, RN, and CSI indices are utilized to assess the risks posed by objects in the high-risk Low Earth Orbit (LEO) region, followed by hierarchical ranking based on their risk levels. The results indicate a high degree of consistency, reaching 62.85Moreover, compared to traditional space environment indices, the MBSI exhibits potential for assessing risks associated with large constellations and the overall orbital environment. This study focuses on analyzing satellite clusters at different orbital altitudes within the STARLINK constellation, utilizing Two-Line Element (TLE) data. Through the implementation of the MBSI index, the study examines the spatial distribution of collision risks among satellite clusters over varying time intervals and assesses the risk profiles across different altitude layers during the same time frames. These findings offer valuable insights for the implementation of space sustainability policies and the management of space mission risks.