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Space carrying capacity assessment and allocation (10-E9.4)

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NORMALIZING ORBITAL CAPACITY CHARACTERIZATION

Abstract

The continued growth of the space object population raises serious concerns about enduring space safety in Low Earth Orbit (LEO). The means to characterize the extent of the deterioration of space safety is difficult to quantify as there are many dynamic, subjective, and complex variables involved. This paper examines three disparate approaches to quantifying the orbital capacity of LEO. These three models are (1) the aggregated orbital capacity through the collision risk-based THEMIS approach; (2) the Criticality of Spacecraft Index (CSI); and (3) the Risk Balance Model (that consider risks posed normalized by risk abated and altitude of objects).

After short review of each modeling approach, the methodologies, strengths, and limitations of each model will be scrutinized to identify universal trends of operational importance. These findings are used to create a framework for further analyses and offer observations of the likely evolution of the LEO environment and indicators for when the stability of the population is worsening. The actual increase in space object population in LEO will likely take many decades to centuries to evolve, however, this analysis identifies unambiguous early indicators of the acceleration of the debris environment that can serve as a tripwire for pursuing more stringent debris mitigation and remediation efforts.

Key issues identified in this investigation are adherence to debris mitigation guidelines, determination of collision probability and increased risk on active spacecraft due to the increase of debris number in some orbital regions, fragmentation realities, constellation growth, maturity of space traffic coordination best practices, and trackability capabilities. The diversity of the three models applied in this paper provide a solid foundation for frank dialogue and objective debate that contributes to a more valuable overall understanding of the dynamics of the situation than any single modeling approach could provide.