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

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EXTENDING A RISK METRIC FOR INDIVIDUAL MISSIONS TO EVALUATE OVERALL RISK IN ORBIT

Abstract

Assessing the risk associated with new missions in orbit has become increasingly important. With the large number of spacecraft and debris now in orbit, there are many more close encounters between objects, which makes it more difficult to estimate the risk over the lifetime of a mission. Several approaches exist for determining the collision risk associated with a single object. This work uses a novel methodology for calculating the induced risk of a mission to define a more general measure of risk in the space environment. Risk is quantified as the product of likelihood and severity. Likelihood refers to the likelihood of a collision occurring and severity refers to the consequence of a collision. The proposed approach approximates collision likelihood between populations of objects based on the intersection of their distributions. This intersection computes the probability of the minimum orbit intersection distance between the distributions being less than a threshold distance value and scales this probability based on the number of objects. The model of severity uses data from simulated fragmentation events to model the likelihood of collisions with fragments based on parameters of the collision. These values of likelihood and severity give a risk measure for an individual mission. We extend this metric to the whole environment by calculating the risk for a range of orbits within a regime and taking summary statistics as a measure of overall risk. The resulting metric considers the distribution of objects not only in altitude but also over orbital parameters of inclination and eccentricity, as well as right ascension in GEO. Example results are shown for baseline environment conditions and a range of future projected scenarios in LEO, MEO, and GEO regimes. The proposed risk metric requires assumptions on the covariance and masses of objects as well as defining the threshold distance for calculating the intersection. We further examine the effect of varying these parameters to see how different modelling assumptions would affect the metric.