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# QUANTIFYING THE INDUCED AND ENCOUNTERED RISK OF SPACE MISSIONS

**Abstract**

The rapidly changing space environment motivates new approaches to assess risk in orbit. For new missions, it is important to measure the additional risk they create in the environment and the risk to the mission itself to find ways of minimising this risk. Several methods exist to calculate the risk associated with individual conjunction events. However, these cannot extend to every conjunction over a mission lifetime. Calculating the severity of a collision typically involves simulating the fragmentation and propagating the generated fragments. Such simulations are often stochastic and therefore require many Monte-Carlo runs to generate descriptive statistics. This is also too computationally expensive to run for every potential collision for a mission. New approaches to find high-risk objects as targets for active debris removal create "debris indices" that measure likelihood and severity of fragmentations. The severity can come from statistics of the object and environment to generate faster estimates. Here we present a conceptually similar approach to calculate risk for new missions.

Our proposed measure of risk calculates the likelihood and severity separately. The risk likelihood is the probability of collision. To calculate this probability, the background population is modelled as a distribution over orbital parameters. This distribution is for all objects within an orbit regime at a snapshot in time. The probability of collision for a mission of interest is then approximated by intersecting the background distribution with the distribution for this mission. The risk severity quantifies the effect of a collision. This has two aspects: the impact on the rest of the space environment and on the mission itself – referred to as "induced" and "encountered" risk, respectively. We define separate severity factors for the induced and encountered risk to assess the outcome of a collision event. The encountered severity factor only considers the effect on the mission itself. This can range from low severity collisions with small particles to loss of the mission. The induced severity factor includes the impact of a fragment cloud from a potentially catastrophic collision. Instead of directly simulating the fragmentation, the calculation of severity uses parameters of the collision such as the impact energy and location. This approach gives fast estimates of risk for a mission against a population snapshot that can be extended to calculating the mission's long-term risk.