20th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Modeling and Risk Analysis (2)

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MODELLING THE RESILIENCE OF SPACE INFRASTRUCTURE TO COLLISIONS IN SPACE

Abstract

The risk of collisions between objects in Low Earth Orbits is increasing as megaconstellations share space with decades of satellites, debris and micrometeoroids. Businesses, Governments and Critical National Infrastructure are using space systems at a scale never seen before. GNSS timing signals are used to synchronise high speed financial transactions and energy networks, while communications networks depend on satellites for connectivity, broadcast infrastructure and backhauling. At the same time, multi-band imagery intelligence is used to continuously monitor global, national, and regional environments, as well as civil and national defence interests. However, society's dependence on space systems means it is vulnerable to any threats to space infrastructure. It is therefore becoming increasingly imperative to integrate the risk of collisions into a wider system model that can quantify the loss of satellite services. "SpaceAware Resilience" is a new model which models the chain of infrastructure from satellite, through downlink to ground station and then to critical ground infrastructure such as military assets, national or commercial infrastructure (such as broadband services). Previously it modelled only the downstream impacts of degraded services from satellites but did not model the risk to the satellite systems themselves. In this work, the satellite collision element of the model is described. Firstly, vulnerabilities of a generic spacecraft's elements to impact are identified. Next, existing methods which have been developed to calculate the probability of collisions between defined objects are compared and discussed. The European Space Agency's Debris Risk Assessment and Mitigation Analysis (DRAMA) tool is then used to calculate some example probabilities of impact. Some limitations of current debris tracking and collision estimations are highlighted when DRAMA is applied to the collision between Iridium-33 and Cosmos-2251 in 2009. These probability outputs are then input to a SpaceAware Resilience for downstream effect modelling. The outputs from this can then be used by those managing space assets to gain an understanding of where the critical points in their chain of infrastructure are. It is hoped that this improved threat model will help agencies, companies and government learn more about the key vulnerabilities of space systems and ultimately the infrastructure they serve and where to place the emphasis in mitigations.