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SPACE DEBRIS SYMPOSIUM (A6)
Hypervelocity Impacts and Protection (3)

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COMPUTATIONAL METHODOLOGY TO PREDICT SATELLITE SYSTEM-LEVEL EFFECTS FROM UNTRACKABLE SPACE DEBRIS

Abstract

The unconstrained growth in space debris poses an increasing systemic risk to space operations. To support space debris risk assessments, probabilistic models have been developed to estimate incident fluxes of smaller debris particles (typically less than 10 cm), which currently cannot be tracked by the US Space Surveillance Network. Using a debris flux model and an appropriate ballistic limit equation (BLE), the risk of penetration of the spacecraft wall from debris impacts can be calculated, as is currently done to satisfy safety requirements for manned space missions. However, for unmanned missions, penetration of the spacecraft wall is not necessarily critical and may be an overly conservative indicator of mission risk. For an optimized satellite design, the influence of debris impacts on internal components and the overall system needs to be evaluated.

This paper proposes a computational methodology to predict the satellite system-level effects of impacts from untrackable space debris. This approach seeks to improve the accuracy of current debris risk assessments by assessing the physical damage to internal components from debris impacts and correlating these effects to system functional impairment. The proposed method combines a debris flux model with the Schäfer-Ryan-Lambert (SRL) BLE, which accounts for the shielding effects of components behind the spacecraft structure wall. Debris impact trajectories and component shadowing effects are considered. The failure probabilities of individual satellite components as a function of mission time are calculated. These results are correlated to expected functional impairment through the functional architecture of the system. The Fault Tree Analysis methodology is used to account for functional dependencies and redundancies within the system. This approach predicts the expected system-level effects from untrackable space debris as a function of time.