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Impact-Induced Mission Effects and Risk Assessments (3)

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A CONCEPT FOR A NOVEL PREDICTIVE FRAMEWORK FOR HYPERVELOCITY IMPACT RISK ASSESSMENT BASED ON MODULAR TRANSFER FUNCTIONS.

Abstract

Micrometeoroids and orbital debris (MMOD) pose a substantial threat to spacecraft. Consequently, there is a demand for suitable tools for the design of spacecraft shielding. Over the past decades, the complexity of these shielding designs has grown considerably alongside technological progress. Engineers presently have access to various predictive tools, including empirical impact tests, ballistic limit equations (BLEs), numerical simulations and artificial neural networks (ANNs).

While BLEs, as semi-empirical equations, are widely employed for the preliminary design of spacecraft shielding due to their simplicity and cost-effectiveness (compared to other predictive tools), their accuracy tends to diminish when applied to novel and complex shielding concepts.

We present a concept for a novel predictive framework composed of a modular set of physics-informed transfer functions. During a particle's impact on the spacecraft's outer structure, a fragment cloud is generated. In the scope of the presented framework, this fragment cloud is defined by a state vector. Additionally, each component of the outer spacecraft structure (for example bumper plates, honeycomb cores, MLI and metallic foam) and the spaces in between these components are characterised using a set of transfer functions. These transfer functions are used to extrapolate the state vector of the fragment cloud when moving through the outer spacecraft structure.

Understanding the state of the fragment cloud offers potential for more detailed predictions than "penetration or no penetration". This includes satellite break-up criteria to avoid further debris generation or assessing impact effects on functional components. Furthermore, the derived transfer functions can serve as an input for future physics-based ANNs and the modular nature of the approach eases the transfer of existing test data to novel designs.