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

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A NEW METHOD TO PREDICT THE CATASTROPHIC DISINTEGRATION OF SPACECRAFT UPON COLLISION WITH LARGE ORBITAL DEBRIS

Abstract

The main limitation of the current method for predicting spacecraft catastrophic fragmentation upon collision with large debris is the total independence of the critical value of the energy-to-target mass ratio from both the satellite configuration and impact point. In fact, each target has its own disintegration energy threshold depending on its structure and the part of the spacecraft that is hit by the debris, but this is not accounted for by the classical 40J/g rule. To go beyond these limitations, the method proposed in this paper calculates the amount of impact energy that is injected into the system based upon the structural properties at the impact location, and then it determines how energy is transmitted from the given source to other spacecraft parts. In this way, it becomes possible to predict how impact energy is partitioned among some selected macroscopic structural subsystems, each of them is finally evaluated versus its own shattering threshold. Energy partition is performed by solving a system of equations written according to the Statistical Energy Analysis(SEA) approach. SEA is a powerful tool to describe the high frequency energy sharing in large structures with a significative reduction of the number of degrees of freedom in the model as compared to deterministic models. The structure is divided into major parts connected by interfaces, each with known damping and transmission properties (Damping Loss Factors-DLF and Coupling Loss Factors-CLF). DLF and CLF parameters refer to macroscopic spacecraft parts (no detailed modeling such as FEA is requested) and hence they can be roughly predicted numerically from basic information on the component material and geometry. This paper describes in details the proposed energy-partition method and presents its employment to a geometrical representative model of a spacecraft subject to impact on different parts. Results are finally compared to those obtainable by application of the classical 40J/g rule. It is shown that spacecraft disintegration is highly influenced by the impact point and the subsystems structural properties.