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

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ASSESSMENT OF SATELLITE EQUIPMENT VULNERABILITY TO HYPERVELOCITY IMPACTS BY USING THE SRL BALLISTIC LIMIT EQUATION

Abstract

Spacecraft risk from hypervelocity impacts is typically assessed using software such as ESA's ESABASE-DEBRIS or NASAs BUMPER code. The number that characterizes this risk is the Probability of No Penetration (PNP). The PNP is a measure for the statistical time interval between two penetrating impacts on a spacecraft. The software tools calculate the PNP using (a) flux models that provide the number of meteoroid and debris particles that impinge on the spacecraft and (b) empirical equations that describe the penetration resistance of the spacecraft structure wall (known as ballistic limit equations (BLE)). This approach is justified for manned modules. For an unmanned spacecraft, the perforation of the external wall is not necessarily critical for the spacecraft mission.

Current methodology for assessing the risk of hypervelocity impacts to unmanned spacecraft considers penetration of the outer hull. However, this fails to account for the intrinsic penetration resistance of internal components such as equipment casing walls, insulations, coatings, etc. A new ballistic limit equation (coined the SRL equation) has been developed which allows this intrinsic shielding to be included in the calculation of ballistic limit impact parameters of typical satellite equipment placed behind typical satellite structure walls. The considered equipment is fuel pipes, heat pipes, high pressure vessels, liquid filled pressurized tanks, harness, electronics boxes and batteries. The considered structure walls are typical sandwich panel- or Whipple shield structure wall configurations.

By utilizing the SRL equation, the penetration resistance of identified critical equipment is considered, thus enabling a more comprehensive look at satellite impact risks than what is possible with the current risk assessment methodology.

In this paper, the SRL equation will be presented and its application explained. To demonstrate the capability of the equation, it will be applied in a simplified risk-analysis to a box-shaped satellite orbiting in a sun-synchronous orbit. The simplified satellite has a typical structure wall and contains pressure equipment. The PNP calculated with the SRL equation is then compared to the PNP as calculated from the approach currently followed.