SPACE DEBRIS SYMPOSIUM (A6)
Modeling and Risk Analysis (2)

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MATERIAL DENSITY DISTRIBUTION OF SMALL DEBRIS IN EARTH ORBIT

Abstract

Over 200 spacecraft and rocket body breakups in Earth orbit have populated that regime with debris fragments in the sub-micron through meter size range. Though the largest debris fragments can cause significant collisional damage to active (operational) spacecraft, these are few and trackable by radar. Fragments on the order of a millimeter to a centimeter in size are as yet untrackable. But this smaller debris can result in damage to critical spacecraft systems and, under the worst conditions, fragmenting collision events. Ongoing research at the NASA Orbital Debris Program Office on the sources of these small fragments has focused on the material components of spacecraft and rocket bodies and on breakup event morphology. This has led to fragment material density estimates, and also the beginnings of shape categorizations.

To date the NASA Standard Breakup Model has not considered specific material density distinctions of small debris. The basis of small debris in that model is the fourth hypervelocity impact event of the Satellite Orbital Debris Characterization Impact Test (SOCIT) series. This test targeted a flight-ready, U.S. Transit navigation satellite with a solid aluminum sphere impactor. Results in this event yield characteristic length (size) and area-to-mass distributions of fragments smaller than 10 cm in the NASA model. Recent re-analysis of the SOCIT4 small fragment dataset highlighted the material-specific characteristics of metals and non-metals. Concurrent analysis of Space Shuttle in-situ impact data showed a high percentage of aluminum debris in shuttle orbit regions. Both analyses led to the definition of three main on-orbit debris material density categories – low density (< 2 g/cc), medium density (2 to 6 g/cc), and high density (> 6 g/cc).

This report considers the above studies in an explicit extension of the NASA Standard Breakup Model where separate material densities for debris are generated and these debris fragments are propagated in Earth orbit. The near Earth environment is thus parameterized by debris density percentages within subsections of that environment. This model version is used in the upgraded NASA Orbital Debris Engineering Model (ORDEM2008).