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EXAMINATION OF DEBRISAT FRAGMENT CHARACTERISTICS FOR IMPROVED FRAGMENTATION MODELING

Abstract

Characteristics of medium- and small-sized debris from hypervelocity collisions are poorly understood. The debris from on-orbit events is generally too small to determine even basic physical properties on a large scale, so ground testing is required to provide the detailed debris characteristics. To obtain this information, which affects debris lethality and orbit evolution characteristics, the DebriSat experiments were conducted. The DebriSat project is a joint NASA, U.S. Department of Defense, The Aerospace Corporation and University of Florida (UF) project to increase understanding of debris production from hypervelocity collisions. A high-fidelity satellite mock-up and lower fidelity upper stage mock-up were impacted in a test chamber by 600 g projectiles at approximately 7 km/s. The resulting debris from each test was collected and it currently being characterized at UF.

The DebriSat data promises to be a valuable resource for numerous applications. The Aerospace Corporation uses the fragmentation model IMPACT to simulate debris from explosions and hypervelocity collisions. The model generates debris properties including numbers, masses, spreading speeds, and physical characteristics such as size and area-to-mass ratio. Although the model includes effects of material type on debris characteristics, the limited amount of data available before DebriSat restricted the extent to which the material-based characteristics could be represented.

This paper discusses a number of the observed properties of the larger sample of DebriSat debris characterized over the last year. The debris covers a wider range of materials and a significantly larger size range than in previous studies, enabling the examination of the effects of material on fragment characteristics such as length-to-width ratio, effective density ratio, and area-to-mass ratio. Previous research was limited to examination of small, primarily carbon fiber reinforced polymer (CFRP), fragments in the range of a few millimeters. With the wider range of fragment sizes available in the new data, including debris in the centimeter size range, the paper will examine how the debris fragment characteristics vary with fragment size over multiple orders of magnitude. The paper also examines the modeling implications of the wider range of fragment characteristics available. Areas for model improvements are identified through comparisons with IMPACT results as well as areas where the model can be broadened to include the additional insights provided by the fragment data.