

Statistical Approach on Utilizing Ground-based Experiments to Model Break-up Events

Andrew Vavrin¹, John Seago², Austen King³, Phillip Anz-Meador³, Mark Matney⁴

¹GeoControl Systems- Jacobs JETS II Contract, NASA Orbital Debris Program Office, NASA Johnson Space Center, MC XI5-9E, 2101 NASA Pkwy, Houston, TX 77058, USA

²Oasis T&E- Jacobs JETS II Contract, NASA Orbital Debris Program Office, NASA Johnson Space Center, MC XI5-9E, 2101 NASA Pkwy, Houston, TX 77058, USA

³Jacobs, NASA Orbital Debris Program Office, NASA Johnson Space Center, MC XI5-9E, 2101 NASA Pkwy, Houston, TX 77058, USA,

⁴NASA Orbital Debris Program Office, NASA Johnson Space Center, 2101 NASA Parkway, Mail Code XI5-9E, Houston, TX 77058, USA

ABSTRACT

Two laboratory-based impact tests have been conducted to develop and extend the capability of NASA satellite breakup models. The first experiment, the Satellite Orbital Debris Characterization Impact Test (SOCIT), was conducted by the U.S. Department of Defense and NASA in 1992. It employed a fully functional U.S. Navy Transit spacecraft, fabricated from materials commonly used in the 1960s. SOCIT fragmentation data formed the basis of the current NASA Standard Satellite Breakup Model (SSBM). A second experiment, DebrisSat, was conducted in 2014 by the DebrisSat consortium: the NASA Orbital Debris Program Office, the United States Space Force Space Systems Command, formerly the Air Force Space and Missile Systems Center, the Air Force Arnold Engineering Development Complex, and the University of Florida. This impact test was performed on a high-fidelity mock-up satellite assembled from modern components. Data from both experiments are expected to contribute to the next-generation models for on-orbit breakup analyses, long-term environment predictions, and debris risk assessment.

This paper uses the direct statistical sampling of the SOCIT and DebrisSat data ensembles to model an on-orbit breakup event, rather than the analytic expressions estimated from the samples in the SSBM and its predecessor. This direct method involves drawing fragments (*i.e.*, sampling with replacement) from each fragmentation data-subset containing mass, shape category, material density, characteristic length, mass, and cross-sectional area. As part of the sampling process, the properties of sampled fragment data (*e.g.*, area-to-mass ratios) are numerically checked to ensure they do not contain unrealistic quantities. The process to simulate a breakup cloud composed of fragments from SOCIT and DebrisSat datasets is discussed. The methodology for ensuring that conservation of overall mass of the sampled fragment cloud under this sampling approach is highlighted. Finally, the results are compared with simulated clouds generated from SSBM for specific historical breakup events.