

Hypervelocity Impact Characterization on Hubble Space Telescope Multi-Layer Insulation

Melissa A. Murray⁽¹⁾, Phillip D. Anz-Meador⁽¹⁾, and Heather M. Cowardin⁽²⁾

⁽¹⁾ Jacobs, NASA Orbital Debris Program Office, NASA Johnson Space Center, Mail Code XI5-9E,
2101 NASA Parkway, Houston, TX 77058, USA

⁽²⁾ NASA Orbital Debris Program Office, NASA Johnson Space Center, Mail Code XI5-9E,
2101 NASA Parkway, Houston, TX 77058, USA

ABSTRACT

Multi-layer insulation (MLI) is a common material used on rocket bodies and spacecraft to provide thermal regulation. This material is typically attached on the surface of the object in orbit and is thus exposed to the space environment and to micrometeoroid and orbital debris (MMOD) impacts. Occasionally, these exposed surfaces are returned and used by NASA's Orbital Debris Program Office (ODPO) for analysis. When used to assess impacts on surfaces over time, materials like MLI provide an opportunity for *in situ* measurements to support the Orbital Debris Engineering Model (ORDEM) development and validation.

During the 2009 Hubble Space Telescope (HST) Serving Mission, the MLI blankets covering the HST electronics bays 5, 8, and 10 were removed and subsequently analyzed by the ODPO in 2010. The bay 5 blanket was used in concert with ground-based hypervelocity impact tests on single layer MLI to validate the ORDEM 3.1 computer model of the OD environment, but further research was required to properly differentiate the impact features attributed to MM or OD.

The ORDEM 3.1 validation effort identified several areas of further study to improve model validation and understanding of the space environment. Among these topics are the effects of underlying MLI layers on first layer impact feature characteristics, the effects of space weathering and associated damage to the surface on impact feature characteristics, and the transition from perforating to cratering regions. To better understand hypervelocity impact damage and long-term degradation of MLI surfaces, further hypervelocity impact testing was proposed and completed from 2020 to 2022.

This paper discusses test conditions and parameters with resultant impact hole analyses of single layer versus multi-layered samples, space-exposed samples versus pristine, equivalent samples, and perforation versus cratering criteria in the difficult transition region. Damage equations, with associated uncertainties, are estimated from the test parameters and presented. The results of a feasibility study are described, in which the Scanning Electron Microscopy/Electron Dispersive X-ray was used to examine the MLI layers to differentiate MM and OD impacts. Finally, the extension of HST MLI outcomes and analysis methodology as it applies to future returned MLI samples is discussed.