Highlights of NASA's Orbital Debris Program Office *In Situ* and Laboratory Measurements

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ABSTRACT

NASA's Orbital Debris Program Office (ODPO) maintains various returned spacecraft materials, capabilities, and facilities used for *in situ* and laboratory measurements that directly support orbital debris environmental models. *In situ* measurements include the analysis of exposed and returned hardware surfaces. These surfaces serve as passive sensors for the small-sized micrometeoroid and orbital debris (MMOD) flux below the sensitivity of ground-based radar and optical sensors. Various instruments and techniques are used to determine the size and depth of selected impact features, and – if feasible – the composition of the projectile material. Analysis of the impactor residues enables the differentiation of MM and OD for debris below 1 mm to support modeling the OD environment. In addition, projectiles identified as OD can be further differentiated in low-, medium-, and high- density impactors based on chemical analyses.

In addition to *in situ* measurements, the ODPO has also worked in collaboration with the U.S. Space Force Space Systems Command (formerly the U.S. Air Force Space and Missile Systems Center), the Aerospace Corporation, and the University of Florida on a laboratory-based hypervelocity impact test, DebriSat, conducted at the Air Force Arnold Engineering Development Complex in 2014. The resulting data from this impact test series are being analyzed to assess the fragments' sizes/masses, materials/densities, shapes, and other parameters of interest. The DebriSat project provides the data needed to update NASA's breakup models and size estimation models using the simulated orbital breakup of a modern, low Earth orbit spacecraft. Ultimately, over 200,000 fragments from this impact test will be stored at NASA Johnson Space Center (JSC) and further analyzed by the ODPO. This project will also use machine learning techniques to infer physical parameters of fragments embedded in the soft-catch foam used in the impact experiment. Applied to X-ray imagery of the foam panels, these techniques promise to minimize human-in-the-loop processes for fragment extraction and physical characterization. A brief overview of this project and data collected will be presented.

Lastly, the ODPO provides various capabilities hosted at NASA JSC for optical inspections and measurements using a variety of techniques and scientific instrumentation to support both *in situ* and laboratory measurements. The ODPO's Optical Measurement Center (OMC) is an advanced facility for photometric and spectroscopic laboratory measurements of targets, including fragments from the DebriSat project. The OMC simulates telescopic observations by using space-like illumination conditions and source-target-sensor orientation techniques. Additionally, the OMC is uniquely equipped to acquire pseudo-bidirectional reflectance distribution data for broadband photometric measurements, thus removing aspect angle dependencies that can affect target size estimates using the optical size estimation model. Narrow-band surface material characterization using spectroscopic instrumentation gives insight into how the albedo parameter – also important in the optical size estimation model – may vary depending on the state of the material. The OMC also performs simulations of photometric measurements using optical ray-tracing software to model the OMC optical throughput. In addition to the OMC, the ODPO houses a start-of-the-art Fragment Analysis Facility that uses multiple microscopic inspection instruments to support *in situ* measurements and material characterization. An overview of both facilities will be highlighted in this paper.