Imaging Systems Utilized in the DebriSat Fragment Size Characterization Process

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The DebriSat project was conceived to provide NASA and the DoD with an updated dataset to improve existing satellite break-up models. The DebriSat test article is a 50 kg-class satellite designed with components, materials, and processes commonly utilized in modern LEO satellites. This test article was then subjected to a laboratory hypervelocity impact (HVI) test to emulate a catastrophic on-orbit collision. In the post-HVI phase, fragments from the HVI test are being carefully characterized, where mass and size measurements are taken. Mass balances are used to measure the fragments mass and two imaging systems are utilized to measure the fragments sizes. The two imaging systems are referred to as the 3D and 2D imaging systems, depending on whether or not the fragments minimum dimension is greater than 3 mm; both imaging systems utilize point-and-shoot cameras for image acquisition. The set of parameters calculated by the imaging systems include characteristic length, average cross-sectional area, and volume.

The 3D imaging system uses six point-and-shoot cameras to obtain 126 images of the object on a turntable which are then processed using a space-carving algorithm to generate a 3D point cloud representation of the object. The 2D imaging system takes an image of the fragment from a single point-and-shoot camera and uses an edge detection algorithm to generate a 2D outline of the object. A right-angled prism mirror has been added to provide a side view of the fragment. From the point clouds, the three largest orthogonal dimensions are determined using a convex hull algorithm. The volume and the average cross-sectional area calculations are also computed on the imaging systems. Once the size characteristics are determined, measurement data, images, and associated metadata are archived in the database.

This paper describes the development, operations, and updates to the imaging systems, including automations to minimize operators from physically contacting the system. Additionally, preliminary characterization data from the imagers are also discussed.