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IMPROVING THE CALCULATION OF AVERAGE CROSS-SECTINOAL AREA FOR DEBRISAT FRAGMENTS USING DISCRETE PROJECTED AREAS

Abstract

Debris fragments from the hypervelocity impact testing of DebriSat are being collected and characterized for use in updating existing satellite breakup models. One of the key parameters utilized in these models is the ballistic coefficient of the fragment, which is directly related to its area-to-mass ratio. Typically, the cross-sectional area of the object perpendicular to the direction of motion is used to compute the area-to-mass ratio. However, since the attitude of fragments can vary during their orbital lifetime, it is customary to use the average cross-sectional area in the calculation of the area-to-mass ratio. The average cross-sectional area is defined as the average of the projected surface areas of an object and has been shown to be equal to one-fourth of the total surface area of a convex object. In previous satellite debris studies, average cross-sectional area of debris fragments was estimated based on each fragment's size characteristics (i.e., characteristic length).

An imaging system based on the volumetric reconstruction of a 3D object from multiple 2D photographs of the object was developed for use in determining the size characteristic of the DebriSat fragments. For each fragment, the imaging system captures N images from varied azimuth and elevation angles and processes them using a space-carving algorithm to construct a 3D point cloud of the fragment. Each of the N images is a projected area of the fragment from a particular orientation. This paper describes a process by which the N discrete projected areas of the fragment can be used to calculate the fragment's average cross-sectional area. Initially, three numerical observation scenarios are investigated to gain insight into computing average cross-sectional area from discrete projected areas. The insight gained from these investigations is then applied to calculating average cross-sectional area from the discrete projected areas of the images from the imaging system. The average cross-sectional areas of several convex test objects are computed using actual images from the imaging system and compared to their known values of one-fourth their surface areas. Additionally, for comparison, the average cross-sectional areas for the same test objects were determined using models from previous satellite debris studies. On average, the process described in this paper shows significant improvement in the accuracy of the average cross-sectional area when compared to the results from the previous models for the convex test articles examined in this study.