A study of the material density distribution of space debris

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Material density is an important, yet often overlooked, property of orbital debris particles. Many models simply use a typical density to represent all breakup fragments. While adequate for modeling average characteristics in some applications, a single value material density may not be sufficient for reliable impact damage assessments. In an attempt to improve the next generation NASA Orbital Debris Engineering Model, a study on the material density distribution of the breakup fragments has been conducted and summarized in this paper.

The material density distribution of the on-orbit breakup debris population may be estimated by combining three sources of data: available pre-launch information on satellite materials, ground-based satellite breakup experiments, and chemical compositions of residuals collected from returned surfaces. Analysis of these data provides a basis to compile a simple mass density distribution as a function of particle size. For example, about 75% of on-orbit breakup debris fragments come from upper stages, which are simpler and more standardized than payloads in construction and composition. Available material information from manufacturers can be used to develop a reasonable distribution function for this component. For spacecraft breakup debris, it has been found that the range of material densities may be simplified into three representative values: high (e.g. steel), medium (e.g. Aluminum), and low (e.g. plastic). Although the three data sources mentioned above are not comprehensive, and some interpretation and extrapolation are needed, the resulting density distribution still represents a step forward in providing more reliable damage assessments for future debris models.