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Impact-Induced Mission Effects and Risk Assessments (3)

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HOW TO EFFECTIVELY MAP SPACE DEBRIS IMPACT CRATER DISTRIBUTION AND MORPHOLOGY ON SPACECRAFT HULLS

Abstract

Hypervelocity collisions of space infrastructure with space debris are widely considered as one of the major threats to humankind's extended presence in low Earth orbits (LEO). While larger objects can be located, tracked, and its trajectories forecasted to reduce the likelihood of collisions, the greatest risk to space missions comes from non-trackable debris in the critical size range of few millimeters to centimeters. For this category of space debris, spacecraft rely on passive mitigation derived from respective risk assessment simulations. Those simulations are in turn based on statistical particle environment models such as ESA's MASTER and NASA's ORDEM. Within the critical size range, however, these models heavily depend on sparsely available data from in-situ detectors and retrieved hardware, leading to large uncertainties in their flux predictions.

Here, we propose a two-step methodology to retrieve impact crater information in the critical size range by the imaging of spacecraft surfaces. This approach is specifically well suited for the investigation of space infrastructure with prolonged exposure to debris in LEO as well as available onboard imaging capabilities. Specifically, we investigate the requirements for using video imagery to find and characterize debris-related impact craters on the Columbus module of the International Space Station (ISS). Furthermore, we evaluate the application of stereoscopic imaging to determine the morphology of selected craters.

The results of the study are two-fold. On the one hand, we verify the general applicability of the approach for impact crater characterization on spacecraft hulls employing a generic camera model. Additionally, we derive the optimal recording settings for a) the detection and b) the morphological study of small impact craters.

The presented methodology allows for the in-orbit characterization of space debris impact craters on spacecraft. This presents an important step to reduce the uncertainties in current particle environment models and allow for a more precise estimation of impact-related risks for future space missions.