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Impact-Induced Mission Effects and Risk Assessments (3)

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GROUND-BASED EXPERIMENTAL REFLECTANCE VERIFICATION FOR SATELLITE HYPERVELOCITY IMPACT CHARACTERIZATION

Abstract

The increasing amount of space debris in orbit constitutes a significant threat to operational satellites. The development of mitigation risk techniques can leverage thorough research studies on the effects of impacts on surfaces, serving as a valuable resource to investigate the effects of space debris on the space environment. Surface deformation resulting from hypervelocity impacts can be detected through various ground-based experimental techniques. An on-ground experimental study about optical reflectance should be conducted to recognize and assess a pre-launch model that analyzes the potential consequences of in-orbit impacts. In this framework, the Sapienza S5Lab research group is exploiting a ground-based facility able to investigate the optical reflectance behavior of objects' surfaces before and after undergoing deformation due to a simulated impact with a space debris. The system is composed of a camera mounted on a robotic arm and a light source, simulating the solar spectrum, positioned upon an arch rotating along its z-axis. During every simulation, the "Sun" and observer move along a one-meter radius hemisphere centered on the object being analyzed, at defined positions based on the specific study case. The simulations are accomplished on three different 5-centimeter slabs representing a pocket cube side surface. One sample remains intact, while the other two are subjected to a laboratory space debris impact experiment conducted at the University of Padua. The analysis aims to establish a pre-launch database by focusing on the optical reflectance characterization, particularly regarding rotations about the three main body axes. This study serves as an initial step in calibrating the facility, which will be utilized for the comprehensive characterization of the entire satellite, considering its specific features. Several experiments based on the replicas of the CubeSats missions developed at S5Lab have been conducted to reach the ultimate goal in the facility development, which implies the implementation of an on-ground system capable of accurately defining a pre-launch brightness characterization model referred to potential impact scenarios. To enhance the characterization and simulations, additional analyses have been undertaken utilizing an RF tracking system and radio reflection profiling of samples carried out via a drone. This paper examines the conceived method to carry out the simulations, as a scheduled procedure, and the facility implementation together with the components configuration's definition. Finally, a model settlement is presented as a strong basis for future developments in advanced on-ground impacts analysis techniques to mitigate risks and safeguard space assets.