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PRACTICAL PARTICLE IMPACT RISK ASSESSMENT IN SATELLITE PROJECTS

Abstract

This paper presents an overview of standard debris and micro-meteoroid particle impact risk assessment methodologies in satellite projects. Furthermore, it introduces a new approach bridging the gap between low-fidelity early-phase estimations and high-effort later-phase simulations. Demonstrating system reliability with respect to impacts of debris and micro-meteoroid particles is a common requirement found in satellite missions today. Analyses intended to show compliance are of varying complexity, effort and precision. This depends on the phase of the satellite lifecycle, the referenced debris mitigation standard and the system reliability requirements. In general it can be stated that in early phases, such as B1 or B2, preliminary assessments are done. The first step is a simple characterisation of the debris and micro-meteoroid environment in a particular orbit. The next step considers the satellite cross-sectional area as well as preliminary information about the materials and geometric configuration of the structure and unit walls. Results of this step can be used to derive requirements for unit wall thicknesses and materials from a particle impact point of view. At this point, a detailed analysis of debris and micro-meteoroid flux distributions can be used to specify unit wall properties leading to a given probability of no penetration. The overall system probability of no penetration can be computed from the results of detailed 3D impact tools such as ESABASE2. Due to high efforts needed to prepare 3D satellite models for such analyses, those tools are generally used during later design phases. As a result the spacecraft design may need to be modified if vulnerable items are identified. The advanced stage of satellite design at this point makes changes difficult and expensive. It is therefore desired to have analyses in early phases of the design lifecycle with the highest precision possible while keeping analysis efforts to a minimum. A detailed analysis of orbital debris and micro-meteoroid flux data partly bridges the gap between low-fidelity early-phase estimations and high-effort later-phase simulations. It is shown that a thorough analysis of the information already available in early phases does allow drawing more certain and precise conclusions. Consequently, the satellite design can be guided by impact protection requirements in early design phases. This avoids design adaptations in later phases when many parameters have already been fixed. The consequence is an overall cost reduction for impact risk mitigation.