Paper ID: 40460
student

15th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations (IP)

Author: Mr. Mirko Trisolini
University of Southampton, United Kingdom

Dr. Hugh G. Lewis
University of Southampton, United Kingdom
Dr. Camilla Colombo
Politecnico di Milano, Italy

DEMISABILITY AND SURVIVABILITY MULTI-OBJECTIVE OPTIMISATION FOR PRELIMINARY SPACECRAFT DESIGN

Abstract

In a period where the evolution of the space environment is causing increasing concerns for the future of space exploitation and sustainability, the design-for-demise philosophy has gained an increased interest. Nonetheless, satellites designed to demise still have to survive the space environment polluted by space debris for many years. Building a spacecraft such that most of it will demise during the re-entry may lead to designs more vulnerable to debris impacts, thus compromising the reliability of the mission. In fact, the demisability and the survivability of a satellite can both be influenced by a set of common design choices like the material selection, the geometry definition, and the position of the components inside the spacecraft. Given the competing nature of the demisability and the survivability, we have developed a method to evaluate the effect of preliminary design choices on the survivability and demisability of a simplified spacecraft configuration since the early stages of the mission design. First, a demisability and a survivability models have been developed. The improved demisability model exploits a parent-child structure, additionally taking into account the early detachment of external panels and of the internal components connected to them. This is coupled with the survivability model, which can compute the survivability considering different external shielding options and internal configurations. The vulnerability is computed probabilistically using a novel approach, which makes use of the concept of vulnerable zones, avoiding the expensive computations of ray tracing methods. Then, a multi-objective optimisation framework has been developed to find trade-off solutions that consider both demisability and survivability design drivers since the early stages of the mission design. The output from the models is used to compute the two objective functions, which are the two criteria developed to evaluate the level of demisability and of survivability. Starting from the results already obtained for a single type of internal component (i.e. tanks), the analysis is extended, and both the design of internal components and external shielding are considered in the optimisation, including the position of the components inside the spacecraft, which was not directly considered before. The results of the multi-objective optimisation are presented for a simplified representative satellite configuration, and the resulting trade-off solutions displayed as Pareto fronts. The mission scenario considered refers to sun-synchronous missions, as they are highly exploited low Earth orbits with very high commercial value. In addition, they have interesting characteristics for a combined survivability and demisability analysis.