14TH IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Modelling and Risk Analysis (2)

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SPACECRAFT DESIGN OPTIMISATION FOR DEMISE AND SURVIVABILITY

Abstract

Among the mitigation measures introduced to cope with the space debris issue there is the de-orbiting of decommissioned satellites. Guidelines for re-entering objects call for a ground casualty risk no higher than 10-4. To comply with this requirement, satellites can be designed through a design-for-demise philosophy. Still, a spacecraft designed to demise through the atmosphere has to survive the debris populated space environment for many years. The demisability and the survivability of a satellite can both be influenced by a set of common design choices such as the material selection, the geometry definition, and the position of the components inside the spacecraft. Within this context, two models have been developed to analyse the demise and the survivability of satellites. Given the competing nature of the demisability and the survivability requirements, a multi-objective optimisation framework was developed, with the aim to identify trade-off solutions for the preliminary design of satellites. As the problem is nonlinear and involves the combination of continuous and discrete variables, classical derivative based approaches are unsuited and a genetic algorithm was selected instead. The genetic algorithm uses the developed demisability and survivability criteria as the fitness functions of the multi-objective algorithm. The paper presents a test case, which considers the preliminary optimisation of tanks in terms of material, geometry, location and number of tanks for a representative Earth observation mission. The configuration of the external structure of the spacecraft is fixed. Tanks were selected because they are sensitive to both design requirements: they represent critical components in the demise process and impact damage can cause the loss of the mission because of leaking and ruptures. The results present the possible trade off solutions, constituting the Pareto front obtained from the multi-objective optimisation.