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SPACE DEBRIS SYMPOSIUM (A6)
Modelling and Orbit Determination (9)

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SURVIVABILITY AND DEMISE CRITERIA FOR SUSTAINABLE SPACECRAFT DESIGN

Abstract

In the context of a sustainable use of the space, a series of debris mitigation measures have recently been developed, including the de-orbiting of spacecraft at the end of their operational life. The consequent ground casualty risk growth associated with the increased frequency of re-entering objects can be limited by designing a spacecraft following a design for demise philosophy. Still, a spacecraft designed to demise through the atmosphere has to survive the space environment for many years. This means that the spacecraft design has also to take into account the survivability issues associated with on-orbit debris and meteoroids impacts. The paper presents the definition and development of survivability and demisability criteria in order to analyse a simple spacecraft configuration against these two design drivers. Simple objects such as spheres, cylinders and boxes are analysed as representative of spacecraft components and structures. The survivability analysis relies on a panelised geometrical representation of the spacecraft and a debris flux model to evaluate the impacts over the mission lifetime. The penetration of a particle is assessed with ballistic limit equations. The model is then used to compute the penetration probability as the survivability criterion. The demise is examined following an object oriented approach where the aerodynamics and aerothermodynamics are analysed using motion and shape averaged coefficients; the trajectory follows a three degree-of-freedom dynamics, and the ablation is modelled through a lumped mass approach. The results of a demisability analysis are given in the form of residual mass fraction. The defined survivability and demisability models are used to study their sensitivity to various spacecraft design parameters such as the component's shape, material, and wall thickness, but also for different initial orbit conditions and re-entry trajectories from Low Earth Orbit. Results shows how spacecraft design parameters and orbit initial conditions affect the design choices when considering the effects on the demise and survivability of a spacecraft.