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EXTENSION OF ESA'S SURVIVAL AND RISK ANALYSIS TOOL WITH HEMISPHERE AND LATTICE SHAPES

Abstract

The very dynamic nature of space flight activity, in combination with a progressive growth in space debris, requires associated space debris mitigation standards and practices to co-evolve. Similarly, there is a strong need for the development of tools to assess and verify compliance with those standards and derived requirements for specific satellite missions. The Debris Mitigation Facility (DMF) includes a set of activities run by the European Space Agency (ESA) to address those needs. The well-known and widely used Meteoroid and Space Debris Terrestrial Environment Reference (MASTER) model and the Debris Risk Analysis and Mitigation Assessment (DRAMA) tool suite are being combined into a single framework following the model-based engineering paradigm to facilitate mission-centric design and execute dedicated workflows tailored towards the verification of space debris mitigation requirements. This paper will give an overview of some of the new functionalities added to the Survival And Risk Analysis (SARA) module of the Debris Risk Analysis and Mitigation Assessment (DRAMA) tool in the framework of the DMF facility activities. First of all, a new primitive which is a hollow hemisphere has been added. Since no analytical expressions exist for aerothermodynamics, a numerical approach has been taken. A database is created using Computational Fluid Dynamics (CFD) and Direct Simulation Monte-Carlo (DSMC) tools on a discretized set of attitudes, for three flow conditions, and for different stages of the ablation process. The aerodynamic forces and heating rates are normalized so that they can be used during the full trajectory simulation in SARA. Secondly, the overload function has been extended to include the shading effects between over-ridden objects. The overload function can now also be extended by a user-defined database. This overload functionality has been tested on two shapes for which an association with an existing primitive is difficult. The first shape is a shape-optimized bracket, as shown in figure 1. The second shape is a lattice structure as shown in figure 2. The aerodynamic and aerothermal behaviour is characterized using both CFD and DSMC tools. Both shapes have void spaces and thin structures with small local radii, which could improve the demise process with respect to traditional non-optimized shapes. This possible by-product of shape optimization with the objective of mass reduction is also discussed in the current paper.