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UPGRADE OF THE SPACECRAFT ENTRY SURVIVAL ANALYSIS MODULE (SESAM) OF THE ESA'S DEBRIS RISK ASSESSMENT AND MITIGATION ANALYSIS (DRAMA) TOOL

Abstract

In 2015, ESA's "ESA Space Debris Mitigation Compliance Verification Guidelines" handbook was released, dealing with the practical aspects of how missions can demonstrate their compliance to, among others, the applicable maximum on-ground risk figures. To aid various projects in verifying the requirements, ESA's Space Debris Office has initiated the upgrade of the DRAMA "Debris Risk Assessment and Mitigation Analysis" software suite. The software tools provided by DRAMA enable an assessment of mitigation strategies for the operational and disposal phases of a mission, including the risk posed due to mission's space debris and the effectiveness of an end-of-life strategy. Within this framework, DEIMOS Space is responsible for the SESAM (Spacecraft Entry Survival Analysis Module) module of DRAMA, being subcontractor of HTG under an ESA contract. The objective of SESAM is to assess a spacecraft's survivability by modeling the re-entry of a space system into the Earth's atmosphere. The destruction

of a re-entering object is a complex, highly stochastic multi-disciplinary problem. The dynamics of the entry must be coupled with the aerothermodynamics, the thermo-mechanical loads evaluation, and the deformation and fragmentation processes. Together with the detailed modeling of these processes, the object properties in terms of geometry, mass distribution and materials, are also required. Several tools to model the re-entry process have been developed by space agencies and industry. They can be classified in two main categories: object-oriented and spacecraft-oriented. The first is characterized by a finite-element approach to modeling the objects and processes involved; the second uses simpler models of spacecraft and components, together with trajectory and aerothermodynamics calculations to model the demise. SESAM follows the object oriented approach implementing state-of-the-art features and innovative functionalities. Among others, an interesting and unique feature (not found in literature) is implemented: users can build up spacecrafts as combinations of multiple primitives (spheres, cones, cylinders and boxes) with two types of relationships between them: "included in" (one primitive is fully shielded by another one) or "connected to" (two primitives are both partially exposed to the flowfield). This is achieved combining fast aerothermodynamic predictions with innovative shading factors computations (fraction of visible primitives) based on voxels techniques from computer graphics. These relationships are treated as individual thermal connections during the simulation, which interact with the environment and the primitives they connect. SESAM is presented in this paper. Results produced are used by the SERAM module of DRAMA to assess the risk on-ground of objects surviving re-entry.