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# ANALYTICAL APPROACH FOR REENTRY ANALYSIS AND DESIGN FOR DEMISE ASSESSMENTS

**Abstract**

In the frame of ESA CleanSat initiative for Space Debris Mitigation Techniques and Space Sustainability, one of the most important topics is the intentional design of spacecraft hardware in order to obtain a complete ablation to reduce the casualty risk on ground, especially in the case of uncontrolled atmospheric reentry during post mission disposal, noted as Design for Demise (D4D).

This paper is based on the past studies regarding reentry analysis of simple-shaped objects, approximated to spacecraft components, and it is inspired by the theoretical background inside DRAMA, the current ESA tool suite to assess the compliance with international requirements of space missions.

It proposes a fast analytical approach for understanding general processes which lead to demise/survival of reentering objects and to analyze the demise of spherical shells, cylindrical shells, boxes and flat plates. Simplified assumptions have been used like exponential atmosphere above a planar Earth surface, flight dynamic model based on Allen-Eggers theory, Lees stagnation point heat transfer formula, heating based on Stanton number for integral heat transfer, infinite heat conduction within the body and averaged thermal data of materials.

Analytical and numerical models are used in this study and the results which have been achieved, are presented, including demise criteria, demise ranges for several object/material combinations and highlighting the main parameters that influence the demisability of each simple-shaped object.

Based on the mathematical background developed, analytical and numerical tools for design for demise assessment have been developed to perform re-entry analysis and on-ground risk assessment. The results focus on the demisability of the objects in order to gain a deeper understanding in D4D for the benefit of early-phase space mission studies within space industries.

Keywords: Space Debris Mitigation, ESA CleanSat, Design for Demise, Atmospheric Reentry