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DEMISABILITY OF CRITICAL SPACECRAFT COMPONENTS DURING ATMOSPHERIC RE-ENTRY

Abstract

According to international safety guidelines, the on-ground casualty risk for a re-entering object shall not exceed 1 in 10,000. The casualty risk can be reduced in two ways: (1) by selecting a suitable impact area and population density within, or (2) by reducing the casualty area from the surviving fragments. Due to the cost associated with a controlled, targeted re-entry the latter option has attracted much attention. To achieve the requirement by reducing casualty area, the number, size and kinetic energy of the surviving fragments have to be limited.

The fragments which survive re-entry are often from recurring spacecraft components (e.g. propellant tanks, reaction wheels, solar array drive mechanisms, magnetorquers, etc.), therefore the interest of applying designs which increase the demisability of these components is high. Understanding the demise process of these components during re-entry helps in identifying feasible design-for-demise options.

SCARAB (SpaceCraft Atmospheric Re-entry and Aerothermal Break-up) is a high-fidelity software tool developed to simulate the thermal destruction of spacecraft during atmospheric re-entry. It can be used to evaluate the effectiveness of different design-for-demise strategies. For this study, we conducted re-entry risk analysis of two critical spacecraft components, solar array drive mechanism and reaction wheel, using SCARAB. In order to assess the break-up and demise behaviour of the components, detailed models were created using design input from the manufacturers. Initial conditions for the simulations were selected within a release window (60-100 km) along a reference trajectory.

We have investigated the casualty risk metrics for the components. We derived the most-probable casualty area over release altitude, and investigated its uncertainties. Together with the manufacturer, we identified feasible design-for-demise options for the components and evaluated their impact on the casualty risk.