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Author: Dr. David Riley
Deimos Space UK Ltd, United Kingdom

Mrs. Irene Pontijas Fuentes
Deimos Space UK Ltd, United Kingdom
Mr. Jan-Christian Meyer
OHB System AG-Bremen, Germany
Mr. Gerrit Proffe
OHB System AG, Germany
Mr. Tobias Lips
Hypersonic Technology Göttingen, Germany
Ms. Friederike Beyer
ESA, The Netherlands
Mr. Tiago Soares
European Space Agency (ESA), The Netherlands

DESIGN FOR DEMISE: SYSTEMS-LEVEL TECHNIQUES TO REDUCE RE-ENTRY CASUALTY RISK

Abstract

"Design for Demise" considers modifications to spacecraft at different design levels to meet the space debris mitigation requirements. Given the benefits in mass and cost of uncontrolled re-entry within the 25-year timeframe, a requirement is imposed that the risk of casualties must be below 10^{-4} following uncontrolled re-entry. We present a project run for ESA by Deimos Space, together with OHB System and HTG, to identify, analyse and evaluate through detailed simulations a set of techniques to reduce the re-entry casualty risk of any element of a satellite. We identified the elements that are critical from a re-entry point of view based on dedicated simulations, and identified Design for Demise techniques applicable to those critical elements.

To validate the proposed techniques in representative mission scenarios, we applied a number of different Design for Demise techniques to CarbonSat, a proposed ESA Earth Observation mission. We selected a number of changes which could be made at systems level, and developed them via a Concurrent Engineering Facility study to the depth of a mission Phase A, including detailed specification of the changes ensuring technical feasibility. A multi-disciplinary assessment of their advantages and disadvantages was performed. Aspects considered for each technique include its success in reducing the risk, its impact at system level, how broadly applicable it is, and the costs associated with it, including one-off development efforts and recurring costs. Techniques assessed included:

- Designing a spacecraft without some or all of its outer panels
- Using strategically-placed openings or break-out patches in outer panels for early influx of airflow
- Moving critical components such as reaction wheels and magnetorquers outside of the main spacecraft structure
- Using demisable structural joints to encourage early break-up of the spacecraft

- Containment of hard-to-demise components, reducing the total casualty area by holding them together so that they land as a single object

Through object-oriented modelling using Deimos' DEBRIS tool and detailed spacecraft-oriented modelling using HTG's SCARAB tool we assess the reduction in casualty area achieved. For CarbonSat we found that containment gave the best reduction in the casualty area, and that increasing the exposure to airflow made little difference. We discuss the applicability of these results to other spacecraft, and the lessons that can be learned from this process to guide the application of Design for Demise to future missions.