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# THE DESIGN OF A FRAGMENTATION EXPERIMENT FOR A CUBESAT DURING ATMOSPHERIC RE-ENTRY

**Abstract**

Space debris mitigation has become essential for the continued use of space. With the growing space debris population, regulations now require satellites to be removed from populated orbits within 25 years of their mission's end. This has led to a greater number of small-to-medium sized satellite missions using atmospheric re-entry as a method for disposal. To predict and minimise the risk of surviving debris following a satellites re-entry, Design for Demise (D4D) processes using re-entry analysis tools have been developed.

Re-entry analysis tools tend to under-predict satellite survivability during re-entry. To improve these model's additional information is required to better understand the re-entry environment. Early re-entry missions had limited success recording flight data. However, in recent years, the flexibility of tailoring a CubeSat mission to withstand and record re-entry has made these studies more viable. The most prevalent uncertainty in re-entry analysis tools that is yet to be measured during re-entry is satellite fragmentation. Currently, knowledge of satellite fragmentation is limited to interpretations of visual observations of re-entry events from ground or air if an accurate re-entry location and time are known.

As such, STRATHcube, a student-led CubeSat project for Space Situational Awareness developed at the University of Strathclyde, aims with its secondary payload to provide flight data investigating the conditions under which solar panel fragmentation occurs. This experimental payload aims to utilise the flexibility the CubeSat platform provides, developing and testing an initial framework for on-board satellite monitoring during re-entry.

This paper will outline the challenges encountered when designing a CubeSat experiment for re-entry studies. These challenges include limited mass, power and volume inherent to a CubeSat mission, high aerothermal and dynamic loads, potential satellite instability and difficulties in communication, due to limited uplink time prior to satellite demise, as well as difficulties communicating directly with ground stations. The approaches considered and developed for solar panel monitoring and associated re-entry measurements for heat transfer, temperature, velocity, and attitude will be detailed. With a heat flux sensor, thermocouples, pressure sensors, IMU, IR thermal imaging and mechanical break switches considered as potential sensor packages for further testing. Initial re-entry simulations are also used to develop the mission profile and sensor package selection. With these activities, the STRATHcube re-entry

experiment aims to develop a framework for fragmentation studies, with the obtained flight data allowing for greater validation and verification of satellite fragmentation for re-entry tools and D4D.