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EFFECTS OF LONG-TERM EXPOSURE TO THE LOW-EARTH ORBIT ENVIRONMENT ON DRAG AUGMENTATION SYSTEMS

Abstract

Spacecraft in low-Earth orbit are exposed to environmental threats which can lead to material degradation and component failures. The presence of atomic oxygen and collisions from orbital debris have detrimental effects on the structures, thus affecting their performance. Cranfield University has developed a family of drag augmentation systems (DAS), for end-of-life de-orbit of satellites, addressing the space debris challenge and ensuring that satellites operate responsibly and sustainably. De-orbit devices are stowed on-orbit for the duration of the mission lifetime and, once deployed, the devices must withstand this harsh low-Earth environment until re-entry; a process which can take several years.

The DAS' deployable aluminised Kapton sails are particularly susceptible to undercutting by atomic oxygen. Additionally, collisions with debris could accelerate the degradation of the system and generate additional debris. This paper will discuss the results from an ESABASE2 risk assessment study, quantifying the probability of collisions between the deployed drag sail and orbital debris. These results will be compared to a proposed hypervelocity impact testing campaign, detailed in this paper, used to validate the results from ESABASE2 and to confirm that no additional debris will be created upon impact. Similarly, the results from a simulation assessing the reaction of the DAS materials to atomic oxygen will be discussed and compared to a proposed study at a Long Duration Exposure Facility (LDEF).

The atmospheric models required to simulate the aforementioned risks are complex and often fail to accurately predict performance or degradation observed in the space environment. A previous UKSA Pathfinder project, conducted at Cranfield University, highlighted this issue when different atmospheric models with varying levels of solar activity yielded drastically different re-entry times. A comparison will be performed between the results of our simulations and the data from two deployed DAS to validate and improve our models. This research will benefit the wider space community by expanding our understanding of the effects of long-term exposure on certain materials, as well as improving the validity of future low-Earth atmospheric models.