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NUMERICAL EVALUATION OF THE INFLUENCE OF PRE-ARRANGED FAULT LINES IN THE FRAGMENTATION OF SATELLITES SUBJECTED TO HYPERVELOCITY COLLISIONS

Abstract

In this paper, the response of satellites with structural fault lines to high-energy collision is studied to evaluate 1) the damage propagation to the entire structure in presence of fault lines and 2) their influence on the overall satellite fragmentation. A numerical tool called "Collision Simulation Tool", developed in the framework of ESA contract "Numerical simulations for spacecraft catastrophic disruption analysis", led by CISAS-UniPD with Etamax GmbH as subcontractor, has been employed to describe accurate fragment distributions of satellites subjected to hypervelocity impacts.

The 1U CubeSat impact on a satellite designed in the framework of the H2020 project ReDSHIFT, led by CNR-IFAC with DII-UniPD as one partner, has been performed and the relevant results are discussed. The simulations have involved three satellite models in two configurations each. The target is a 7.42 kg satellite composed of a case and an internal equipment tray on which all the subsystems and the payload are mounted. All the components have been reproduced by macro-elements, while their structural connection have been implemented through "links". Three target models have been produced: 1) a "baseline" model, made of linked elements with the same geometry of the CAD model; 2) a "weakened" model, made of the linked elements of the baseline model, except for the case plates and the equipment tray which are divided into 4 plates and weakly linked, therefore representing the fault lines; 3) a "weakened-without-links" model, where the weakened model does not include links. The weakened plates represent the 23% of the target total mass. The impactor has a mass of 1 kg and a velocity of 7 km/s. The impact energy-to-mass ratio (EMR) is 2911 J/g. The impact is simulated in two scenarios: one where the impactor points at the satellite centre of mass and one where the impactor hits a satellite edge. Results show that for a destructive central impact the fault-lines presence reduces the structure energy absorption, resulting in a higher number of small fragments. For a less-destructive impact, such as a glancing impact, the fault-lines presence inhibits the fracture propagation to the entire satellite. This leads to a localized damaged area, a smaller fragment number and a cumulative distribution containing a small number of trackable fragments (this might be more desirable than a high number of not-trackable cm-size fragments). Since collisions might be expected mostly glancing, fault lines may be effective for mitigating space-debris generation and further investigation is recommended.