17th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Impact-Induced Mission Effects and Risk Assessments (3)

Author: Dr. Giulia Sarego
University of Padova, CISAS – "G. Colombo" Center of Studies and Activities for Space, Italy, giulia.sarego@gmail.com

Dr. Matteo Duzzi
T4i, Italy, matteo.duzzi@gmail.com
Dr. Andrea Valmorbida
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, andrea.valmorbida@unipd.it
Dr. Lorenzo Olivieri
CISAS "G. Colombo" - University of Padova, Italy, lorenzo.olivieri@unipd.it
Dr. Cinzia Giacomuzzo
University of Padova, CISAS – "G. Colombo" Center of Studies and Activities for Space,, Italy, cinzia.giacomuzzo@gmail.com
Prof. Alessandro Francesconi
University of Padova - DII/CISAS, Italy, alessandro.francesconi@unipd.it

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.