Paper ID: 28621

66th International Astronautical Congress 2015

SPACE DEBRIS SYMPOSIUM (A6)
Hypervelocity Impacts and Protection (3)

Author: Prof. Alessandro Francesconi
University of Padova - DII/CISAS, Italy, alessandro.francesconi@unipd.it

Dr. Cinzia Giacomuzzo
Italy, cinzia.giacomuzzo@unipd.it
Ms. Laura Bettiol
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, laura.bettiol.1@studenti.unipd.it
Prof. Enrico C. Lorenzini
Università degli Studi di Padova, Italy, enrico.lorenzini@unipd.it

A NEW BALLISTIC LIMIT EQUATION FOR THIN TAPE TETHERS

Abstract

Electrodynamic tethers represent one of the possible means to de-orbit defunct satellites from Low-Earth-Orbit at end of life. However, tethers survivability to orbital debris impacts is still debated because of the large area they expose to the space environment. Recently, increasing consideration has been given to thin-tape tether geometries, whose response to space debris threat is believed to be better than that of round wires. This paper describes a new Ballistic Limit Equation (BLE) applicable for thin tapes, to go beyond previous investigations referring at most to the impact resistance of round-wires (furthermore neglecting the damage dependence from the impact velocity and angle). In this paper, a new approach for BLE derivation is presented, which combines experimental results (in total 24 impact tests) and numerical simulations (in total 112 runs). The resulting BLE is non-monotonic with respect to the impact angle and presents a minimum at certain values of the impact obliquity, depending from the debris size and speed. In other words, the minimum particle diameter which is just able to cut a tape at a given velocity decreases with increasing impact obliquity up to a certain angle above which the damage is reduced due to early debris fragmentation triggered by shock waves propagating into the material. Notably, it has been observed that there is a minimum value of debris velocity v* below which no critical damage is possible and, furthermore, there is a minimum velocity-dependent value d* of debris diameter below which no critical damage is possible. This feature of BLE is extremely important, since it sets a minimum particle diameter for risk assessment and thus excludes a large part of the flux from risk computations. In conclusion, the newly-developed BLE confirms that thin tapes are significantly more resistant than round wires of equivalent cross-section; this is due to the intrinsic ballistic response of tapes, not only to their reduced cross-section at high impact obliquity.