A ballistic limit equation for hypervelocity impacts on CFRP Al H/C satellite structures

S. Ryan (1,2), F. Schäfer (1), R. Destefanis (3), M. Lambert (4)

(1) Fraunhofer-Institut für Kurzzeitdynamik, Ernst-Mach-Institut (EMI), Freiburg, Germany, (2) RMIT University, Melbourne, Australia, (3) Alcatel Alenia Space, Turin, Italy, (4) ESA-ESTEC, Noordwijk, The Netherlands (shannon.ryan@emi.fhg.de / Fax: +49 (0) 761/2714-416 / Phone: +49 (0) 761/2714-402)

Composite sandwich panels consisting of Carbon Fiber Reinforced Plastic facesheets bonded to Aluminum honeycomb cores (CFRP Al H/C SP) are amongst the most commonly used structures for satellites due to their relative low mass and high thermal and mechanical stability. To assess the threat of micrometeoroid/orbital debris (M/OD) on a satellite mission, equations which define the limits of structural perforation in terms of impactor mass, velocity and angle are required. This type of equation is referred to as a Ballistic Limit Equation (BLE). There is presently no validated BLE existing for application in the risk assessment of CFRP Al H/C SP structures.

During a recent experimental test campaign performed in the framework of ESA Contract 16721 (e.g. [1]) using EMI's two-stage light-gas guns, the ballistic performance of multiple representative CFRP Al HC SP structural configurations (GOCE, Radarsat-2, Herschel/Planck, BeppoSax) was investigated. The experimental results have been used to adjust and validate a new empirical BLE derived from an existing Whipple Shield BLE, which provides a significant improvement in the accuracy of ballistic performance prediction over existing techniques. Additionally, the equation is capable of predicting the ballistic limit of an Electronic-box representative structure located behind the structural wall.

Good agreement with the experimental results is achieved for the vast majority of test set-ups. For some set-ups, the ballistic limit was conservatively predicted; however this is attributed to the additional protective merit of the honeycomb core encountered at higher angles of impact obliquity.

In this paper a comparison of the new equation with existing ballistic limit equations is made, and differences in the predictive methodology are discussed. The ballistic performance of the various CFRP Al H/C SP structures tested are compared directly, and with equivalent Al H/C SP structures.

1. F. Schäfer, R. Destefanis, S. Ryan, W. Riedel, M. Lambert. Hypervelocity Impact Testing of CFRP/Al Honeycomb Satellite Structures. *Proc. 4th European Conference on Space Debris*, ESA, Darmstadt, 2005