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

Author: Dr. Hedley Stokes
PHS Space Ltd, United Kingdom, hedley_stokes@msn.com

Mr. Claude Cougnet
EADS Astrium, France, claude.cougnet@airbus.com
Mr. Johannes Gelhaus
Technische Universität Braunschweig, Germany, j.gelhaus@tu-bs.de
Dr. Michael Oswald
EADS Astrium, Germany, michael.oswald@airbus.com
Mr. Uwe Schaefer
EADS Astrium, Germany, Uwe.Schaefer@airbus.com
Mr. Christophe Theroude
EADS Astrium, France, christophe.theroude@airbus.com

A DETAILED IMPACT RISK ASSESSMENT OF TWO LOW EARTH ORBITING SATELLITES

Abstract

With the dramatic increase in debris in low Earth orbit (LEO) during the past decade, it has become increasingly necessary for satellite manufacturers to quantify accurately the impact risk to high-value unmanned spacecraft operating in this region – a fact that has been underlined recently by the emergence of a new international standard, ISO 16126, which describes methods for performing impact risk analyses. A number of software models have been developed over the years which analyse impact risk by calculating the probability of no penetration (PNP) of the outer surfaces of a spacecraft. Whilst this is a reasonable determination for crewed spacecraft, it is inadequate for unmanned spacecraft since there is a significant likelihood that a penetration through the outer structure will not lead to failure. Thus, a higher fidelity analysis is required.

One software model that has been specially designed for this purpose during the past 15 years is SHIELD3. This unique tool has the capability to evaluate the interaction of penetrative particles with equipment inside a spacecraft using a variety of damage equations and debris cloud models. By combining this information with knowledge of the equipment redundancies, the software can calculate the probability of no failure (PNF) of the satellite. Until now the tool has only been used on incomplete or simplified spacecraft designs. However, a project called ReVuS, which is funded by the European Commission's Seventh Framework Programme, has provided the first opportunity to apply SHIELD3 to the designs of two different LEO satellites at a high level of detail.

To analyse the spacecraft – one a radar satellite, the other an optical satellite – the following data inputs were used: MASTER-2009 debris and meteoroid fluxes, IGES graphics files, material properties of all surfaces, and equipment redundancies and failure criteria. The results of the simulations were output in various forms, including: 3D geometrical displays of impact and penetration fluxes, tables of PNPs for individual equipment and PNFs for groups of redundant equipment, and plots of satellite PNF versus impactor size. This latter result was especially interesting as it revealed which particle sizes were the greatest source of impact risk for the two satellites. It also defined the critical size of particle that each satellite must withstand to satisfy a certain PNF requirement. This is important when deciding if additional impact protection is necessary. Suitable protection options will be investigated and reported later in the ReVuS project.