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SPACE DEBRIS RISK ASSESSMENT OF SPACECRAFT PROTECTED BY 3D PRINTED PANELS

Abstract

The work described here has been performed as part of an ongoing EC-funded research project called ReDSHIFT (Revolutionary Design of Spacecraft through Holistic Integration of Future Technologies). This paper focuses on those aspects of ReDSHIFT relating to the protection of spacecraft against space debris. Specifically, a comprehensive debris risk assessment is presented to demonstrate how a spacecraft might benefit from the application of 3D printed shield panels.

As an enabling technology, 3D printing is well suited to rapid prototyping of panel structures. Furthermore, it allows the construction of unusual panel designs which might be difficult to realise using traditional manufacturing techniques. In keeping with the project's holistic design approach, several different multi-functional 3D printed panel designs have been developed and investigated. Two of these panel designs are considered here – a multi-shock panel comprising four equally-spaced bumper layers, and a double-wall panel sandwiching a corrugated bumper layer.

The assessment of a spacecraft employing 3D printed panels was performed using the SHIELD3 impact risk analysis model. SHIELD3 evaluates the survivability of a spacecraft design by simulating the damage caused by penetrative debris impactors to equipment located inside and outside the spacecraft. It does this using a range of empirical damage equations, such as ballistic limit equations and fragmentation cloud models. From these simulations, the software can calculate the 'probability of penetration' of each internal equipment item and therefore the overall 'probability of failure' of the spacecraft. In this study, SHIELD3 computed these probabilities for a simple cube-shaped spacecraft comprising several internal equipment items. The key variable in the analysis was the application of each of the 3D printed panel types to the six outer faces of the spacecraft. Based on an extensive set of simulations it was possible to draw conclusions about the suitability of the panels for protecting spacecraft against space debris. The provision of superior impact protection, especially compared to standard spacecraft structures of equivalent mass, is a particularly important design requirement of the panels.