SPACE DEBRIS SYMPOSIUM (A6)
Poster Session (P)

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AN ANALYTICAL METHOD FOR THE PROPAGATION TOWARDS INTERNAL COMPONENTS OF DEBRIS CLOUDS ORIGINATED BY SPACE DEBRIS IMPACTS ON SPACECRAFT WALLS

Abstract

One of the possible approaches to assess the survivability of spacecraft internal equipment to space debris impacts is to model the debris cloud propagating inside the vehicle after perforation of external walls. In this way, damage to spacecraft components is related to the physical properties of the fragments in the cloud, e.g. mass, trajectory and velocity. Besides a reliable debris cloud model, this approach requires to calculate what part of secondary debris clouds is intercepted by each spacecraft internal equipment and this can become a difficult task when complex geometry is involved and mutual shadowing occurs between adjacent surfaces. This paper describes an explicit analytical method to project debris clouds onto internal components, without the need of ray-tracing each individual particle in the cloud. This simplified procedure employs geometric view factors used for thermal calculations and then applies to them a proper correction which accounts for the debris cloud axis orientation and spread angle. This correction is requested since geometric view factors are obtained for surfaces which emit rays along every direction in the half space containing the target, and hence they are not adequate to simulate the flux of secondary fragments produced by hypervelocity impacts, which is contained in the debris cloud cone. Furthermore, mutual shadowing between components (and hence protecting effects related to different equipment layouts) is automatically accounted by a "second-level" use of the same analytical formulas applicable to "stand-alone" couples of surfaces (with no consideration to shadowing). Finally, for validation purposes, the results obtained with the proposed method are compared with those obtained with a special anisotropic ray-tracing procedure which fires rays only within the debris cloud cone (reference case). It is shown that the analytical method is highly accurate in most practical situations, being a valid and simple alternative to computationally-intensive tray-tracing algorithms.