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# A VULNERABILITY ANALYSIS METHOD OF SPACECRAFT UNDER SPACE DEBRIS IMPACT

**Abstract**

While we assess the space debris impact risks of spacecraft, the probability of no penetration (PNP) is adopted as an accepted criterion. As a common practice, penetration of shield structure does not necessarily result in the failure of a component, and the degradation of component function does not necessarily lead to the failure of the whole spacecraft system. In order to properly assess the failure degree of a spacecraft under the impact of debris, a vulnerability analysis method is proposed in this paper. For the case of satellites, the vulnerability analysis process of a simulated satellite under space debris hypervelocity impact is presented, as well as preliminary results.

Firstly, according to the original mission and the damage degrees of the satellite after being impacted by debris, the damage levels of "K", "A" and "B" are defined. The failure mode and effect analysis (FMEA) is performed to determine the influence degree of sub-system/system function degradation resulting from the failure of component/sub-system.

Furthermore, a method named "shot line" is adopted to assess the damage degree of components of satellite under the impact of debris. The failure criteria and the damage probabilities of components are established by this method, too.

Finally, the satellite system damage probability PK/H of different damage levels is calculated, which is described as a function of Ps and Pk/hi. And the logic relationship and PK/H and Ps or Pk/hi is constructed by Fault Tree Analysis (FTA) . Where, Ps is the impact probability of shield structure of the satellite or exterior shell of a component, obtained by the ORDEM orbital debris environment model. Pk/hi is the failure probability of component i given a hit, determined by FMEA and shot line method.

The presented methodology can be used to predict the influence of the failure of spacecraft system impacted by centimeter-level or millimeter-level space debris, which is significant to the impact risk assessment and shield structure optimization design of spacecraft.