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BUMPER: A TOOL FOR ANALYZING SPACECRAFT MICROMETEOROID AND ORBITAL DEBRIS RISK

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ABSTRACT

Introduction

"*Bumper*" is NASA's computer program for analyzing spacecraft micrometeoroid and orbital debris (MMOD) risk. Bumper was developed in the late-1980s and has been continuously used and maintained since. The user base has grown from a few government entities to now include numerous commercial entities as well. The NASA Johnson Space Center (JSC) Hypervelocity Impact Technology (HVIT) Team is responsible for all aspects of the Bumper software.

Bumper has been used to characterize MMOD risk on hundreds of spacecraft. All of the International Space Station (ISS) modules, visiting vehicles and numerous external components and systems have been analyzed. Bumper was used to analyze each of the Space Shuttle missions since STS-50. The Orion Multi-Purpose Crew Vehicle (MPCV) MMOD shielding is being developed using Bumper as well. Bumper has also been used on numerous telescopes (Hubble, James Webb, and Fermi Gamma-ray Space Telescopes), scientific probes (Stardust, New Hori-

zons, Parker Solar Probe), and Earth observation satellites (Landsat, Joint Polar Satellite System). Bumper is also being used to analyze the micrometeoroid risk and support design of the Deep Space Gateway (DSG) and Mars Sample Return (MSR) missions.

The HVIT Bumper Configuration Control Board (CCB) ensures that all changes to the code are approved, reviewed, and documented. Most of the changes are made to add new MMOD damage "*ballistic limit equations*" (BLEs). BLEs are typically added in response to completion of a hypervelocity impact (HVI) test series and development of an associated BLE. Other less frequent changes include updates of the debris or meteoroid environment models, feature enhancements, and feature retirement. Some BLEs are commercially sensitive and/or proprietary, so the CCB also manages code user-version control and software distribution.

The current version – "Bumper 3" – is a FORTRAN executable that utilizes a 64-bit architecture. Bumper 3 has numerous features that make it a powerful tool for analyzing spacecraft MMOD risk. Bumper uses the latest orbital debris and micrometeoroid environment models. Bumper also easily processes large spacecraft geometry models, recognizes hidden surfaces, permits BLE assignment by name or number, and conducts quality checks of the spacecraft geometry model. Bumper 3 can also be used to estimate the effects of particle penetration through thin, high-standoff distance hardware components such as solar arrays and radiators. This is done using a special HVIT-developed technique know as the "3-Part Analysis."

The paper introduces the Bumper 3 MMOD risk analysis code and provides an example MMOD risk assessment showing Bumper's role in the overall MMOD protection design process.

Figures

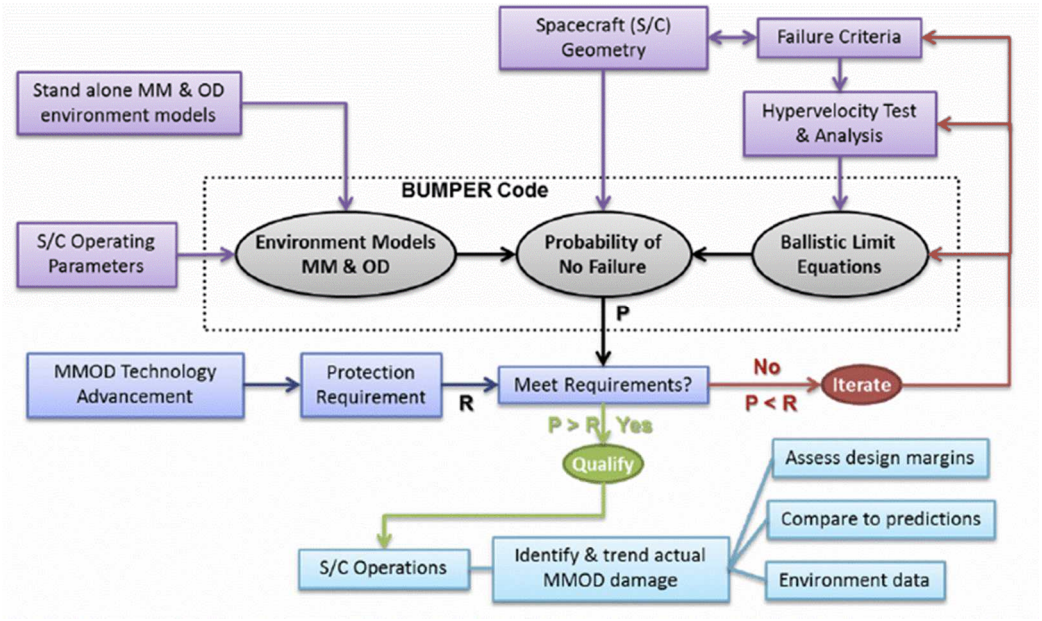

Figure 1 - Spacecraft MMOD Protection Design Process

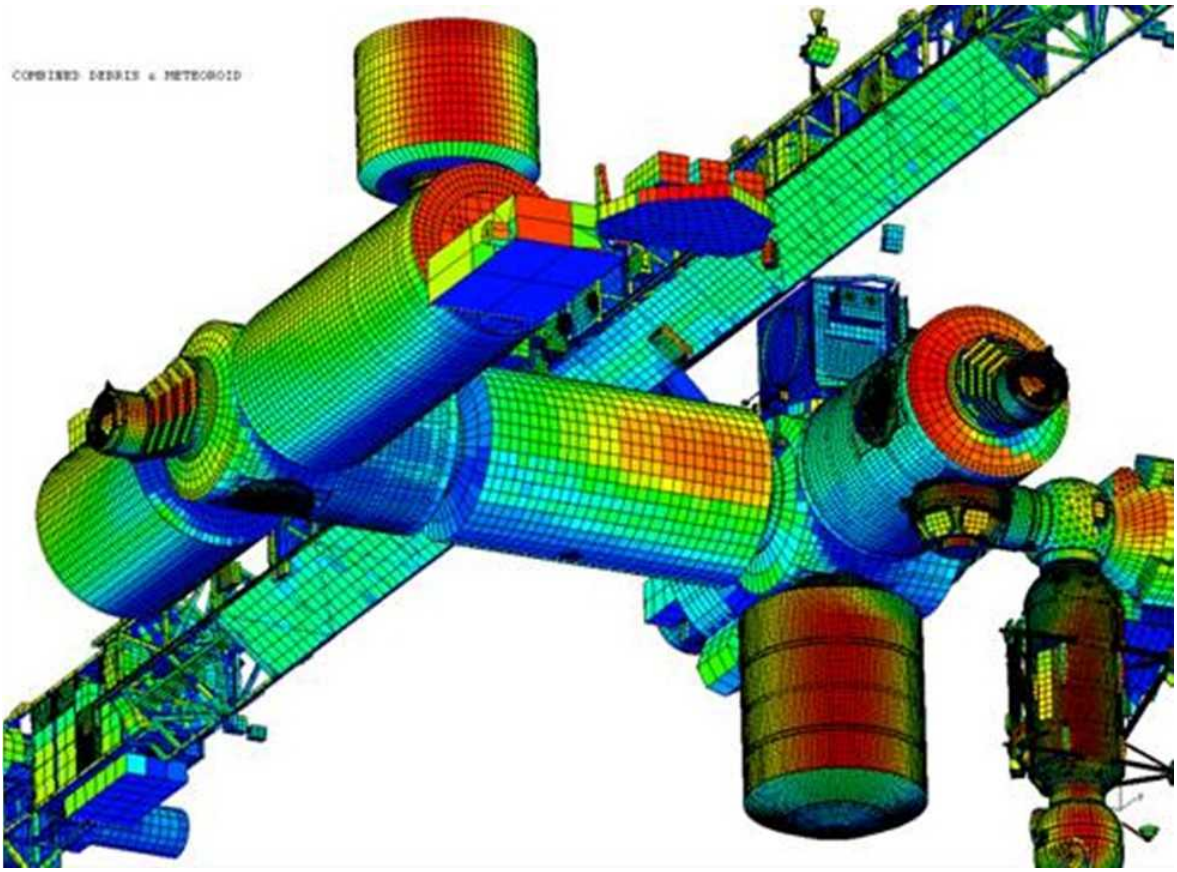

Figure 2 - International Space Station MMOD Impact Risk Color Contour