

Extravehicular Activity Micrometeoroid and Orbital Debris Risk Assessment Methodology

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ABSTRACT

A well-known hazard associated with exposure to the space environment is the risk of vehicle failure due to an impact from an micrometeoroid and orbital debris (MMOD) particle.

Among the vehicles of importance to NASA is the extravehicular mobility unit (EMU) “space-suit” used while performing a US extravehicular activity (EVA). An EMU impact is of great concern as a large leak could prevent an astronaut from safely reaching the airlock in time resulting in a loss of life. For this reason, a risk assessment is provided to the EVA office at the Johnson Space Center (JSC) prior to certification of readiness for each US EVA.

To assess the risk of failure, a detailed finite element model (FEM) of the EMU has been created which has regions for the various shielding configurations. Each shielding configuration is based on the layers and materials over the innermost bladder layer that maintains the acceptable atmospheric environment for the astronaut. Ballistic limit equations (BLE) for each shielding configuration have been determined from hypervelocity impact testing of samples of the EMU layup.

Timelines of each EVA provide the major worksite locations on the International Space Station (ISS) for each of the EVA tasks, and EVA training runs in the Neutral Buoyancy Lab (NBL) determine the appropriate body orientation at each worksite. From this information, the FEM is produced for the specific EVA which includes multiple EMU FEMs (placed at each

worksite location) on a simplified ISS FEM to take into account the effect of shadowing (protection) offered by the ISS structure.

The EVA FEM along with the MMOD environment files (which predict an impacting particle flux based on inputs for orbital parameters, spacecraft attitude and analysis date) are input into the Bumper-3 code to determine a probability of failure for a nominal EVA from the sporadic environment. To address events outside of the background environment, environment factors from the Orbital Debris Program Office at JSC and the Meteoroid Program Office at Marshall Spaceflight Center (MSFC) are used to account for recent orbital debris breakup events and meteor shower activity in the probability of failure. The culmination of the analysis is an EVA risk, like that shown in Figure 1 for a recent, typical EVA. As can be seen in the risk contour, the EVA risk assessment indicate that the gloves, arms and legs are the riskiest regions of the EMU with respect to failures as a result of MMOD.

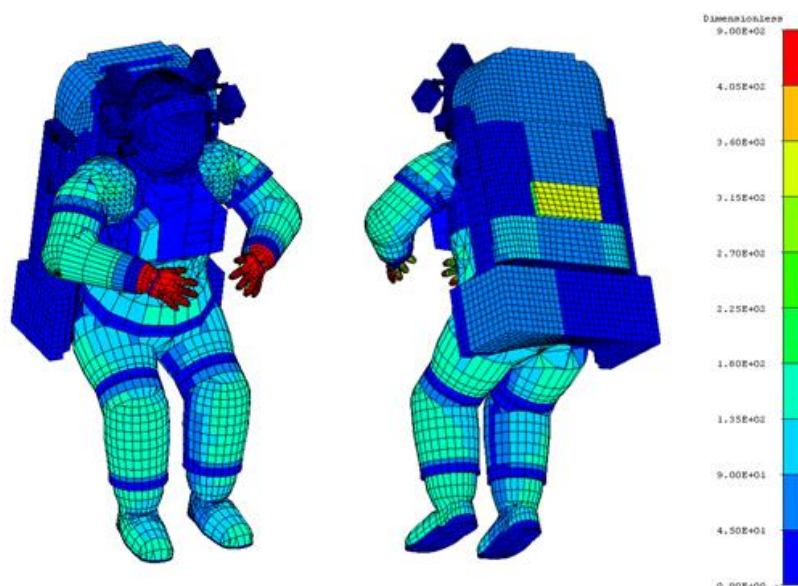


Figure 1 – Extravehicular Mobility Unit MMOD Risk Plot (red areas = higher risk, blue areas = lower risk)