Meteoroid Engineering Model (MEM) 3: NASA’s newest meteoroid model

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ABSTRACT

Meteoroid impacts threaten spacecraft and astronauts at all locations within the Solar System. At certain altitudes in low-Earth orbit, orbital debris dominates the risk, but meteoroids dominate within 250 km of the Earth’s surface and above 4000 km [1]. In interplanetary space, orbital debris is nonexistent and meteoroids constitute the entire population of potentially dangerous impactors.

Meteoroids can induce a variety of effects on a spacecraft surface, including cratering and/or spalling, severing components, attitude disturbances, and the production of conductive plasmas that can prompt harmful electrical discharges. Each effect has a different dependence on impactor mass or size, density, impact angle, and relative speed. Therefore, meteoroid environment models such as MEM must fully describe the directionality, velocity, density, and mass distribution of meteoroids. NASA’s Meteoroid Environment Office (MEO) created the Meteoroid Engineering Model (MEM) to meet this need [2].

We present version 3 of the Meteoroid Engineering Model, which offers numerous improvements over previous versions. For instance, MEM 3 incorporates new meteoroid bulk density distributions based on meteoroid ablation modeling [3, 4]. It more closely matches the meteoroid directionality observed by the Canadian Meteor Orbit Radar (CMOR) [5]. The algorithms for computing the effects of nearby massive bodies have been corrected, and the code also preserves all correlations between speed and directionality. We have validated the code against impact data from the Long Duration Exposure Facility (LDEF) and Pegasus missions as well as meteor radar observations.

MEM 3 also offers several improvements in performance. The code runs about 3 times faster than MEMR2 for the same choice of model fidelity; alternatively, users can opt to generate higher-fidelity results. Sub-models have been eliminated in favor of a single model that automatically detects and handles nearby massive bodies, allowing users to analyze transfer trajectories in a single run. Mercury, Venus, and Mars have been included in addition to the Earth and Moon. MEM 3 offers more user assistance and better error handling in general. Finally, the code now has cross-platform support: command-line versions are available for Mac and Windows users. In summary, MEM 3 offers a more accurate and easier-to-use model of the meteoroid environment in the inner Solar System.

REFERENCES