

Meteoroid and orbital debris fluxes in Earth orbit

William Cooke, Mark Matney, **Althea V. Moorhead**, Andrew Vavrin

Low Earth orbit is populated with a substantial amount of orbital debris, and it is usually assumed that the flux from these objects contributes to most of the hypervelocity particle risk to spacecraft in this region. The meteoroid flux is known to be dominant at very low altitudes (<300 km), where atmospheric drag rapidly removes debris, and at very high altitudes (beyond geostationary), where debris is practically non-existent. The vagueness of these boundaries and repeated questions from spacecraft projects have prompted this work, in which we compare the fluxes of meteoroids and orbital debris capable of producing a millimeter-deep crater in aluminum for circular orbits with altitudes ranging from the top of the atmosphere to 100,000 km. The outputs from the NASA debris and meteoroid models, ORDEM 3.0 and MEMR2, are combined with the modified Cour-Palais ballistic limit equation to make a realistic evaluation of the penetrating particle fluxes, thereby establishing the relative contributions of hazardous debris and meteoroids throughout near-Earth space. It is found that the orbital debris flux strongly depends on altitude and inclination, spanning several orders of magnitude. In contrast, the meteoroid flux varies by only a factor of few over the range of orbits considered. Meteoroids dominate the penetrating flux at altitudes below 250 km and above 4000 km, whereas the orbital debris flux is up to 500 times greater than that of the natural background for high inclination sun-synchronous orbits. The contributions of the two populations to the flux varies significantly with the orientation of the surface relative to the spacecraft velocity. The meteoroid flux is reduced to less than a percent of the total for ram, port and starboard facing surfaces and is greater than or equal to the debris flux for surfaces facing wake and orbital zenith. The results also show that the ideal location for a meteoroid detector in low Earth orbit – if one has to place an instrument there – is on the wake facing surface of a spacecraft in a polar orbit, as the debris flux is less than 1% of that of meteoroids.