# Solid Particle Environment for Herschel and Planck

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In the following the solid particle environment for the Herschel and Planck missions is specified. The given impact fluences and parameters can be used for risk assessments and design purposes.

## Space Debris

Space debris is man-made. Space debris particles are mainly found in Earth orbit at altitudes below 2000 km and in GEO. For the Herschel and Planck missions, assumed to be located at L2 (1500000 km from Earth), impacts from space debris particles can be neglected.

## Meteoroids

Meteoroids are natural particles in space which mainly originate from asteroids or comets. Every spacecraft in orbit is exposed to a certain meteoroid flux.

### Meteoroid fluences

Table 1 gives the predicted number of impacts by micrometeoroids for the Herschel and Planck missions during a period of 1 year. Given are the cumulative values (number of impacts by particles with a given minimum mass or larger) for a range of minimum masses. As indication the corresponding particle diameters are also given, assuming spherical shape and a mass density of 2.0 g/cm$^3$. The calculated fluences are based on the interplanetary meteoroid model at 1 AU as presented in ref. 1. The model is applicable at distances close to 1 AU from the sun.

Given is the number of impacts per year from one side to a randomly oriented surface area of 1 m$^2$.

### Meteoroid streams

The fluences given in Table 1 include yearly averaged contributions from meteoroid streams. Such a consideration of stream effects is usually sufficient for long duration missions like the Herschel and Planck missions. Significant additional contributions from individual streams could only occur if stream fluxes reach storm conditions with impact rates in certain size ranges up to $10^3$ – $10^4$ times the normal background flux for periods of up to a few hours.

**Fluence uncertainties**

The meteoroid fluences for a given mass are considered accurate to within a factor 2.

**Meteoroid velocities**

Near Earth meteoroids which are bound to the solar system can impact a spacecraft with relative velocities of 0 - 72 km/s with an average of 15 - 23 km/s.

**Meteoroid mass densities**

The mass density of meteoroids varies widely from about 0.15 - 8 g/cm$^3$. Estimated average densities range from 0.5 to 2.5 g/cm$^3$.

**Impact directions**

The meteoroid flux model from Ref. 1 assumes an isotropic distribution of the incident particles. This is a reasonable approximation for long duration missions, where directional effects like contributions from individual meteoroid streams will average out. However, for any spacecraft with fixed attitude the motion itself does introduce a directional dependence of the incoming fluxes with highest fluxes on the forward facing surfaces.

## Application Guidelines

For impact risk assessments and design purposes the impact fluences given in Table 1 shall be used. Fluences for intermediate masses can be obtained by interpolation, or be derived directly from the model in Ref.1, which is also included in Ref. 2.

Impact fluences scale linearly with exposed surface area and mission duration.

For all particles a mass density of 2.0 g/cm$^3$ shall be used.

The velocity distribution of impacting meteoroids is given in Ref. 2. For a simplified analysis a constant impact velocity of 20 km/s can be used.

An isotropic incident distribution shall be used for all surfaces. For a simplified analysis a fixed impact direction of 45$^o$ from the surface normal shall be assumed.

To assess the resulting damage the impact fluences will have to be used together with so called damage equations which describe specific impact features (e.g. crater or hole size, penetration capability) as function of the parameters of the incident particle and of the target properties. Equations for many typical damage criteria can be found in the public literature.

More detailed information on the meteoroid flux model, its uncertainties and on the impact risk analysis procedure in general can be found in Ref. 2. In addition, the Inter Agency Debris Committee (IADC) is preparing a Protection Manual, which will contain more detailed information on impact risk procedures, shielding designs and damage equations. This manual should become available at the end of 2002 or in 2003.

## References

1. E. Gruen, H.A. Zook, H. Fechtig and R.H. Giese, 'Collisional Balance of the Meteoroid Complex', Icarus **62**, pp244-272, (1985).

2. European Cooperation for Space Standardization (ECSS), Space Engineering, Space Environment, ECSS-E-10-04A, 21 January 2001.
(The content of this document is available online at:
http://www.estec.esa.nl/wmwww/wma/ecss.html)

**Table 1:** Cumulative number of meteoroid impacts for a range of minimum particle masses for the Herschel and Planck missions. Given are the integrated fluences, $N_{met}$, per $m^2$ of meteoroids of given mass, m, or larger to one side of a randomly oriented surface for an exposure duration of 1 year. Spherical shape and a mass density of 2.0 $g/cm^3$ were used to convert masses to diameters.

| Minimum Mass [g] | Diameter [mm] | $N_{met}$ [$/m^2$/year] |
|---|---|---|
| 1.0 E-13 | 4.57 E-4 | 2.63 E+3 |
| 1.0 E-12 | 9.85 E-4 | 1.09 E+3 |
| 1.0 E-11 | 2.12 E-3 | 4.73 E+2 |
| 1.0 E-10 | 4.57 E-3 | 202 |
| 1.0 E-9 | 9.85 E-3 | 95.4 |
| 1.0 E-8 | 2.12 E-2 | 37.5 |
| 1.0 E-7 | 4.57 E-2 | 9.58 |
| 1.0 E-6 | 9.85 E-2 | 1.49 |
| 1.0 E-5 | 0.212 | 0.147 |
| 1.0 E-4 | 0.457 | 1.04 E-2 |
| 1.0 E-3 | 0.985 | 5.99 E-4 |
| 1.0 E-2 | 2.12 | 3.08 E-5 |
| 0.1 | 4.57 | 1.50 E-6 |
| 1.0 | 9.85 | 7.04 E-8 |