Effects of Operating Parameters on MMOD Risk
NASA Hypervelocity Impact Technology (HVIT) Group

Eric Christiansen/JSC-XI4
Dana Lear/JSC-XI4
Jim Hyde/JSC-XI4 (JETS)
Presentation Overview

• **Effects on MMOD Risk:**
  – Altitude
    • Debris
    • Meteoroid
  – Inclination
  – Year of Flight
  – Spacecraft Orientation
  – Mission Duration
Effect of Altitude on MMOD Risk: Debris

- Debris flux varies significantly with altitude
- Generally peaks in the 800-1000 km altitude range

Debris Risk versus Altitude
(2mm diameter debris, year = 2021, alt 400-1500 km)
• Meteoroid flux is relatively insensitive to altitude
• Increases about 6% between 400km and 1500km
Effect of Inclination on MMOD Risk

- Debris risk increases with inclination and levels out/decreases between 80-110 degrees

Debris Risk versus Inclination
(2mm diameter debris, year = 2021, alt 824 km, inc = 28.5 to 110 degrees)
Debris flux varies each year
Smaller debris particles affected more than large
Effect of Orientation on MMOD Risk

- Orientation can have large effect on risk
- Applies to debris and meteoroids

<table>
<thead>
<tr>
<th>FEM (Color contour: Red = high penetration risk, Blue = low penetration risk)</th>
<th>Number of MMOD Penetrations</th>
<th>PNP</th>
<th>N Ratio</th>
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</thead>
<tbody>
<tr>
<td>9.31E-5</td>
<td>8.22E-5</td>
<td>1.06E-4</td>
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<tr>
<td>0.99991</td>
<td>0.99992</td>
<td>0.99989</td>
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<td>1.13</td>
<td>1.0</td>
<td>1.29</td>
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</tr>
</tbody>
</table>

Source: Ref: TM-2009-214785, Section 2.11.5, p25. (1m diameter by 1.5m long cylinder, year 2010, duration 1 year, 400km altitude, 0.13 cm Al 6061-T6 bumper, 10 cm standoff, 0.32 cm Al 2219-T87 rear wall, ORDEM 2k, 91 Meteoroids)
Effect of Mission Duration on MMOD Risk

- Debris (and meteoroid) risks increase linearly with exposure duration.
Summary

- **Effects on MMOD Risk:**
  - **Altitude**
    - Debris flux varies considerably with altitude
    - Can be significantly higher than at lower altitudes
    - Meteoroid flux is relatively insensitive to increasing altitude
  - **Inclination**
    - Debris risk generally increases with inclination
    - Decreases and increases between 80-110 degrees
  - **Year of Flight**
    - Debris risk generally decreases from 2020-2024
    - Increases from 2024-2030/2031, then decreases
  - **Spacecraft Orientation**
    - Some orientation have lower risk than others
  - **Mission Duration**
    - Debris and meteoroid risks increase linearly with exposure duration