A Europa CubeSat Concept Study for Measuring Europa's Atmosphere

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Task

• JPL is flying Europa Multiple Flyby Mission (Europa Clipper) – Launches mid 2020s
• Interested in what could be done with a 3U CubeSat deployed from the clipper
• Resulted in DARCSIDE
  • Deployable Atmospheric Reconnaissance CubeSat with Sputtering Ion Detector at Europa
Europa Atmosphere

- Decided to study Europa’s atmosphere
- Two Experiments
  - Drag measurement – Heritage to Mars aerobraking
  - High energy particle detector – Heritage to Voyager particle detectors
- Want to improve understanding of icy satellites (moons)
- Implications for understanding Europa’s surface
Formation of Europa’s Atmosphere

McGrath et al. (2009)
Planetary Protection

• Planetary Protection Category III Mission
  • Can never touch the surface of Europa
  • Has significant implications for mission termination sequence
Mission Design
Orbital Trajectory

• Release shortly before apogee
• Cruise 175.66h (7 days)
• Burn right before Europa increases drag & sets up bi-elliptic transfer
• Targeting a pass over Europa at 1km – 10km
• Mission Termination generates an inclined orbit with a lower perijove then Europa.

<table>
<thead>
<tr>
<th>Maneuver</th>
<th>ΔV (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Burn</td>
<td>3.1</td>
</tr>
<tr>
<td>Optional burn to increase drag</td>
<td>200</td>
</tr>
<tr>
<td>Mission Termination</td>
<td>100</td>
</tr>
<tr>
<td>ADACS &amp; TCM</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>333.1</td>
</tr>
</tbody>
</table>
Particle Detector

- Voyager Heritage

D1-D4 are silicon strip detectors. Each pair, (D1, D2) and (D3, D4), will provide a set of x-y coordinates for the $\Theta$ correction. $\Delta E$ (dE) is measured in each layer. dx is the layer thickness corrected for the angle. The total Energy deposited is the sum of all the $\Delta E$'s. The particle stops before exiting the last layer.

$$dE/dx \sim Z^2/v^2$$
$$E \sim 1/2 m v^2$$
MEMS Nano-G Accelerometer

- Under development by AFRL
- Detection limit of 10 nano-g ($9.8 \times 10^{-8} m/s$)
- Capable of measuring predicted drag on DARCSIDE

Deployables
Europa Atmosphere models

• Used published models to initialize Europa’s neutral atom torus
• Assumed atmospheric models based on two particle populations:
  • Bound (but exponentially decreasing w/altitude)
  • Escaping
• Computed family of atmospheric density profiles with range of surface gas densities
Atmosphere Density

Modeled Density Profile Variations with Surface Density

- Low Escaping + Scale Height
- Escaping + Scale Height
- Escaping Plume + Scale Height

Altitude (km)

Density (kg km\(^{-3}\))
Drag Estimates

Acceleration as a Function of Time (500 km)

**DARCSIDE**

- Low Escaping + Scale Height
- Escaping + Scale Height
- Escaping Plume + Scale Height
- ADES Detection Cutoff

**EUROPA CLIPPER**

- Low Escaping + Scale Height
- Escaping + Scale Height
- Escaping Plume + Scale Height
- ADES Detection Cutoff
DARCSIDE Spacecraft Bus
DARCSIDE Avionics

Star Trackers

Accelerometer

Avionics Stack (CDH, EPS, COMM)
Questions?