Comparison of JGO and JEO

Christian Erd, Karla Clark

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### Baseline Mission Driving Requirements

<table>
<thead>
<tr>
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<th>JEO</th>
<th>JGO</th>
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<tbody>
<tr>
<td>Mission Lifetime</td>
<td>~9 years</td>
<td>~9 years</td>
</tr>
<tr>
<td>Range to Sun</td>
<td>~0.7 AU to 6 AU</td>
<td>~0.7 AU to 6 AU</td>
</tr>
<tr>
<td>Parts Class</td>
<td>Class S, QML V</td>
<td>Class S, QML V</td>
</tr>
<tr>
<td>FPGAs</td>
<td>Not yet approved</td>
<td>Approved</td>
</tr>
<tr>
<td>Die Level Rad Hardness</td>
<td>100 krad</td>
<td>No requirement</td>
</tr>
<tr>
<td>APML</td>
<td>Required</td>
<td>Recommended, also suggest COTS, but with verification</td>
</tr>
<tr>
<td>Power</td>
<td>Constrained (5 MMRTGs)</td>
<td>Constrained (Solar)</td>
</tr>
<tr>
<td>Mass</td>
<td>Constrained (Atlas V 551)</td>
<td>Constrained (Ariane V)</td>
</tr>
<tr>
<td>Heritage</td>
<td>No direct heritage</td>
<td>Useful heritage from Bepi Colombo and Rosetta</td>
</tr>
<tr>
<td>Radiation</td>
<td>See next pages</td>
<td>See next pages</td>
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*Requirements similar but mission designs impose unique challenges*
Radiation: TID

Dose-depth curve for both JEO and JGO

- Factor of \( \approx 10 \) difference at 10 mm (394 mils)
- Factor of \( \approx 3 \) difference at 2.5 mm (100 mils)

TID Radiation can be a long term performance issue
Radiation: Flux

Unshielded Flux levels for Juno, JEO at Io and Europa and JGO at Ganymede and Callisto

JGO reduces the instantaneous flux requirement by staying away from Io and Europa’s orbits

Flux-induced transient effects vary depending on point in tour
Baseline Shielding Approach

**JEO**
- Formal Radiation Design Factor (RDF) of 2 required
  - Part/material shielded to \( \frac{1}{2} \) its capability
- Distributed shielding
  - Centralized 6U chassis for instrument electronics available but not required
  - Instrument Sensors/detectors external to 6U chassis require own shielding

**JGO**
- Formal Radiation Design Factor (RDF) of 2 required
  - Part/material shielded to \( \frac{1}{2} \) its capability
- Combination of vault and spot shielding
  - Central vault for spacecraft and instruments assemblies
  - Instrument Sensors/detectors external to vault require own shielding

*Levels of TID radiation influence “system” design implementation*
Radiation: Other

• Charging (surface and internal) issues for JEO would be expected to be more severe than other previous NASA missions due to extended time spent in regions in high electron flux

• Displacement Dose Damage
  – JEO: $1 \times 10^{10}$ MeV/g (or equivalent $2.3 \times 10^{12}$ cm$^{-2}$ of 50 MeV protons) behind 2.5 mm aluminum shielding
  – JGO: $3 \times 10^{8}$ MeV/g (or equivalent $7 \times 10^{10}$ cm$^{-2}$ of 50 MeV protons) behind 10 mm aluminum shielding (preliminary estimate)

• Single Events Effects
  – SEE environment for both JEO and JGO are dominated by Galactic Cosmic Rays
    ▪ Similar to other missions
  – Trapped protons and heavy ions are NOT significant factor except for extremely lightly shielded components

**JEO instruments would need to design to more stringent radiation levels**
Planetary Protection

**JEO**
- Provisional Category III
- $1 \times 10^{-4}$ on contaminating Europa’s (or Callisto’s or Ganymede’s) Ocean
- Selected approach requires all hardware to be sterile at Europa Orbit Insertion
  - Pre-launch - Dry Heat Microbial Reduction or Radiation
  - Post Launch - Radiation

**JGO**
- Expected Category II+
- Likely requirement: $1 \times 10^{-4}$ on contaminating Ganymede’s (or Callisto’s or Europa’s) Ocean
- Selected approach requires basic cleanliness during assembly but not sterilization; and set of analyses (trajectory, reliability, etc.)

*Strict sterilization requirements for JEO may imply instrument redesign*
Summary

• Basic requirement classes are similar
• Minimum distance of JEO is closer to Jupiter – higher radiation environment
• Requirement levels would be generally more stringent & challenging for JEO
• Instruments proposed for both spacecraft should design for each application separately
  – Specifically addressing the challenges of JEO
  – Avoid over-designing for JGO