**Two Deep Space Mission Concepts using Small Radioisotope Power Systems**

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The Radioisotope Power Systems (RPS) Program Mission Analysis Team objectives for these two mission concept studies were to explore capabilities that could utilize small size RPS power options and determine optimal qualities of small and very small RPS with anticipated mission applications for low-cost, low-mass missions.

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**CENTAUR FLYBY**

**Study Goals:**
- Determine if Discovery-class missions can be enabled by small RPS
- Determine if mission concepts can be closed with one GPHS module.
- Understand the science and mission drivers for power needs.
- Determine utility of different configurations of small RPS for supporting science investigations via power or payload system trades:
  - Payload trade: Instrument selection, number of instruments
  - RPS trade: Number of RPS, number of GPHS per RPS, small RTG and small SRG
- Number of Spacecraft
- Number of Objects to flyby

**Study Guidelines:**
- Baseline of 4 spacecraft each in 100 kg range
- Study standalone spacecraft enabled by small RPS
- Each spacecraft uses same configuration with same science instruments
- All spacecraft could be launched on the same launch vehicle
- Discovery class cost profile
- Launch date to be after 2020, small RPS available within 7 years
- Use of small (20-60 W) radioisotope power
- Reasonable power level available for timely data return
- Battery supplies additional power during science operations and data return communication periods

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**Small RPS Concepts**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1-GPHS Small SRG</th>
<th>1-GPHS Small RTG</th>
<th>3-GPHS Small RTG</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOM Power</td>
<td>58 W</td>
<td>21 W</td>
<td>64 W</td>
</tr>
<tr>
<td>EOM Power</td>
<td>46 W</td>
<td>14 W</td>
<td>42 W</td>
</tr>
<tr>
<td>Mass</td>
<td>10 kg</td>
<td>10 kg</td>
<td>20 kg</td>
</tr>
<tr>
<td>Dimensions</td>
<td>49 x 70 x 18 cm</td>
<td>64 cm diameter (incl fins), 17 cm height</td>
<td>31 cm height</td>
</tr>
<tr>
<td>Cold-side Temp (BOM, 4K sink)</td>
<td>313 K</td>
<td>325 K</td>
<td>323 K</td>
</tr>
<tr>
<td>Voltage</td>
<td>28 ± 6 V</td>
<td>5 ± 1 V</td>
<td>28 ± 6 V</td>
</tr>
<tr>
<td>Degradation</td>
<td>1.16%/year</td>
<td>2.5%/year</td>
<td>2.5%/year</td>
</tr>
<tr>
<td>Efficiency (BOM)</td>
<td>3.5%</td>
<td>2.9%</td>
<td>2.9%</td>
</tr>
</tbody>
</table>

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**Mission Description**

The **Centaur Flyby** mission concept would send four similar or identical 170 kg SmallSats to at least two different Centaur objects, with the study focusing primarily on 2060 Chiron. The mission concept would perform New Frontiers level science; the specifics science goals would have to characterize the Centaur targets by determining:

- **Surface Morphology** via camera
- **Structure** via gravity structure with two-way Doppler radio
- **Composition** via hyperspectral IR spectrometer

The concept payload consists of an imaging camera, based on MESSENGER MDIS Narrow Angle Camera (NAC) heritage, and a spectrometer, based on Marco Polo VIS-IR heritage.

**mW RPS Concepts**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hf-2</th>
<th>BiTe</th>
<th>RCS Propellant Tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration</td>
<td>Single</td>
<td>Stack</td>
<td>Disk</td>
</tr>
<tr>
<td>BOM Power</td>
<td>40 mW</td>
<td>0.1 mW</td>
<td>0.6 mW</td>
</tr>
<tr>
<td>Mass</td>
<td>0.33 kg</td>
<td>0.37 kg</td>
<td>1.35 kg</td>
</tr>
</tbody>
</table>

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**Study Goals:**
- Determine utility of different configurations of mW RPS for supporting science investigations via power or payload system trades:
  - Payload Options
  - RPS-Based RPS: Number of RHUs, Configuration, Number of RPS
- Investigate payload options to determine the sensitivity of the hard lander system to different payloads and ops concepts
  - Option 1: Science Floor
  - Option 2: Augmented payload
  - Additional instruments
  - Increased duty cycle
- Trade across RPS size and configuration to determine impacts on mission design

**Mission Description**

The **Meteorology And Seismology Enabled by Radioisotopes (MASER)** mission concept would use a network of 4+ hard landers as a Mars geophysical and climate network, with long-term seismometry and climate monitoring enabled by RPS. To fit in an EDL aeroshell, the concept would use mW RPS.

The primary science objective of the MASER would be to characterize the internal structure, thermal state, and meteorology of Mars, with the following concept payload: EDL accelerometers, temperature and pressure sensors, seismometer, optical monitor (for suspended dust and vapor), and wind sensor.

The hard landers would use six mW RPS units for a total of ~220 mW power, with ultra-capacitors for peak power requirements. The RPS thermal output would be used to maintain internal temperature. The lander would link with a relay satellite with UHF 10 minutes/day. Landing loads would be 600 g using a parachute and crushable materials.

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**Pre-Decisional Information – For Planning and Discussion Purposes Only**