NEXT Thrusters & Power Processing Units

Scott W. Benson, NASA Glenn Research Center
Discovery Technology Day
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NEXT GFE Project Approach

- PSD considering providing 2 NEXT thrusters and 2 NEXT Power Processing Units (PPU) as GFE to Discovery

- NASA GRC is formulating a possible procurement to complete development of the PPU to TRL6 and to provide PPU and thruster flight hardware
  - Industry Day held in December with substantial industry attendance
  - RFI issued with multiple positive responses received

- As described in RFI, NASA GRC is pursuing a cost-shared development that results in dual-use of the NEXT thruster and PPU technologies

- If a mission using NEXT is not selected, GFE hardware would be preserved for future PSD mission use

*There is no explicit or implied commitment for future procurements in this presentation.*
NEXT Thruster Characteristics

- Thruster characteristics and capabilities established with high-fidelity Prototype Model (PM) unit
- Extended Throttle Levels test-demonstrated and in definition
- Provides higher thrust-to-power capability

Performance Characteristics

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Thruster Power Range, kW</td>
<td>0.5-6.9</td>
</tr>
<tr>
<td>Max. Specific Impulse, sec</td>
<td>4190</td>
</tr>
<tr>
<td>Thrust, mN</td>
<td>26-236</td>
</tr>
<tr>
<td>Max. Thruster Efficiency</td>
<td>71%</td>
</tr>
<tr>
<td>Max. Beam Current, A</td>
<td>3.52</td>
</tr>
<tr>
<td>Max. Beam Voltage, V</td>
<td>1800</td>
</tr>
<tr>
<td>Mass (with harness), kg</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Lifetime Capability

- Thruster long duration test voluntarily terminated in March 2014, fully functional over throttling range
  - 918 kg demonstrated xenon throughput
  - 51,184 hr of operation
  - 35.5 MN-sec total impulse
- >600 kg throughput capability after applying 1.5x qualification factor
- Thruster lifetime margin for missions using > 400 kg throughput should be determined through analysis of a specific mission throttle profile
PPU GFE procurement allows for further development of existing design or new path based on demonstrated design.

Characteristics of existing design shown
- Planning values for consideration only

**Performance Characteristics**

<table>
<thead>
<tr>
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<th>Existing</th>
<th>Planning</th>
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<tbody>
<tr>
<td>Input Power Range, W</td>
<td>630 - 7240</td>
<td>700 - 7375</td>
</tr>
<tr>
<td>Peak Efficiency</td>
<td>95%</td>
<td>93%</td>
</tr>
<tr>
<td>Conducted Waste Heat, $W_T$</td>
<td>75 - 340</td>
<td>160 - 520</td>
</tr>
<tr>
<td>Primary Power Input Voltage, V</td>
<td>82 - 160</td>
<td>TBD</td>
</tr>
<tr>
<td>Housekeeping Input Bus, V</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Housekeeping Power, W</td>
<td>16 - 28</td>
<td>16 - 33</td>
</tr>
<tr>
<td>Mass, kg</td>
<td>33.9</td>
<td>+20% MGA</td>
</tr>
</tbody>
</table>

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NEXT Implementation

- NEXT-based ion propulsion system (IPS) for Discovery
  - Thruster & PPU GFE
  - IPS architecture to be defined by mission
  - Xenon Feed System, Gimbal and Control Interface to be provided within PI-cost

- NEXT technology project also developed:
  - Xenon feed system – TRL 6
  - Gimbal – TRL 5
  - DCIU simulator

DCIU – Digital Control Interface Unit
HPA – High Pressure Assembly
LPA – Low Pressure Assembly

HPA/LPA – Aerojet-Rocketdyne
Gimbal – ATK
TRL Status

- Four independent TRL assessments of NEXT technology

- Thruster: TRL 6 (3 of 4)
  - Prototype Model unit
  - Performance and Functional demonstration, alone and in IPS
  - Thermal characterization and qual-level thermal-vac testing
  - Qual-level vibration testing on NEXT gimbal
  - Lifetime demonstration by test and modeling

- PPU: TRL 4 (3 of 4)
  - Engineering Model unit
  - Performance and Functional demonstration, alone and in IPS
  - Operations in ambient and vacuum across a range of allowable flight temperatures
  - Component failures prevented completion of qual-level environmental testing
Development Schedule

- GFE hardware procurement preparations in progress

- Target schedule:
  - Contract award: October 2014
  - Development phase complete: September 2016 (prior to target date for mission selection)
    - PPU at TRL 6
    - Any design updates to thruster formalized
  - Flight hardware delivery by June 2018
    - PPU and thruster hardware deliveries not necessarily tied together

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AO Library Content

- Anticipated AO Library Content
  - Detailed thruster characteristics
  - Baseline throttle table
  - Extended throttle table and supporting information

- Detailed PPU characteristics (existing design)
- PPU development planning (to be updated as procurement is formalized)

- Thruster and PPU requirements
- Thruster and PPU interface definition

- Control functionality guidance

There is no explicit or implied commitment for future procurements in this presentation.
Contact Information

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Hall Propulsion System Power Processing Unit
Briefing for Discovery AO Technology Day
April 9, 2014

NASA Glenn Research Center
Luis Pinero & Hani Kamhawi

Colorado Power Electronics Inc.
Geoff Drummond and Vlad Shilo
Hall Propulsion Power Processing Unit

• PSD’s In-Space Propulsion Technology (ISPT) Program has been working with a promising SBIR project to develop a low-cost 4.5-kW class wide output range Hall Power Processing Unit (PPU) for Discovery-class planetary missions.
  • Colorado Power Electronics (CPE) has successfully developed a PPU and is poised to take the design to flight certification (TRL 6+) by September 2016.
  • QM PPU will incorporate control electronics for the PPU power modules, VACCO TRL 7 xenon feed system, and thruster/PPU telemetry.
  • CPE has submitted a cost proposal and NASA programs have committed funding to start the effort by next month.

• Designed to operate several Hall thrusters:
  • NASA’s High Voltage Hall Accelerator (HIVHAC), Aerojet-Rocketdyne XR-5 (BPT-4000), Space Systems Loral SPT-140.
  • Thruster acquisition and Hall propulsion system development to be addressed by mission proposal teams.

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Schedule a 1-on-1 session or contact GRC POC for more info.