RPS Looking Forward – Not Back

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Study Objectives

Determine the characteristics of a next-generation RTG that would “best” fulfill Planetary Science Division (PSD) mission needs. This study is limited to systems that convert heat to electricity using thermocouples. “Best” is defined as a confluence of the following factors:

- An RTG that would be useful across the solar system
- An RTG that maximizes the types of potential missions: flyby, orbit, land, rove, boats, submersibles, balloons
- An RTG that has reasonable development risks and timeline
- An RTG that has a value (importance, worth and usefulness) returned to PSD that warrants the investment, as compared with retaining existing baseline systems

Assumptions

- Consideration of investment, development timeline, and risks will be included; a cost estimate to produce the new system will be part of a follow-on task that will look at potential system technologies and concepts and development costs.
- This study will be performed by NASA and DOE and will not include industry. It will include participants from APL, GSFC, GRC, JPL, UDRI, and DOE.
- The notional RPS will be GPHS based and be compatible with current or planned DOE facilities and associated capabilities.

Approach (1/2)

- Mission Set Evaluation:
  - Evaluate the database of mission concepts currently collected and destinations across the solar system to assess Power, Size, and Environments.
  - Draft RTG key requirements for each solar system destination, considering trajectories, mass and flight times.
  - Perform 2-3 mission assessment studies with RTG notional concepts to understand mission impacts to the RTG notional concepts and RTG key requirements. Update key requirements.

Approach (2/3)

- RTG Evaluation:
  - Work with the mission community to assess the perceived needs of a next-generation RTG
    - Collect information from RTG-powered missions managed at JPL and APL
    - Collect information on pros and cons from mission concepts that have considered or are considering flying an RTG, specifically MMRTG or eMMRTG, at APL, GSFC, and JPL.
  - Develop RTG notional concepts to test confluence of technology benefits and RTG key requirements and generator concept drawings. Update key requirements.
  - Assess and trade single RTG vs modular RTG vs multiple RTG designs. Do we keep MMRTG upgraded with the enhanced thermoelectrics (eMMRTG) along with a new deep-space system or do we develop a modular, dual destination system? How does sustainment factor in the long-term availability and costs?

Approach (3/3)

- Technology Evaluation:
  - Develop a risk assessment of the potential next-generation RTG technologies. The technologies considered must be “in-hand”: SKD, SKD/Zintl/LaTe, BiTe, PbTe/TAGS, or SiGe.

“In-hand” technologies	Current generators	Recent generators	Production status of technology
BiTe	N/A	N/A	Commercial and military uses
PbTe/TAGS	MMRTG (MSL, M2020)	SNAP-19 (VKG)	Sustainment of production on-going
SiGe	GPHS RTG (CAS, GLL, ULS, PNH)	MHW-RTG (VGR)	Production halted 10+ years ago
SKD	eMMRTG	N/A	Technology transfer to industry beginning 4th of 6 years
SKD/Zintl/LaTe	Conceptual	N/A	5 yr technology transfer to industry to start in FY19

- Final integration and concepts:
  - Complete concepts and integrate information to finish final out-brief.

Thermoelectrics in Space: A Success Story

RTG-Powered, U.S. Missions

Mission	RTG type (number)	TE	Destination	Launch Year	Mission Length	Power Level***
Transit 4A	SNAP-3B7(1)	PbTe	Earth Orbit	1961	15	2.7
Transit 4B	SNAP-3B8 (1)	PbTe	Earth Orbit	1962	9	2.7
Nimbus 3	SNAP-19 RTG (2)	PbTe	Earth Orbit	1969	> 2.5	~ 56
Apollo 12*	SNAP-27 RTG (1)	PbTe	Lunar Surface	1969	8	~ 70
Pioneer 10	SNAP-19 RTG (4)	PbTe	Outer Planets	1972	34	~ 160
Triad-01-1X	SNAP-9A (1)	PbTe	Earth Orbit	1972	15	~ 35
Pioneer 11	SNAP-19 RTG (4)	PbTe	Outer Planets	1973	35	~ 160
Viking 1	SNAP-19 RTG (2)	PbTe	Mars Surface	1975	> 6	~ 84
Viking 2	SNAP-19 RTG (2)	PbTe	Mars Surface	1975	> 4	~ 84
LES 8	MHW-RTG (2)	Si-Ge	Earth Orbit	1976	15	~ 308
LES 9	MHW-RTG (2)	Si-Ge	Earth Orbit	1976	15	~ 308
Voyager 1	MHW-RTG (3)	Si-Ge	Outer Planets	1977	37	~475
Voyager 2	MHW-RTG (3)	Si-Ge	Outer Planets	1977	37	~475
Galileo	GPHS-RTG (2)	Si-Ge	Outer Planets	1989	14	~ 574
Ulysses	GPHS-RTG (1)	Si-Ge	Outer Planets/Sun	1990	18	~ 283
Cassini	GPHS-RTG (3)	Si-Ge	Outer Planets	1997	11	~ 885
New Horizons	GPHS-RTG (1)	Si-Ge	Outer Planets	2005	9 (17)	~ 246
MSL	MMRTG (1)	PbTe	Mars Surface	2011	4 (to date)	~ 115
*Mars 2020***	*MMRTG (1 baselined)*	*PbTe*	*Mars Surface*	*2020*	*(3)*	*> 110*

*Apollo 12, 14, 15, 16, and 17 **Planned ***Total power at Beginning of Mission (W)*

From a few watts up to ~ 900 W, up to 37 years of operation (and counting)

RTG – Radioisotope Thermoelectric Generator

Schedule Overview

- Schedule Outline
  - Study initiated – 7/19/16
  - Pros & Cons of MMRTG/eMMRTG from flight centers – 8/10/16
  - Mission set identified – August 31, 2016
  - DRAFT RTG requirements developed – September 23, 2016
  - Assess technology risks – October 10, 2016
  - DRAFT RTG Concepts around technologies – October 27, 2016
  - NASA mission assessment of top RTG concepts – November 2016
  - Finalize presentation – December 2016
  - Brief RPSP and PSD – January 2017

Study Deliverable

- Power point briefing on:
  - Key requirements for next-generation RTG(s) concepts
  - Risks associated with development of enabling technologies
  - Risks imposed by minimizing RTG concepts while maximizing destinations
  - RTG notional concept(s) that addresses the requirements and maximizes value (importance, worth, and usefulness)
  - Next steps to developing a next RTG system

Questions?