New Frontiers 3
Use of Radioisotope Heater Units (RHU)

Briefing to

New Frontiers 3 AO Community Workshop

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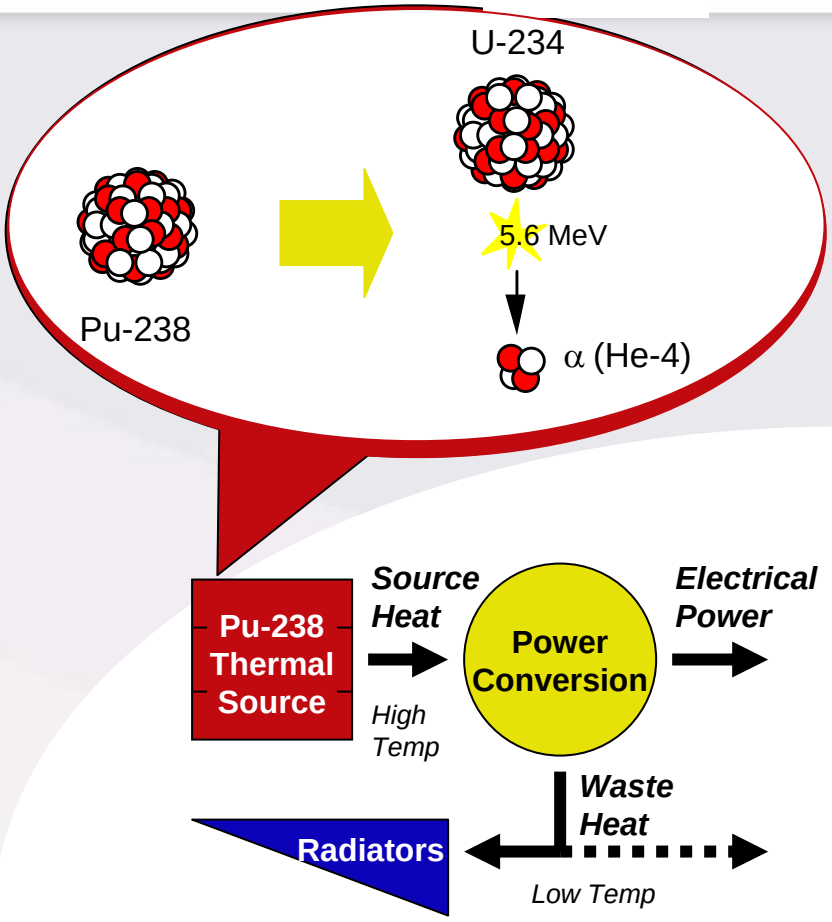
Leonard A. Dudzinski
Program Executive, Radioisotope Power Systems
NASA Headquarters, Science Mission Directorate

Leonard.A.Dudzinski@nasa.gov
202-358-2553 Voice Mail

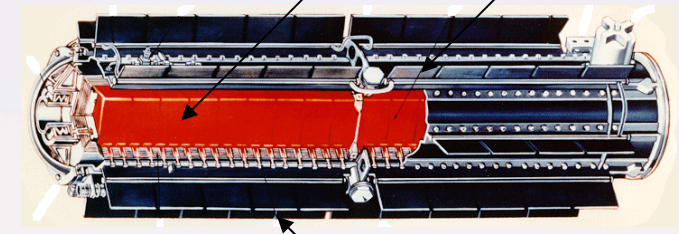
Radioisotope Power Systems (RPS)



- **Heat produced from natural alpha (α) particle decay of Plutonium (Pu-238)**
  - 87.7-year half-life
- **For electrical power generation, a small portion of heat energy (6%-35%) is converted to electricity via passive or dynamic processes**
  - Thermoelectric (existing & under development)
  - Stirling (under development)
  - Brayton, TPV, etc. (future candidates)
- **Waste heat rejected through radiators – or can be utilized for thermal control of spacecraft subsystems**

Radioisotope Power Systems (RPS) are <u>not permitted</u> on missions proposed to NF3 AO.

Radioisotope Heater Units (RHU) are permitted.



GPHS-Radioisotope Thermoelectric Generator (RTG)

Radioisotope Power System Program
Overview

- The RPS Program provides Radioisotope Power Systems capability to NASA's planetary science missions, and other NASA missions that require it
  - Investments are driven by mission need

Program Content

- ASRG development project
  - ASRG development engineering unit (EU) completed
  - ASRG flight system development starting formulation
- MMRTG being readied for flight in MSL project, future flight units uncertain
- Small RPS flight development project being initiated
- RPS technology investments for advanced flight system capabilities
- Technology maturation to ready technologies for flight system development
- Activities supporting RPS use (launch approval, heat source procurement)

The RPS program exists to meet science and exploration needs

Radioisotope Heater Unit (RHU) Definition and Purpose

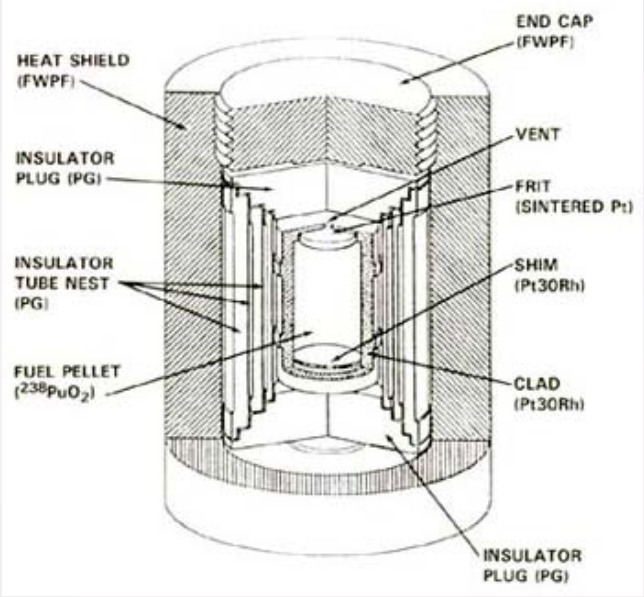
- RHUs are small devices that provide heat through radioactive decay of a small pellet of plutonium dioxide (comprised mostly of plutonium-238).
- Provides highly localized heating of sensitive equipment (such as electronics) in deep space where insolation is an insufficient source of heat.
- Transfers heat to spacecraft structures, systems and instruments directly without moving parts or intervening electronic components

Benefits:

- *Eliminates electric heaters*
- *More electric power for spacecraft, science*
- *Reduced complexity*
- *Less potential EMI*
- *Reliable, consistent thermal power for decades*

Characteristics of RHUs include:

- Highly reliable, continuous, and predictable heat output
- Simple, No moving parts
- Compact structure
- Resistant to radiation and meteorite damage
- Heat produced is independent of distance from the sun
- Heat is transferred through direct contact with components
- Extremely rugged and safe.



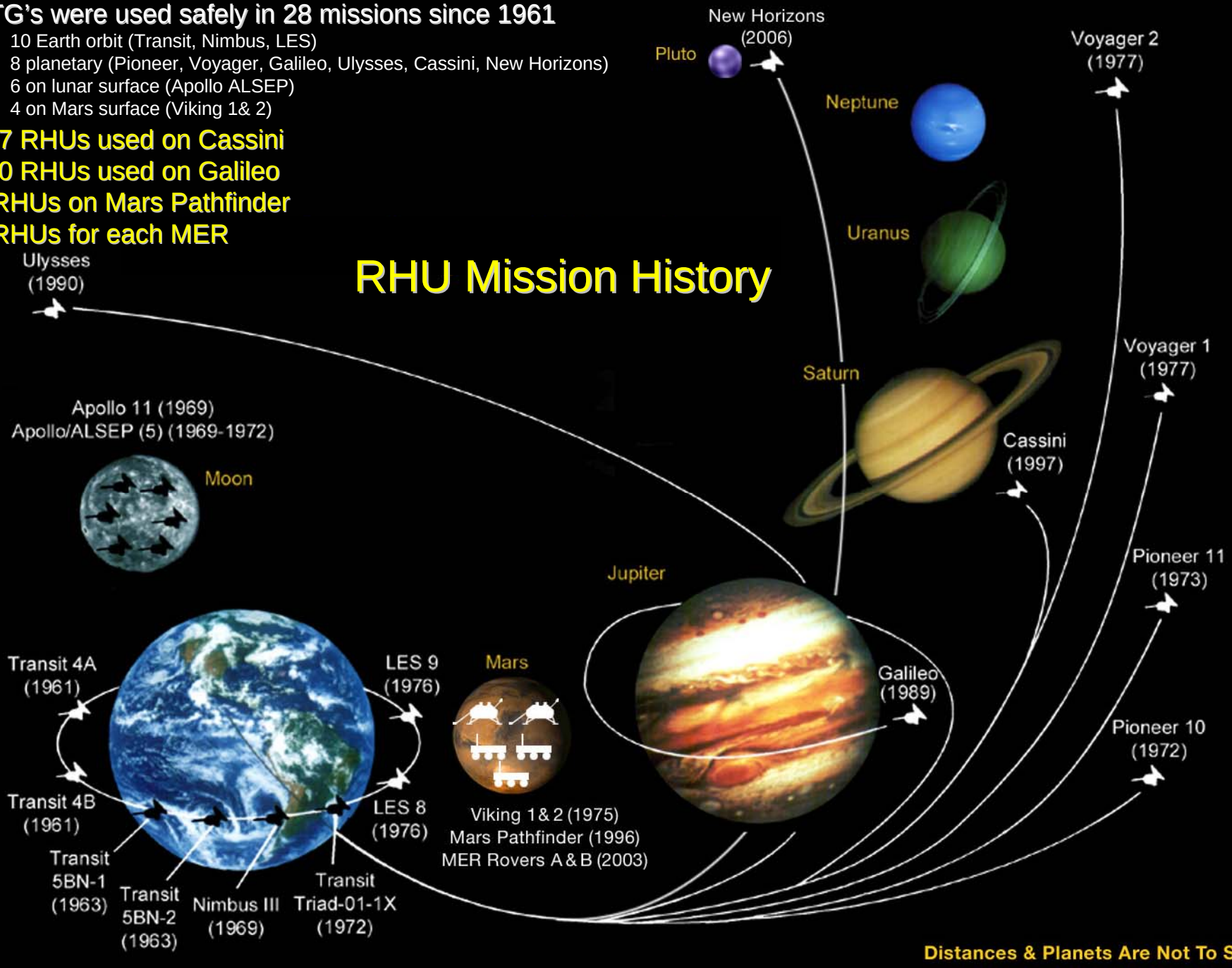
- *1.3 inches long and 1 inch in diameter (the fuel pellet is about the size and shape of a pencil eraser)*
- *Approximately 2.7 grams of plutonium dioxide (2 grams of Pu-238)*
- *Total weight of the RHU is approximately 40 grams (1.4 ounces)*
- *RHUs can be used singly or in groups*
- *Installed via a bolt-on fixture*

RHU Proposal Considerations

- Cost per RHU: (TBD)
  - Missions will pay the replacement cost for each RHU (including DoE expenses)
  - DoE will provide a cost per RHU in the final AO
- Use of RHU on a mission carries additional cost to be managed within the cap
  - National Environmental Policy Act compliance (NEPA)
  - Nuclear Launch Safety Approval (NLSA) requirements
  - Special launch processing and RHU/spacecraft integration at KSC VAF
- Currently DoE has 60 RHUs in inventory, with up to 11 additional that may be made available, based on mission requirements and constraints
- RHUs in inventory range in power from .86 to .92 W_{th} (decayed to a 2012 time frame)
  - Sixty RHUs where made in the mid to late 90's
  - The remaining eleven RHUs where made in 1984
- A plan to produce additional RHUs is in work, additional availability TBD
  - Proposals should limit planned RHU usage accordingly

RHU Mission History

- RTG's were used safely in 28 missions since 1961
  - 10 Earth orbit (Transit, Nimbus, LES)
  - 8 planetary (Pioneer, Voyager, Galileo, Ulysses, Cassini, New Horizons)
  - 6 on lunar surface (Apollo ALSEP)
  - 4 on Mars surface (Viking 1& 2)
- 117 RHUs used on Cassini
- 120 RHUs used on Galileo
- 3 RHUs on Mars Pathfinder
- 8 RHUs for each MER



5.2.5 Use of Radioactive Material *(excerpts taken from draft AO)*

- *Requirement 25:* "The proposal shall include a listing of the estimated radioactive materials to be used (isotope, form, quantity). The proposal shall provide a rationale for the use of radioactive materials and possible alternatives. Include allocation of cost and schedule resources, which is consistent with supporting the NEPA process and the NLSA process."
- "The Proposed use of radioactive materials of any quantity and any isotope…will require review for environmental impact and Nuclear Launch Safety Approval (NLSA)"
  - (NLSA) requirements are specified in NPR 8715.3 Chapter 6
  - Full interagency review and approval of a nuclear launch safety plan from the Executive Office of the President is required for radioisotope power sources per Presidential Directive - National Security Council Memorandum #25 (PD/NSC-25)
  - Preparation of an Environmental Impact Statement (EIS) is required to satisfy the National Environmental Policy Act (NEPA) requirements.
- *Requirement 26:* "The costs of RHUs and their associated services (including NEPA & NLSA) shall be included within the PI-Managed Mission."
  - "If RHUs are to be used NASA and the Department of Energy (DOE) will provide these, as well as the services associated with their provisioning Government-Furnished Equipment (GFE) and Government Furnished Services (GFS)."
  - "Launch processing of a mission that uses RHUs carries an additional cost."