RADIOISOTOPE POWER SYSTEMS PROGRAM

Presentation to
Planetary Advisory Committee
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Power to...
Planned launch 2028
RPS Program Elements

• Deliver reliable radioisotope power systems to enable science and exploration missions resulting in the following tangible outcomes over time

- Flights of RPS powered science missions
- Sustaining RPS capabilities for future missions (talent, infrastructure, and production)
- Efficient and cost effective NEPA and launch authorization
- Develop a new vacuum rated RPS for future missions
- Develop technologies for future flight systems

HQ Program Commitment Agreement (PCA) update includes focus on commercial and international RPS development opportunities
RPS Program Functionality

Program Integration
- Scheduling
- Risk Management
- Acquisitions and Contract Management
- Budget Analysis/Planning/Forecasting
- Export Control
- CM/DM

Mission Integration
- RPS/RHU Missions (M2020, Dragonfly)
- AO Formulation and Support
- MMRTG Builds, Users Guides
- Decadal Support
- Modeling and Testing

Stakeholder Engagement
- Strategic Comm
- Public Engagement
- STEM
- Website Design
- Messaging/Branding/Marketing
- Nuclear Community Coordination

NEPA & Launch Authorization
- NEPA Coordination
- Launch Authorization
- Multi-Mission Databooks (MMDB)
- Radiological Contingency Mission Coord w/DOE, KSC
- Policy Support

Systems Engineering & Integration
- Technical management
- Product Realization
- Surrogate Mission Function
- Project IRB Mgt.

Key Technical Support
- JPL
- APL
- Support Service
- Contractors

Department of Energy
- Constant Rate Production and Mission Support

Radioisotope Power Systems Program Office
- Program Manager (PM)
- Deputy Program Manager (DPM)
- Chief Engineer (CE)
- Chief Safety Officer (CSO)
- Administrative

NG RTG Project

HEPGT
NASA Current RPS Missions: The Power to Explore

• Perseverance
  • Launched in July 2020
  • Seeking signs of ancient life and collecting rock and soil sample
  • Provided an MMRTG under budget, ahead of schedule, above power, during the COVID-19 pandemic

• Dragonfly
  • Flights to explore Saturn’s moon Titan, an organic-rich ocean world
  • Planned launch no earlier than 2028
  • A Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) will enable Dragonfly to explore beneath the thick, hazy atmosphere of Titan
NASA Near Future RPS Missions: The Power to Explore

• NASA Rosalind Franklin Project
  • ESA Mars robotic rover mission with NASA contributions
  • NASA-ESA MOU final iterations underway with NASA/DOE
  • Up to 40 LWRHU, and potential to include one Am-241 RHU from UKSA

• Potential New Frontiers Mission
  • Up to 2 MMRTGs and up to 20 LWRHU
  • AO release no earlier than 2026
Technology Investments Enable New Radioisotope Generators

Radioisotope Power System
Heat Source

LWRHU
Light Weight Radioisotope Heater Units

Multi-Mission Radioisotope Power System

MMRTG
Multi-Mission Radioisotope Thermoelectric Generator

Vacuum-Rated Radioisotope Power System

Next Gen RTG
Next Generation Radioisotope Thermoelectric Generator

Current Flight Systems
Lightweight Radioisotope Heater Units (LWRHU)

• Current Cassini-era LWRHUs available (~0.8 $W_{th}$)
• DOE reconstituting approximately 1 $W_{th}$ LWRHU production capability
  • Capability completed at ORNL
  • Capability at INL and LANL to be completed by 2026
  • Dedicated run is planned for 2027

• Documentation
  • LWRHU Programmatic Environmental Assessment completed (cost savings to missions)
  • LWRHU System-Specific Documented Safety Analysis completed and in DOE approval cycle
  • LWRHU User Guide is available for request
Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)

- **F1** on Mars on Curiosity  
  - Current Power $77.2 \text{ We}$
- **F2** on Mars on Perseverance  
  - Current Power $101.9 \text{ We}$
- **F3** at INL ready for a mission  
  - Completed 1-MMRTG 48-couple module
- **F4** slated for Dragonfly  
  - Machined, inspected, cooling tube fatigue analysis

*Current as of December 2023*
Next Gen Mod 1 = ~GPHS-RTG

- A revectored design of the heritage GPHS-RTG was the results of a DOE Phase 1 industry effort for a new technology-based system
- Built by Aerojet Rocketdyne under INL letter contract
- Reestablish GPHS RTG production capability
  - Use of proven heritage design with proven long life and low degradation
  - Cost effective
  - Low risk
- 90% heritage design, but lower heat; lower power; 2 trades going on to consider change to stretch the housing; more efficiency of the couples; EODL~177-210 W_e
- Maintains opportunity for enhancements providing increased performance & greater efficiency (Mod 2)
Congress uses these CJs to appropriate funding to execute (and sometimes modify) the plan.

The Office of Management and Budget (OMB) establishes the plan for NASA to implement, including the required budget on an annual basis through “Congressional Justifications” or CJs.

NASA uses these recommendations to establish a framework plan for potential implementation.

The planetary science Decadal Survey provides recommendations for NASA on science priorities, potential missions, and an overall strategic approach.

The Decadal Survey is also received as input to Congress and OMB, and influences their decision process.

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The power demands of the directed missions identified in the CJs and/or appropriation inform the nuclear fuel supply strategy and is sized to meet anticipated demand.
• **Constant Rate Production**
  • Department of Energy has reestablished the capability to domestically produce plutonium-238 in support of RPS.
  • RPS is well positioned to enable future exploration.

**RPS Fuel Production and Availability**
Alternative Isotopes

- In addition of plutonium-238, research and development in alternative fuels are underway across the industry, both domestic and international.

- A viable fuel alternative should have the following characteristics:
  - Exist in an insoluble form and/or otherwise not be readily absorbed into the body
  - Exist in a form such that it presents no or minimal chemical toxicity
  - Have relatively low neutron, beta, and gamma radiation emissions, so as to not adversely affect spacecraft instruments or require excessively massive shielding
  - Stability at high temperatures, to enable consistent performance over many years
  - Long half-life, so that it can generate for many years sufficient heat for transformation into electricity
  - High power density, so a small amount of it can generate a substantial amount of heat

- Example candidate alternatives:
  - Americium-241 (half-life 432.7 years)
  - Strontium-90 (half-life 28.8 years)

- Technology investments in conversion efficiency has enhanced the viability of alternative isotopes.
Future Systems: NASA Partnerships in Commercial Development

• Zeno: Harmonia Tipping Point award for development of a Stirling RPS utilizing americium-241
  • Project will develop an electrically heated flight-qualification unit and an Am241 heat source

• Aerospace Corp & JPL: APPLE NIAC Phase II award to develop ~2 W_e RTG modules that can be configured in multiples on a spacecraft that also utilizes the waste heat
  • Heat source of novel design using plutonium-238 or americium-241

• USNC: Nyx NIAC Phase II award to develop an RPS utilizing a short half-life isotope along with a medium half-life isotope for a novel science mission capability
Launch Authorization Process

- NSPM-20 replaces the prior standard employed (PD/NSC-25) for U.S. Launch Authorization (8/2019)
- NSPM-20 necessitates update to NASA NPRs
  - Guidelines vary with quantity and form of material planned for use, as well as, with potential radiological risk
  - Updating NPR 8715.3D Chapter 6* “Nuclear Safety Launching of Radioactive Materials” to NPR 8715.y for compliance with NSPM-20
    - Interagency Nuclear Safety Review Board (INSRB)
    - Reporting levels and launch authorization vary based on Tier
    - RPS mission require DOE SAR


NSPM-20 Risk-Based Tiered Approval

• Tier I applies when all of the following apply:
  • The quantity of radioactive material equals more than and including 1,000 times the “A2 value” and up to and including 100,000 times the “A2 value” established in the International Atomic Energy Agency’s (IAEA) current standards for safe transport of radioactive material;
  • Safety analysis finds that there is no credible accident scenario (less than 1 in a million chance) that might result in radiation exposure of 5 rem or greater Total Effective Dose (TED) to any member of the public; and
  • The space nuclear system is not a nuclear reactor.

• Tier II applies when any of the following applies:
  • The quantity of radioactive material exceeds 100,000 times the “A2 value” established in the IAEA current standards for safe transport of radioactive material; or
  • Safety analysis finds that the there is a credible accident scenario (greater than or equal to 1 in a million chance) that might result in radiation exposure of 5 rem to 25 rem TED to any member of the public; or
  • The system is a nuclear reactor that uses low-enriched uranium fuel.

• Tier III applies when either of the following applies:
  • Safety analysis finds that there is a credible accident scenario (greater than or equal to 1 in a million chance) that might result in radiation exposure greater than 25 rem TED to any member of the public; or
  • The system is a nuclear reactor using any nuclear fuel other than low-enriched uranium.
Delivering on NASA Missions!

- Dragonfly
- Rosalind Franklin Mission
- New Frontiers 5

Currently within RPS Mission planning set

- Discovery
- Flagship

Under consideration based on PSD budget availability