National Aeronautics and Space Administration

NASA Glenn Nuclear Projects Overview

Space Technology Project Office Summary | Tim Smith | August 1, 2022

FSP Project Overview

STMD Space Nuclear Tech. Portfolio Mgr: Anthony Calomino
GRC Project Manager: Todd Tofil
INL Project Lead: Sebastian Corbisiero
Collaborative Organizations: NASA GRC, DOE-NE, INL

Project's Big Picture

- Develop and deliver a space qualified fission surface power source flight unit to the launch site by 2029
- Project's scope includes the fission power system flight hardware and all development hardware
  - The scope does not include the Lander, Launch Vehicle, Cable Cart, or Rover/Transporter
  - The scope does not include integration with the lander, launch ops or lunar demonstration
  - The Project is a collaboration with DOE
    - Idaho National Laboratory will manage the design and development contracts. Los Alamos provides reactor expertise.
- The Project, through flight hardware delivery, is funded entirely by STMD

Key Performance Points

- 40 kWe output at 120 Vdc
- 6000 kg mass goal, fits on a lander and a rover
- 5 rem/year above background radiation limit at 1km
- Transportable to locations away from the lander
- User loads from 0 to 100% power at the user interface

Acquisition Strategy

Phase 1

- Three, 12-month efforts for an initial design
- Purpose is to show there are viable design options and inform the Phase 2 procurement

Phase 2

- An independent proposal solicitation, evaluation, and selection process to cover DDT&E, including a separate nuclear ground test unit and payload delivery by December 2029

Government Reference Technical Concept

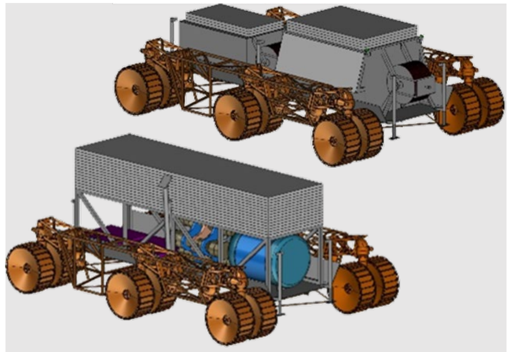
Operations Approach:

- Lander: Provides transit and delivery to the Moon; deploys the FSP System to the lunar surface
- Rover/Transporter: Six-wheel Pressurized Rover chassis

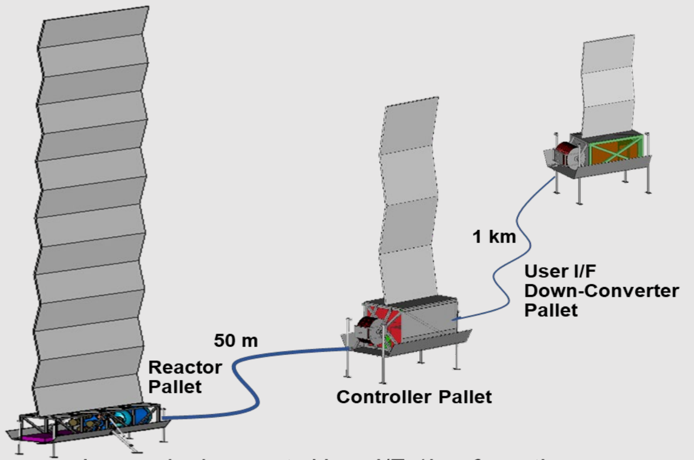
Concept Results (Glenn Research Center's COMPASS Team and FSP Project):

- FSP System delivered in 3 pallets on one lander: Reactor, Controller, Voltage Down-Converter Pallets
  - **Reactor Pallet:** HALEU reactor, power conversion, radiator, RF communication, start-up battery
  - **Controller Pallet:** Stirling controllers, radiator, spool and 50 m cable
  - **Voltage Down-Converter Pallet:** Converts high transmission voltage to 120 Vdc at the user interface. Includes a radiator, spool and 1 km cable

The concept complies with the Phase 1 requirements

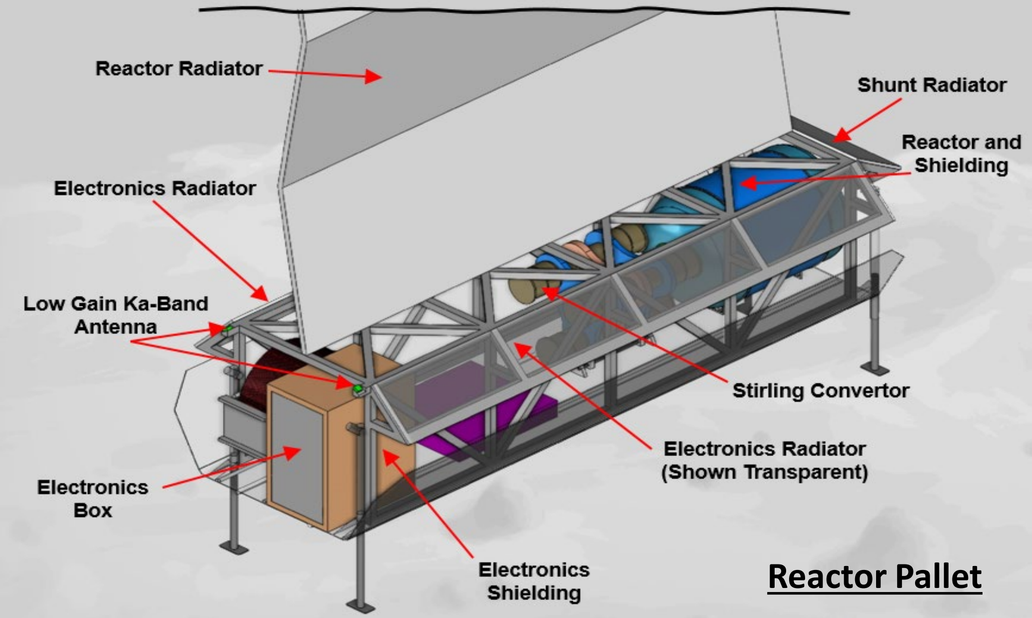


Stowed configuration for lunar transport, 3 pallets



- Lunar deployment. User I/F 1km from the reactor

Deployed configuration



Reactor Pallet

Space Nuclear Propulsion (SNP) Project

Description

- The SNP Project will demonstrate the viability of a high-assay low-enriched uranium (HALEU) fuel elements for a government test reference design
- Three industry teams in Phase 1 are working to design a demonstration-fidelity nuclear thermal propulsion (NTP) system scalable for human transport
- GRC supports by leading materials testing & standards and multi-physics analysis support for proposed FE/ME (fuel/moderator elements)

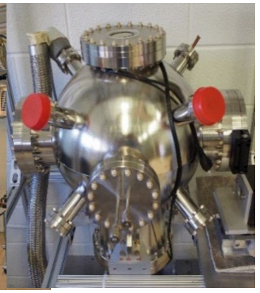
Significance

- Well characterized thermal conductivity and material properties data is essential for reducing model heat transfer uncertainties and determining overall reactor feasibility
- Improving state of the art of materials testing/data gathering for material structural strength in a hot hydrogen environment

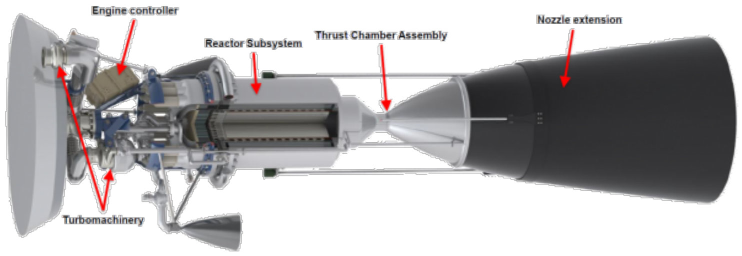
Accomplishments / Activity

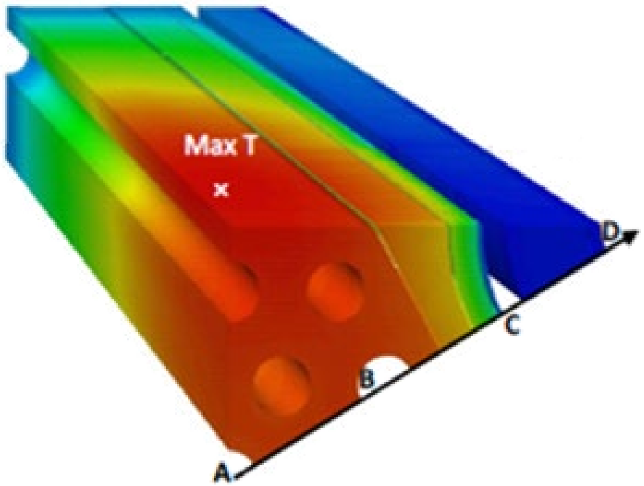
- Updated Materials Data Book released
- Laser Rig - new laser procurement to better couple to expected SNP materials
- Down-selected to chemical reduction method of Mo-30W production and post-processing techniques (CerMet fuel matrix material)
- Provided Training on Numerical Propulsion System Simulation (NPSS) to NASA, Industry and OGA

GRC 3500W CO2 Laser Rig



NTP Test Chamber



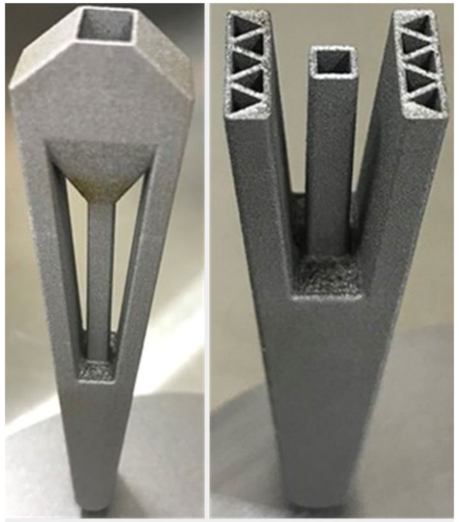


Game Changing Development Program Materials Portfolio

Refractory Alloy Additive Manufacture Build Optimization (RAAMBO)

Project Description:

- New project looking to advance the current state-of-the-art for Additively Manufacturing Refractory Alloys
- Improve performance while reducing mass, production risks, cost and lead time
- Application for Landers, Nuclear Thermal Propulsion, Re-entry vehicles, Green Propulsion, Kilo-Power



AM W Wing Leading Edge

Optimized and Repeatable Components in Additive-Manufacturing (ORCA)

Project Description:

- Radically enhance performance of additive components for full application adoption in landers and industry
- Focus on AM post processing, evolving AM materials, modeling and validation

Post-Process Polishing of AM Metallics

Radioisotope Power Systems Program

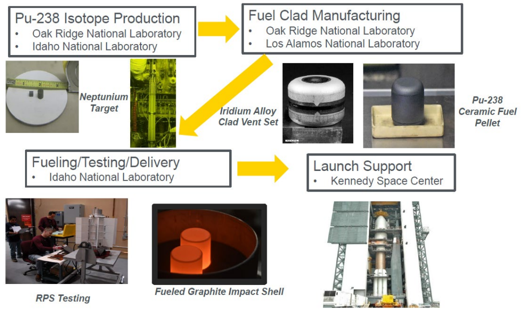
Overview

August 1, 2022

J. Michael Newman
Radioisotope Power System Program Mission Integration Manager

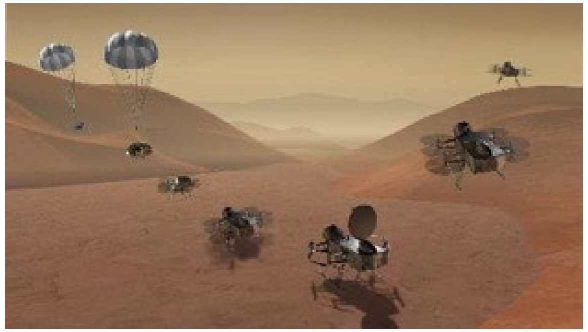
60 Years of Partnership using Radioisotope Power Systems

- 24 Successful RPS Missions Exploring the Solar System
- DOE/NASA partnership with processes to support missions and new system development
- Constant Rate Production (CRP)
  - Sized to meet PSD mission needs, reevaluated on a yearly basis with a 10-year sliding window
    - Increasing plutonium production
  - Investment in infrastructure to reduce risks
    - Hot Press 4 to be completed by the end of this year
- NASA Mission Support
  - Mars 2020 mission – Provided an **MMRTG $14 M under budget**, 2 months **ahead of schedule**, and **6.3 W_e above required power**, all during the unprecedented COVID-19 pandemic
  - Dragonfly mission – Supporting MMRTG trades and NEPA and Launch Authorization
  - DOE holds authority for nuclear activities, similar to NASA technical authority



CRP Supply Chain

Perseverance



Dragonfly

Technology Investments Enable New Radioisotope Generators

Radioisotope Power System Heat Source

Multi-Mission Radioisotope Power Systems

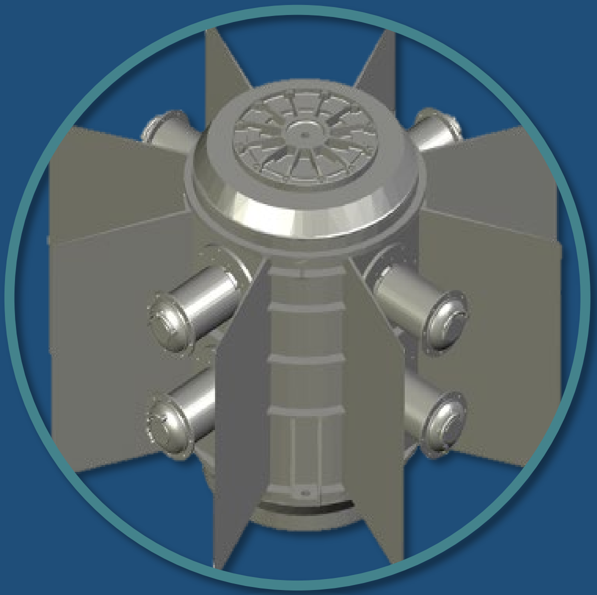
Vacuum Rated Radioisotope Power System

LWRHU

Light Weight Radioisotope Heater Units

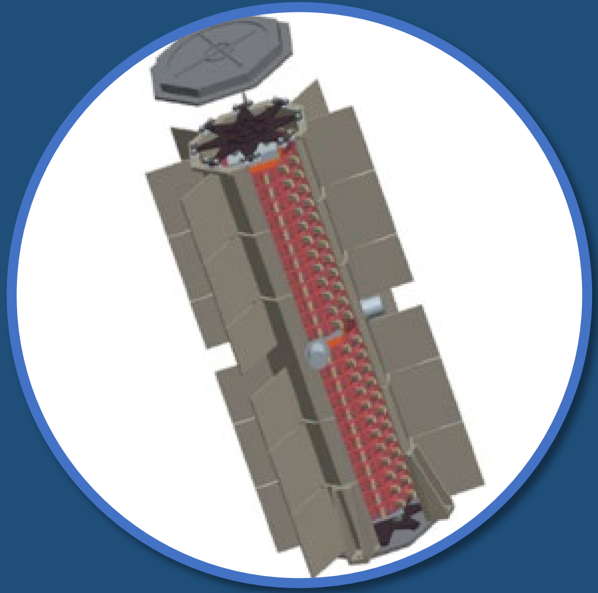
MMRTG

Multi-Mission Radioisotope Thermoelectric Generator



DRPS

Dynamic Radioisotope Power System



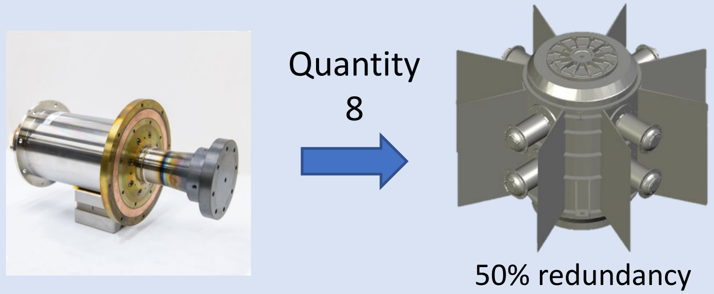
Next Gen RTG

Next Generation Radioisotope Thermoelectric Generator

Status of Dynamic Radioisotope Power Systems (DRPS)

- DRPS provide multi-mission capability with significantly lower HS-PuO_2 consumption and thermal properties that uniquely enable some science missions
- Investment in multiple robust dynamic conversion technologies
- Convertors proven for over 14-year mission duration
  - Several in-hand convertors, linked in design with new convertor systems, have operated for over **15** years each
- Focus on improved reliability and robustness
- DOE flight system design contract initiated in FY21; Aerojet Rocketdyne performing flight design
  - Multi-mission design with lunar surface protoflight as first use
- Protoflight unit to target lunar demonstration
  - Demo serves as pathfinder for dynamic conversion for deep space DRPS-powered missions and for fission-based power designs

Sunpower Free-Piston Stirling



DRPS Goals:

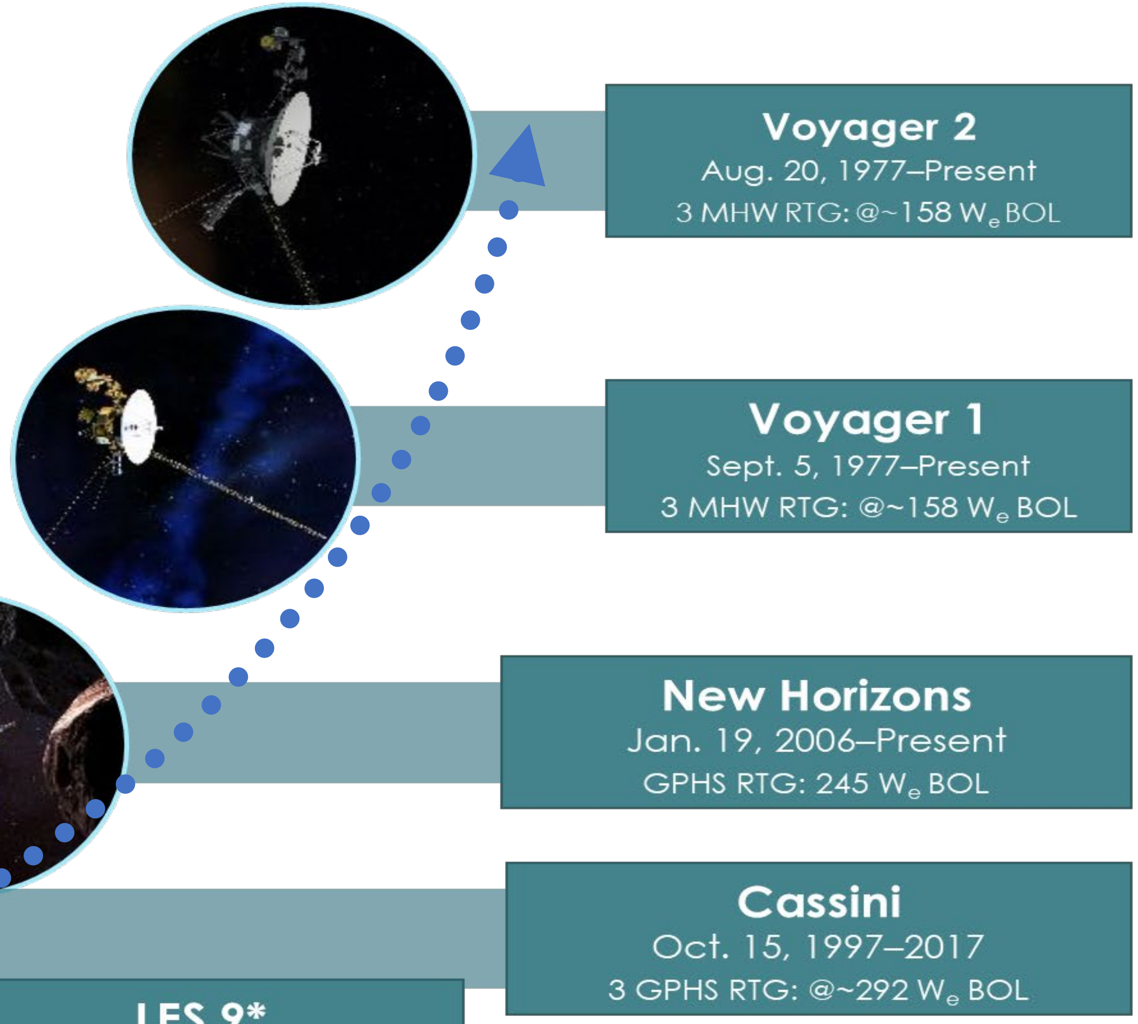
Design lifetime: At least 14 yrs in space

Electrical power output: 300 to 400 W_e, RPS thermal to electric efficiency: > 20%

Capability: On the lunar surface, in the vacuum of deep space, in the atmospheres of planets such as Mars and Titan, and on distant icy moons, such as Enceladus

Next Gen RTG

- Regain GPHS-RTG deep space power capability
- Aerojet Rocketdyne under INL contract
- Reestablish GPHS-RTG production capability by 2027
  - Use of proven heritage design with proven long life and low degradation
  - More cost effective
  - Less risk
- 90% heritage design, but lower heat; lower power; EODL~177 W_e



* U.S. Air Force Mission