

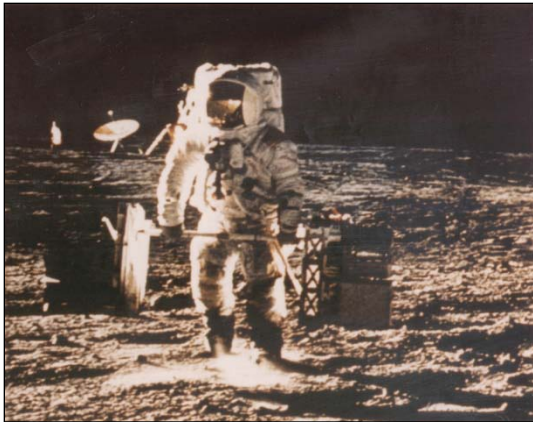


Idaho National Laboratory

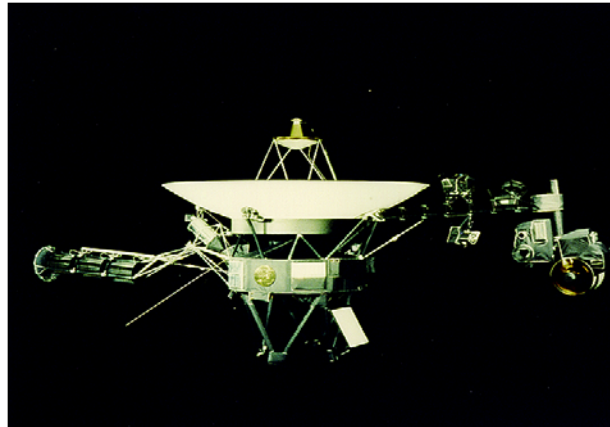
Recent Radioisotope Power Systems Efforts, Pluto New Horizons and Mars Scientific Laboratory: ORNL, LANL, INL and SNL

**S. G. Johnson
Director, Space Nuclear Systems and Technologies
February 8, 2011**

Space RPS Missions



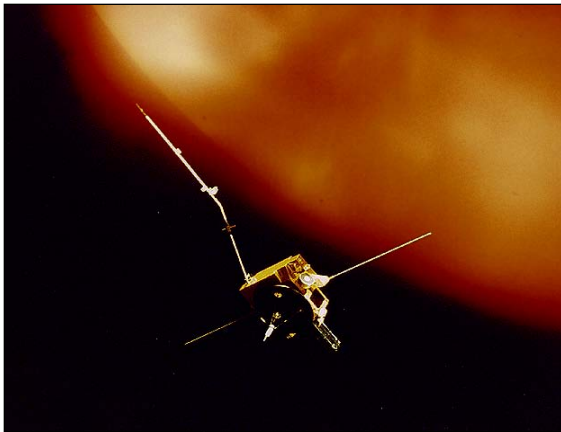
Apollo (1969 - 1972)



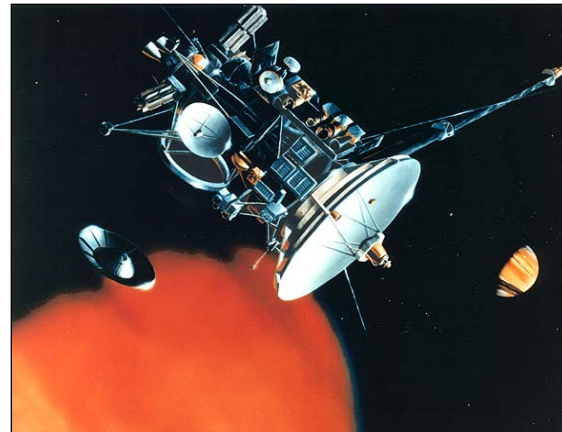
Voyager (1977)



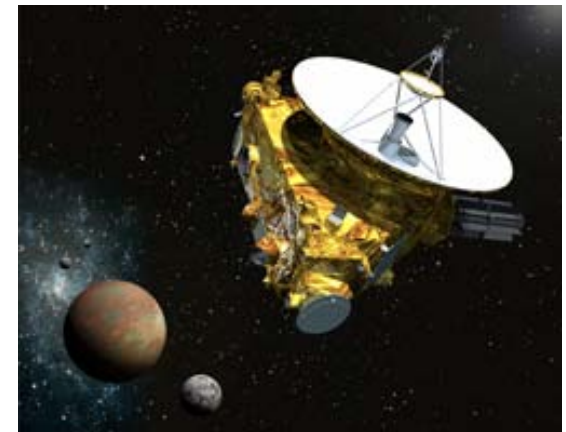
Galileo (1989)



Ulysses (1990)



Cassini (1997)



New Horizons (2006)

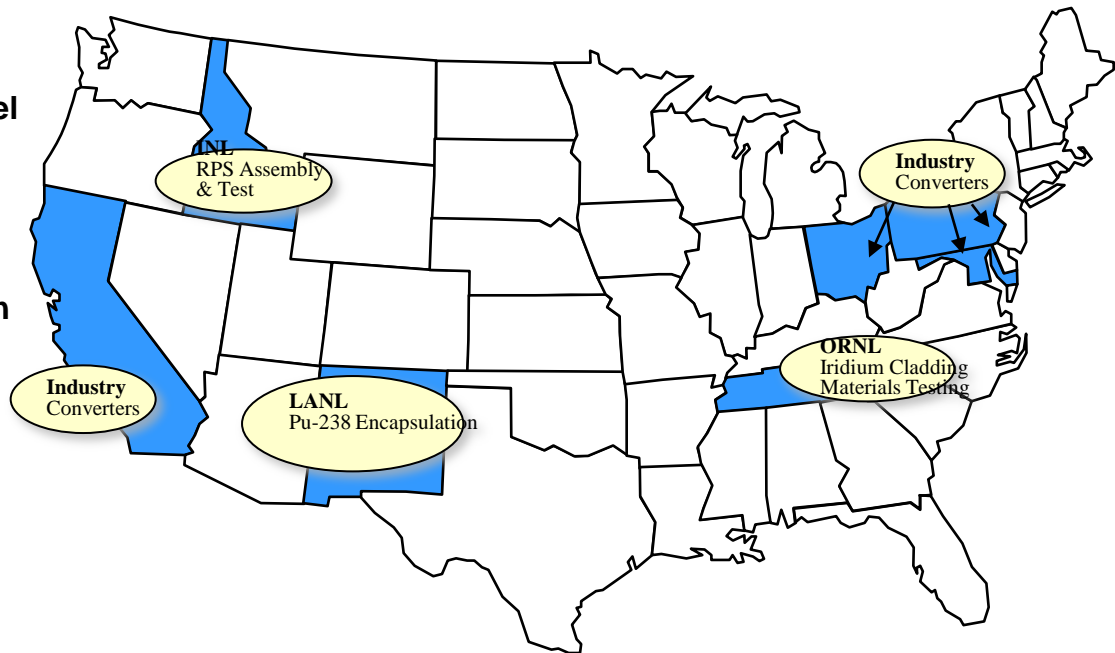
For all prior missions, RPS have continued to operate far beyond their design life

Recent Campaigns

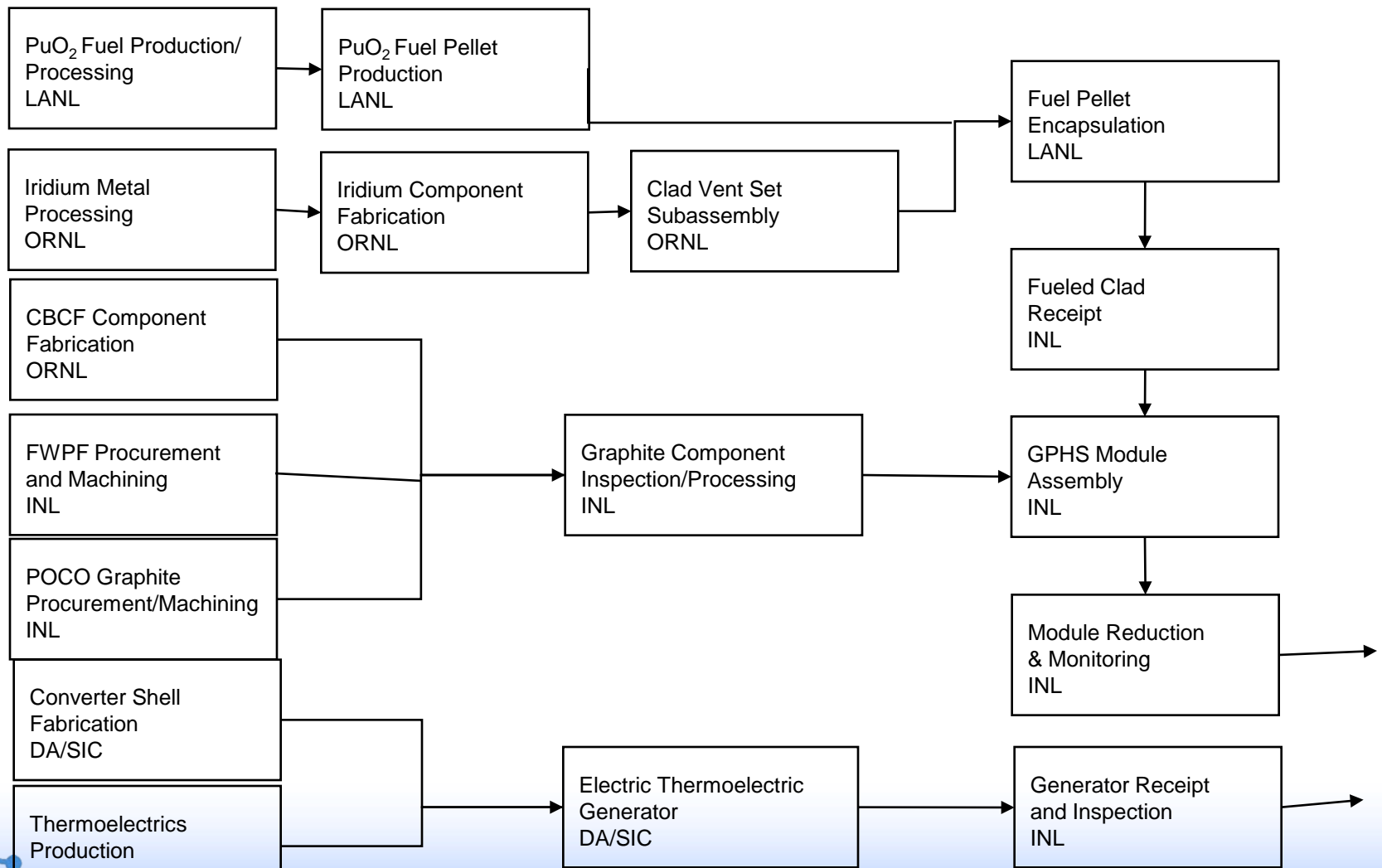
- **GPHS-RTG-Pluto New Horizons- 2002-5**
- **MMRTG-Mars Scientific Laboratory- 2006-9**

DOE's Current RPS Infrastructure

- **DOE maintains** infrastructure
 - Nuclear facilities
 - Purification and encapsulation of Pu-238 fuel at LANL
 - Heat source and generator assembly, testing and delivery at INL
 - Heat source hardware production and materials testing at ORNL
 - Safety analyses and testing
 - SNL
 - Pu-238 supply
 - Storing neptunium-237 (Np-237) at INL
 - Interim Russian purchase (using NASA funds)
 - DOE issues and manages system integration contracts



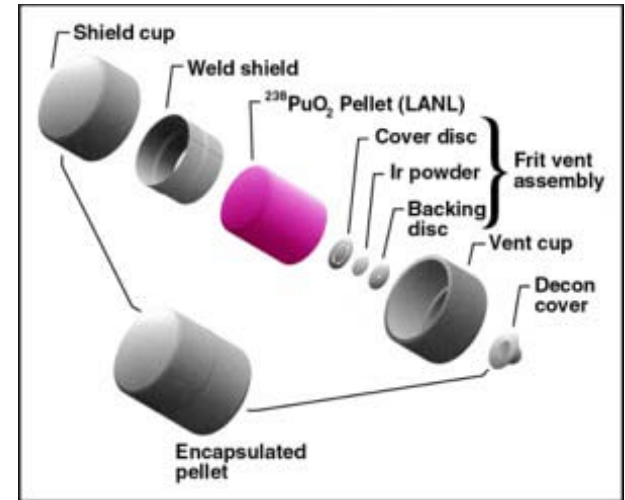
GPHS/RTG Process Flow and Responsibilities



Component Fabrication

Oak Ridge National Laboratory

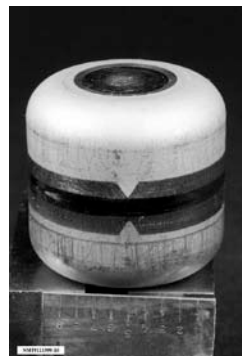
- **Iridium Metal Processing**
 - Iridium Powder Procurement
 - Ingots, Billets, Sheet and Foil
- **Iridium Component Manufacturing**
 - Frit Vent Fabrication
 - Decon Cover Fabrication
 - Iridium Cup Forming
 - Weld Shield Fabrication
 - Weld Shield Cup Subassembly
 - Vent Cup Subassembly
- **CBCF Component Fabrication**
 - Insulator Sleeves and Discs



Purification and Encapsulation of Pu-238

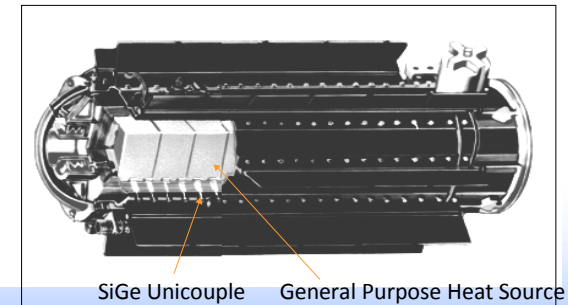
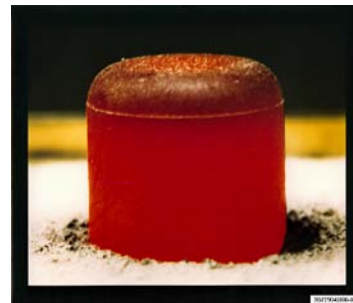
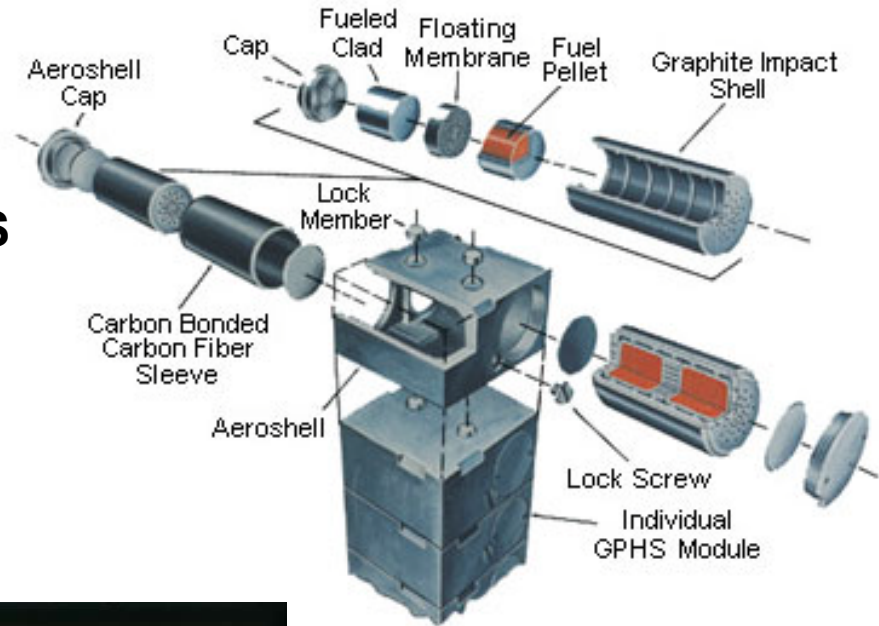
Los Alamos National Laboratory

- **Previously conducted at various DOE sites**
 - Mound Site in Miamisburg, Ohio
 - Savannah River Site
- **Current Status**
 - **Operating at Los Alamos National Laboratory:**
 - Purification of Pu-238 (scrap recovery)
 - Pelletization of purified Pu-238
 - Encapsulation of Pu-238 pellet
 - Simulant fuel clad production
 - Impact testing
 - Metallography
 - Chemical analysis
 - Nuclear material storage and security
 - Waste handling and disposal



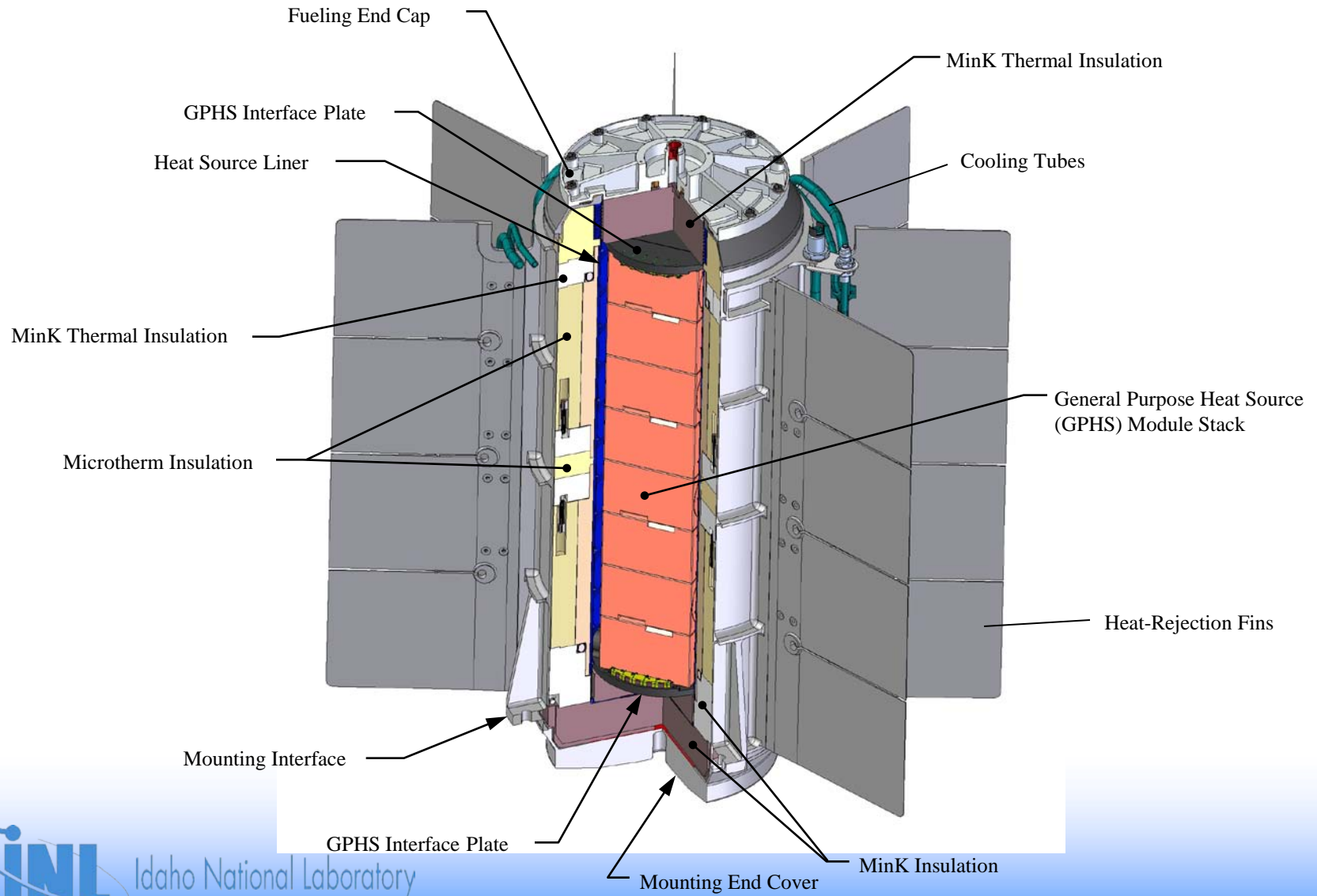
GPHS Heat Sources

- Fuel is assembled into General Purpose Heat Sources (GPHS)
- Each GPHS-RTG contains 18 GPHS modules (300 W_e), 72 FCs
- Each MMRTG contains 8 GPHS modules (110 W_e), 32 FCs
- Each GPHS module contains
 - ~600 g PuO₂ in 4 fuel clads
 - ~11 kg PuO₂ in 18 modules
 - ~4.8 kg PuO₂ in 8 modules



Radioisotope Thermoelectric Generator

Flight MMRTG Design



Space and Security Power Systems Facility (SSPSF) Construction (January-July 2004)& ORR (Sept. 2004): Phased design work (siting, foundation, building, windows) coupled with close coordination between INL and contractor to allow for simultaneous construction and equipment installation were the keys to success.



Fueling and Testing Operations

- **General Purpose Heat Source Assembly**
- **RTG Assembly**
- **RTG Acceptance Testing**
- **RTG Delivery to NASA**
- **RTG NASA Ground Operations**

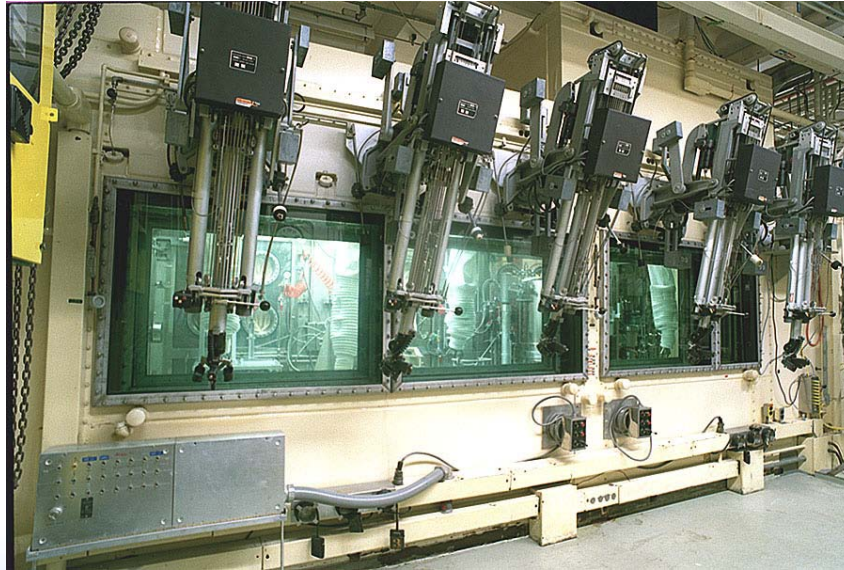


Readiness Activities

- **Prior to any operation**
 - **Rigorous procedure preparation (2-9 months out)**
 - **Internal walk-through for management (2 months out)**
 - **Formal walk-through for external review committee (1 month out)**
 - **Final readiness check within 24 hour of commencement of operations (1 day out)**
 - **Careful monitoring and control of non-compliances through-out production, assembly and testing lead to a quality product (continuous)**
 - **Special focus on interfaces with external organizations**
 - **Tight control and qualification of tooling, materials and instruments is fundamental to success (continuous)**

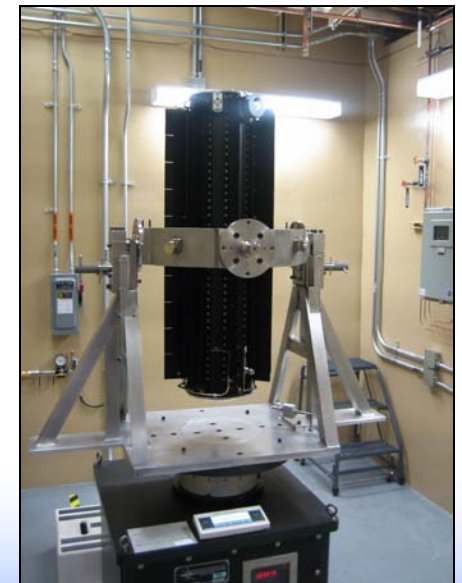
Idaho National Laboratory

- **GPHS Heat Source Assembly**
- **RTG Assembly**



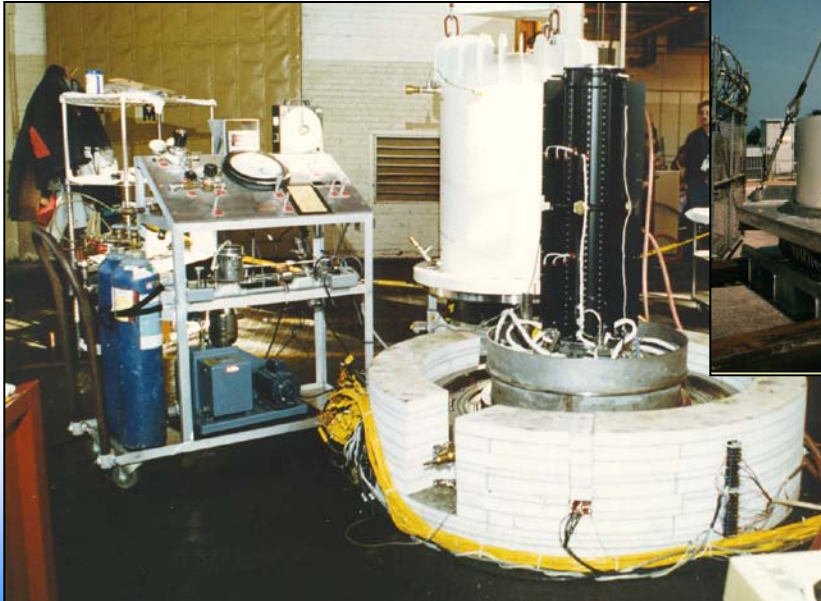
Idaho National Laboratory

- **Acceptance Testing: vibrational, mass property, magnetics and thermal vacuum**



RTG Shipment

- Installation of RPS into 9904 shipping container
- Transported using DOE/OST-supplied tractor and couriers
- Removal of RPS from shipping container



KSC Readiness Activities

- **Prior to any operation**
 - **Rigorous procedure preparation (18-24 months out)**
 - **Walk-through with full participation by external partners (KSC, CCAFS, JPL/APL, DOE) (12-18 months out)**
 - **Re-check of procedures (1 month out)**
 - **Final readiness check within 24 hour of commencement of operations (1 day out)**
 - **Careful monitoring and control of non-compliances through-out production, assembly and testing lead to a quality product (continuous)**
 - **Special focus on interfaces with external organizations**
 - **Tight control and qualification of tooling, materials and instruments is fundamental to success (continuous)**

Kennedy Space Center Ground Operations



RPS for New Horizons and MSL

300 Watt Generator Class- GPHS-RTG

- Ulysses (1), Galileo (2), Cassini (3)
& Pluto New Horizons (1)
- BOM Power (2006) 250 W_e
- Modules 18
- Mass 127 lbs
- Length 4 ft
- Fin tip-to-tip diameter 1.5 ft
- Launched Jan 19, 2006
- Jan 24, 2006 249.5 W_e

110 Watt Generator Class- MMRTG

- MSL (1)
- BOM Power (2011) 115 W_e
- Modules 8
- Mass 97 lbs
- Length 2 ft
- Fin tip-to-tip diameter 2 ft
- Launch Window 2011



NEW HORIZONS

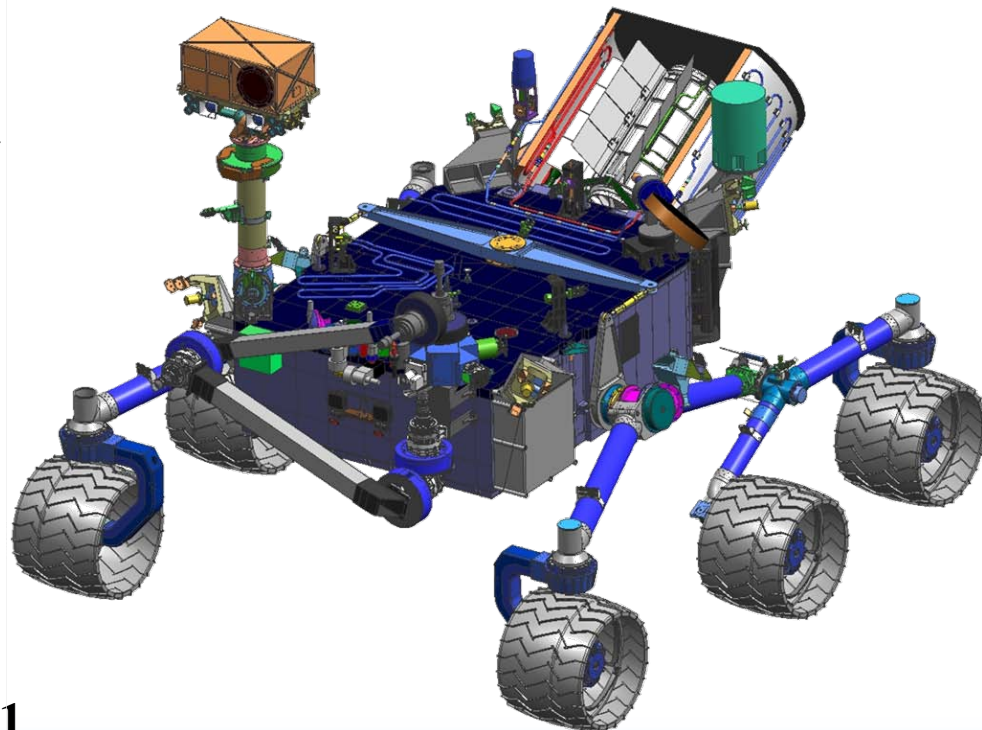
*NASA's Pluto-Kuiper Belt Mission:
The First Mission to the Last Planet*



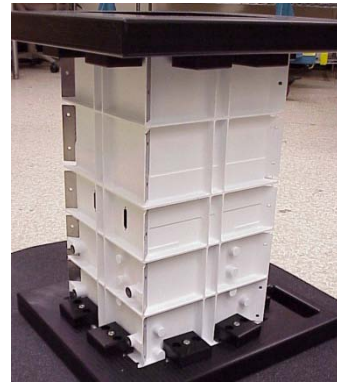
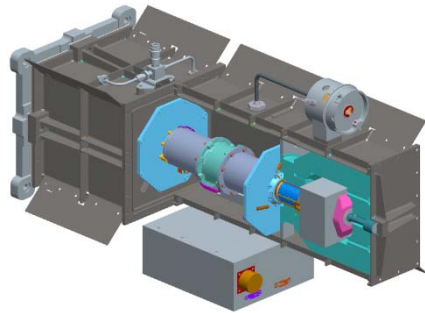
MMRTG

- **Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)**
- **Fueling & testing completed (May 2009)**
- **Collection of 10 scientific instruments for assessing the geological features of the Mars polar regions.**
- **Mounted on a mobile platform powered by the MMRTG.**
- **Launch planned for late 2011**

RPS



Upcoming RPS Projects Managed by DOE



Advanced Stirling Radioisotope
Generator (ASRG) for NASA

Readiness for first use
targeted for 2015

Summary: To Infinity and Beyond....

- **Purpose:** To provide the sources of power NASA space missions for which solar energy or other power sources are inadequate.

