Identification of Isotope Needs

Radioisotope Power Systems Program


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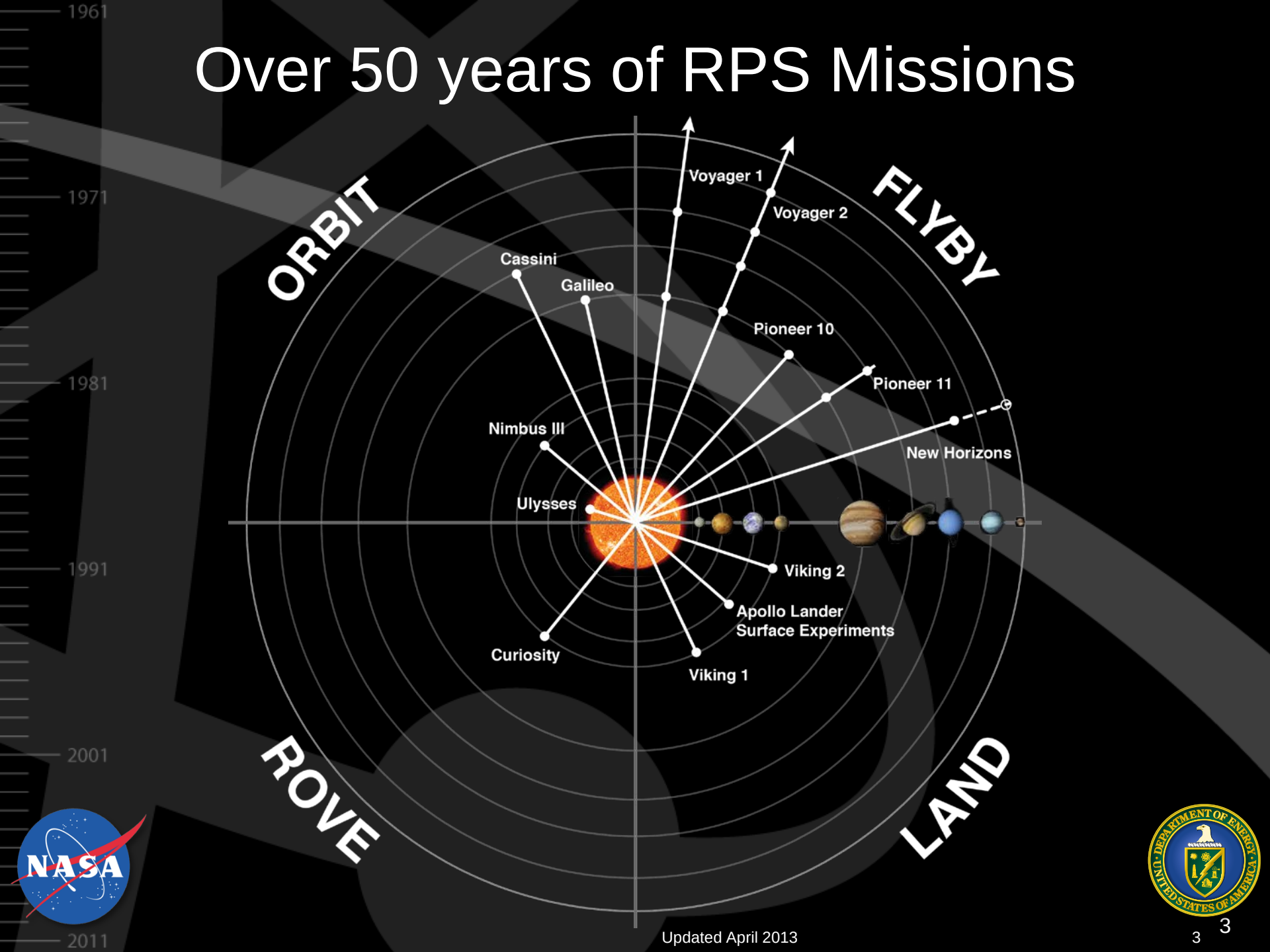
NASA Radioisotope Power Systems Program
Program Goal

Ensure the availability of power for the exploration of the solar system in environments where conventional solar or chemical power generation is impractical or impossible.

- The targeted missions are in the Flagship, New Frontiers, Mars, and Discovery Programs
- Program can support all NASA missions

The HQ RPS Program Executive is the NASA lead for ensuring the supply of Plutonium-238 to NASA missions

Over 50 years of RPS Missions



Updated April 2013

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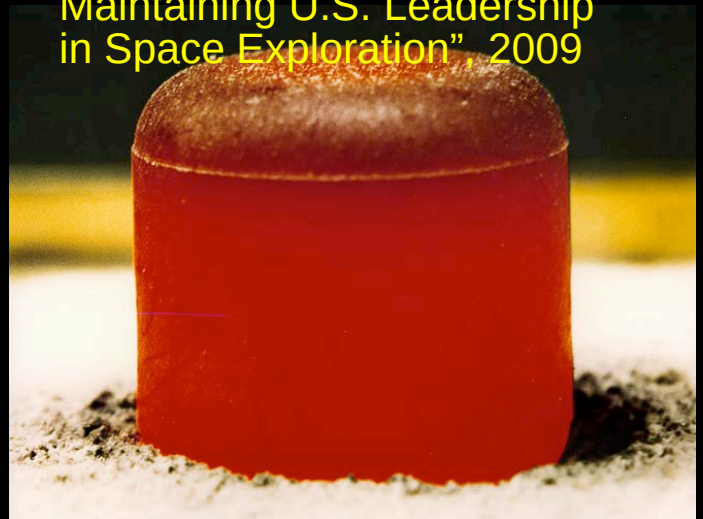
Bottom Line

- **^{238}Pu is essential for space exploration**

  "Unless and until a new source of Pu-238 is established, the restricted supply Pu-238 will increasingly limit both the quality and quantity of U.S. space science in many mission areas, and continued U.S. leadership in these areas will be at risk"

National Research Council report: "Radioisotope Power Systems: An Imperative for Maintaining U.S. Leadership in Space Exploration", 2009

HFIR fuel core at ORNL



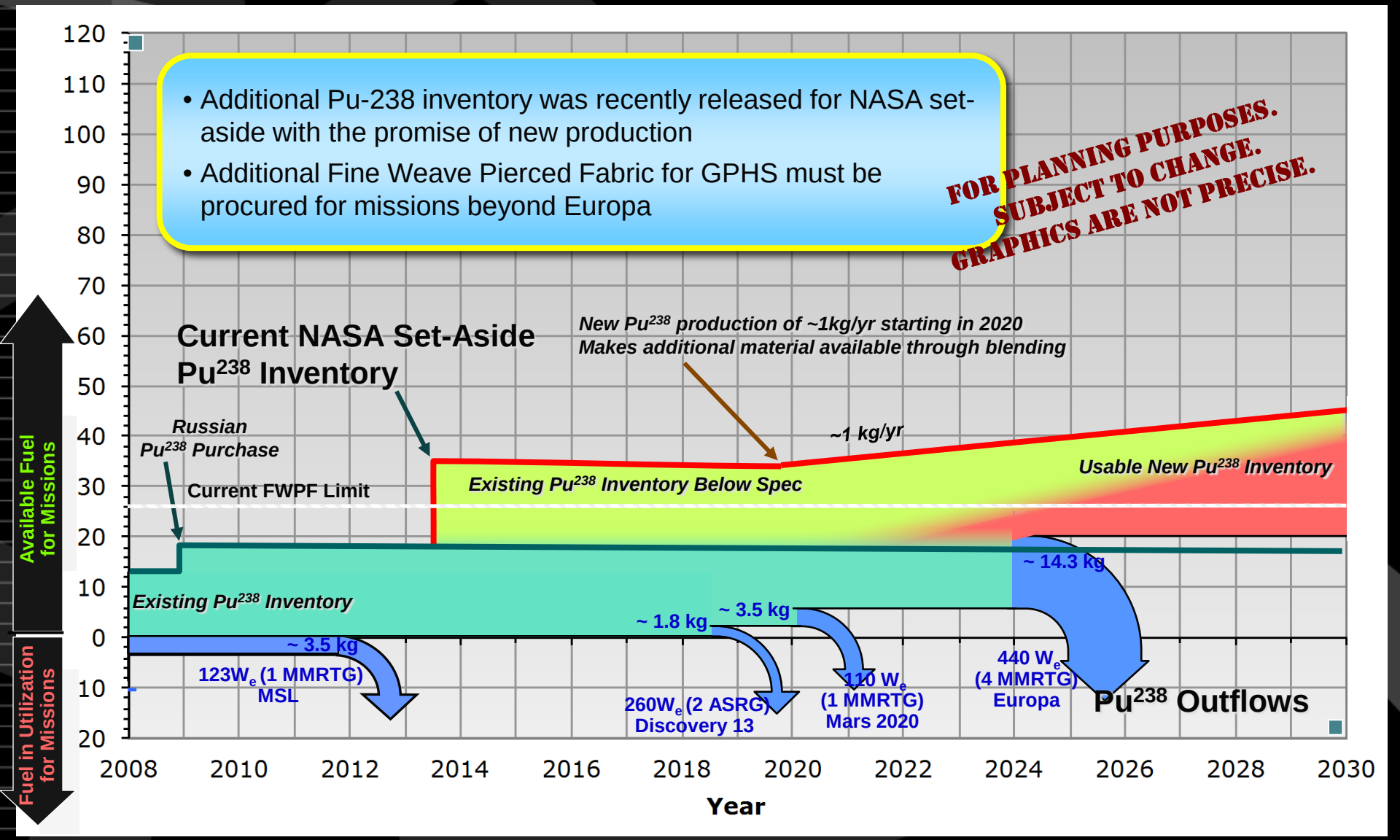
Radioisotope Power System Applications in Near Term Planetary Missions

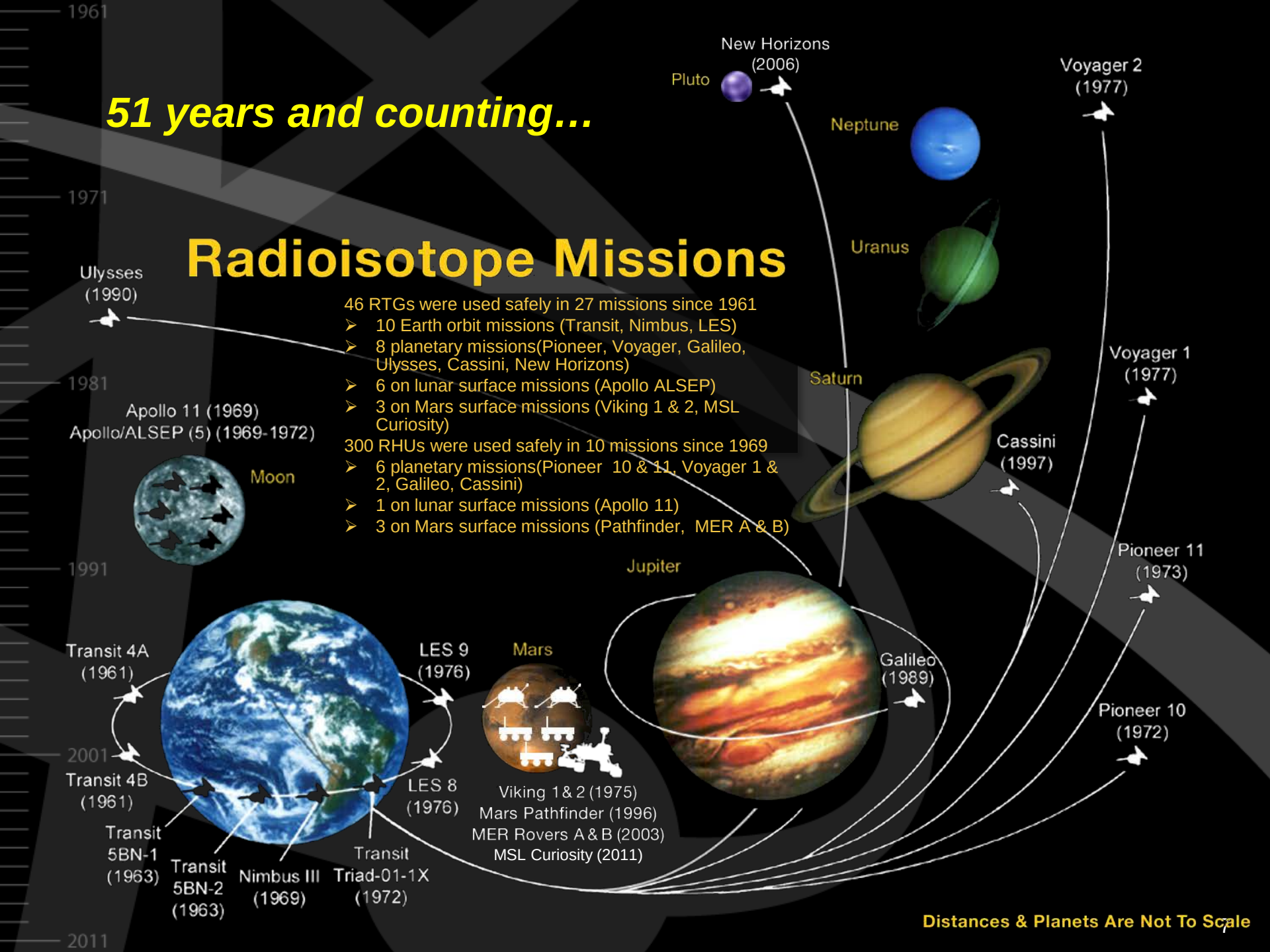
Evolving SMD RPS Mission Planning Set post Decadal Survey

Large Directed / New Frontiers / Discovery / Mars / Lunar / Other	Projected Launch Year	Power Reqmnt (W_e)	RPS Type (Flight + Spare)	Status
Mars Science Lab	*2011*	100	1 MMRTG	*Operational*
Juno (New Frontiers 2)	*2011*	No RPS Requirement		*On its way*
Discovery 12	*2016 - 17*	*200 - 300*	*2 ASRG*	***Not Selected***
Osiris-REX (NF3)	2016	**Directed non-RPS**		***In Development***
Solar Probe	2019	**Directed non-RPS**		***In Development***
Discovery 13	2019 - 23	200 - 300	2 ASRG	
MSM (Mars 2020)	2020	100 - 150	1 MMRTG + Spare	***In Planning***
Europa or Uranus or Other†	2020 - 25	500 - 1000	4 ASRG or MMRTG + Spr	*† If Funded*
New Frontiers 4	2022 - 23	300 - 500	4 ASRG + Spare	
Discovery 14	2024 - 25	200 - 300	2 ASRG	
New Frontiers 5	2028 - 29	300 - 500	4 ASRG + Spare	

- 6 year-cadence New Frontier mission opportunities would likely require 500 W_e RPS
- Every Discovery mission opportunity is proposed to offer an RPS option
- Radioisotope heater units may be required on these and other missions
- Other science, exploration, and demo missions not yet identified may also require RPS

Plutonium Supply vs Current Planetary Requirements
NASA Set-Aside




51 years and counting…
Radioisotope Missions
46 RTGs were used safely in 27 missions since 1961
10 Earth orbit missions (Transit, Nimbus, LES)
8 planetary missions(Pioneer, Voyager, Galileo, Ulysses, Cassini, New Horizons)
6 on lunar surface missions (Apollo ALSEP)
3 on Mars surface missions (Viking 1 & 2, MSL Curiosity)
300 RHUs were used safely in 10 missions since 1969
6 planetary missions(Pioneer 10 & 11, Voyager 1 & 2, Galileo, Cassini)
1 on lunar surface missions (Apollo 11)
3 on Mars surface missions (Pathfinder, MER A & B)
1961
1971
1981
1991
2001
2011
New Horizons (2006)
Pluto
Voyager 2 (1977)
Neptune
Uranus
Ulysses (1990)
Voyager 1 (1977)
Saturn
Cassini (1997)
Apollo 11 (1969)
Apollo/ALSEP (5) (1969-1972)
Moon
Jupiter
Pioneer 11 (1973)
Transit 4A (1961)
LES 9 (1976)
Mars
Galileo (1989)
Pioneer 10 (1972)
Transit 4B (1961)
LES 8 (1976)
Viking 1&2 (1975)
Mars Pathfinder (1996)
MER Rovers A&B (2003)
MSL Curiosity (2011)
Transit 5BN-1 (1963)
Transit 5BN-2 (1963)
Nimbus III (1969)
Transit Triad-01-1X (1972)
Distances & Planets Are Not To Scale

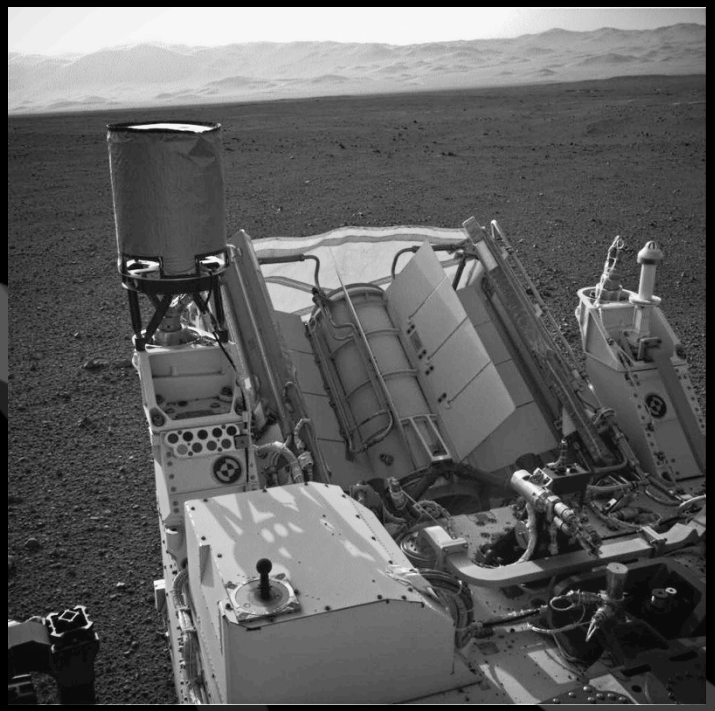
Deployed RTG Status

Mission	Generators	Predicted (last prediction *)	Actual	Epoch of prediction
Cassini (10/1997)	3	646 W, av	645.0 W, av	April, 2013*
Voyager 1 (9/1977)	1	263.3 W	262.69 W	June, 2013
Voyager 2 (8/1977)	1	262.9 W	264.1 W	April, 2013*
Pluto New Horizons (2006)	1	212 W (DOE Prediction at launch)	209.12 W	July, 2013
Mars Science Lab (11/2011)	1	109 W, av (qrtrly)	110.8 W, av	July, 2013

* Predictions were made more than a quarter ago unless otherwise noted.

MMRTG Status

- F1 performing well on Mars
- F2 completed and in bonded storage
- F3 preparing for workmanship test
  - Estimated Completion in bonded storage 9/2013
- F2 or F3 to be used for Mars2020
  - Working agreements
- Pratt-Whitney-Rocketdyne has become Aerojet-Rocketdyne

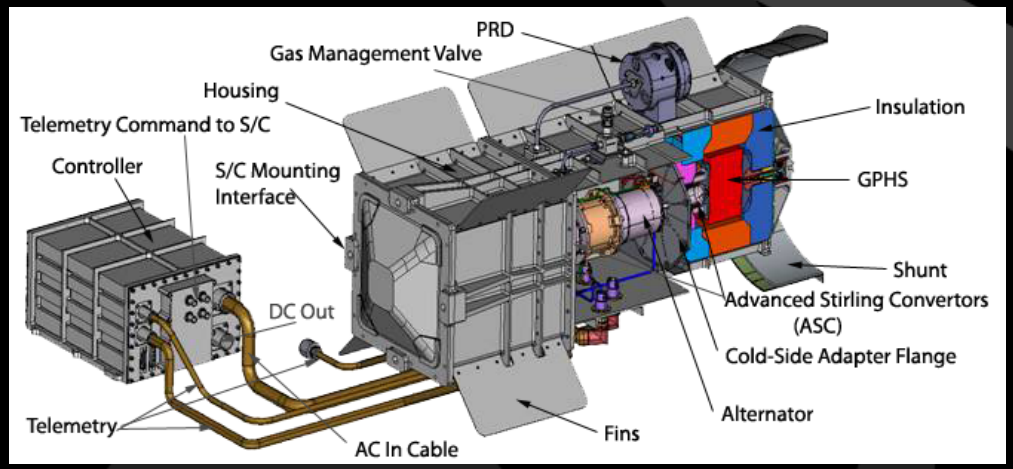


ASRG Status

ASRG Key Performance Parameters

- Technical Performance Metrics are established for mass, power and reliability
- Current Best Estimates

- Current Best Estimates (CBEs) are
  - Mass: 29.3 kg
  - Power: 140.8 W
  - Reliability: 96.9%



Performance Parameters Are Stable And Have Adequate Margins Against Requirements

Summary

- Pu Production successfully continuing on path to production
- Deployed RPS successfully operating as designed
- 1 flight system ready for use another ready 9/2013
- ASRG development successfully continuing
- Preserving current capabilities to fly RTG
- Developing mission and system concepts focused on increasing science data collected as a function of RPS mission costs