Overview of NASA Fission Surface Power

Nuclear and Emerging Technologies for Space (NETS-2023)

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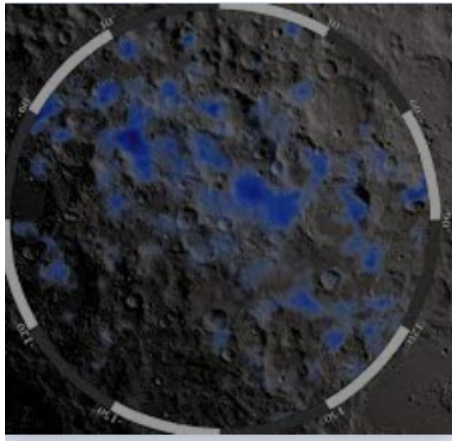
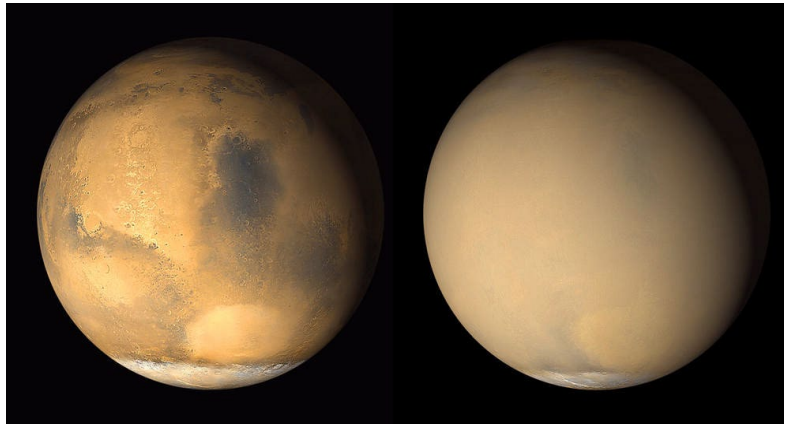
Why Develop a Fission Surface Power System?
Nuclear Power for the Moon and Mars

- Nuclear power systems will enable robust exploration of the Moon and Mars
  - Reliable and robust energy production is essential to human and scientific exploration missions to the Moon (to support Artemis) and Mars
  - Fission power systems can provide abundant and continuous surface power in all environmental conditions on the Moon and Mars:
    - Lunar night is 14.5 Earth days long and permanently shadowed regions may contain water ice. Surface nuclear power is required for a sustainable lunar presence
    - Mars has recurring planet-wide dust storms that can last for weeks or months
  - A fission system designed for a capability demonstration on the Moon will be directly applicable to human Mars exploration
  - Recent analyses indicate that a Mars fission surface power system is likely to enable 2x less mass to be flown to space and be more reliable than a comparable solar power system in the 10 to 40 kWe class


Permanently Shadowed Region…
lunar.gsfc.nasa.gov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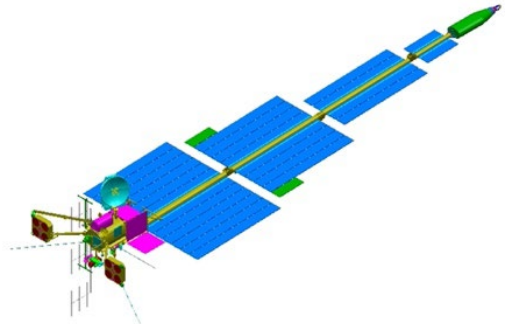
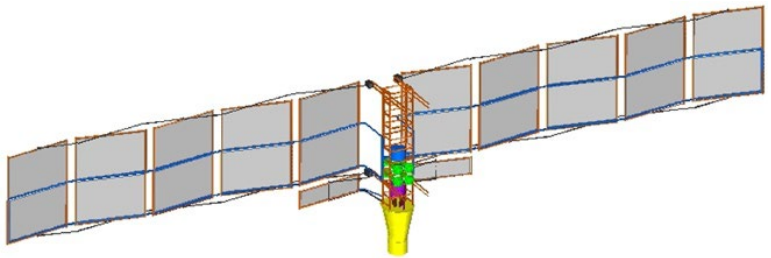
Brief History of NASA Developments

2000 2005 2010 2015 2020

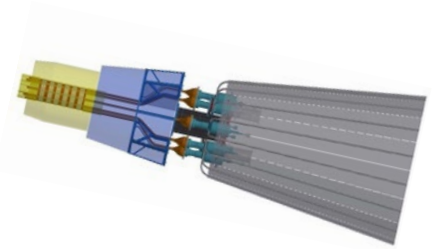
Prometheus | **Fission Surface Power** | **Kilopower** | **FSP 2.0**



- 200 kWe, 20 yr life
- NEP science mission to Jovian moons
- 1200K HeXe-cooled UN reactor with Brayton
- 6600 kg, 33 kg/kWe
- Prime selected and PMSR completed (~$400M spent)



- 40 kWe, 8 yr life
- Long-duration lunar & Mars surface power
- 900K NaK-cooled UO2 reactor with Stirling
- 5800 kg, 145 kg/kWe
- Non-nuclear system test completed (~$50M spent)



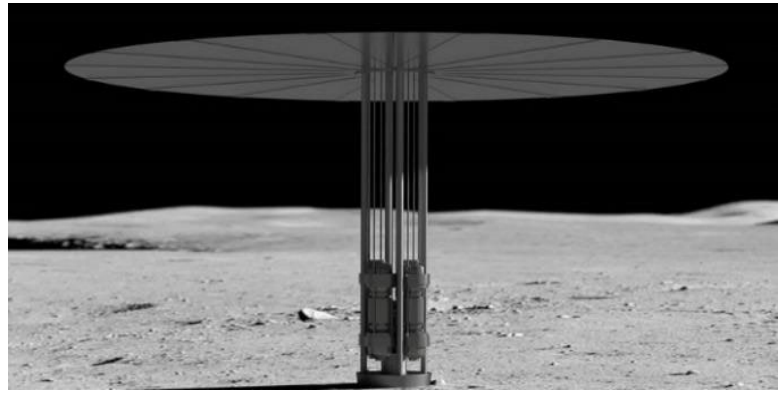
- 1 kWe, 10 yr life
- Low-tech fission alternative to RPS
- 1100K Na HP-cooled UMo reactor with Stirling
- 400 kg, 400 kg/kWe
- Reactor prototype test completed (~$20M spent)

What is a Fission Surface Power System?

- The Fission Surface Power hardware development is part of NASA Space Technology Mission Directorate's (STMD) Space Nuclear Technologies Portfolio
  - Fission Surface Power
  - Nuclear Thermal Propulsion and Nuclear Electric Propulsion
- It is an autonomous nuclear power system that is launched, placed on the Moon's surface by a lander, transported to its operational location, activated, and connected to a user power interface up to a kilometer away
- It will have a ten-year life, consisting of a 1-year demonstration followed by operational support for Artemis
- It will be designed so it is extensible to Mars missions

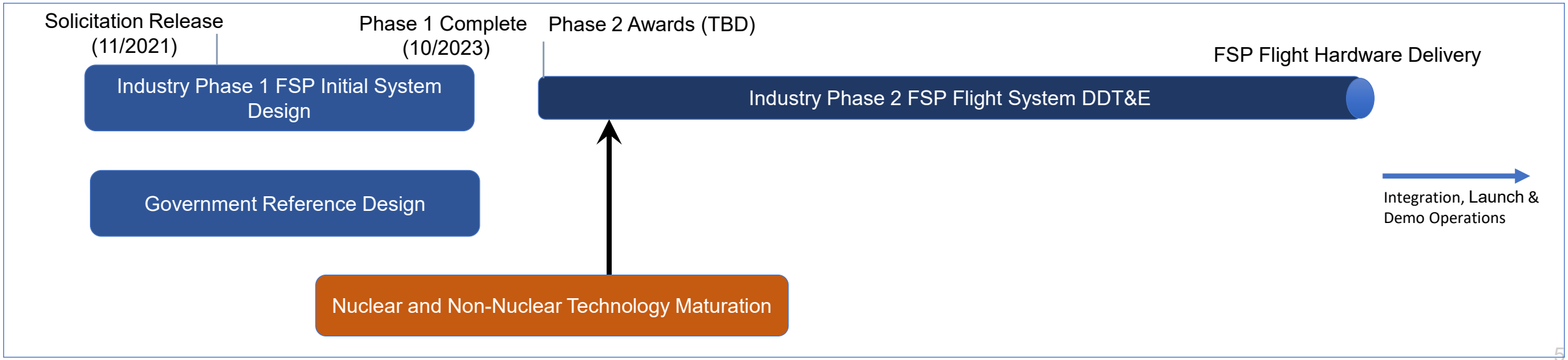
Key Design Characteristics

- 40 kWe output at 120 Vdc
- 6000 kg mass limit, fits on a lander
- 5 rem/year above background at 1km
- Operate on the lander, or be transported



Fission Surface Power System Development Strategy

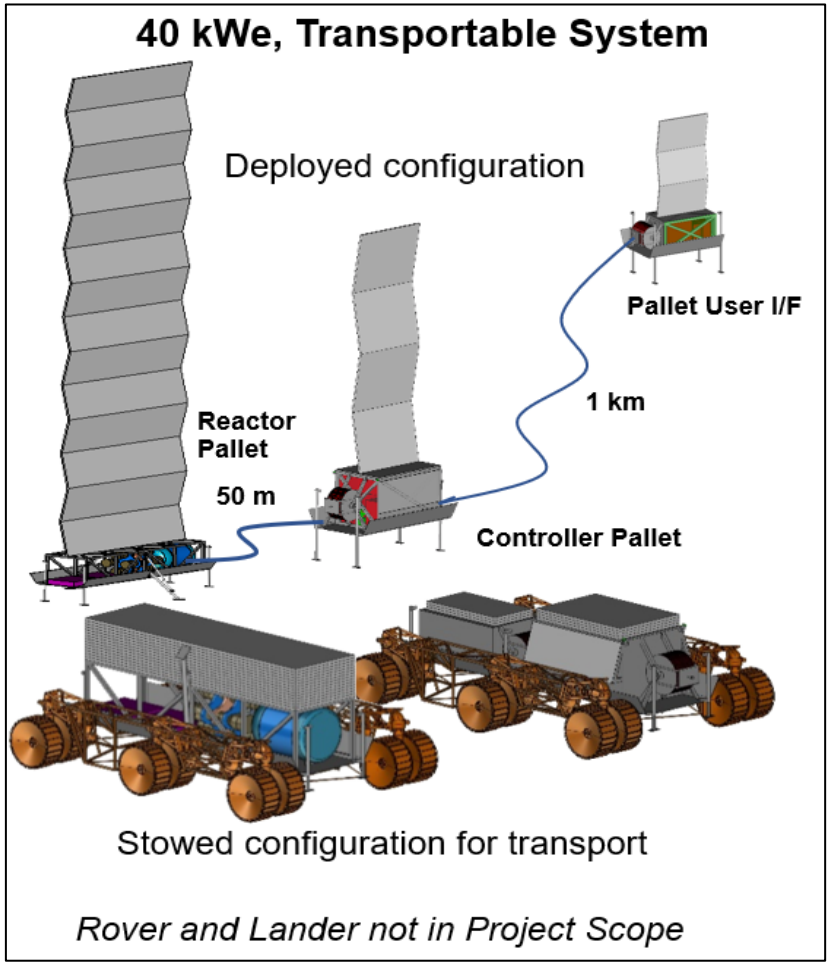
- **Awarded three Phase 1 - FSP System Design Contracts**
- **Government Reference Design**
  - Evolving reactor and integrated system design to guide subsystem trades
- **Government Technology Maturation underway**
  - DOE working on metal hydride moderators, shielding and instrumentation and controls
  - DOE holding periodic webinars for OGA's and industry (12/9/22, 4/27/23)
  - NASA initiated PMAD development investigations and integrated heat pipe – Stirling converter test underway
- **Phase 2**
  - Will be a separate, open and competitive procurement
  - Deliverables include a qualification unit and flight unit



NASA Government Reference Design Concept

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

- **FSP System delivered in 3 pallets:** Reactor, Controller, User Load Interface
- **Reactor Pallet:**
  - A HALEU-moderated reactor with radiation shielding to protect co-located plant equipment, nearby electrical controls (50 m), and crew habitation area (1 km)
  - Power conversion consists of four 12 kWe Stirling converters (48 kWe gross)
  - Deployable radiators that leverage the International Space Station design but operate at higher temperature (>400 K)
  - Shielded Ka-Band link for communications to Earth
- **Controller Pallet:** Stirling electrical controllers, high-voltage boost electronics, thermal management, spool and 50 m cable
- **User Load Interface:** Electronics to convert high transmission voltage to 120 Vdc for loads, thermal management, spool and 1 km cable



A 40 kWe transportable FSP system is feasible

Fission Surface Power Summary

- NASA is working with the Department of Energy and their federally funded laboratories to establish a lunar fission surface power system
- NASA focus is on designing, building, and demonstrating a low enriched uranium fission surface power system that is directly applicable for Moon and Mars, scalable to higher power levels
- NASA will continue to be closely engaged with industry to seek innovative, unique design approached for fission surface power systems