Development Status of the Fission Surface Power Technology Demonstration Unit

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Presentation Outline

• Fission Power Systems
• The Fission Surface Power Technology Demonstration Unit
  – Overview
  – Component Development
    • Reactor Simulator
    • Annular Linear Induction Pump
    • Stirling Engine
    • Heat Rejection
  – Sub-System Testing
    • Heat Rejection System
    • RXSim Sub-system
  – System Level Test Status
Fission Power Systems (FPS)

Fission Surface Power (FSP) (10 – 100 kW)

Nuclear Propulsion (100 kW - ~1MW)

Small Reactor (Kilopower) (1 – 10 kW)
FSP Technology Demonstration Unit

- Non-nuclear demonstration of a Fission Surface Power System
- Full-scale FSP components
- Thermal vacuum environment
- Heat provided by a reactor simulator
- Originally designed to achieve TRL 6
Technology Demonstration Unit (TDU)

Original Design

Reduced budget design
Core Simulator

- Thermally and hydraulically similar to FSP core
- Tested with TDU ALIP at MSFC June 2012
- Delivered to GRC January 2013
- Can be operated in constant power, constant temperature, or reactivity feedback modes.
ALIP

• Annular Linear Induction Pump (ALIP)
  – Electromagnetic pump / No moving parts
  – Two Pumps manufactured
  – Both were tested in the ALIP Test Circuit at MSFC

ALIP installed at MSFC
Sub-System Testing at MSFC

• Core simulator demonstrated to 50 kW\textsubscript{t}
• FSP and TDU ALIP pump curves have been generated
• Flow resistance curves have been generated
  – Showed that larger of the two ALIPs must be used during TDU testing
• All components tested at nominal and maximum temperatures
Stirling Power Conversion Units

• Two 6 kW Stirling convertors have been fabricated and tested by Sunpower
  – Convertor 1 was fabricated in Fall of 2011
  – Convertor 2 was fabricated in Spring of 2012
• Tested as individual convertors
  - Convertor 1 reached full power in Dec 2011
  - Convertor 2 reached full power in July 2012
• Combined into a 12 kW PCU April 2013
  • Electrically heated test finished in Late 2014.
  • NaK heat exchanger fabrication delayed
Radiator Testing

Material Innovation 2nd Gen RDU (2009)

Advanced Cooling Technologies
Composite Radiator (2011)

GRC Affordable Radiator (2013-2014)

Phase II SBIR with ACT to deliver 6 radiator panels using affordable design approach
Heat Rejection Sub-System Testing

- Completed in January 2013
  - Demonstrated water pump compatibility in thermal vacuum
  - Verified start-up, shutdown, and emergency drain procedures
  - Pump performance data has been incorporated into TDU system models
RxSim Subsystem Test
Hot NaK Preparation / Preliminary Work

• NaK Storage
• Fill/Drain
• Steam Cleaning
• NaK and Caustic Disposal
• Safety Permit
• Operating Procedures
RxSim Subsystem Test
NaK Testing

- Operated through full operating range
- Verified component performance
- Validated subsystem models
TDU System Model Validation

- Verify internal Core Sim Temps
- Verify Flow and Pump Power
- Verify Thermal Losses
- Verify Steady-State Operating Conditions and Transient Response.
System Level TDU Test Status
Fabrication/Assembly Delay

• Complicated braze geometry was difficult to fabricate
• New NaK Heater Head Design Being Fabricated
  – Material changes eliminated difficult brazes
  – Final engine assembly scheduled for May 2015
Conclusion

Component Testing Complete

Sub-System Testing Complete

TDU Testing scheduled for June 2015