Development Status of the Fission Power System Technology Demonstration Unit

- **This paper summarizes the progress that has been made in the development of the Fission Power System Technology Demonstration Unit (TDU). The reactor simulator core and Annular Linear Induction Pump have been fabricated and assembled into a test loop at the NASA Marshall Space Flight Center. A 12 kWe Power Conversion Unit (PCU) is being developed consisting of two 6 kWe free-piston Stirling engines. The two 6 kWe engines have been fabricated by Sunpower Inc. and are currently being tested separately prior to integration into the PCU. The Facility Cooling System (FCS) used to reject convertor waste heat has been assembled and tested at the NASA Glenn Research Center (GRC). The structural elements, including a Buildup Assembly Platform (BAP) and Upper Truss Structure (UTS) have been fabricated, and will be used to test cold-end components in thermal vacuum prior to TDU testing. Once all components have been fully tested at the subsystem level, they will be assembled into an end-to-end system and tested in thermal vacuum at NASA GRC.**

Development Status of the Fission Power System Technology Demonstration Unit

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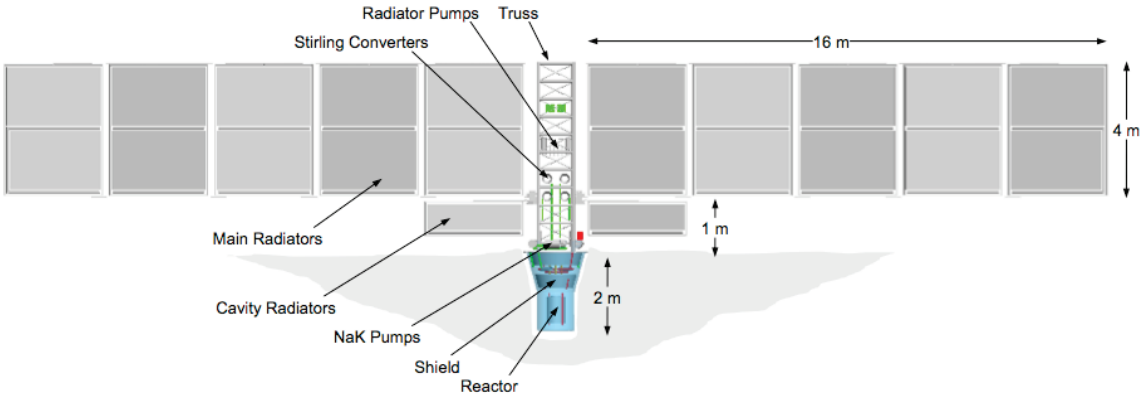
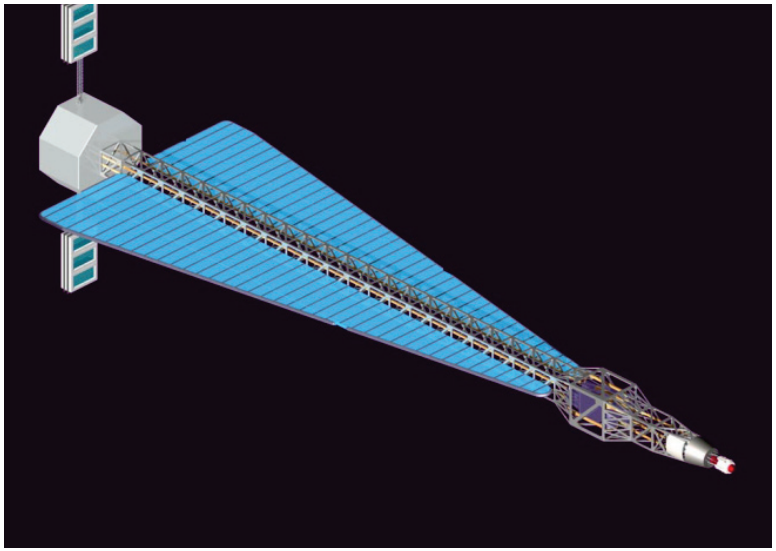
Presentation Outline

- Fission Power Systems
- The Technology Demonstration Unit
  - Overview
  - Component Development
    - Hot-End Components
    - Stirling Power Conversion
    - Structural Components
    - Heat Rejection
      - Facility Cooling System
      - Radiators
  - Sub-System Testing
    - Hot-End Testing
    - Stirling Power Conversion Unit Testing
    - Cold-End Testing
- Conclusions

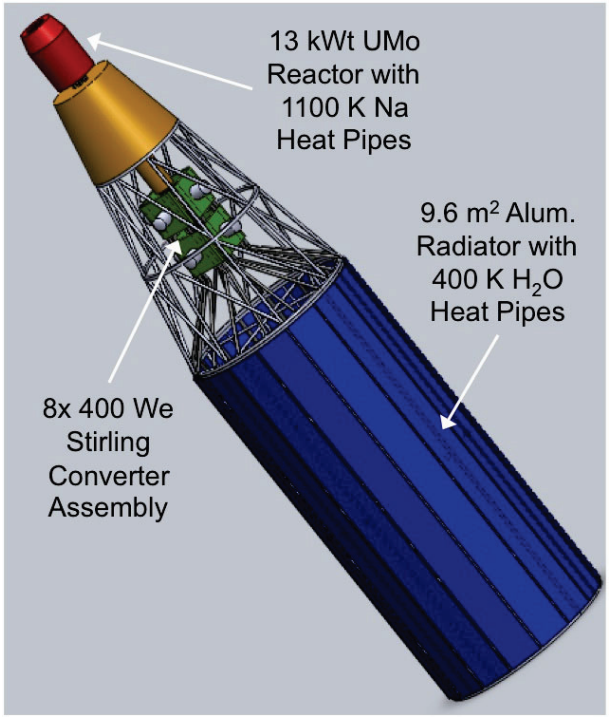
Fission Power Systems (FPS)

Fission Surface Power (10 – 100 kW)





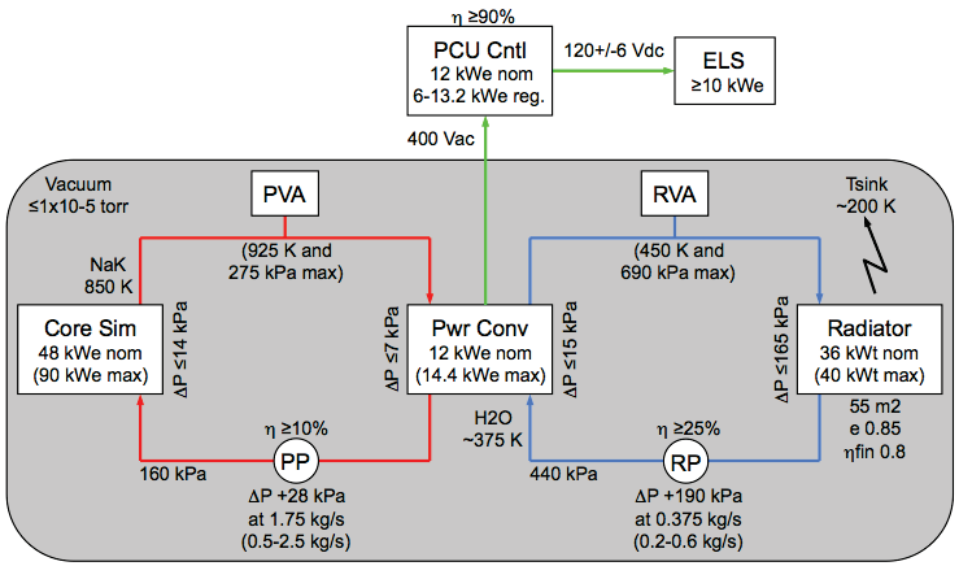
Nuclear Electric Propulsion (100 kW - ~1MW)

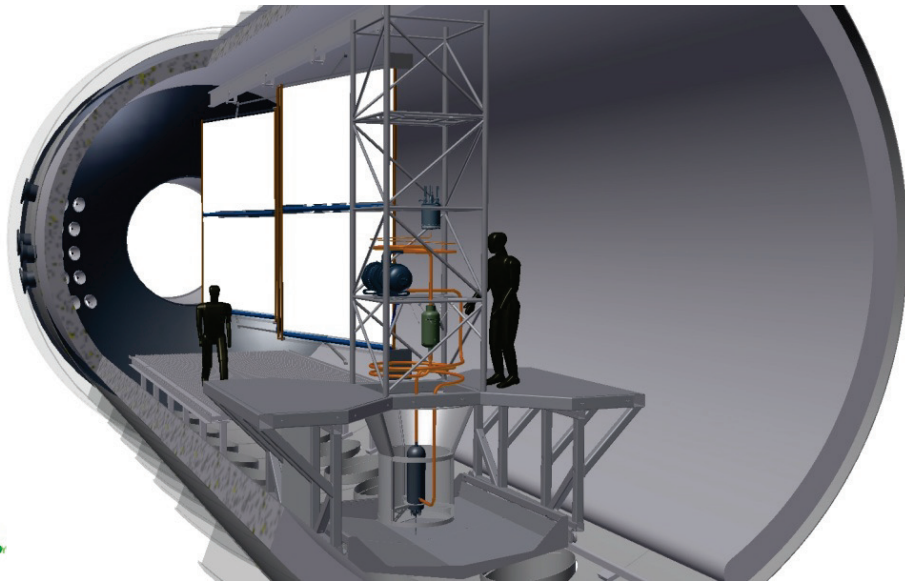


Small Reactor for Science Missions
(500 W – 5 kW)

FPS Technology Demonstration Unit

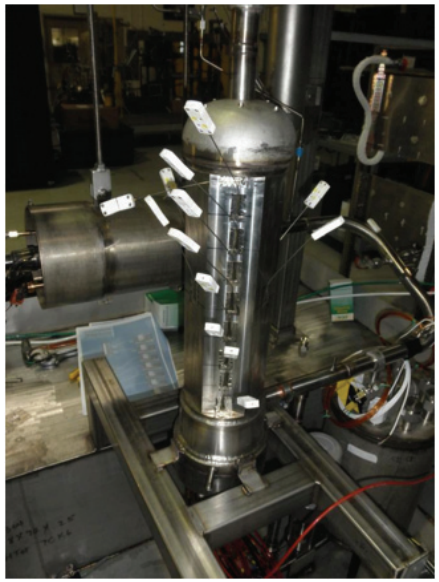
- Non-nuclear demonstration of a Fission Power System
- Full-scale FPS components
- Thermal vacuum environment
- Heat provided by a reactor simulator



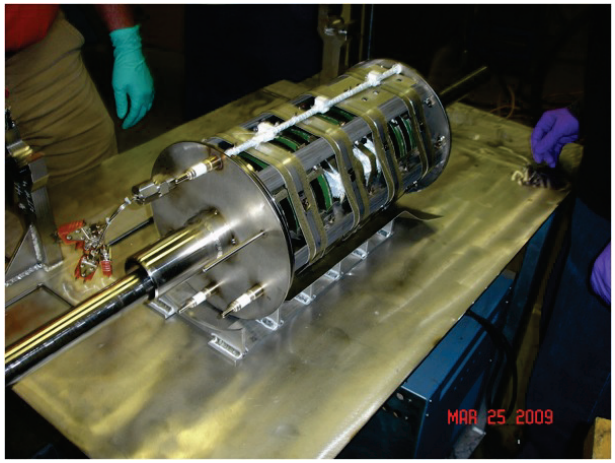


Hot-End Components

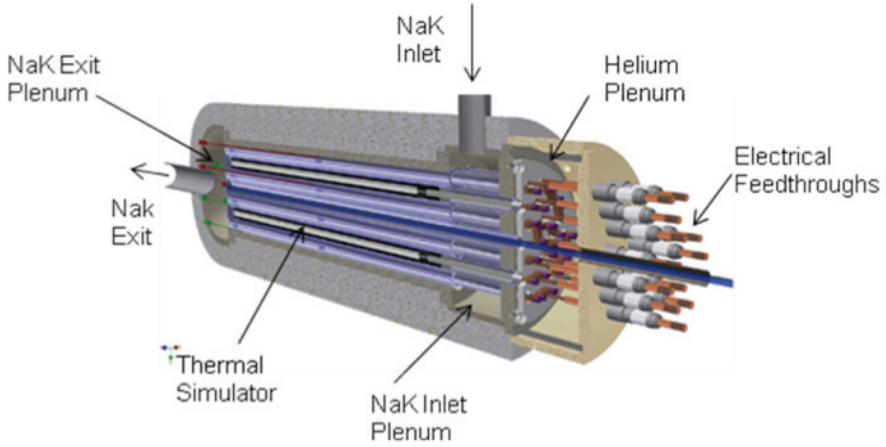
- Core Simulator
  - Electrically heated
  - Thermally and hydraulically similar to FPS core
- Annular Linear Induction Pump (ALIP)
  - Electromagnetic pump / No moving parts
  - Previously tested in the ALIP Test Circuit
- Currently being tested at the sub-system level



Core simulator



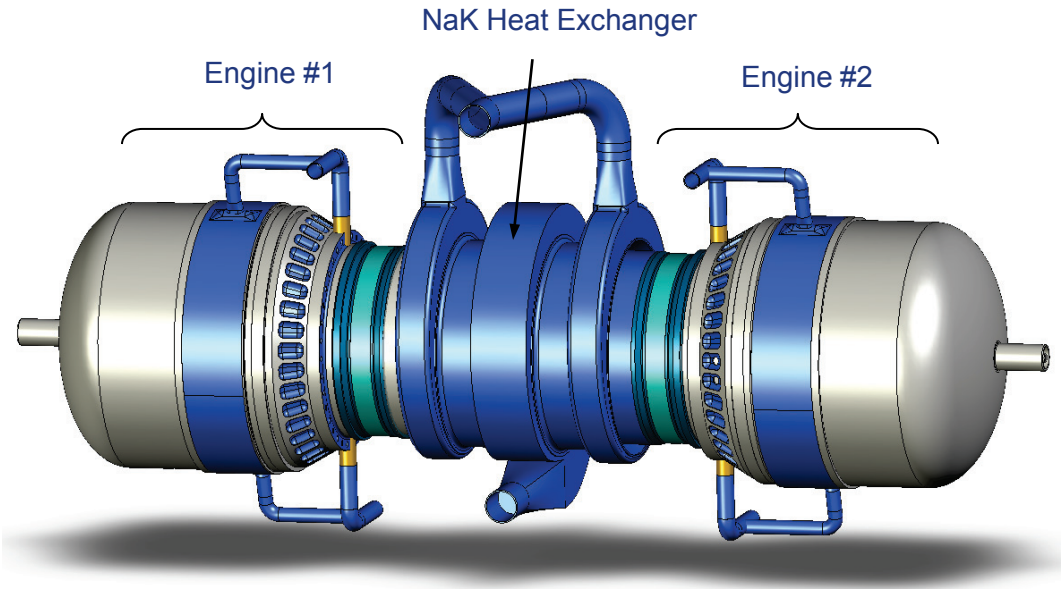
ALIP installed at MSFC

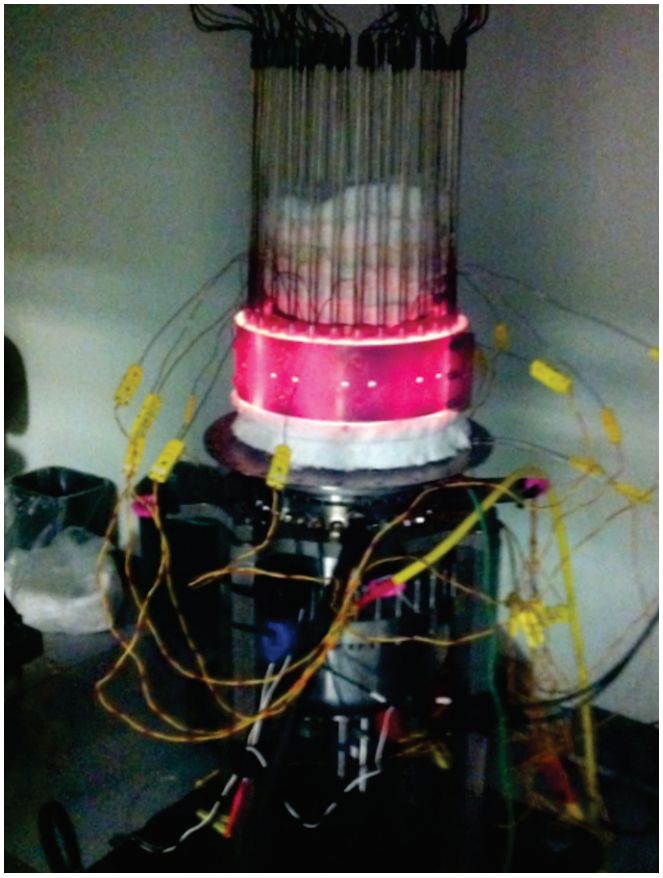


Core simulator cross section

Stirling Power Conversion Units

- Two Stirling convertors manufactured separately
  - Convertor 1 was fabricated in Fall of 2011
  - Convertor 2 was fabricated in Spring of 2012
- Will be combined into a single PCU by combining the expansion spaces of each convertor



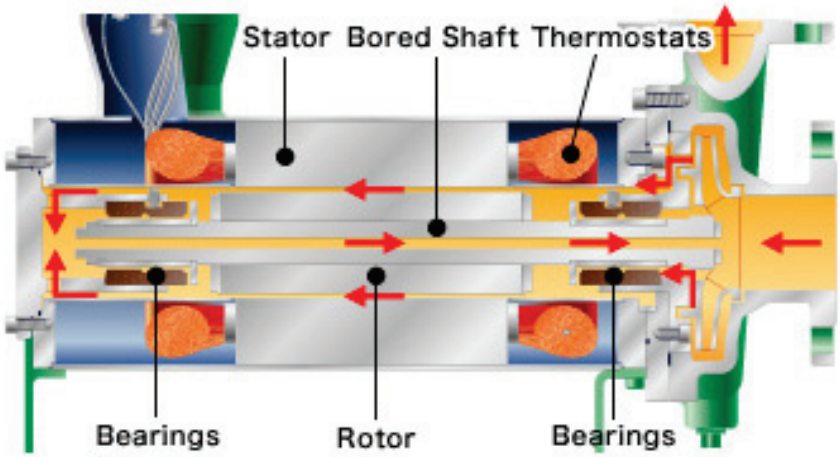


Structural Components

- Build-up Assembly Platform (BAP) and Upper Truss Structure (UTS) have been fabricated and assembled.
- The BAP/UTS will be used to mount all TDU components in a flight-like configuration.
- The UTS is designed to accommodate additional FPS components (i.e. deployable radiators and additional PCUs).
- This structure will be used to test cold-end components in VF 6 prior to TDU testing

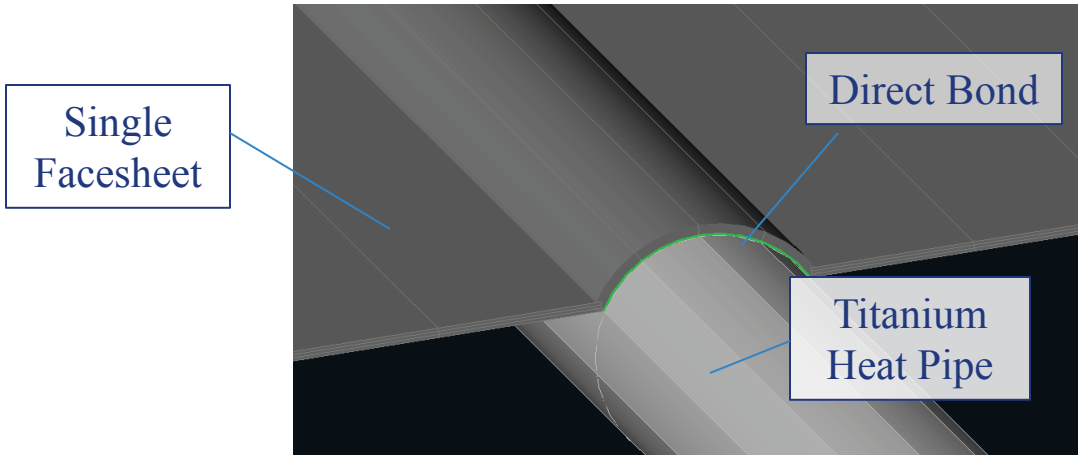
Heat Rejection

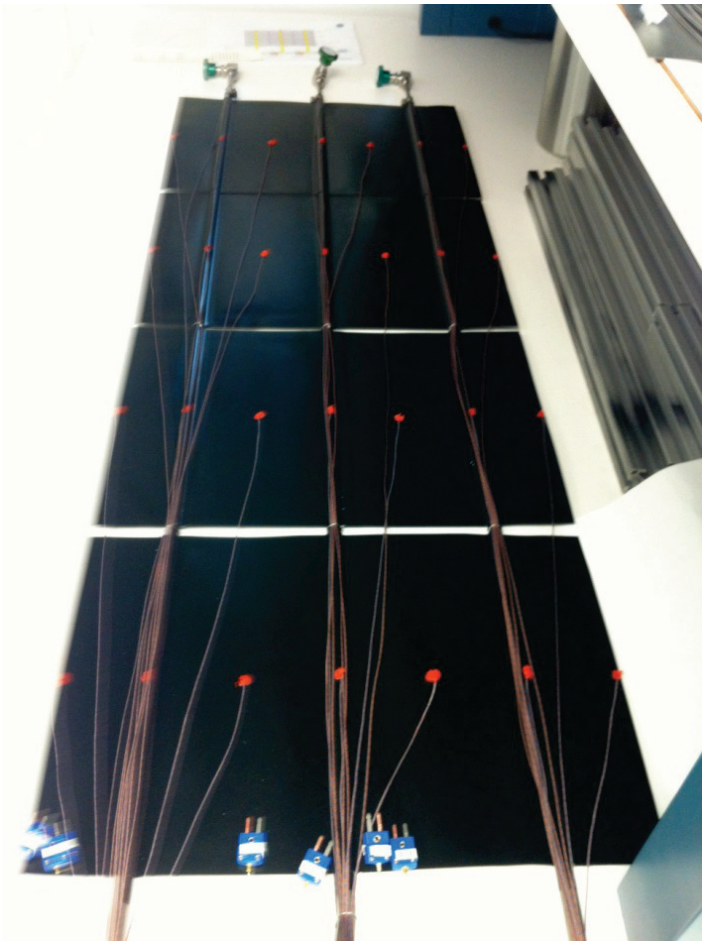
- FPS heat rejection comes from heat pipe radiators
- TDU heat rejection Phase I
  - Forced convection heat exchanger outside of the vacuum chamber
- Phase II
  - Prototypic radiators inside of vacuum chamber
  - This phase has been cancelled due to budget constraints
- The forced convection heat exchanger has been tested at the component level
- The vacuum compatible pump has been procured and will be tested at the subsystem level



Affordable Radiators

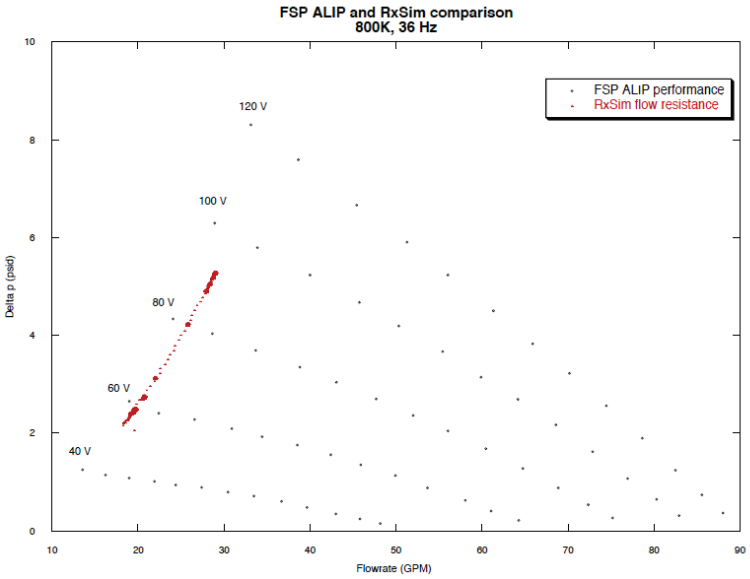
- Affordable designs
  - Low cost materials
  - Fewer components
  - Reduced mass
  - Greater technical risk





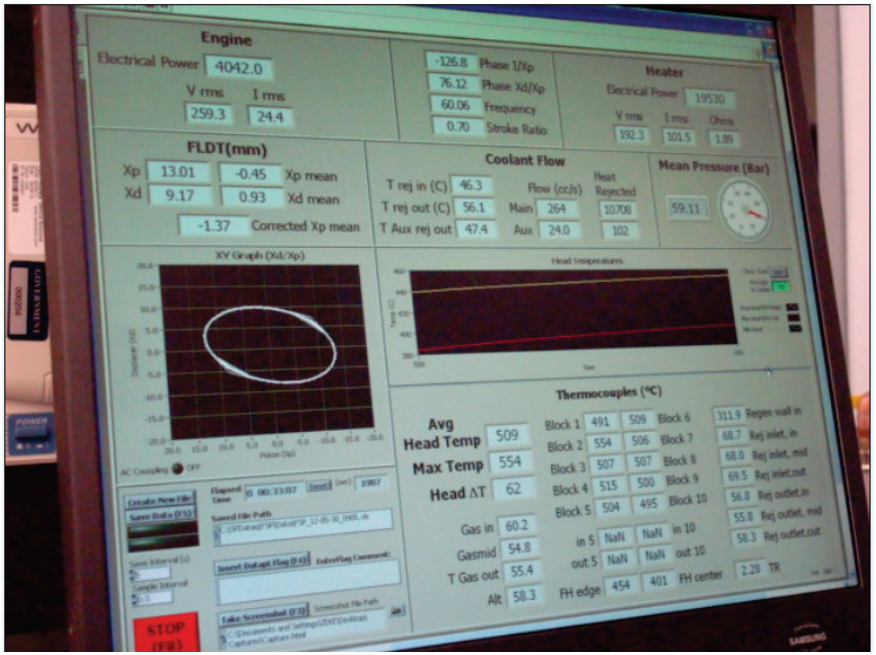
Hot-End Testing

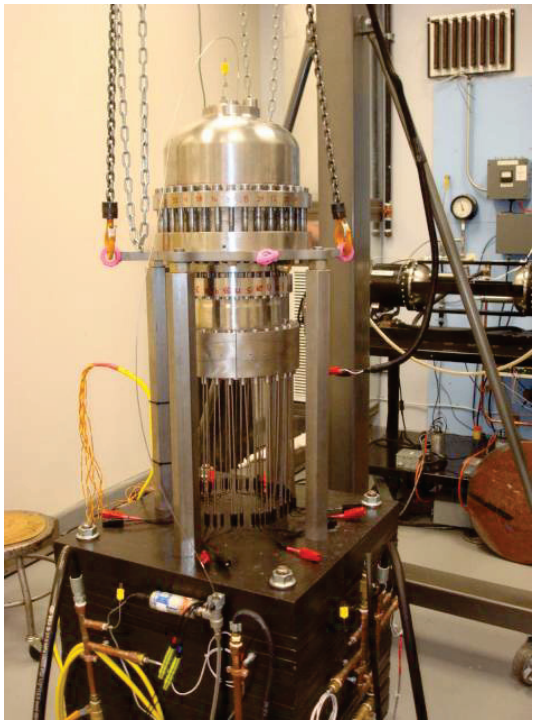
- Core simulator demonstrated to 50 kW_t
  - Operated in constant power and constant temperature mode
  - Reactivity feedback mode will be demonstrated
- FSP and TDU ALIP pump curves have been generated
- Flow resistance curves have been generated
- All components tested at nominal and maximum temperatures



Stirling PCU Testing

- Tested Separately
  - Convertor 1 reached full power in Dec 2011
  - Convertor 2 reached full power in July 2012
- Convertors will be combined into a single PCU at the conclusion of checkout testing

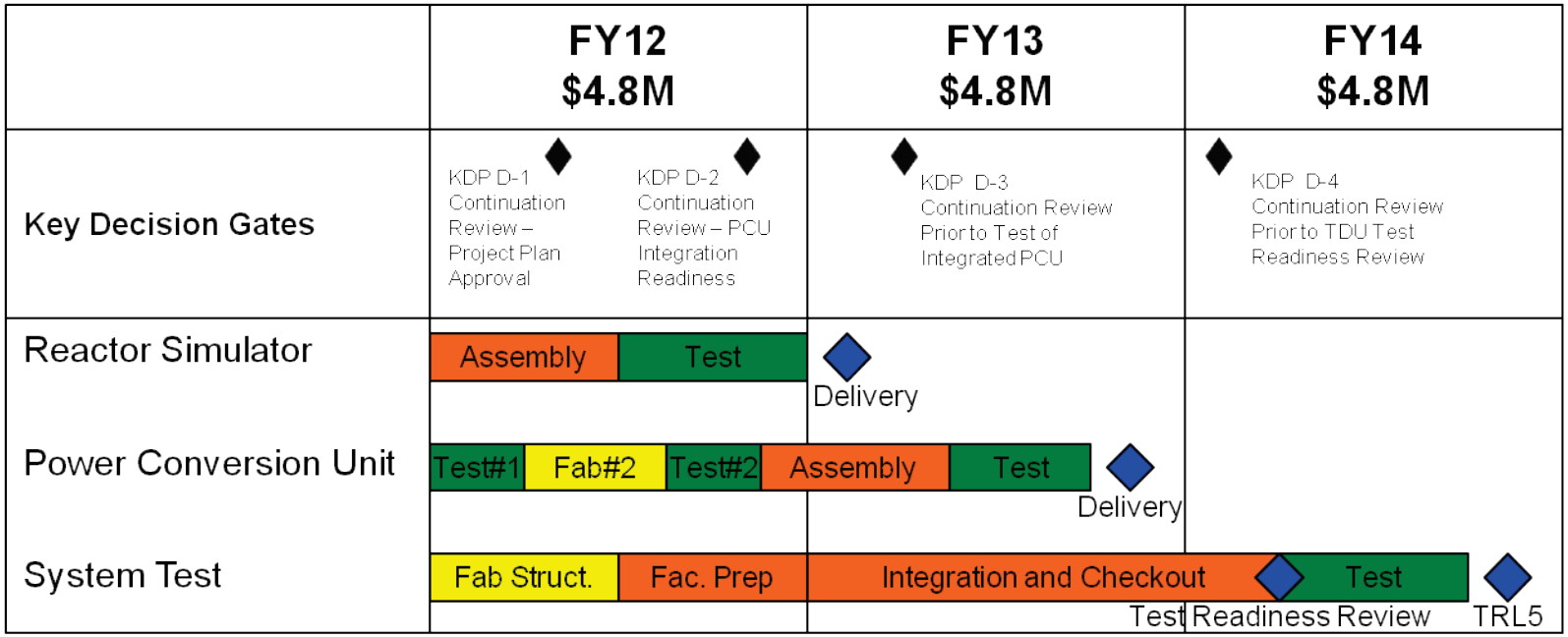




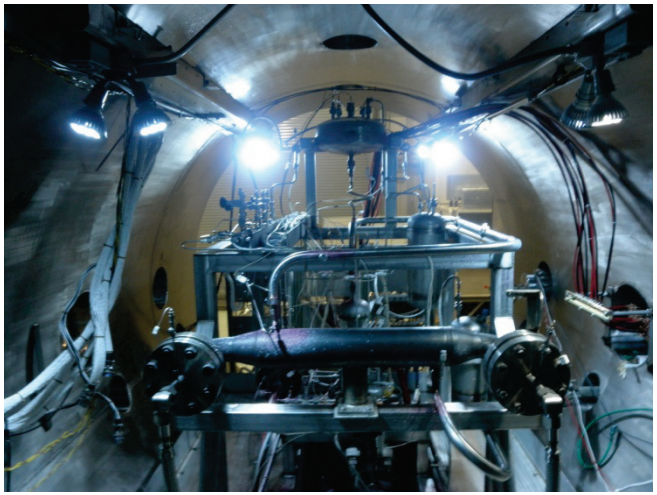
Cold-End Testing

- Design and layout are complete
- Major components have been fabricated and delivered
  - Pump
  - Volume Accumulator
  - Heat exchanger
- Auxiliary components have been ordered
  - Plumbing
  - Mounting Structure
- Assembly will begin in August 2012
- Testing will include
  - Fill/Drain/Backup water systems
  - Pump and flow resistance curves

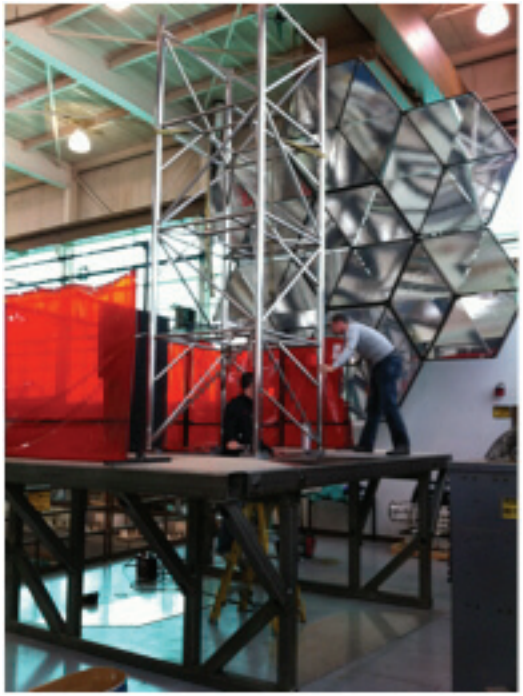
Schedule


FY12
$4.8M
FY13
$4.8M
FY14
$4.8M
Key Decision Gates
KDP D-1 Continuation Review – Project Plan Approval
KDP D-2 Continuation Review – PCU Integration Readiness
KDP D-3 Continuation Review Prior to Test of Integrated PCU
KDP D-4 Continuation Review Prior to TDU Test Readiness Review
Reactor Simulator
Assembly
Test
Delivery
Power Conversion Unit
Test#1
Fab#2
Test#2
Assembly
Test
Delivery
System Test
Fab Struct.
Fac. Prep
Integration and Checkout
Test
Test Readiness Review
TRL5

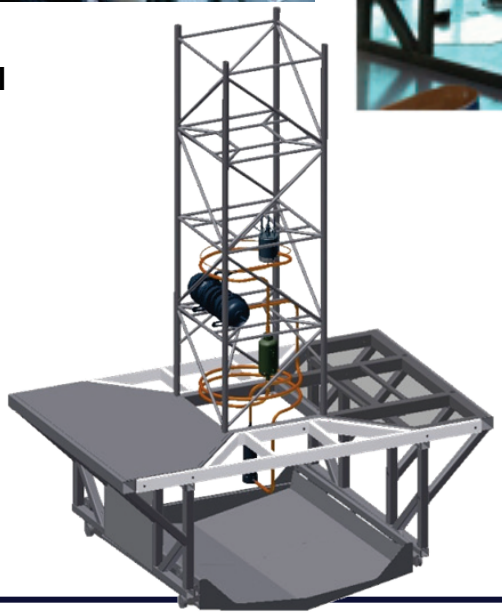
Major TDU Component Hardware Complete!



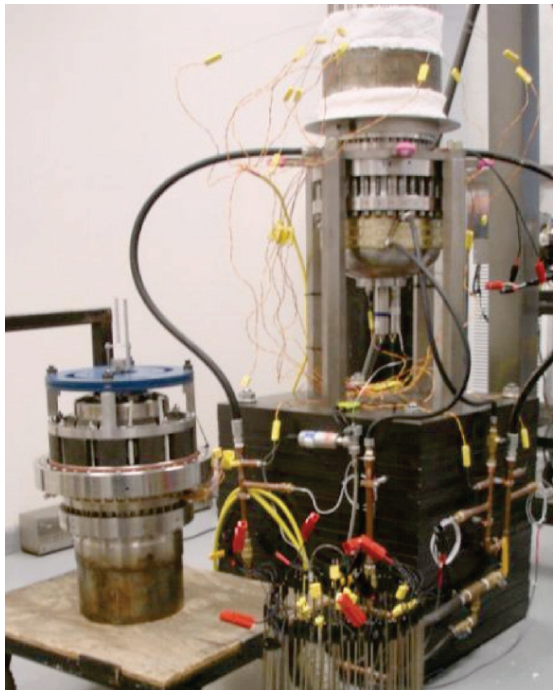
Reactor Simulator in MSFC Environmental Chamber



Completed TDU Structure Outside GRC Vacuum Facility 6



TDU Concept Layout



Complete pair of TDU Power Conversion Unit Stirling Engines

Conclusions

- All major TDU components have been fabricated
  - Most have been tested at the component level
- Hot-End sub-system testing is nearing conclusion
  - Core simulator has been demonstrated at maximum steady-state temperatures and heat fluxes
  - ALIP has been run in a representative flow loop at all anticipated operating conditions
- PCU sub-system testing is underway
  - Both convertors have demonstrated full power
  - On schedule for thermodynamic coupling late this year
- Cold-end subsystem testing is in the build-up phase
- All testing is on schedule for TDU testing in early 2014