National Aeronautics and
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High-Efficiency Stirling Generators for Science

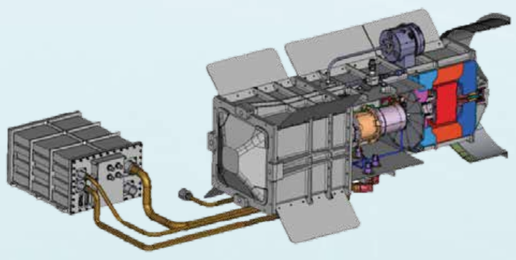
Presented by: Jim Withrow | Project Manager | NASA Glenn Research Center | James.P.Withrow@nasa.gov | (216) 433-8315

The **Stirling Radioisotope Generator** remains a future option for Planetary Science missions despite the ASRG flight project cancellation. Work continues at NASA Glenn Research Center (GRC) to demonstrate system life and reliability while developing new features that should increase robustness and expand mission use for a variety of science exploration customers.

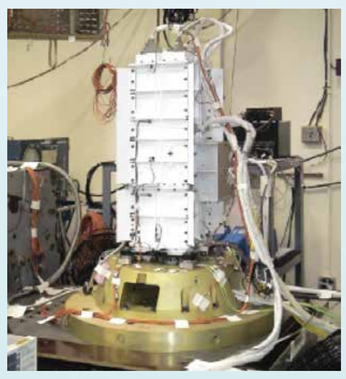
ASRG Accomplishments

While the ASRG flight development was not completed, there were many intermediate achievements including:

- Engineering Unit (EU) completed environmental verification test campaign at Lockheed Martin and operated for 33,000 hours at GRC
- Final Design Review completed by Lockheed Martin under contract to DOE with design goals of 140 Watts BOM, 30 kg total mass, 4.7 W/kg specific power
- Integrated System Test Pathfinder demonstrated flight-like components in a system context



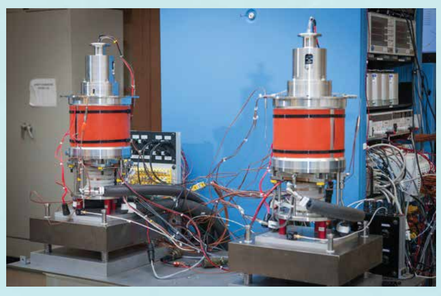
140 W (30 kg)

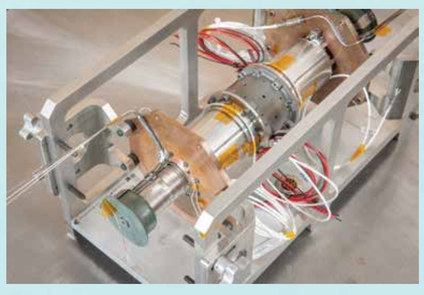


The Advanced Stirling Convertor

The Sunpower ASC technology has seen significant improvements over multiple hardware design cycles, resulting in a high fidelity convertor:

- Original convertor started under SBIR with heritage to Sunpower flight cryocooler experience (RHESSI)
- 80 W unit is >35% efficient at ASRG design conditions: Thot=760°C, Tcold=90°C, 4.5 mm amplitude, 102 Hz
- 25 convertors delivered to GRC and over 315,000 cumulative hours of operation
- Latest Engineering Model (E3) convertors built to flight prints with flight-quality processes – 4 delivered; 4 more in production at Sunpower





ASRG System Engineering Unit #2

FY14 resources provided for high fidelity, system-level demonstration using engineering components. Objectives include:

- Test ASRG EU2 performance relative to ASRG flight requirements
- Characterize EU2 steady-state and dynamic system performance including power output, operating sensitivities, disturbance forces, and fault transients
- Validate system interfaces and electrical performance in a spacecraft context (RPS Systems Integration Lab)

Next Generation Stirling

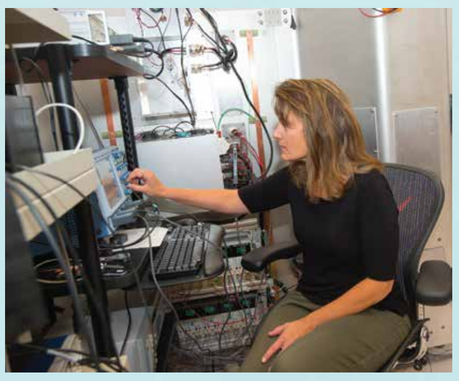
Potential design improvements include:

- Multi-layer insulation for mass reduction and increased thermal efficiency
- Backup heat source cooling to permit convertor shutdown and restart
- Cold-end heat pipes for efficient heat rejection
- High temperature alternators for expanded mission environments
- Advanced controllers and active balancers to allow continued generator operation after internal faults

Radioisotope Power Systems (RPS), System Integration Laboratory (RSIL)

NASA has invested in advancing RPS technologies by building RSIL, located at GRC, which:

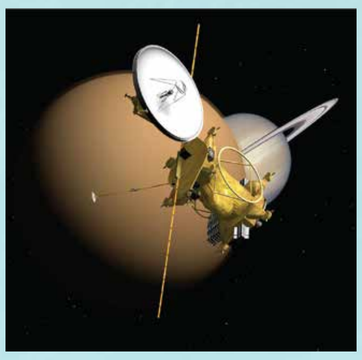
- Verifies and validates new technologies
- Is extremely versatile, capable of testing RPS and hybrid systems consisting of combinations of RPS and other power sources.
- End-to-end system testing using a wide range of mission operating scenarios eliminates component integration problems.
- Verifies Power Quality of systems and components



Potential Mission "Pull"

ASRG is a key supporting capability in 16 of 31 Mission Concept Studies performed for the 2011 Planetary Science Decadal Survey, including:

- Mercury Lander
- Lunar Geophysical Network
- Lunar Polar Volatiles Explorer
- Mars Polar Climate Mission
- Jupiter Europa Orbiter
- Io Observer Mission
- Trojan Tour and Rendezvous Mission
- Titan Saturn System Mission
- Saturn Atmospheric Entry Probe
- Saturn Ring Observer
- Enceladus Flyby and Sample Return
- Enceladus Orbiter
- Titan Lake Lander
- Uranus Orbiter and Probe
- Neptune-Triton-Kuiper Belt Objects Mission
- Chiron Orbiter



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