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Power system milestones

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*The **Aerospace Power Systems Technical** Committee focuses on the analysis, design, test or application of electric power systems or elements of electric power systems for aerospace use*

In June the **Cassini mission** marked 10 years of exploring Saturn, its rings and moons. Its radioisotope thermoelectric generators are performing as predicted, with propellant as the life-limiting factor of the mission. It is a project of NASA, the European Space Agency and the Italian Space Agency, and is managed by the Jet Propulsion Laboratory for NASA.

MESSENGER, the Mercury Surface, Space Environment, Geochemistry and Ranging mission, marked 10 years since its August 2004 launch and more than three Earth years (14 Mercury years) in orbit. The spacecraft operates in one of the most challenging and demanding environments with solar arrays designed for the high solar intensity (11 suns) and high temperature by tilting the panels as the solar intensity increases. The Johns Hopkins University Applied Physics Laboratory built and operates the spacecraft and manages the mission for NASA.

In another milestone, NASA's Opportunity Mars rover reached 10 years of operation and now holds the **off-Earth roving distance record** of 40 kilometers. Opportunity's power system uses triple junction solar cell technology and a rechargeable lithium-ion battery. The Jet Propulsion Lab manages the project for NASA.

NASA, ATK Space Systems and Deployable Space Systems Inc. are developing **lightweight solar arrays** with innovative packaging and deployment schemes for high-power solar electric propulsion systems. Twenty-kilowatt-scale units of ATK's MegaFlex and DSS' Mega-ROSA were built and tested in 2014. Testing included thermal-vacuum deployment at the Glenn Research Center's Plum Brook Station and Boeing's El Segundo, California, facility; plasma environment testing at JPL; and radiation testing at NASA's Goddard Space Flight Center, along with stowed and deployed dynamics testing, deployed strength and stiffness testing, and analytical correlation to structural and thermal data.

Engineers at NASA's Marshall Space Flight Center, working with Jacobs Engineering and ManTech International, built and tested a large, **inflatable solar array** that could provide 1 kilowatt in Earth orbit. The solar array could be folded and deployed without damaging the solar cells in a laboratory environment.

A **non-nuclear power conversion** demonstration unit for a large fission reactor power system was tested at full power before delivery in September to Glenn. It uses a 12 kilowatt-electric Stirling developed by Sunpower Inc. and features a unique sodium-potassium heat exchanger integrated with a pumped sodium-potassium heat transfer loop developed by NASA's Marshall Space Flight Center.

NASA is developing more efficient **thermoelectric technologies** that can increase performance by two to four times over state-of-practice systems with a 25 percent improvement in electrical power output at beginning of life over the current thermoelectric system operating on Mars and reduced performance degradation over time. Several advanced high-temperature thermoelectric materials and high-temperature rare earth compounds have been developed for integration into advanced power generation devices at JPL. The stability of their thermoelectric properties has been demonstrated for over 18,000 hours at temperatures up to 1,323 kelvins. Teledyne Energy System Inc. will mature JPL's lab scale thermoelectric materials, components and couple production processes into flight-like ready couples and modules.

NASA

Sunpower's 12 kilowatts-electric power conversion unit with electrically heated heater head.

A 1 kilowatt non-flow-through polymer electrolyte membrane fuel cell developed by NASA with Infinity Fuel Cell and Hydrogen Inc. was integrated and tested in a rover power module. It eliminates the mass, volume and parasitic power penalties associated with water management in conventional fuel cells.

NASA is researching the use of high-temperature solid oxide fuel cells that could use hydrocarbon boil-off, residuals and methane that reduce the need for pure hydrogen and oxygen and large waste heat rejection systems.