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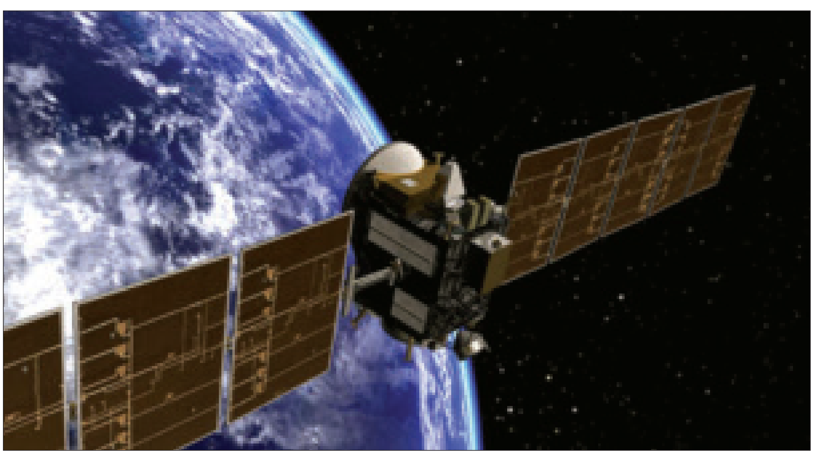
Aerospace power systems

This year brought significant advances in both solar and nuclear power technology and their application to complex space missions, many in harsh environments. Photovoltaic cells for space saw significant technical breakthroughs using lower mass multijunction cells with improved bandgap optimization and spectral utilization. Inverted Metamorphic cells are being demonstrated by Emcore, Spectrolab, and MicroLink Devices, some achieving efficiencies exceeding 32%, with flight-ready cells expected in the near future. Further enhancements already demonstrated in the laboratory indicate that efficiencies exceeding 37% can be realized in a few years.



Dawn will orbit Vesta, then transfer to orbit around the dwarf planet Ceres.

Meanwhile, the current standard triple-junction cell technology with efficiencies exceeding 29% has led to lower cost and higher reliability, while array integrators are pursuing higher power levels of tens to hundreds of kilowatts with more compact packaging to allow smaller launch vehicles, or higher capability from a single launch vehicle. Array approaches being demonstrated to satisfy up to 300 kW per mission include Ultraflex from ATK, high-power HPSA from Boeing, and the rollout ROSA from Deployable Space Systems. To improve cost and reliability, modularity and automation approaches also have been developed, such as the MOSAIC standardized module from Vanguard Space Systems.

The NASA New Frontiers mission Juno, the first solar-powered spacecraft to explore Jupiter, was launched on its five-year trip to Jupiter's polar orbit. The Lockheed Martin spacecraft is spin stabilized with three solar panel wings that span approximately 66 ft and produce 12 kW of power at 1 AU and about 420 W at Jupiter. Juno uses a highly elliptical orbit to avoid the radiation belts and keep the solar panels in sunlight continuously. Two 55-A-hr lithium-ion batteries provide energy storage for load leveling, and the power electronics are shielded in a vault to protect them from the harsh radiation environment.

The NASA Discovery Program Dawn entered orbit around the asteroid Vesta, on its way to being the first spacecraft to orbit an asteroid and then transfer to orbit around a dwarf planet, Ceres. Dawn, provided by Orbital Sciences, includes high-power 2.6-kW xenon ion thrusters producing 92 mN. The thrusters are powered by a solar array rated at 10 kW at 1 AU and delivering 1.3 kW at 3 AU at end of mission.

The Mars Science Laboratory mission, managed by JPL as part of the NASA Mars Exploration Program, was delivered for launch late this year. It includes the Curiosity rover, slated to land inside Gale crater on Mars. Curiosity is powered by the Boeing MMRTG (multimission radioisotope thermoelectric generator), which provides 2.5 kWh per day while contributing to the rover's thermal stability through waste heat recirculation.

The advanced Stirling radioisotope generator (ASRG), in development by the Dept. of Energy on behalf of NASA, has undergone extended operational testing of an engineering unit developed by Lockheed Martin, including a pair of Stirling convertors provided by Sunpower. Testing at NASA Glenn achieved over 14,000 hr of reliable operation. The ASRG uses only one-quarter of the plutonium dioxide fuel needed by radioisotope thermoelectric generators to produce a similar amount of power, thus extending the limited national supply of plutonium 238.

NASA and DOE began building a non-nuclear system-level technology demonstration unit of a fission reactor power source, comprising a reactor simulator, power conversion unit, and heat rejection system. NASA Marshall assembled the reactor simulator with electromagnetically pumped liquid metal NaK at temperatures up to 900 K. Sunpower has started assembly of the Stirling engines to prepare for future integration and test at NASA Glenn in the thermal vacuum facility. The heat rejection system will be added later for system-level demonstration by 2016.

by the **AIAA Aerospace Power Systems Technical Committee**