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AIAA

Aerospace power systems

Lightweight solar arrays having the highest specific power ever achieved are under development and in use on advanced missions. ATK's UltraFlex solar array contributed to the success of the Mars Phoenix lander. Its 2.1-m-diameter wings achieved a power density exceeding 118 W/kg using Spectrolab 28.3% efficient UTJ solar cells. Larger diameter versions of the UltraFlex wing are being developed, with successful vacuum deployment of a 5.5-m, 175-W/kg wing prototype in a ground demonstration. Further scale-up to 5.9-m-diam UltraFlex wings is envisioned as a planned power platform for NASA's Orion CEV and other missions.

Concentrating photovoltaic arrays are the focus of a DARPA Phase 2 development award to Boeing for design, analysis, and fabrication of a multikilowatt ground demonstration article. Boeing is teamed with DR Technologies, Northrop Grumman, and Emcore to create the Fast Access Spacecraft Testbed (FAST) high power generation system, including solar concentration, power conversion, power management and distribution, heat rejection, and structures, along with necessary deployment, pointing, and tracking mechanisms. When combined with state-of-the-art electric propulsion systems, FAST will form the technological basis for a lightweight, high-power, highly mobile spacecraft platform, with scalability to 175 kW, and at a high system specific power level of 130 W/kg, more than three times those of conventional systems.

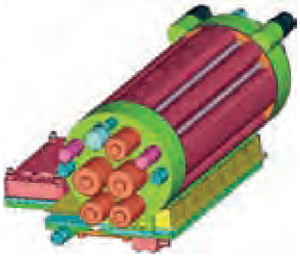
The advanced solar cells also have benefits on Earth. Both Boeing and Emcore are offering concentrator systems that reduce the size of the solar cell and the associated cost per watt so that utility-scale systems can take advantage of space quality and performance. This year saw a new world efficiency record set by Spectrolab for a concentrator solar cell converting 41.6% of concentrated terrestrial sunlight to electricity.

NASA is developing energy storage technology, including fuel cells and batteries, to meet the expected needs of a lunar outpost. "Non-flow-through" proton-exchange-membrane fuel cell stacks and electrolyzers coupled with low-permeable membranes are being developed and integrated with reactants stored at pressures over 2,000 psi. These technologies form the basis for a regenerative fuel cell module providing 3 kW for 10,000 maintenance-free hours, for application to a lunar outpost. Key advanced battery technologies include silicon composite anodes, lithiated mixed-metal-oxide cathodes, and low-flammability electrolytes providing tolerance to electrical and thermal abuse. They are being developed to achieve a specific energy of 150 W-hr/kg and 320 W-hr/liter. With 80% capacity retention after 2,000 cycles, these safety-enhanced cells are ideal for mobility systems such as EVA suits and lunar rovers.

The Mars Phoenix Lander uses ATK's UltraFlex solar array wings.

Lithium-ion battery technology is achieving wide application for spacecraft and launch vehicles, with flight-ready systems offered by ABSL Space Products, AEA Technology, and Saft. ABSL has provided lithium-ion battery technology for over 60 vehicles, including the NASA Kepler space telescope, Lunar Reconnaissance Orbiter, and Lunar Crater Observation and Sensing Satellite, launched this year.

Radioisotope power systems are facing critical challenges to continued efficient use of nuclear power in space, including a U.S. shortage of plutonium-238 for radioisotope thermoelectric generators. Increasing the supply of radioisotope sources and development of higher efficiency advanced Stirling radioisotope generators are being proposed to enable the nuclear power option for missions such as the Outer Planets Flagship 1.



A 3-kW non-flow-through fuel cell stack is being designed to help meet the needs of a future lunar base.

NASA and the Dept. of Energy continue to conduct research and subsystem testing of fission surface power technologies. An initial focus of the joint project is to develop a 40-kWe nuclear reactor that could power the proposed Shackleton Lunar Base and to enhance the potential to power a Mars base. Critical subsystem technology developed at NASA Glenn includes a lightweight composite full-scale radiator panel built by Material Innovations, successfully tested in a vacuum chamber down to –125 C. At NASA Marshall, Stirling engines built by Sunpower were producing over 2 kW of electricity at a gross thermal efficiency of about 32% using pumped liquid metal at 550 C.

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