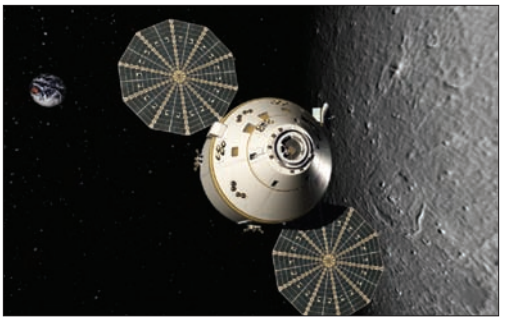
Aerospace power



Ultraflex, used on the solar array on the Phoenix Mars spacecraft, is also planned for use on the Orion crew exploration vehicle.

by **Ted Stern** and the **AIAA Aerospace Power Systems Technical Committee**

NASA's work on the Orion crew exploration vehicle continued this year. The conceptual design of Orion's electrical power system, completed by Lockheed Martin and NASA, includes a pair of 6-m-diam, ATK UltraFlex solar arrays and 12 lithium-ion batteries. The power system architecture, currently configured with three main power buses, will begin subscale development testing shortly, demonstrating battery charge control, power quality, and solar array compatibility in LEO and lunar environments.

UltraFlex solar array technology attained maturity with its first spaceflight on NASA's Mars Phoenix mission. The Mars Phoenix spacecraft benefited from the extremely lightweight flexible blanket array, which stows very compactly and unfolds like a fan into a circular solar array over 2 m in diameter. Using Spectrolab UTJ solar cells with more than 28% efficiency, the array generates 770 W at a record 118 W/kg specific power, including all array structure and mechanisms. Another advanced solar array technology was demonstrated with NASA's THEMIS spacecraft constellation, which began its mission powered by electrostatically clean solar arrays and lithium ion secondary batteries, all designed to provide an electromagnetically clean environment for sensitive scientific instruments.

To support solar system exploration, NASA has been developing advanced space nuclear power technologies. The NASA fission surface power (FSP) project completed a multiagency system study concluding that FSP could be affordably developed, tested, launched, and deployed to the lunar surface for outpost power. The study envisions a cost-effective 40-kWe system concept comprising a low-temperature, liquid-metal-cooled fast reactor with low development risk, coupled to free-piston Stirling converters. NASA and the DOE are developing the critical technologies—reactor components and materials, liquid metal pumps, multikilowatt Stirling converters, heat pipe radiators, and power distribution systems.

NASA/DOE work on the advanced Stirling radioisotope generator (ASRG) is reducing the Pu-238 fuel requirement through increased efficiency, while achieving higher specific power with lower mass components. This effort, led by Sunpower, has demonstrated a free-piston Stirling converter with better than 38% efficiency. This high efficiency enables the ASRG to achieve a specific power of over 7 W/kg, a factor of two improvement for radioisotope generator technology. Sunpower's Stirling converter development and Lockheed Martin's completion of the ASRG engineering unit design are leading to fabrication, qualification testing, and delivery to NASA for performance and life testing in 2008. NASA has recommended the ASRG for use on a future Discovery/Mars Scout mission in the 2012/2013 time frame.

Improvements in solar cell technology are advancing the performance of photovoltaic power generation systems through development of both thin film and high-efficiency crystalline cells. United Solar Ovonic received a follow-on contract from the Air Force Research Laboratory (AFRL) to develop new amorphous silicon ultralightweight space solar arrays on thin stainless steel foil and polymer substrates. These cell technologies have been tested in AFRL experimental missions such as the recently launched TacSat-2 satellite. AFRL selected Ascent Solar Technologies to develop an innovative, flexible thin-film tandem solar cell using CIGS (copper-indium-gallium-selenium), with the goal of demonstrating thin film photovoltaic efficiencies of 20%.

Crystalline solar cells have been achieving higher efficiencies than ever before using metamorphic materials. The metamorphic cell allows use of mismatched photovoltaic materials, giving designers more freedom in multijunction cell material selection for greater absorption and conversion of sunlight. This could lead to four-, five-, and six-junction cells with efficiencies as high as 50%. EMCORE attained a record space solar conversion efficiency of 31% with its inverted metamorphic multijunction solar cells. These advances have also been applied to the terrestrial photovoltaic technology, with EMCORE demonstrating 37% peak conversion efficiency on its terrestrial concentrating solar cell products, currently in volume production. The National Renewable Energy Laboratory, together with Boeing Spectrolab, received an R&D 100 Award recognizing its high-efficiency metamorphic multijunction concentrator solar cell, the first solar cell to break the 40% terrestrial conversion efficiency barrier.