technology selections for human-rated NASA Constellation Systems and other relevant missions. In addition, the program has successfully cultivated mutually beneficial relationships between the team's industrial partners, which will ultimately result in reduced systems-level cost and reduced times for technology maturation.

Find out more about the research of Glenn's Electrochemistry Branch:
http://grc.nasa.gov/WWW/Electrochemistry/

Glenn Contact:
Dr. Richard S. Baldwin, 216–433–6156, Richard.S.Baldwin@nasa.gov

JPL Contact:
Dr. Ratnakumar V. Bugga, 818–354–0110, Ratnakumar.V.Bugga@nasa.gov

Authors:
Dr. Richard S. Baldwin, William R. Bennett, Dr. Ratnakumar V. Bugga, Gary A. Horsham, Concha M. Reid, and Dr. Marshall C. Smart

Headquarters Program Offices:
Exploration Systems Mission Directorate, Innovative Partnership Program Office

Programs/Projects:
Exploration Technology Development Program, Energy Storage Project

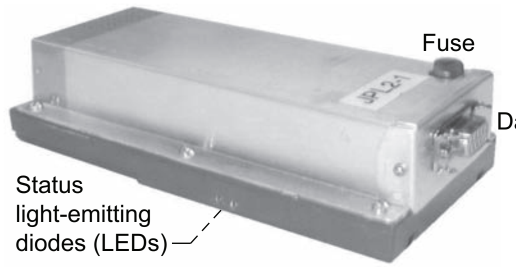
Lithium-Ion Battery Demonstrated for NASA Desert Research and Technology Studies

Lithium-ion batteries have attractive performance characteristics that are well suited to a number of NASA applications. These rechargeable batteries produce compact, lightweight energy-storage systems with excellent cycle life, high charge/discharge efficiency, and low self-discharge rate. NASA Glenn Research Center's Electrochemistry Branch designed and produced five lithium-ion battery packs configured to power the liquid-air backpack (LAB) on spacesuit simulators. The demonstration batteries incorporated advanced, NASA-developed electrolytes with enhanced low-temperature performance characteristics. The objectives of this effort were to (1) demonstrate practical battery performance under field-test conditions and (2) supply laboratory performance data under controlled laboratory conditions. Advanced electrolyte development is being conducted under the Exploration Technology Development Program by the NASA Jet Propulsion Laboratory.

NASA Desert RATS battery installed on a spacesuit LAB.

Field trials were completed at the 2007 NASA Desert Research and Technology Studies (Desert RATS) outings at Cinder Lake, Flagstaff, Arizona. Desert RATS is a NASA-led team of research partners involved in developing technologies applicable to the human exploration of a planetary surface (the Moon and Mars). Individual teams work throughout the year on promising new technologies that are candidates for demonstration at the outing. The demonstration batteries produced at Glenn powered the LAB cooling system as well as two secondary loads. The nominal power level was approximately 18 W, with a maximum of 31 W. In previous work, a commercial camcorder battery powered the LAB.

Demonstration batteries used four lightweight, 4.5-A-hr pouch cells, connected in series. The pouch cells, manufactured by Quallion LLC, were based on a product developed for the U.S. Army's Communications-Electronics Research, Development and Engineering Center under the Ultra Safe High Energy Density Rechargeable Soldier Battery Program (Contract No. W15P7T–05–C–P212). Cells were prepared using two NASA-developed electrolyte formulations. Control cells, prepared with Quallion electrolyte, were included as a control.



NASA demonstration lithium-ion battery.

The Desert RATS demonstration batteries were completed between May and September 2007. Design features included internal protection against over-current, over-discharge, and over-temperature. Controls for charging were external to the battery. Two prototype batteries were tested in Desert RATS dry-run activities at the Johnson Space Center from August 13 to 17, 2007. These trials verified fit and function with the Desert RATS spacesuits and helped identify areas of improvement for the batteries and support equipment. In laboratory testing at room temperature, the 500-gram Desert RATS batteries produced 66 W-hr, sustaining a constant power output of 38.6 W over 103 min of discharge time. This corresponds to a specific energy of 130 W-hr/kg, which represented a 24-percent improvement over the commercial camcorder battery.

Three field trials were successfully completed at Cinder Lake from September 10 to 12, 2007. Extravehicular activities of up to 1 hr and 50 min were supported, with residual battery capacity sufficient for 30 min of additional run time. Additional laboratory testing of batteries and cells is underway at Glenn's Electrochemical Branch.

Find out more about the research of Glenn's Electrochemistry Branch:
http://www.grc.nasa.gov/WWW/Electrochemistry/

ASRC Aerospace Corporation Contact:
William R. Bennett, 216–433–2486,
William.R.Bennett@nasa.gov

Glenn Contact:
Dr. Richard S. Baldwin, 216–433–6156,
Richard.S.Baldwin@nasa.gov

Authors:
William R. Bennett and
Dr. Richard S. Baldwin

Headquarters Program Office:
Exploration Systems Mission Directorate

Programs/Projects:
Exploration Technology Development Program, Energy Storage Project

Passive Cooling Plates Studied for Fuel Cells

The required characteristics of passive cooling plates for fuel cells were analyzed at the NASA Glenn Research Center. Fuel cells are typically cooled using a liquid coolant that is circulated through coolant cavities that are adjacent to each cell in a fuel cell stack. These coolant cavities must be sealed to prevent leakage between the coolant cavities and the hydrogen and oxygen cavities, as well as any leakage external to the fuel cell stack. In addition to the components inside the fuel cell stack, this approach to fuel cell cooling requires valves, a coolant pump, and external plumbing to circulate the coolant; a coolant accumulator to account for the volumetric expansion and contraction of the coolant during operation; sensors to monitor and control the cooling process; and the associated electronics for both power and control. Ideally, if the fuel cell stack temperature and heat removal could be controlled passively by highly thermally conductive plates, there would be a significant reduction in overall fuel cell system mass and complexity. Without the need to seal a coolant inside the cell stack, the number of fluidic seals could be substantially reduced, improving the reliability of the fuel cell stack fluidic integrity.

The cooling studies revealed that for small- to moderate-size fuel cells (≤225 cm^2 in active area) cooling plates of less than a millimeter in thickness could be used if the thermal conductivity of the plates was 800 W/m/K or greater. Although this thermal conductivity is about twice that of copper, there are materials that have thermal conductivities greater than 1000 W/m/K that could potentially be used.