Lithium-Ion Batteries for Aerospace Applications

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Rechargeable lithium-ion batteries offer significant performance and cost benefits for many future space missions. The projected benefits include reduced weight and volume of the energy storage system, improved reliability and low power system life cycle costs. In view of these advantages, NASA is considering the use of lithium ion-batteries in many aerospace applications such as planetary landers, planetary rovers, planetary orbiters, earth orbiting spacecraft (GEO and LEO) and astronaut equipment. Air Force is considering using these batteries in various applications, such as unmanned aerial vehicles, military aircraft and earth orbiting spacecraft (GEO & LEO). Some of NASA's missions that are scheduled to use these batteries in the near term include the Mars 2001 Lander, the Mars 2003 Rover, Europe, Pluto fly-by, and Solar Probe. Plans are also being made to replace the existing hydraulic Auxiliary Propulsion Unit (APU) of the Shuttle with an electrically controlled system using 100 – 150 kWh Li-Ion batteries. These batteries are also being considered for use in cameras, astronaut equipment, satellite tools etc.

Planetary missions such as landers and rovers require lithium-ion batteries (28 V, 6-35 Ah) that are capable of operating at temperatures as low as –20°C. Low earth orbiting spacecraft and planetary orbiters require lithium-ion batteries that can provide 30,000-50,000 cycles at 30-40% depth of discharge. GEO spacecraft require lithium-ion batteries that have an operating life greater than ten to fifteen years. Some aircraft applications require high voltage (28-300V), and high capacity (30-100 AH) batteries that can operate from –40°C to +60°C. Further, these batteries need to meet stringent environmental requirements such as vibration, shock, and high impact. Commercially available lithium-ion cells do not meet many of the space mission requirements. Small capacity lithium-ion cells (1-4 Ah) that only provide 500-1000 cycles are presently available commercially. Further, battery packs limited to 2-4 cells are being supplied for consumer applications. State-of-art lithium-ion cells need improvements in several areas, such as cell size/capacity, cycle life, and operating temperature. In addition, the safety of large capacity cells/and batteries is also a serious concern for space applications.

A joint DOD/NASA program has been established to develop lithium-ion batteries with the capabilities required by future NASA and DOD missions. The specific objectives of this program are to 1) develop high specific energy and long cycle life lithium-ion cells and batteries, 2) establish production sources, and 3) demonstrate technology readiness for rovers and landers by 2000, GEO missions by 2001, aviation/UAV's by 2001, military terrestrial applications by 2001 and LEO missions by 2003. The technical approach involves a) development of advanced electrode materials and electrolytes to achieve improved low temperature performance and cycle life, b) optimization of cell design to achieve high specific energy, c) development of cells (6-100 Ah) and batteries (16-300 V) of various sizes required for various future missions, and d) the development of control electronics for smart battery management. These batteries will be initially used in missions where weight and volume are critical and cycle life requirements are low to moderate (200-1000).

The development of lithium-ion cells for lander and rover applications is nearing completion. Prototype cells developed for these applications were evaluated for their performance characteristics, including room temperature cycle life, low temperature cycle life (-20°C), rate capability as a function of temperature, pulse capability, self-discharge and storage characteristics, as well as, mission profile capability. The results obtained so far indicate that they can meet mission performance needs such as low temperature operational capability, eight to ten month cruise stand storage requirement, cycle life and pulse capabilities. Testing of the cells for GEO and LEO missions and aircraft applications is in progress. This paper gives an outline of the DOD-NASA Li-ion program and progress made so far by US Air Force and NASA in developing lithium ion cells for future aerospace missions.

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