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Controlling the environment

by Brian O'Connor and the Space Environmental Systems Program Committee

*The **Space Environmental Systems Program Committee** focuses on environmental and thermal control technologies for aircraft, spacecraft and exploration missions.*

During the past year, environmental and thermal control systems have been implemented on numerous flight projects using traditional and cutting-edge technologies, while work continues toward advanced, enabling technologies for future missions.

NASA's **Curiosity rover** completed its first year on Mars in 2013. At the heart of the rover's thermal control system, a mechanically pumped liquid loop is maintaining benign temperatures for the rover's avionics despite the harsh Martian environment. It does this by supplying heat from the radioisotope thermoelectric generator and rejecting excess heat through radiators.

Multilayer insulation must protect ESA's BepiColombo spacecraft from intense temperatures during its mission to Mercury. Credit: ESA.

NASA completed its preliminary design review of the **Space Launch System**, NASA's next-generation heavy-lift rocket. Preparations for the review entailed definition of the system's thermal design environments and thermal interfaces, including those of the Orion crew vehicle and ground systems. The review showed that the current thermal design meets key requirements and also identified areas for improvement.

Research that may help to enable the space missions of the future is also under way. One study uses **shape memory alloys** to deploy a passively controlled radiator surface that can turn down the amount of heat rejected by a spacecraft. Another study is investigating new formulations of thermal control **fluids** that have freeze points below -90 C and are safe in human habitats. NASA's newly formed Space Technology Mission Directorate and Small Business Innovation Research program provide much of the funding for these studies.

To accommodate a future spacecraft, a facility used in the Apollo program received major upgrades. NASA Johnson's Chamber A, one of the world's largest space environment chambers, was modified for use in the **James Webb Space Telescope** (JWST) program, which funded the modernization. The goal was to increase the chamber's efficiency and enable it to simulate the extreme environments of future deep space missions. The updates to the refrigeration and control system allow the chamber to be controlled to temperatures ranging from below -258 C (15 K) to more than 57 C (330 K), at very low vacuum pressures.

Before the JWST flight test, a JWST **Pathfinder** will be cryogenically tested three times in **Chamber A**. The Pathfinder consists of flight-like features including a backplane structure segment with two primary mirror assemblies, a secondary mirror structure, and a secondary mirror assembly. The structure will be outfitted with flight-like thermal blankets and thermal simulators for missing mirrors that enable thermal performance similar to the flight unit. Because fully instrumenting the flight unit would substantially impact launch mass, the Pathfinder test will serve as a guide for the flight test. The thermal test will allow insight into critical gradients, and produce data that will help predict the cryogenic thermal performance of the flight unit.

In Europe, ESA's **Intermediate eXperimental Vehicle**, an atmospheric reentry demonstrator, completed a drop test from 3,000 m. The test validated the entire descent and recovery phases, including the interfaces with the high-temperature thermal protection system. The demonstrator is scheduled for a launch test in the summer of 2014.

BepiColombo, ESA's planned mission to **Mercury**, completed thermal balance tests of insulation samples representative of the flight design. The multilayer insulation will protect the spacecraft from the extreme heating it will experience on the mission. JAXA, the Japan Aerospace Exploration Agency, is ESA's partner in the program.