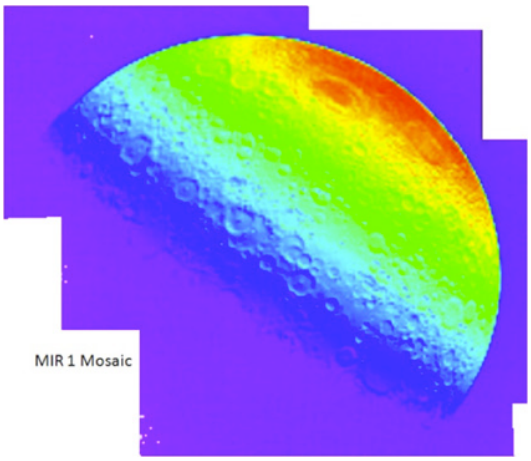
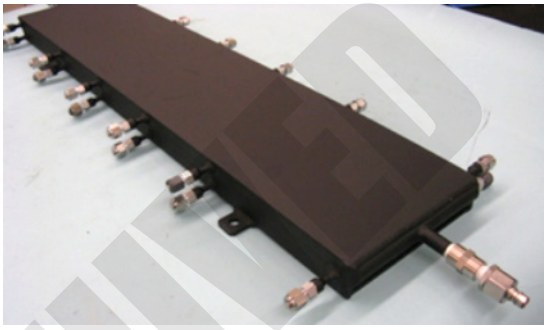
NASAfacts

# Space Technology
## Game Changing Development
## Phase Change Material Heat Exchangers Development and Demonstration Project

Space environments offer many unique challenges when designing a spacecraft. Among these challenges, thermal control can be considered as the ultimate cross-cutting discipline for space vehicle design. From the simplest satellite to the most complex, human-rated vehicle, all spacecraft require thermal control. As NASA moves on to exploring beyond Low Earth Orbit, the harsh environment of space requires novel thermal control hardware for mission success. An example of this is the lunar orbit environment due to the moon's high infrared incident load from its surface. The figure below is an IR snapshot of the lunar surface taken by the Lunar Reconnaissance Orbiter. The extreme surface variation results in large extremes in radiator sink temperatures while the vehicle is orbiting the moon. The large sink temperature fluctuations are problematic because it is impractical (sometimes even impossible) to use a radiator as the sole means of heat rejection by a vehicle.




*IR image of lunar surface taken by the Lunar Reconnaissance Orbiter.*



*A prototype of United Technologies Aerospace Systems' wax phase change material heat exchanger.*

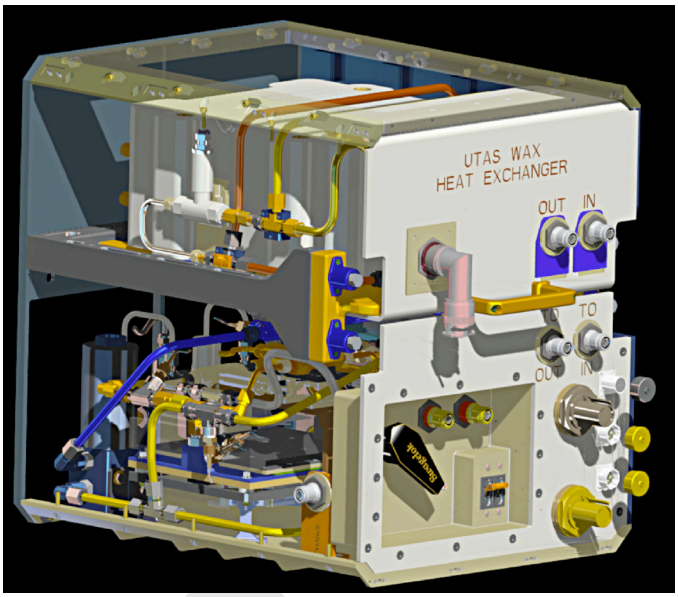
For long duration vehicles, such as NASA's planned Orion spacecraft, phase change material heat exchangers (PCM HX) can be used to provide supplemental heat rejection as a way to compensate for radiator performance. A typical PCM HX is used to store excess thermal energy during periods of high heat loads and/or hot thermal environments by melting a material. The energy is later rejected by the radiator, freezing the material and preparing it for the next heat load period. NASA's Game Changing Development is taking on a technology development and demonstration effort to design, build, and test the next generation of PCM HXs on the International Space Station. The primary objective of the task is to develop a PCM HX that operates through numerous freeze and thaw cycles without risking the structural integrity of the heat exchanger.

NASA has partnered with UTAS to build a wax-based PCM HX for flight demonstration. The design utilizes a novel phase management approach to ensure the wax freezes and thaws in a way that does not jeopardize the structural integrity of the heat exchanger.

In parallel to this effort, NASA is developing a new generation of water-based PCM HXs. By transitioning these heat exchangers to water, a considerable mass savings can be gained due to water's higher heat of fusion. The heat of fusion of a phase change material determines the amount of energy that can be stored per unit mass of the material. Although water is considered a benign phase change material, it provides unique challenges due to its expansion upon freezing. As a bottle of water could break because of water expansion if frozen, the structure of water-based PCMs could also break, or significantly weaken, due to water expansion. NASA has partnered with a small business, Mezzo Technologies, to facilitate the development of the water-based PCM. Mezzo Technologies specializes in the fabrication of unique, microtube heat exchangers.

Along with the aforementioned development efforts in the area of phase change material heat exchangers, NASA is also in the process of developing a unique test platform to facilitate the testing of these PCM HXs. The test facility utilizes a specialized thermal control system that utilizes heaters and thermoelectric devices to facilitate the freeze and thaw cycle of a PCM HX. The facility

*Mezzo Technologies' microtube heat exchangers.*




*Rendering of the Phase Change Heat Exchanger Demonstration Facility for the International Space Station.*

along with UTAS's Wax PCM HX are planned to reach the International Space Station in 2016. Upon completion of test, the wax PCM HX will be replaced by the water PCM HX currently under development.

The Phase Change Material Heat Exchanger Development and Demonstration project is a great example of how NASA leverages commercial partnerships to facilitate its goal of reaching to new destinations. As NASA moves on to a new era of space exploration, technology development and demonstration projects like this will pave the way for developing reliable systems needed for space exploration.

The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

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