

Phase Change Material (PCM) Heat Exchanger Development Project

Game Changing Development Program | Space Technology Mission Directorate (STMD)



ANTICIPATED BENEFITS

To NASA funded missions:

The project has identified two PCM HX concepts that have paths for possible infusion to future vehicles such as Orion. The project includes development and an eventual technology demonstration on the International Space Station (ISS). The first heat exchanger is wax-based and has reached a TRL of 4. The project will build a wax-based PCM HX in partnership with UTC Aerospace for flight demonstration on ISS. Testing a wax-based PCM HX in a relevant environment will allow an "off the shelf" option for future vehicles, such as Orion, that require long duration supplemental heat rejection.

DETAILED DESCRIPTION

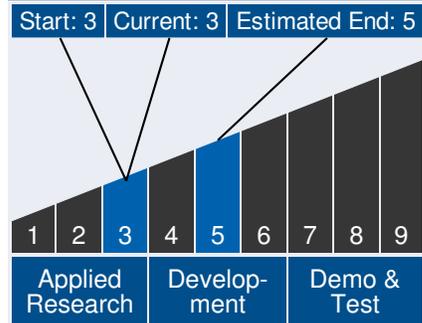
The primary focus of the project is to provide future space vehicles a reliable form of long duration supplemental heat rejection (SHREDs). SHREDs allow a vehicle to reject waste energy when nominal means do not allow so. The project is investigating, through partnerships with UTC Aerospace and Mezzo Technologies, the use of wax and water based PCM HX. The project will culminate with a technology demonstration on ISS.



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Technology Maturity



Management Team

Program Executive:

- Lanetra Tate

Program Manager:

- Mary Wusk

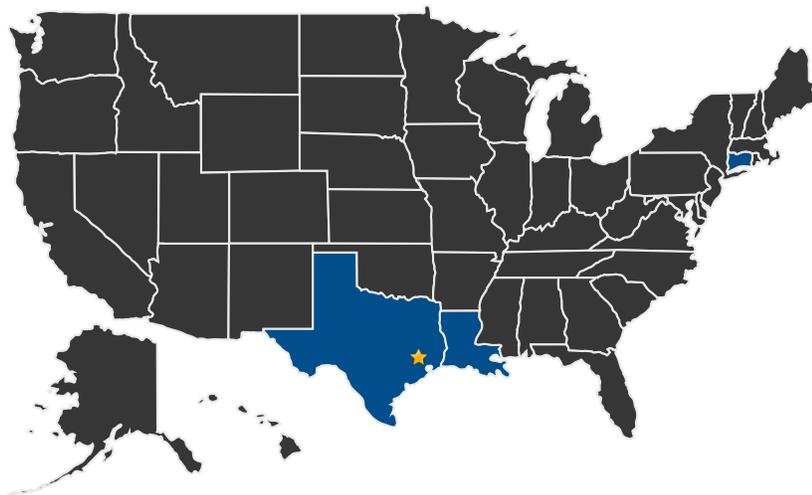
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U.S. WORK LOCATIONS AND KEY PARTNERS



■ U.S. States
With Work

★ **Lead Center:**
Johnson Space Center

Other Organizations Performing Work:

- Human Exploration and Operations Mission Directorate
- Mezzo Technologies (Baton Rouge, LA)
- Solar Atmospheres
- UTC Aerospace Systems

Management Team (cont.)

Project Manager:

- Rubik Sheth

Principal Investigator:

- Molly Anderson

Technology Areas

Primary Technology Area:

Thermal Management Systems (TA 14)

- └ Thermal Control Systems (TA 14.2)
 - └ Heat Rejection and Energy Storage (TA 14.2.3)
 - └ Phase Change Heat Exchanger – Phase Change Material Thermal Storage (Heat Sinks & Storage) (TA 14.2.3.3)
 - └ Phase Change Heat Exchanger – Phase Change Material Thermal Storage (Heat Sinks & Storage) (TA 14.2.3.3)

DETAILS FOR TECHNOLOGY 1

Technology Title

Phase Change Material (PCM) Heat Exchanger Development

Technology Description

This technology is categorized as a hardware component or part for manned spaceflight

Project has identified two PCM HX concepts that will be designed, developed and demonstrated on-board the International Space Station (ISS):

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- The first heat exchanger is wax-based, is currently at TRL4. The heat exchanger utilizes paraffin wax to aid in the process of supplying a vehicle a sources of supplemental heat rejection when needed. NASA Johnson Space Center has partnered with UTC Aerospace via a NASA NRA.
- The second heat exchanger is a water-based Phase Change Material Heat Exchanger and is currently at a TRL of 3. Johnson Space Center has partnered with Mezzo Technologies to develop the next generation of light weight water based PCM HXs.
 - Leveraging a Phase III Maturation SBIR in partnership with Mezzo Technologies to evaluate multiple water-based PCM HX concepts.

Initial phase of development includes the development and fabrication of wax PCM HX with UTAS for flight demonstration on the International Space Station. The ISS Program is supporting the project by providing resources to build and certify for flight a platform that can aid in demonstrating these PCM HXs on the ISS. In parallel to this effort, the project will work with Mezzo Technologies to advance the TRL of the water based PCM HX. Water is known to have the double latent energy storage of wax based PCMs. With this increase in energy storage, by using water as a PCM, the project can leverage possible mass and volume savings. If determined viable, the project will transition the development into the fabrication of a flight water PCM HX for demonstration on the same ISS research platform. Through testing these heat exchangers in an environment that only the International Space Station can provide, NASA will help advance PCM HX technology for future exploration and commercial crew vehicles. Currently, Orion has baselined the use of PCM HXs in its Exploration Mission 2 architecture.

Capabilities Provided

The general concept of a PCM HX allows for a media of phase change material to freeze and thaw within an enclosed volume to provide a source of thermal capacitance to a vehicle. The performance of the heat exchanger is dictated by the amount of energy storage it has and its ability to contain the PCM without any compromise to the containment mechanism of the PCM. Therefore, the key performance criterion for this development effort is the wax and water heat exchangers repeatability and overall mass. The energy storage capability of a PCM HX is governed by the latent energy storage of the PCM. Since the latent energy storage is a fixed value, this is a number that cannot be optimized for a given PCM. As the wax PCM Heat Exchanger has reached a TRL of 4 through UTC Aerospace's development effort, the objective of this project is to advance the TRL of the heat exchanger to TRL 5. This means to test the wax PCM heat exchanger in a relevant environment. The key performance criterion for this development effort is the heat exchanger repeatability. On the other hand, the water PCM HX development key performance criteria include the heat exchanger mass and its repeatability in performance. Upon completion of the first phase

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of the water PCM HX effort, it will be determined by subject matter experts if the water PCM HX technology has reached an appreciable TRL through development efforts with Mezzo Technologies. If so, the project will transition into a flight demonstration phase of the water PCM HX for the same level of testing the Wax PCM HX will go through. In culmination to the Phase Change Material Heat Exchanger Project, future vehicles like Orion and other commercial crew providers will have viable supplemental heat rejection technologies they can rely on for future missions.

Potential Applications

Potential applications of the PCM HX technology include future exploration vehicles such as Orion and other crewed and uncrewed vehicles requiring some form of supplemental heat rejection. Currently Orion has baselined the use of a PCM HX on its Exploration Mission 2 flight architecture. This is due to the fact that it currently plans on orbiting the moon. Due to the Moon's harsh environment, there is a need for supplemental heat rejection for an orbiting vehicle.