



NASA SBIR 2016 Phase I Solicitation

Z2.01 Active Thermal Control Systems for Space Exploration

Lead Center: JSC

Participating Center(s): GRC, GSFC, JPL, MSFC

NASA is seeking unique solutions for mid-temperature thermal control technologies that will facilitate a low mass highly reliable thermal control system for an exploration vehicle. Future human spacecraft will require more sophisticated thermal control systems that can operate in severe environments ranging from full sun to deep space and can dissipate a wide range of heat loads. Planetary systems (both human and robotic) need to minimize mass and maximize performance to enable more science payloads, and face complications from dust and regolith in many locations, and from the Mars atmosphere. The systems must perform their function while using fewer of the limited spacecraft mass, volume and power resources while increasing the reliability of these components. Furthermore, as human missions require longer extravehicular activities, the need for a closed loop, mass efficient thermal control system is needed for the EVA Suit. NASA's Technology Roadmaps 6 and 14 cover many of the defined key performance parameters sought through this SBIR. The following sub-topics seek to cover the gaps outlined through this solicitation.

Variable Heat Rejection Technologies

As NASA moves beyond low earth orbit, exploration vehicles that must accommodate various mission scenarios find a need for variable heat rejection. A vehicle may need to operate in severe environments ranging from full sun to deep space while managing a wide range waste energy rejection including active and dormant phases. Heat rejection systems and/or radiators that can operate at low fractions of their design heat load in the cold environments that are required for deep space missions. Room temperature thermal control systems are sought that are sized for full sun yet are able to maintain set point control and operate stably at 25% of their design heat load in a deep space (0 K) environment. This variation in heat rejection is often described as a turn-down ratio. NASA Technology Roadmap Area 14 outlines a turn down goal of 6 to 1 by a thermal control system operating at the scale of kilowatts of waste energy removal. Solutions for variable heat rejection may include the use of novel thermal control fluids, advanced radiator technologies, and/or variable conductance.

Advanced-Closed Loop EVA Thermal Control

NASA has evolved space suit technology beyond the Extravehicular Mobility Unit (EMU) state of the art for exploration missions. However, the latest iteration of the portable life support system includes the use of a Suit Water Membrane Evaporator to facilitate the rejection of waste energy produced by the suit, which still vents water vapor like the EMU sublimators. Longer duration extra vehicular activities and systems that do not impact the environment of Mars are needed, including a closed loop, non-venting EVA thermal control system capable of working in the Martian atmosphere. The solicitation seeks novel approaches to close the thermal control system of the Suit so that minimal to no consumables are used for rejection of waste energy. Approaches may include, but are not limited to, novel radiative approaches, desiccant systems to reclaim evaporants, etc. Examples of such technologies and goals are outlined in NASA's Technology Roadmap Area 06.

Highly Efficient, Low Pour Point Thermal Control Fluids

Most if not all space vehicles have the need for a thermal control fluid that does not freeze at relatively low temperatures. These fluids with low pour points come with decreased thermal performance, causing an increase in system mass to the thermal control system. This scenario was apparent with JPL's Mars Science Laboratory as well as the Orion Vehicle. Vehicles subjected to the environments of deep space through transit scenarios to the Moon and Mars especially need a highly efficient thermal control fluid with low pour point. Ideally, this new thermal control fluid would have a pour point near -110°C with thermal physical properties near water. Furthermore, for use in human systems, this thermal control fluid would have low toxicity, flammability, and vapor pressures for use in a habitable volume.

Advanced Heat Exchangers

Air/liquid, liquid/liquid, coldplates, and phase change material heat exchangers are at the core of any thermal control system for a vehicle. Advances in manufacturing may yield a considerable mass savings over the current state of the art heat exchangers. Furthermore, lightweight non-venting phase change heat exchangers are sought to ameliorate the environmental transients that would be seen in planetary (Martian or Lunar) orbit. Heat exchangers that have minimal structural mass and good thermal performance are sought. Furthermore, the use of phase change materials that have a transition temperature between 8°C - 12°C with heat of fusions above 200 kJ/kg are needed. The goal is a ratio exceeding $2/3$ phase change material mass and $1/3$ structural mass. Condensing heat exchangers (air/liquid heat exchangers) are deemed to be a critical component of a closed loop environmental control life support system. The need for highly reliable condensing heat exchangers that do not contaminate due to microbial growth and do not impact the water processing system of an ECLSS system due to coatings on the HX is of high need for future human systems. Finally, advances in the aforementioned heat exchangers are expected to utilize new materials and manufacturing techniques over conventional brazing processes used today. NASA's Technology Roadmap Area 14 details various points of interest for these heat exchangers.