NASA SBIR 2017 Phase I Solicitation

Z2.01 Thermal Management

Lead Center: JSC

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

Technology Area: TA14 Thermal Management Systems

Exploration Vehicle Thermal Systems

Variable Heat Rejection Technologies

Exploration vehicles require variable heat rejection due to the potential to operate in environments ranging from full sun on one side to a cold deep space environment, while rejecting a range of waste heat loads. NASA Technology Roadmap Area 14 identifies a turn down goal of 6 to 1 for a thermal control system. Room temperature thermal control systems are sought that are sized for nominal operation in full sun exposure, yet are able to maintain set point control and stable operation at one-sixth of their design heat load when in a deep space (0°K) environment. Solutions for variable heat rejection may include novel architectures, novel thermal control fluids, advanced radiator technologies, and/or variable working fluid/radiator conductance. Radiator-based technologies should have an areal mass no greater than 5.8 kg/m^2.

Advanced-Closed Loop Extravehicular Activity Thermal Control

NASA continues to evolve space suit technology for exploration missions; however, the portable life support system (PLSS) includes a water evaporator to reject waste energy produced by the suit. Closed-loop, non-venting thermal heat rejection systems that are capable of rejecting heat in the Martian atmosphere are needed to create a PLSS that minimizes consumable use and does not impact the Mars environment. NASA seeks novel approaches to close the thermal control system of the space suit, targeting 80% or greater reductions in evaporated water mass for the same heat rejection. However, the mass and volume of the system must be limited as it must be carried on the crewmember's back. Approaches may include novel radiative approaches and/or desiccant systems to reclaim evaporants, as well as other novel solutions. Examples of such technologies and goals are outlined in NASA's Technology Roadmap Area 06, but more innovative concepts are also sought.

Advanced Heat Exchangers and Coldplates

Air/liquid heat exchangers (HXs), liquid/liquid HXs, and coldplates are at the core of any active thermal control system for a space vehicle. While these individual components are small, they are found throughout spacecraft vehicles and their cumulative mass and volume is significant. Advances in materials or manufacturing may yield a considerable mass savings over the current state of the art heat exchangers. NASA's Technology Roadmap Area 14 details various points of interest for these heat exchangers, and key goals are listed below:

- Corrosion resistant coldplates with less than the state of the art 8.8 kg/m^2 mass per area.

- Heat exchangers with minimal structural mass and good thermal performance to reduce mass below 2 kg/kW of heat transfer, assuming delta-T on the order of 5°C.
- Condensing heat exchangers (air/liquid heat exchangers) for closed loop life support, achieving highly reliable 3-year minimum lifetime, not contaminated by microbial growth, and whose coatings do not impact the life support system's water recovery system.

High Lift Heat Pumping Devices

Heat pumps are needed to reject spacecraft waste heat to a higher temperature sink. At lunar equatorial locations, lunar surface temperatures can climb to 400°K, making it difficult to reject waste heat at nominal temperatures. A more severe application involves rejecting waste heat for a Venus lander where environmental sink temperatures can exceed 700°K. Ground-based designs that do not rely on gravity for elements of heat pump operation, such as lubricant management, contaminant control, or phase separation, are a reasonable starting point for a high lift heat pump device for extreme environment applications. However, these designs must be adapted or proven to work in space applications. Intermittent operation in microgravity, low gravity, and/or in severe environments, such as hard vacuum, radiation, and extreme temperatures, are significant challenges to viable space-based heat pumps. NASA seeks targeted improvements for space-based heat pump technology, which may include exceptionally long life, low mass, and operation with high temperature lifts (50°C or more) and a coefficient of performance at least at 30% of Carnot efficiency.

Thermal Insulation for Pressurized Environments

To enable longer duration missions to the surface of Venus, advanced insulation systems are required. External insulation on a Venus lander pressure vessel allows the system to take advantage of the thermal mass of the pressure vessel and reduce the heat transfer rate into the pressure vessel. The goal is to extend mission lifetime to collect and transmit more science data by allowing multiple communication passes with an orbiter. In addition to Venus in-situ explorers, this insulation can be used for future deep atmospheric probes for gas giant planets, or even in high temperature and pressure chemical processes in other systems. The current state-of-the-art in insulation systems considered for the Venus atmosphere are heavy, fragile and difficult to implement on the exterior of a pressure vessel. NASA seeks a lightweight, flexible insulation system that can be accommodated on the exterior of a pressure vessel. The insulation thermal conductivity should be less than 0.1 W/m-K at 470°C and 90 bar pressure in a carbon dioxide environment.