NASA SBIR 2008 Phase I Solicitation

X2.01 Spacecraft Cabin Ventilation and Thermal Control

Lead Center: JSC

Participating Center(s): ARC, GRC, GSFC, JPL, JSC, KSC, LaRC, MSFC

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Advanced technologies are sought for cabin ventilation and thermal management for next generation human spacecraft including lunar lander, lunar habitat, and pressurized rovers.

Spacecraft Ventilation

Controlling acoustic noise levels within spaceflight vehicles is needed to provide for adequate voice and ground communications, habitability, and alarm audibility. This will become very important with longer duration missions such as Lunar Habitat and Mars missions. Past experience has shown that controlling acoustic noise levels inside the spacecraft depend upon development of quiet ventilation system and environmental control system fans and pumps, as well as inclusion of effective noise controls to reduce the noise that is created (i.e., source and path technologies).

Advances are sought in the general areas of source noise-level reduction, vibration isolation, acoustic absorption, and sound blocking and sealing (i.e., source and packaging). Noise reduction technology should achieve significant noise reductions (> 5dB) with minimal impacts to performance characteristics (pressure rise and flow rate). Noise reductions and performance capabilities should be demonstrated. Materials should meet flight requirements for flammability, frangibility, and off-gassing. Ventilation fans and fluid pumps are the major source of interior spacecraft noise. Fan and pump technologies that prevent the generation of acoustic noise or limit its transmission to mounting structure or surrounding air are desired. Technologies achieving 5 dB or greater attenuation and accommodating variable equipment speeds, variable acoustic spectrums, and atmospheric pressures from 8 to 15 psia are required.

Thermal Control Systems

Future spacecraft will require more sophisticated thermal control systems that can dissipate or reject greater heat loads at higher input heat fluxes while using fewer of the limited spacecraft mass, volume and power resources. The thermal control designs also must accommodate the harsh environments associated with these missions including dust and high sink temperatures. Modular, reconfigurable designs could limit the number of required spares.

The lunar environment presents several challenges to the design and operation of active thermal control systems. During the Apollo program, landings were located and timed to occur early in the lunar day, resulting in a benign thermal environment. The long duration polar lunar bases that are foreseen in 15 years will see extremely cold thermal environments, as will the radiators for Martian transit spacecraft. Long sojourns remote from low-Earth orbit will require lightweight, but robust and reliable systems.

Innovative thermal management components and systems are needed to accomplish the rejection of heat from lunar bases. Advances are sought in the general areas of radiators, thermal control loops and equipment. Variable emissivity coatings, clever working fluid selection, or robust design could be used to prevent radiator damage from freezing at times of low heat load. Also, the dusty environment of an active lunar base may require dust mitigation and removal techniques to maintain radiator performance over the long term.

The lunar base may include high efficiency, long life mechanical pumps. Part of the thermal control system in the lunar base is likely to be a condensing heat exchanger, which should be designed to preclude microbial growth. Small heat pumps could be used to provide cold fluid to the heat exchanger, increasing the average heat rejection temperature and reducing the size of the radiators.

Thermal management of the lunar habitat, landers, and rovers may require mechanically pumped two-phase fluid loops. Innovative design of the loops and components is needed.

Future space systems may generate large amounts of waste heat which could either be rejected or redirected to areas which require it. Novel thermal bus systems which can obtain, transport, and reject heat between various components are sought. The system should be highly configurable and adaptable to changes in equipment locations. Large diurnal temperature changes in the environment are expected. Possible systems include single and two-phase pumped fluid loops, capillary-based loops, and heat pumps.

A scaling methodology is needed to allow long term 1-g testing of two-phase systems (including pumped two-phase loops, heat pumps, and condensing heat exchangers) representative of the $1/6^{th}$ Earth-normal gravity of the Moon.