NASA SBIR 2007 Phase I Solicitation

X11.01 Thermal Control for Surface Systems and Spacecraft

Lead Center: JSC

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

Advanced technologies are sought for thermal management of Earth-orbiting spacecraft, the human lunar habitat, landers, and rovers, for Martian transit spacecraft, as well as planetary expeditions to Jupiter, Venus, and their moons. 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.

Earth-orbiting spacecraft contain instruments, such as LIDAR lasers and electronics systems and/or components, which can generate high thermal dissipation loads at high heat flux rates. Spacecraft instruments can have tight temperature control requirements and/or thermal gradient requirements (micro-Kelvin requirements). Spacecraft instruments operate in temperature regimes ranging from cryogenic to above ambient (-180ÂºC to +100ÂºC). Radioisotope thermoelectric generators (RTGs) generate relatively large amounts of heat. Design plans for Earth-orbiting spacecraft seek smaller (down to MEMS level components or instruments) and reconfigurable designs.

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 at lunar twilight, 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. Radiators on the Moon's poles and on a Martian transit vehicle are required that will operate and survive in very cold environments. 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 and Martian transit spacecraft active thermal control systems will 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.

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 1/6th Earth-normal gravity of the Moon.