NASA SBIR 2011 Phase I Solicitation

X3.04 Spacecraft Cabin Ventilation and Thermal Control

Lead Center: JSC

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

Future spacecraft will require quieter fans, better cabin air filtration, and advanced active thermal control systems.

Small Fan Aero-Acoustics

Procedures and non-intrusive apparatus to measure the sound pressure levels in the inlet and exhaust duct of a candidate spacecraft ventilation fan are requested. Details of the aerodynamic design and the predicted aerodynamic performance of the candidate spacecraft cabin ventilation fan are reported in NASA CR-2010-216329, "Aerodynamic Design and Computational Analysis of a Spacecraft Cabin Ventilation Fan". The duct diameter for this fan (89 mm) falls below the minimum diameter required (150 mm) by ASHRAE Standard 68. The pressure rise at design point for this fan (925 Pa) exceeds the maximum recommended (750 Pa) in ISO 10302. The procedure that is requested to be developed should apply to fans of similar size and capacity (or greater) as the identified candidate spacecraft ventilation fan. The procedure developed should overcome the deficiencies in the standards by providing plots of overall sound power levels as a function of fan flow rate (from full flow to fully throttled conditions) along lines of constant fan rotational speed in the inlet and exhaust ducts. Values of the radial and circumferential duct mode sound power levels calculated from the pressure measurement should be recorded and made available for subsequent examination at all tested conditions. It also must be shown that the flow-induced microphone self-noise, if any, does not contribute significantly to the measured fan sound pressure levels or sound power levels. Validation of the measured fan sound power levels must be shown for a sub-set of the performance range using an alternate technique.

Methods of Particulate Separation and Filtration from Air

Methods of particulate air filtration and/or separation targeting a range of particle sizes from tens of micron down to submicron in conjunction with efficient methods of regeneration are sought. The proposed technical solutions should reduce crew maintenance time and eliminate the need for consumable filter elements. These units should be able to handle large surges of particles and operate over very long periods. They should also be self-cleaning in-place (preferable) or off-line. Targeted technologies should be compact and lightweight, easily integrated with the spacecraft life support system, and provide viable methods for disposing of collected particulate matter while minimizing or eliminating direct contact by the crew.

Active Thermal Control Systems

Thermal control systems will be required that can dissipate a wide range of heat loads with widely varying environments while using fewer of the limited spacecraft mass, volume and power resources. The thermal control system designs must accommodate high input heat fluxes at the heat acquisition source and harsh thermal environments at the heat rejection sink. Advances are sought for microgravity thermal control in the areas of:

- Innovative Thermal Components and System Architectures that are capable of operating over a wide range of heat loads in varying environments (for example, a 10:1 heat load range in environments ranging from 0 to 275K).
- Two-phase Heat Transfer Components and System Architectures for nuclear propulsion that will allow the acquisition, transport, and rejection of waste heat on the order of megawatts,.
- Heat rejection hardware for transient, cyclical applications using either phase change material heat exchangers or efficient evaporative heat sinks.
- Smaller, lighter high performance heat exchangers and coldplates.
- Low temperature external working fluids (a temperature limit of less than 150K with favorable thermophysical properties - e. g., viscosity and specific heat).
- Internal working fluids that are non-toxic, have favorable thermophysical properties, and are compatible with aluminum tubing (i.e., no corrosion for up to 10 years).
- Low mass, high conductance ratio thermal switches.
- Long-life, lightweight, efficient single-phase thermal control loop pumps capable of producing relatively high-pressure head (~4 atm).
- Dust tolerant long-life radiators.
- Variable area radiators (e. g., variable capacity heat pipe radiators or drainable radiators).
- Radiators compatible with inflatable volumes.
- Thermal systems and/or components to extend operational times for spacecraft under the extreme planetary environments, for example: the Venusian surface at approximately 460C and 98 atm.
- Flexible heat pipes.
- Methods to predict the performance of cryogenic multi-layer insulation blankets at 1 atmosphere and during ascent venting.
- Advanced thermal analysis tools that utilize stream processing to improve computational speed over conventional approaches. Possible candidates are: view factor calculation via ray tracing, orbital heating rate calculations, and thermal environment modeling.
- Inflatable/deployable shades to enhance reduce boiloff of cryogenic propellants in long-term storage in low earth orbit.