NASA SBIR 2016 Phase I Solicitation

S3.07   Thermal Control Systems

Lead Center: GSFC

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

Future Spacecraft and instruments for NASA's Science Mission Directorate will require increasingly sophisticated thermal control technology. Innovative proposals for the cross-cutting thermal control discipline are sought in the following areas:

- Components of advanced small spacecraft such as CubeSat/SmallSat will have very small masses (i.e., small thermal capacitance), and their temperatures are highly sensitive to variations in the component power output and spacecraft environmental temperature. Advanced thermal devices capable of maintaining components within their specified temperature ranges are needed. Some examples are:
    - Phase change systems with high thermal capacity and minimal structural mass.
    - High performance, low cost insulation systems for diverse environments.
    - High flux heat acquisition and transport devices; d) thermal coatings with low absorptance, high emmittance, and good electrical conductivity; and e) a miniature pumped fluid loop system that is lightweight, provides radiator turndown, and consumes minimal power (< 2W).
- Current capillary heat transfer devices require tedious processes to insert the porous wick into the evaporator and to seal the wick ends for liquid and vapor separation. Advanced technology such as additive manufacturing is needed to simplify the processes and ensure good sealing at both ends of the wick, especially for miniature thermal systems for CubeSat/SmallSat applications. Additive manufacturing technology can also be used to produce integrated heat exchangers for pumped fluid loops in order to increase heat transfer performance while significantly reducing mass, labor and cost.
- Science missions are more dependent on optically sensitive instruments and systems, and effects of thermal distortion on the performance of the system are critical. Current Structural-Thermal-Optical (STOP) analysis has several codes that do some form of integrated analysis, but none that have the capability to analyze any optical system and do a full end-to-end analysis. An improvement of existing code is needed in order to yield software that can integrate with all commonly used programs at NASA for mechanical, structural, thermal and optical analysis. The software should be user-friendly, and allow full STOP analysis for performance predictions based on mechanical design, and structural/thermal material properties.
- Missions with high sink temperatures require temperature lifting devices in order to dissipate the heat. Some advanced devices having long life, high efficiency are sought for, including absorption/adsorption systems, advanced TECs, etc. The use of heat lift devices can also reduce the radiator area, hence realizing mass and volume savings.

- Current analysis for ablation analysis of re-entry vehicles utilizes various computer codes for predicting the following individual phenomena: aeroheating, ablation, thermal response behind the bond line, thermal radiation, and structural response to thermal and pressure environments. The interfaces between each code lead to potential errors, inaccuracy, and huge computer run time. What is needed is a single code that evaluates the trajectory or input conditions, predicts aeroheating over the surface, does an integrated

ablation-thermal analysis, and then uses that thermal and pressure gradient to do a full structural analysis. Even better would be a link back to the aeroheating prediction code to revise the aeroheating based on shape change from structural analysis and ablation.

- New techniques for measuring the internal pressure of arcjet test samples are sought. Modern ablation codes such as FEAR and CHAR solve the Darcy flow equations to track both the internal pyrolysis gas pressure and mass flow. However, there is currently no data available to validate the internal pressure calculations due to a lack of a reliable and accurate measurement system. The internal pressure calculation becomes even more important when analyzing flexible thermal protection system materials which are highly porous.

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware demonstration. Phase II should deliver a demonstration unit for NASA testing at the completion of the Phase II contract.