



## NASA SBIR 2017 Phase I Solicitation

### S3.06 Thermal Control Systems

Lead Center: GSFC

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

Technology Area: TA14 Thermal Management Systems

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:

- Advanced thermal devices capable of maintaining components within their specified temperature ranges are needed for future advanced spacecraft. 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.
  - Thermal coatings with low absorptance, high emittance, and good electrical conductivity.
  - Radiator heat rejection turndown devices (e.g., mini heat switches, mini louvers).
  - Miniature pumped fluid loop systems with passive valve for radiator heat rejection turndown, and consumes minimal power.
- 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. 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.
- Thermoelectric converts (TEC) have advantages of small size, long life, solid state design, and no moving parts or fluid operation, and have been used on many science instruments requiring dedicated/localized cooling to meet their stringent requirements. However, they have historically exhibited poor efficiency and have not been able to provide the cold temperatures needed by certain types of space science instruments. Research and development in areas of advanced materials, processes, and designs are needed in order to improve its efficiency, and extend its low temperature (<90K) capability for space science application.
- Water has been used in two-phase thermal control devices such as heat pipes due to its high heat transport capability. However, water has two main drawbacks that limit its use in many aerospace applications. Its

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expansion upon freezing creates a concern about rupture of the heat pipe and the concern for reliable startup from an initially frozen state. Water-containing azeotropes, which behave as a single-component working fluid, can offer substantial benefits as alternatives to use of pure water for applications where freeze/thaw and frozen startup concerns exist. High-performance water azeotropes which can lower the freezing point of water below  $-40^{\circ}\text{C}$  while providing improved reliability for aerospace thermal control systems are needed.

- Three-dimensional (3D) integrated circuits (ICs) offer unprecedented functionality and efficiency in small form factors, but their operation is constrained by the current remote cooling paradigm that relies on conduction and heat spreading across multiple interfaces. An embedded approach, which facilitates in-situ cooling of the chip stack is needed. Such a cooling device must also accommodate high heat fluxes and minimize the thermal resistance between the heat source and sink.

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.

*Note to Proposers - Cubesat thermal technologies have been moved to a new STMD subtopic: Z8.03 Small Spacecraft Power and Thermal Control*