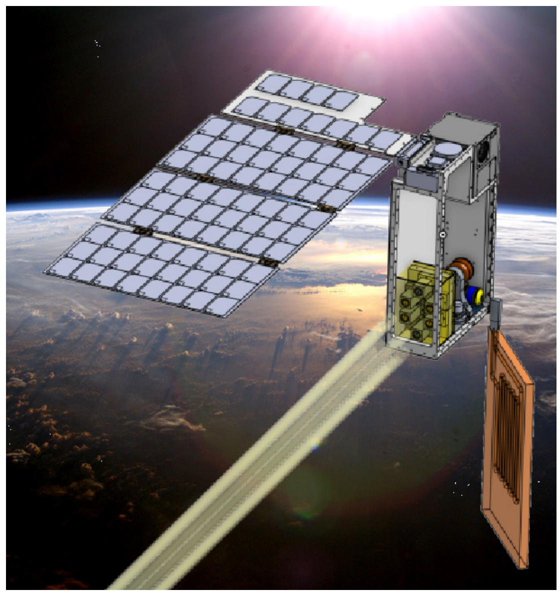
NASA facts

Active Thermal Architecture for Cryogenic Optical Instrumentation (ATACOI)

Development of a Miniaturized Active Thermal Control System for CubeSat Applications

The Active Thermal Architecture for Cryogenic Optical Instrumentation (ATACOI) project will demonstrate an advanced thermal control system for CubeSats and enable the use of cryogenic electro-optical instrumentation on small satellite platforms. Specifically, the project focuses on the development of a deployable solar tracking radiator, a rotationally flexible rotary union fluid joint, and a thermal/vibrational isolation system for miniature cryogenic detectors. This technology will represent a significant improvement over the current state of the art for CubeSat thermal control, which generally relies on simple passive and conductive methods.

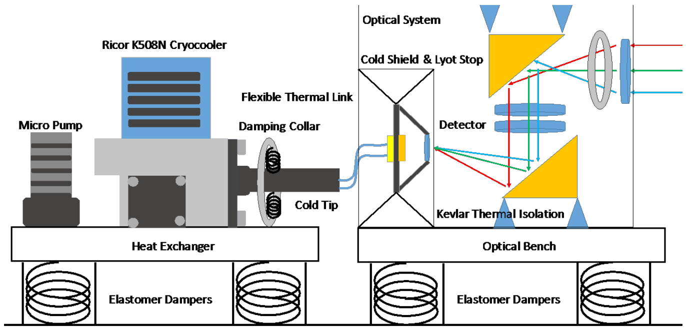

Concept for a SABER-Lite reference mission

The project team's work will include the design, fabrication, and relevant testing of an additively manufactured deployable tracking radiator. Deployment will be accomplished via a two-axis spring deploy with the primary rotation and tracking axis being the same as the rotational axis of a miniature fluid rotary union hinge. A tracking sensor and control system will be coupled with a driver motor to allow for pointing of the radiator. Design metrics include deployment away from the CubeSat body of a 20 cm X 30 cm additively manufactured radiator (UAM-Ultrasonic Additive Manufacturing) with an internal deployment mechanism volume less than 3 cm X 3 cm X 10 cm. An existing single phase, two stage mechanically pumped fluid loop (MPFL), previously developed under the Active CryoCubeSat project, will exchange thermal loads from an internal heat exchanger to the external radiator via the flexible fluid joint. Typical ambient temperatures of -10 °C to 50 °C are possible with thermal loads greater than 30 Watts (W). One or more vendor procured miniature tactical cryocoolers will be mounted to the UAM heat exchanger to provide cryogenic cooling and a stable environment for subcooled detectors. Cold tip temperatures less than 100° K will be possible with greater than 0.5 W of thermal rejection. Finally, a passive/active thermal and vibrational isolation system will be implemented for the coupled UAM heat exchanger and miniature cryocooler as well as the cryocooler cold tip and detector assemblies. This will prevent any inherent vibrations of the thermal control system to induce jitter amplitudes of more than 0.005° within the detector. It will also mitigate parasitic thermal loads greater than 200 mW from the CubeSat or instrumentation structures. To reduce the size and complexity of the MPFL, the ATACOI architecture utilizes aluminum additive manufacturing techniques to embed mini liquid coolant channels within the structure of the heat exchanger, radiator, and CubeSat chassis.

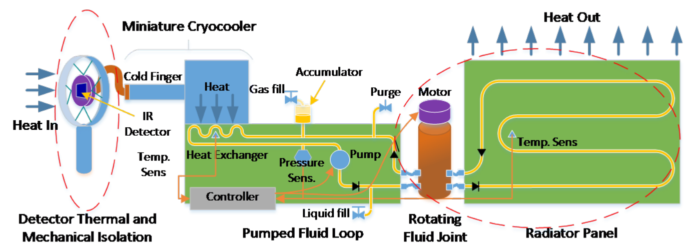
Advanced cryogenic mid-wave infrared and long-wave infrared remote instruments are critical to NASA missions focused on Earth and helioscience. Improving the capabilities of CubeSats to support such instruments will enable these advanced missions on small satellite platforms and provide a low cost-to-orbit option with clear scientific benefits. Two reference missions under consideration as testbeds for the ATACOI subsystem are the limb viewing Sounding of the Atmosphere using Broadband Emission Radiometry (SABER)-Lite mission and the National Oceanic and Atmospheric Administration's (NOAA) Nadir viewing Earth Observation Nanosatellite Infrared (EON-IR) mission. Saber-Lite aims to replace the aging SABER instrument on the Thermosphere Ionosphere Mesosphere Energetics Dynamics (TIMED) spacecraft with a low-cost CubeSat replacement. EON-IR is an upcoming CubeSat mission intended to fill the data gap of the Cross-track Infrared Sounder (CrIS) on the Joint Polar Satellite System (JPSS). NASA's 2014 heliophysics roadmap lists the development of CubeSats and next generation instruments as its highest priority. ATACOI represents a major step in terms of that roadmap by introducing advanced active thermal control methods to CubeSats. In addition, this technology will essentially eliminate conduction thermal gradients within a spacecraft and therefore greatly enhance the thermal load management capabilities and environments of CubeSats thus expanding their mission capabilities.

The ATACOI project is a collaboration between Utah State University's Center for Space Engineering and NASA's Jet Propulsion Laboratory.

The ATACOI project is managed and funded by the Small Spacecraft Technology Program (SSTP) within the Space Technology Mission Directorate. The SSTP expands U.S. capability to execute unique missions through rapid development and in space demonstration of capabilities for small spacecraft applicable to exploration, science, and the commercial space sector. The SSTP will enable new mission architectures through the use of small spacecraft with goals to expand their reach to new destinations, and challenging new environments.



A conceptual diagram of the isolation system for the ATACOI Electro-Optical Interconnect.



A conceptual diagram of the ATACOI Test Bed.

For more information about the SSTP, visit:

www.nasa.gov/directorates/spacetech/small_spacecraft

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