National Aeronautics and Space Administration

Active Thermal Architecture for Cryogenic Optical Instrumentation (ATA)

Active Thermal Control for CubeSats and Small-Satellites

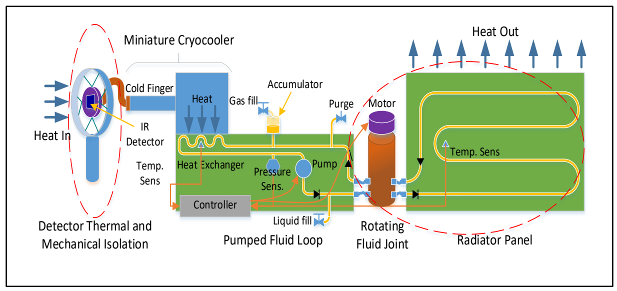
The ATA system is an integrated active thermal control subsystem for CubeSat's and Small Satellites. Capable of scaled and variable thermal control, as well as high power rejection. The ATA's intended use includes:

- Bus environ thermal control
- Payload thermal management
- High power rejection

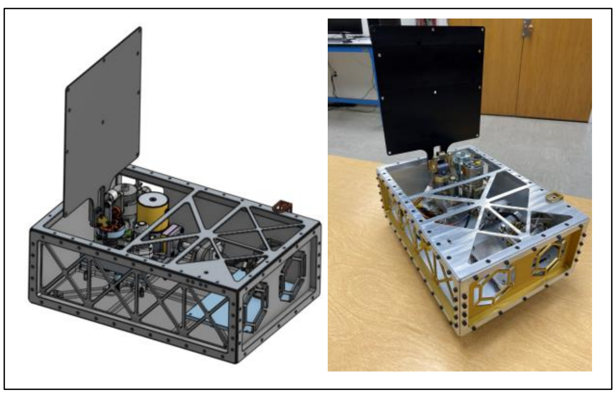
This active technology represents a significant improvement over the current state of the art for CubeSat thermal control which generally relies on simple passive & conductive methods. The ATA project has developed an integrated active thermal control prototype and demonstrated it in relevant ground based testing raising the TRL to 6.

The ATA system represents several new technologies, including leveraging advanced Ultrasonic Additive Manufacturing (UAM) fabrication techniques to embed fluid channels directly into the CubeSat chassis and deployable tracking radiator. Thus simplifying, and miniaturizing the pumped fluid loop heat exchange. Deployment and tracking are accomplished via custom built 2-axis continuous miniature rotary fluid joints, and a Contorque based spring deployer. A tracking sensor and control system coupled with a driver motor allow for pointing of the radiator. The team also developed a tunable Kevlar based electro-optical detector mount and a adjustable piston fluid accumulator for the ATA system.

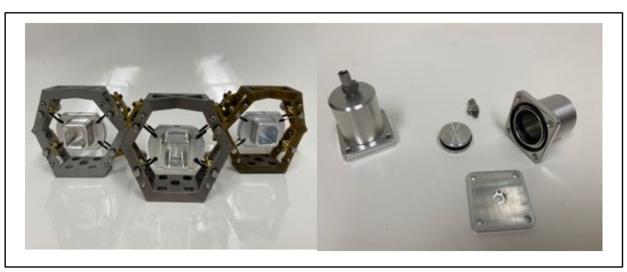
Design metrics include deployment away from the CubeSat body of a 4U radiator with an internal deployment mechanism volume less than 4X4X10 cm. An existing single phase, two stage mechanically pumped fluid loop (MPFL), previously developed under the Active CryoCubeSat project, will exchange thermal loads 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 60 W. one or more Ricor K508N miniature tactical cryocoolers can be mounted to the



Principle of Operation of the ATA System



Integrated ATA Prototype

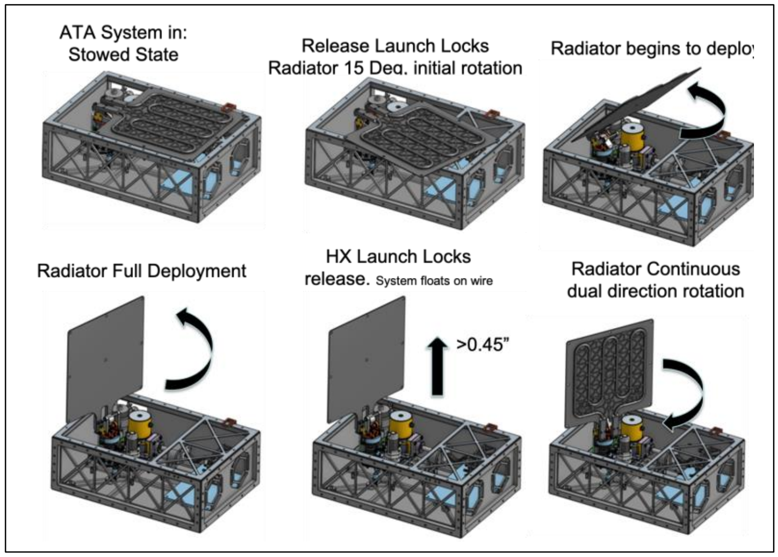


Aluminum, Titanium, PEEK Kevlar Detectors & Piston Fluid Accumulator

NASAfacts

UAM heat exchanger to provide cryogenic cooling and a stable environment for subcooled detectors. Cold tip temperatures between 60-100 K will be possible with greater than 0.5 W of thermal rejection. Finally, a series of passive vibrational isolation systems de-couple the UAM heat exchanger and miniature cryocooler from the CubeSat chassis 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.

The ATA system enables the thermal accommodation of miniature cryocoolers and cryogenic electro-optical instrumentation on Small Satellite platforms. Advanced cryogenic MWIR and LWIR remote instruments are critical to NASA missions in the earth and helioscience directorates. Therefore, improving the capabilities of CubeSats 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 ATA subsystem are the limb viewing SABER-Lite mission and the Nadir viewing NOAA EON-IR missions. Saber-Lite aims to replace the aging SABER instrument on the TIMED spacecraft with a low-cost CubeSat replacement. EON-IR is an upcoming CubeSat mission intended to fill the data gap of CrIS on JPSS. NASA's 2014 heliophysics roadmap lists the development of CubeSat's and next generation instruments as its highest priority. ATA represents a major step in terms of that roadmap by introducing advanced active thermal control methods to CubeSat's. 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.



ATA Deployment and Operational Concept

Project management is centered at Utah State Universities Center for Space Engineering and is in partnership with NASA JPL.

Collaboration includes:

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- Lucas Anderson: CO-PI
- A.J. Mastropietro JPL Institutional PI
- Jonathan Sauder JPL

The Active Thermal Architecture project is managed by the Small Spacecraft Technology Program (SSTP), which is chartered to develop and mature technologies to enhance and expand the capabilities of small spacecraft with a particular focus on communications, propulsion, pointing, power, and autonomous operations. The SSTP is one of nine programs within NASA's Space Technology Mission Directorate (STMD).

For more information about the SSTP, please visit:
http://www.nasa.gov/smallsats

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