ACMES Active Cooling for Multispectral Earth Sensors

A high-performance CubeSat bus to support the ACMES Mission.

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Taking Out The Trash (..for ESTO)

NASA STMD Funded

Electrical Power Generation

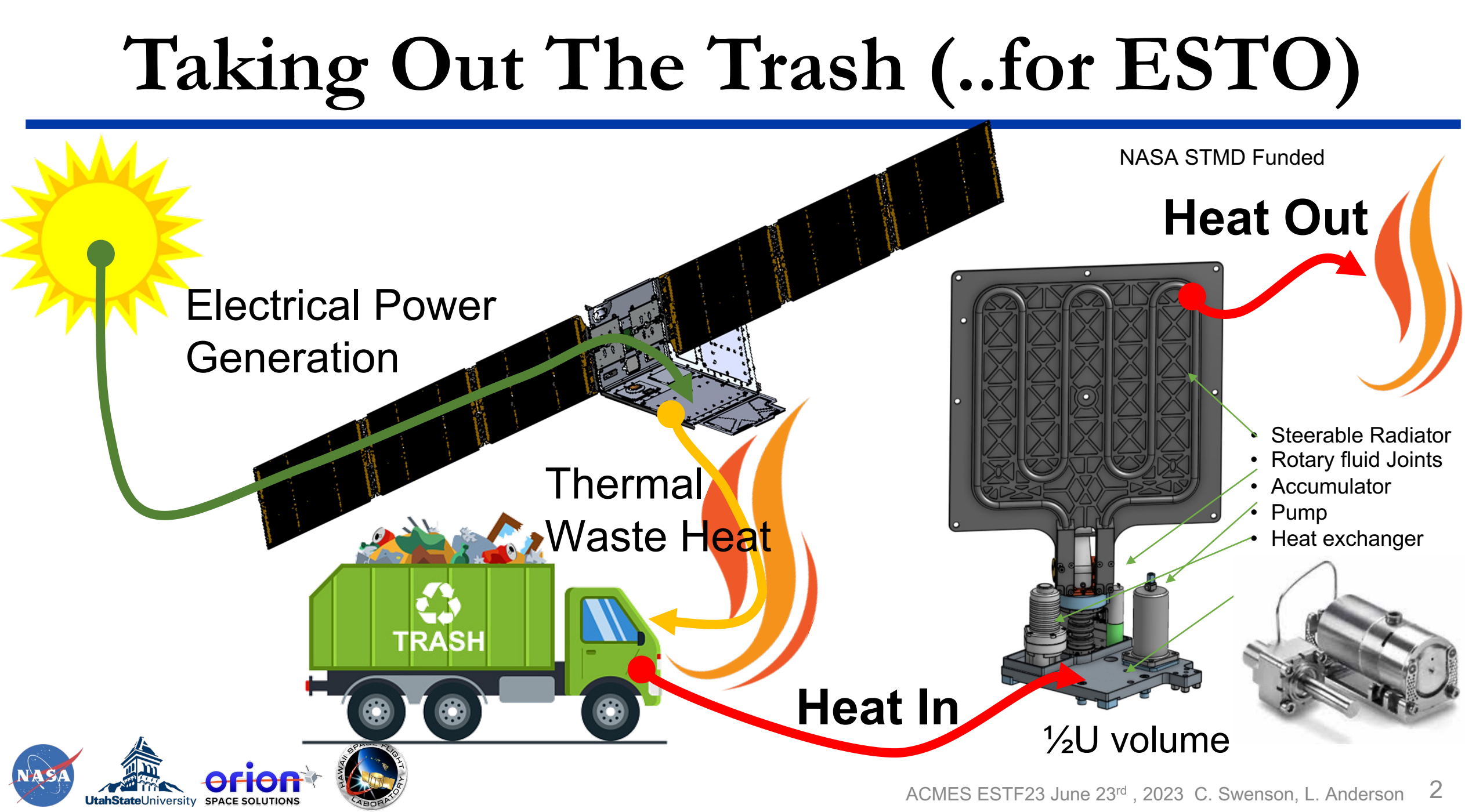
Thermal Waste Heat

Heat Out

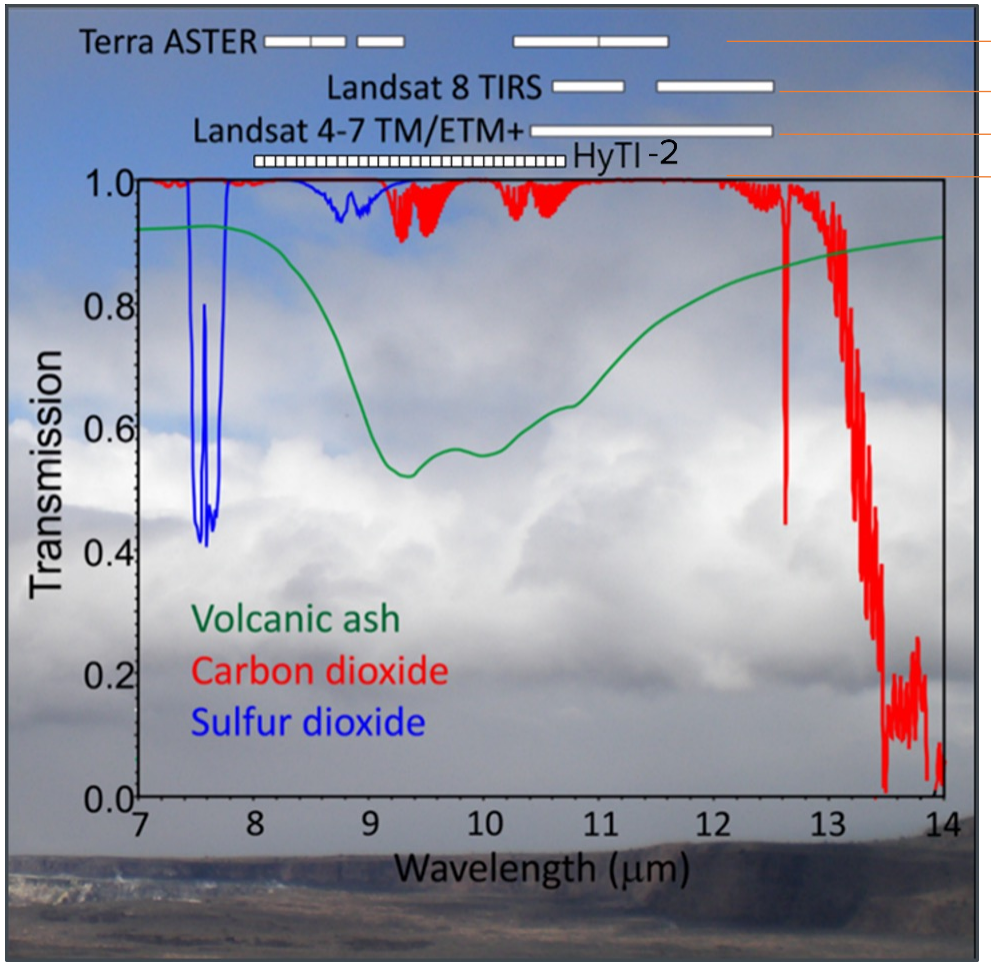
Heat In

- Steerable Radiator
- Rotary fluid Joints
- Accumulator
- Pump
- Heat exchanger

½U volume



Long Wave IR Measurements



- 1999, 90 m/pixel
- 2013 (2021), 90 m/pixel
- 1970, 120, m/pixel
- 2024, 45 m/pixel

HyTI-2 will acquire data at 45 m resolution in 25 spectral channels between 7.5-12.5 mm.

Can you do it in a spacecraft about the size of four loafs of sandwich bread?

ECE 5240 Space Mission Design

Nicholas Wallace, Joseph Dewsnup, Nathan Brinkerhoff, Travis Blaylock, Kelly Burch, Andrew Nelson, Dalton Yerke, Grable Hart, Tyler Rose, Weston Seegmiller, Charles Swenson, Lucas Anderson

Zachary Hall, David Allen, Zachary Clarke, Michael Kirk, Jason Powell, Rowan Antonuccio, Benjamin Lewis, Oliver Parkinson, Nathan Dickson, Alessa Love, Bruno Mattos

Not Pictured: Aubrey Hjorth, David Pipkin, Isaiah Olsen

ACMES NASA InVEST Mission

Primary Goal: Enable the operation of cryogenic optical instruments on CubeSats.

Objective 1.1) Demonstrate on-orbit the active thermal control of the HyTi instrument

Objective 1.2) Demonstrate on-orbit the thermal control of the ACMES high-power CubeSat.

Secondary Goal: Provide LWIR observations of the Earth's surface.

Objective 2.1) Effectively operate a multispectral sensor as if it were part of a scientific mission to observe the land masses of the Earth for at least one year (up to four years).

Objective 2.2) Demonstrate the effectiveness of non-mechanical scanning multispectral sensor technology.

Tertiary Goal: Create unique opportunities for a diverse set of students to contribute to NASA's work in exploration and science.

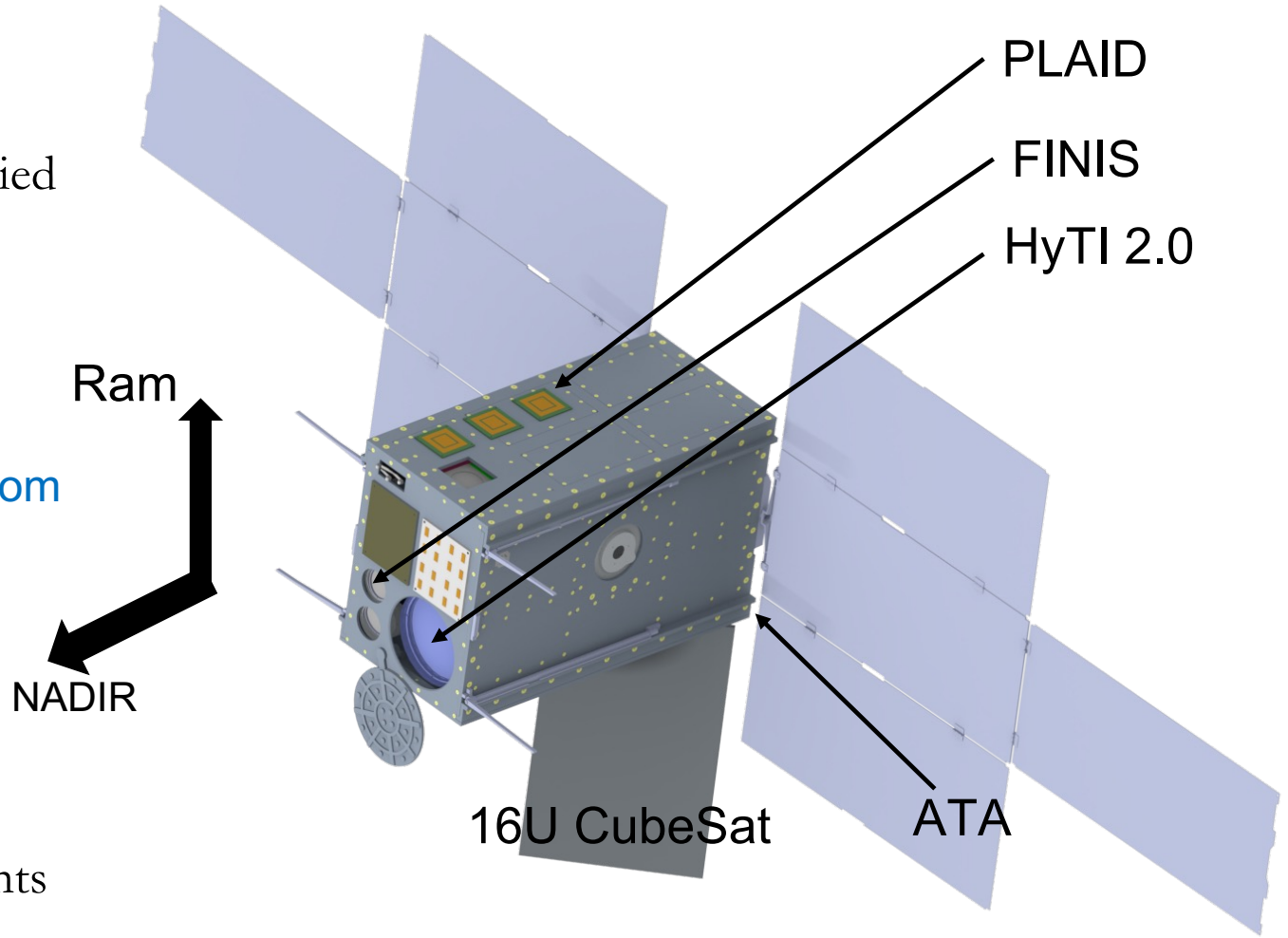
Objective 3.1) Provide research and satellite development experiences that enable students to contribute to the ACMES mission through the FINIS and PLAID payloads.

Objective 3.2) Inspire students to contribute to NASA's work in exploration and science.

Concepts for Meeting Goals

- ***Primary Goal***
  - A 16U high-power CubeSat
  - HyTI 2.0 LWIR cryogenic sensor
  - Cryocooler and instrument thermal load carried by the Active Thermal Architecture
- ***Secondary Goal***
  - One-year technology demonstration
  - Three-year science mission
    - HyTi 2.0 Hyperspectral sensor
    - FINIS Hyperspectral sensor

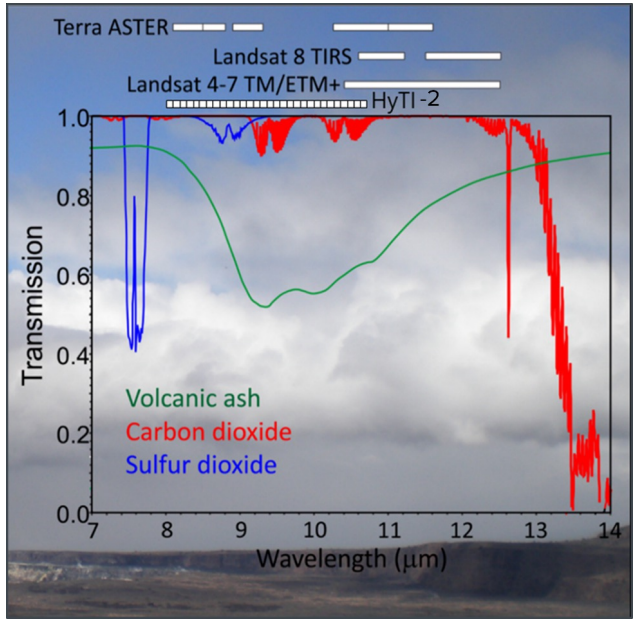
    } Push-broom scanned
  - Orbit
    - 550 km Altitude, Noon-Midnight Sun Synchronous (~constant lighting)
- ***Tertiary Goal***
  - USU ECE 5230 Space mission design course
  - FINIS and PLAID student science instruments

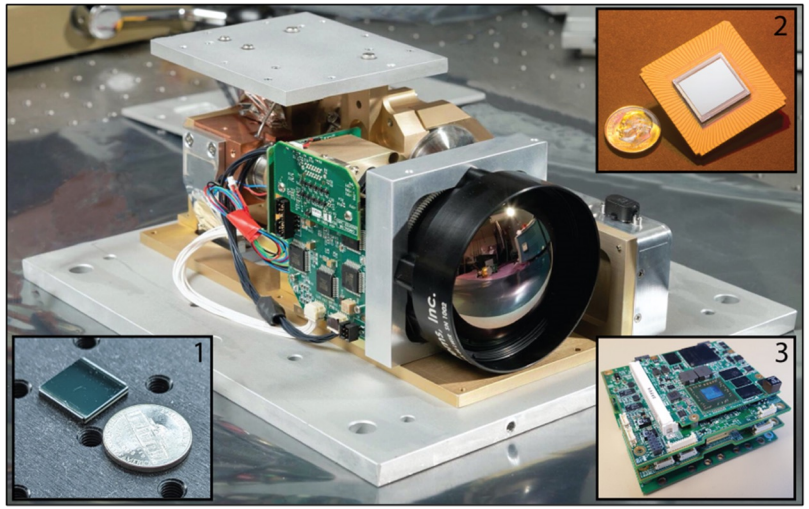


ACMES: HyTI 2.0

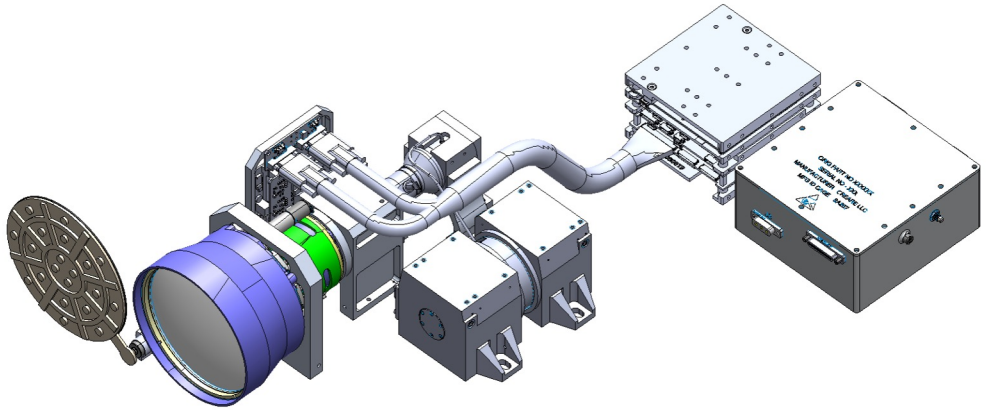
HyTi is an advanced high spatial, high spectral LWIR hyperspectral imager for LandSat-like observations of the Earth. The second generation of HyTi (HyTi 2.0) will fly with the ACMES mission as one of the two primary payloads

- No moving parts Fabre Perot spectrometer
- High spectral (25 bands)
- High spatial (<45 m)
- LWIR (8-10.7 microns)
- Narrow band NE∆Ts of < 0.3 K
- Hot-Bird focal plane array---1280 x 1024
- >140 Hz sampling rate
- Subcooled to 68 K to 72 K
- UniBAP IX-10 high performance computer
- AIM SF100 cryocooler





HyTI 1.0 Spectrometer Prototype



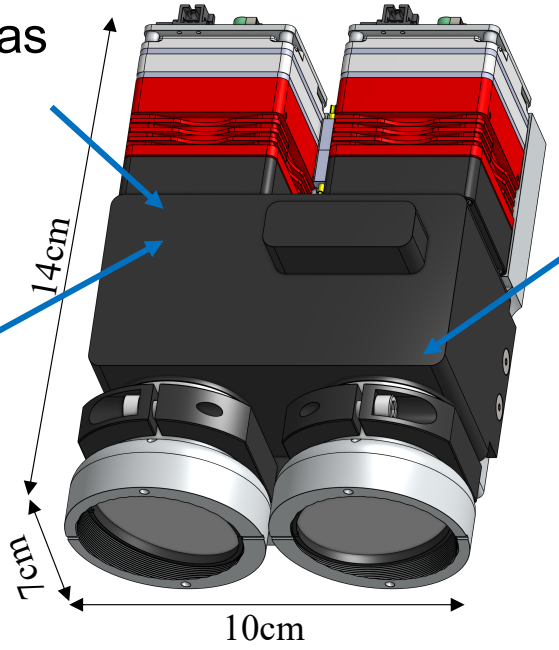
HyTI 2.0 CAD Concept

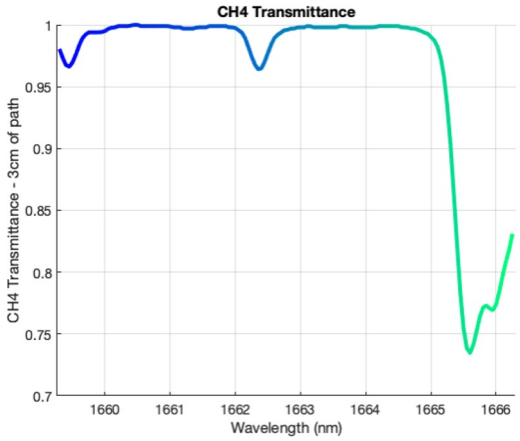
FINIS (CH_4 Measurement)

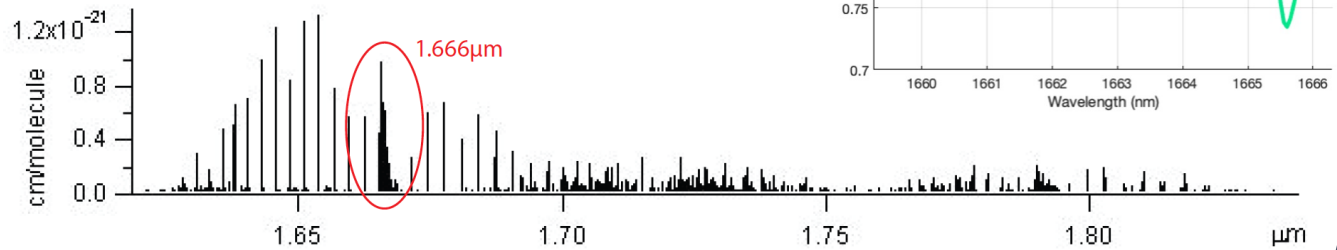
SWIR cameras

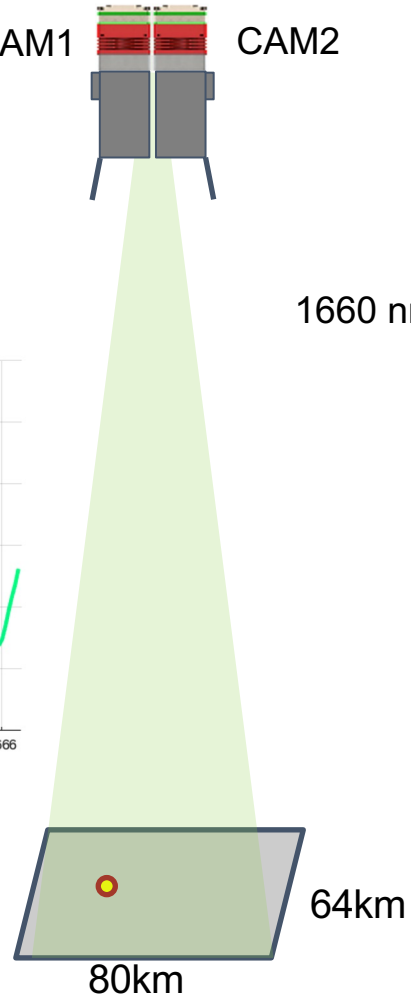
Lens Tubes with Optics

Shutter / Calibration Plane



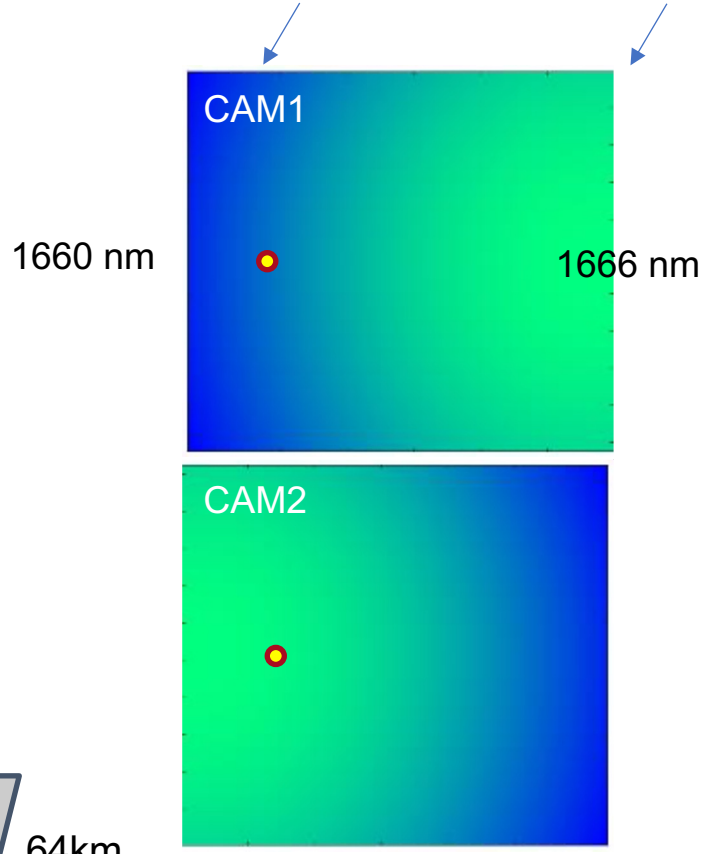






Transmission Band

Absorption Band

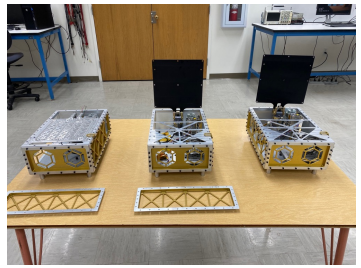


Focal Plane Spectrum Map

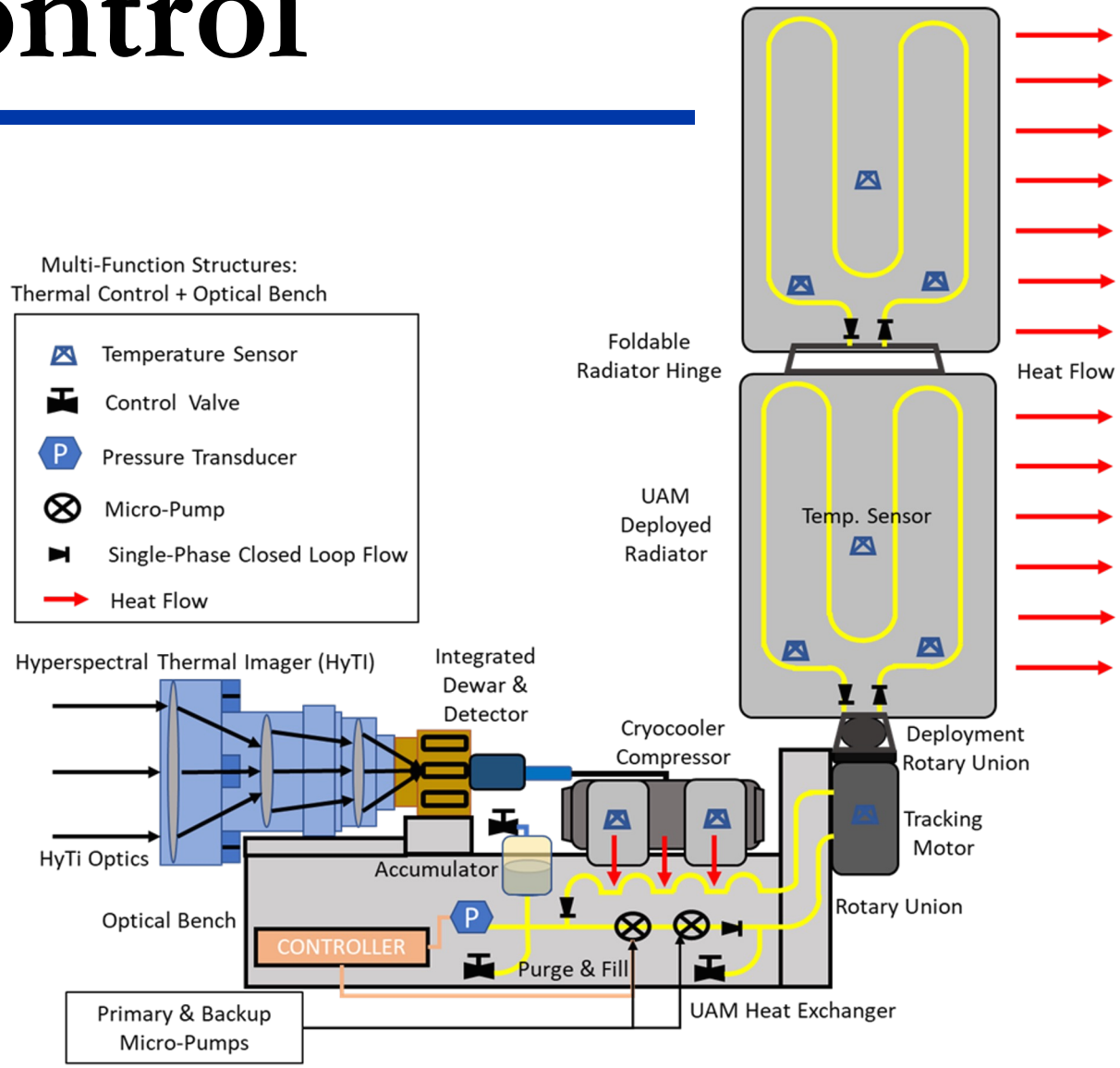
Active Thermal Control

The ATA technology is based on a two-stage, single-phase Mechanically Pumped Fluid Loop (MPFL) architecture.

- Working fluid is circulated between an internal heat exchanger and a deployable tracking radiator
- This first stage rejects bulk thermal loads and accommodates a tactical (2nd stage) cryocooler for electro-optical instrumentation thermal management
- Bus thermal environment management
- Payload or system thermal control
- High power rejection
  - Scalable with solar array growth
- 3D UAM fabrication Multi-functional design



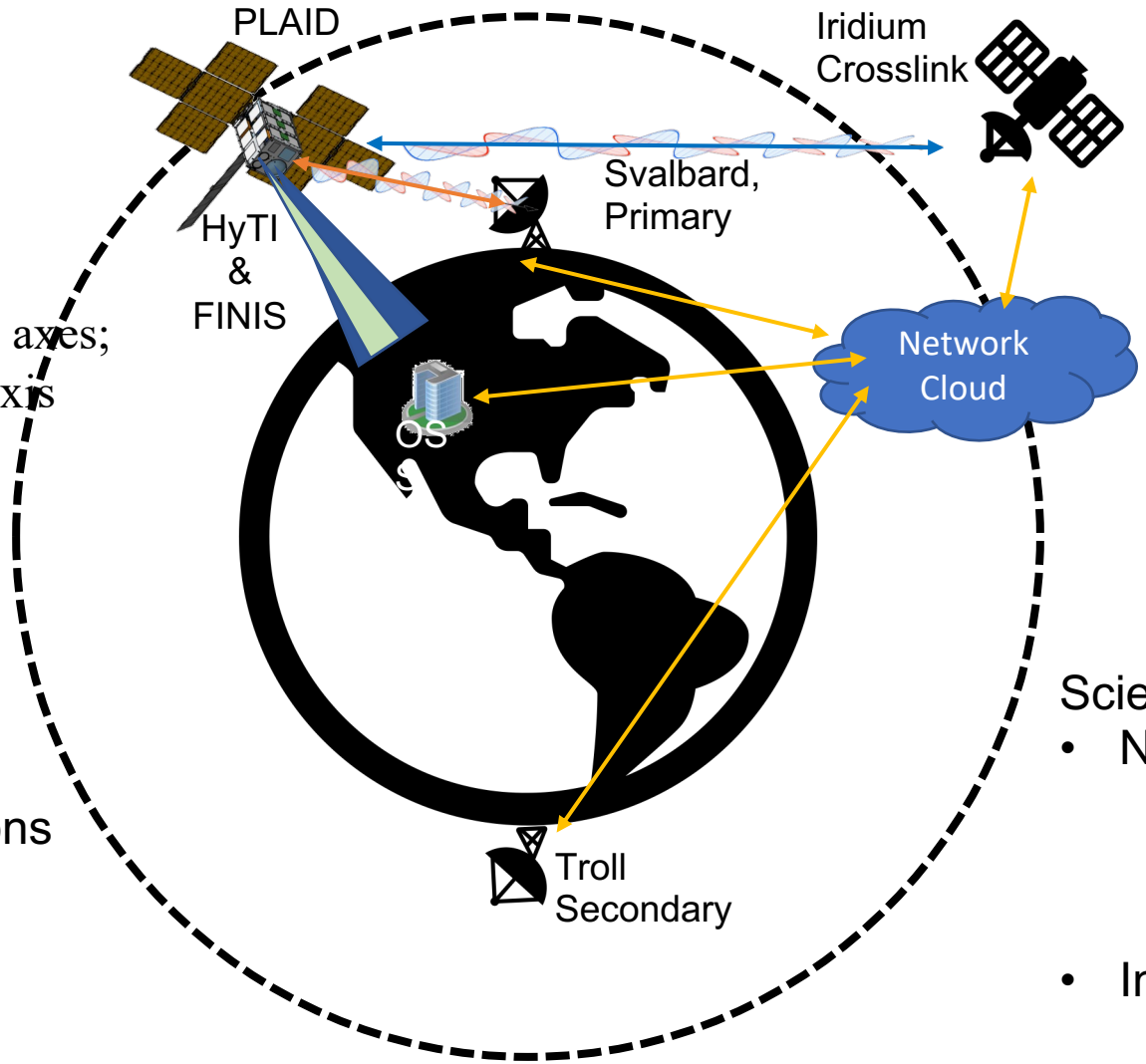
ATA 6U Prototype



ACMES ATA Operational Concept

Concept of Operations

- 16U CubeSat Bus
- 550 km SSO Orbit
  - LTAN ~10:00 to 12:00
- Attitude Control
  - Star Cameras, Wheels
  - ±0.003 deg (1-sigma) for 2 axes; ±0.007°(1-sigma) for 3rd axis

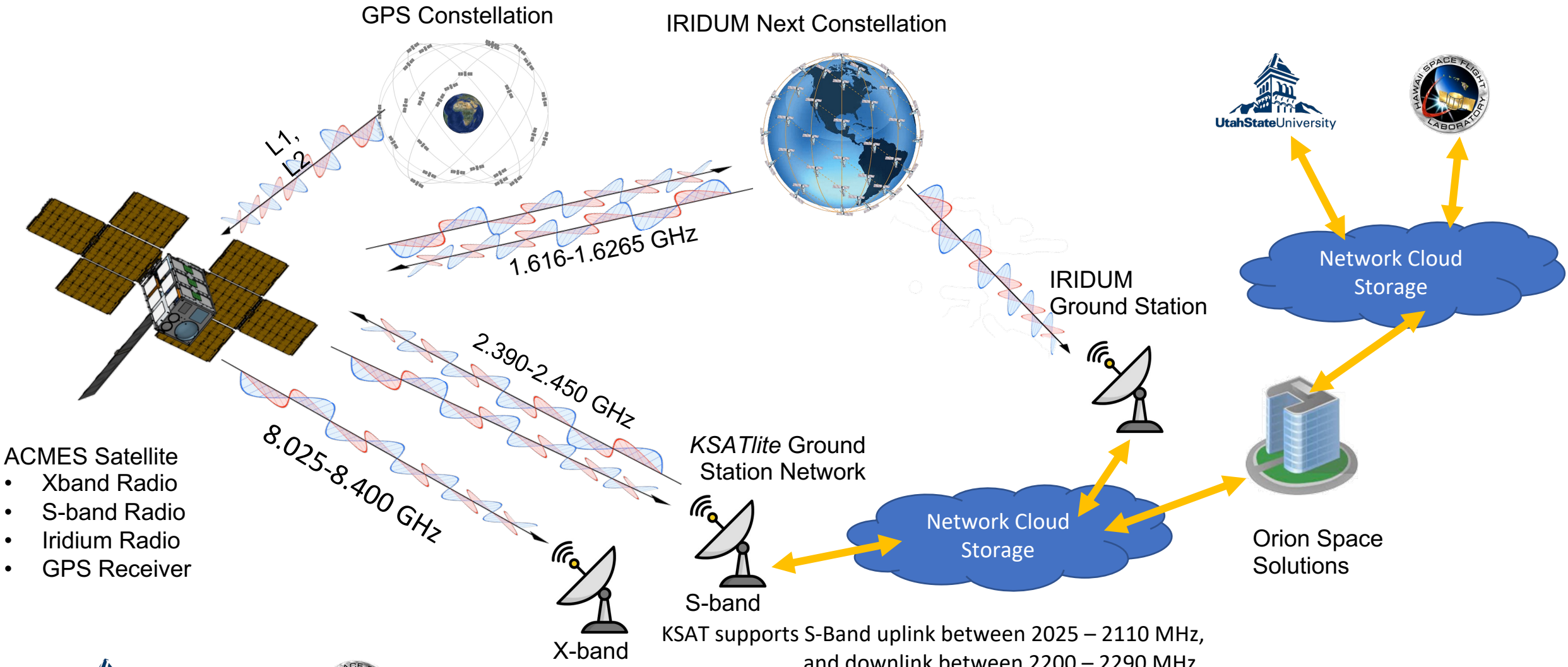


Telemetry
- X-Band Down DVB-S2X
- S-Band Transceiver
- Iridium Crosslink
- GNSS

Ground Support
- KSAT Lite Network
  - Kratos QMR & QRX
- High Latitude Ground Stations
- Multiple Contacts per day

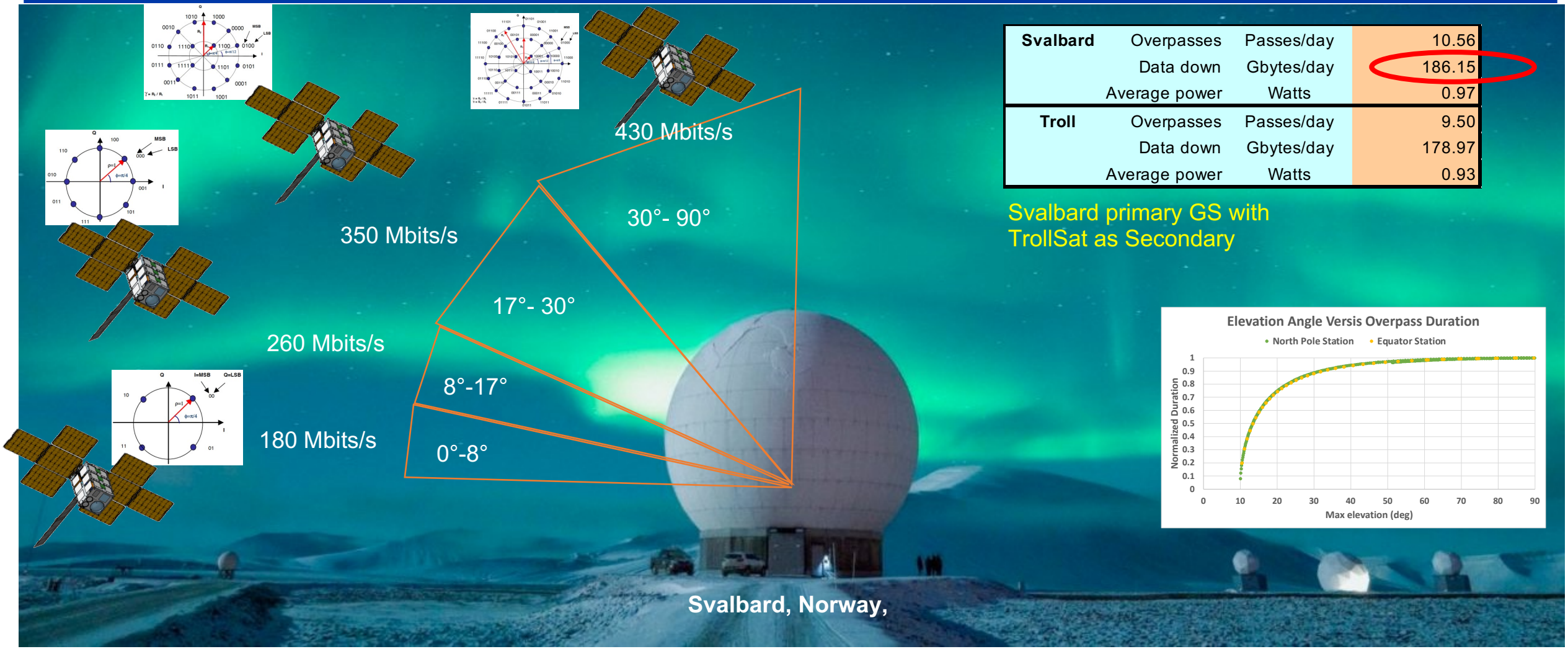
Scientific CONOP
- Nadir viewing IR observation
  - HyTI Hyperspectral imaging
  - FINIS Methane detection
  - 100% Ground Coverage
- In Situ Ionosphere monitoring

ACMES Communication Architecture



KSAT supports S-Band uplink between 2025 – 2110 MHz, and downlink between 2200 – 2290 MHz.
The X-Band downlink (8000-8400 MHz).

X- band Downlink Concept



Svalbard	Overpasses	Passes/day	10.56
	Data down	Gbytes/day	186.15
	Average power	Watts	0.97
Troll	Overpasses	Passes/day	9.50
	Data down	Gbytes/day	178.97
	Average power	Watts	0.93

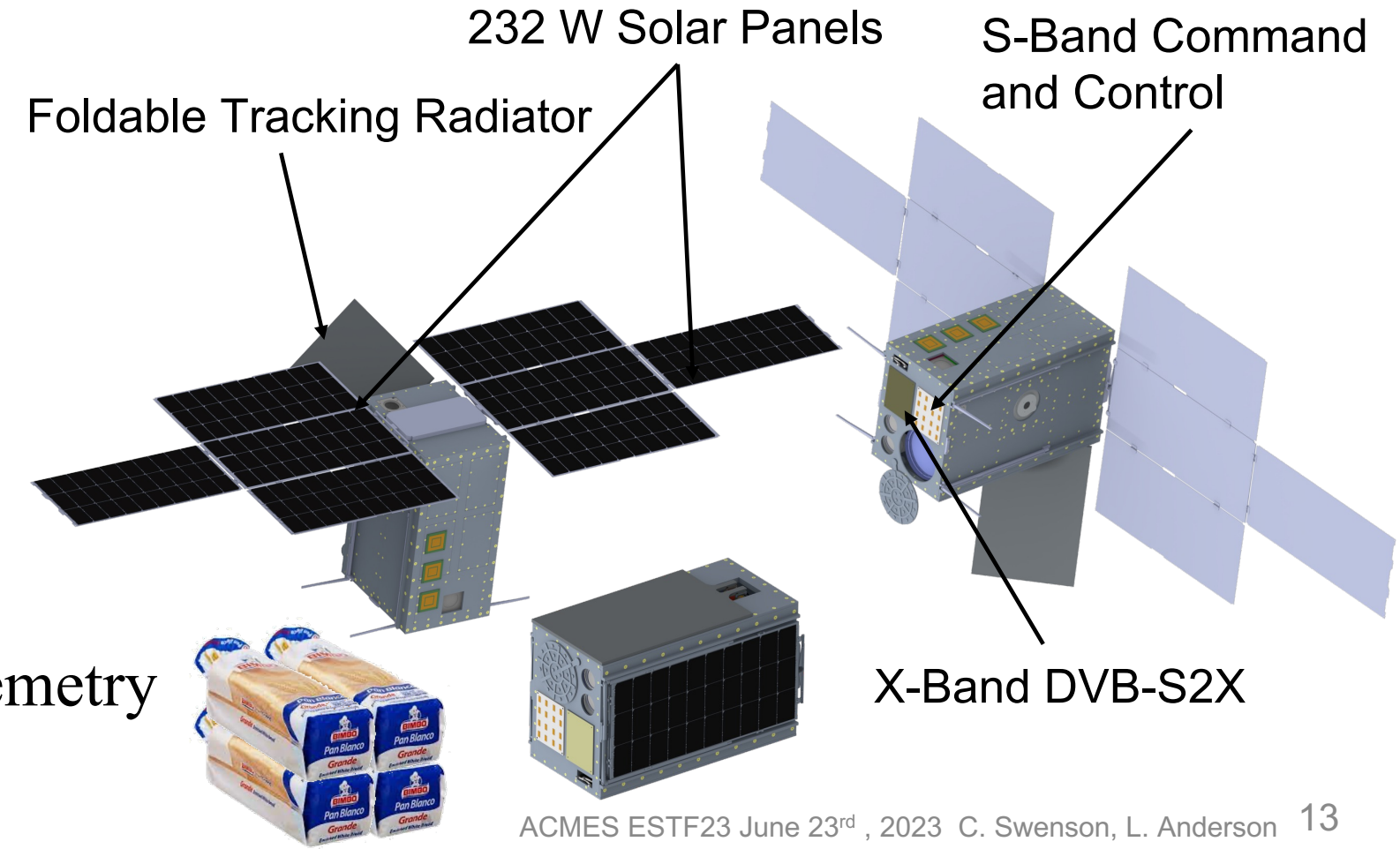
Svalbard primary GS with TrollSat as Secondary

Commercial Product

The Triton bus is a versatile and customizable CubeSat bus developed by Orion Space Solutions. Standard sizes vary between 3U and 27U.

Features:

- Up to 14U payload volume
- 40 kg mass
- 400 W peak power
- Common computing
- Power management
- Active thermal control
- Propulsion
- High data rate S/X band telemetry



Questions