HyTI: high spectral and spatial resolution thermal infrared imaging from a 6U CubeSat

Presented by

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On behalf of the HyTI Team
HyTI Mission Goals

To demonstrate high spectral, high spatial, and high SNR long-wave infrared imaging, and high performance on-board computing to process the resulting data, on a 6U CubeSat platform

1. HIGP Fabry-Perot LWIR imaging interferometer (TRL\text{in} = 4)

2. JPL T2SLS Barrier InfraRed Detector (BIRD) focal plane array (TRL\text{in} = 5)

3. Unibap Deep Delphi iX5 heterogeneous onboard computer (TRL\text{in} = 5)
Relevance of HyTI to NASA’s Earth Science mission

Earth scientists have never had access to high spatial and high spectral longwave infrared image data from Earth orbit.
HyTI Science Measurement Approach

Acquire L0 frames at 139 Hz

Across track (swath)

In track

DN

Frame

Spectral radiance (W m\(^{-2}\) sr\(^{-1}\) μm\(^{-1}\))

Wavelength (μm)
HyTI Thermal Infrared Interferometric Imaging Spectrometer
What HyTI data will look like
L2 science products will be generated on-board HyTI

Temperature, humidity

SO₂ concentration

Training

SO₂(known) = \alpha_1 L_1 + \alpha_2 L_2 + \cdots + \alpha_{25} L_{25}

\alpha_1 = \begin{pmatrix} 
\alpha_{1,1} \\
\vdots \\
\alpha_{k,1} 
\end{pmatrix}, \cdots

Validation and implementation

SO₂(unknown) = \alpha_1 L_1 + \alpha_2 L_2 + \cdots + \alpha_{25} L_{25}

Temperature, emissivity

SO₂ concentration

Temperature, emissivity
HyTI spacecraft subsystems

Structure (TRL=9)
- ISIS STS 6UXL TRL=9

Payload (TRL=4)
- Multi-element lens (NEOS/FLIR) TRL=6
- Focus motor (Faulhaber AM1020) TRL=4
- Fabry-Perot interferometer (LightMechanical) TRL=6
- BIRD FPA (JPL) TRL=5
- Integrated dewar cooler assembly (AIRS) TRL=4
  - Dewar assembly (AIRS hi-Nyq) TRL=4
  - SIP board (AIRS) TRL=4
  - Dewar board (AIRS) TRL=4
  - Camerlink interface board TRL=4
  - Cryocooler (AIM SF070) TRL=4
  - Cryocooler drive electronics (Creare) TRL=5
- Current ripple filter (Creare) TRL=5

Communications (TRL=5)
- X-band downlink (Syrlinks EW/C7) TRL=9
- X-band patch antenna (SPAN-X-T3) TRL=9
- S-band transceiver (ISIS) TRL=5
- S-band patch antenna (ISIS) TRL=5
- GlobalStar duplex (NSL EyeStar-D2) TRL=9
- Global Star simplex (NSL EyeStar-S3 (STX3)) TRL=8

Command and Data Handling (TRL=5)
- Payload OBC (Unibap DD-Hx5) TRL=5
- Spacecraft OBC (ISIS OBC) TRL=9

Electrical and Power (TRL=5)
- Solar panels (x4 ISIS SPA) TRL=9
- Power distribution and battery pack (ISIS IEPS) TRL=5

Attitude determination and Control (TRL=9)
- Reaction wheels (CubeSpace CubeADCS) TRL=9
- Torque rods (CubeSpace CubeADCS) TRL=9
- Star Tracker (CubeSpace CubeStar) TRL=9
- Nadir sensor (CubeSpace CubeSense) TRL=9
- Sun sensor (CubeSpace CubeSense) TRL=9
- Magnetometers (CubeSpace CubeADCS) TRL=9
- ADCS OBC (CubeSpace CubeComputer) TRL=9
- GPS (NovAtel OEM719-5S5-LNN-TBE-H) TRL=9
A Day-in-the-Life of HyTI

- GlobalStar L-band (TIm D/L; Cmd U/L)
- Slew to nadir
- Sun soak (L0 to L1/L2 processing)
- L0 data collection
- Calibration (slew to space/Moon)
- Payload data D/L to KSAT ground station (X/S-band)

252 CONUS passes in one month
HyTi Power Budget

- **Total**
- **Cryocooler**
- **Camera**
- **Payload OBC**
- **Bus**
- **ADCS**
- **Comms**

**Power (W)**

- Cool FPA ambient to 68 K
- Cryocooler maintains FPA at 68 K
- Slew spacecraft (deep-space look)
- Payload OBC processes L0 to L1 and L2
- Payload OBC transfers L1/L2 to X-band radio
- Downlink

**Time (s)**

- L0 data acquisition

**Power generation**

**Power consumption**

**Battery capacity**

**Battery capacity (Wh)**

**Time (hours)**
HyTI Thermal Control
HyTI payload status

Payload shipping from AIRS to JPL next week for radiometric testing and payload-level vibe
HyTI bus status

Awaiting delivery of FM for two Creare cooler support boards (next week) and FM of ISISpace EPS (tbc)
HyTI bus status

Fit-check/populating frames
HyTI bus status – current flat-sat

Frame 1: Unibap payload OBC

Frame 2: X-band (Tx); S-band (Tx/Rx); EPS DU2

Frame 3: Bus OBC; ADCS; EPS DU1

Dummy load (cooler)

Cryocooler controller (EM)

Current ripple filter (EM)

GPS
Summary

- Space-validating innovative new technology to provide Earth scientists with high spatial and spectral resolution thermal infrared image data from a 6U CubeSat

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