Hyperspectral – Infrared Imager (HyspIRI) Mission

Mission Concept Review

HyspIRI VSWIR Instrument

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with contributions from the HyspIRI Team

National Aeronautics and
Space Administration

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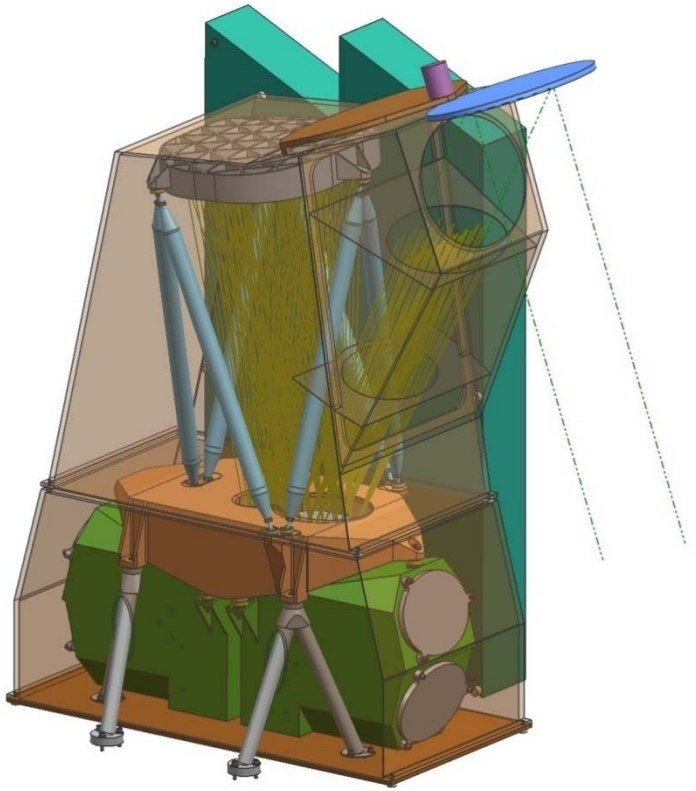
California Institute of Technology
Pasadena, California

VSWIR - Instrument Concept

- *Outline*

  1. *Introduction*
  2. *Key Requirements & Performance*
  3. *Key Trades and Results*
  4. *Technology Readiness & Heritage*

HyspIRI – VSWIR '10



Mass (CBE)	***55Kg***
Power (Ave.)	***41Watts***

Key VSWIR Requirements

Radiometric	Requirement	Status
Range & Sampling	0 to 1.5 x benchmark radiance, 14 bits	Demonstrated via analysis and 14 bit ADC bread board electronics
Accuracy	>95% absolute radiometric, 98% on-orbit reflectance, 99.5% stability	Demonstrated – AVIRIS, MaRS
Precision (SNR)	See spectral plots at benchmark radiances	Demonstrated via analysis
Linearity	>99% characterized to 0.1 %	Demonstrated via test, MaRS and M3
Polarization	<2% sensitivity, characterized to 0.5 %	Demonstrated via analysis of design and test data on the grating
Scattered Light	<1:200 characterized to 0.1%	Demonstrated in MaRS and M3

Spectral	Requirement	Status
Range	380 to 2500 nm (solar reflected spectrum)	Demonstrated – AVRIS, MaRS, M3
Sampling	<= 10 nm {uniform over range}	Demonstrated – MaRS, M3
Response	<= 1.3 X sampling (FWHM) {uniform over range}	Demonstrated – MaRS, M3
Accuracy	<0.5 nm	Demonstrated – MaRS, M3

Key VSWIR Requirements

Spatial	Requirement	Status
Range	>145 km	Demonstrated by design and analysis (150 km)
X-track Sampling	>2400	Demonstrated by design and analysis (2500)
Sampling	<= 60m (Nadir)	Demonstrated by design and analysis
Response	<= 1.2X sampling (FWHM)	Demonstrated by MaRS and M3
Uniformity		
Spectral Cross-Track	>95% cross-track uniformity {<0.5 nm min-max over swath}	Demonstrated by MaRS and M3
Spectral-IFOV-Variation	>95% spectral IFOV uniformity {<5% variation over spectral range}	Demonstrated by MaRS and M3

Other Key	Requirement	Status
Data rate	~ 300 Mbits per second	Met by preliminary architecture and parts selection – all required parts are at or above TRL 6
Compression	3:1 lossless	Met by algorithm test on MaRS data. Algorithms implemented in breadboard electronics and flight FPGA
Pointing Knowledge	30m radius (3σ) ~ 9 arcsec (3σ) = 3 arcsec (1σ) reconstructed	Met by analysis and the use of ground tie points
Mass	<55 kg	Met by current design with 30% margin – working to increase margin

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Instrument Approach

Spectroscopy in the range 400 to 2500 nm at 10 nm with high uniformity and high precision (SNR) is required to capture the molecular absorption and constituent scattering signatures for this mission. The following instrument options have been considered to achieve this objective.

- **Selected: Offner spectrometer (Hyperion, CRISM, ARTEMIS, M3, COMPASS^{air} TB^{air})**
  - Full range from 380 to 2500 nm demonstrated. Efficiency for high SNR optimized with multiple blaze grating demonstrated. Uniformity from design through alignment demonstrated. Snapshot acquisition detector. Dispersion efficiency tunable to optimize use of detector.
- Prism dispersion spectrometer
  - Dispersion is non-uniform. Cross-track and spectral-IFOV uniformity not inherent in optical design. Dispersion efficiency not tunable in detail to optimize use of detector full well.
- Wedge/Linear-variable filter spectrometer
  - Full spectral range coverage from 380 to 2500 nm has not been demonstrated maintaining 10 nm spectral sampling and response function. Filter uniformity is a concern over wide spectral and spatial domain. Fast, high throughput, beams interplay with filter spectral bandpass undermines uniformity.
- Fourier Transform Spectrometer
  - Dispersion is non constant with wavelength. Not typically built to operate below 1 micron. Detector dynamic range and photon shot noise concern. Architecture for > 2000 cross track elements and >200 spectral channels not identified. Not well suited for wide or moderate field of view. Requires IMC.
- Liquid Crystal Tunable & Acousto-Optical Tunable
  - Time sequential acquisition undermines uniformity. Low TRL, polarization sensitive. Limited spectral range. Requires IMC.

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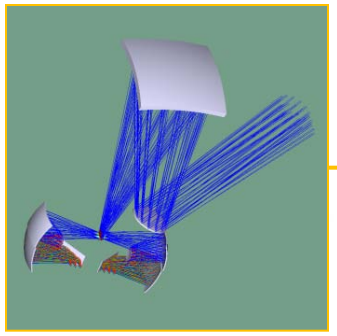
Optics

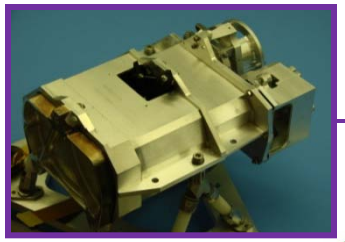
• Front End Telescope
consists of a primary spherical mirror and a secondary aspherical mirror

• Back End Spectrometers
consist of 2 optimized Offner spectrometers



Spectrometers (2x)

- 2 identical Offner spectrometers
- Each contains:
  - E-Beam grating
  - Si air slits
  - FPA assembly

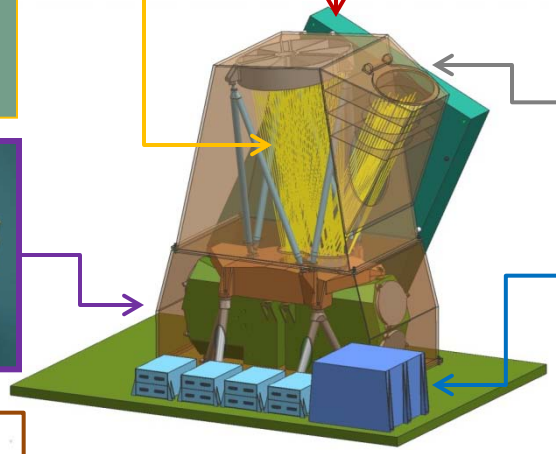


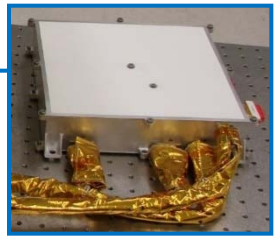
Radiator

- Area 0.6m²
- M3 technology heritage

Baffle/Cover/Cal Panel

- *Launch cover*
- *Used as a solar reflectance calibration target*



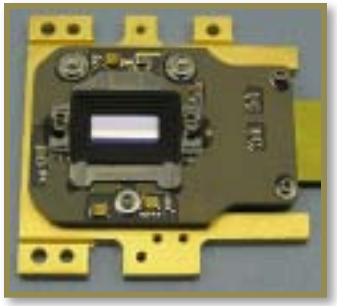


Electronics

- M3 Derivative 4x
- Electronic concept is based upon available flight approved parts
- Ins. control, Data Compression, mode control

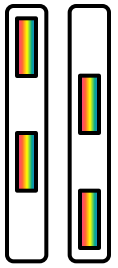
FP A (2x)

- Mount is adjustable in 6 DOF
- Thermal strap connects mount to radiator
- Each assembly contains two Teledyne 6604a detector arrays
- Includes integral OSF



Detectors (4x)

- Teledyne 6604a detectors; full flight heritage from M3.
- Analog I/O
- Each spectrum readout as snapshot, so that there is no time delay, yaw, or jitter impact to the spectral-IFOV-uniformity.



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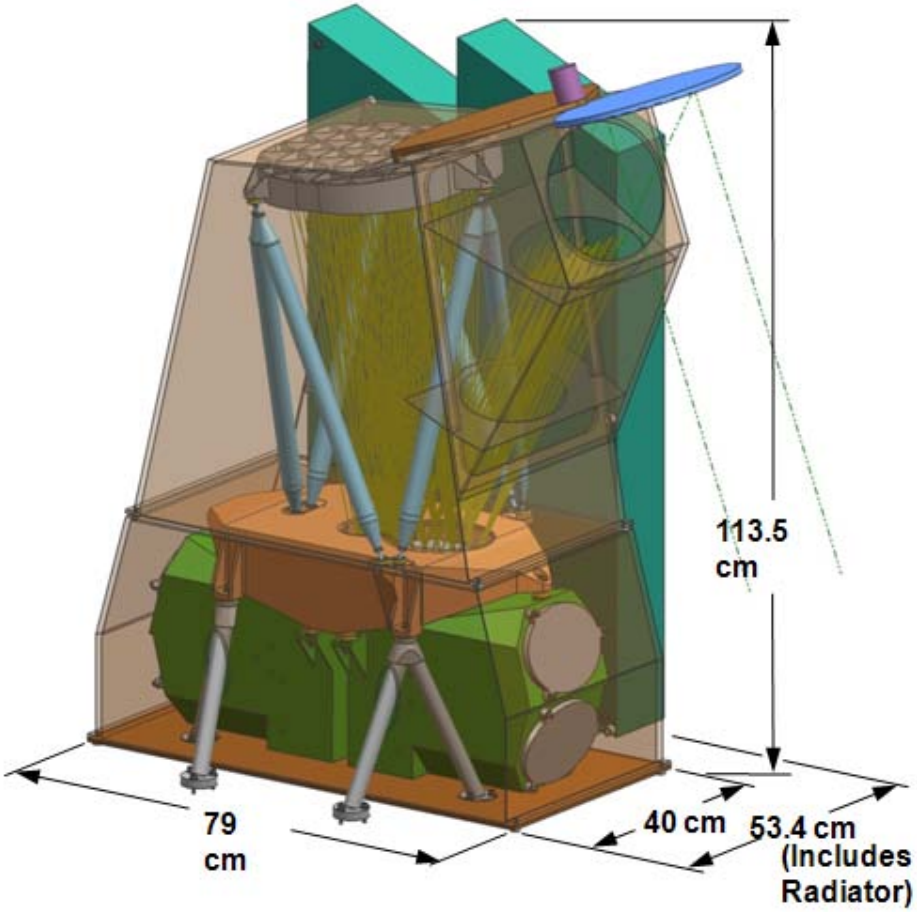
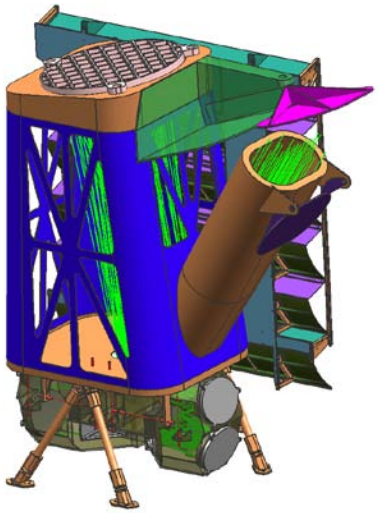
Changes

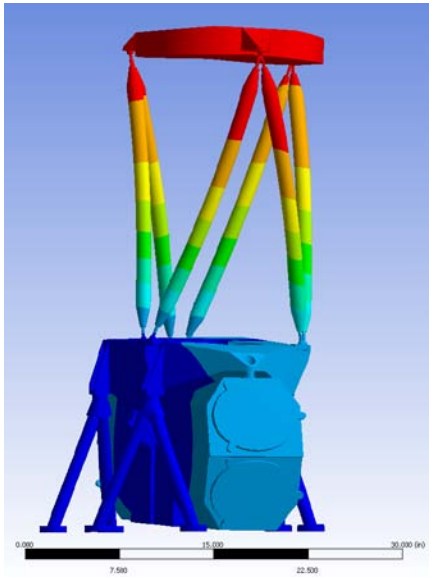
a) **Optical bench**
b) **CG Bipods**
c) **Telescope Bipods**
d) **Thermal enclosure**
e) **Optimized radiator**
f) **Cal. Cover**

Results

a) **Mass is reduced**
b) **Structure is mechanically sound (120Hz)**
c) **Improved thermal isolation**
d) **Smaller radiator**
e) **Electronic parts =>TRL6**







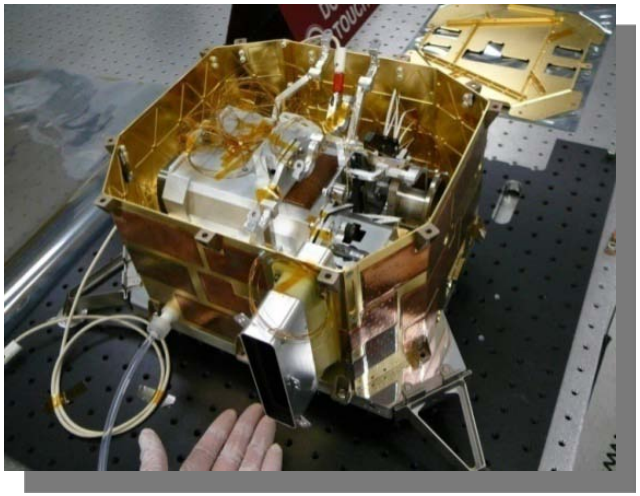
TRL & Heritage

No new technology is required for HyspIRI – VSWIR

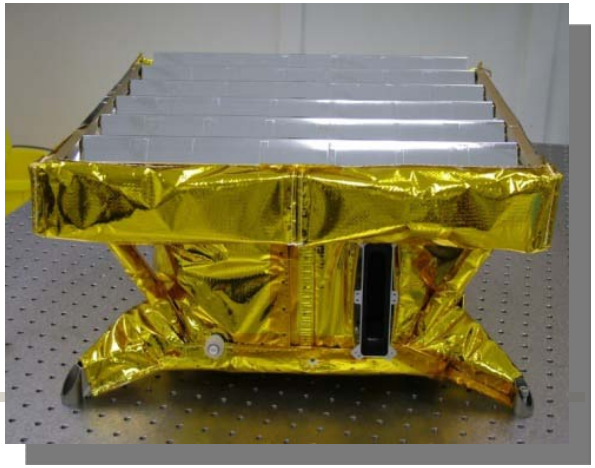
Technology Readiness Highlights

Key Technology	TRL	Comments
Spectrometer	9	Offner design flown on Hyperion, CRISM and M3
Grating	9	Flown on Hyperion, CRISM, M3
Detector array	9	Flown on M3
Opto-Mechanical (alignment & stability)	9	Flown on M3

M3 Spectrometer

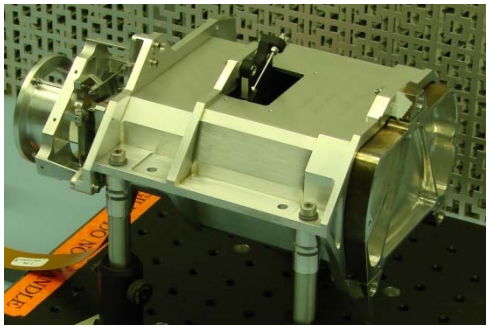


VSWIR has high heritage in instrument architecture, requirements, manufacturing, vendors, management and engineering staff

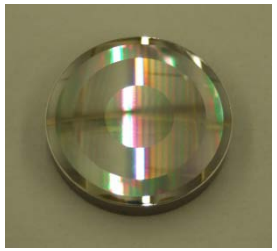


Key Technologies are Proven

1. Uniform Offner spectrometer (Mouroulis Design)

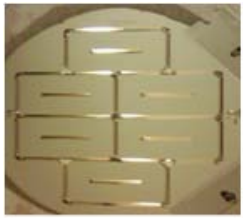


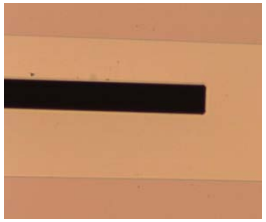
2. Finely adjustable optics and detector mounts that can be locked within fraction of a micron (0.1 microns)

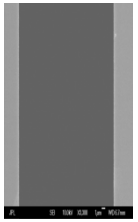


3. Electron beam fabricated gratings (large ruling period)

1. Electron beam fabricated air slits(non-uniformity < .05 microns)







2. Alignment and calibration sources and methodologies to achieve and verify requirements.