

# **Hyperion Imaging Spectrometer on the New Millennium Program Earth Orbiter-1 System**

---

**Jay Pearlman, Stephen Carman, Paul Lee,  
Lushalan Liao  
TRW**

**November, 1999**

# Earth Orbiter 1

Goddard Space Flight Center



As the first New Millennium Program Earth Orbiter Mission, EO-1 will demonstrate advanced land imaging instruments and high payoff spacecraft technologies.

Lead: Raytheon

# Hyperion Hyperspectral Imager

---



# **Earth Orbiter - 1 Mission**

---

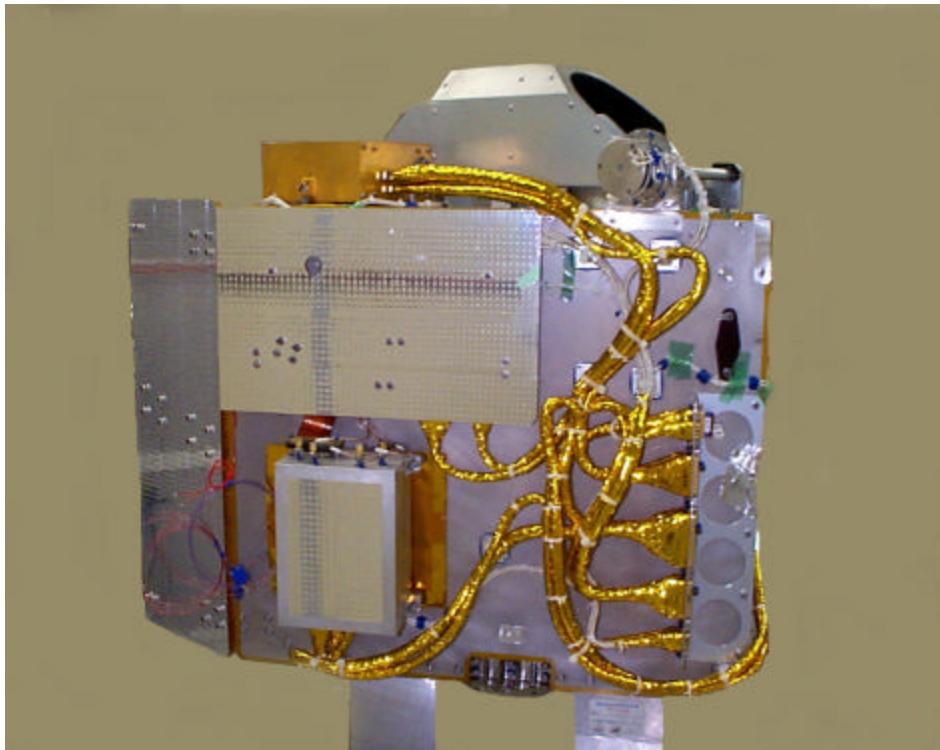
**Three revolutionary land imaging instruments on EO-1 will collect multi-spectral and hyperspectral scenes over the course of the EO-1 Mission in coordination with the Enhanced Thematic Mapper (ETM+) on Landsat-7. Detailed comparisons of the EO-1 and ETM+ images will be carried out to validate these instruments for follow-on missions.**



**Breakthrough technologies in lightweight materials, high performance integrated detector arrays and precision spectrometers will be demonstrated in these instruments.**

# Hyperion Imaging Spectrometer

---



**Convex Grating spectrometers  
with CCD VNIR and HgCdTe  
SWIR detectors (60µm pixels)**

**30m spatial and 10nm spectral  
resolutions over 7.5km swath  
and 400-2500nm spectral range**

**Multiple calibration options:  
lamps, lunar, solar, ground  
imaging and laboratory**

**Hyperspectral Imaging Capability  
to address technology and Earth  
Observation applications**

# Advanced Land Imager (ALI)

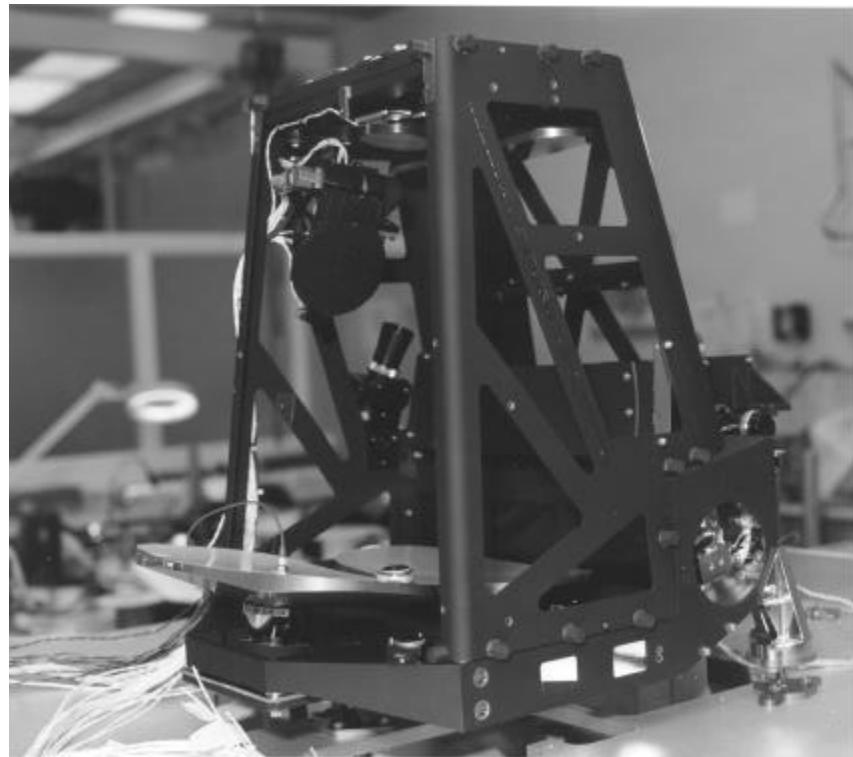
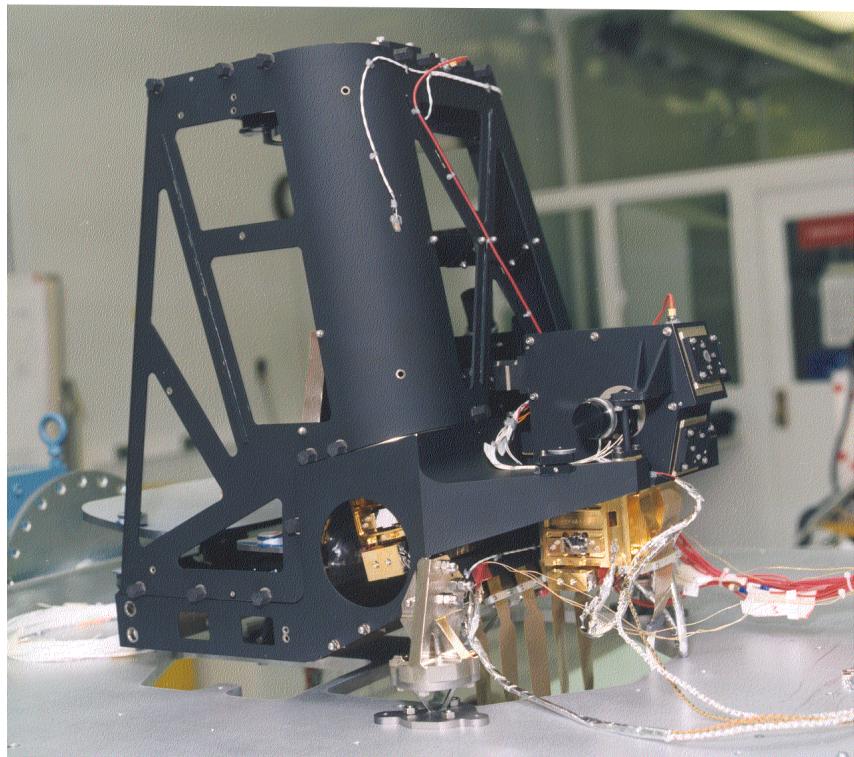
---



- Objective is to validate pushbroom technologies for Landsat applications
- Pushbroom Multi-Spectral Sensor - 9 multi-spectral (MS) channels and a pan channel
- Spectral coverage enhances Landsat ETM+ but excludes LWIR channel
- Swath width is 37km and MS ground resolution is 30m.
- S/N is 100 or better

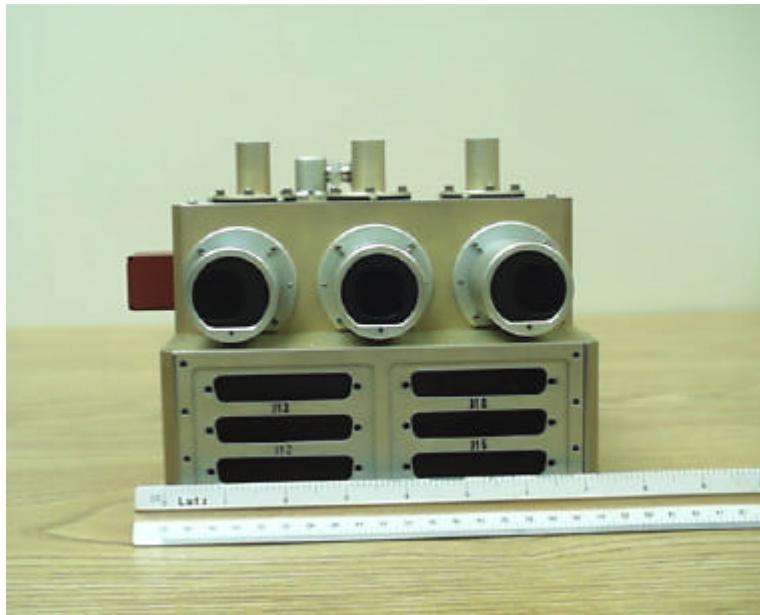
# EO-1 ALI Optical Structure by SSG

---



# LEISA Atmospheric Corrector

---



- **Correction of multi-spectral surface imagery for atmospheric variability (water and aerosols).**
- **High spectral, moderate spatial resolution (250m), large swath (180km) hyperspectral imager using wedge filter technology**
- **Spectral coverage of 0.89 - 1.6mm, bands selected for optimal correction of high spatial resolution images.**

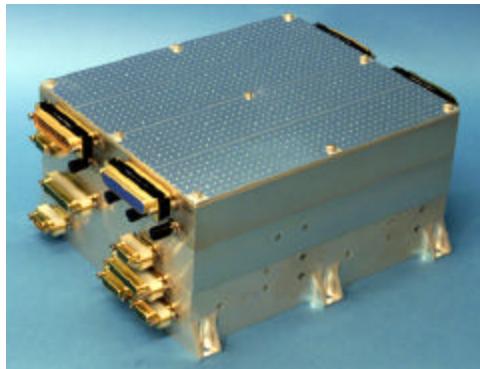
# EO-1 Instrument Overviews

---

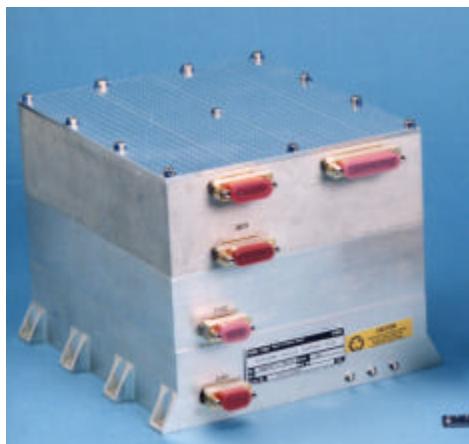
Parameters	EO-1	HYPERION	AC
<b>Spectral Range</b>	0.4 - 2.4 $\mu\text{m}$	0.4 - 2.5 $\mu\text{m}$	0.9 - 1.6 $\mu\text{m}$
<b>Spatial Resolution</b>	30 m	30 m	250 m
<b>Swath Width</b>	36 Km	7.5 Km	185 Km
<b>Spectral Resolution</b>	Variable	10 nm	6 nm
<b>Spectral Coverage</b>	Discrete	Continuous	Continuous
<b>Pan Band Resolution</b>	10 m	N/A	N/A
<b>Total Number of Bands</b>	10	220	256

# Hyperion Subsystems

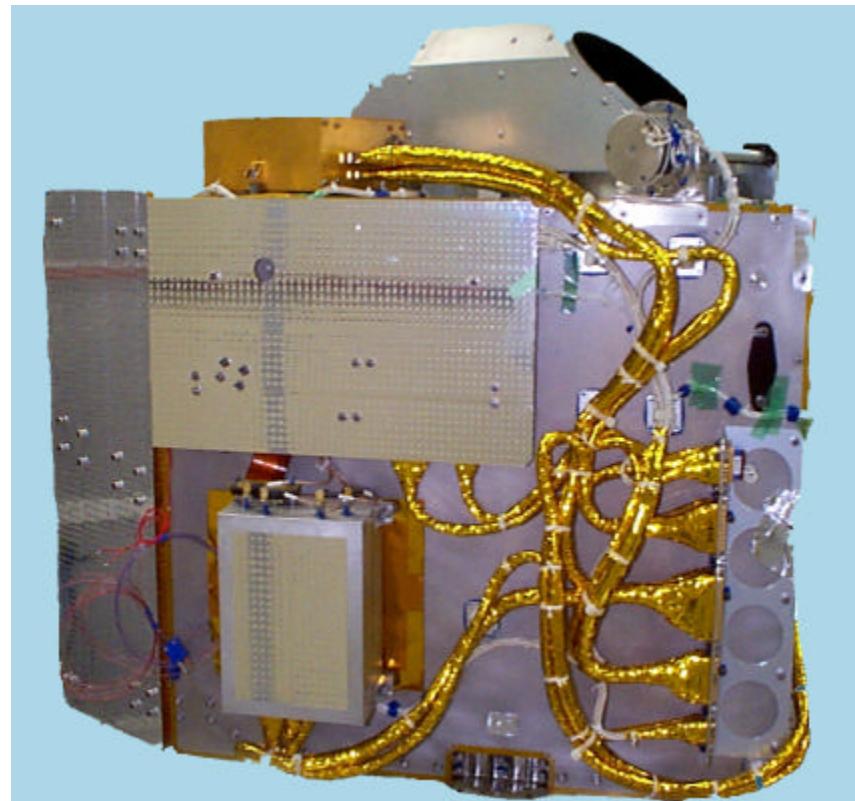
---



**Hyperion  
Electronics  
Assembly**



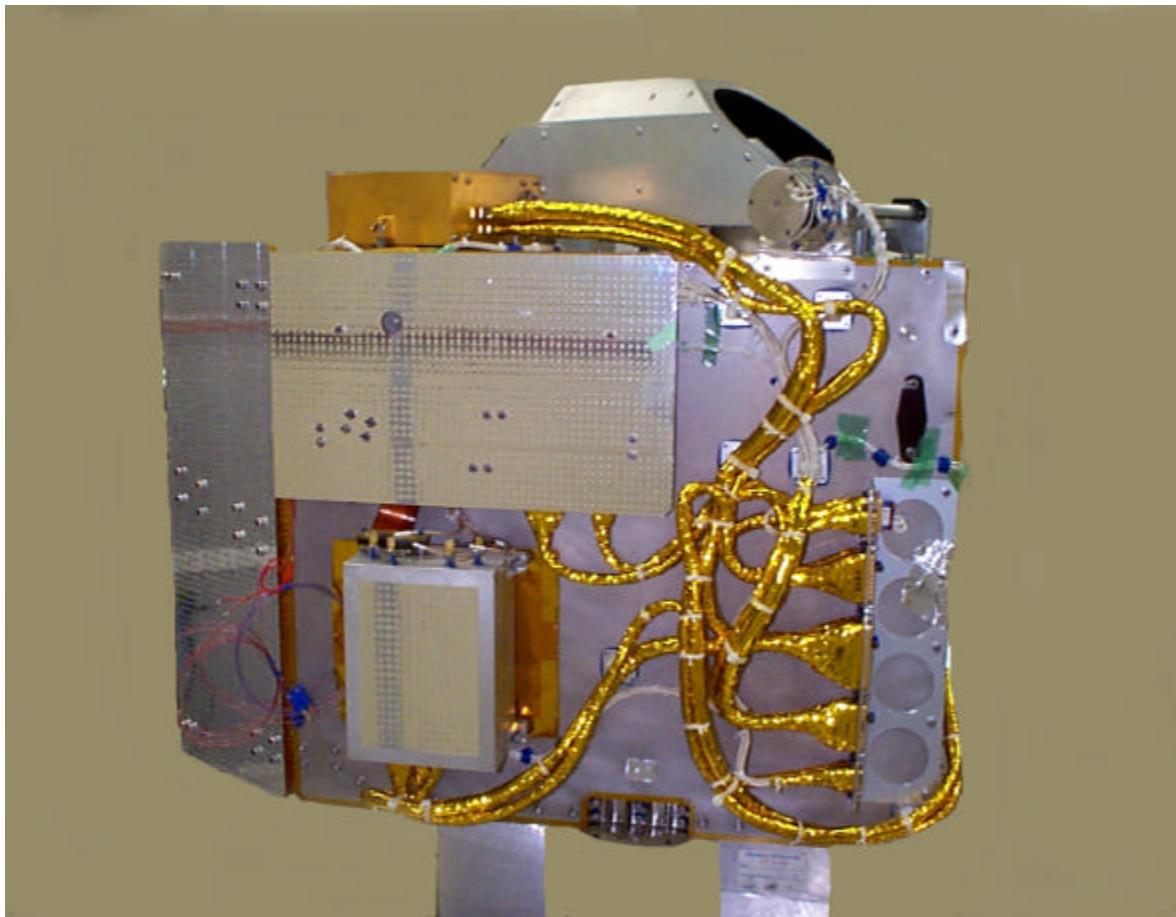
**Cryocooler  
Electronics  
Assembly**



**Hyperion Sensor Assembly (HSA)**

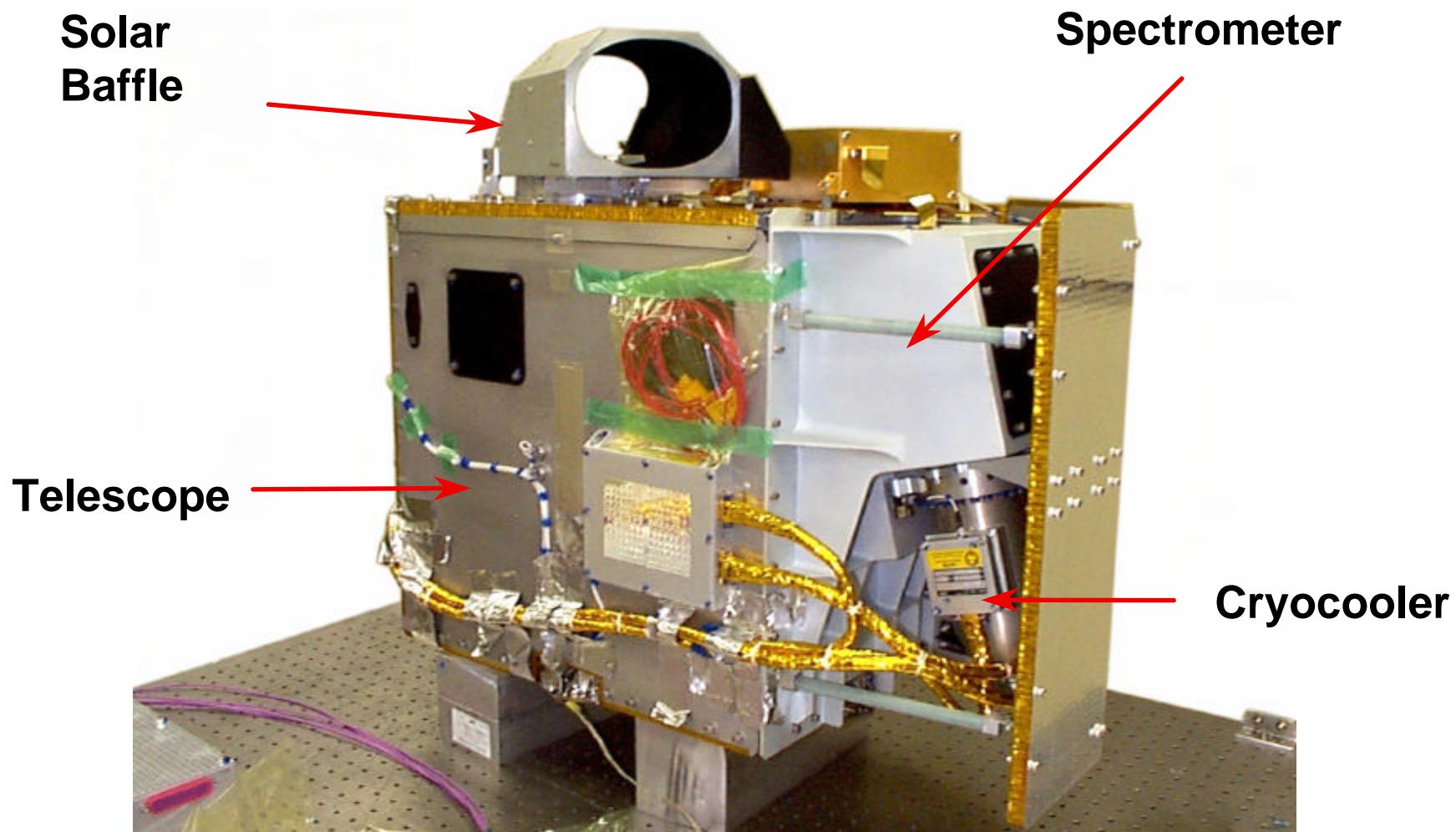
# Hyperion Sensor Assembly (HSA)

---

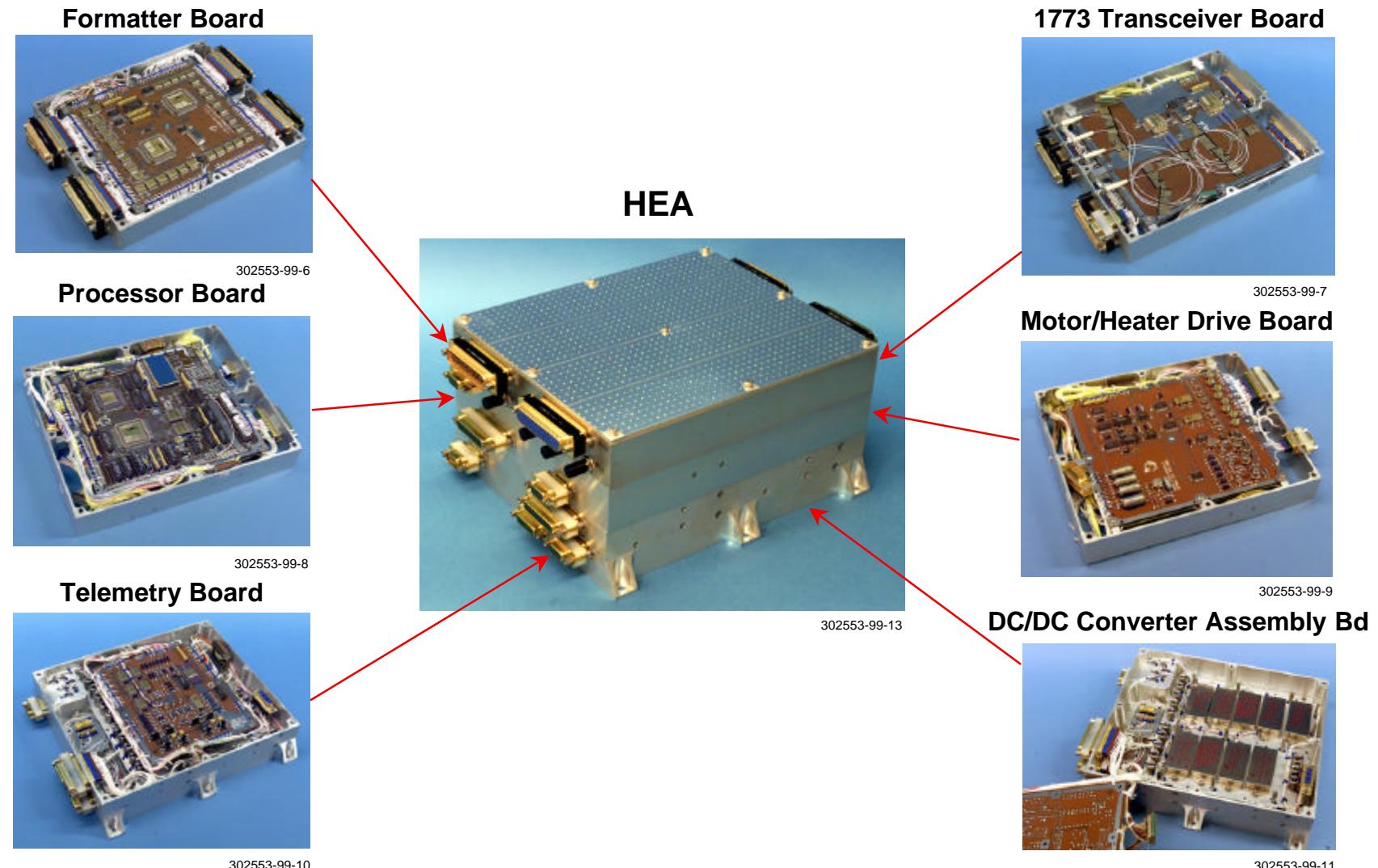


# Hyperion HSA Subsystems

---

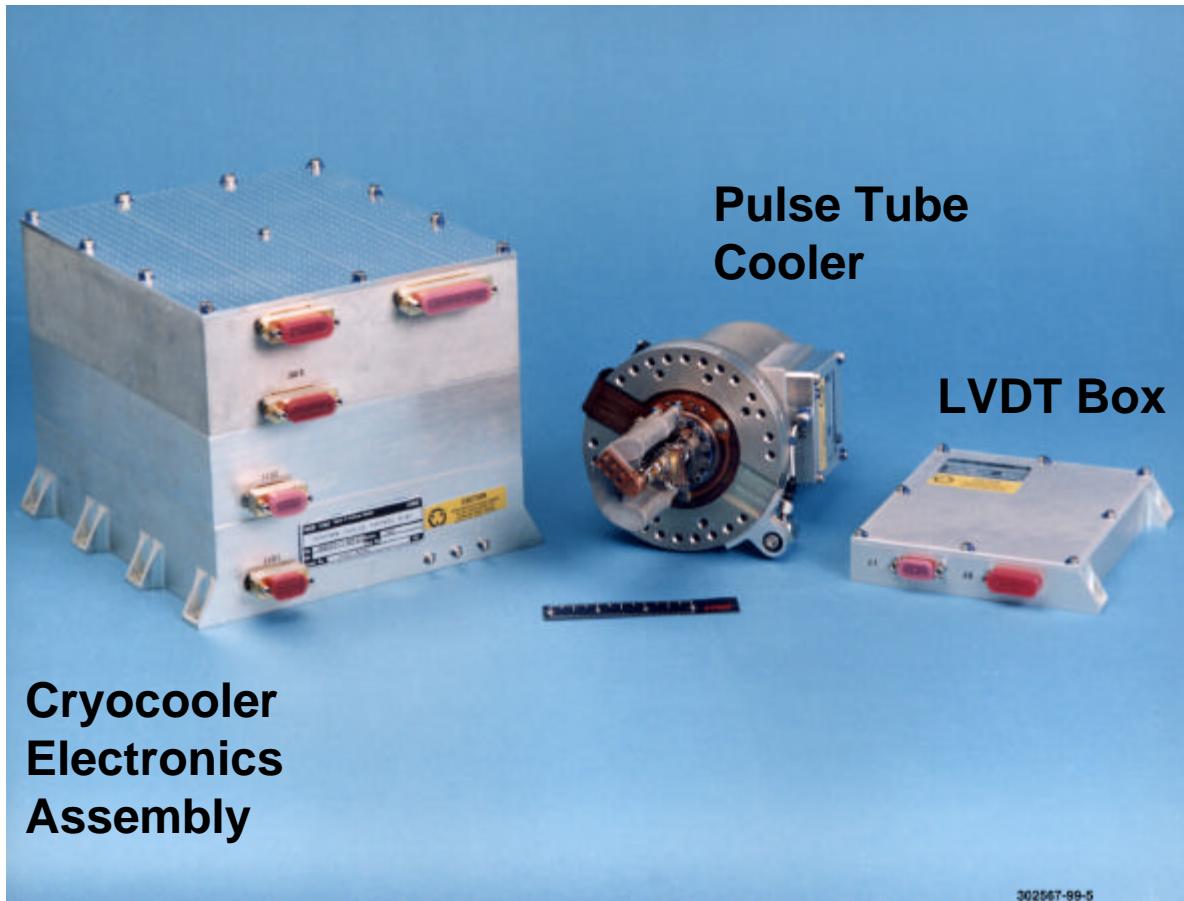


# Hyperion Electronics Assembly



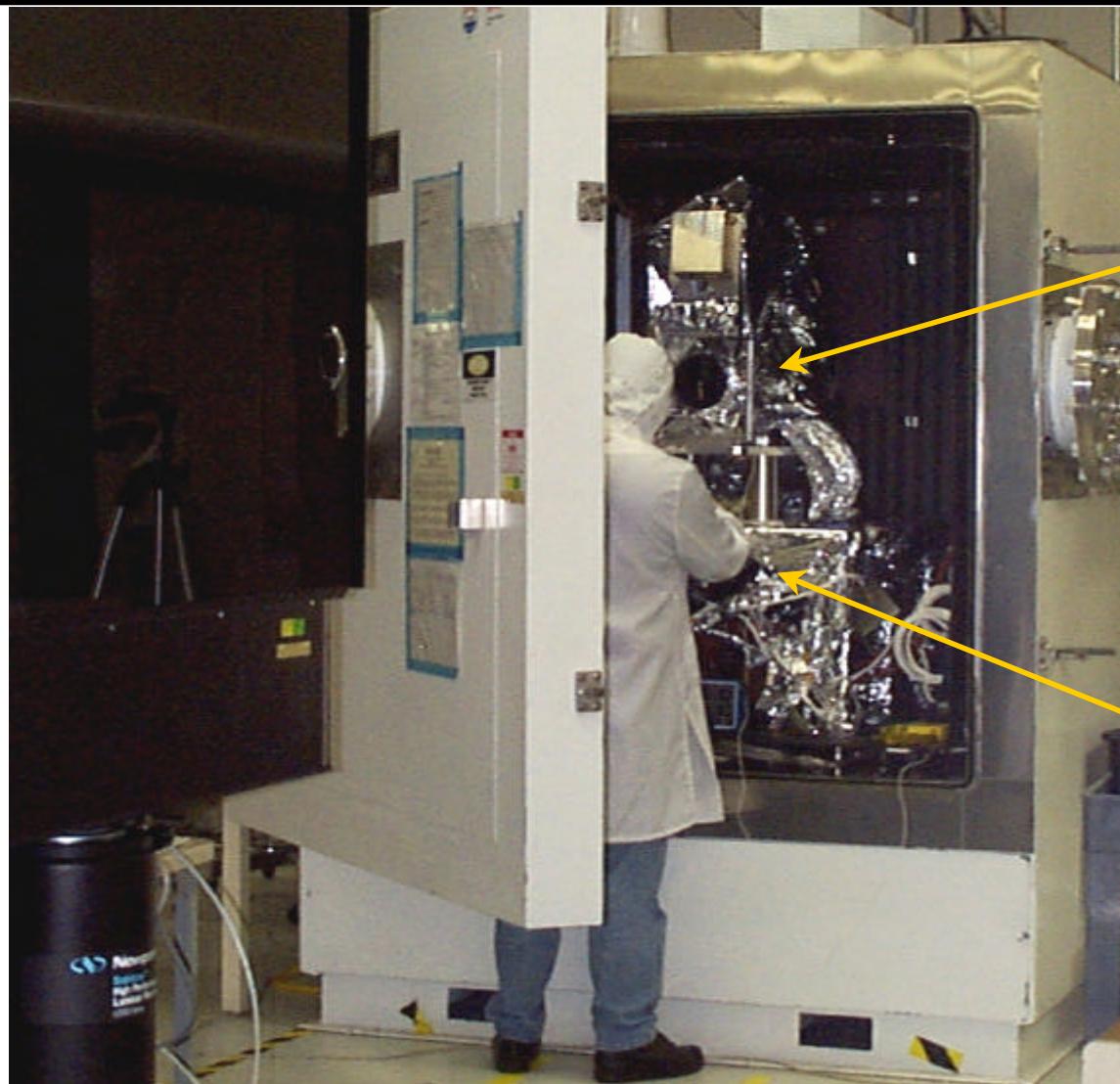
# Hyperion Cryocooler Subsystem

---



# Hyperion in Vacuum Chamber

---

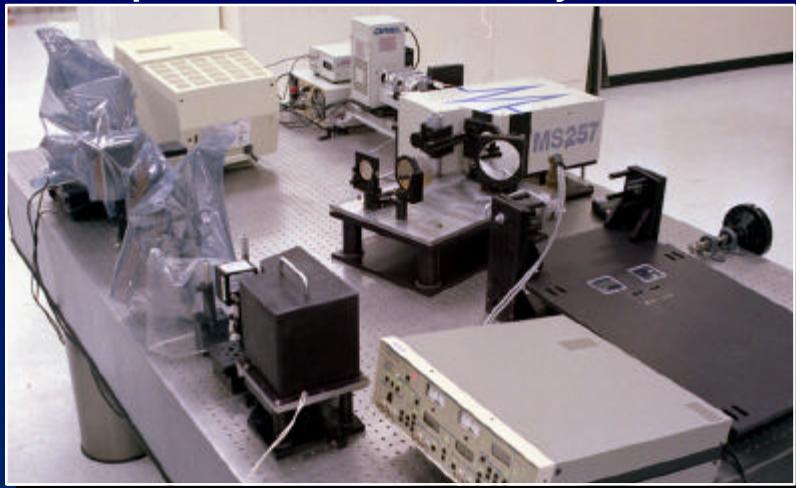


**Hyperion**

**Ground  
Support  
Equipment**

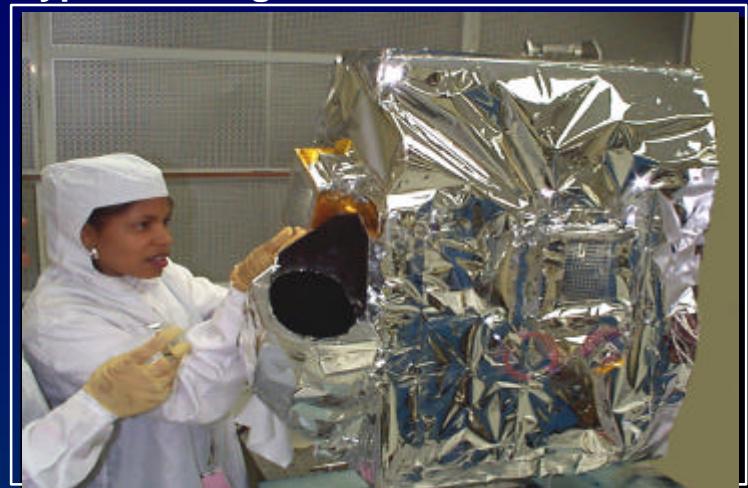
# MSTB Provides Absolute Radiometric and Spectral Calibration

Multi-Spectral Source Assembly



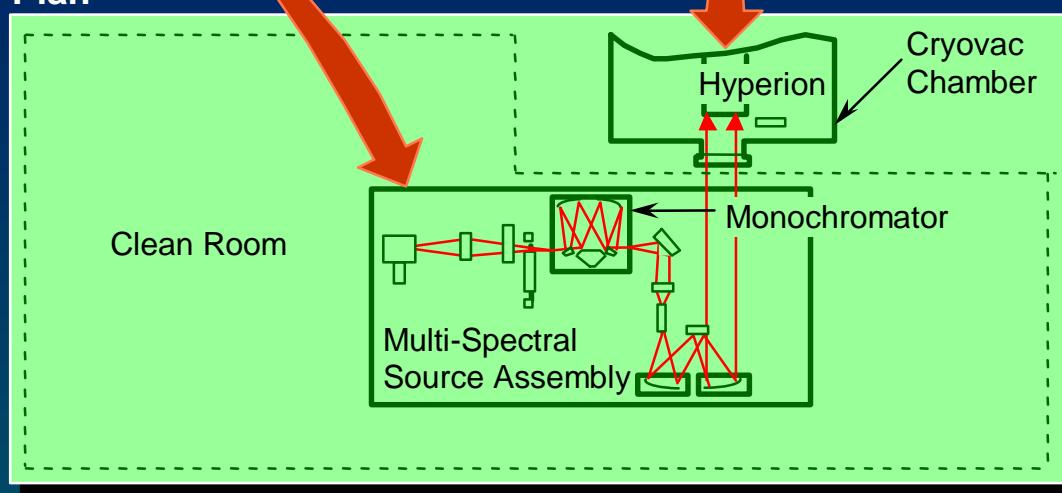
275072-95-2

Hyperion Integration and Test



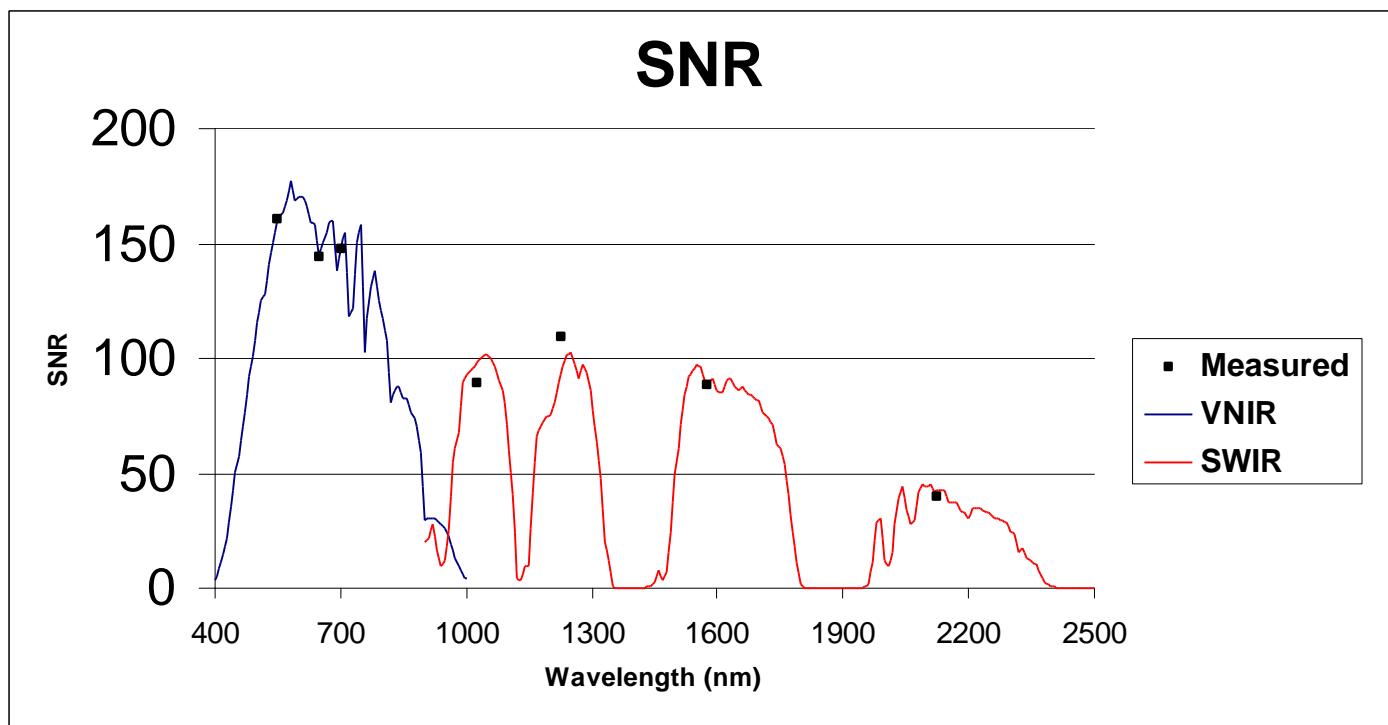
278039-96

Plan



# System SNR

Radiometric performance model base on 60° Solar zenith angle, 30% albedo, standard scene.



Hyperion Measured SNR						
550 nm	650 nm	700 nm	1025 nm	1225 nm	1575 nm	2125 nm
161	144	147	90	110	89	40

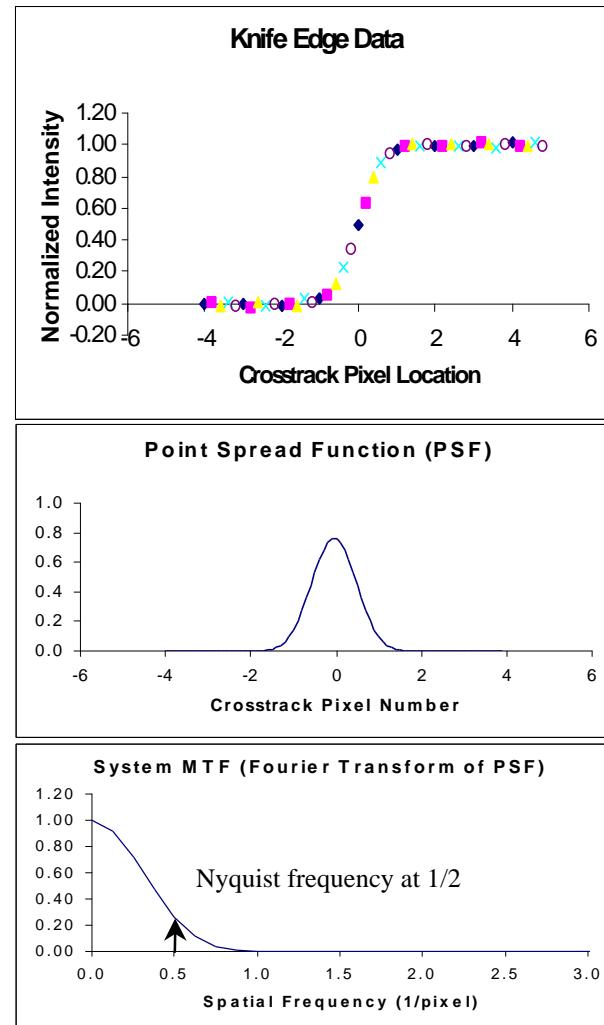
# Image Quality Assessment (MTF)

**Cross-Track MTF Measured using the knife-edge and slit techniques**

- Knife-edge perpendicular to the entrance slit of Hyperion
- Over-sampling by tilting steering mirror in fractional-pixel steps
- Derivative of Knife-Edge Data is the PSF
- MTF is the Fourier transform of PSF.

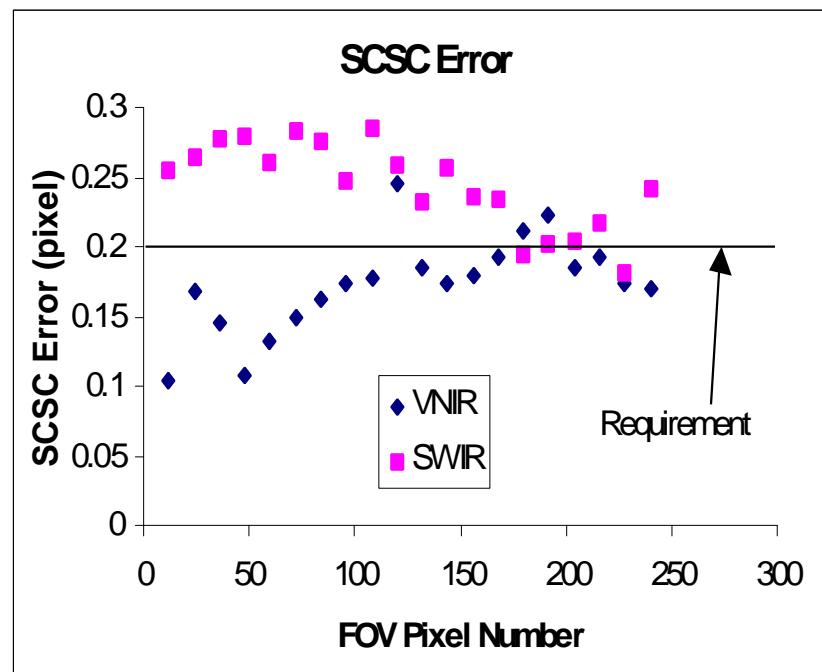
**Along-Track MTF is the Fourier transform of the convolution of PSF and along-track smear.**

Measured Average Along-Track MTF Values						
500 nm	630 nm	900 nm	1050 nm	1250 nm	1650 nm	2200 nm
0.26	0.26	0.24	0.28	0.28	0.26	0.26

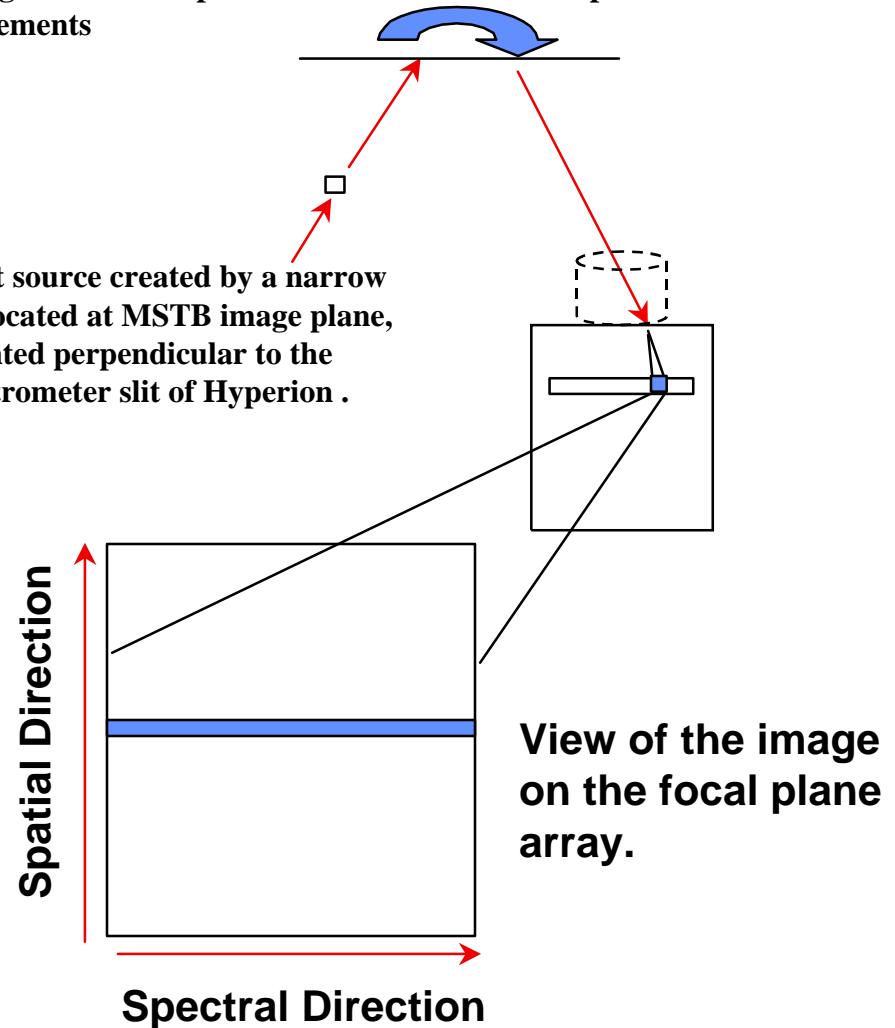


# Spatial Co-Registration of Spectral Channels

Measured with broadband point source at 20 locations on each focal plane array



Steering mirror used to move the image of the point source along cross-track spatial direction in fractional pixel increments



# VNIR Spectral Response

---

VNIR Channel Center Wavelengths (nm, accuracy +/- 0.5 nm)					
Spectral channel FOV #	13	31	40	48	57
6	477.40	656.46	753.6	834.29	925.38
71	478.45	657.45	754.12	834.91	925.14
136	477.97	656.83	753.66	834.40	925.29
196	476.75	655.69	752.83	833.41	924.38
251	475.15	654.59	751.3	831.94	922.77

VNIR FWHM of Spectral Response Functions (nm)					
Spectral channel FOV #	13	31	40	48	57
6	11.23	10.51	10.6	11.12	11.11
71	11.6	10.38	10.85	11.34	11.34
136	11.34	10.26	10.68	11.26	11.31
196	11.38	10.21	10.69	11.35	11.3
251	11.25	10.16	10.62	11.28	11.23

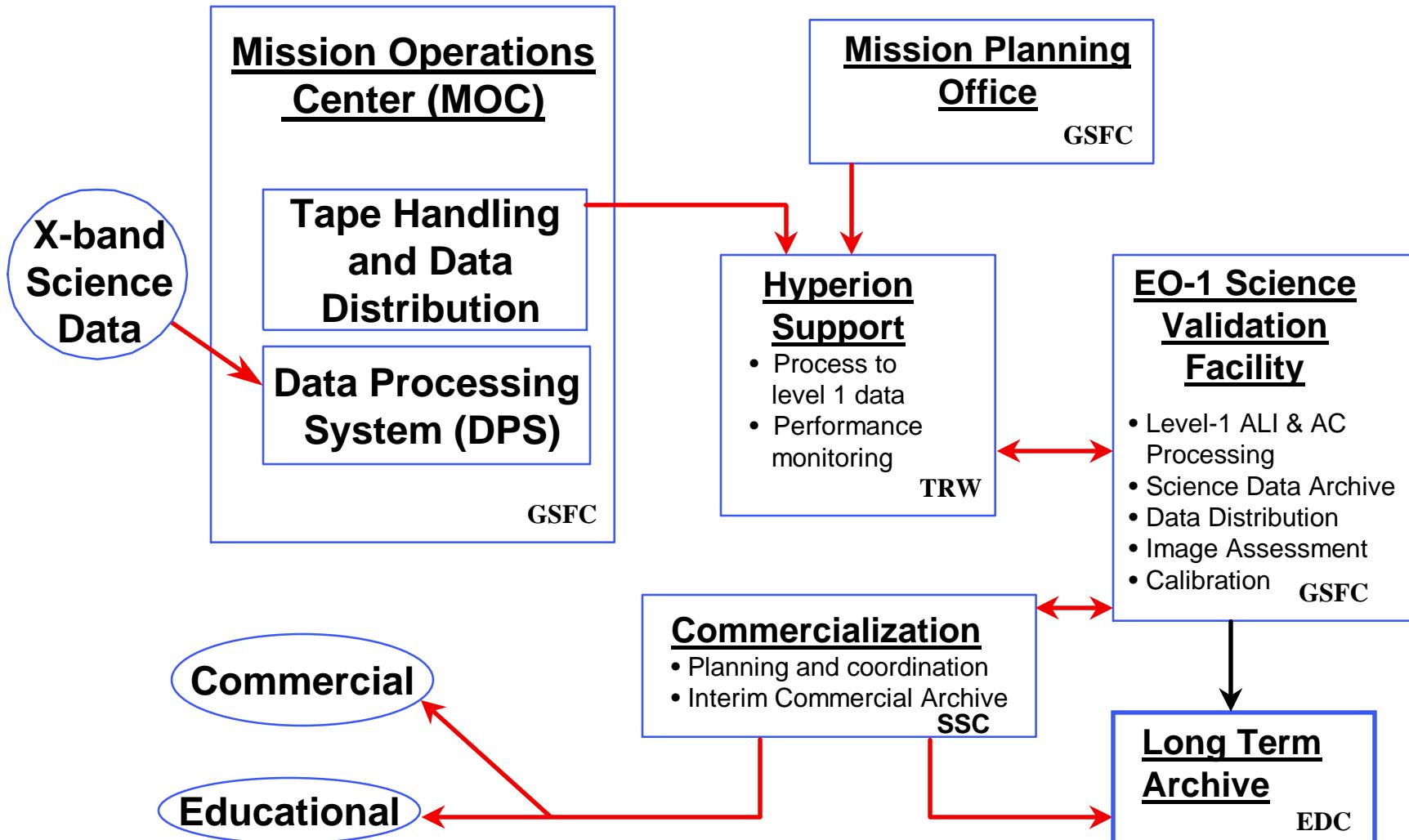
# SWIR Spectral Response

---

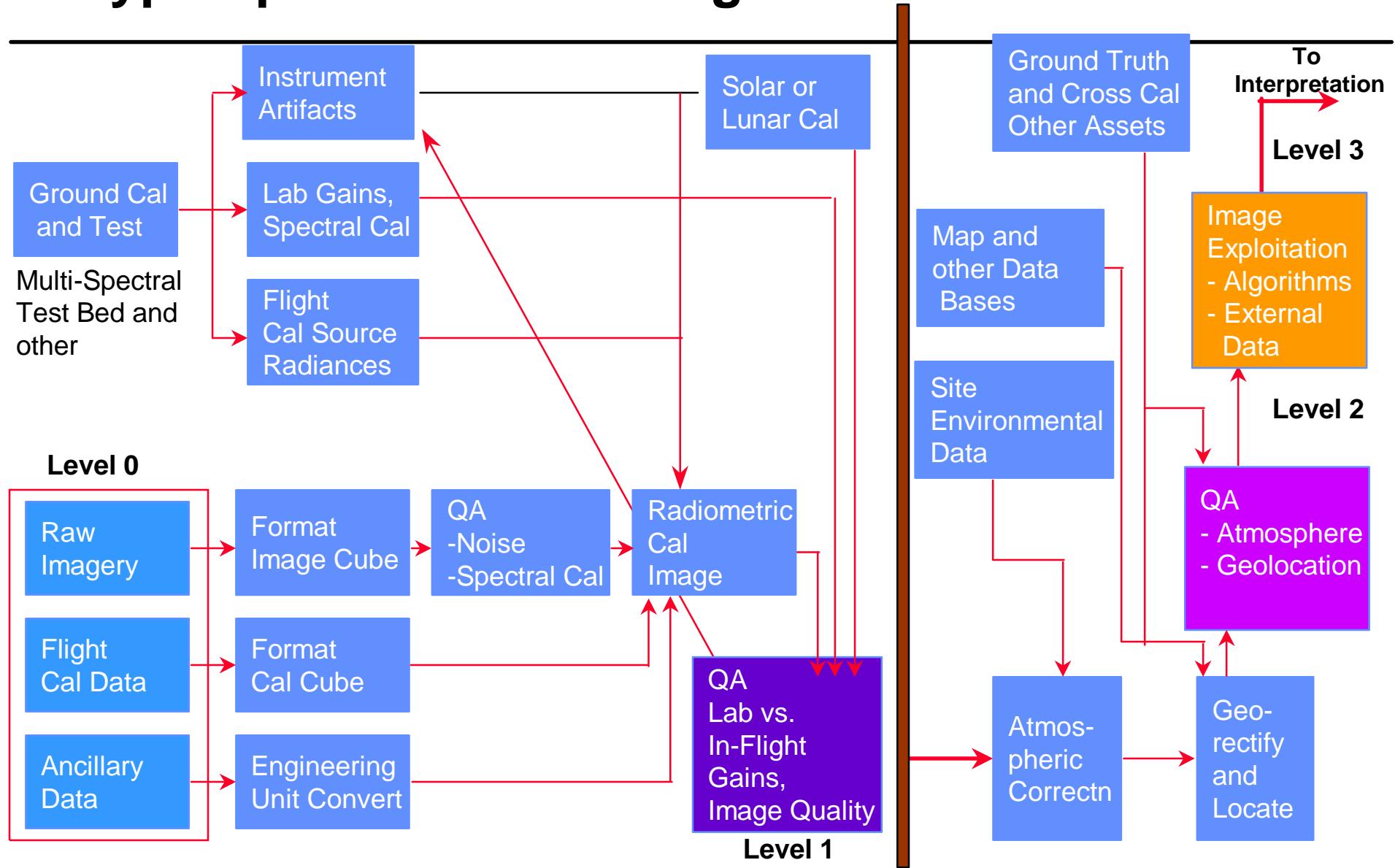
SWIR channel Center Wavelengths (nm +/- 0.5 nm)						
FOV # \ Special channel	27	57	87	126	156	
6	2314.08	2012.19	1711.16	1314.34	1013.3	
71	2314.18	2012.11	1711.42	1315.19	1013.21	
136	2313.97	2012.19	1711.55	1315.12	1013.23	
196	2313.9	2012.1	1711.62	1315.14	1013.19	
251	2313.66		1711.07	1314.22	1012.93	

SMR FWHM of Spectral Response Function (nm)						
FOV # \ Special channel	27	57	87	126	156	
6	10.44	10.64	11.55	10.55	10.69	
71	10.45	10.79	11.4	10.6	11.01	
136	10.42	10.93	11.84	10.83	11.18	
196	10.45	11.05	11.59	10.8	11.19	
251	10.19		11.33	10.6	11.02	

# *Hyperion Data Flow*



# Hyperspectral Processing Flow



# Early Orbit Checkout -- Objectives

---

## Instrument Activation and Checkout

- Activate to full functionality
- Monitor SOH telemetry
- Calibration check
- Spacecraft-related checkout
  - Geo-reference
  - Impact of jitter & pointing
- Comparison with pre-flight characterization

## Products

- On-orbit characterization
- Calibration sites/maintenance schedule recommendations

# Early Orbit Checkout -- Data Collections

---

## Solar Calibration

- 3X per week initially

## Lunar Calibration

- Near-full moon,  $\pm$  6 days

## Geo-referencing / Jitter Assessment Scenes

- San Francisco Bay, Panama Canal, Iowa farm roads

## Calibration / Characterization Scenes

- Ground truth
- Under flights
- Reference sites

# Early Orbit Checkout -- Characterization Sites

---

## Radiometric calibration

- Tinga Tingana , Australia
- Lake George , Australia
- Uardry , Australia
- Amburla , Australia
- White Sands
- Salton Sea
- Edwards AFB
- Blythe
- Stennis Space Center

## Ground sample distance

- Burdekin, Australia
- Panama Canal
- San Francisco Bay
- Artificial night site
- Iowa farm roads

## Spatial co-registration / MTF

- Moon
- Burdekin, Australia
- San Francisco Bay
- S. Chilean coast

## Straylight / Dynamic range

- Moon
- Clouds over ocean (Lanai)
- Mauna Kea

## Cross track spectral error

- Solar calibration
- Mt. Fitton, Australia

## Spectral sites

- Mt. Fitton, Australia
- Las Vegas
- Artificial night site

# EO-1 Mission Highlights

ORBIT

**705 Km altitude Sun-synchronous,  
circular orbit inclined at 98.2°**

**Descending node - equatorial crossing  
about one minute behind Landsat 7**

LAUNCH  
VEHICLE

**Launch Vehicle: Delta 7320**  
**Launch Date: Winter 2000**  
**Co-manifested with SAC-C**

# EO-1 Orbit

