Development and Operations of the EO-1 Hyperion Imaging Spectrometer

SPIE San Diego 2000

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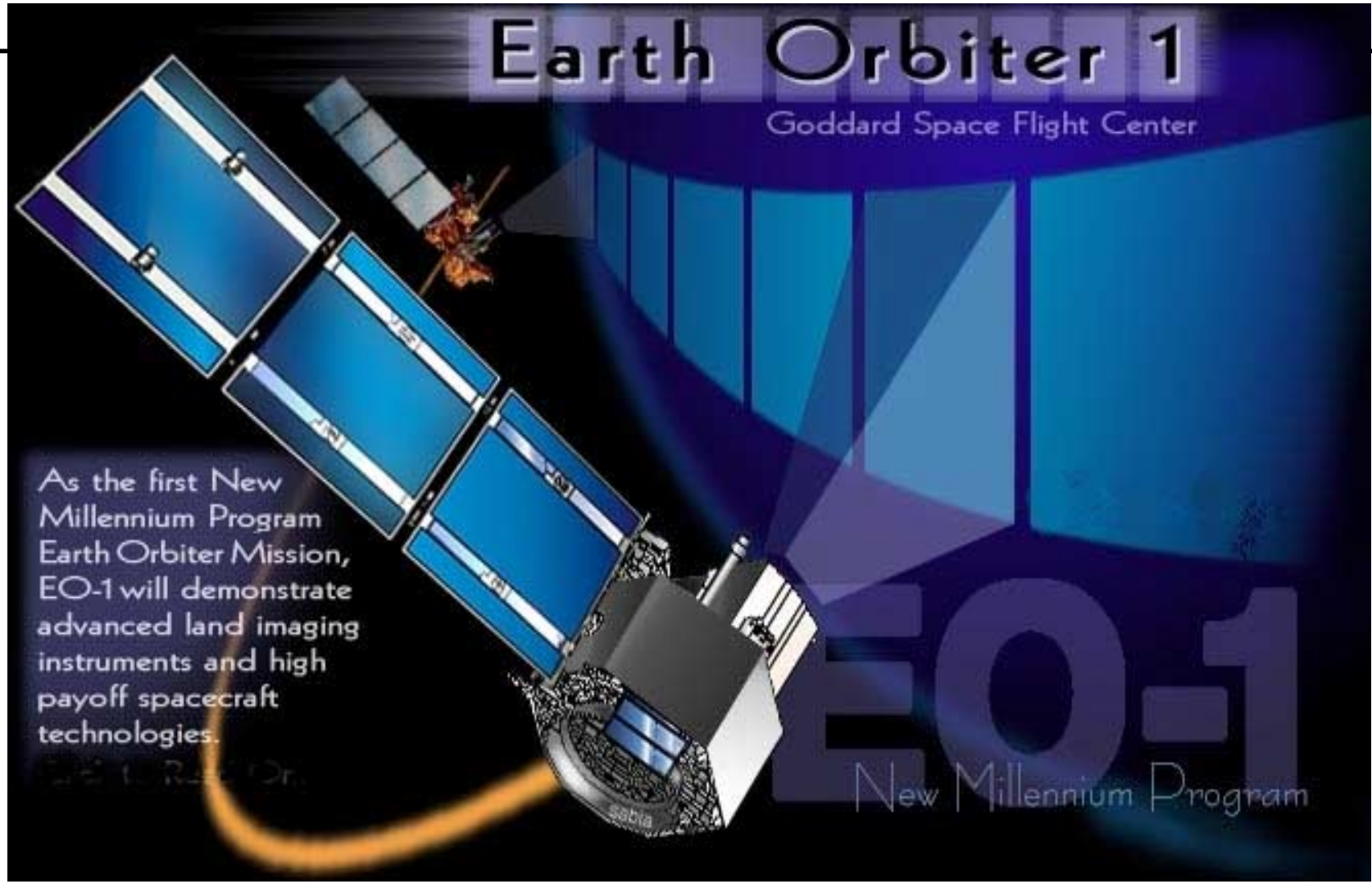

Earth Orbiter 1
Goddard Space Flight Center
As the first New Millennium Program Earth Orbiter Mission, EO-1 will demonstrate advanced land imaging instruments and high payoff spacecraft technologies.
EO-1
New Millennium Program

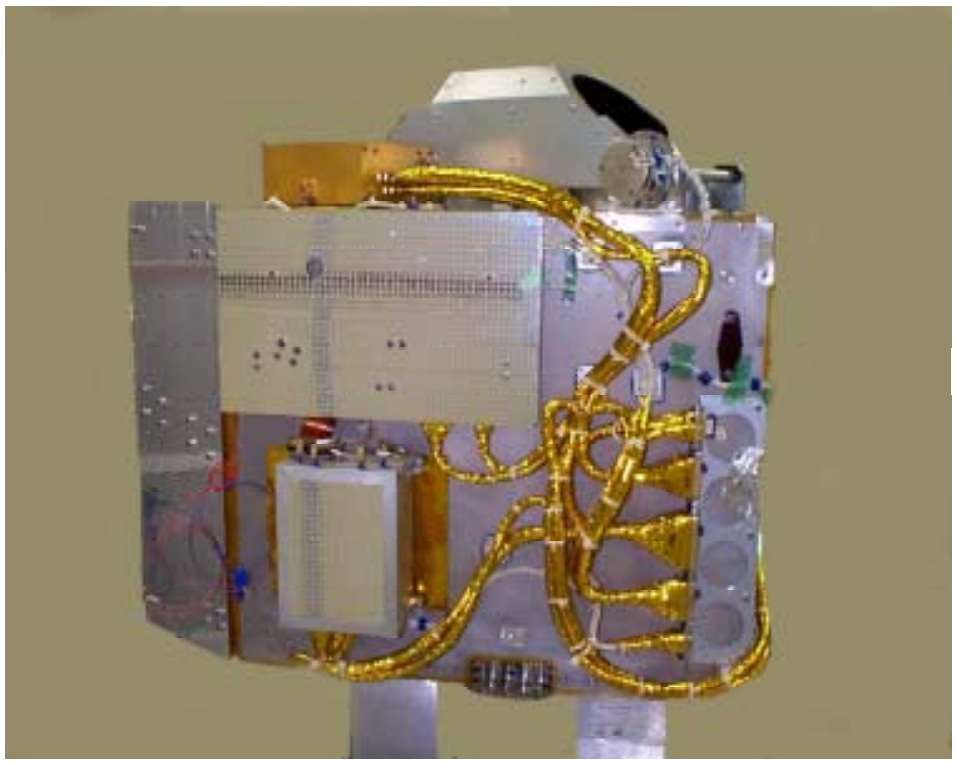
Hyperion Hyperspectral Imager

Earth Orbiter - 1 Mission

Three revolutionary land imaging instruments on EO-1 will collect multispectral 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

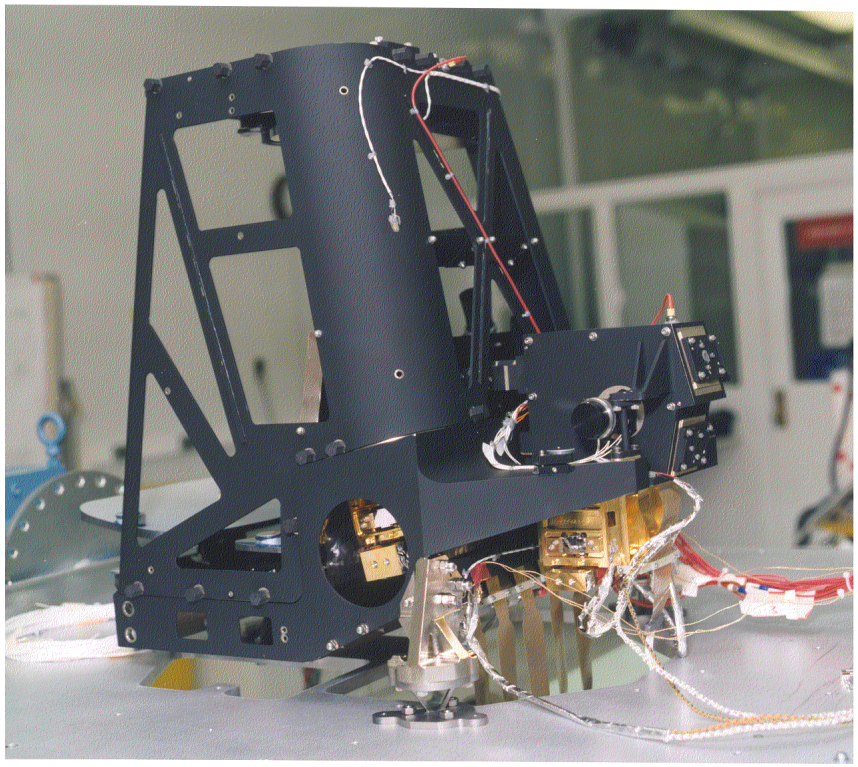
Multiple calibration options: lamps, lunar, solar, ground imaging and laboratory

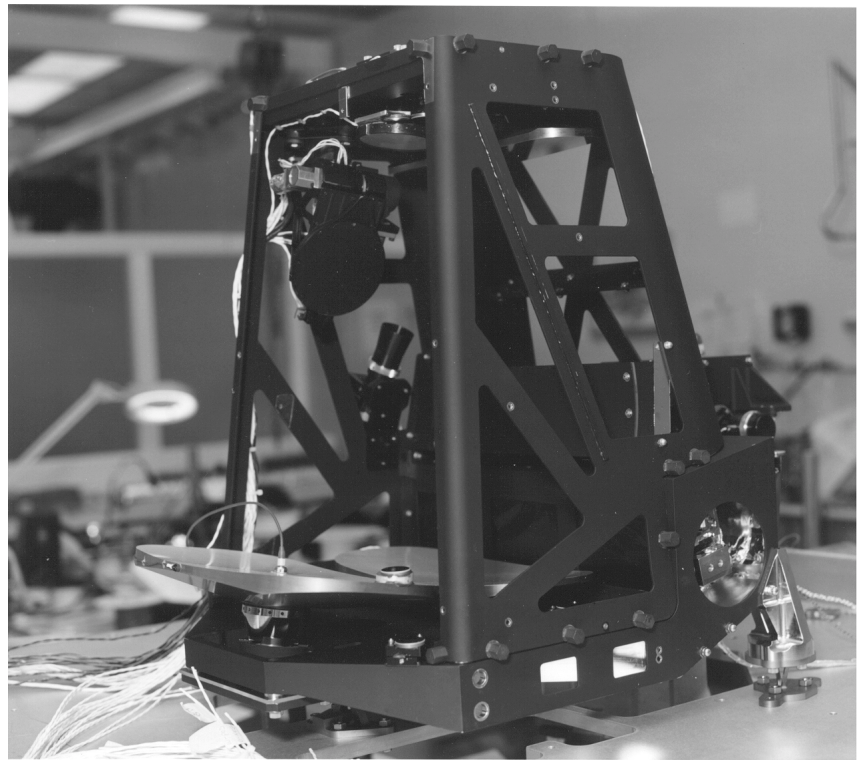
Hyperspectral Imaging Capability to address technology and Earth Observation applications

Advanced Land Imager (ALI)

- **Objective is to validate pushbroom technologies for Landsat applications**
- **Pushbroom Multispectral Sensor - 9 multispectral (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





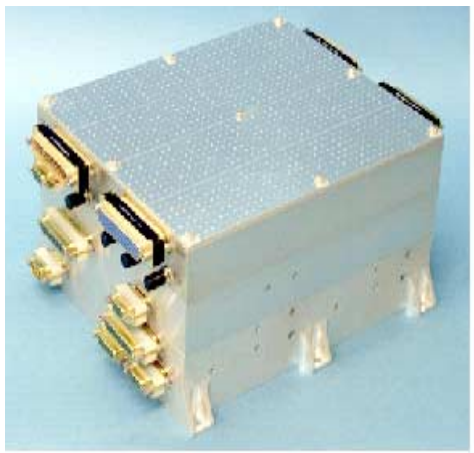
LEISA Atmospheric Corrector

- **Correction of multispectral 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

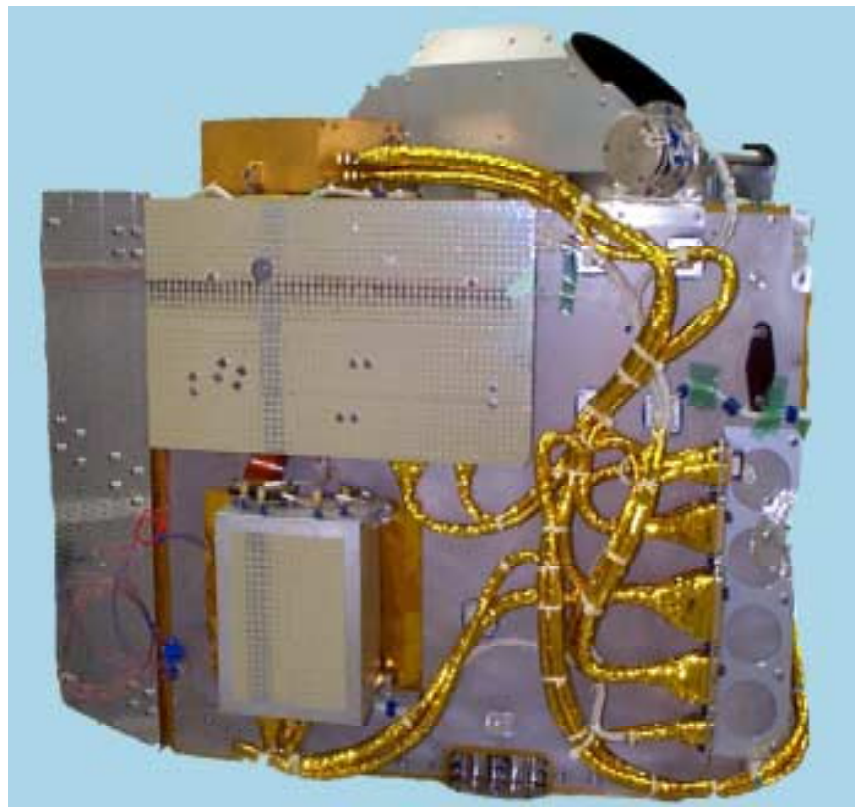
Parameters	ALI	HYPERION	AC
Spectral Range	0.4 - 2.4 μm	0.4 - 2.5 μm	0.9 - 1.6 μm
Spatial Resolution	30 m	30 m	250 m
Swath Width	36 Km	7.5 Km	185 Km
Spectral Resolution	Variable	10 nm	6 nm
Spectral Coverage	Discrete	Continuous	Continuous
Pan Band Resolution	10 m	N/A	N/A
Total Number of Bands	10	220	256

Hyperion Subsystems



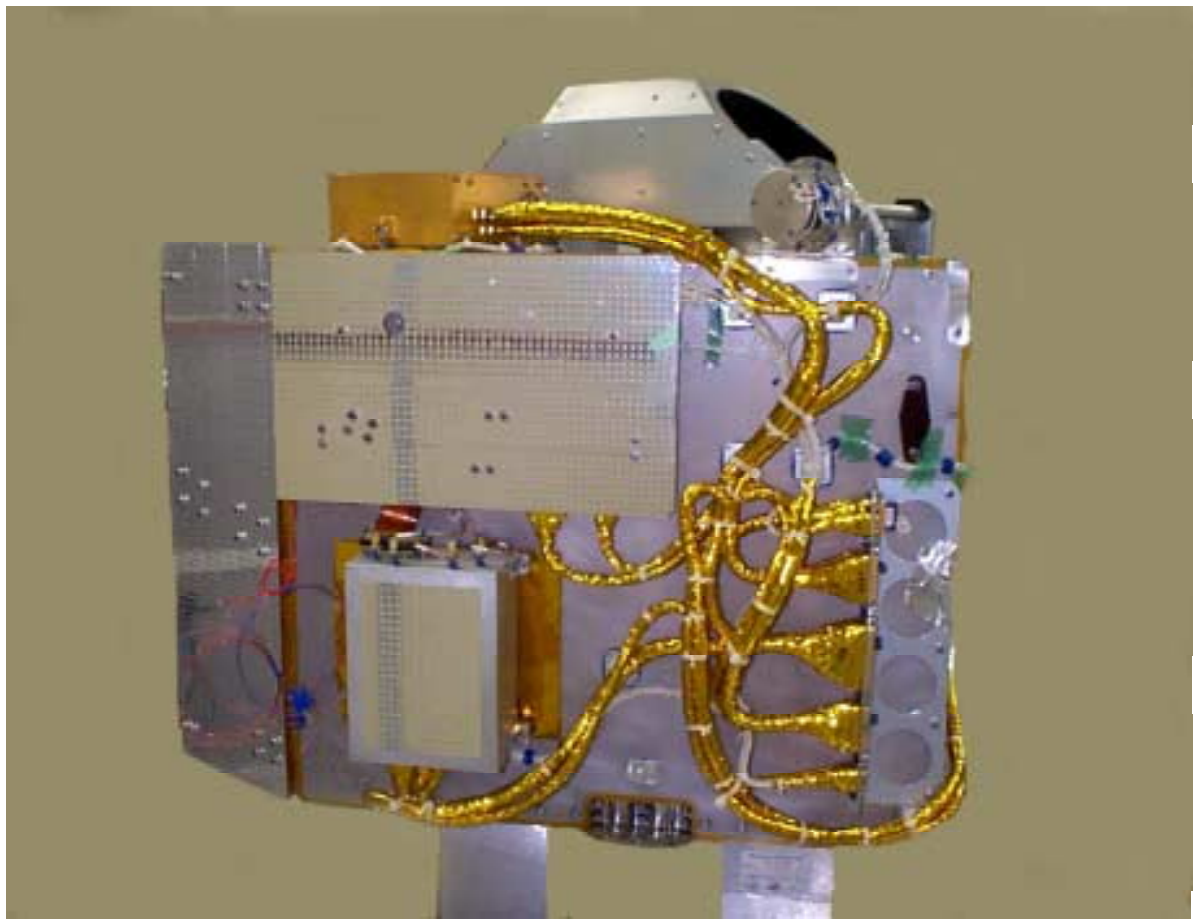
Hyperion Electronics Assembly

Cryocooler Electronics Assembly



Hyperion Sensor Assembly(HSA)

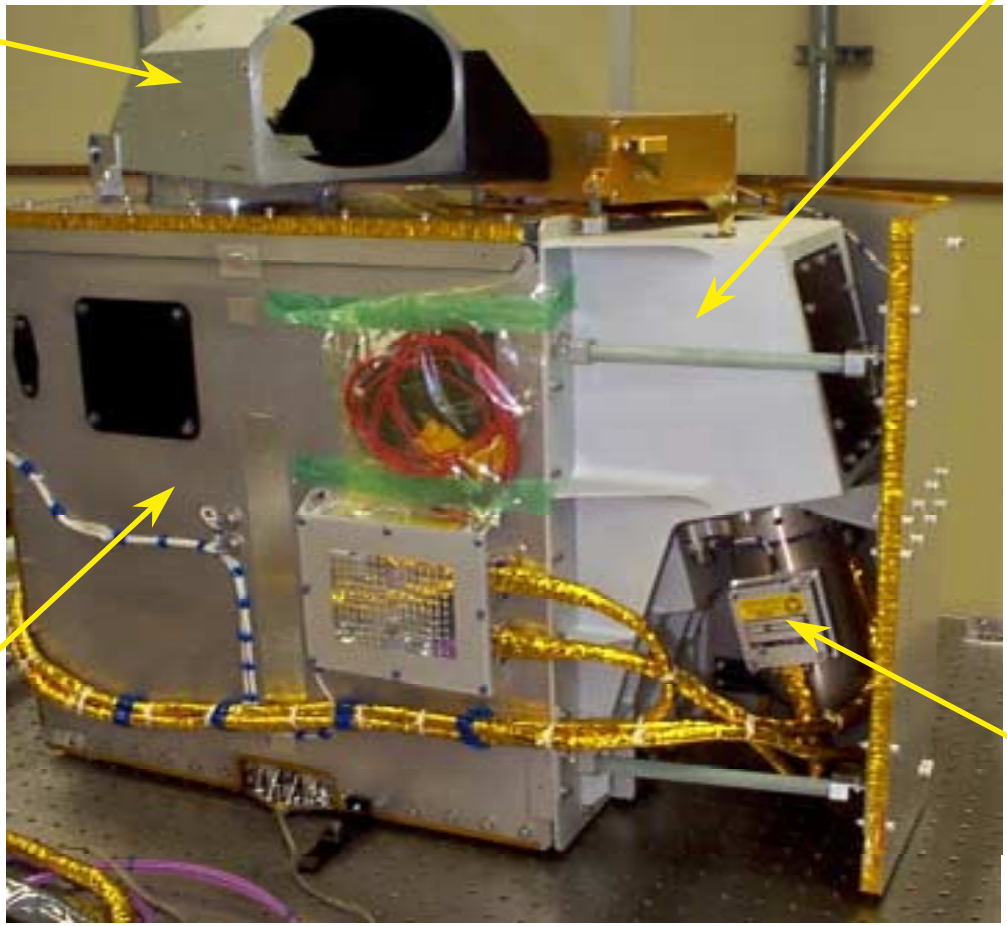
Hyperion Sensor Assembly (HSA)



HYPERION HSA Subsystems

SOLAR BAFFLE

SPECTROMETER

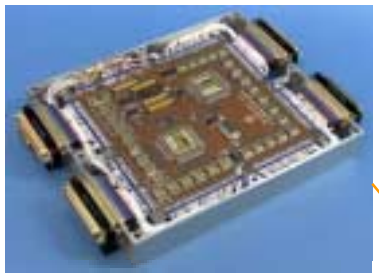


TELESCOPE

CRYOCOOLER

Hyperion Electronics Assembly

Formatter Board



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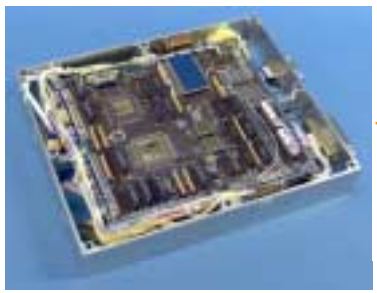
Processor Board



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Telemetry Board

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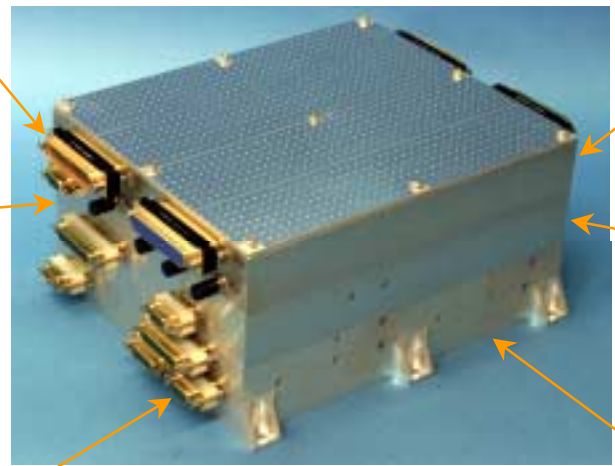
HEA



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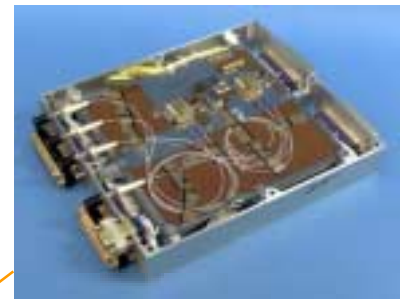
1773 Transceiver Board



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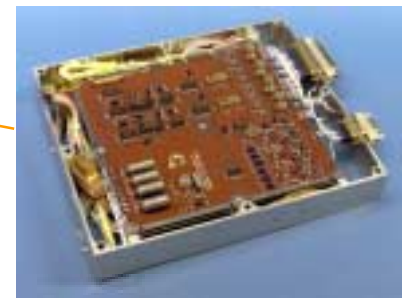
Motor/Heater Drive Board



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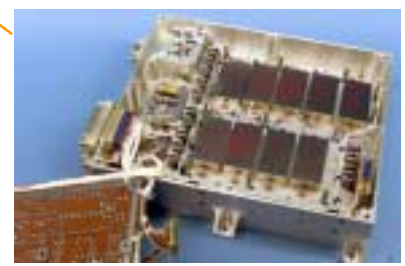
DC/DC Converter Assembly Bd



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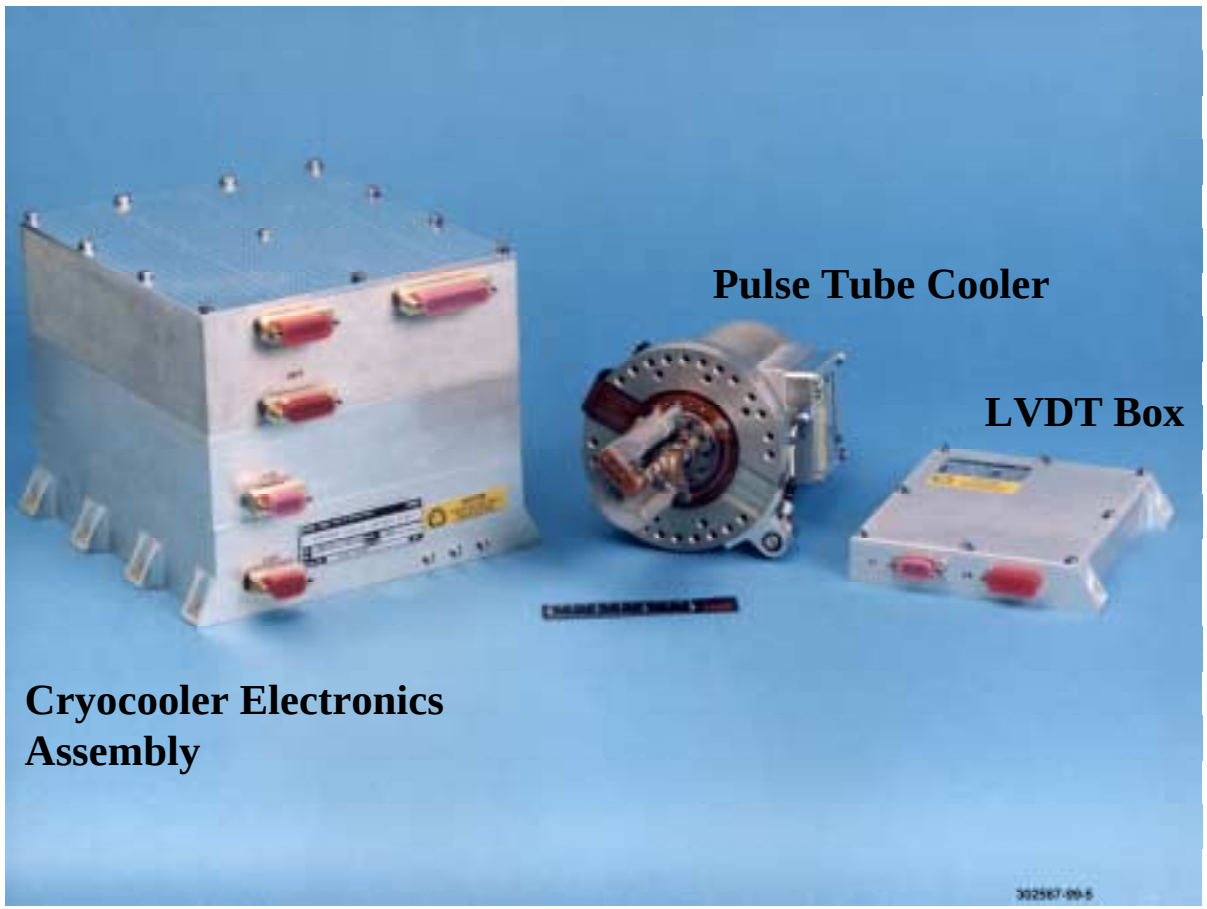
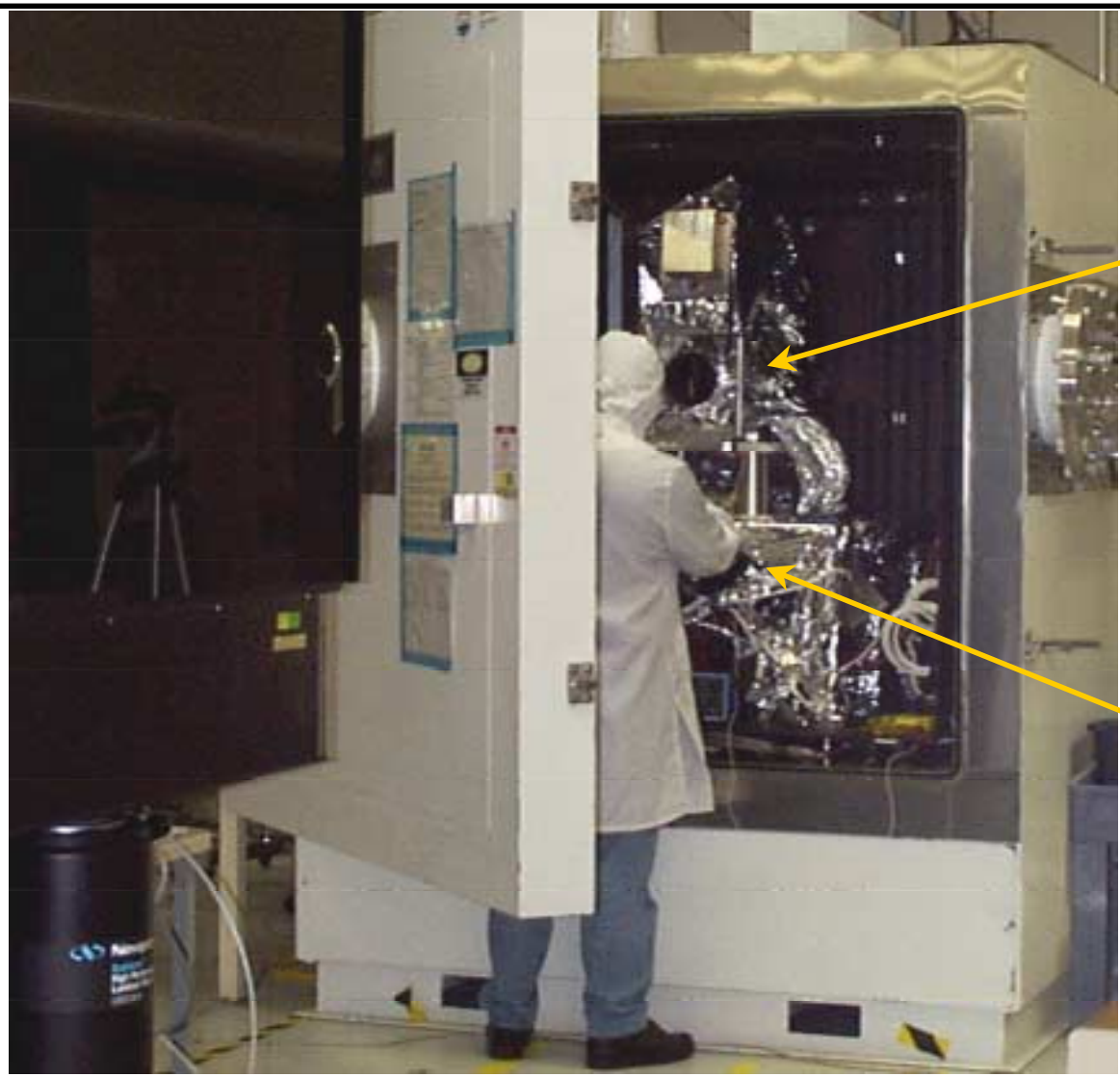
Hyperion Cryocooler Subsystem



Hyperion in Vacuum Chamber



MSTB Provides Absolute Radiometric and Spectral Calibration

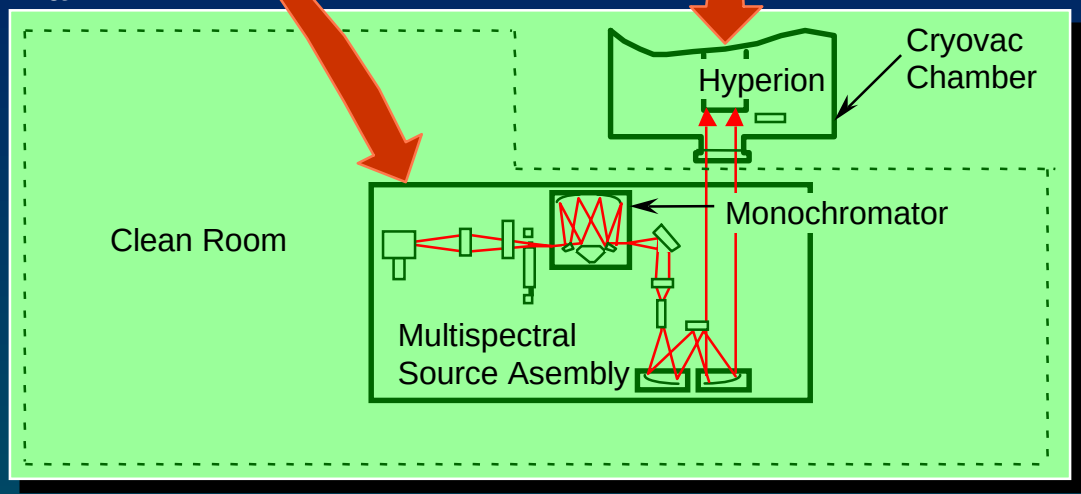
Multispectral Source Assembly

275072-95-2

Hyperion Integration and Test

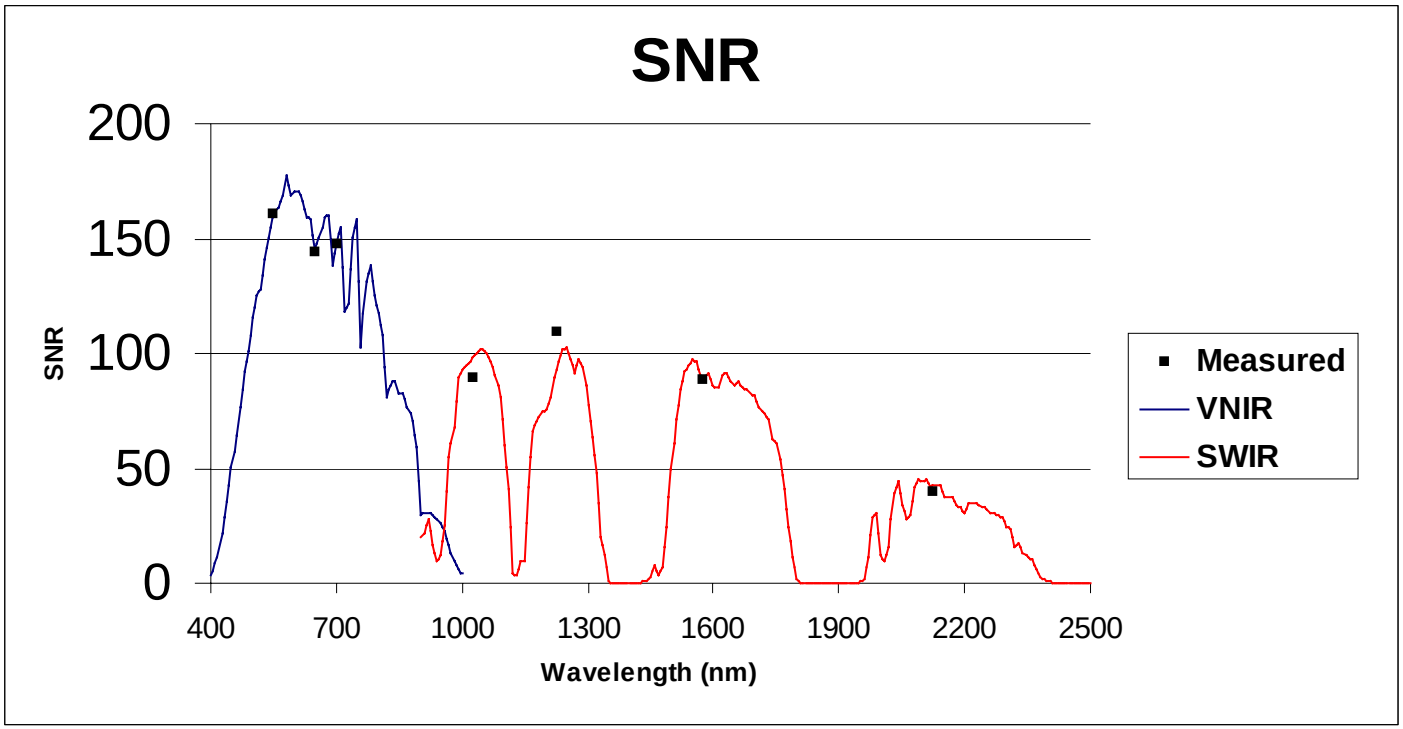
278039-96

Plan



System SNR

Radiometric performance model base on 60^{o} 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

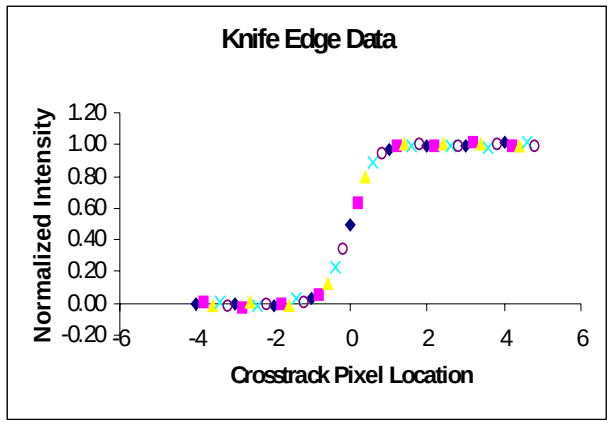
Image Quality Assessment (MTF)

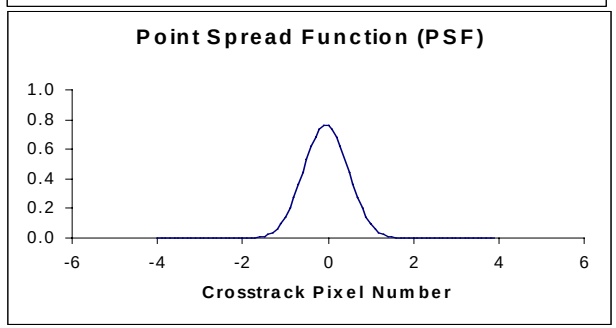
Cross-Track MTF Measured using the knife-edge and slit techniques

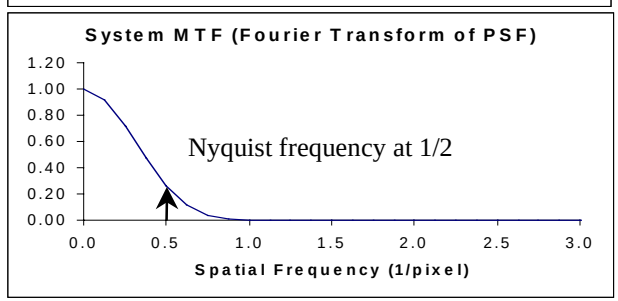
- **Knife-edge perpendicular to the entrance slit of Hyperion**
- **Oversampling by tilting steering mirror in fractional-pixel steps**
- **Derivative of Knife-Edge Data is the PSF**
- **MTF is the fourier transform of PSF.**

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

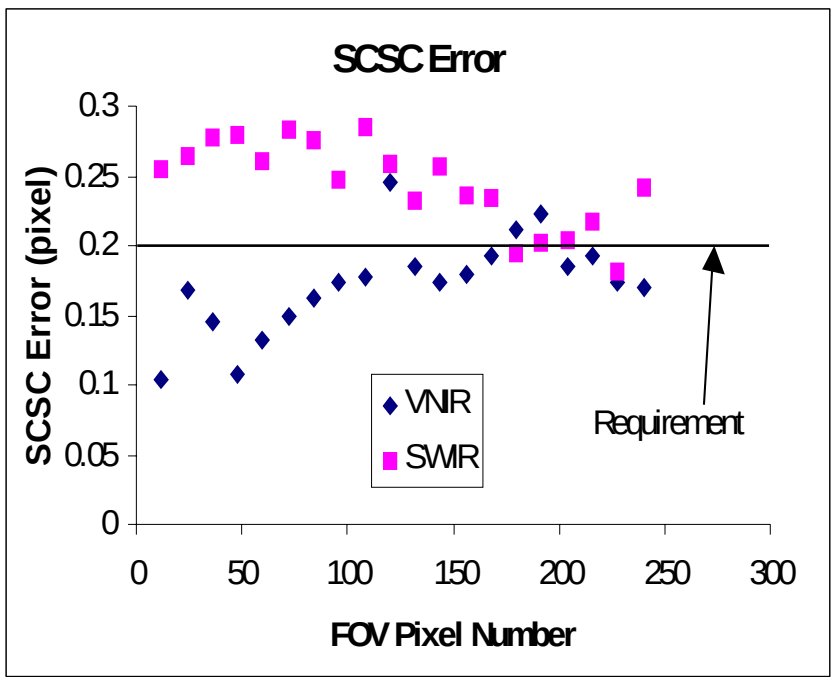






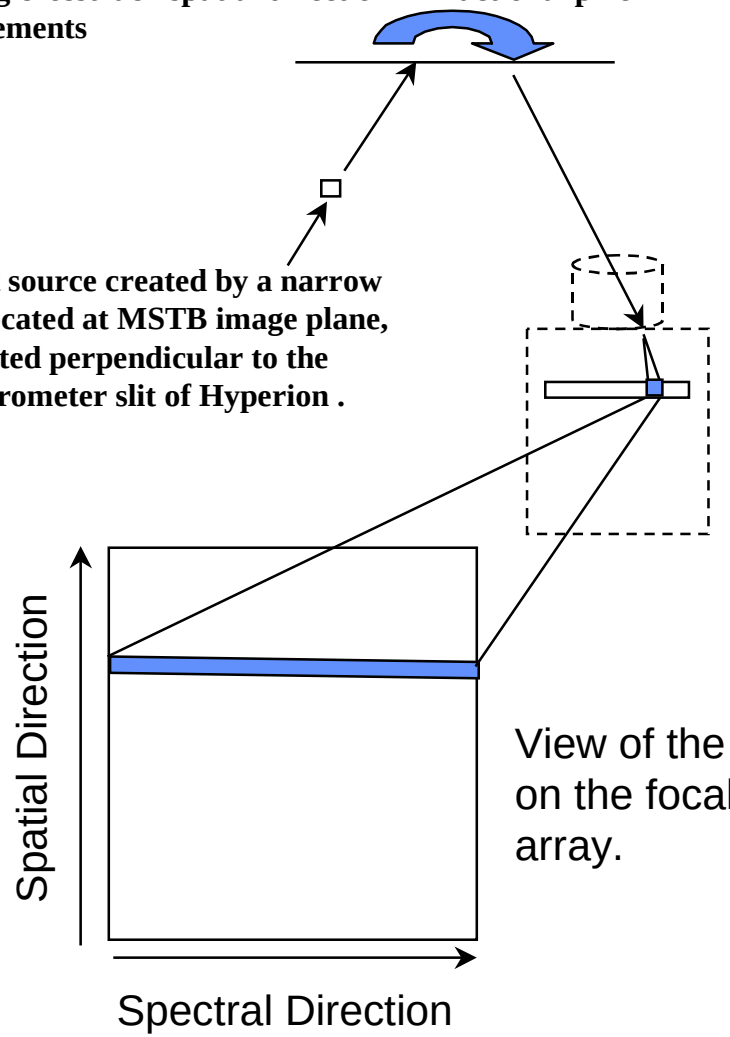
Spatial Co-Registration of Spectral Channels

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 crosstrack spatial direction in fractional pixel increments

Point source created by a narrow slit located at MSTB image plane, oriented perpendicular to the spectrometer slit of Hyperion .



View of the image on the focal plane array.

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

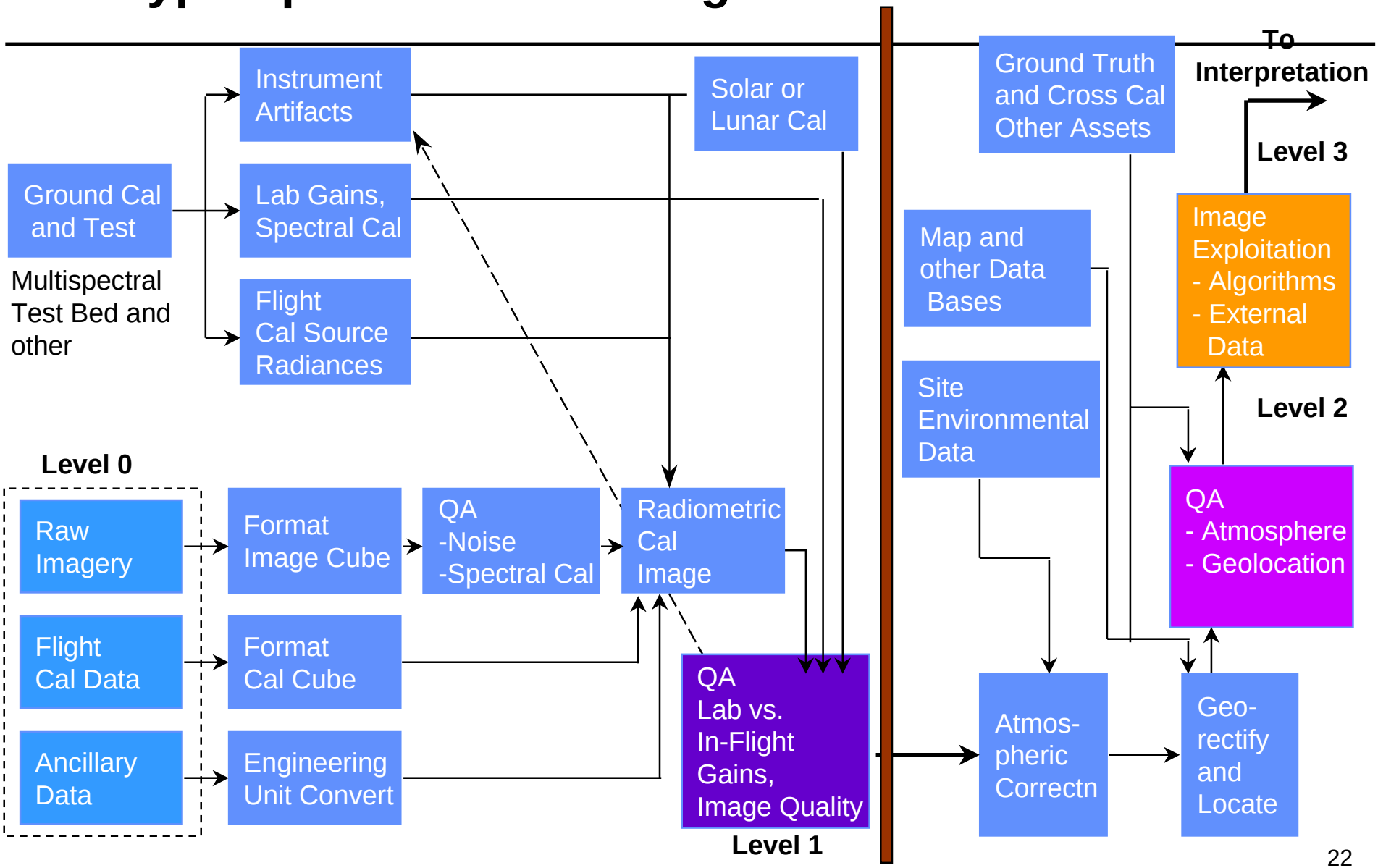
VNIR FWHM of Spectral Response Functions (nm)					
Spectral channel / FOV #	13	31	40	48	57
6	11.23	10.51	10.6	11.12	11.11
71	11.6	10.38	10.85	11.34	11.34
136	11.34	10.26	10.68	11.26	11.31
196	11.38	10.21	10.69	11.35	11.3
251	11.25	10.16	10.62	11.28	11.23

SWIR Spectral Response

SWIR channel Center Wavelengths (nm +/- 0.5 nm)					
Specral channel / FOV #	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

SWIR FWHM of Spectral Response Function (nm)					
Special channel / FOV #	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

Hyperspectral Processing Flow



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

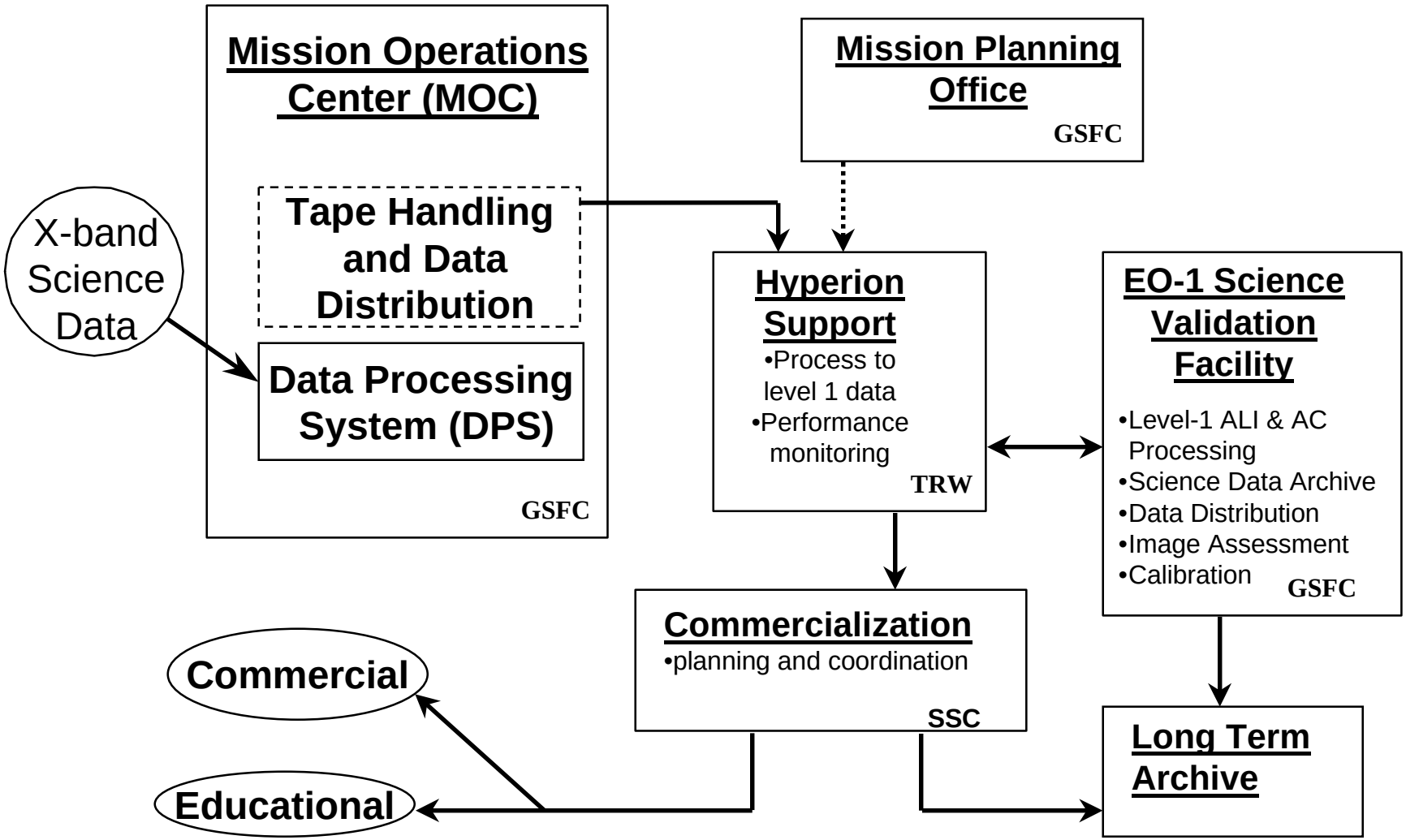
LAUNCH VEHICLE

Launch Vehicle: Delta 7320

Launch Date: Fall, 2000

Co-manifested with SAC-C

Hyperion Data Flow



EO-1 Schedule

Science Validation Team Selection: October, 1999

CHECKOUT

Launch: Fall, 00

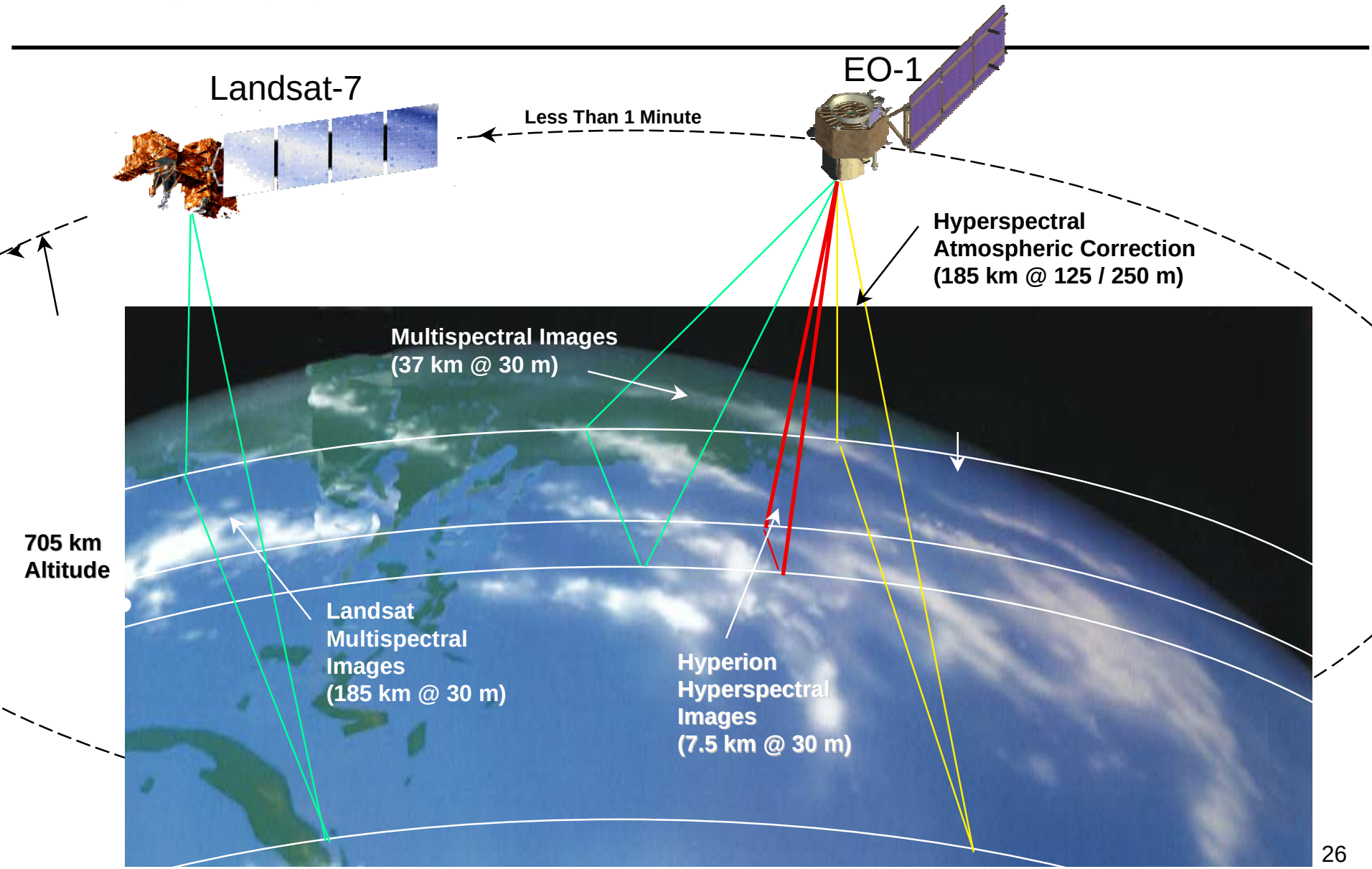
System Checkout: 60 days following launch

OPERATIONS

Science and Technology Validation: from end of checkout to 1 year after launch

Mission Life: 1 year

EO-1 Orbit


Landsat-7
EO-1
Less Than 1 Minute
Hyperspectral
Atmospheric Correction
(185 km @ 125 / 250 m)
Multispectral Images
(37 km @ 30 m)
705 km
Altitude
Landsat
Multispectral
Images
(185 km @ 30 m)
Hyperion
Hyperspectral
Images
(7.5 km @ 30 m)