Section 2

Hyperion, ALI, and the EO-1 Mission

. . . Stephen G. Ungar
NASA GSFC, Code 923

Darla M. Duval
USGS/Raytheon ITSS/EROS DataCenter

EO-1 Mission Facts

ORBIT

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

Descending node with an equatorial crossing about one minute behind Landsat 7

LAUNCH

Launch Date: Nov. 21, 2000

Launch Vehicle: Delta 7320

Co-manifested with SAC-C

ADVANCED LAND IMAGER (ALI)
Multispectral Pushbroom Imager

HYPERION
Hyperspectral Imaging Spectrometer

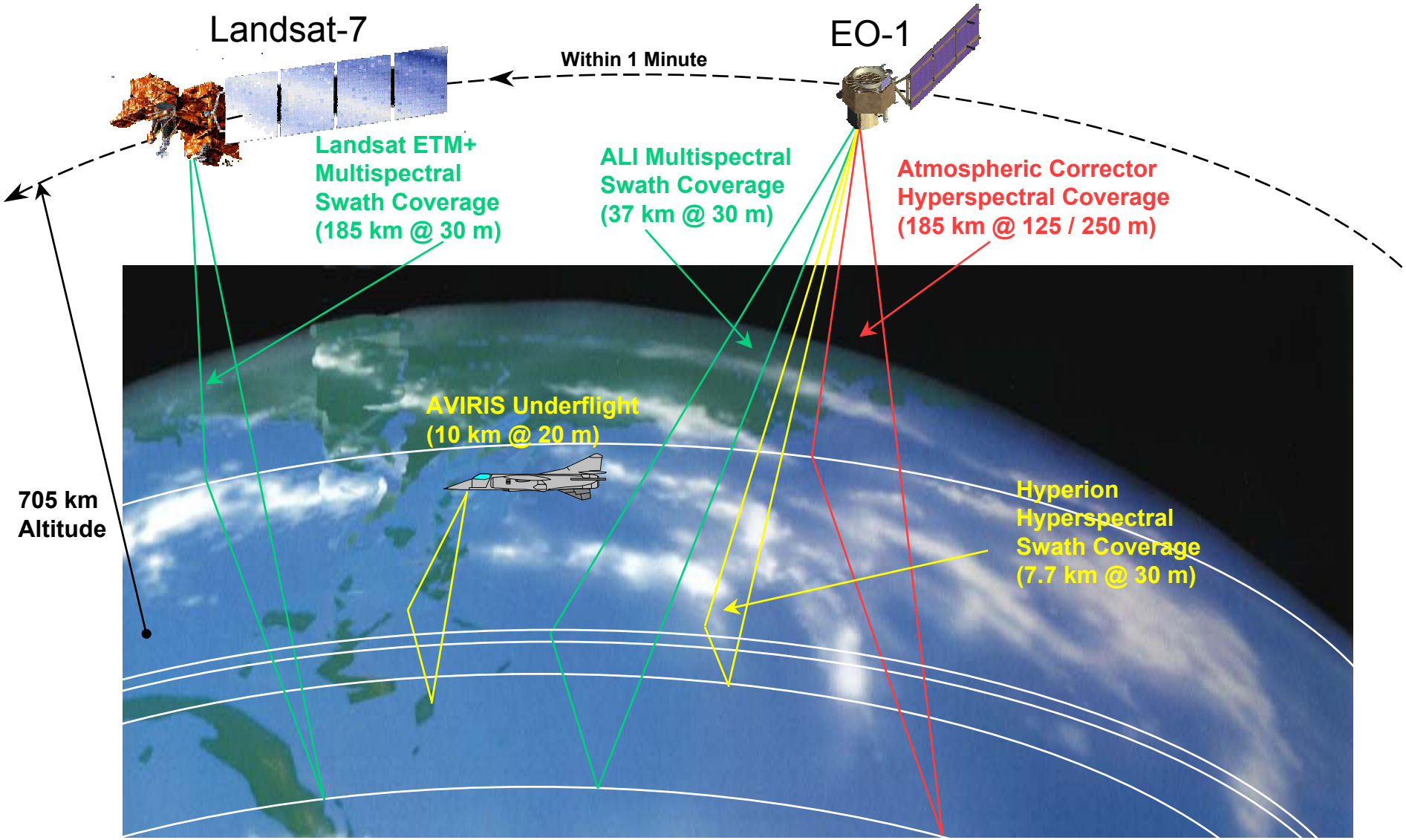
ATMOSPHERIC CORRECTOR (AC)
Wedge Imaging Spectrometer

→ **Wide-band Advanced Recorder / Processor**

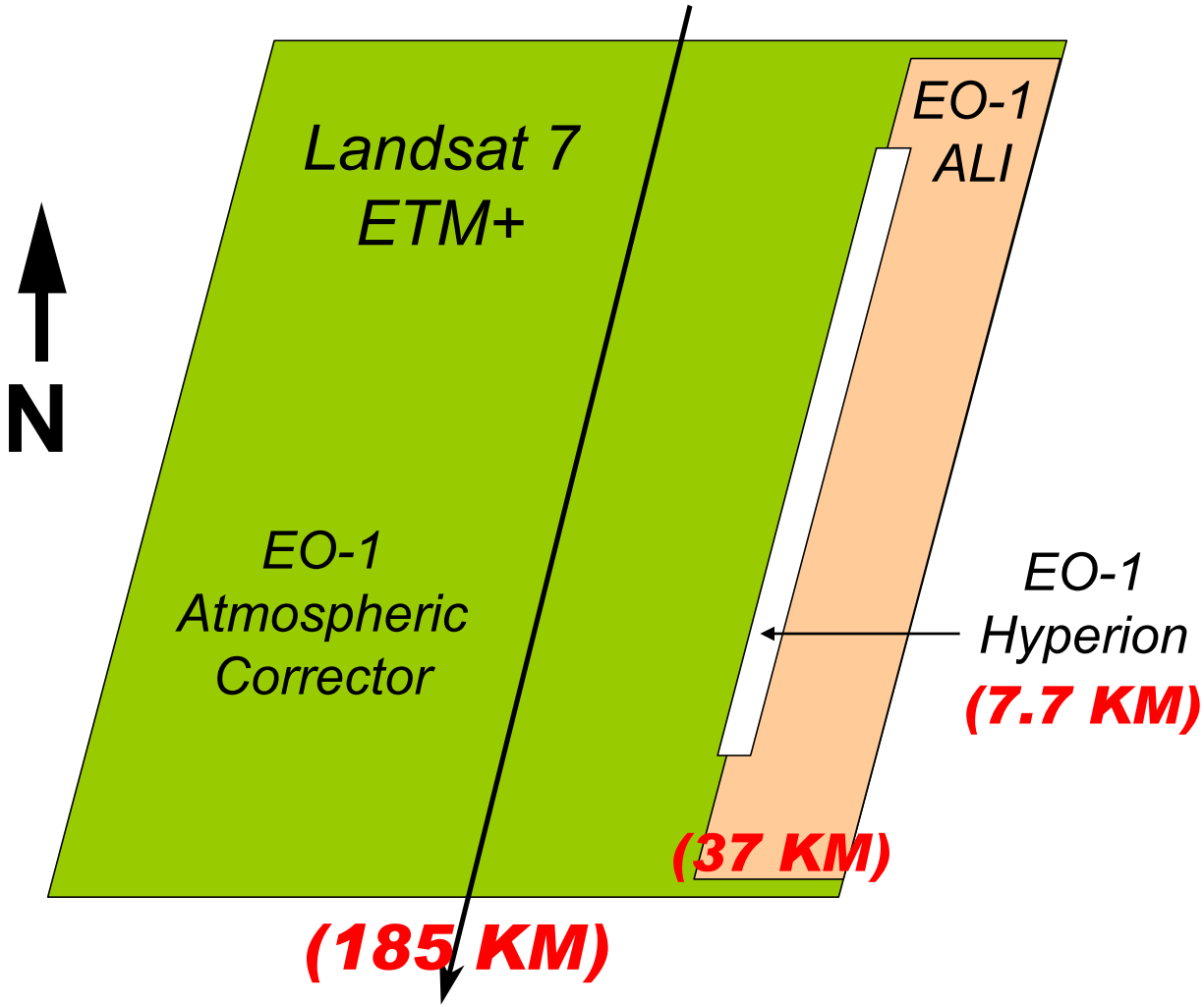
→ X-Band Phased Array Antenna

→ C&DH S-Band Antenna

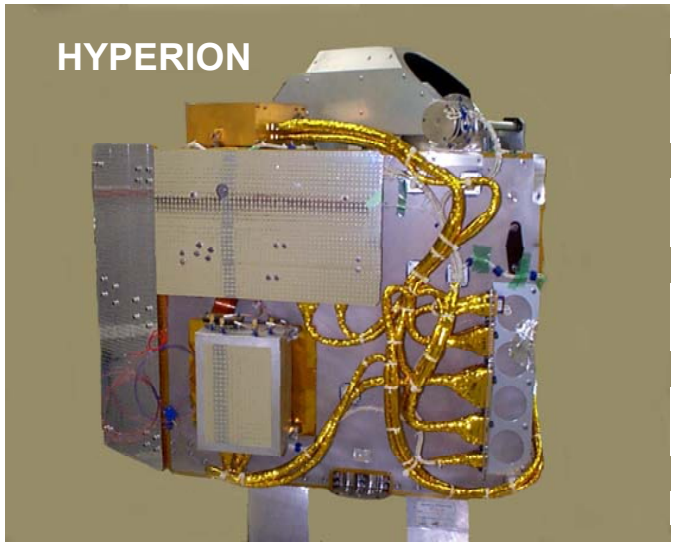
EO-1 & Landsat

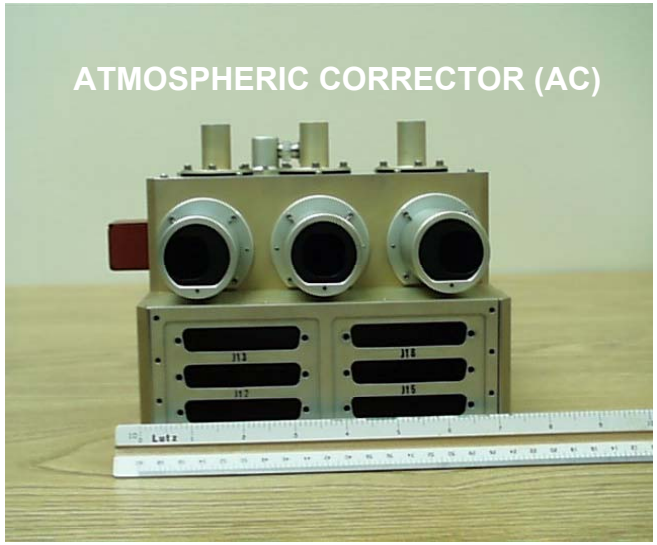

Landsat-7
EO-1
Within 1 Minute
Landsat ETM+
Multispectral
Swath Coverage
(185 km @ 30 m)
ALI Multispectral
Swath Coverage
(37 km @ 30 m)
Atmospheric Corrector
Hyperspectral Coverage
(185 km @ 125 / 250 m)
AVIRIS Underflight
(10 km @ 20 m)
705 km
Altitude
Hyperion
Hyperspectral
Swath Coverage
(7.7 km @ 30 m)

EO-1 & Landsat 7 Descending Orbit Ground Tracks



EO-1 Flight Instruments



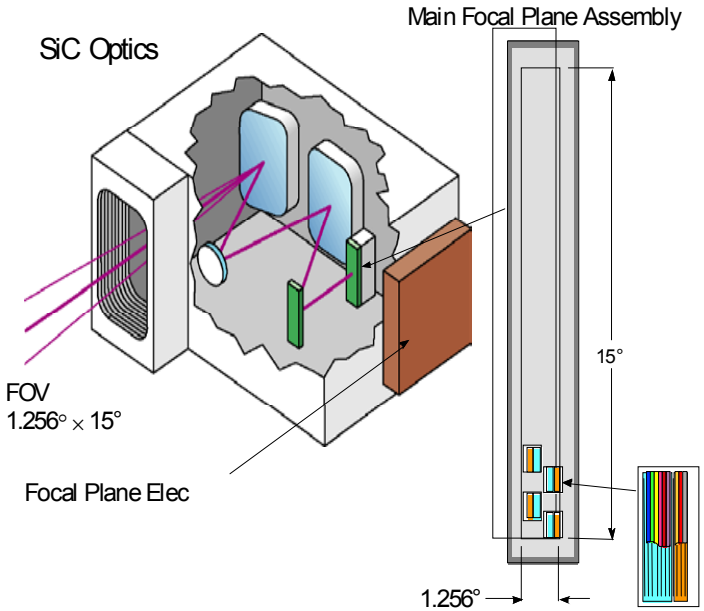


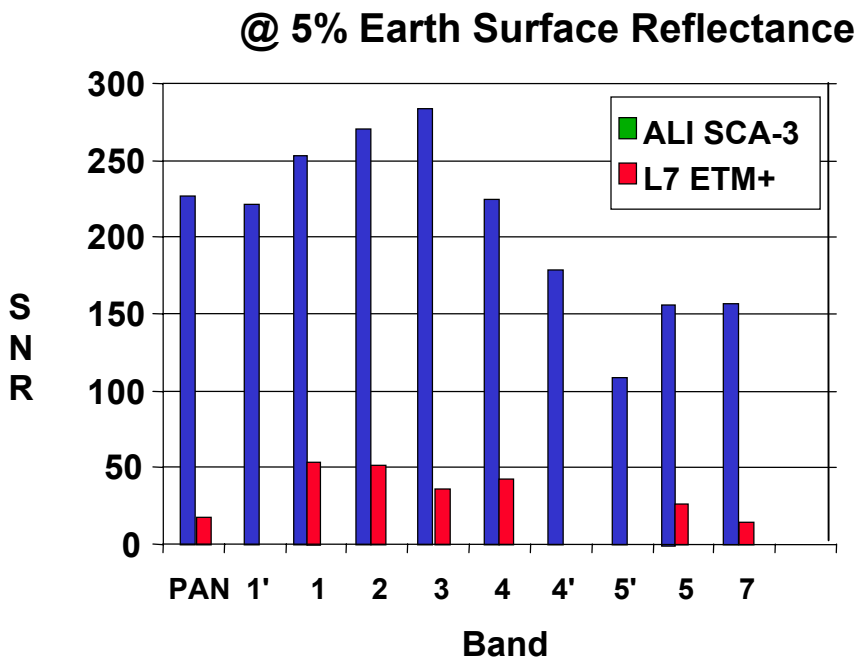
EO-1 Instrument Overviews

Parameters	Landsat 7	EO-1	EO-1	
	ETM+	ALI Multispectral	HYPERION	AC
Spectral Range	0.4 - 2.4 µm *	0.4 - 2.4 µm	0.4 - 2.5 µm	0.9 - 1.6 µm
Spatial Resolution	30 m	30 m	30 m	250 m
Swath Width	185 Km	37 Km	7.5 Km	185 Km
Spectral Resolution	Variable	Variable	10 nm	3 - 9 nm **
Spectral Coverage	Discrete	Discrete	Continuous	Continuous
Pan Band Resolution	15 m	10 m	N/A	N/A
Total Number of Bands	7	10	220	256

** Excludes thermal channel*
*** 35/55 cm^{-1} constant resolution*

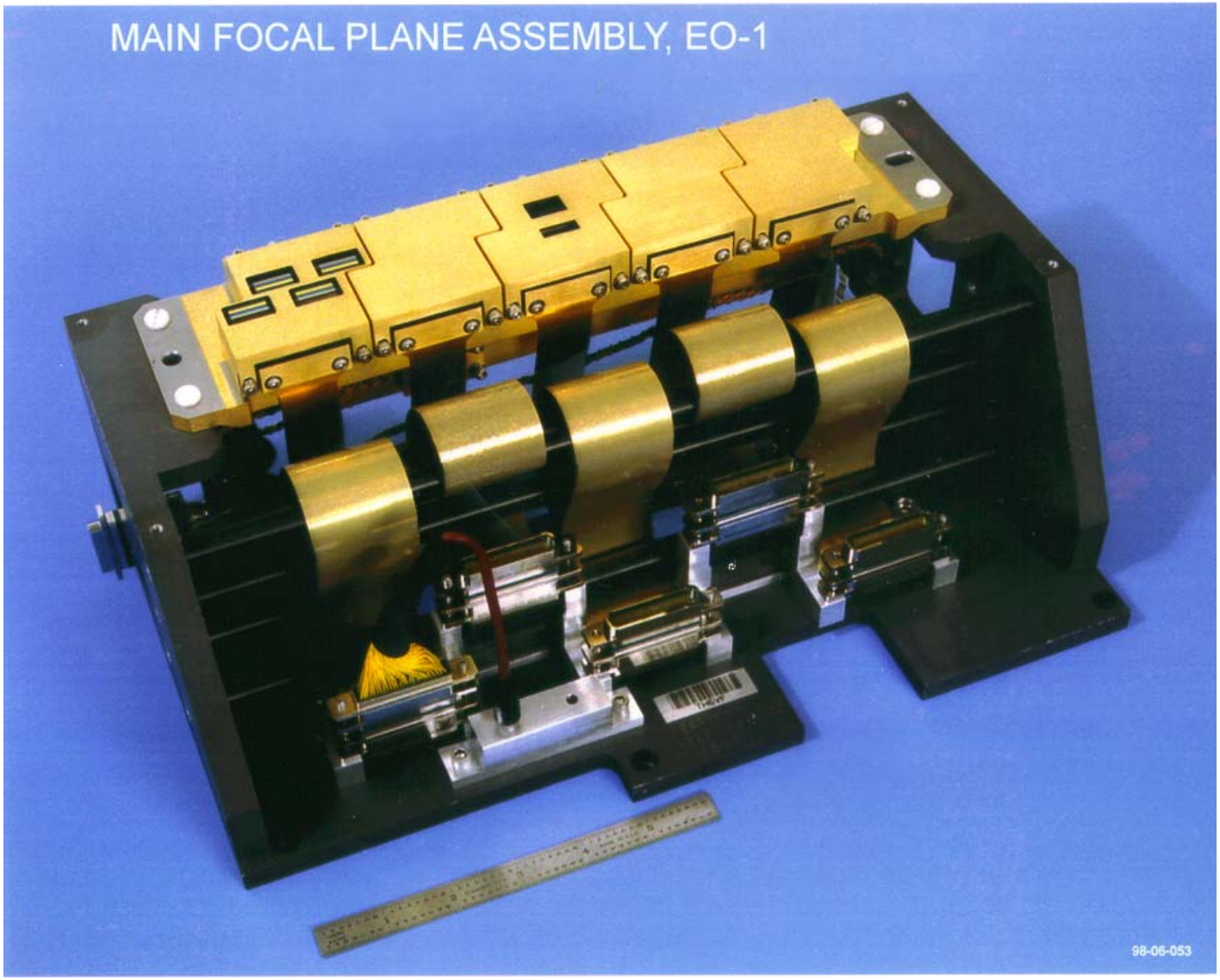
ALI Description



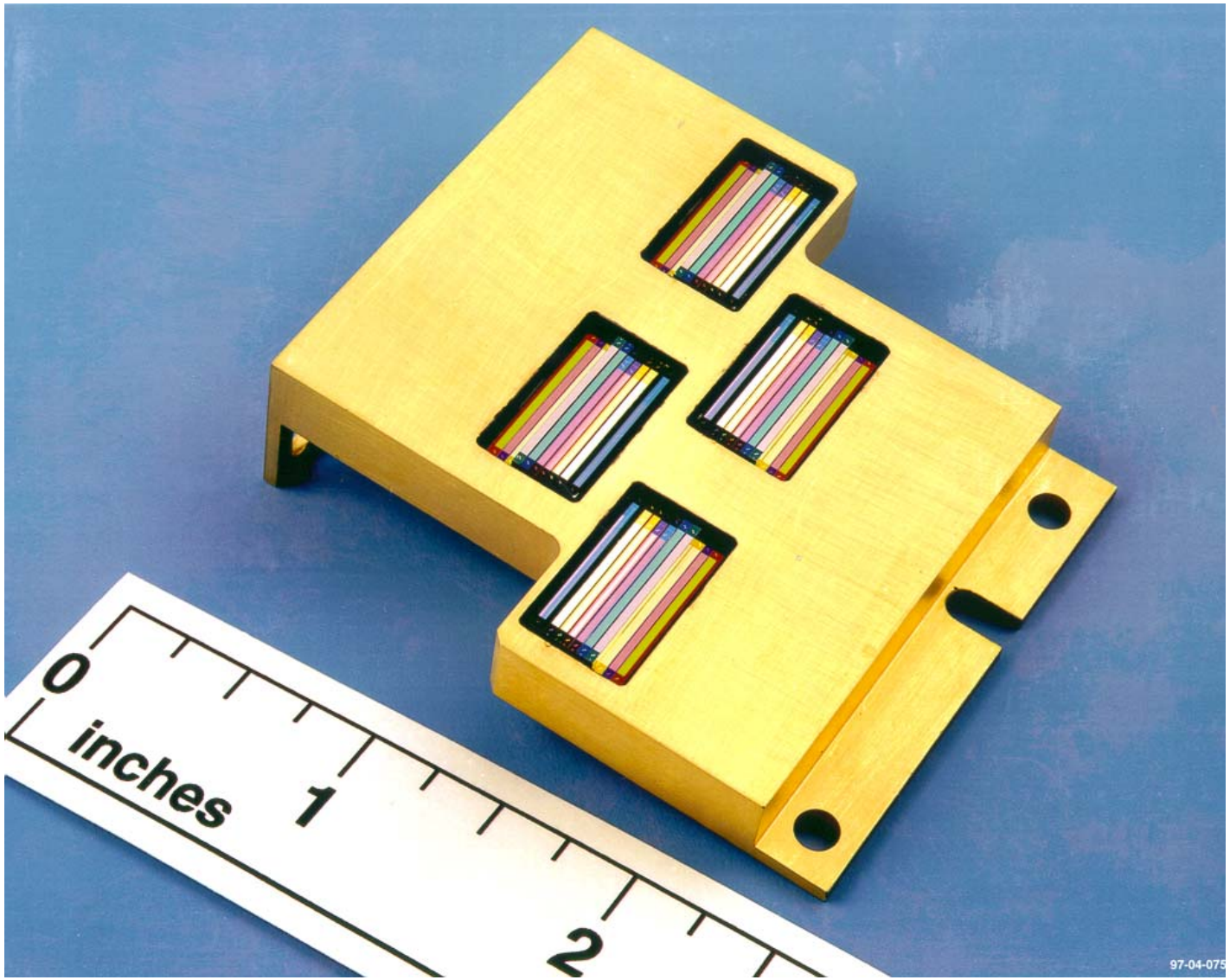


Band	Wavelength (nm)	Band	Wavelength (nm)
Pan	480-690	MS-4	775-805
MS-1’	433-453	MS-4’	845-890
MS-1	450-515	MS-5’	1200-1300
MS-2	525-605	MS-5	1550-1750
MS-3	630-690	MS-7	2080-2350

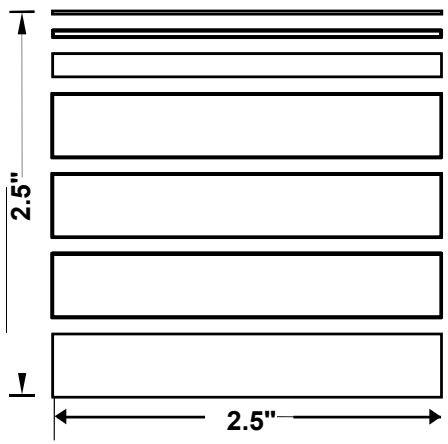
ALI Focal Plane Assembly



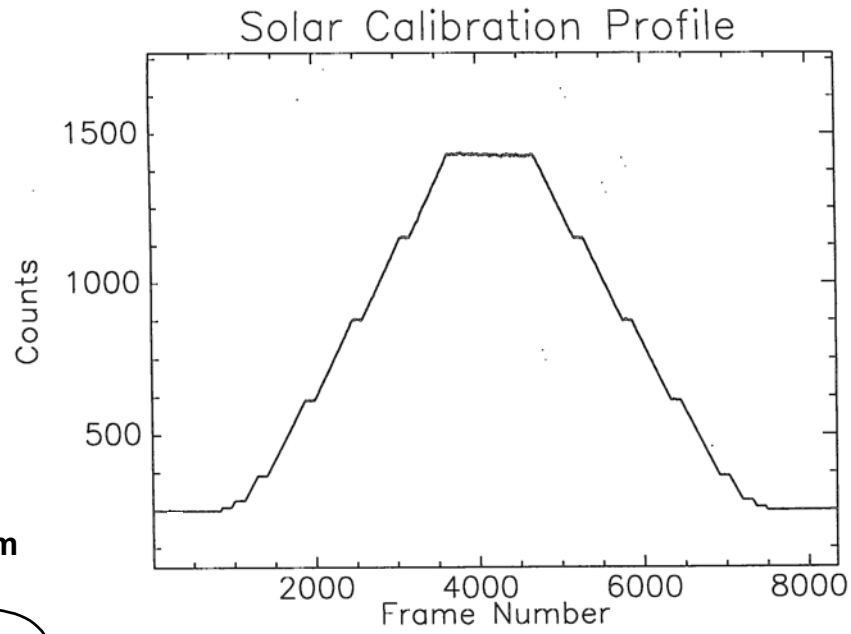
MS/PAN Flight Module

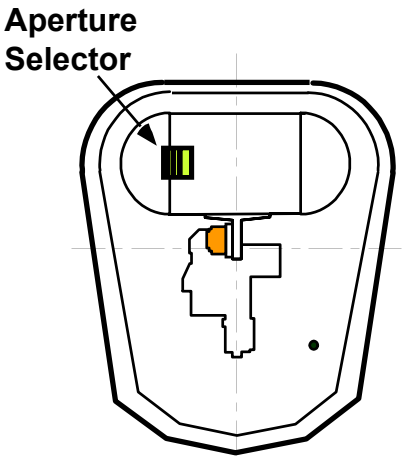


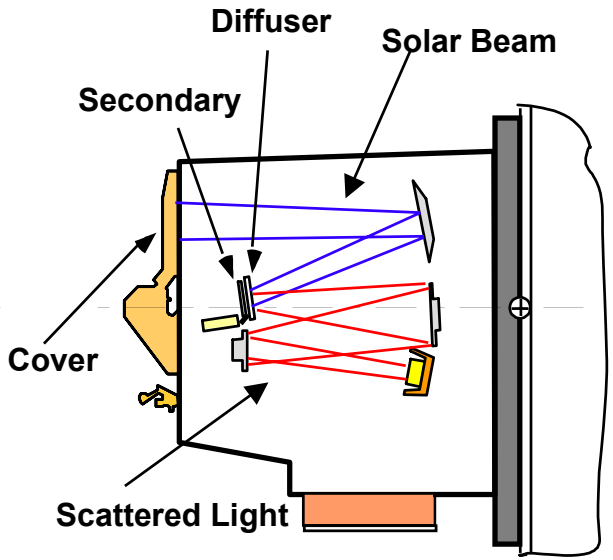
Solar Calibration



Signal Level	Cumulative Signal
1%	1%
2%	3%
7%	10%
20%	30%
20%	50%
20%	70%
20%	90%

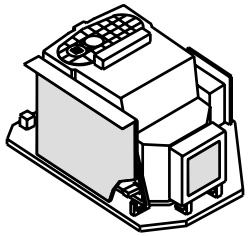


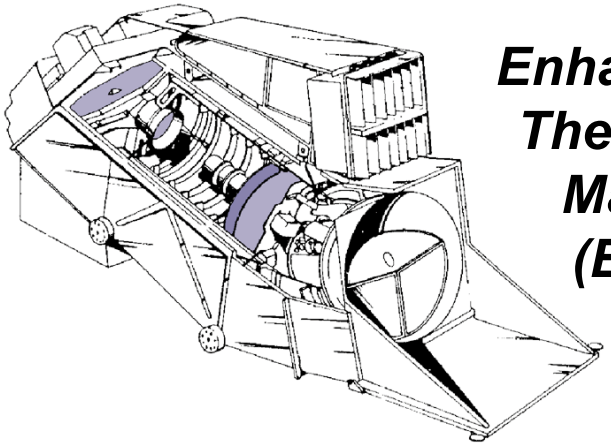




Landsat Instrument Comparison

ALI Based Concept for Future Landsat Instrument





Enhanced Thematic Mapper (ETM+)

100	**Mass (kg)**	**425**
100	**Power (W)**	**545**
0.2	**Size (m^3)**	**1.4**
80X50X50	**Size (cm)**	**196X114X66**
10	**VNIR / SWIR Bands**	**7**
6200	**Detectors Per Band**	**16**
None	**Thermal Bands**	**1**
400	**Data Rate (Mbps)**	**150**
10	**Pan Resolution (m)**	**15**
4-8	**Relative SNR**	**1**

EO-1 Instrument Overviews

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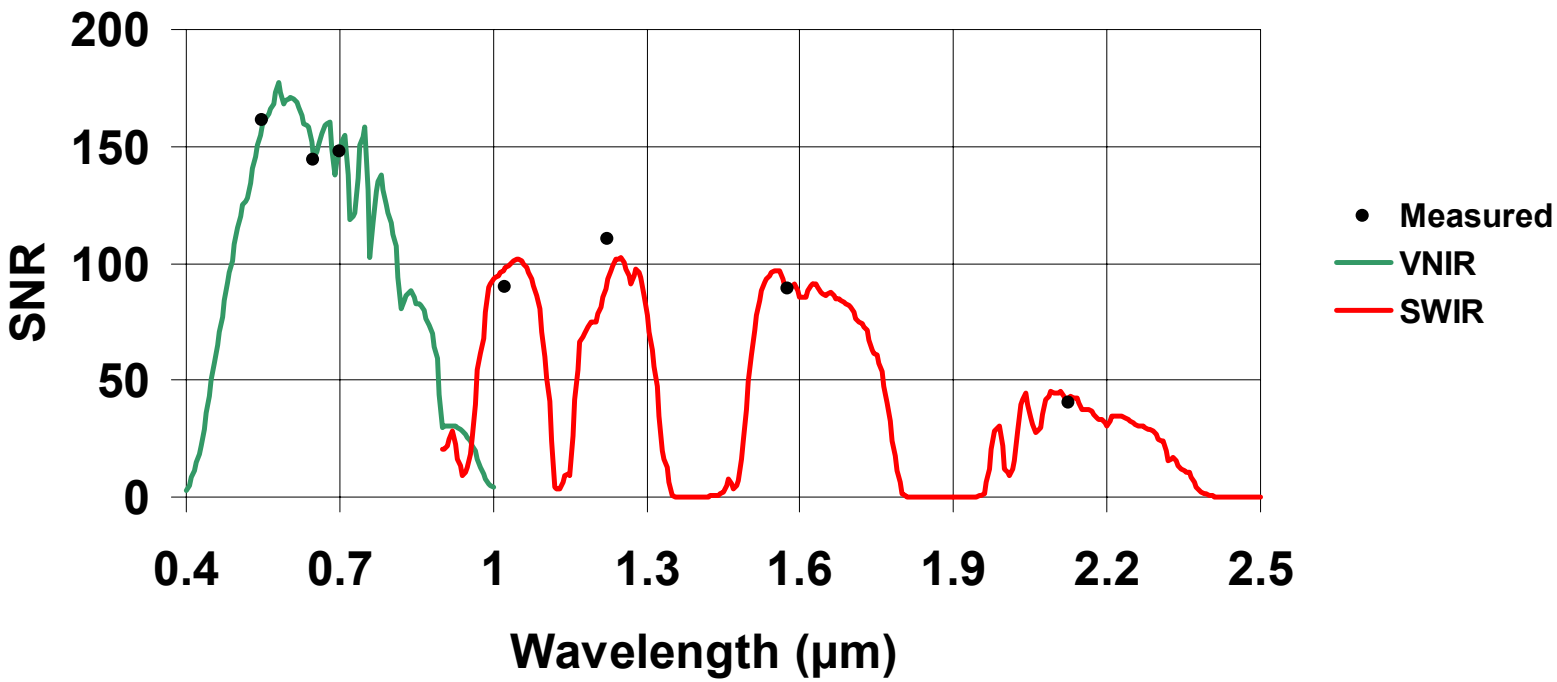
Hyperspectral Analysis derives from the use of contiguous spectral channels, allowing the use of derivatives and sophisticated analysis techniques. The large number of bands allows more complex systems to be addressed without the under sampling inherent in multispectral systems.

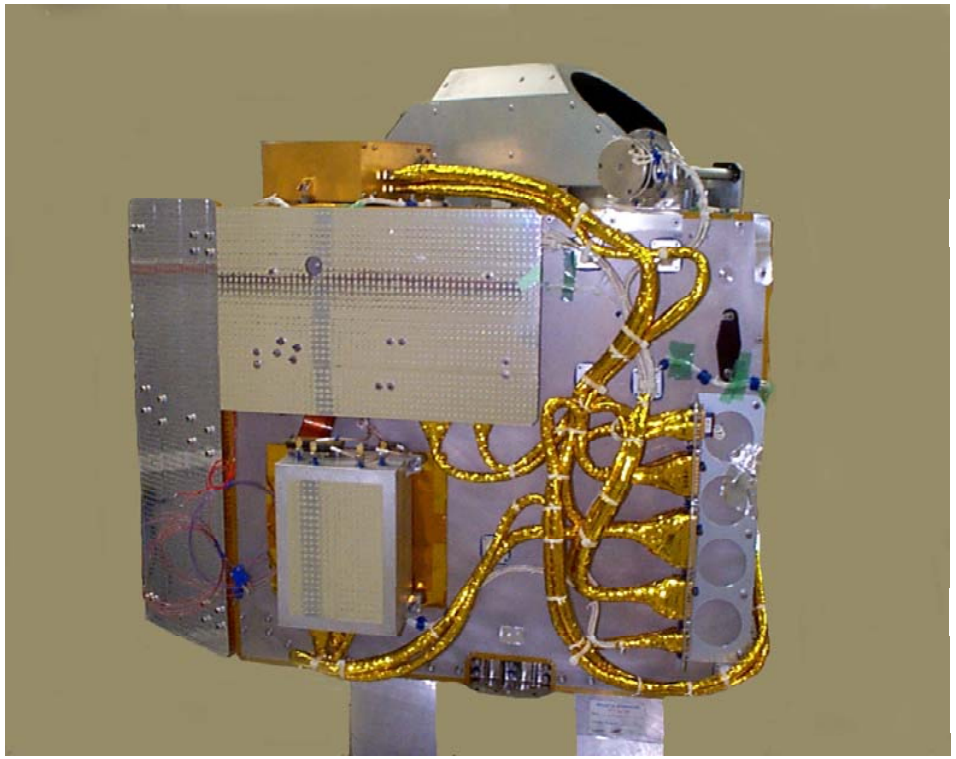
Hyperion S/N Performance

- ***Radiometric performance model base on 60º Solar zenith angle and 30% surface reflectance standard mid-latitude summer scene.***



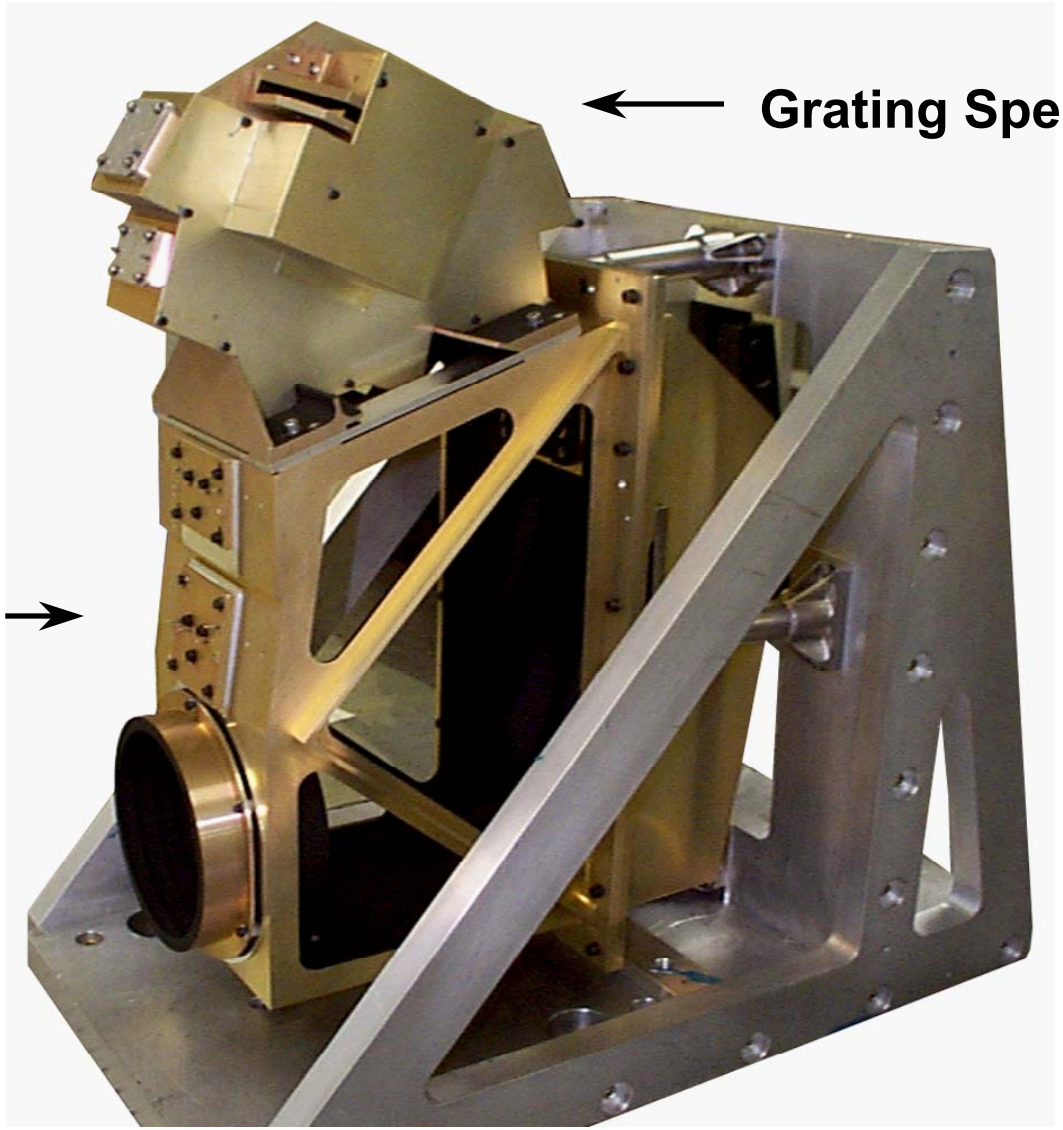
Hyperion Measured SNR						
550 nm	650 nm	700 nm	1025 nm	1225 nm	1575 nm	2125 nm
161	144	147	90	110	89	40

Hyperion Imaging Spectrometer

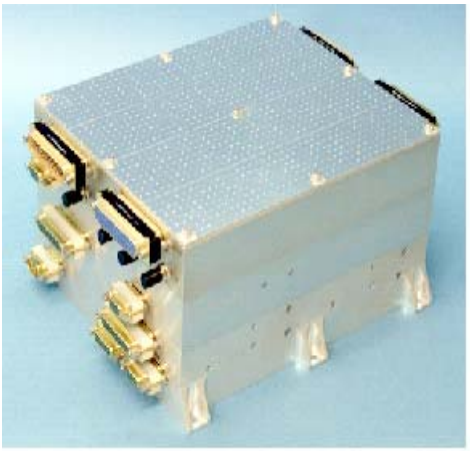


- ***Convex Grating spectrometers with CCD VNIR and HgCdTe SWIR detectors (60µm pixels)***
- ***30m spatial and 10nm spectral resolutions over 7.5km swath and 400-2500nm spectral range***
- ***Multiple calibration options: lamps, lunar, solar, ground imaging and laboratory***
- ***Hyperspectral Imaging Capability to address Earth Observation applications***

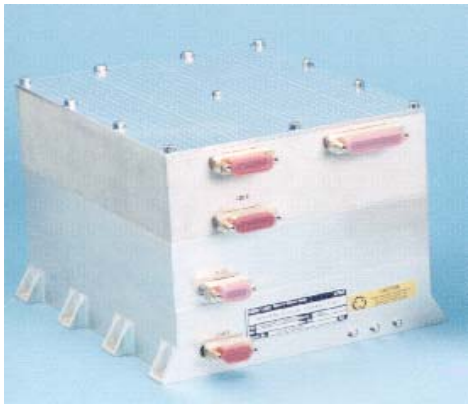
Hyperion Optical System



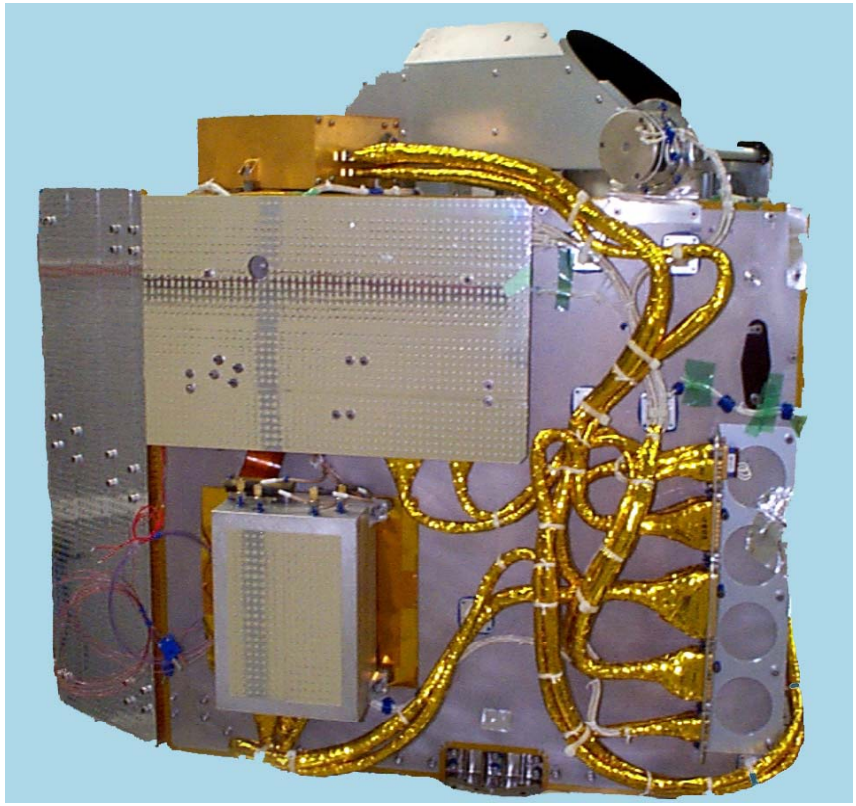
Hyperion Subsystems



Hyperion Electronics Assembly



Cryocooler Electronics Assembly

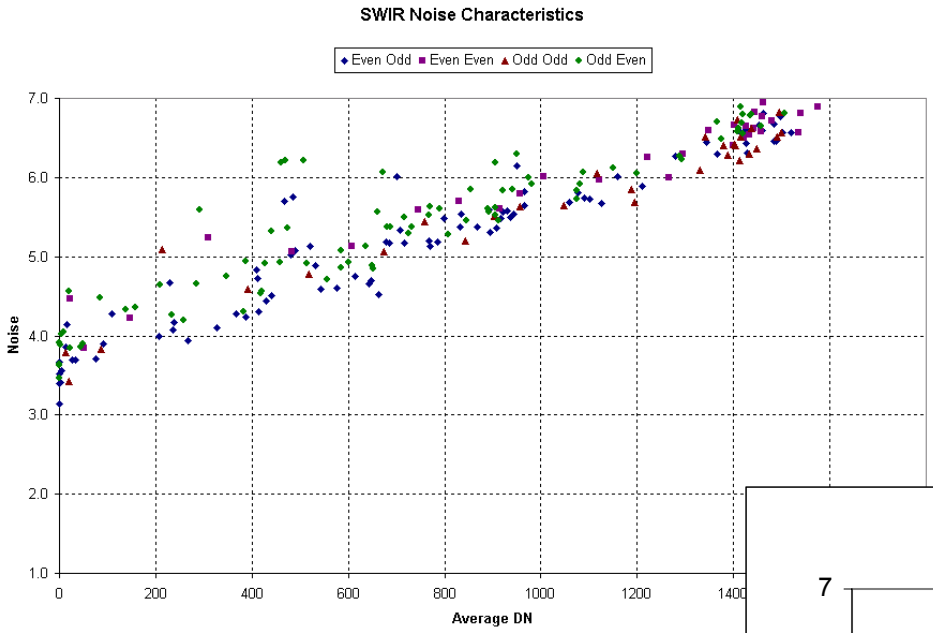


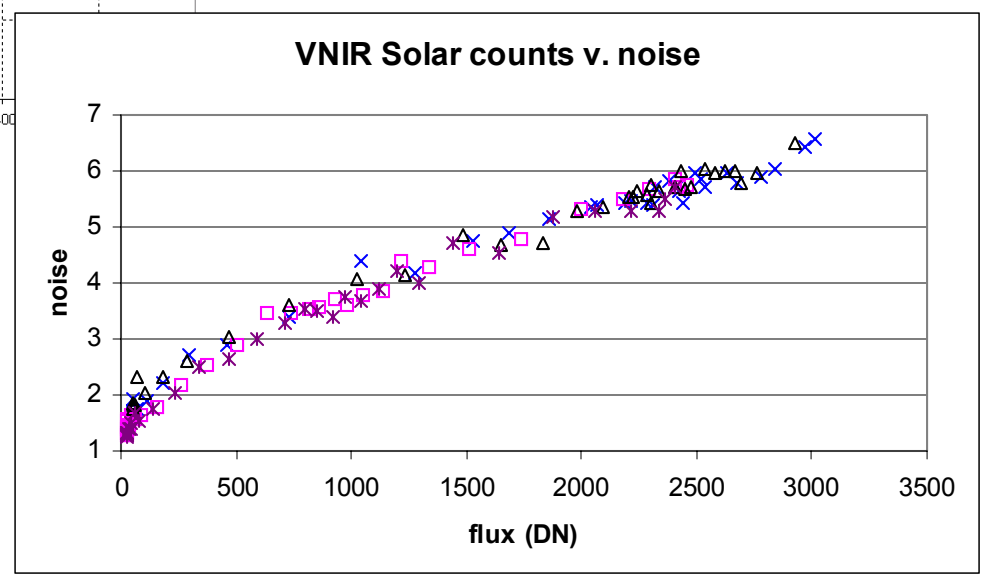
Hyperion Sensor Assembly(HSA)

Signal-to-Noise (Source TRW)

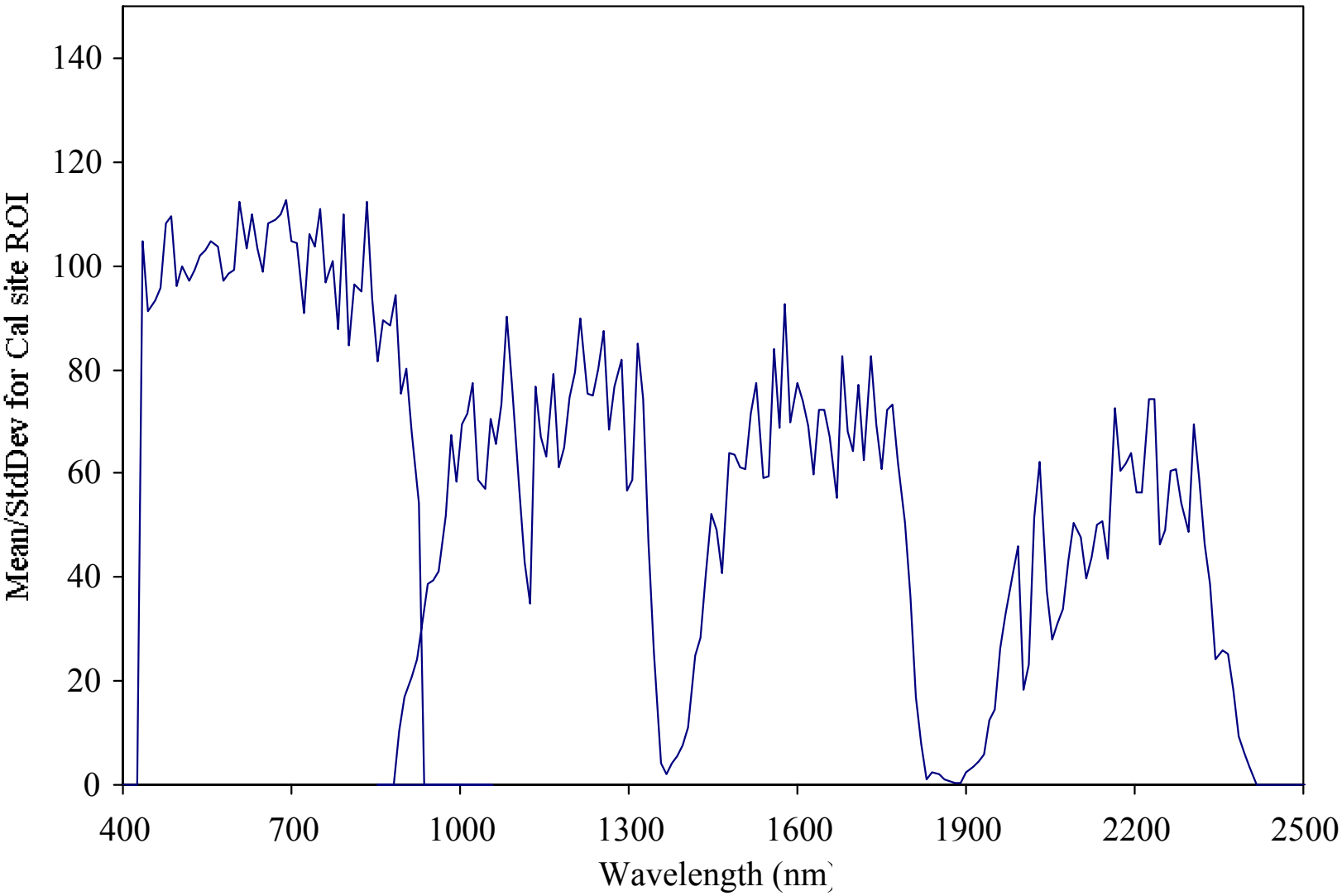
Wavelength (nm)	SNR Requirement	On-Orbit Performance
550	>60	192
650	>60	140
700	>60	140
1025	>60	65
1225	>60	96
1575	>60	64
2125	>30	38

SNR Calculated From Solar Calibration Data





Scene Based Estimate of Hyperion SNR
(Source JPL AVIRIS LAB)



EO-1 Scene Tracking Statistics

Total Scheduled Scenes	2047
Scenes Successfully Downlinked	1626
Level-0 Data Processed	1881
Total Scenes Shipped to PIs	1571

As of COB 10/24/01

Science Validation Team

Day 1 to 90

- ***Instrument Team***
  - *Validate/re-establish and refine pre-launch characterizations*
  - *Provide technology validation*
  - *Participate on Science Validation Team*

Day 61 to 120

- ***NASA Selected Investigators***
  - *Conduct scene based instrument performance characterizations*
  - *Measure ability of instruments to make Landsat-like observations*
  - *Assess capability for addressing earth remote sensing applications*
  - *Assist in technology validation*
  - *Facilitate Commercial Applications (CRSP/SSC)*

Day 31 to 120

- ***International Collaborators***
  - *Argentina, Australia, Canada, Italy, Japan, Singapore*

"First Light" Image of Alaska

Why is the ALI pan band better than the ETM+ pan band?

- ***Improved Radiometric resolution***
  - ***Superior signal-to-noise***
  - ***12-bit versus 8-bit representation of dynamic range***
- ***Inherently higher contrast measurement***
  - ***ALI pan restricted to 480 – 690nm VIS spectral interval***
  - ***ETM+ spans vegetation transition rise (520 – 900nm)***
- ***Smaller pixel size (IFOV)***
  - ***ALI pan IFOV is 10 meters***
  - ***ETM+ is nominally 15 meters (effectively 18 meters)***

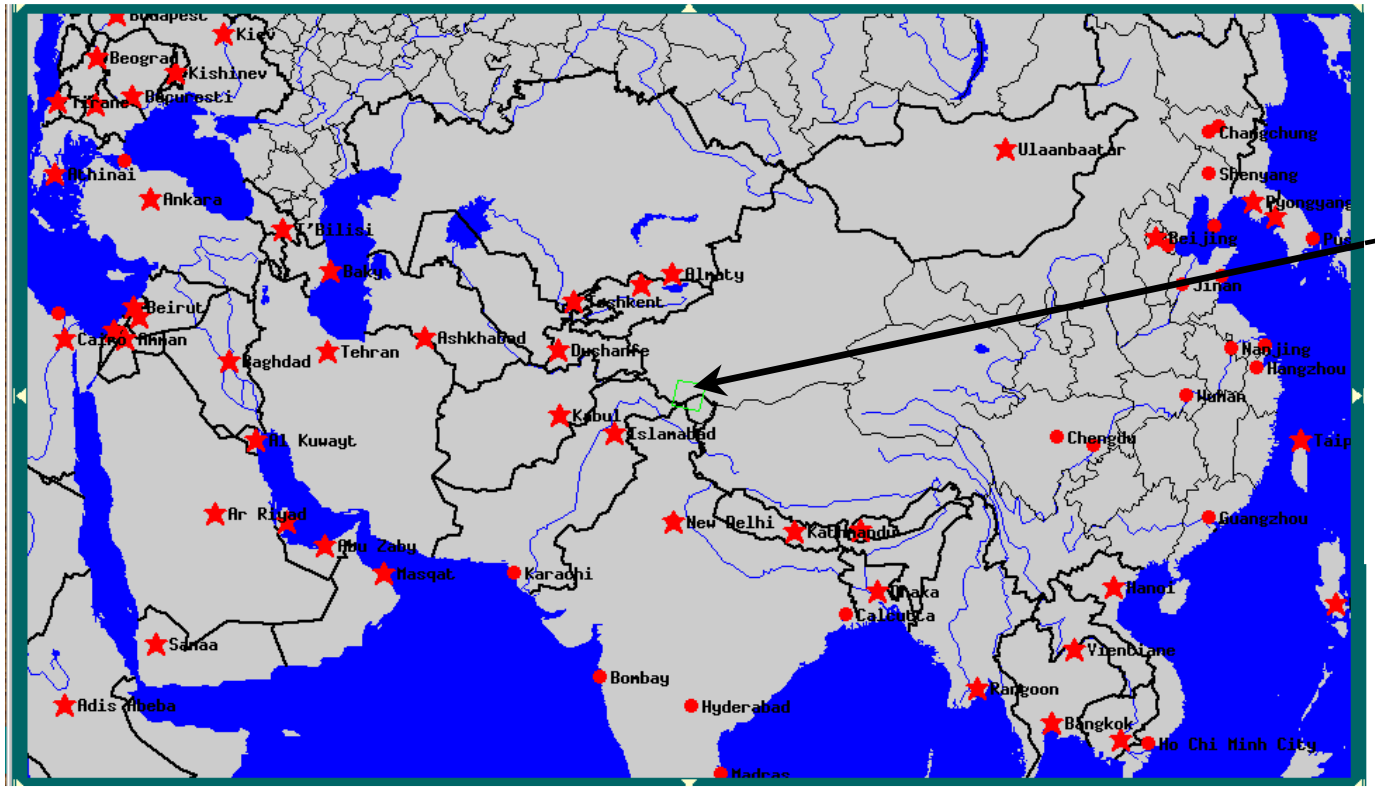
ALI Pan Enhanced 4-3-2 Composite
Washington, DC - December 1, 2000

EO-1/ALI and IKONOS Comparison

ALI Pan Enhanced 4-3-2 Composite
Washington DC, December 1 ,2000

IKONOS MS 4-3-2 Composite
Washington DC, April 1, 2000

Area of First Hyperion Image Collection (Green Square)



Area of First Image

Hyperion Image - Argentina

Hyperspectral DCE Acquired Dec 1, 2000
Color image produced using 3 bands in visible
Blue = band 14 (488 nm)
Green = band 20 (549 nm)
Red = band 38 (731 nm) (red shows areas of new spring growth)

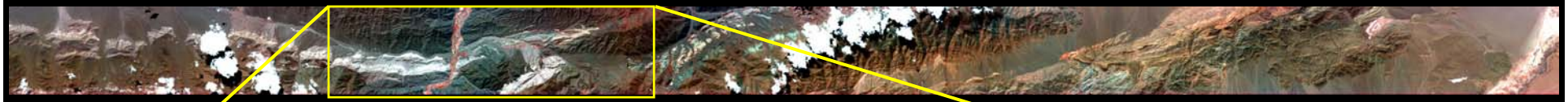
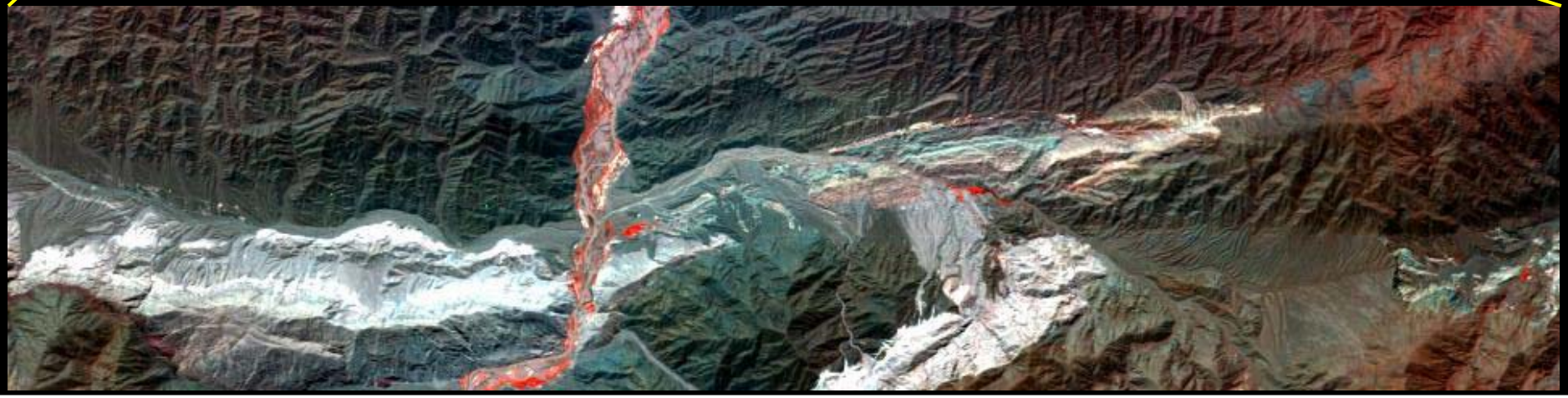
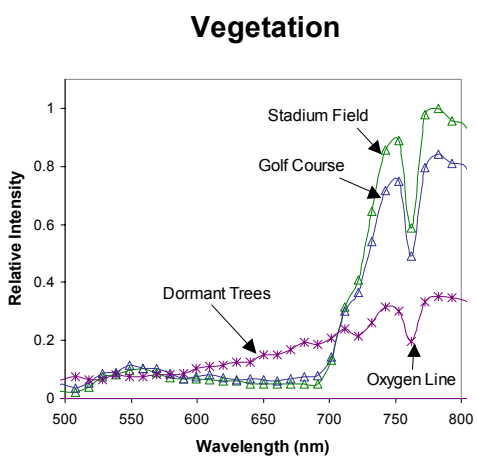


Image No. EO12000336_002002C_r1_image0su
Approx. 7.5 km wide x 65 km long
← NORTH



Hyperion Image taken near Washington DC (Fairfax, VA) on Friday December 1, 2000

The image shown to the right, taken by the Hyperion Imaging Spectrometer on EO-1, reveals the relative chlorophyll content of vegetation in an area of Fairfax County, Va. The spectral profiles indicate healthy grass in the stadium field and golf course. The spectral profile of the trees indicates dormant vegetation.



Oxygen in the atmosphere is detected at near infrared wavelengths in the spectral profiles.

Courtesy of TRW Inc.

Sample Hyperion Images

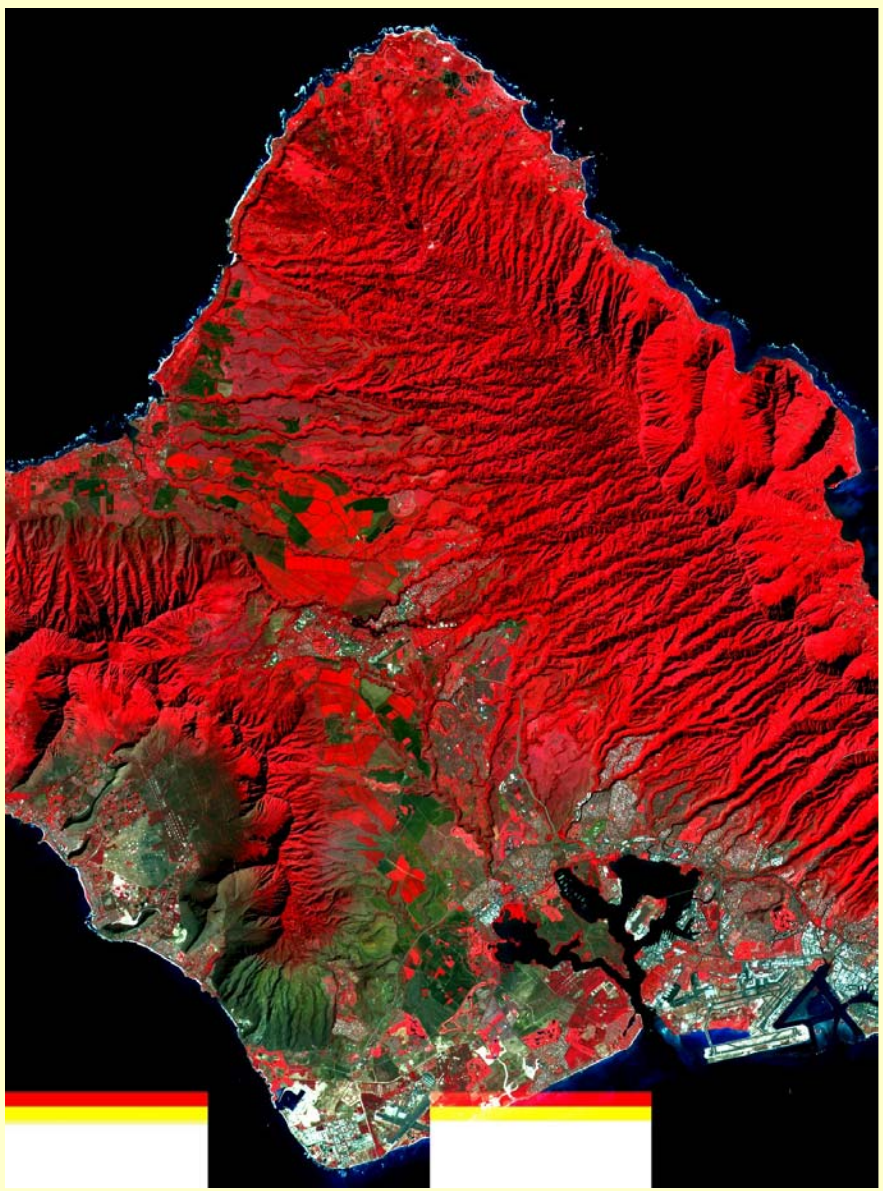
Blythe
Day 007

San Francisco
Salt Ponds
Day 017

LAC Image (1.26µm)

Tumbarumba , Austalia (Lake Hume in center)

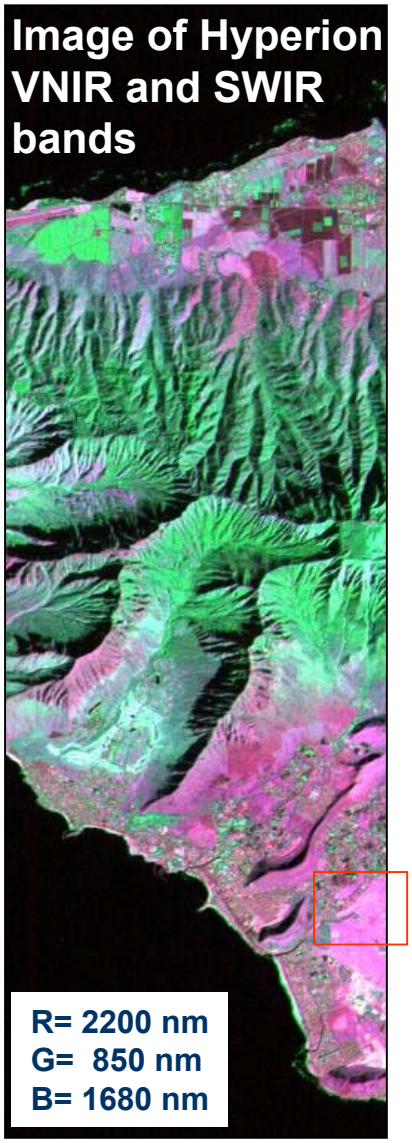
Oahu
December 19, 2000

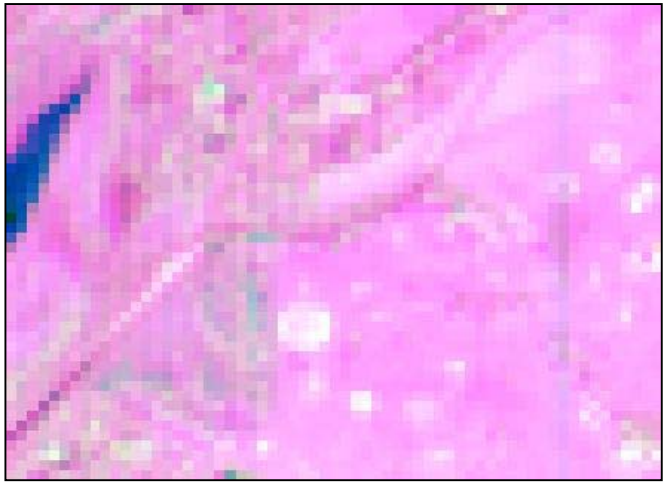


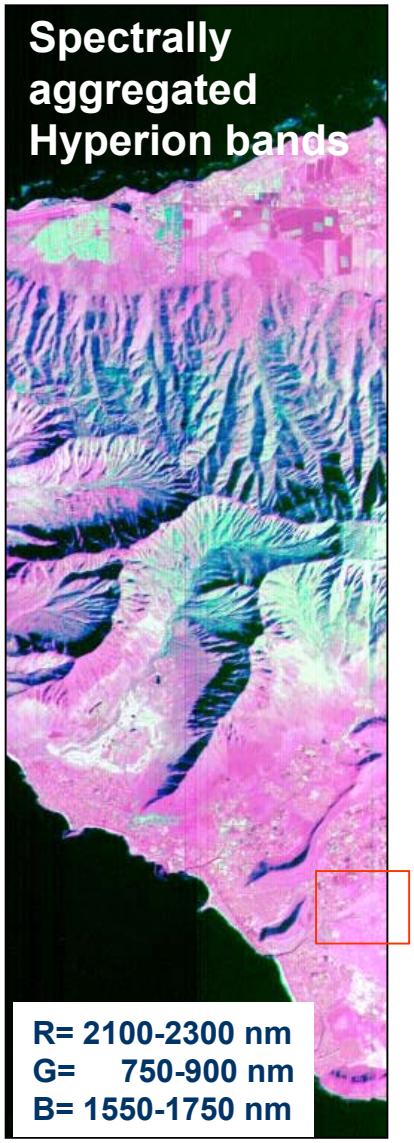
Advanced Land Imager
Color Composite

R = Band 4
G = Band 3
B = Band 2

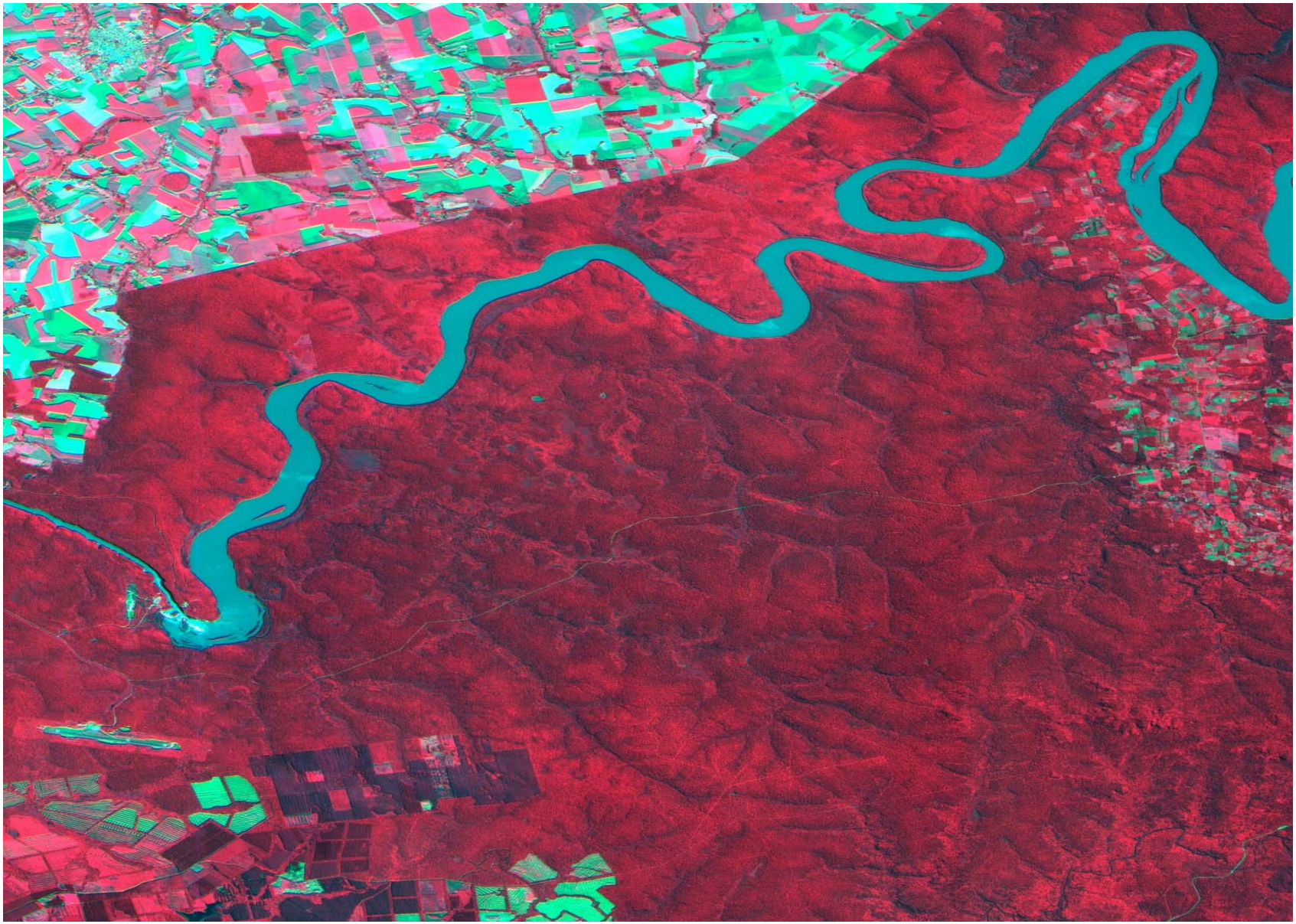
Oahu
December 19, 2000







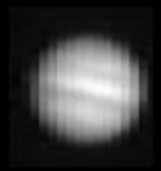
Eldorado, Argentina



You can't do that with EO-1!

(Views with the EO-1 ALI Pan band)

Full Moon



Jupiter

Venus

Half Moon

Saturn

Out of this World Calibration

Hyperion image of the moon

Lunar image provides direct-viewing radiometric measurements for calibration without atmospheric effects.

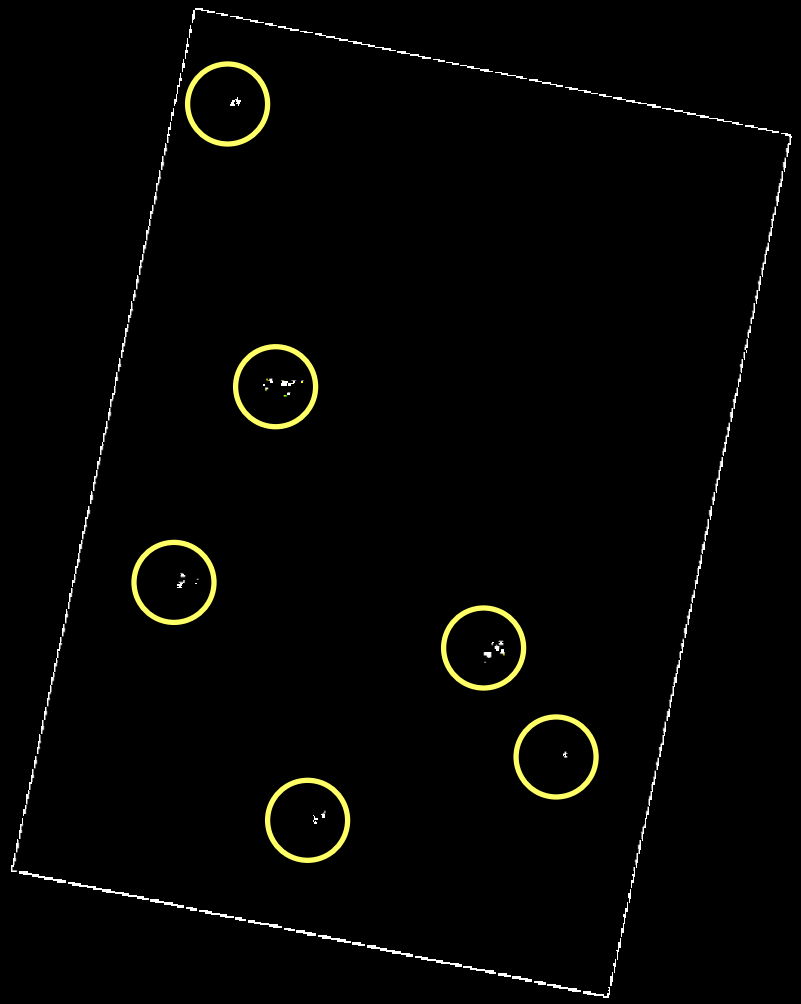
Issues of the lunar model and analysis techniques are being addressed

Courtesy of P. Barry & H. Kieffer

You can't do that with EO-1!

(Views with the EO-1 ALI Pan band)

The Pleiades

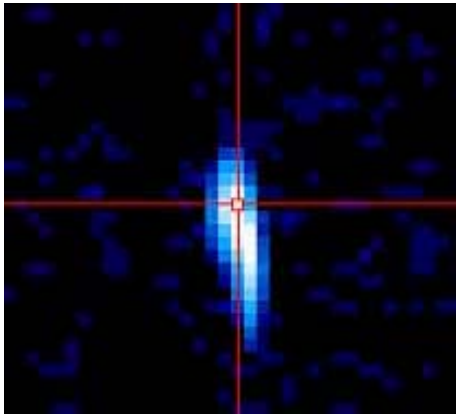


ALI detections

Special Hyperion Characterization Targets

Searchlights -California

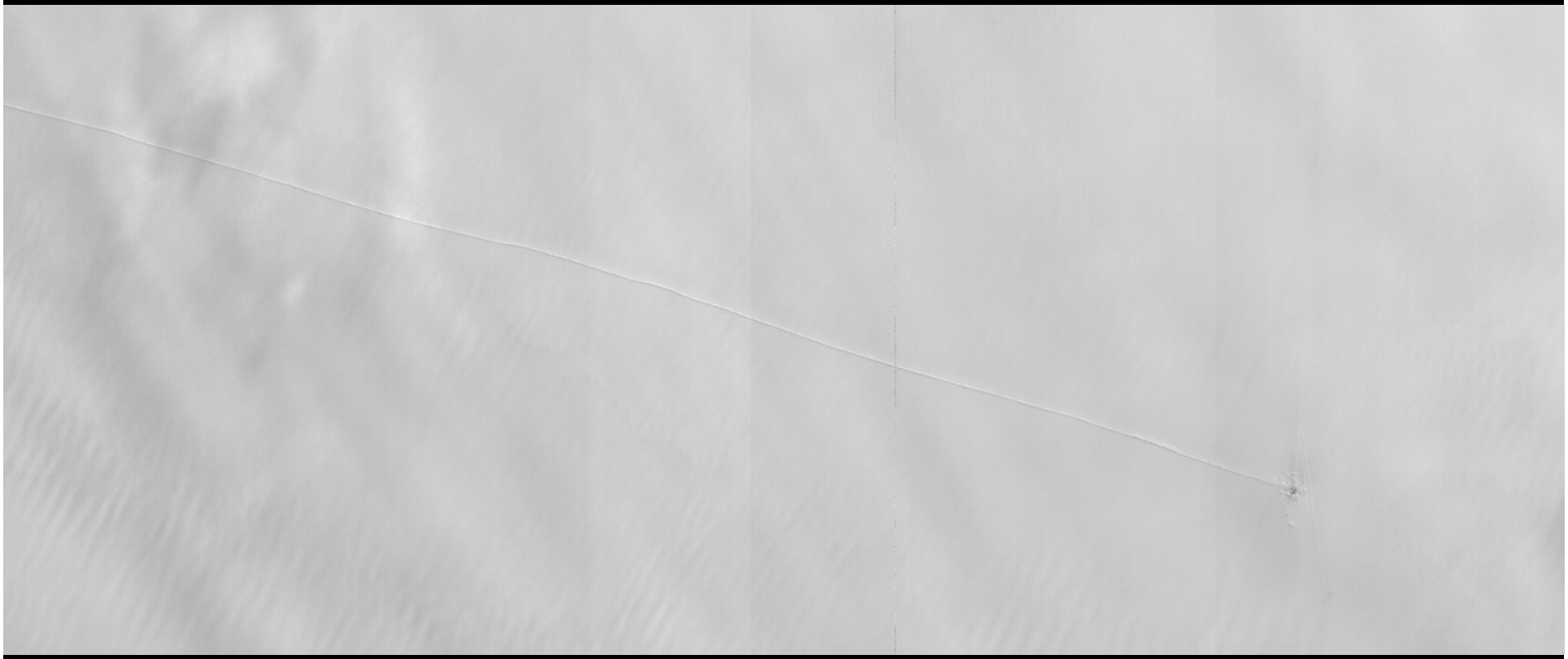
Planets -Venus



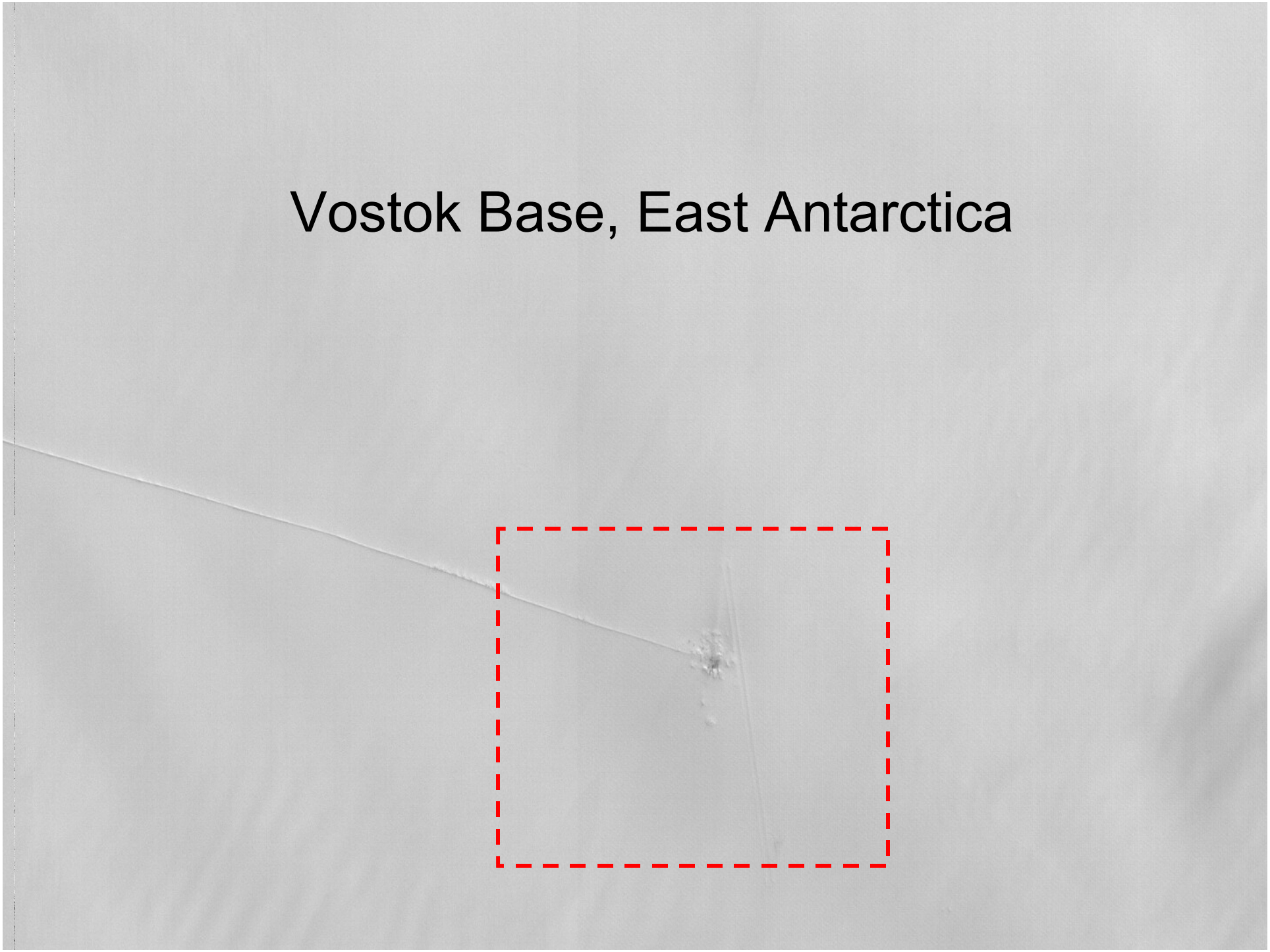
90 deg Yaw

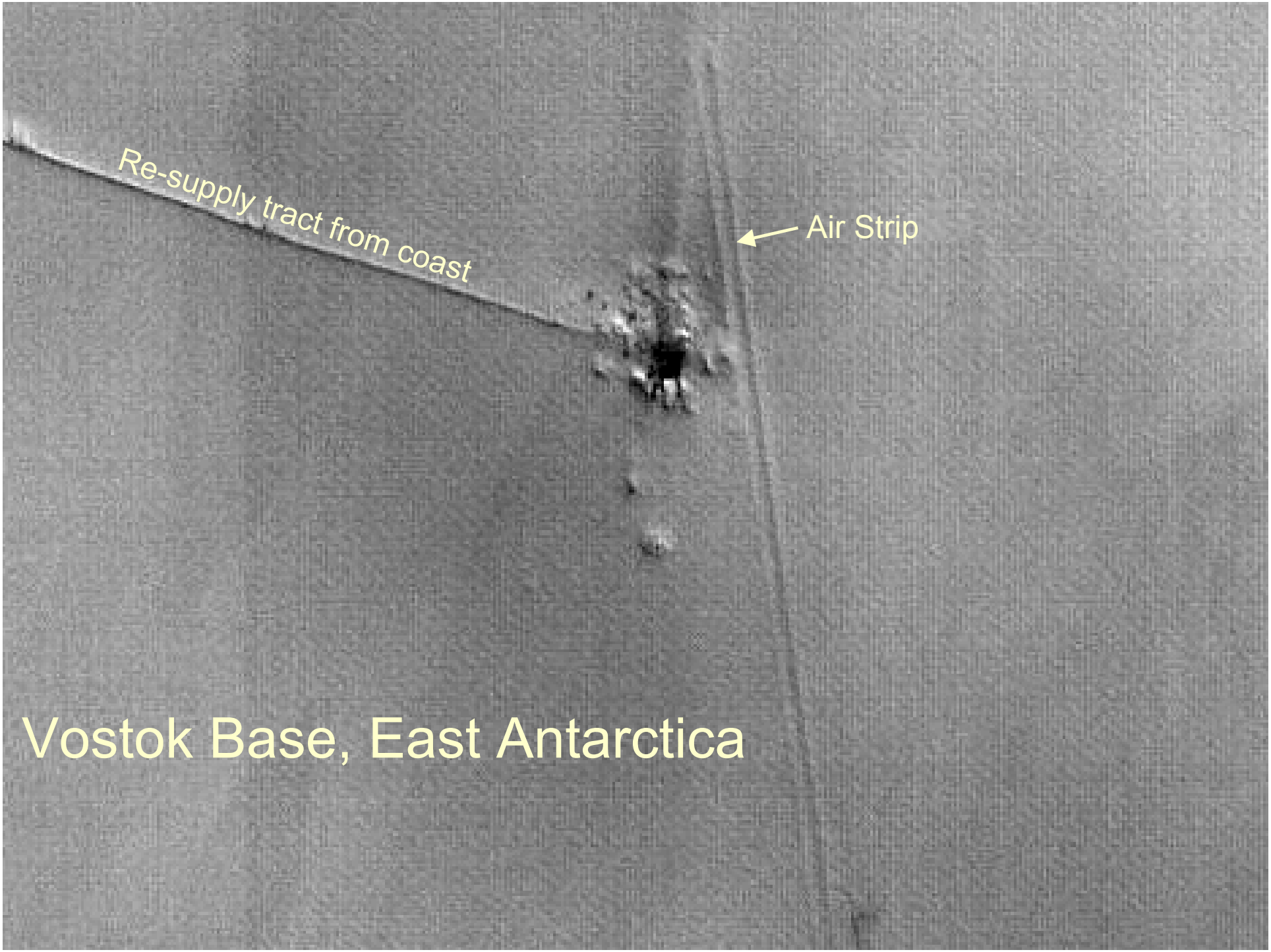
Gas Flares -Moomba

Earth Observing-1



Vostok Base, East Antarctica



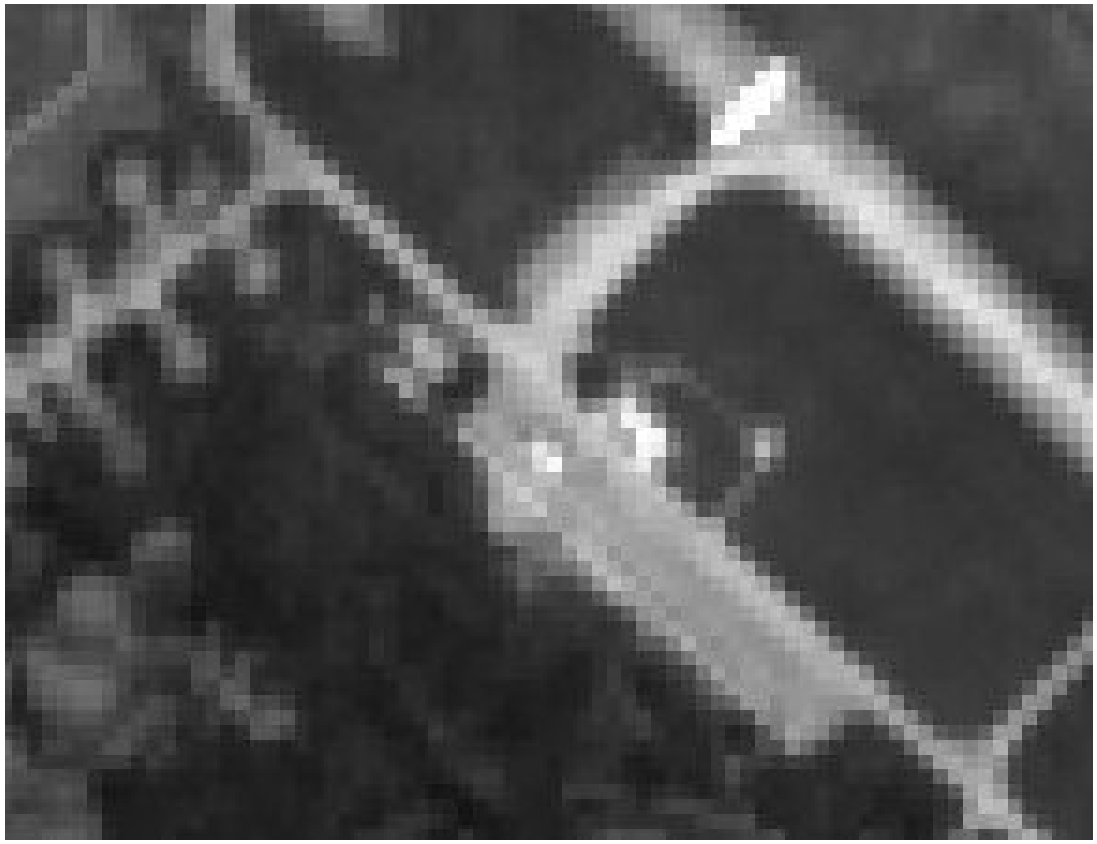


Vostok Base, East Antarctica

Lingshui Airfield 04/10/01

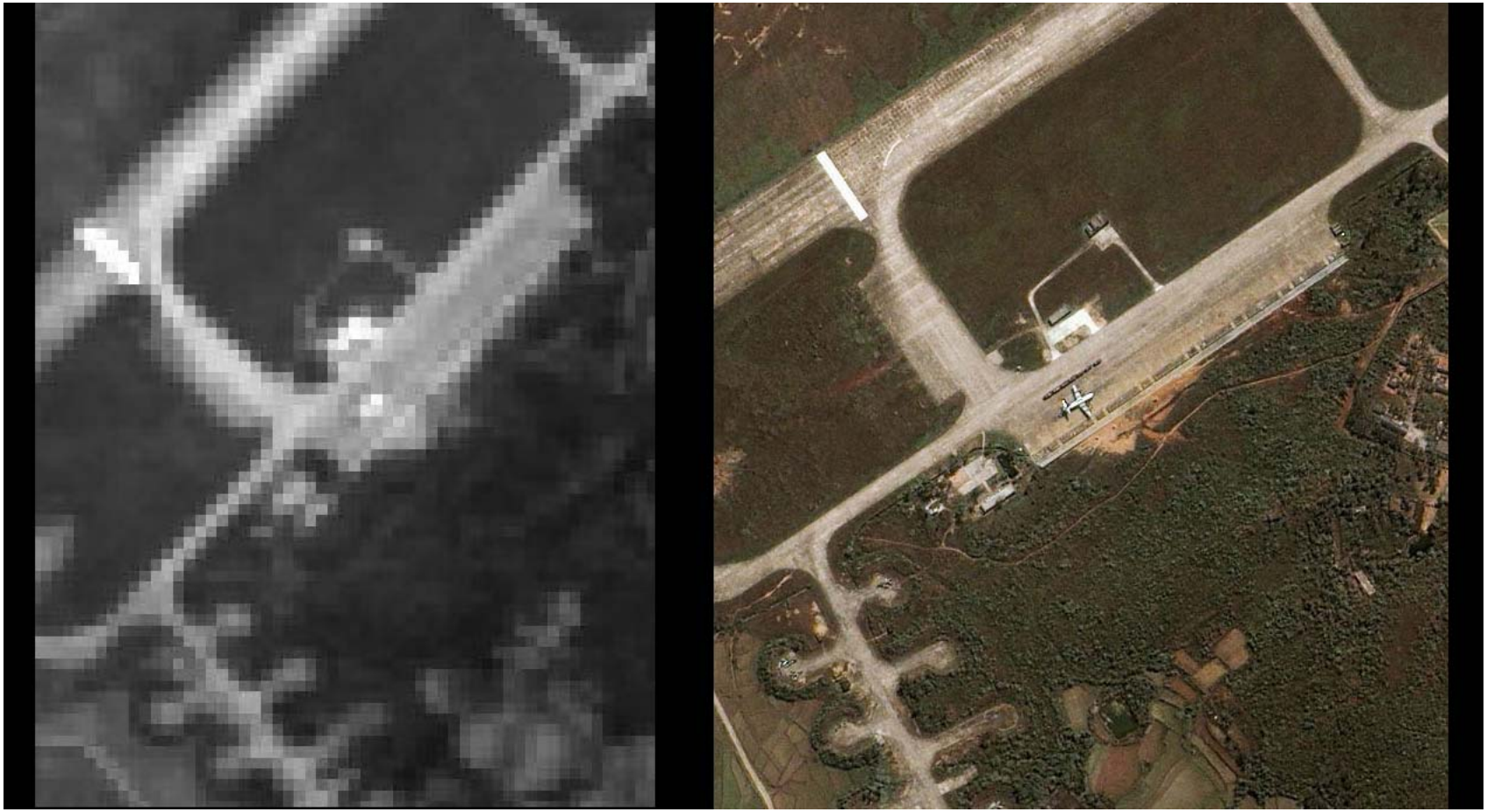
ALI Pan Band

Lingshui Airfield 04/10/01



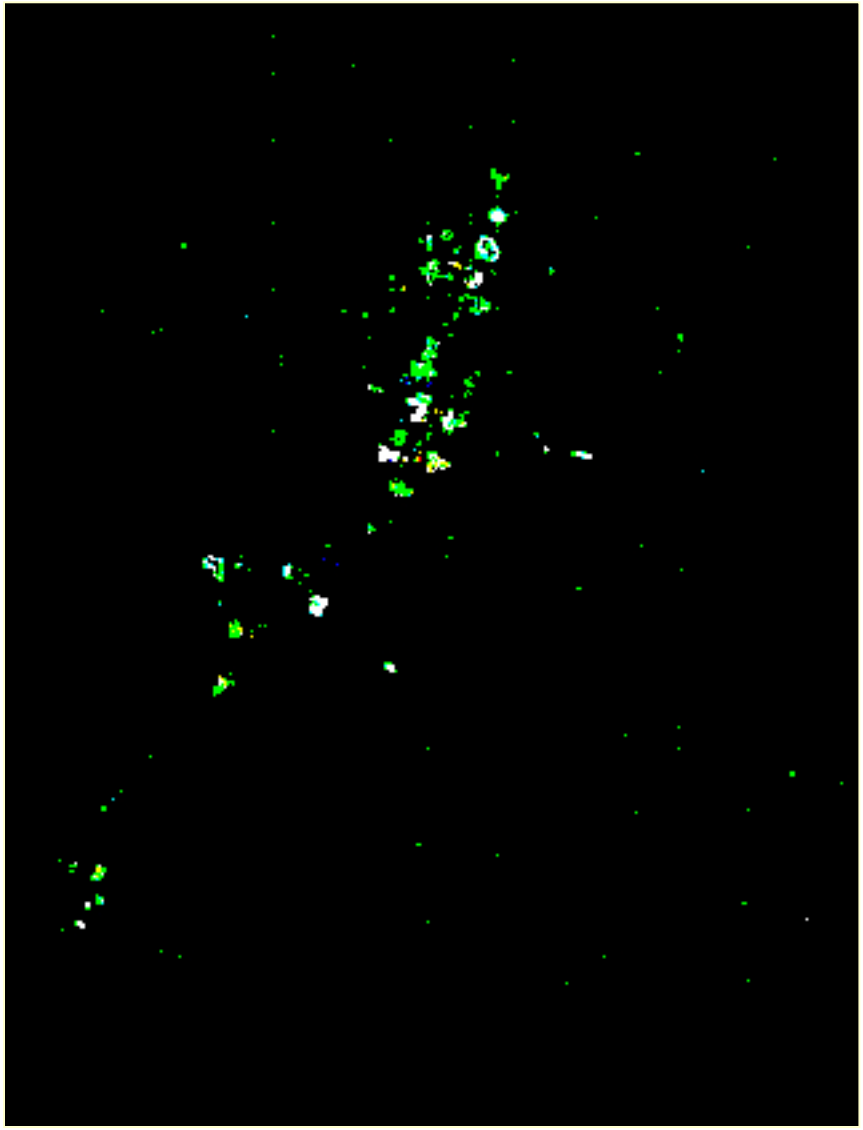
ALI Pan Band

Lingshui Airfield 04/10/01



ALI Pan Band

I can’t tell you!



“The Strip”

Las Vegas

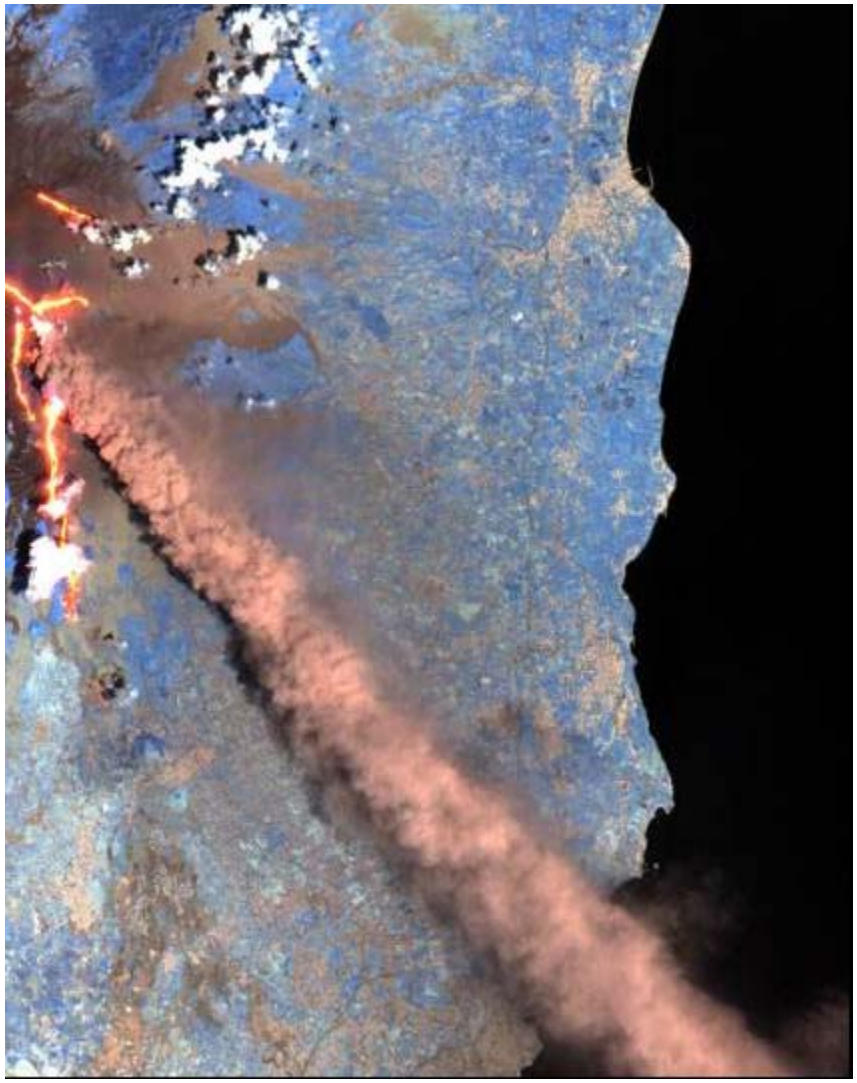
Nevada

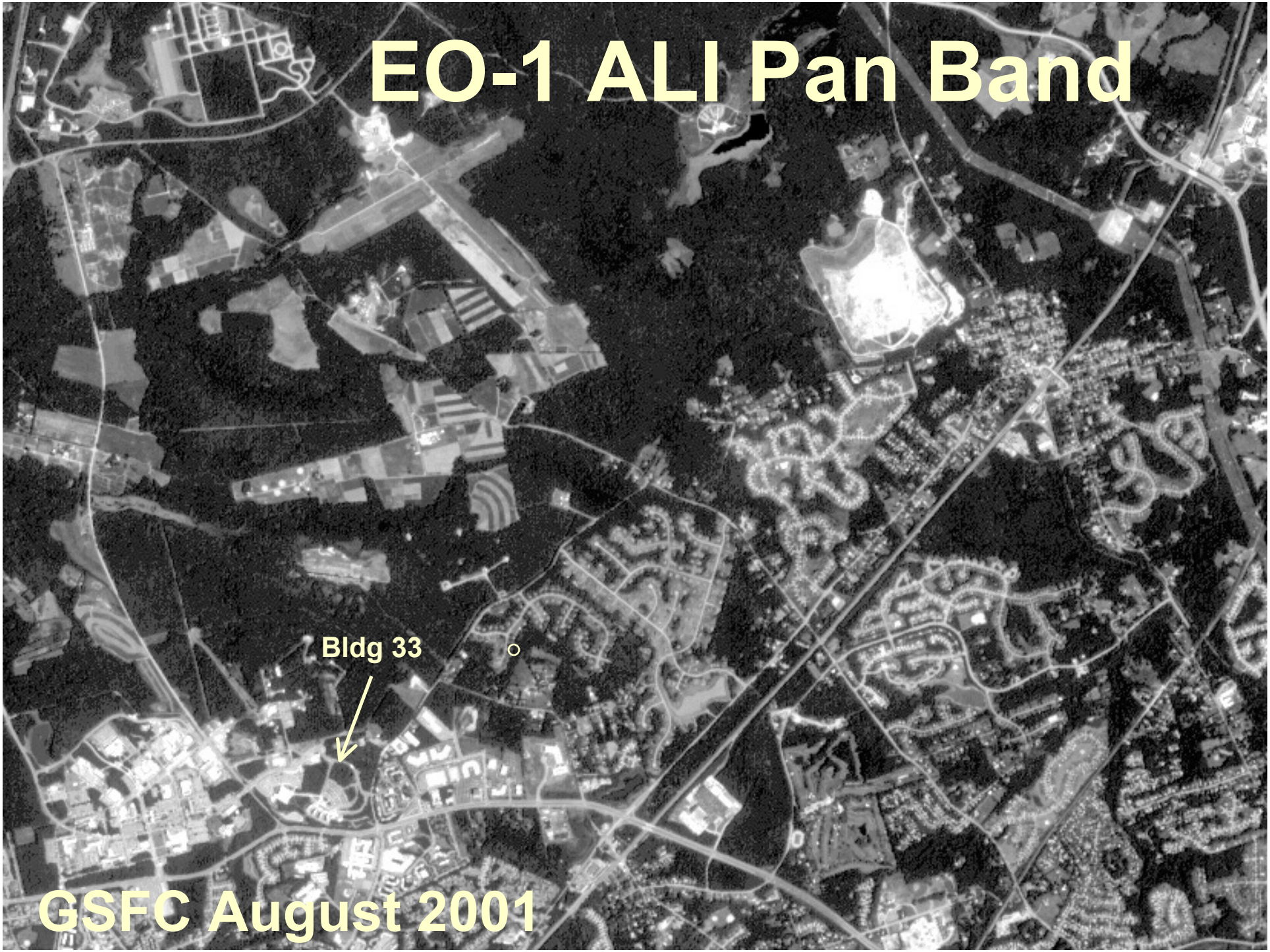
3-2-1 ALI Composite

Mount Etna - July 22, 2001

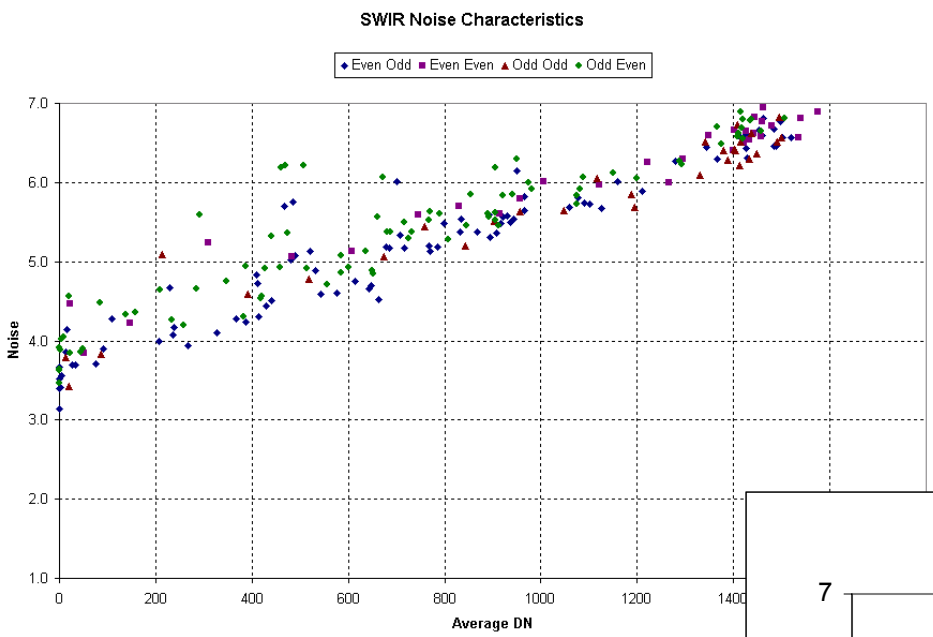
ALI Pan Enhanced 3-2-1

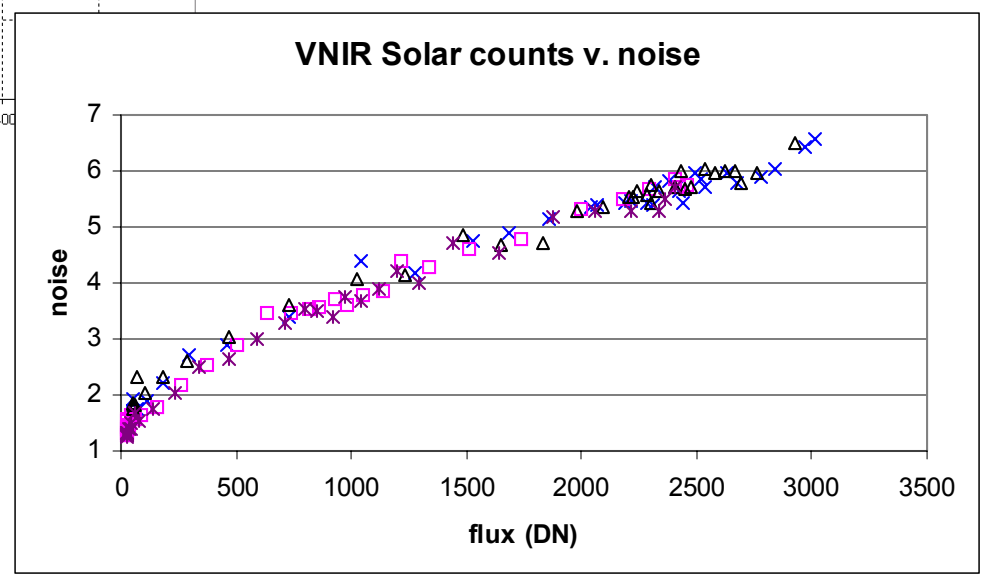
EO-1 ALI Bands 7-5-5'



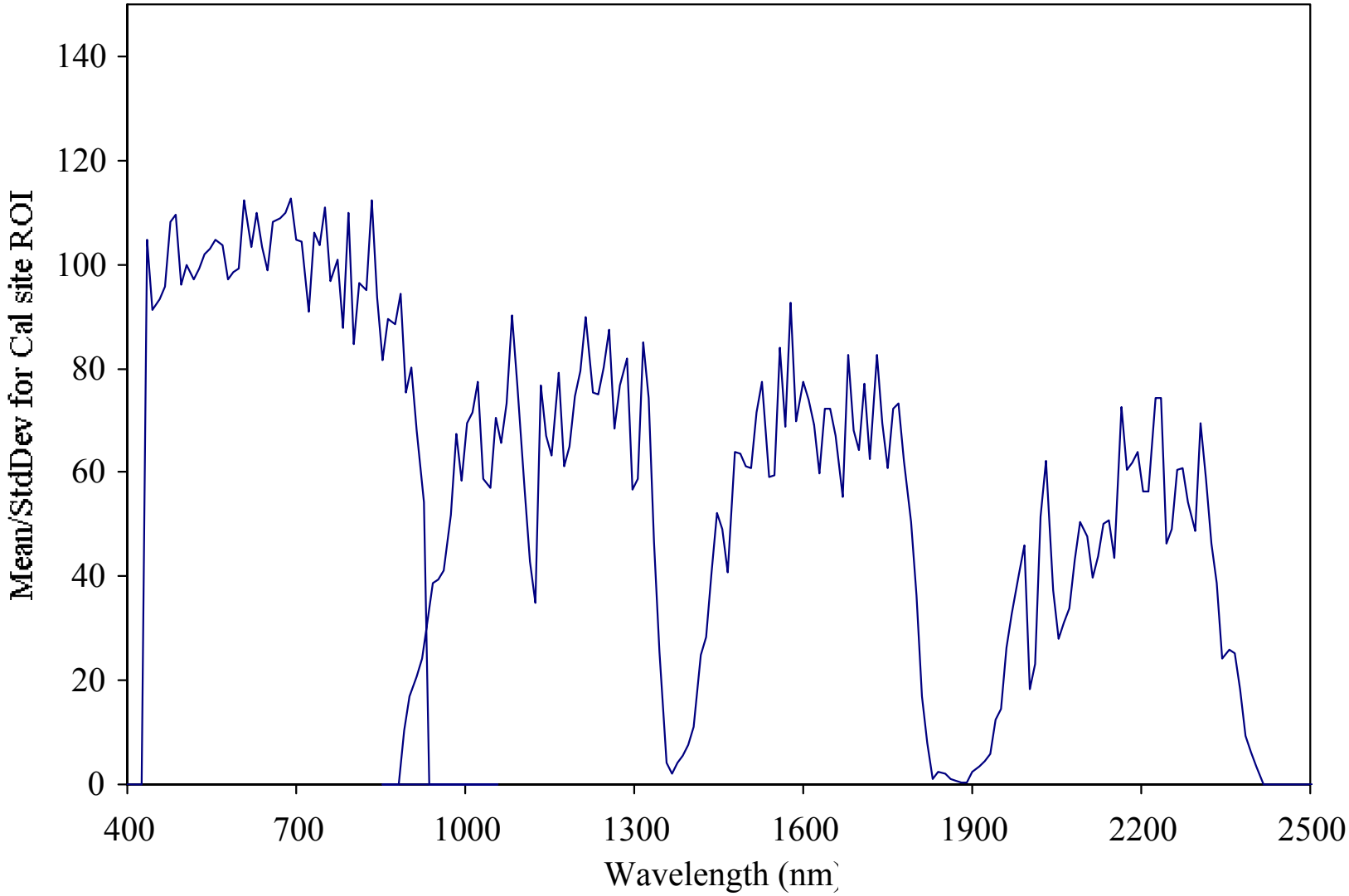

EO-1 ALI Pan Band
Bldg 33
GSFC August 2001

SNR Calculated From Solar Calibration Data





Scene Based Estimate of Hyperion SNR



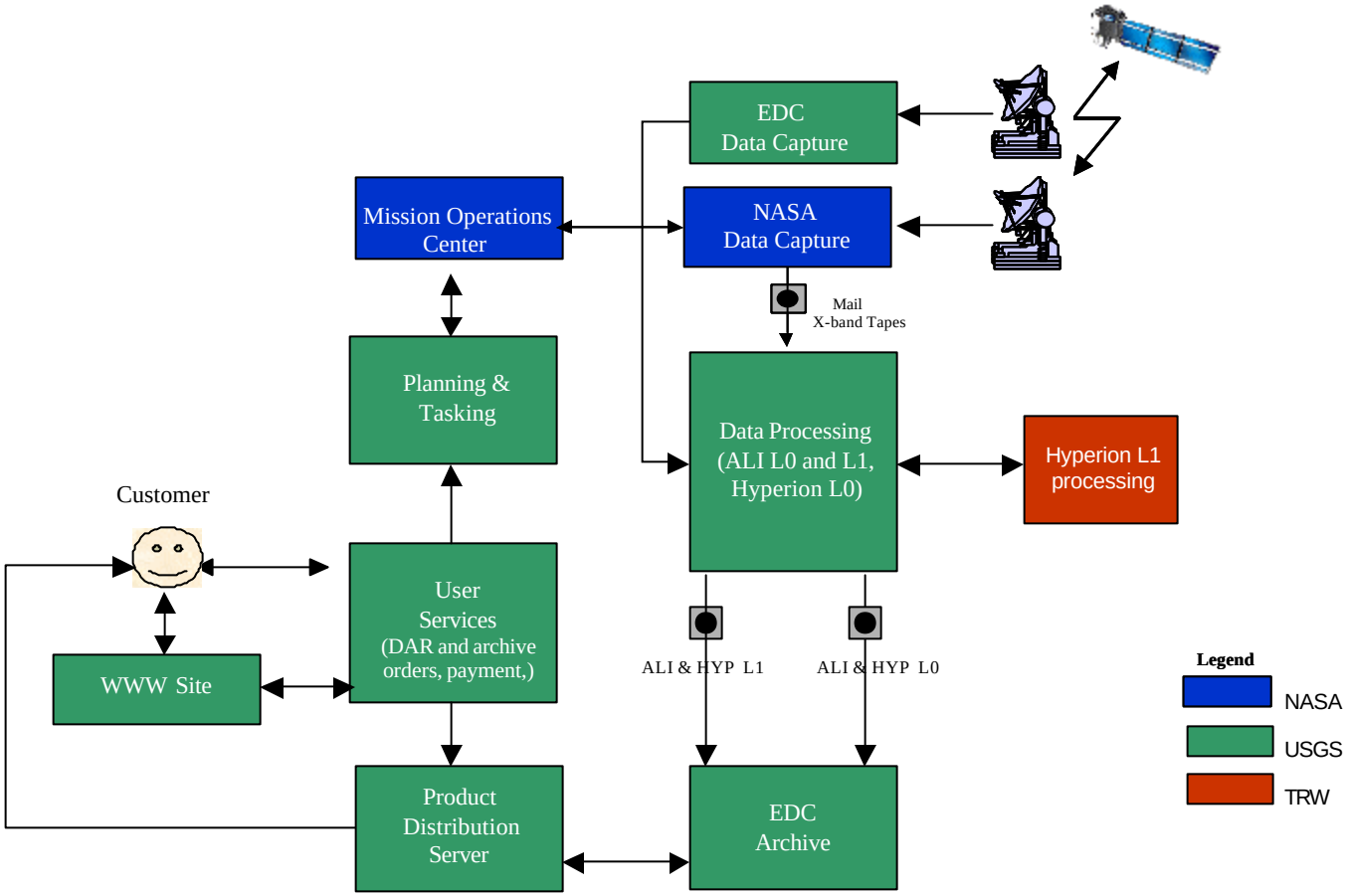
Topics

- ***Extended Mission Approach***
- ***Operations Overview***
- ***Organizational Responsibilities***
- ***EO-1 Products available from USGS***
- ***Data and Pricing Policy***
- ***USGS Project POCs***

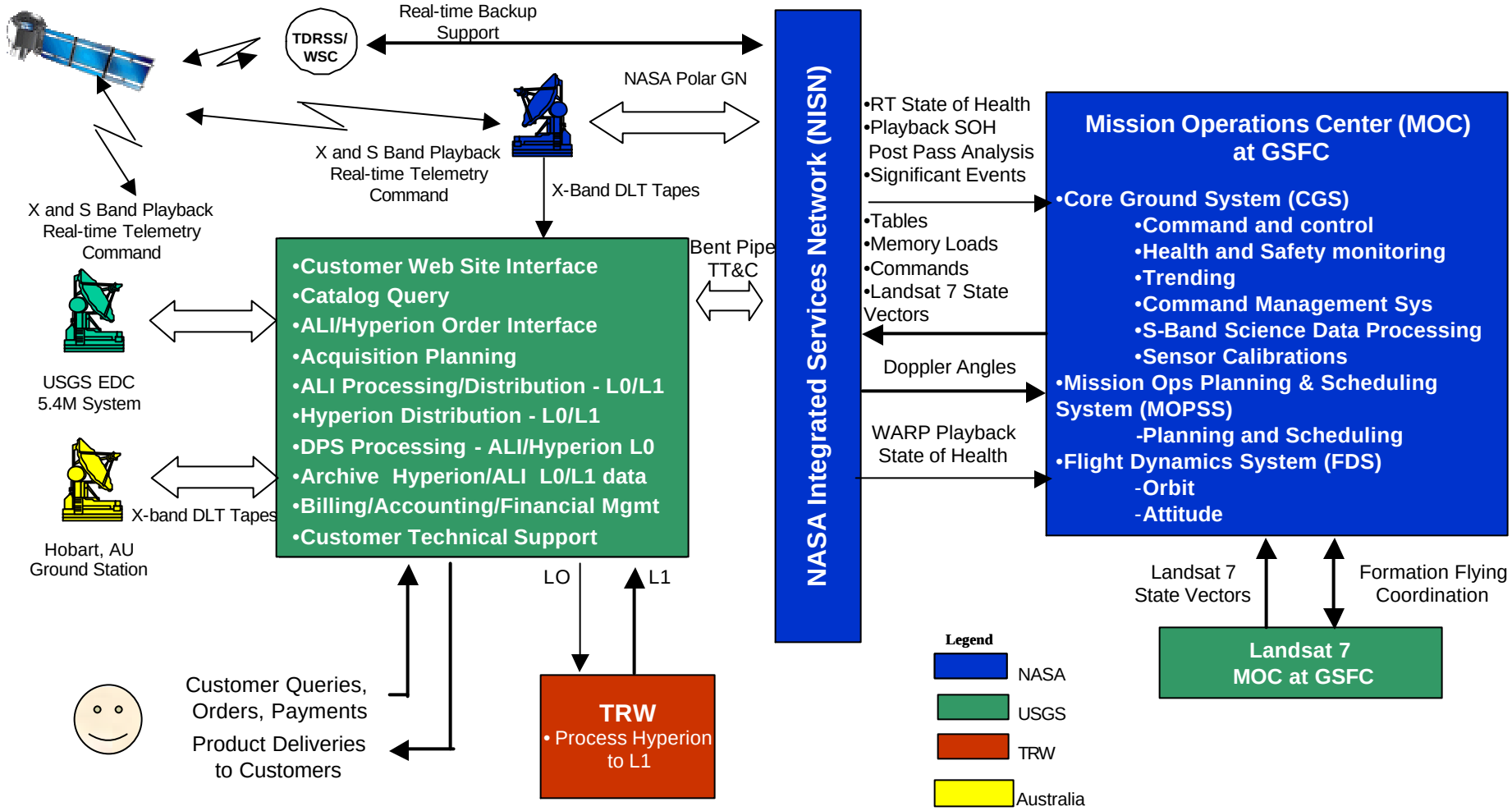
Extended Mission Approach

- ***Phased transition from technology mission to operational***
- ***Products become publicly available***
- ***Operations cost fully reimbursable***
- ***Manual processes initially; automated over time***
- ***Transfer of processing equipment and scheduling responsibilities to EDC underway***
- ***Archive / catalog of 1st year of acquisition data being built***
- ***Data Acquisition Requests (DARs) will be taken for new acquisitions***
- ***At EROS Data Center (EDC) starting mid-December 2001***

Operations Overview



Organizational Responsibilities



EO-1 Products

- ***Archived Products***
- ***Data Acquisitions Requests (DARs) and Products***
- ***ALI L1***
  - *Radiometrically corrected, HDF*
  - *Footprint 37-km across track by 42-km (TBD) along-track*
  - *4 separate detector array files*
- ***Hyperion L1B***
  - *Radiometrically corrected, HDF, 16-bit signed, band interleaved, SWIR and VNIR referenced to each other*
  - *Footprint 7.7-km across track by 42-km (TBD) along-track*
- ***FTP pull, CD, DVD media***
- ***Product reformatting to more user friendly eventually***
- ***L0 data is archived; used only to reprocess L1 products***
- ***Turnaround time initially 48 hours from availability of data at EDC, work to 5 hrs (expedited)***

Data and Pricing Policy

- ***Data in the Public Domain***
  - ***Holdback restrictions may apply for acquisitions (TBD)***
- ***Pricing***
  - ***DAR for 1st sensor = $1500***
  - ***DAR for 2nd sensor (same data collection event) = $300***
  - ***Product from archive = $500 (working to be lower)***

    (regardless of geographic coverage area)
  - ***New DAR products = $700***
    - *42-km (TBD) along track strip*
    - *Different, longer length along-track pricing TBD*
- ***Policy regarding cloud cover and multiple orders for same acquisition product TBD***

USGS Project POCs

- ***Data pricing and policy***
  - ***John Boyd***
  - ***USGS Satellite System Initiatives Program Manager***
  - ***Boyd@usgs.gov*** ***605-594-6163***
- ***User Interface***
  - ***Darla Duval***
  - ***Raytheon ITSS***
  - ***DDuval@usgs.gov*** ***605-594-6993***