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Beyond ASTER: Future VNIR-SWIR and TIR Hyperspectral Instruments

Michael Abrams
Jet Propulsion Laboratory, California Institute of Technology

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Outline of Presentation

- Current scanners
- Ready scanners
- Future scanners

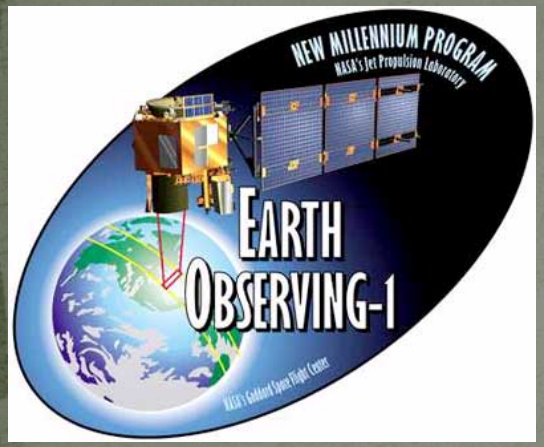
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Current Scanners

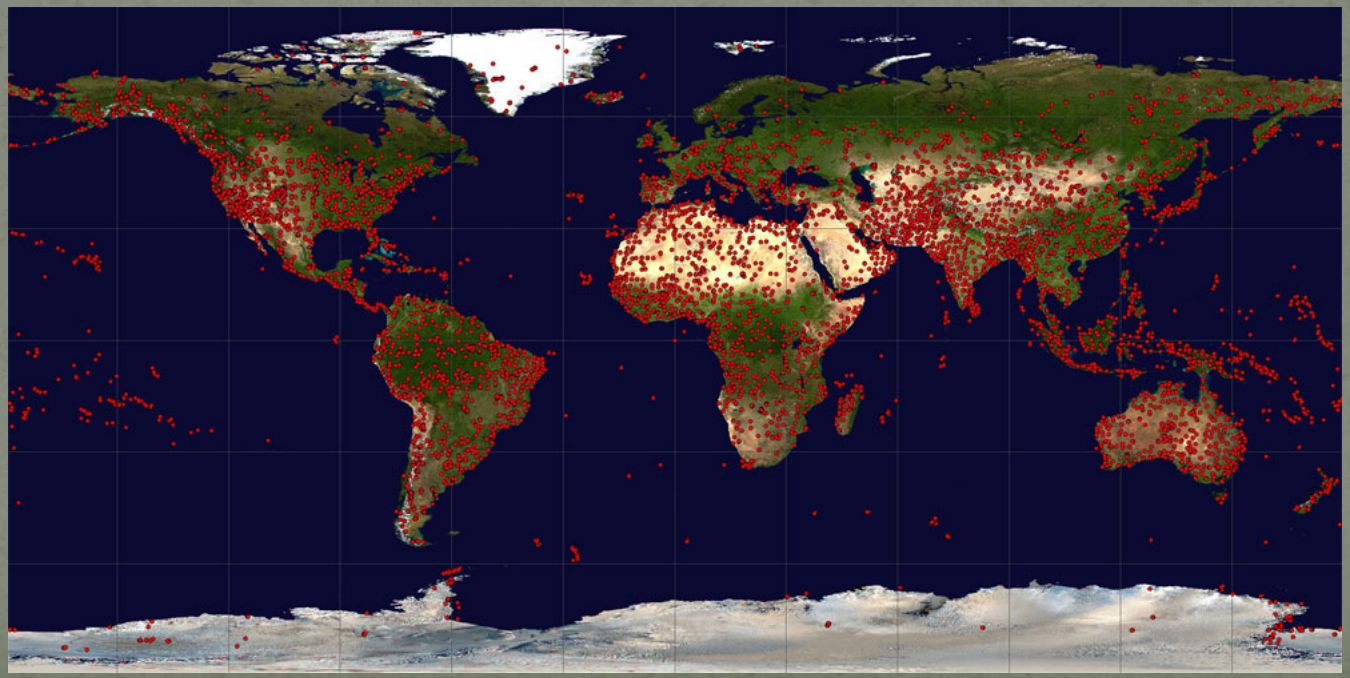
Sensor	**Hyperion**	**CHRIS**	**HySI**	**HJ-1A**	**HICO**
Country and Organization	USA NASA	UK ESA	India ISRO	China CAST	USA NASA/ONR
GSD (m)	30	17/34	506	100	90
Swath at Nadir (km)	7.65	13 (nominal)	129.5	≥50	42
Wavelength Coverage (nm)	357-2576	400-1050	400 - 950	450 - 950	353 - 1081
Number of Bands	242	18/37/6	64	110 - 128	128
Spectral Res. (nm @ FWHM)	10	5.6-32.9	~ 10	5	5.7
Launch Date	2000	2001	2008	2008	2009

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Hyperion

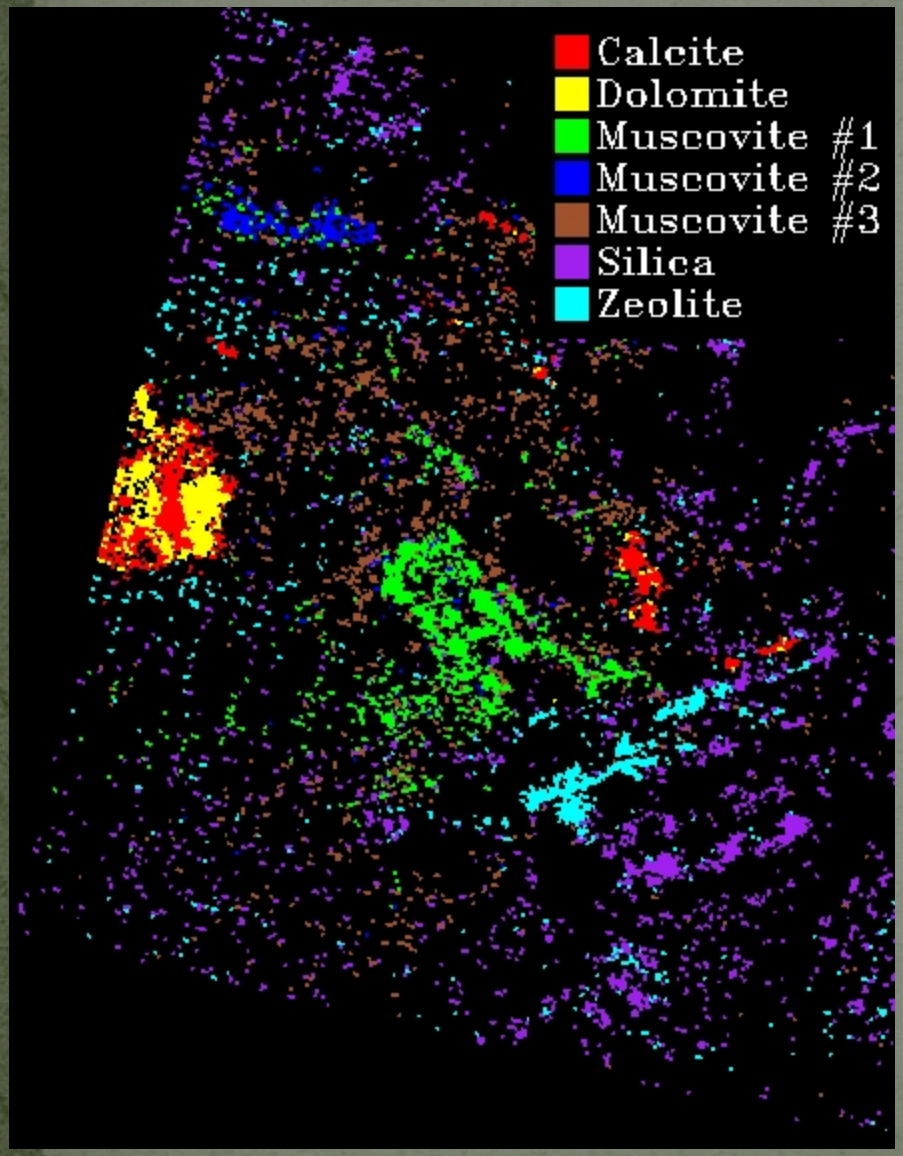


Hyperion operates on NASA's EO-1 spacecraft since 2000. It is a VSWIR hyperspectral scanner, accompanying the ALI multispectral instrument. Hyperion was a technology demonstration, explaining its 7.5 km swath width, and very limited data acquisition capability. Over 11 years, numerous scenes have been acquired, and are available free to users. EO-1 has run out of fuel, and will stop acquiring data soon.

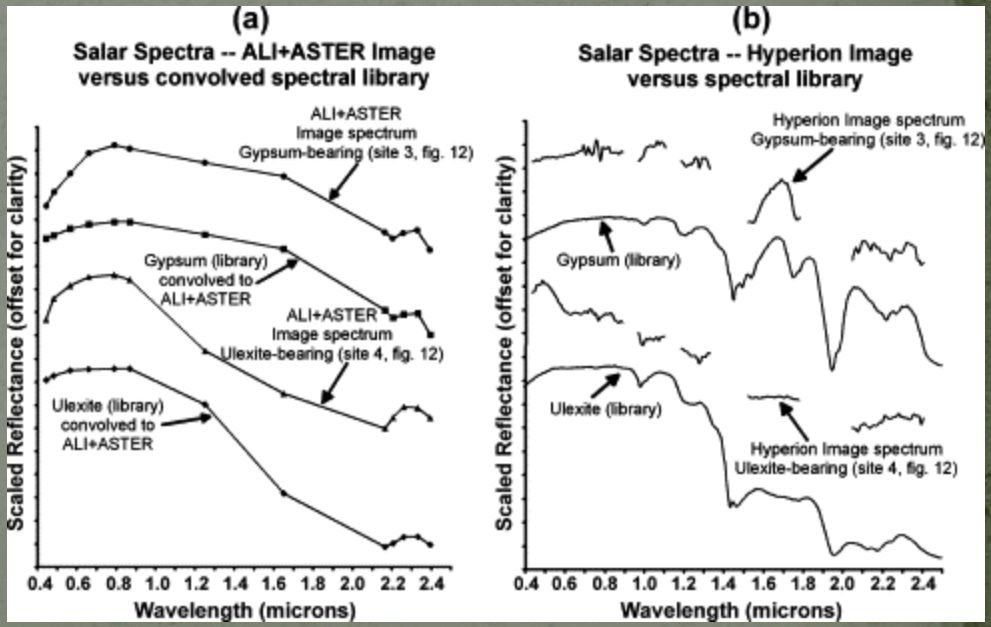


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Hyperion



An example of Hyperion's mineral mapping capability relying on full spectrum hyperspectral imaging from 0.4 to 2.45 μm.



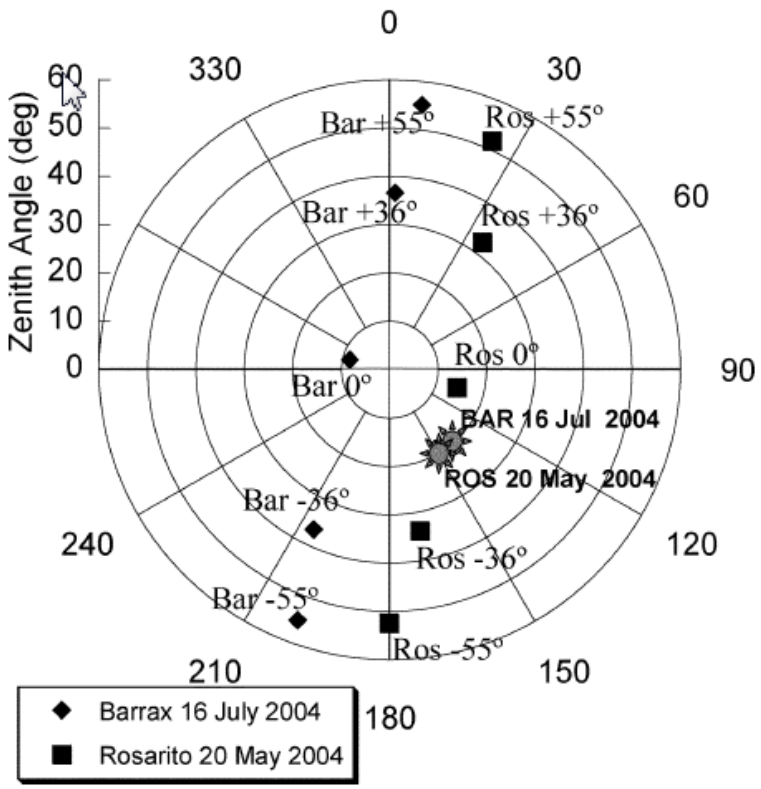
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Current Scanners

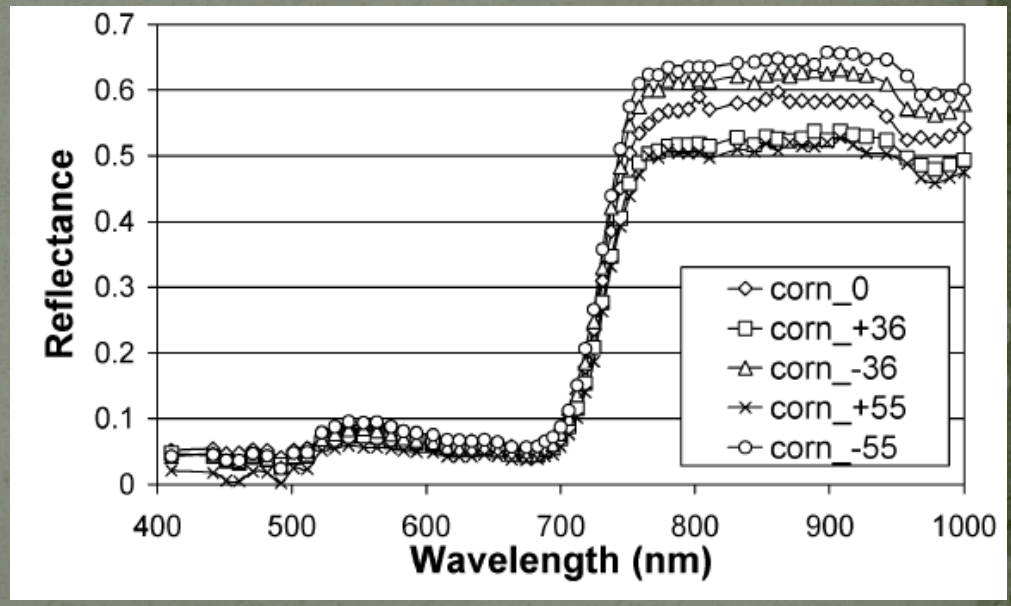
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CHRIS
Compact High Resolution Imaging Spectometer on ESA's PROBA platform



CHRIS acquires 13 x 13 km images with 5 different viewing angles for BRDF studies.



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CHRIS

All CHRIS data are available through ESA's online EOLI catalogue.

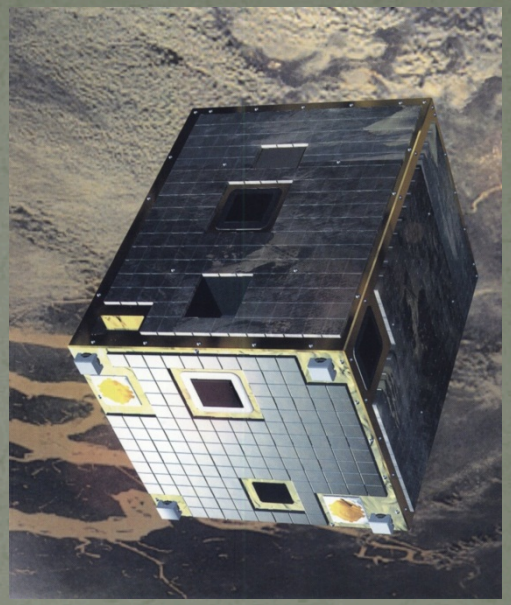
MODE 1: Full swath width, 62 spectral bands, 773nm / 1036nm, nadir ground sampling distance 34m @ 556km

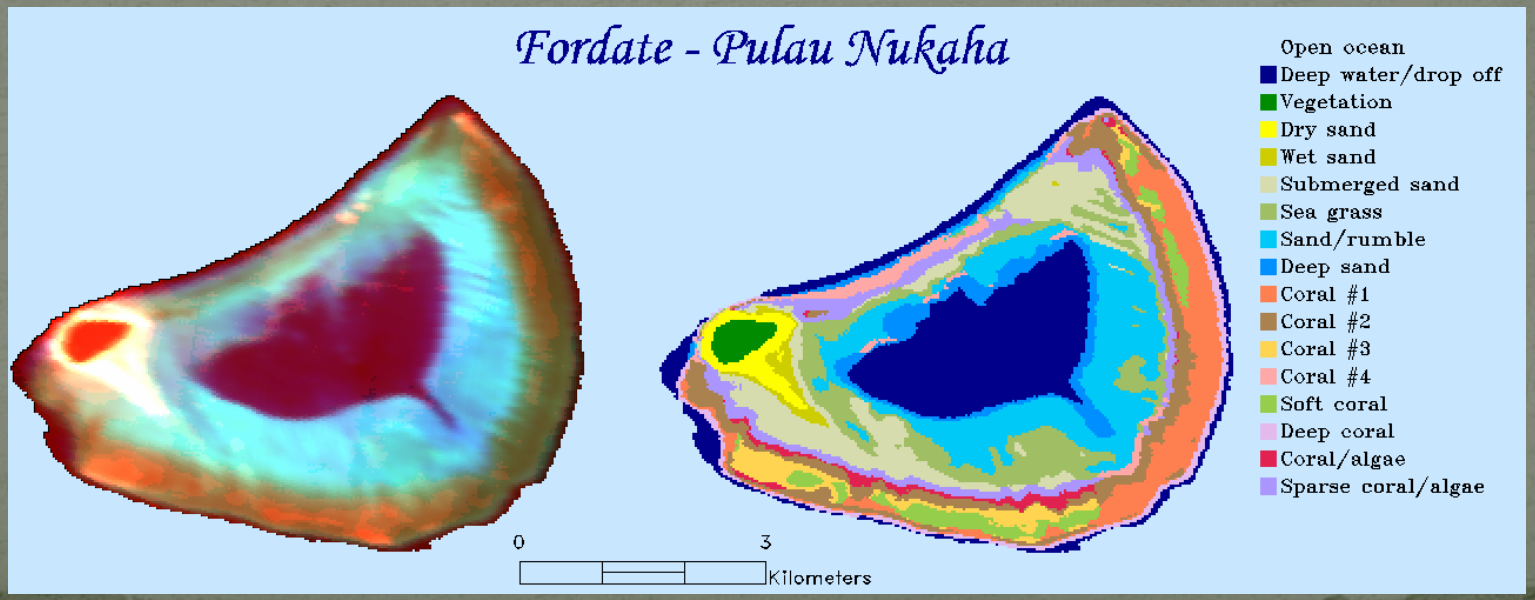
MODE 2 WATER BANDS: Full swath width, 18 spectral bands, nadir ground sampling distance 17m @ 556km

MODE 3 LAND CHANNELS: Full swath width, 18 spectral bands, nadir ground sampling distance 17m @ 556km

MODE 4 CHLOROPHYL BAND SET: Full swath width, 18 spectral bands, nadir ground sampling distance 17m @ 556km

MODE 5 LAND CHANNELS: Half swath width, 37 spectral bands, nadir ground sampling distance 17m @ 556km





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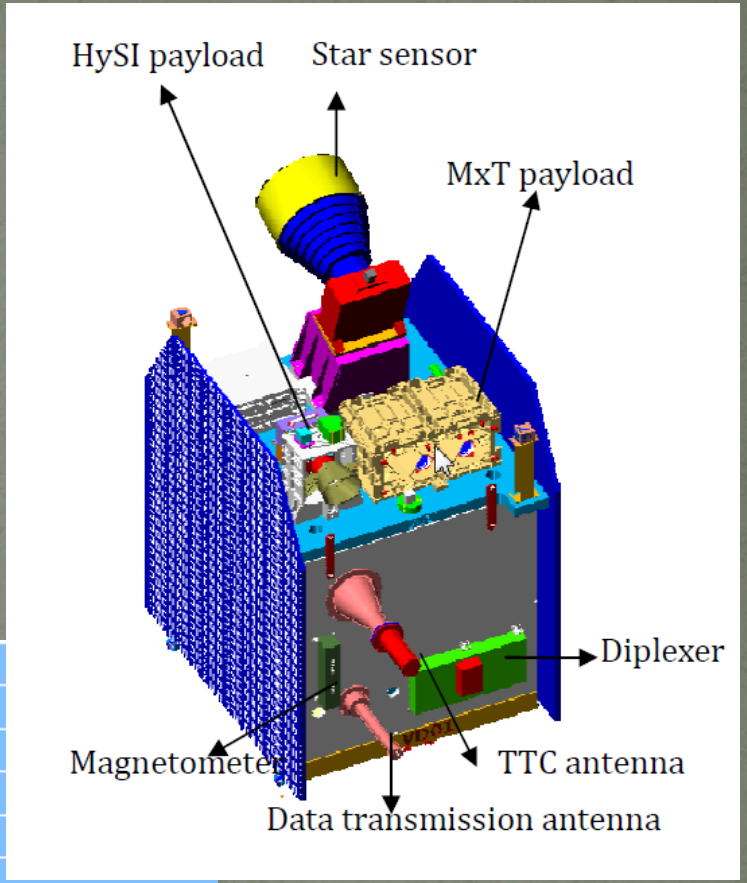
Current Scanners

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HySI

HySI (Hyperspectral camera), is one of two instruments on IMS-1 (Indian Mini Satellite-1), previously called TWSat (Third World Satellite), a small earth observing satellite developed by Indian Space Research Organization (ISRO). It has about 500m IFOV and 129 km swath. Data are made available to developing countries.



Nation:	India
Type / Application:	Earth Observing
Operator:	ISRO
Contractors:	ISRO
Equipment:	
Configuration:	Microsatellite-SSB (SSB-2)
Propulsion:	?
Power:	2 deployable solar arrays, batteries
Lifetime:	2 years
Mass:	83 kg
Orbit:	630 km × 630 km, 97.9°

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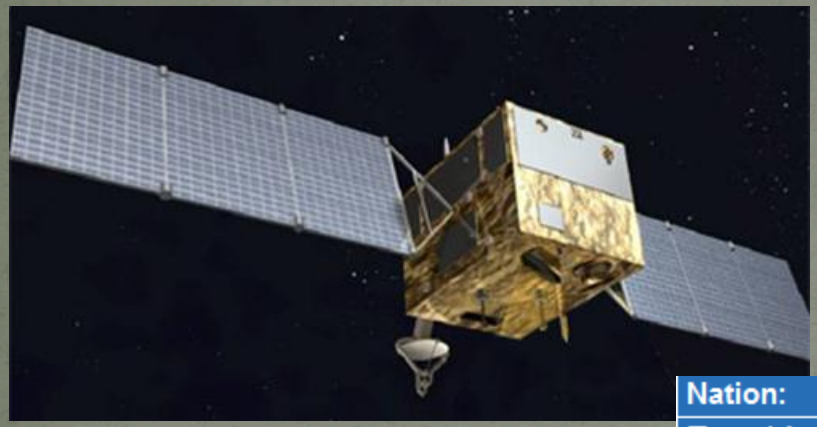
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HJ-1A
Huan-Jing (=Environment) Constellation

HJ-1A is also the Small Multi-Mission Satellite (SMMS) of Asia Pacific Space Cooperation Organization (APSCO) and it will be the important data resources of APSCO space application. SMMS is a joint venture payload between China, Iran, South Korea, Mongolia, Pakistan, Thailand and Bangladesh under the Asian-Pacific organization.



Nation:	China
Type / Application:	Earth observation
Operator:	CAST
Contractors:	DFH Satellite Co. Ltd of CAST
Equipment:	
Configuration:	CAST968B Bus
Propulsion:	
Power:	2 deployable solar arrays, batteries
Lifetime:	
Mass:	
Orbit:	

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HJ-1A

Fourier Transform hyperspectral imager

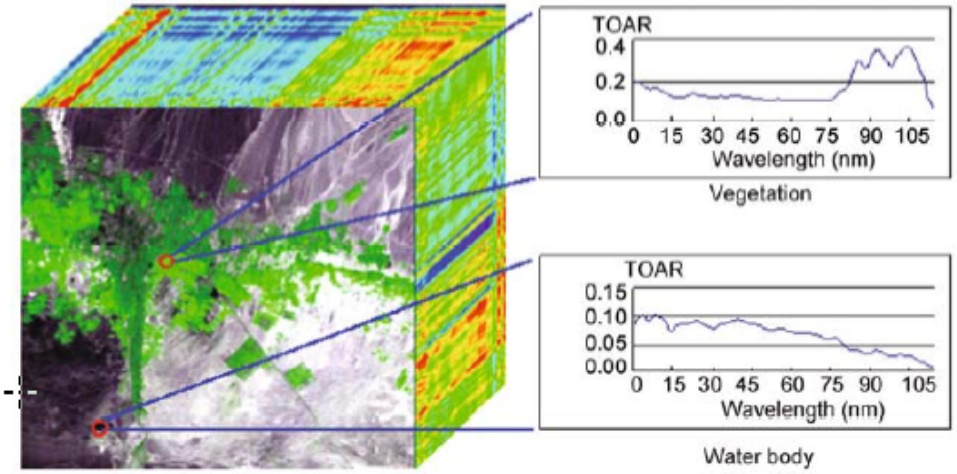


Figure 3 First orbit hyperspectral image of HJ-1A.

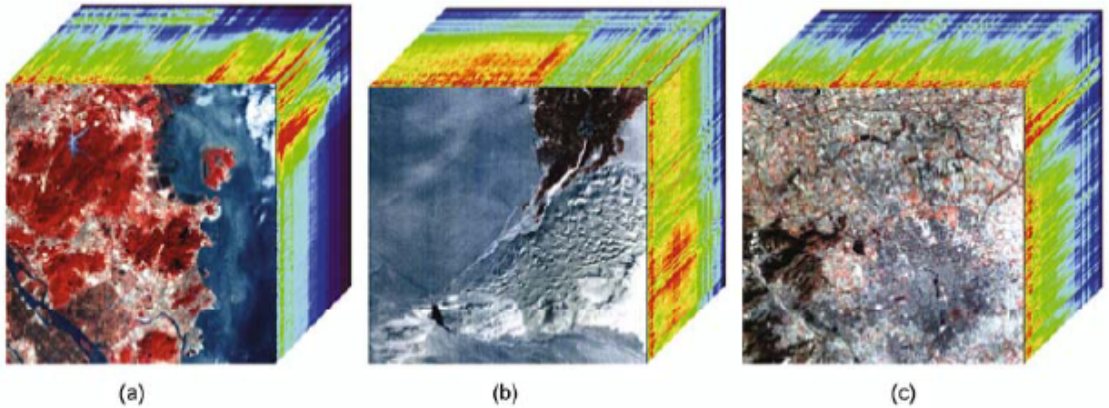


Figure 4 HJ-1A hyperspectral image cubes.

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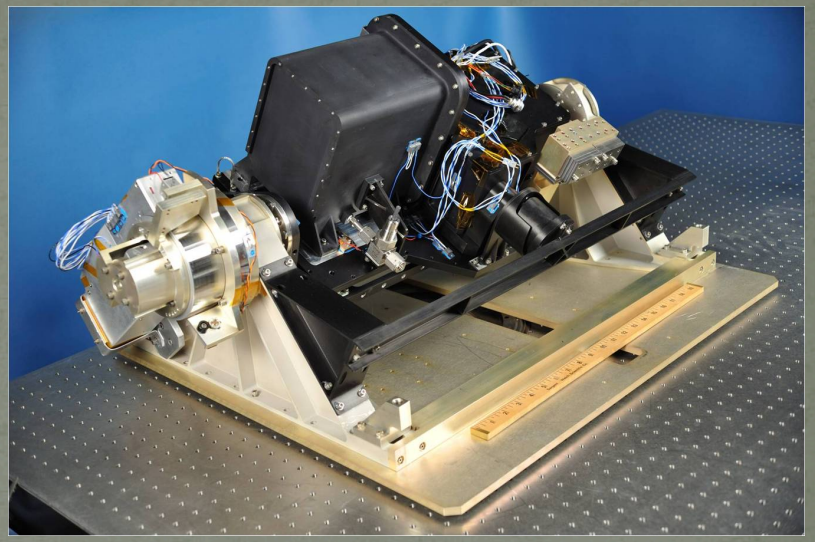
Current Scanners

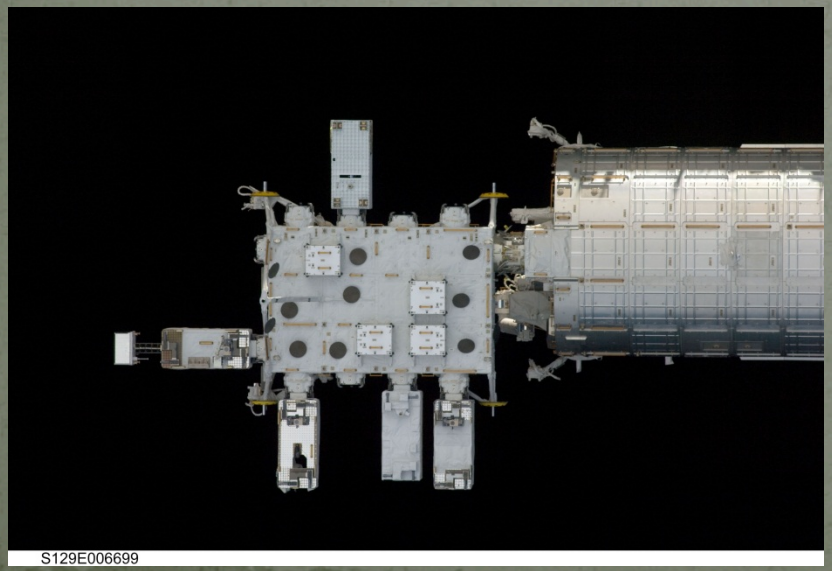
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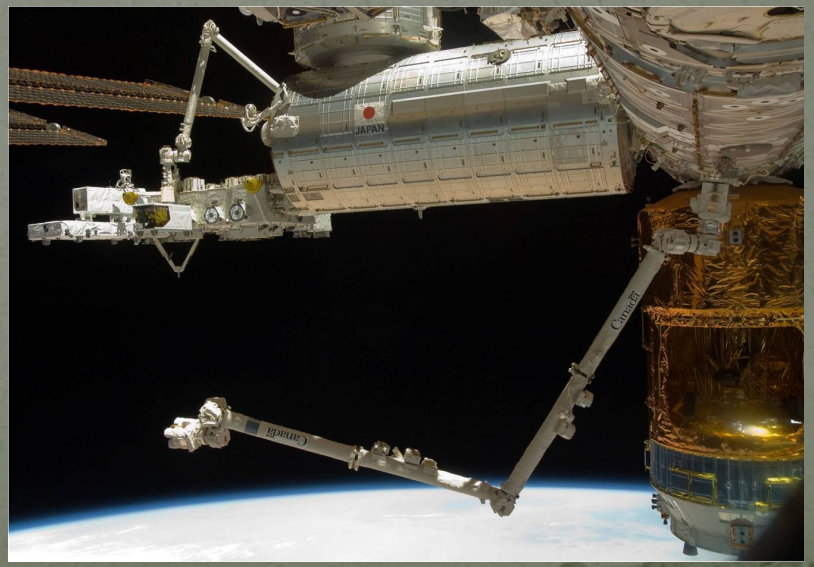
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HICO
Hyperspectral Imager for the Coastal Ocean

HICO is operated on the Space Station by the US NASA and Navy. The data system is done by Oregon State University. HICO is designed for ocean observations







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HICO
Hyperspectral Imager for the Coastal Ocean



HICO Home

- HICO
  - Design & Heritage
  - Calibration
  - Targets
  - Orbit
- Meet the Team
- Meetings
- Publications & Presentations
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Log In

- Become a HICO Data User

Data

- Search Data
- Schedule
- Data characteristics
- Working with the data
- How to request data
- Subscribe
- Request New Target

Image Galleries

Current Projects

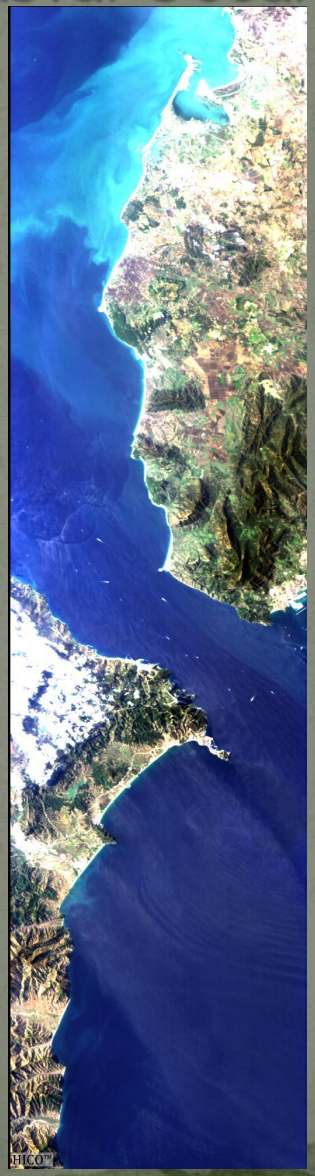
Targets

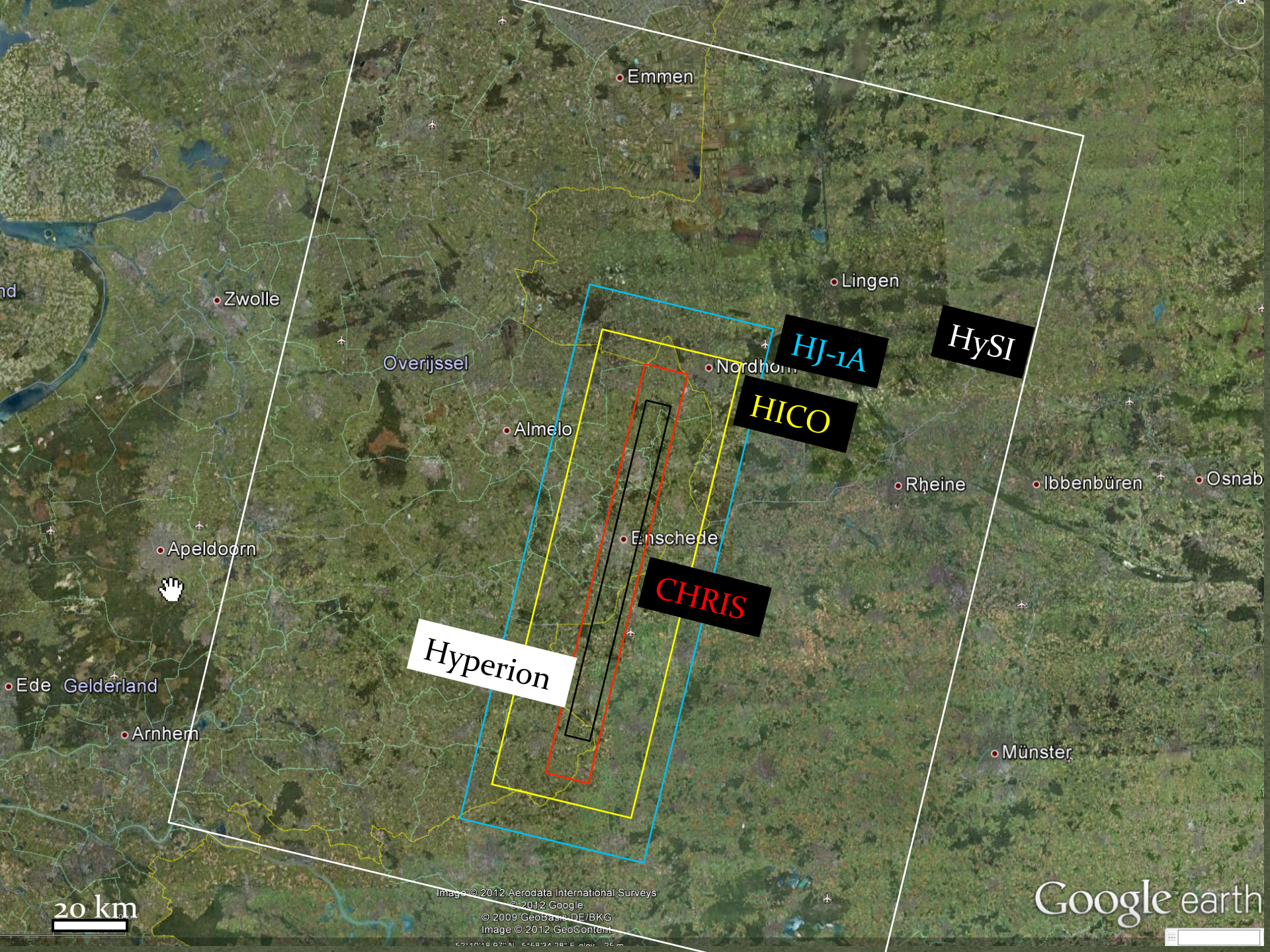
Targets collected by HICO and distributed through this website are shown below (Google Earth plugin required). Alternatively, the targets may be viewed as a list of target names.

Please see below for more information about the image.



Each target covers an area 50 km wide by 200 km long. The target areas are shown as rectangles on the




Emmen
Zwolle
Lingen
HJ-1A
HySI
Overijssel
Nordhorn
HICO
Almelo
Rheine
Ibbenbüren
Osnab
Enschede
Apeldoorn
CHRIS
Hyperion
Ede
Gelderland
Arnhem
Münster
20 km
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Spectral Coverage

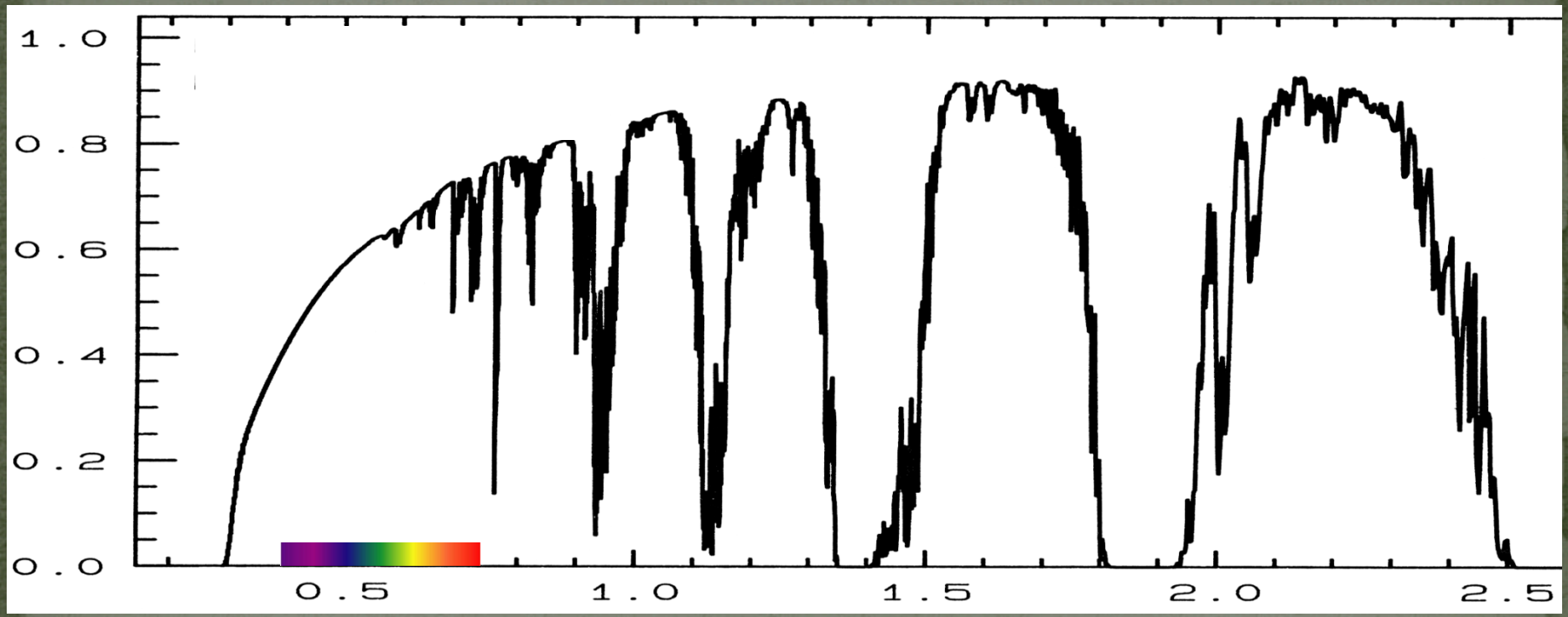
HJ-1A

HySI

Chris

HICO

Hyperion



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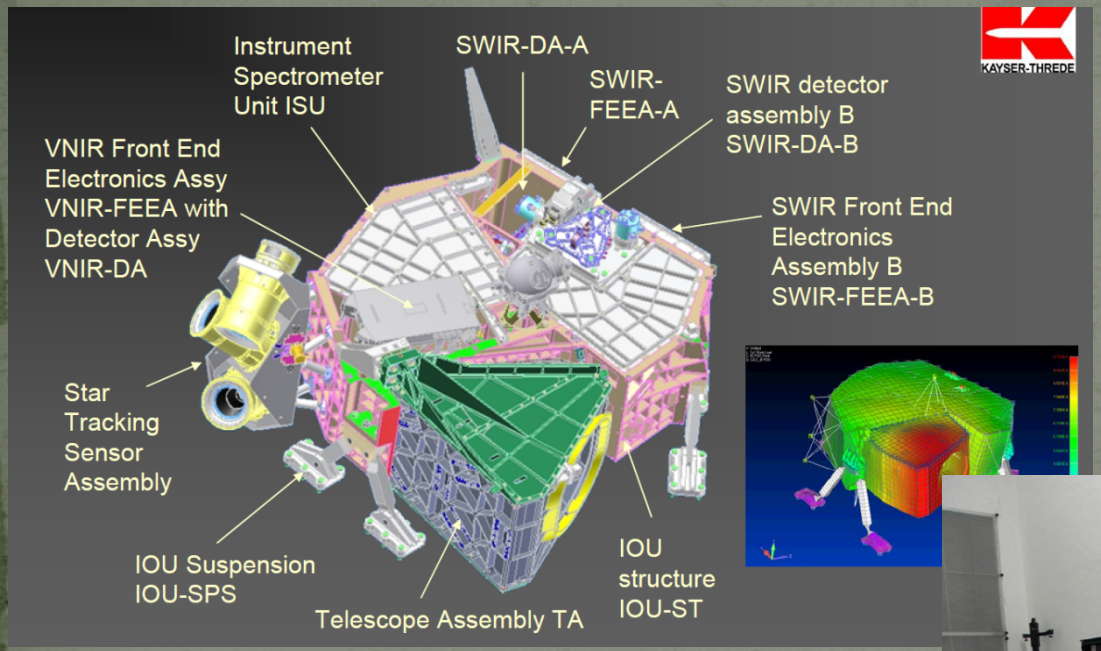
Ready Scanners

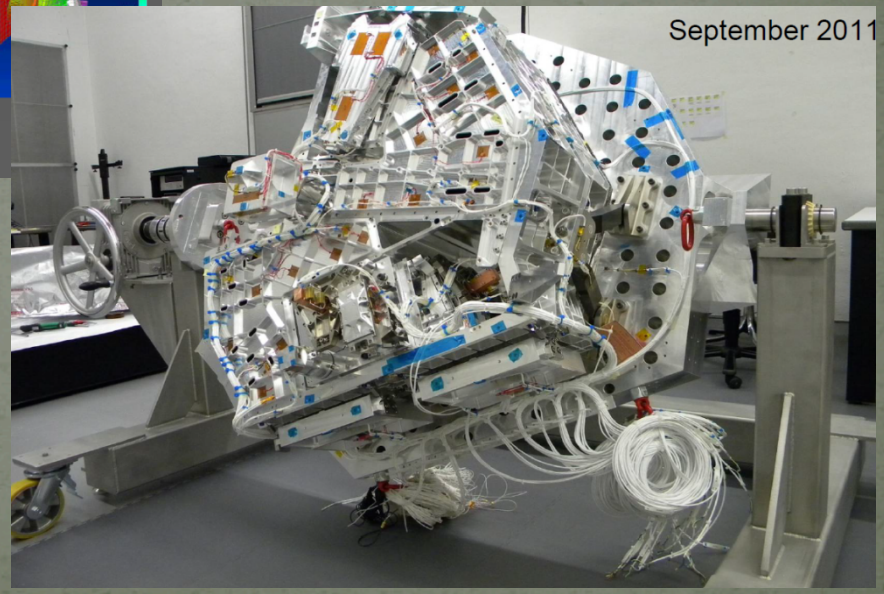
Sensor	EnMAP	PRISMA	MSMI
Country and Organization	Germany GFZ/DLR	Italy ASI	S. Africa SunSpace
GSD (m)	30	30	~15
Swath at Nadir (km)	30	30	~15
Wavelength Coverage (nm)	420 - 2450	400 - 2500	440 - 2350
Number of Bands	218	237	200
Spectral Res. (nm @ FWHM)	5/10 VNIR 10 SWIR	~12	10
Launch Date	2017	2017	?

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EnMAP Hyperspectral Imager

ENMAP

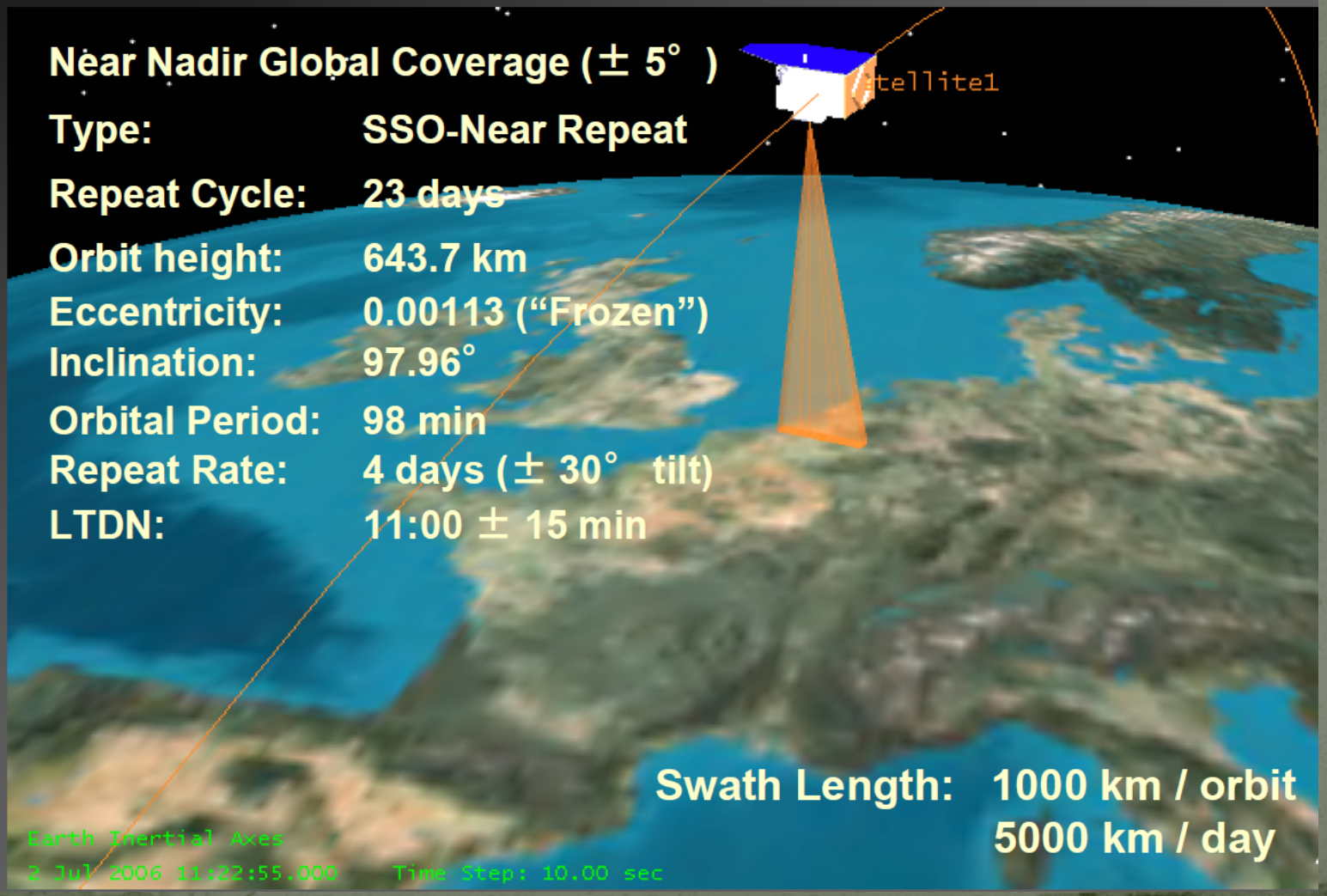




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ENMAP

Main Orbit Parameters



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Ready Scanners

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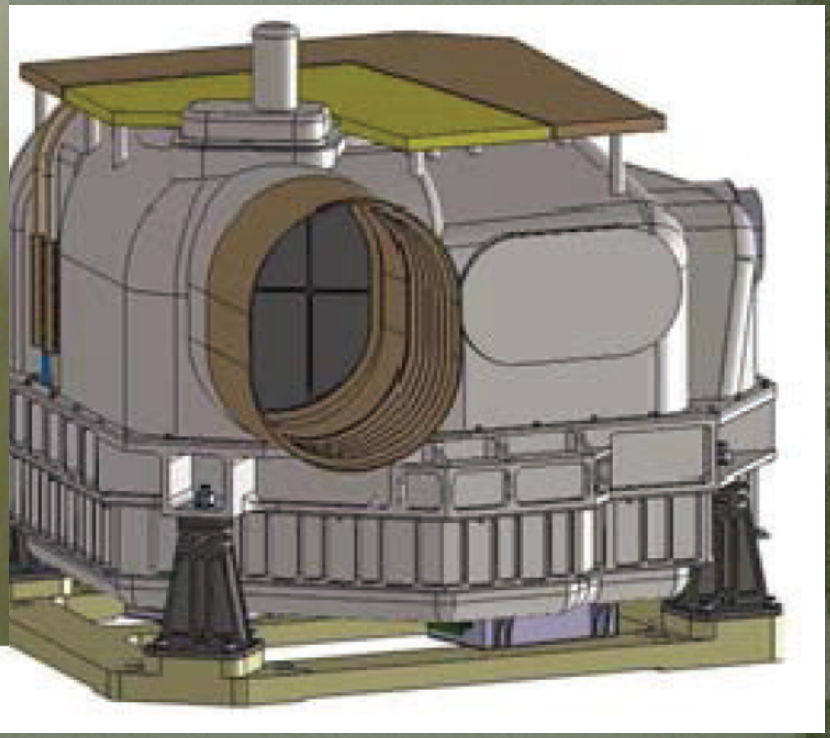
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PRISMA

Italian Space Agency: ~2015 launch(?)







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PRISMA
Italian Space Agency: ~2016 launch(?)

1. Development of algorithms and products for applications in agriculture and land monitoring supporting
the PRISMA mission (to be realised by CNR IMAA)
2. Synergic use of PRISMA products with high spatial resolution meteo-chimical simulation and ground
validation (to be realised by CETEMPS)
3. hyperspectral system analysis for integrated geophysical applications (to be realised by INGV)
4. advanced methods for analysis, integration and optimization of level 1 and level 2 PRISMA products (to
be realised by IFAC CNR)
5. Coasts and Lake Assessment and Monitoring by PRISMA HYperspectral Mission (to be realised by
ISMAR CNR).

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Ready Scanners

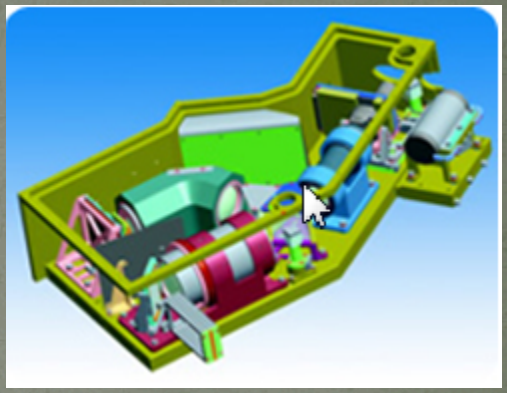
Multi-Sensor Microsatellite Imager (MSMI)

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MSMI

Multi-Sensor Microsatellite Imager (*MSMI*)



Optical SpectroMeter Unit (OSMU) is a hyperspectral imaging spectrometer integrated in a South-African Multi-Sensor Microsatellite Imager (MSMI) onboard of the second generation SUNSAT satellite ZASat2. OSMU contains two spectral channels: one in the visible and one in the infrared range. It has a field of view of 1,25° imaged on a detector of 1000 by 400 pixels. About 200 spectral bands are recorded in the wavelength area between 350 and 2350nm, with a spectral resolution of 5-14nm and at a spatial ground resolution of 15m (seen from height of 600km).

South Africa will provide the satellite bus for the first – indeed, probably for both – of the satellites in the recently announced India Brazil South Africa Dialogue Forum (Ibsa) satellite programme.

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Planned Scanners

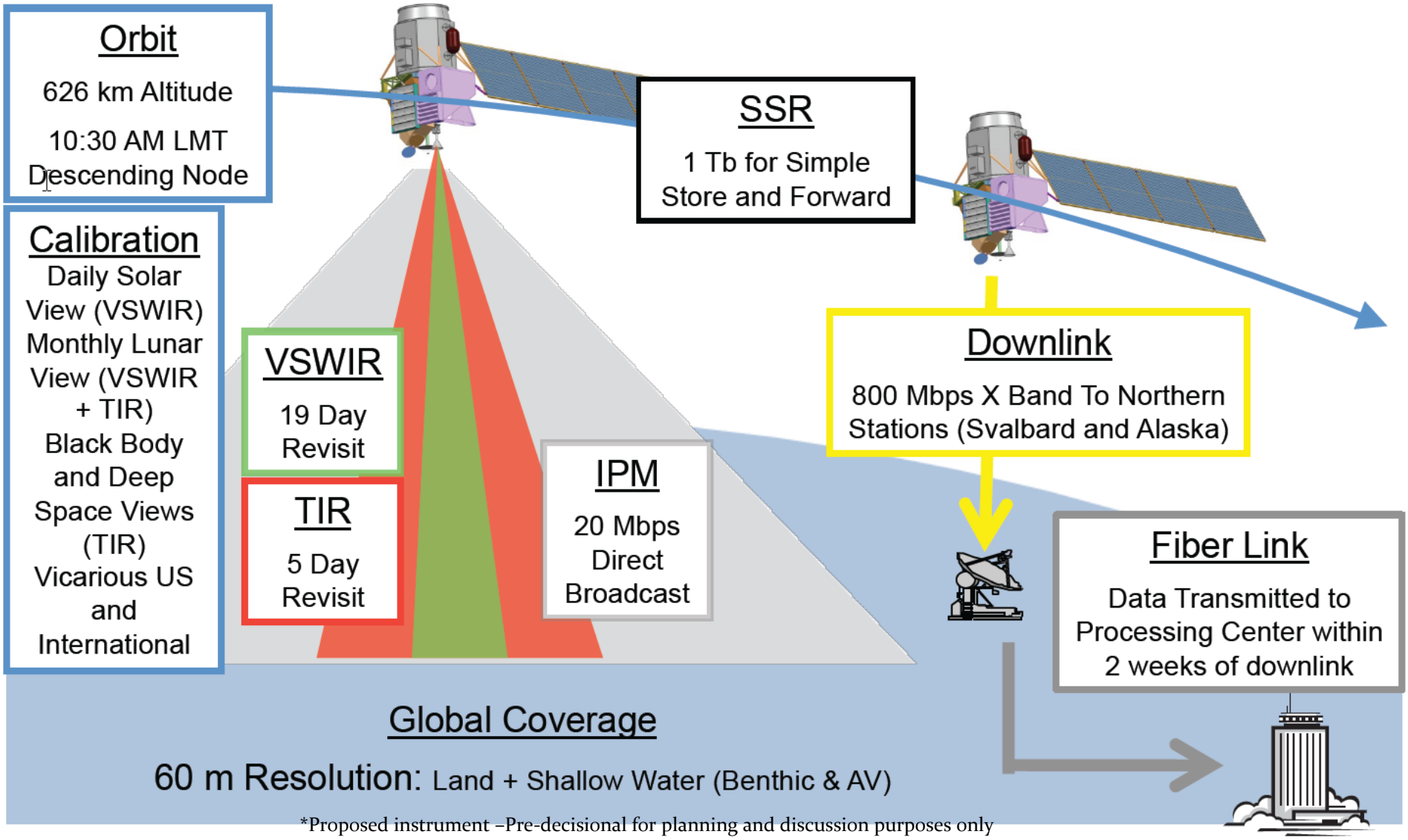
Sensor	HyspIRI*	HISUI-ALOS-3	HYPXIM CA
Country and Organization	USA JPL, NASA	Japan METI	France CNES
GSD (m)	60	30	15
Swath at nadir (km)	145	15	30
Wavelength Coverage (nm)	380 – 2500	400 - 2500	400 - 2500
Number of bands	> 200	185	> 200
Spectral Res. (nm @ FWHM)	10	10 VNIR 12 SWIR	≤ 14 VIS ≤ 10 NIR/SWIR
Launch Date	Baseline > 2020	>2016	~ 2019

*Proposed instrument –Pre-decisional for planning and discussion purposes only

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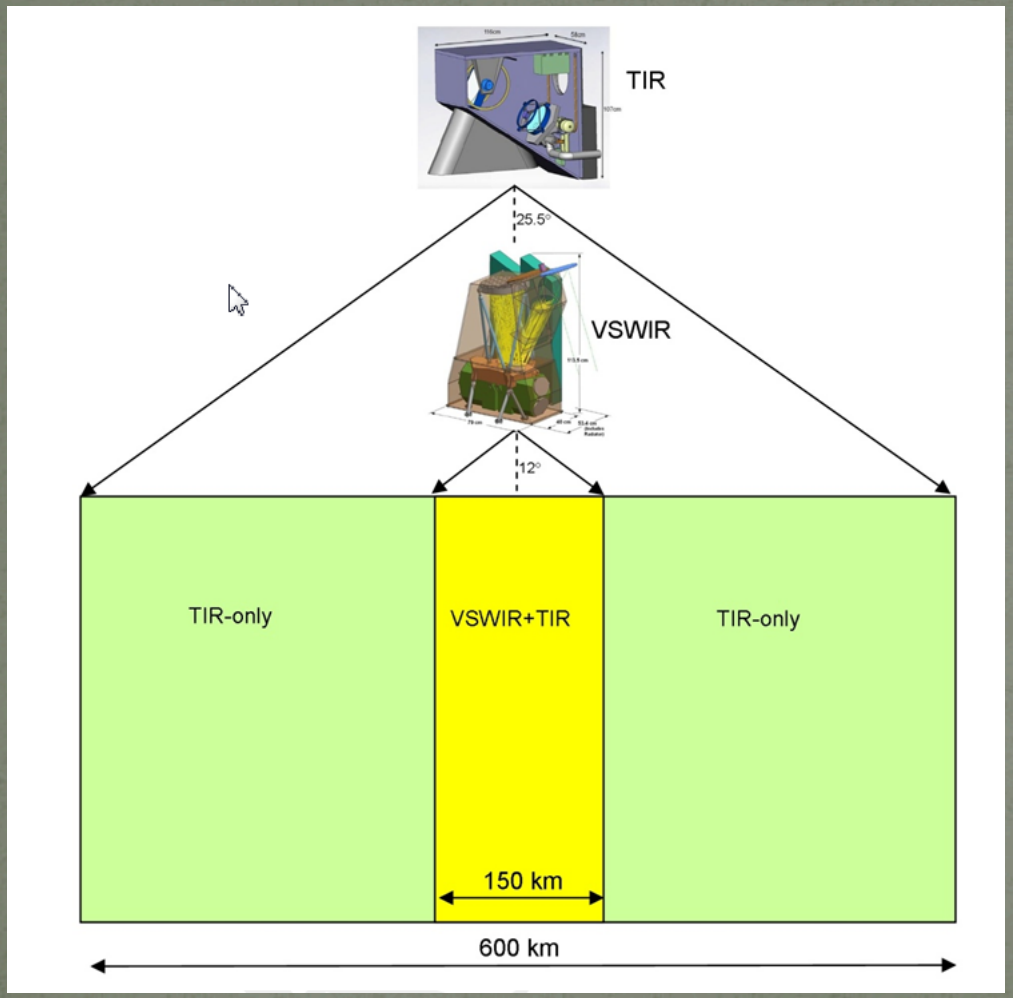
Hyperspectral Infrared Imager - HyspIRI*

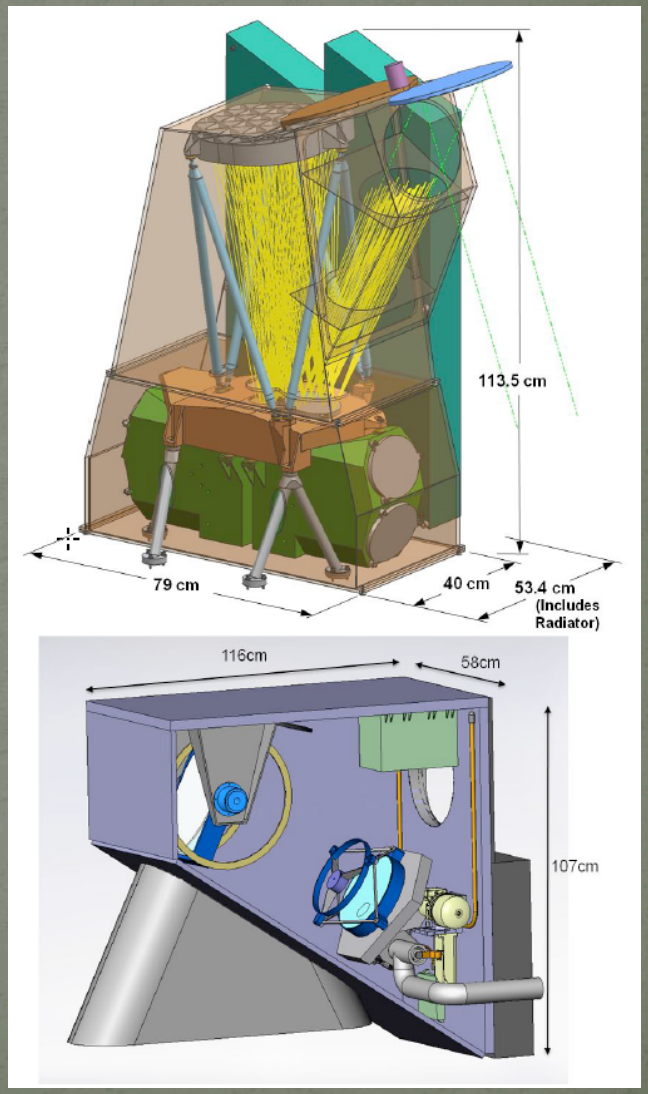


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Hyperspectral Infrared Imager - HyspIRI*





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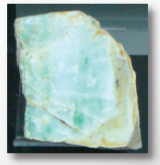
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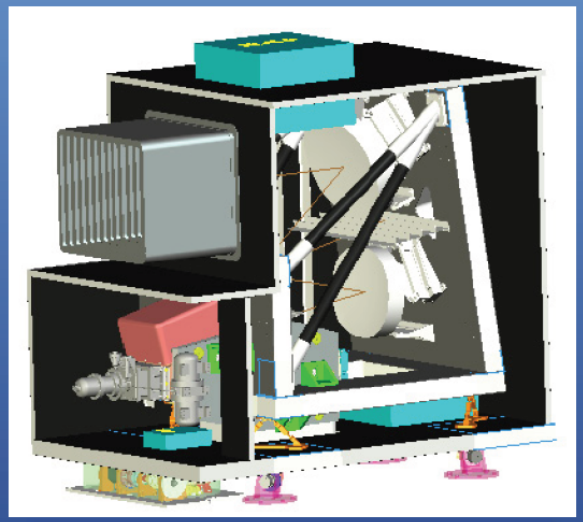


JAXA's ALOS-3 and HISUI (Hyperspectral Imaging Suite)

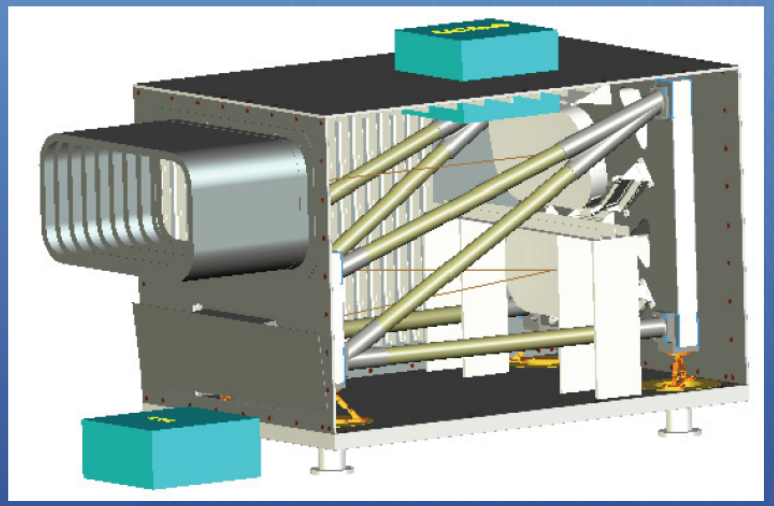




HISUI



Hyperspectral Imager



Multispectral Imager

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HISUI

Parameter		Requirement
Spatial Resolution and Swath Width		30 m and 30 km
Spectral	Bands	185 (VNIR:57 SWIR:128)
	Range	0.4 - 2.5 μm VNIR:0.4-0.97 μm SWIR:0.9-2.5 μm
	Resolution	10 nm (VNIR), 12.5 nm (SWIR)
Signal to Noise Ratio (30% albedo)		≥ 450 @620 nm ≥ 300 @2100 nm
MTF		≥ 0.2
Dynamic Range		≥ 10 bits (current design=12bit)
Data Compression		Lossless (70%)
Pointing Capability		≈ ±3 ° (±30 km)

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Planned Scanners

Sensor	HyspIRI *	HISUI-ALOS-3	HYPXIM CA
Country and Organization	USA JPL, NASA	Japan METI	France CNES
GSD (m)	60	30	15
Swath at nadir (km)	145	15	30
Wavelength Coverage (nm)	380 – 2500	400 - 2500	400 - 2500
Number of bands	> 200	185	> 200
Spectral Res. (nm @ FWHM)	10	10 VNIR 12 SWIR	≤ 14 VIS ≤ 10 NIR/SWIR
Launch Date	Baseline > 2020	>2016	~ 2019

*Proposed instrument –Pre-decisional for planning and discussion purposes only

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HYPXIM

- France's CNES sponsored a mission study to investigate hyperspectral scanners for civilian and military applications
- This resulted in plans for three instrument concepts: HYPXIM-C, HYPXIM-CA and HYPXIM-P Hyper-performance

- HYPXIM-C: 2 satellites, 15 km swath, 15 m resolution, 200 kg weight
- HYPXIM-CA: 30 x 30 km images, 60 kg weight

- HYPXIM-P: 16 km swath, 3-day revisit with pointing, 8 m resolution; 40 bands in TIR with 100 m resolution

SHALOM

Spaceborne Hyperspectral Applicative Land and Ocean Mission

SHALOM is a cooperation between the Italian Space Agency ASI and the Israeli Space Agency ISA based on a satellite carrying a Hyper-spectral Imaging Spectrometer (0,4-2.5 microns), an advanced PRISMA type, and a satellite carrying an infrared camera (8-12 microns).

Phase A study completed early 2013.

Panchromatic

- Swath: 30 km
- Spatial GSD: <2.5 m
- Spectral ranges: 400-700 nm
- SNR = 240

Hyperspectral

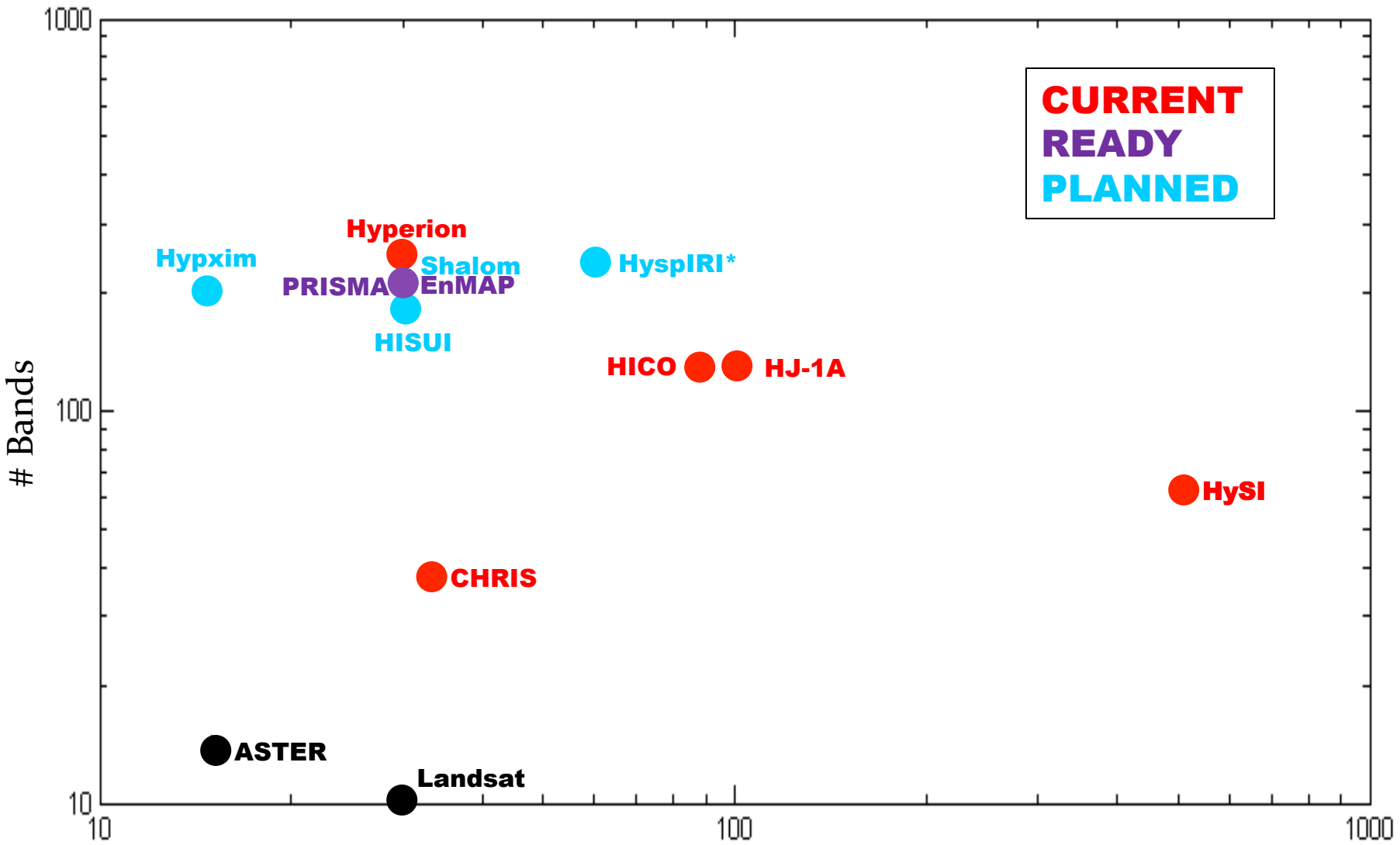
- Swath: 30 km
- Spatial GSD: <\0 m
- Spectral ranges (contiguous spectrum):
  - VNIR: 400-1010 nm
  - SWIR: 920-2500 nm
- Spectral resolution: 10 nm
- SNR

  VNIR: 200 (400-1000 nm)
  600 (@650nm)

  SWIR: 200 (1000-1750 nm)
  400 (@1550nm)
  100 (1950-2350 nm)
  200 (@2100nm)

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IFOV vs Number Bands



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Spectral Coverage and Swath Width

	VNIR	SWIR	TIR	Swath
Landsat	4	2	1	180
ASTER	3	6	5	60
CHRIS	37			13
HYSI	64			130
Hyperion	85	135		7
HJ-1A	110			50
HICO	128			42
EnMAP	85	135		30
PRISMA	90	145		30
HISUI	85	100		15
HYPXIM-P	65	135	40	30
HyspIRI*	85	135	8	145/600
Shalom	90	145		30

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Instrument Lifetimes

