

Spectro-imagerie

Les missions internationales programmées et/ou à l'étude

V.Carrère

Missions spatiales programmées, par ordre chronologique :

- PRISMA (ASI) : Lancement prévu pour 2012?
- EnMAP (DLR) : Lancement prévu pour 2014

A l'étude :

HyspIRI (NASA) : pré-phase A

Autres :

Chine – Canada – Australie – Israël

Capteurs aéroportés :

APEX (Belgique + Suisse)

ARES (DLR)???

AVIRIS - NG

PRISMA – ASI (Italie)
(Precursore IperSpettrale delle Missione Operativa)

Lancement prévu en 2012 ?

OBJECTIFS :

Occupation des sols, agriculture, pollution, qualité des eaux côtières et terrestres, humidité des sols, cycle du carbone, etc.

Principales caractéristiques de la mission :

Spectro-imageur de type « pushbroom »

Résolution spatiale = 30 m

Orbite = 620 km

Trace au sol = 30 km

240 canaux

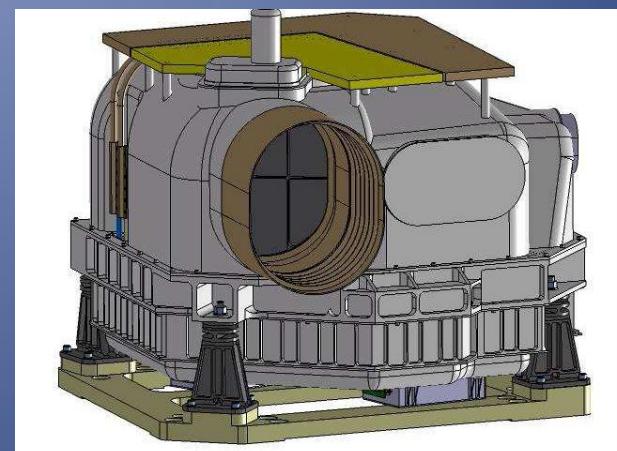
Résolution spectrale < 12 nm

[400 – 2500 nm] + PAN @ 5 m

SNR (30 % réflectance, SZA = 30°, TOA, mid-latitude summer)

> 200 VNIR –SWIR 1

> 100 SWIR 2



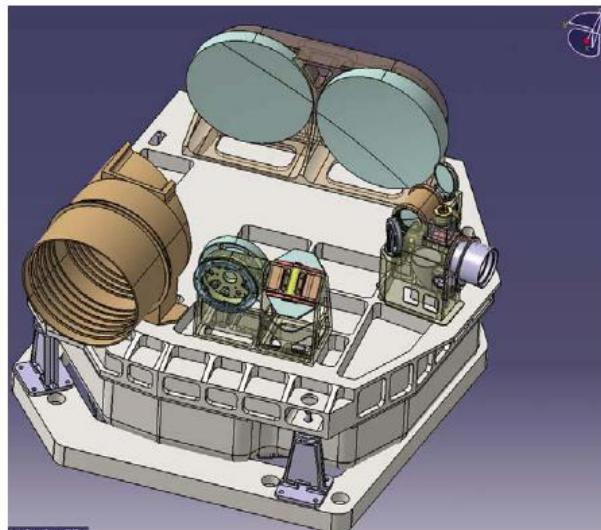


Figure 1. Hyperspectral and panchromatic optical head layout

	<i>VNIR channel</i>	<i>SWIR channel</i>	<i>PAN channel</i>
Spectral range (nm)	400-1010	920-2505	400-700
Spectral width (FWHM nm)	≤ 12	≤ 12	-
Swath width (Km)	30	30	30
Ground sample distance (m)	30	30	5
Spectral bands	66	171	1
S/N ratio	200:1 on 1.0-1.75 μm 400:1 @ 1.55 μm 600:1 @ 0.65 μm	200:1 on 0.4-1.0 μm 100:1 on 1.95-2.35 μm 200:1 @ 2.1 μm	240

Parameter	PRISMA
Volume (L x W x H)	770 x 590 x 780 mm
Weight	< 90 Kg
Average Power	< 110 W
Standby Power	< 50 W
Aperture	210 mm
IFOV	48.34 μrad
Crosstrack FOV	2.77 deg
Digitization	12 bit
Frame rate	230 Hz

Produits :

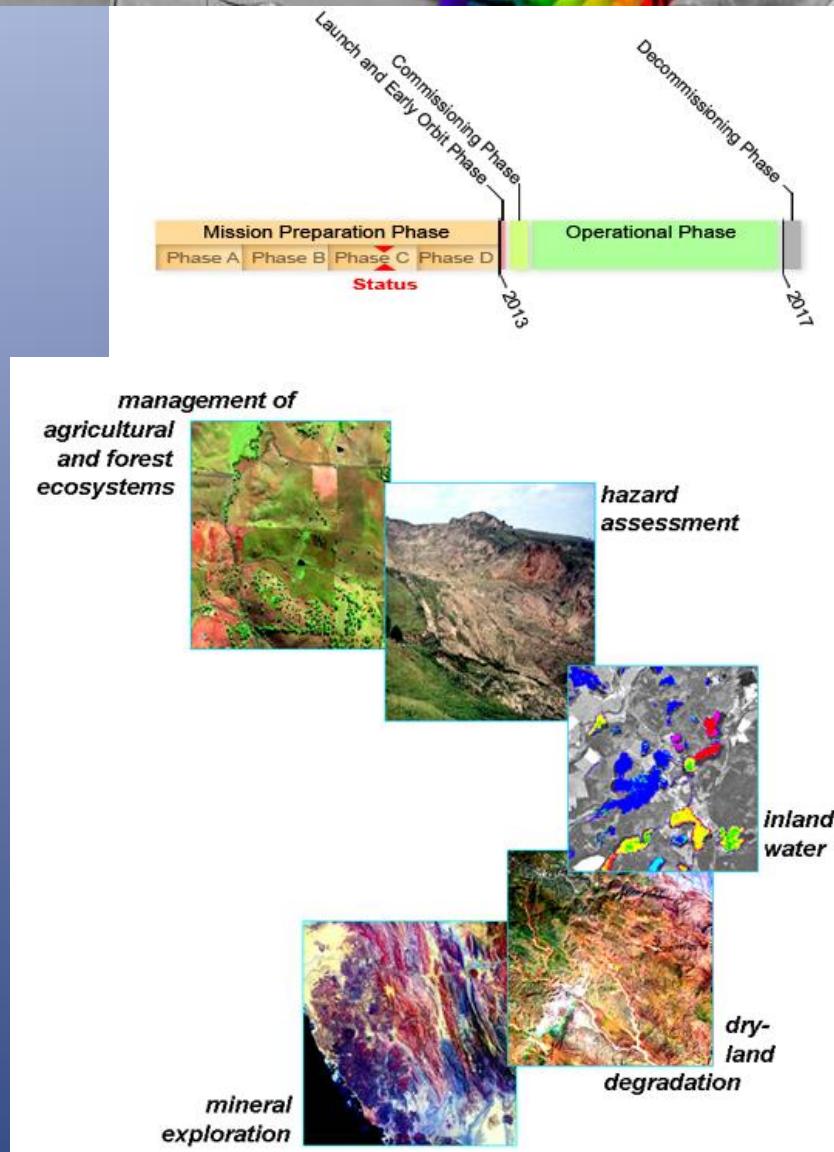
L1 = Luminance

L2 = Réflectance

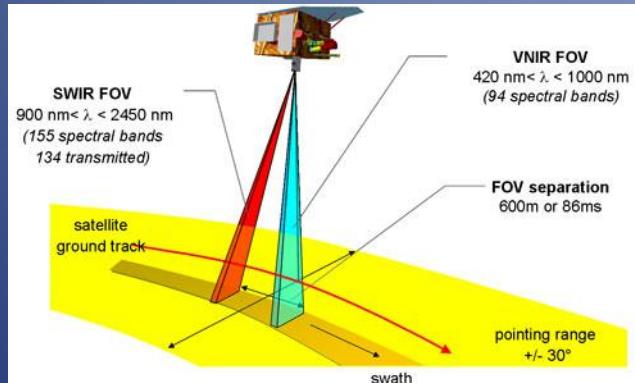
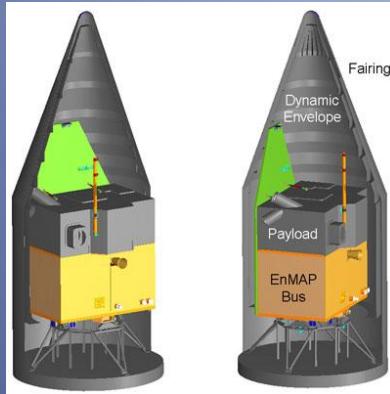
OBJECTIFS DE LA MISSION

DLR + GFZ Potsdam

- To provide high-spectral resolution observations of bio-geochemical and geophysical variables
- To observe and develop a wide range of **ecosystem parameters** encompassing **agriculture, forestry, soil/geological environments and coastal zones/inland waters**
- To enable the retrieval of presently undetectable, **quantitative diagnostic parameters** needed by the user community
- To provide high-quality calibrated data and data products to be used as **inputs for improved modeling and understanding of biospheric /geospheric processes**



CARACTÉRISTIQUES DE LA MISSION



EnMAP System Parameters	
Reference Altitude	653 km
Average Ground Speed	6,9 km / s
Swath Length	30 km
Datatake Capability	5000 km per day ; 1000 km per orbit 150.000 km ² per day
Geometric co-registration (VNIR – SWIR „Images“)	≤ 0.2 GSD (with data post-processing)
Overall EnMAP Pointing stability	< 5 % of a pixel (short term jitter)

EnMAP Satellite Design Features

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Mass at launch fuel budget

810 kg (incl. 80 kg margin)

46 kg hydrazine 1.50 m X 1.80 m X 3.00 m Al-sandwich panel concept with internal shear frame

5 years

25 years after lowering the perigee to 500 km
500m nadir

100m nadir

1.5m/4ms (bus only 0.3/4ms)

5 min for +30° (incl. high accuracy pointing stabilization)

31V nominal

Power System
solar panels (4.6 sqm) 800 W (EOL)

battery supply: Li-Ion cells, 2 modules 132 Ah
3-axis stabilised

sensors: startracker, sun-sensor,
magnetometer, gyroscope

navigation: GPS

actuators: reaction wheels, magnetique torquers
hydrazine blow-down system

thrust: 2 thrusters with 1 N each

propellant capacity: 46 kg hydrazine

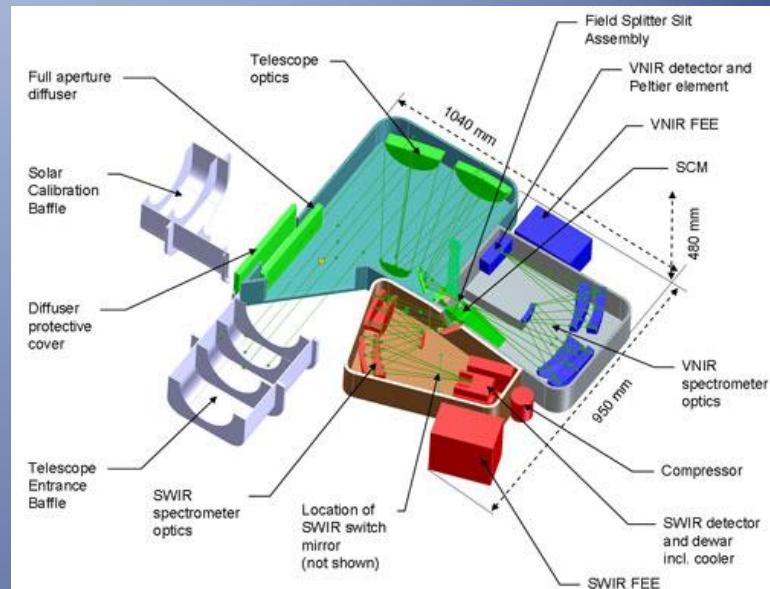
Power System

Attitude control system ACS

Orbit control system OCS

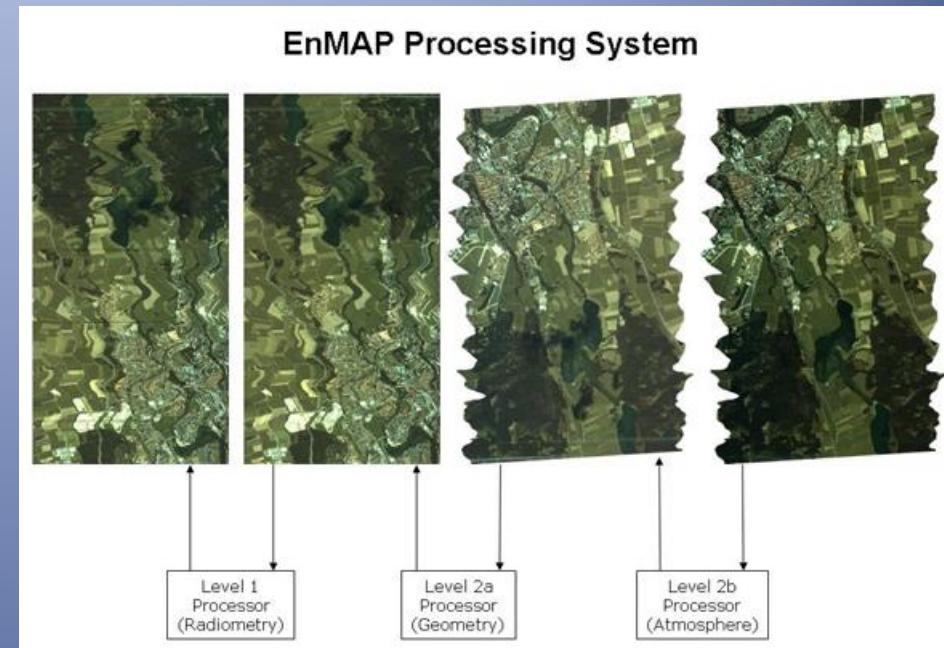
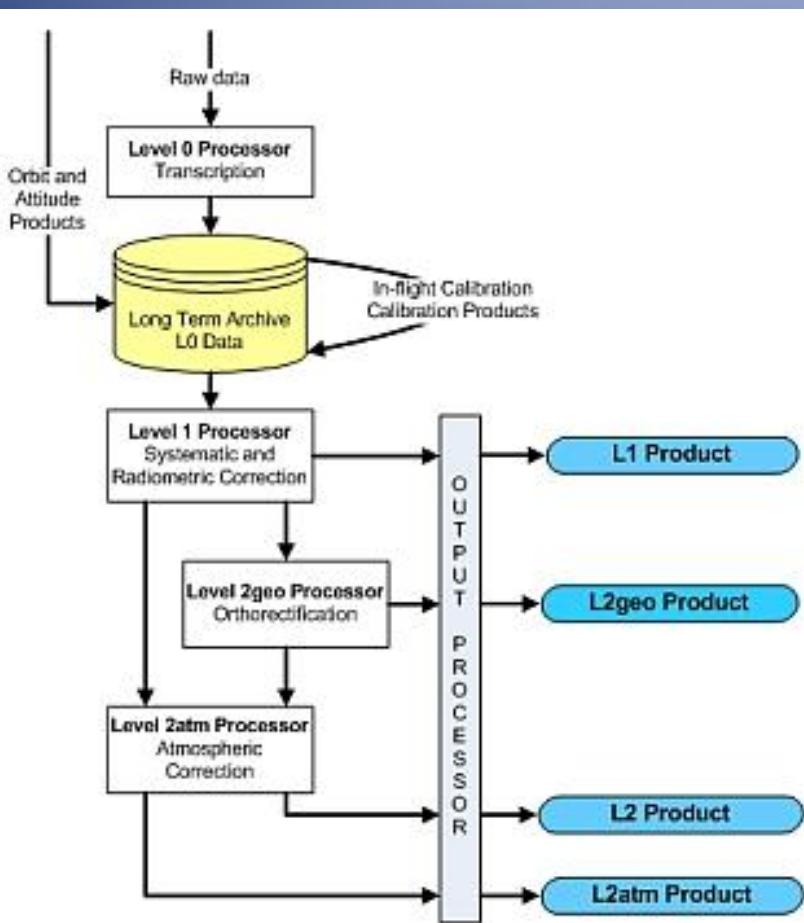
CARACTERISTIQUES DU CAPTEUR

EnMAP Instrument Parameters	
Instrument Type	Hyper spectral imager with two prism imaging spectrometers, Split FOV between VNIR and SWIR
Scanning method	push-broom, pointing capability up to $\pm 30^\circ$ off nadir across track
Telescope	Focal length: 522.4 mm Aperture: 174 mm in diameter F- Number F# 3.0 Type: TMA
Spectrometer slit size (both channels)	24 μ m x 24 mm
Swath width (nadir)	30 km (for the chosen orbit height of 653km) (equivalent to an FOV of 2.63 deg across track)
Geometric sampling distance (nadir), GSD	30 m x 30 m (@ $\sim 48^\circ$ northern latitude) (equivalent to an IFOV of 9.5 arcsec)
Integration time per GSD along track	Max. 4.4 ms, integration time is selectable by software from 1 ms to 4.4 ms (tbc)
System MTF on ground as measured from orbit	> 0.25 @ 60m across track > 0.16 @ 60m along track > 0.64 @ 240m across track > 0.62 @ 240m along track
Noise Equivalent Radiance at ref. radiance [mW/cm ² sr μ m]	VNIR (420-1000 nm): 0.005 SWIR I (900-1390 nm): 0.003 SWIR II (1480- 1760 nm): 0.003 SWIR III (1950-2450 nm): 0.001
SNR	VNIR: 500 @ 495nm, SWIR:150 @ 2200nm at ref. radiance



Radiometric calibration accuracy	5%
Radiometric stability	$\pm 2.5\%$ between two consecutive calibrations
Spectral accuracy / stability	< 0.5 nm
Polarisation sensitivity	< 5 %
Spectral smile and keystone	< 20% of a pixel
On board calibration	Full aperture diffuser; Integrated sphere with various calibration lamps; Shutter for dark measurements;
Instrument Mass	250 kg (with 20% margin)
Instrument Power Consumption	Standby : c.a. 170 W Peak (Calibration) : c. a. 221 W

TRAITEMENTS et PRODUITS



Level 1 - systematic and radiometric correction

Level 2geo - geometric correction

Level 2 - atmospheric correction with geometric correction

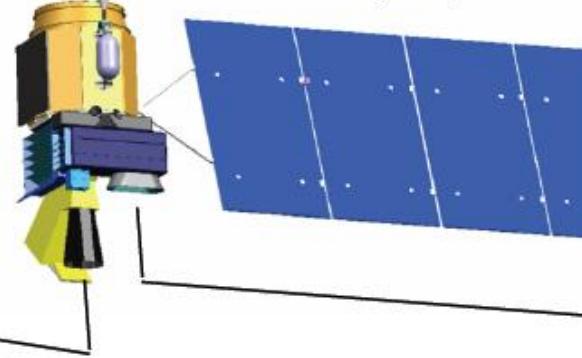
Level 2atm - atmospheric correction without geometric correction



NASA Decadal Survey HyspIRI

Visible ShortWave InfraRed (VSWIR) Imaging Spectrometer

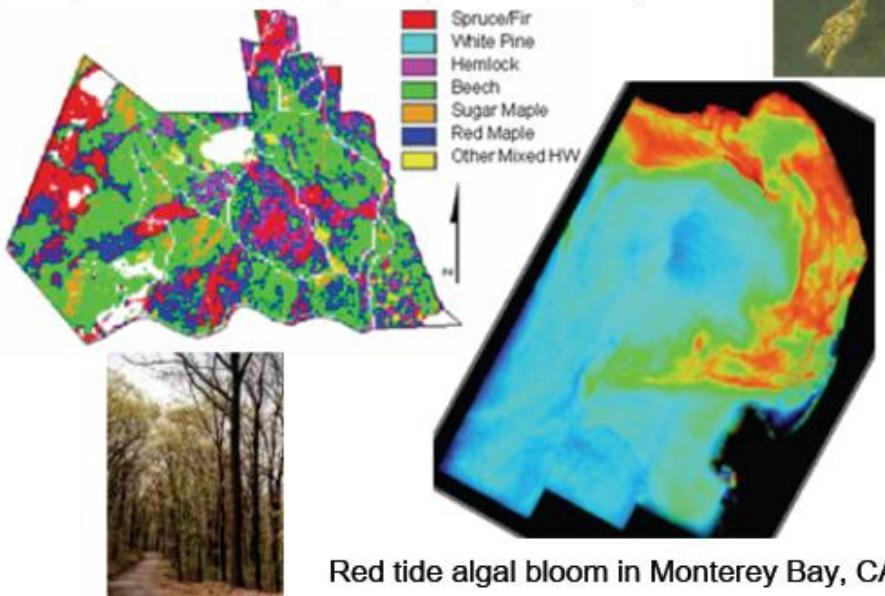
+
Multispectral Thermal InfraRed (TIR) Scanner



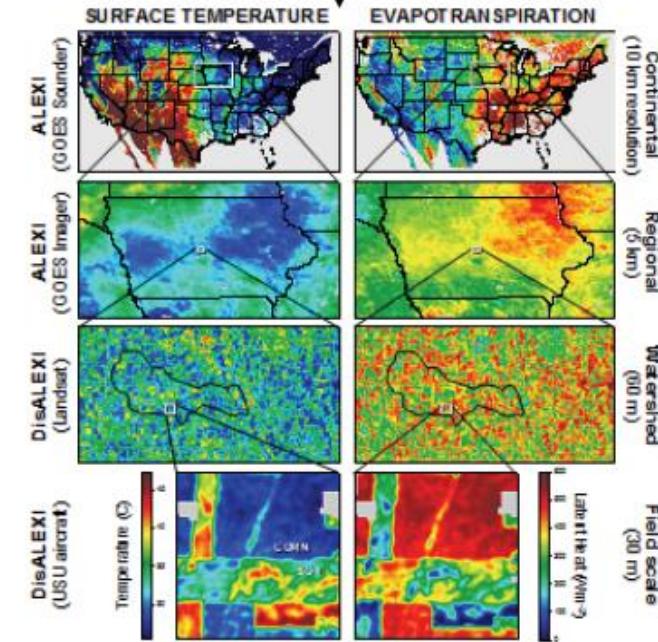
En pré-phase A

VSWIR: Plant Physiology and Function Types (PPFT)

Map of dominant tree species, Bartlett Forest, NH



Multispectral TIR Scanner



Red tide algal bloom in Monterey Bay, CA



OBJECTIFS :

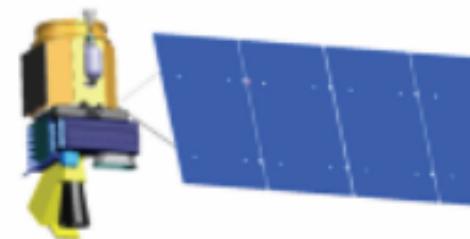
- Couverture globale
- Réflectance, température et émissivité
- Fonctionnement et composition des écosystèmes terrestres et côtiers / changement global
- volcanisme, feux, hydrologie, urbanisation, etc.

Architecture/structure

Three year mission, two Instruments on one spacecraft at 626 km
11 am sun sync orbit: (1) Imaging Spectrometer (VSWIR),
(2) Thermal Infrared Multi-Spectral Imager (TIR)

VSWIR Science Measurement:

- 380 to 2500 nm in 10nm bands
- 60 m spatial resolution, 19 day revisit
- Global land and shallow water (<50m)



TIR Science Measurement:

- 8 Bands (7 bands between 7.5-12 μm & 1 band at 4 μm)
- 60 m spatial resolution, 5 day revisit
- Global land and shallow water
- Day and night imaging

AUTRES?

Chine

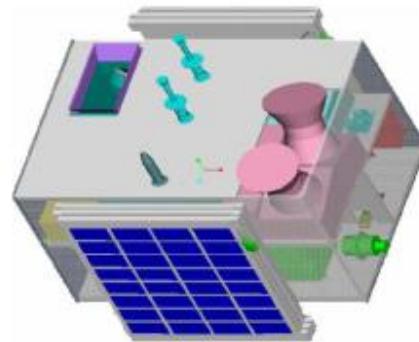


Figure 2. HJ-1B satellite with CCD and infrared camera on board

TABLE II. TECHNICAL SPECIFICATION OF THE HYPER-SPCTRAL CAMERA

Sensor Item \n	Hyper-spectral camera
Band number	128
Band range (μm)	0.45-0.95
Spatial-Resolution	100m
Swath	50km
Aspect angle	±30°
SNR	50db-100db
Data quantization	12bit
Lifetime	≥ 3 year

TABLE III. TECHNICAL SPECIFICATION OF THE INFRARED CAMERA

Sensor Item \n	Infrared camera			
Band number	4			
Band range (μm)	B1 0.75~1.10	B2 1.55~1.75	B3 3.50~3.90	B4 10.5~12.5
Spatial-Resolution	150m 300m			
Swath	720km			
Aspect angle	±29°			
SNR	\			
Data quantization	10bit			
Lifetime	≥ 3 year			

Aéroportés

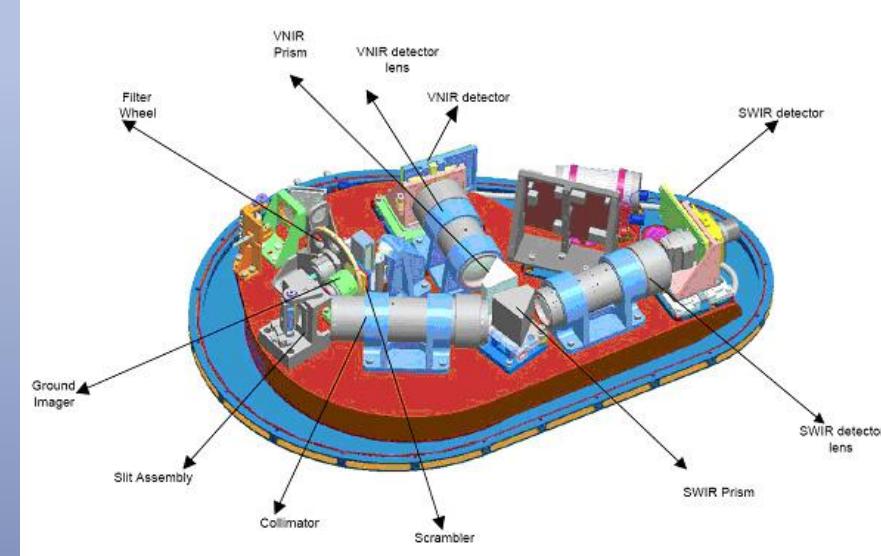
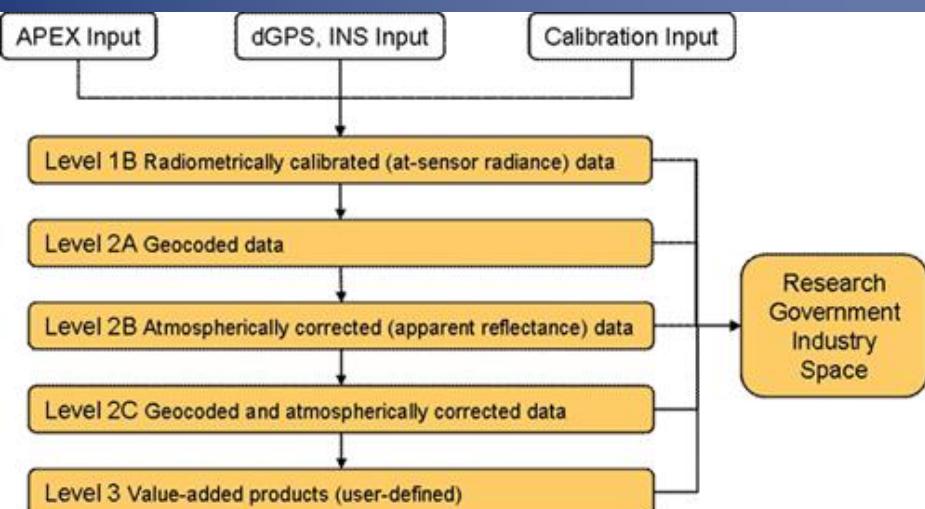


RSL + VITO

APEX DATA LEVELS AND USERS

* Quick looks and data quality reports

* Data processing is performed in the **APEX Processing and Archiving Facility (PAF)**, and various data levels can be distributed to the users



- airborne (**dispersive pushbroom**) imaging spectrometer with **1000 pixels** across track (FOV \pm 14 deg, IFOV 0.48 mrad)
- ground resolution: 2 - 5 m at flight altitudes of 4 - 10 km
- spectral wavelength range covering **380 - 2500 nm** (VNIR and SWIR)
- **spectral sampling interval < 10nm** (560-780 nm: < 5nm)
- **spectral resolution < 1.5 * spectral sampling interval**
- radiometric accuracy $\leq 2\%$, traceable to international standards
- highest signal to noise ratio through advanced detector technology and pressure/temperature stabilization

AVIRIS « Next Generation »

Table 2: NGIS Key Performance Characteristics

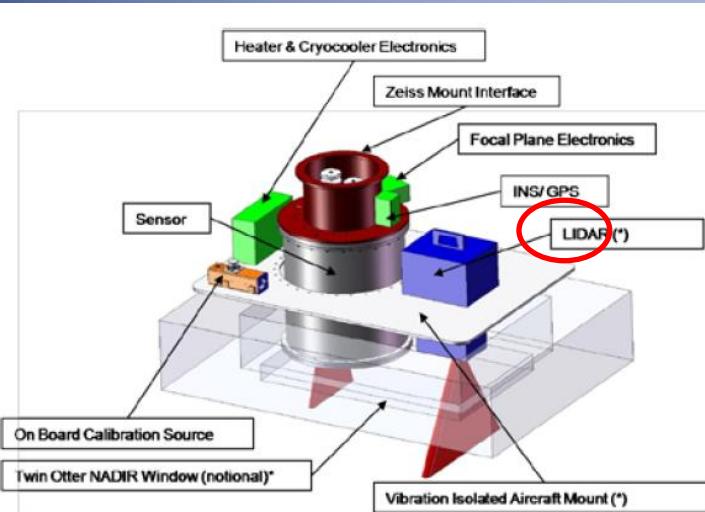
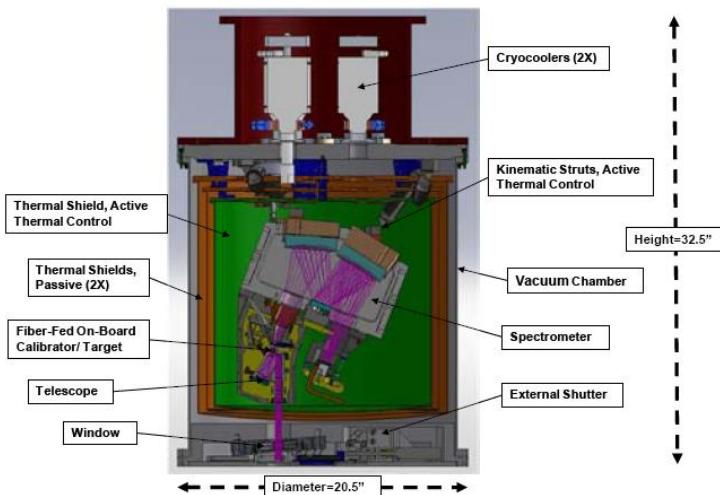


Figure 12: Major components of the NGIS flight package and optional companion instruments.



Optical		
	Wavelength Operational Range	380 to 2510 nm
	Spectral Resolution (FWHM, minimum)	5 nm +/- 0.5nm
	Field of View	36 +/- 2 degrees with 600 resolved elements (large enough FOV to encompass LIDAR (4 spots))
	Instantaneous Field of View	1.0 – 1.5 mradians +/- 0.1 mrad
	Spatial Sampling (maximum observed at resolved elements)	1.0 mrad +/- 0.1 mrad
	Spectral Distortion (smile)	uniformity > 97%
	Spatial Distortion (keystone)	uniformity > 97%
Operations & Environment		
	Operational Real Time Display	Waterfall display allows data quality check
	Self-Sufficiency	Safe operation for 24 hours without maintenance or data download
	Ambient Operating Temperature	-40 to +50C
	Maximum Altitude	18,000 m
	Cool down time	<48 hours
	Operational time / mission	14 days
Electronics		
	FPA	480 (spectral direction) x 640 (cross track)
	Frame Rate	10 – 100 frames per sec
	Pixel size	27 micron x 27 micron
	Calibration	On-Board Calibrator
Software		
	Headless Operation	Autonomous Fault Protection responds to health and safety problems
	Data Rate	up to 74 MB/s of throughput
	Data Volume	up to 1.0 Tb of raw data before disk swap
Mechanical		
	Volume of package	83 cm (H) x 57 cm (diameter) plus electronics boxes and racks
	Mass	465 kg
	Vacuum Requirement	10-4 torr
	Data Resolution	Reported as 14 bit
	Vibrational Environment	Maintain instrument calibration and operations when subjected to worst-case aircraft random vibrational loads (defined for Twin Otter)
	Crash Loads	Maintain structural integrity when subjected to 18g forward, 3 g up, 4.5 g side

- Plus de précisions la semaine prochaine lors du congrès EARSeL à Edimbourg



- A suivre sur notre page Web



- En avant-première !!!!

Le prochain congrès EARSeL sera organisé en 2013 à Nantes