The French EO High Spatial Resolution Hyperspectral Dual Mission HYPXIM An Update

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Historical background - Timeline

2007: 1st French Workshop on Imaging Spectroscopy in Nantes **~ 35 participants**

2009: State of the Art Report from a Group of Expert Scientists (GSH) ordered by CNES

=> Beginning of Phase 0 study

=>

2011: 1st Workshop in Paris **~ 70 participants**

2012: 2nd Workshop in Toulouse **~ 80 participants**

+ 1st Summer School limited to 30 participants

End of Phase 0 => Selected for Phase A but "frozen" due to funding constraints

2013: 8th EARSeL SIG Imaging Spectroscopy Workshop in Nantes

2014: CNES Prospective Seminar => Selected for mid-term (2020-2025)

3rd Workshop in Porquerolles **~ 90 participants**

Mission objectives and characteristics at end of phase 0

GEOSCIENCES

Exploration/Mineral mapping
Environmental impact
Natural/Industrial Hazards
Soil erosion/degradation
Soil properties

PARAMETERS: Mineral composition, concentration, organic C content, soil moisture, grain size, clays

⇒ Relevent scale = mining sites, river banks, geologic formation

⇒ Requires taking into account intimate mixtures and alteration crusts

PLANT BIODIVERSITY

Biodiversity / Invasive plants
Precision agriculture
Forestry

PARAMETERS: Pigments, water and dry matter content, C:N, LAI, light-use efficiency

⇒ Necessity of data at an intermediate scale between *in situ* and global

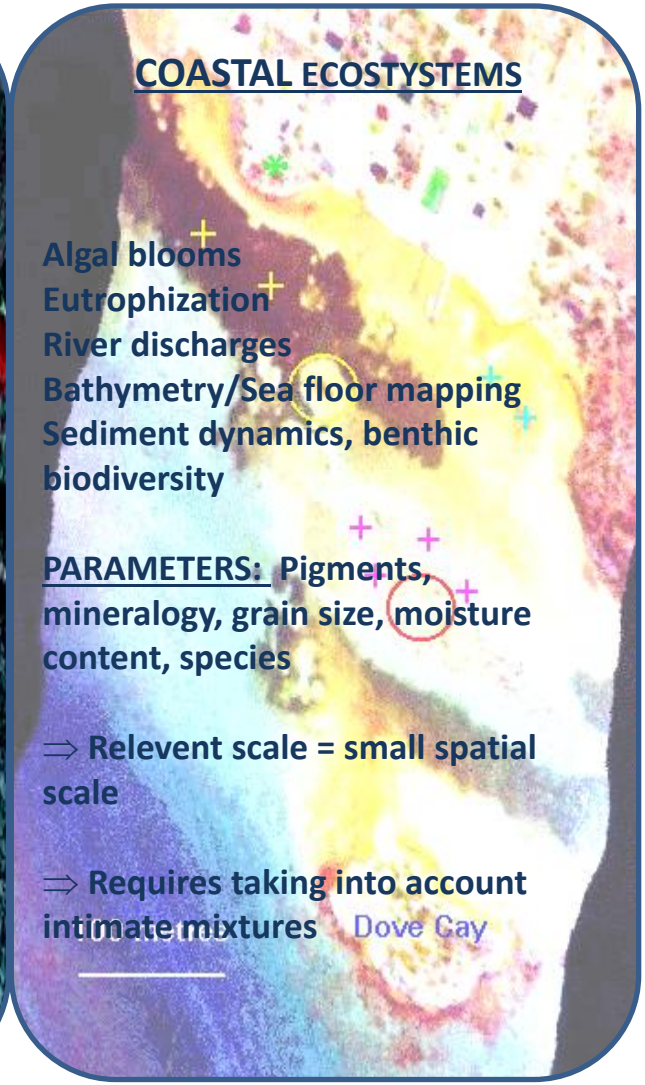
COASTAL ECOSTYSTEMS

Algal blooms
Eutrophization
River discharges
Bathymetry/Sea floor mapping
Sediment dynamics, benthic biodiversity

PARAMETERS: Pigments, mineralogy, grain size, moisture content, species

⇒ Relevent scale = small spatial scale

⇒ Requires taking into account intimate mixtures



V. Carrère et al.

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UNIVERSITÉ DE NANTES

LPG Nantes

Mission objectives and characteristics at end of phase 0

URBAN ENVIRONMENT

Urban planning
Biodiversity
Cartography of urban material
Urban microclimatology
Hydrology

Parameters:
Composition of urban materials (chemistry, permeability, moisture content, dangerous materials), temporal evolution, sanitary state, manmade/natural surfaces

⇒ Relevent scale = small spatial scale

⇒ Fusion Panchro + hyperspectral

⇒ Requires taking into account intimate mixtures, shadows

ATMOSPHERE

Plume characterization: air pollution, biomass burning, volcanic eruption

Air traffic, health, microclimate

Parameters:
Gases: type, abundance
Aerosols: type, abundance, particle size

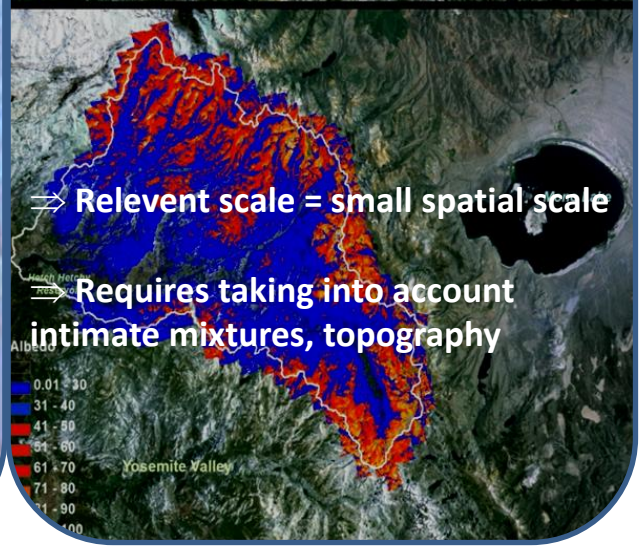
⇒ Relevent scale = small spatial scale

Credit: Digital Globe

CRYOSPHERE

Climate: albedo (dust, algae), surface energy budget, climate change
Hydrology: snowmelt models, liquid water content, floods

Parameters:
grain size, water liquid content, impurities type and content



⇒ Relevent scale = small spatial scale

⇒ Requires taking into account intimate mixtures, topography

Summary of Science Requirements

Sensor characteristics derived from science requirements

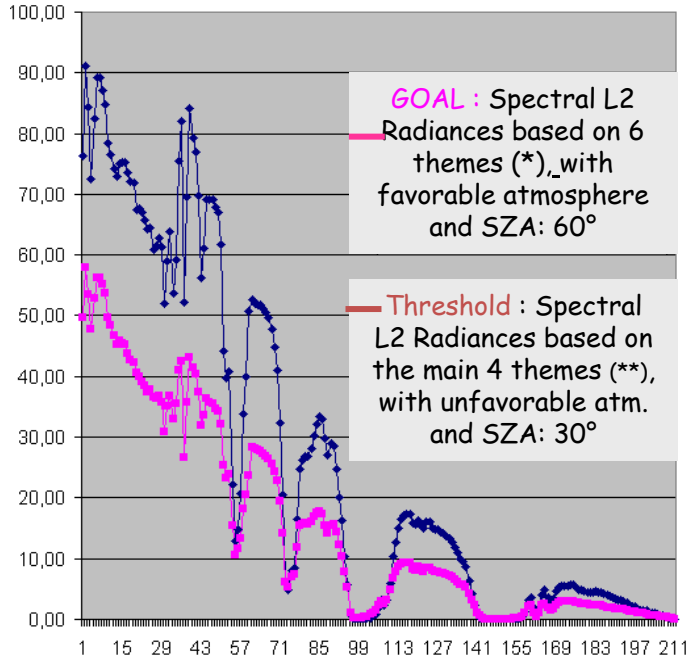
Domain	δλ (nm)	GSD (m)	Swath (km)	Revisit Period	SNR
Geosciences	≤ 10	10	50 - 100	Non critical	>300:1 in VNIR >100:1 in SWIR
Coastal ecosystem	≤ 10	≤10	Variable	Critical for inter tidal monitoring	> 400:1in VNIR
Vegetation biodiversity	≤ 10	≤10	Variable	Critical during growth period	TBC
Urban ecosystem	≤ 10	5	20 - 50	Critical during crisis	>250:1 in VNIR >100:1 in SWIR
Cryosphere	10	5-10	20- 50	< 5 days	>500:1 in VNIR >250:1 in SWIR
Atmosphere	≤ 10	20	10 - 50	Variable	>250:1 in VNIR >150:1 in SWIR

Summary table of mission requirements expressed by the six science user groups where δλ is the spectral resolution, GSD the ground sample dimension and SNR the signal-to-noise ratio, the spectral range is [0.4, 2.5µm].

Some of these requirements have to be refined

HYPXIM: Main Mission Requirements

Domain	Spectrum range (nm)	Spectral resolution δλ (nm)	SNR@L2
VIS	400-700	10	≥ 250:1
VNIR	700-1100	10	≥ 200:1
SWIR	1100-2500	10	≥ 100:1
PAN	400-800	400	≥ 90:1



(*) Goal: Geosciences, Vegetation, Urban, Defence, Atmosphere and Coastal zones
(**) Threshold: Geosciences, Vegetation, Urban, Defence

⇒ **Spectral continuum required from VIS to SWIR, spectral resolution of 10 nm**

⇒ **Spectral SNR with 2 levels of L2 (goal and threshold)**

⇒ **GSD HIS < 8m, and a panchromatic channel (GSD < 2 m) will enhance the scene analysis**

⇒ **Swath: 15 km minimum**

⇒ **Revisit: daily revisit required for some applications, 3-5 days acceptable for defence applications**

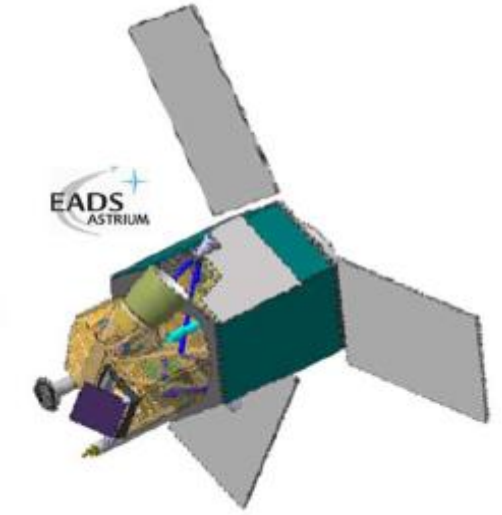
MICROSAT vs MINISAT

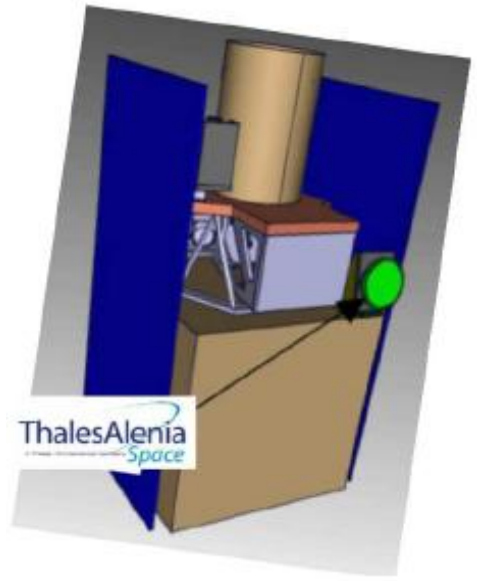
SELECTED

	MICROSAT	MINISAT
Altitude	650 km	660 km
Payload	TMA telescope Φ150 mm Detector VNIR-SWIR 1000 x 256 pixels (off-the-shelf)	TMA or Korsch telescope Φ450 mm, Detector HgCdTe 2000 x 360 pixels (to be developed)
Resolution/Swath	15 m / 15 km	8 m / 16 km
Spectral bandwidth	400 – 2500 nm / < 14 nm	400 – 2500 nm / 10 nm
Panchromatic band	Resolution: 3.75m	Resolution: 1.85m
Payload budget	Mass 70 kg, Power 110 W (imaging),	Mass ~115 kg, Power < 150 W (imaging)
Satellite	195 kg (at launch)	650 kg (at launch)
Revisit period (+/-60° in latitude)	+/-20° across-track imaging : 15 days +/-35° across-track imaging : 3 days (with 2 satellites)	+/-20° across-track imaging : 15 days +/-35° across-track imaging : 3 days (with 1 satellite)
Imaging capacity (for one satellite)	~ 63 000km2 per day (280 images/day)	~100 000 km2 per day (270-450 images)
Link to Ground	X-band link at 160 Mbps (with ground or mobile stations)	X-band link at 620 Mbps (with ground or mobile stations)
Launcher compatib.	Soyuz, Vega, Ariane 5	Soyuz, Vega, Ariane 5
Expected lifetime	5 years (incl. end-of-life operations)	10 years (incl. end-of-life operations)
Thematic analysis (based on 4 experimental test-zones)	Performances coef: 78%	Performances coef.: 89%

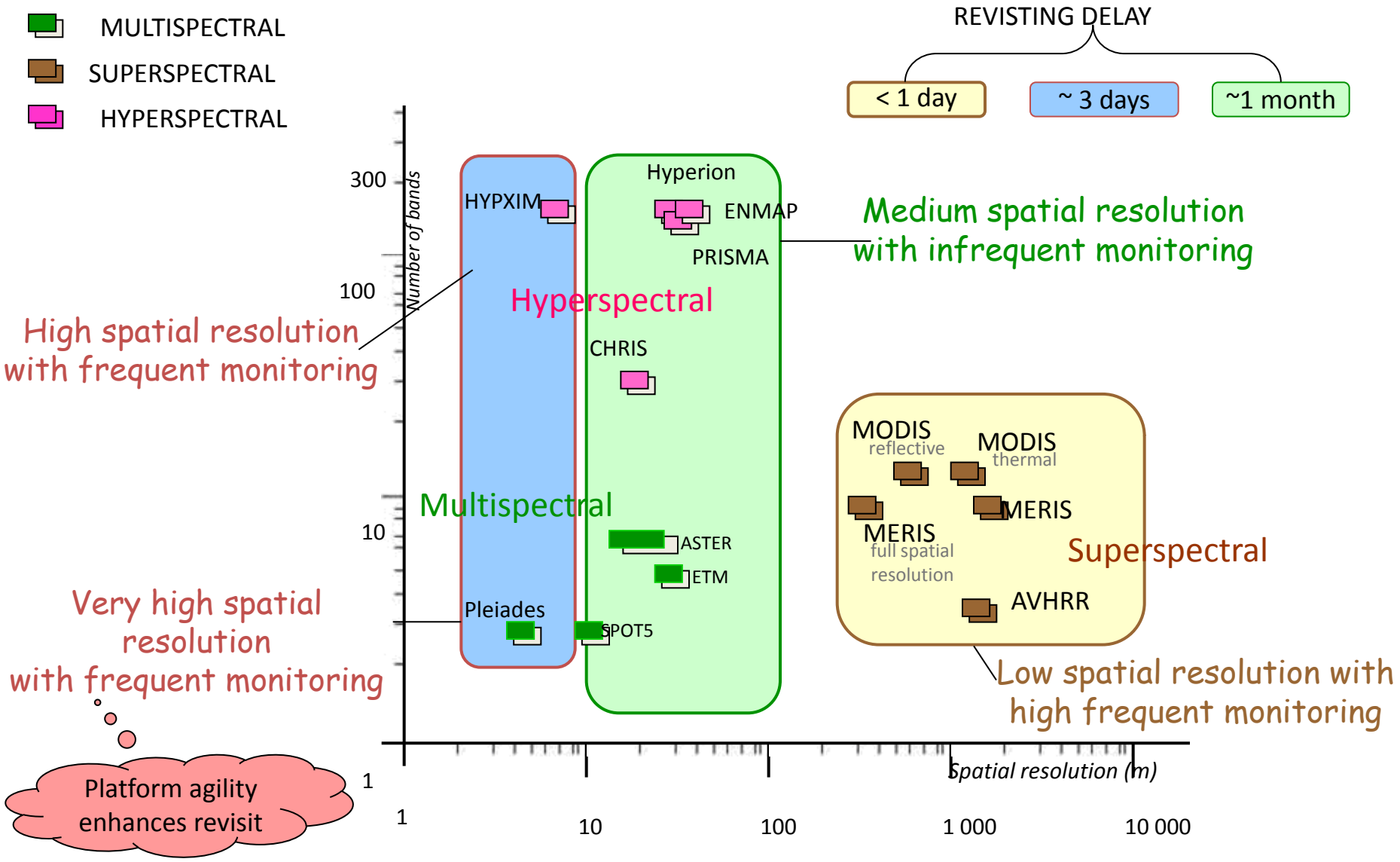
HYPXIM: System Description (as per end of Phase 0)

ALTITUDE	**660 km**
PAYLOAD	**TMA or Korsch telescope, diameter: 450 mm, Prism-based spectrometer, Dedicated panchromatic channel, Detector VNIR-SWIR 2000 x 360 pixels**
HYPERSPECTRAL RESOLUTION / SWATH	**8 m / 16 km**
PANCHROMATIC CHANNEL	**1.85m /16km**
SPECTRAL BANDWIDTH / RESOLUTION	**400 – 2500 nm / 10 nm**
PANCHROMATIC CHANNEL	**1.85m/16km**
PAYLOAD BUDGET	**Mass~115 kg, Power 150W (imaging)**
SATELLITE	**600 kg (at launch)**
REVISIT PERIOD	**With +/-20° across-track imaging: 15 days With +/-35° across-track imaging: 3 days**
IMAGING CAPACITY	**~100 000 km2 per day (270-450 images)**
GROUND-TO-SPACE LINK	**X-band link at 620 Mbps (with ground or mobile stations)**
LAUNCHER COMPATIBILITY	**Soyuz, Vega, Ariane 5**
EXPECTED LIFETIME	**10 years (incl. end-of-life operations)**





HYPXIM: Position in the International Context



Where we stand now – What is next

Science:

• Conclusions of CNES Prospective Meeting: Not a priority, kept as a mid-term mission (2020-2025)

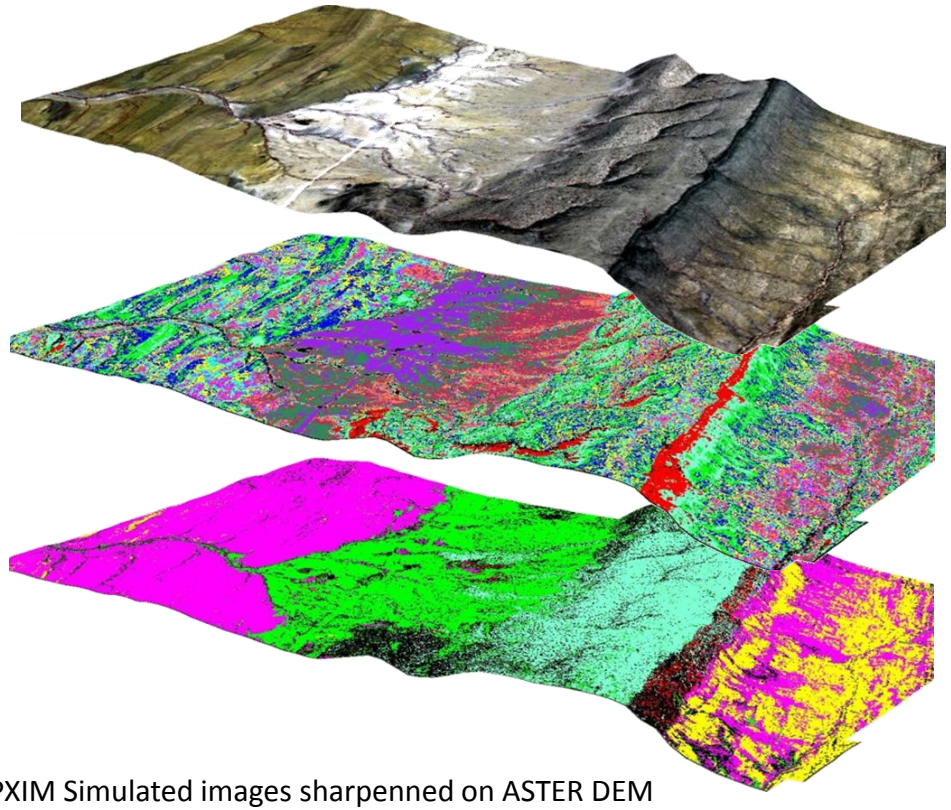
• On going studies to refine SNR, spatial and spectral resolutions for selected applications

• Keep the community active (scheduled workshop in 2015 + summer school)

Defence:

• Dedicated studies => tool box for operatives under construction

• Deadline in 2016



HYPXIM Simulated images sharpenned on ASTER DEM (CNES –BRGM 2012)