HYPXIM – a hyperspectral satellite defined for science, security and defence users

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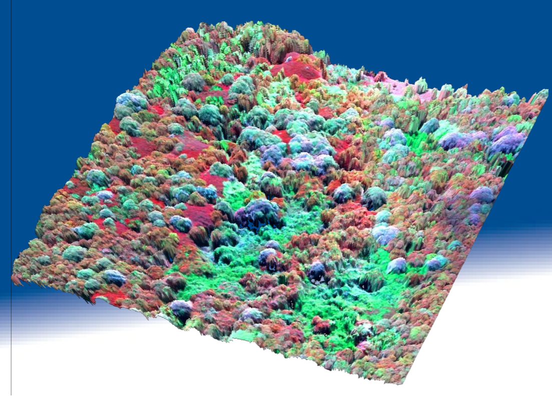
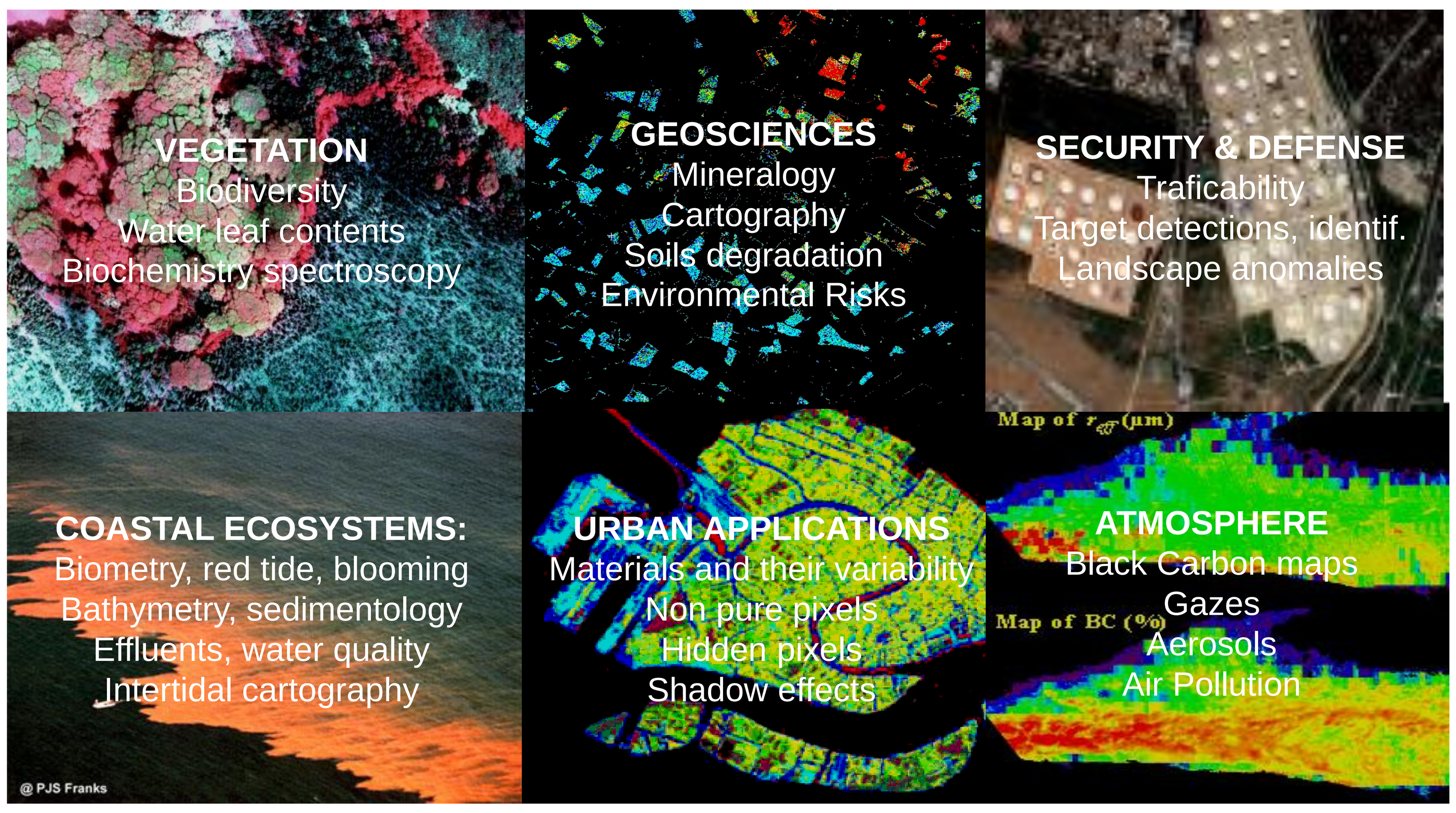


Introduction

Based on sound mission technical requirements provided by a group of national experts in hyperspectral imagery, CNES has been conducting pre-phase A studies with the support of Astrium and Thales Alenia Space, in non-concurrent engineering. Two mission scenarios were defined :

1) HYPXIM-Challenging aims at finding out the highest possible performance level achievable using a microsatellite platform, with a Basic (HYPXIM-CB) and an Advanced (HYPXIM-CA) option,
2) HYPXIM-Performance goal is to reach a higher spatial resolution and to provide a TIR hyperspectral capability.

HYPXIM mission objectives



Radiometry

Spectral continuum is required from VIS to SWIR optical domain with a spectral resolution of 10 nanometers. Spectral continuum is also required for TIR with a spectral resolution of 100 nm.

The panchromatic image can be combined with the hyperspectral image so as to enhance spatial resolution.

Domain	Spectrum (nm)	Bandwidth δλ (nm)	SNR
VIS	400-700	10	≥ 250:1
NIR	700-1100	10	≥ 200:1
SWIR	1100-2500	10	≥ 100:1
PAN	400-800	400	≥ 90:1
TIR	8000-12000	100	> 100:1

Spectral requirements for HYPXIM mission

SNR = Signal-to-Noise Ratio

Ground Spatial Resolution (GSR)

3 classes of needs are identified for VNIR-SWIR domain (0.4 - 2.5 μm) :
- 20 meters and larger => covered by EnMAP and PRISMA missions,
- 10 to 15 meters,
- 5 to 10 meters.

GSR : 50 to 100 meters is required for TIR (8 to 12 μm).

Swath

15 km minimum, up to 30 km.

Revisit period

Daily revisit required for applications (e.g. security & defence) but 3-day revisit period acceptable. Non critical for many applications (geosciences, urban environment, …).

At-sensor radiances

At-sensor radiances are defined by the scientific and defence mission group [1]. For a better understanding, the at-sensor radiances specifications are converted into observable ground reflectances, according to the observation latitude and the sun-zenithal angle. For instance, at 400 nm, a pre-defined at-sensor radiance (called L2 favorable) is reached on June, 21st for a ground reflectance of 0.1 at 40°N latitude (fig. 1).

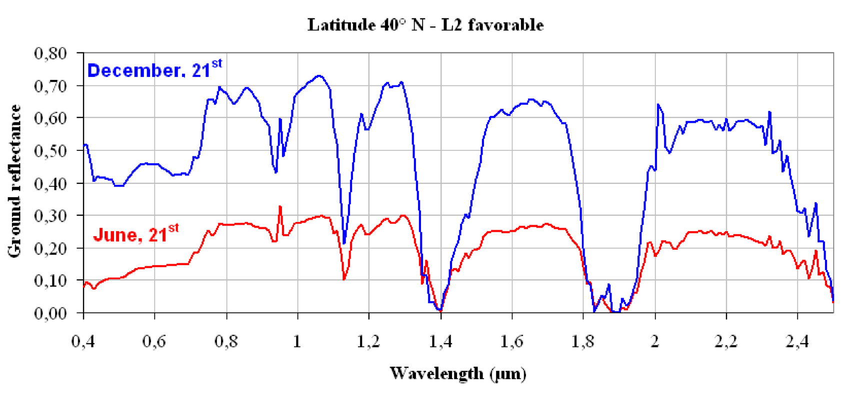
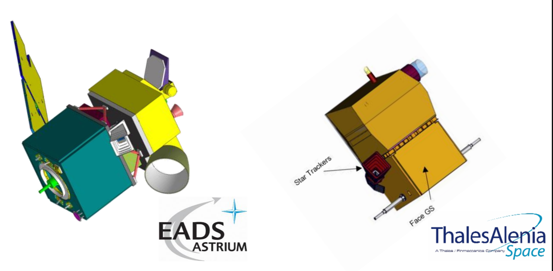


Figure 1 : Ground reflectance providing an at-sensor radiance of L2 favorable, for a site located at 40°N latitude, at 2 dates on June, 21st and December, 21st

HYPXIM-CA : not a micro-challenge



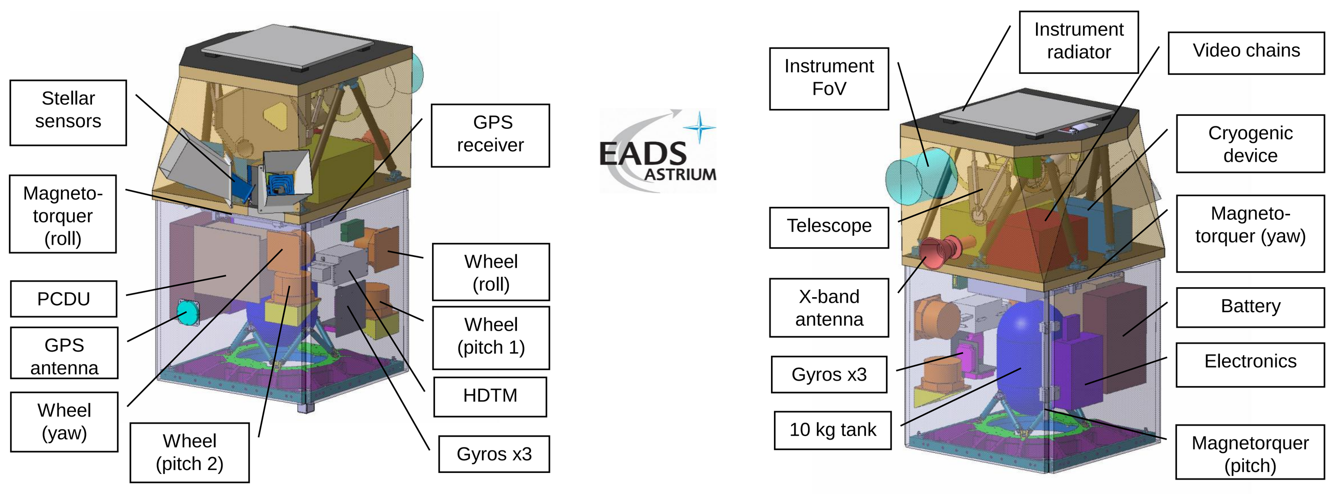
HYPXIM-CA : 2020 timeframe.

Altitude	650 km
Payload	TMA telescope Φ175 mm, prism-based spectrometer Detector VNIR-SWIR 2000 x 360 pixels (to be developed)
Spatial resolution / Swath	15 m / 30 km
Spectral bandwidth / resolution	400 – 2500 nm / 10 nm
Payload budget	Mass 65 kg , Power (imaging) 55 W, Dimensions : 670 x 790 x 650 mm
Satellite	Myriade NG, 195 kg (incl. a 17% margin). Dim. 620 x 600 x 1 327 mm
Revisit period	At satellite's nadir : 90 days with one satellite / 45 days with two With +/-30° across-track imaging : 3-4 days
Imaging capacity (for one satellite)	120 square images per day Up to 500 km strip for a single image 800 km between two consecutive square images
Ground-to-space link	X-band link at 150 Mbps (with ground or mobile stations)
Launcher compatibility	Soyuz, Vega
Expected lifetime	5 years (incl. end-of-life operations)

HYPXIM-CB : off-the-shelf and more compact

HYPXIM-CB : 2018 timeframe.

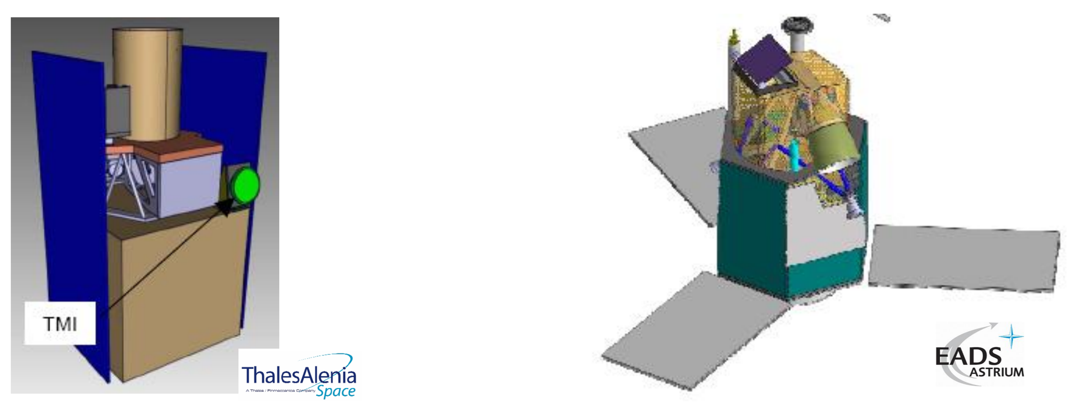
Altitude	650 km
Payload	TMA telescope Φ150 mm with a dedicated panchromatic channel, prism-based spectrometer Detector VNIR-SWIR 1000 x 256 pixels (off-the-shelf)
Resolution/Swath	15 m / 15 km
Spectral bandwidth / resolution	400 – 2500 nm / < 14 nm
Payload budget	Mass 70 kg, Power 110 W (imaging), Dim. 590 x 640 x 500 mm
Satellite	Myriade NG 195 kg (at launch)
Revisit period	Access to any zone within +/-60° in latitude within 30 days, with a roll less than 10° Allowing roll angles up to 40°, revisit time decreases to 3 days (with GSR increased by 50%)
Imaging capacity (for one satellite)	280 square images per day
Ground-to-space link	X-band link at 160 Mbps (with ground or mobile stations)
Launcher compatibility	Soyuz
Expected lifetime	5 years (incl. end-of-life operations)



HYPXIM-CB satellite overview [CNES and industrial property - all rights reserved]

HYPXIM-Performance

Altitude	660 km
Payload	Korsch telescope Φ430 mm with dedicated panchromatic channel, prism-based spectrometer Detector VNIR-SWIR 2000 x 360 pixels (to be developed) For TIR : telescope Φ60 mm, prism-based spectrometer Detector 160x35 pixels
Resolution/Swath	8 m / 16 km For TIR : 100 m / 16 km
Spectral bandwidth / resolution	400 – 2500 nm / 10 nm For TIR : 8 -12 μm / 100-150 nm
Payload budget	Mass <150 kg, Power (imaging) <350 W
Satellite	1-ton range
Revisit period	With +/-20° across-track imaging : 15 days With +/-40° across-track imaging : 3 days
Imaging capacity (for one satellite)	200 square images per day
Ground-to-space link	X-band link at 270 Mbps (with ground or mobile stations)
Launcher compatibility	Soyuz, Vega
Expected lifetime	10 years (incl. end-of-life operations)

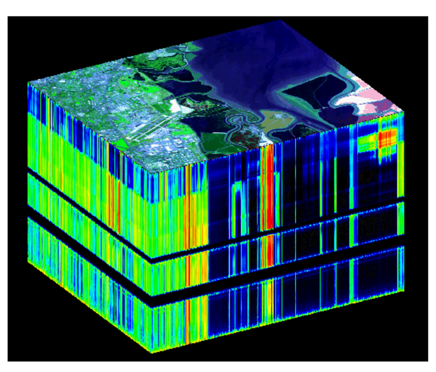


HYPXIM-P satellite overviews [CNES and industrial property - all rights reserved]

Synthesis

The HYPXIM concept introduces the next hyperspectral space sensors generation with :
- enhanced spatial resolution from 15 m to 8 m,
- higher revisit frequency available for Security and Defence actors,
- miniaturization allowing a microsatellite to achieve a high-resolution hyperspectral low cost demonstration mission by 2018,
- a new TIR Hyperspectral capability,
- multi-sensors fusion products using on board PAN and TIR data**.**

HYPXIM missions meet the needs of a wide community of users currently using in situ and high-resolution hyperspectral images (airborne, UAV, etc.).



References

[1] X. Briottet, *et al.* : « HYPXIM : a new hyperspectral sensor combining science/defence applications », Proc. 3rd Workshop on Hyperspectral Image and Signal Processing : Evolution in Remote Sensing, Lisbon, Portugal, 2011.