OVERVIEW OF THE PRISMA SPACE AND GROUND SEGMENT AND ITS HYPERSPECTRAL PRODUCTS

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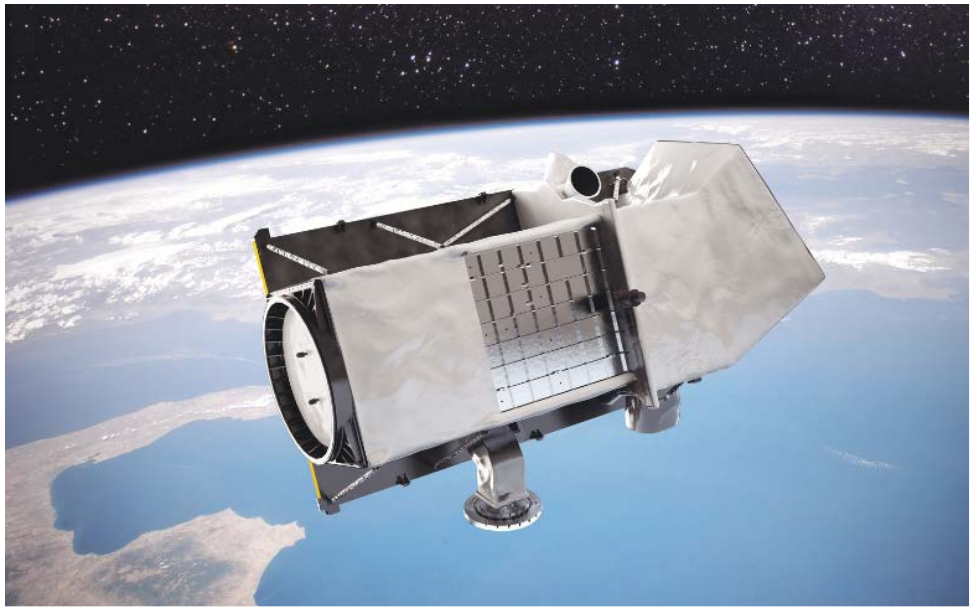
MISSION OVERVIEW

PRISMA: PRecursore IperSpettrale della Missione Applicativa

- An Italian **Earth Observation** hyperspectral mission
- The PRISMA mission is set up keeping into account the national and international initiatives for the implementation of other **hyperspectral missions**. It is in the class of “Small national mission”
- The PRISMA program, realized in the framework of a contract signed between ASI and an Italian Industries Consortium, and is in the development phase.
- The launch is scheduled in 2018 with VEGA launcher (launch window opening on mid 2018)



MISSION OBJECTIVES

1. The PRISMA mission is conceived with **technology demonstration** purpose, and **pre-operative characteristics**
2. The main objective of the mission is to deliver **hyperspectral and panchromatic images** of the Earth (up to level 2d)

It shall operate in two modes:

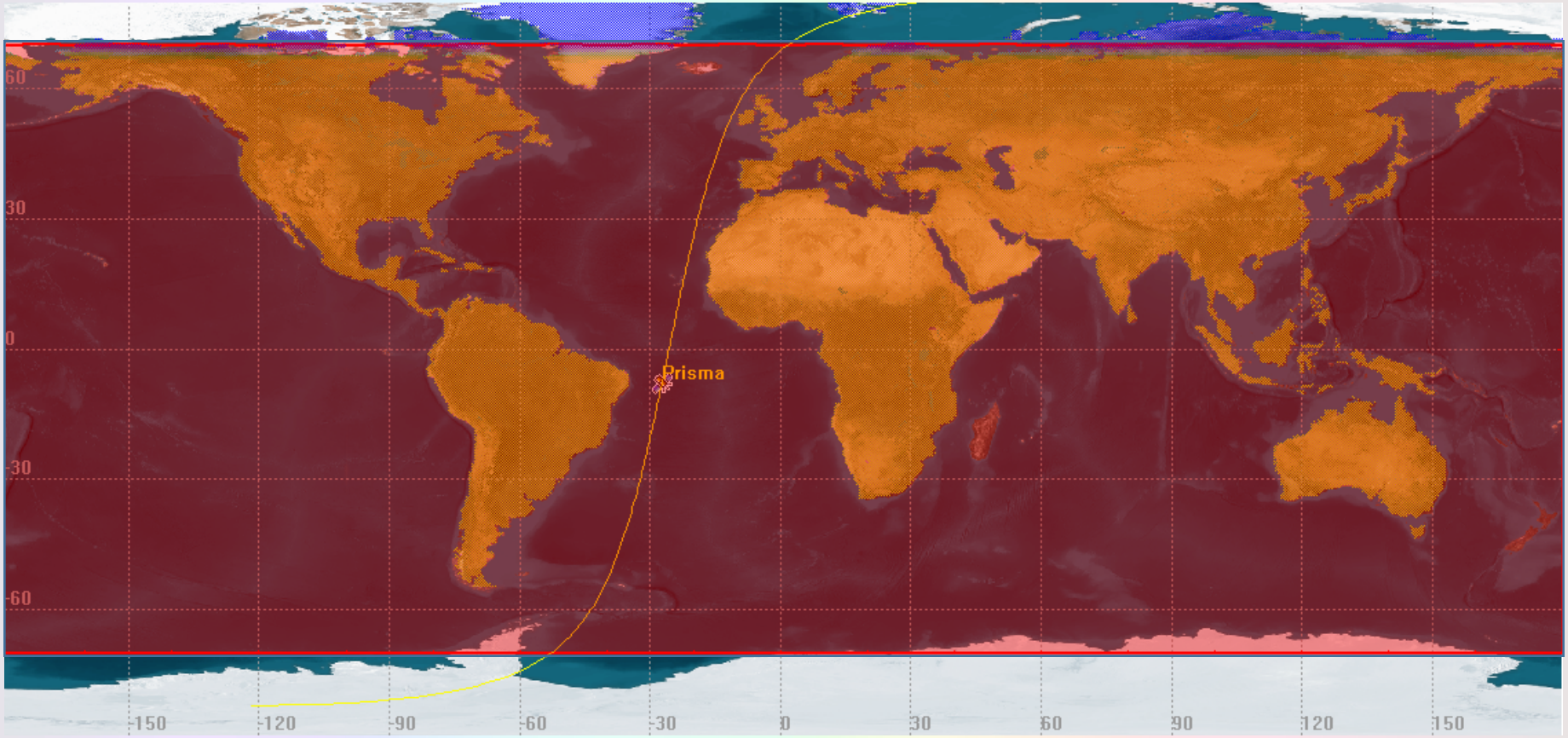
- a **primary mode**, to deliver data from specific individual targets requested by end users (user driven mode)
- a **secondary mode**, namely background mission, to collect, process and distribute hyperspectral and pan products providing a global coverage using any system resources not required for servicing the primary mode activities (data driven mode)

The PRISMA **mission** performs the following **functions**:

- images acquisition
- downloading of the collected images to ground
- processing of the image data
- delivery of the products to the end user

PRISMA MISSION AREA COVERAGE

Primary Area of Interest



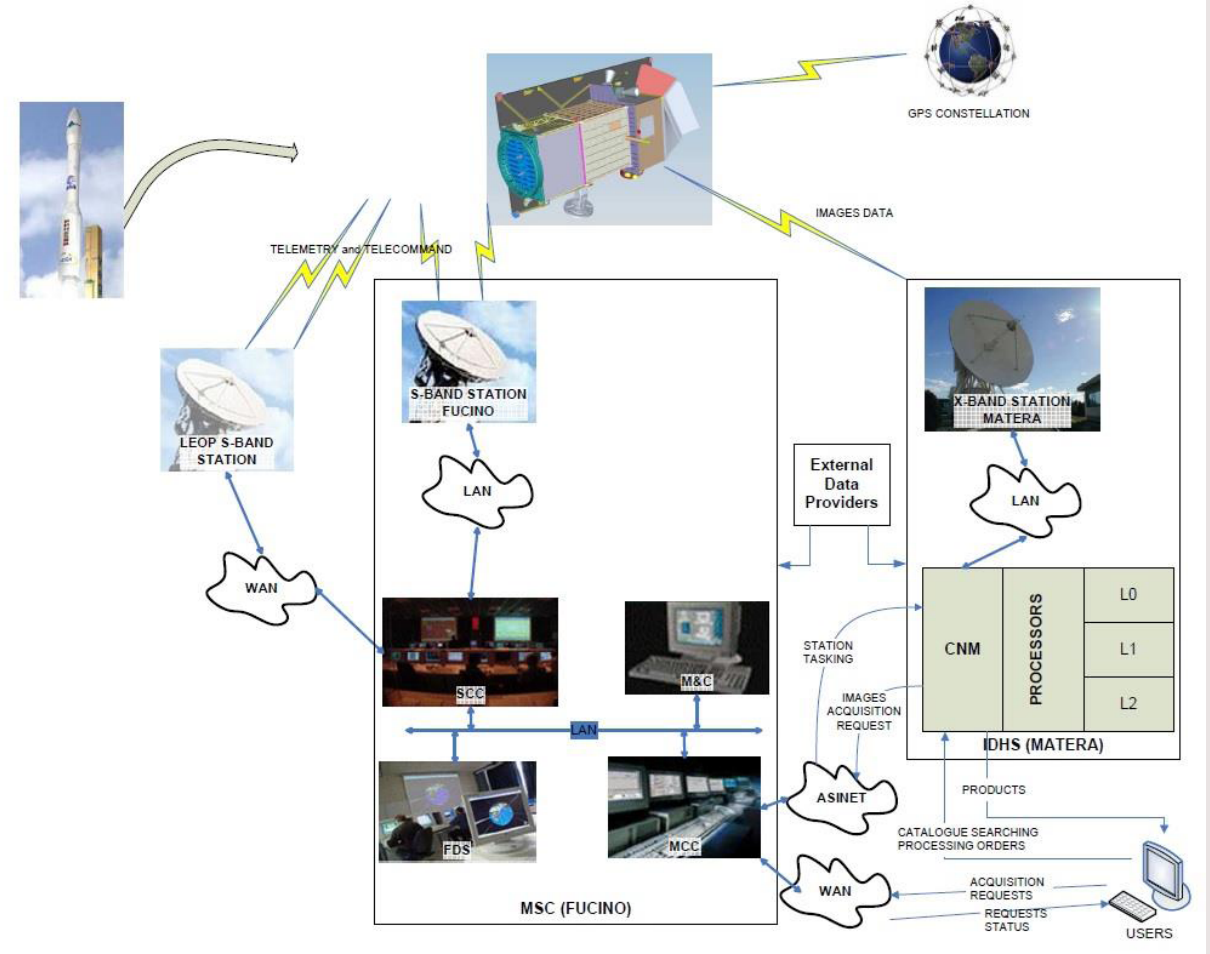
Longitude 180° W ÷ 180° E

Latitude 70° S ÷ 70° N

SYSTEM

The PRISMA system will be composed by the following integrated segments:

- **Space Segment**, consisting in a single satellite, embarking a state of-the-art hyperspectral and panchromatic payload
- **Launch Segment** in charge of placing the satellite into the appropriate orbit (VEGA launcher)
- **Ground Segment** geographically distributed in Italy between Fucino and Matera



MAIN CHARACTERISTICS AND ORBITAL PARAMETERS

Parameter	Performance
Orbit	Sun-synchronous
Semi-major axis [km]	6992.935
Altitude	614,8 km (LEO)
Eccentricity	0.0011403
Inclination [deg]	97.851
Argumentum of Perigee [deg]	90.0
Period [seconds]	5819.7
LTDN	10:30
Repeat cycle	29 days (430 orbits)
Rev/days	14.85
Repetition factor	14.83
Average eclipse [minutes]	~ 34
Lifetime	5 years
Mass P/L + P/F	~ 830 kg (including contingency and balance masses)
PL imaging principle	Push-broom

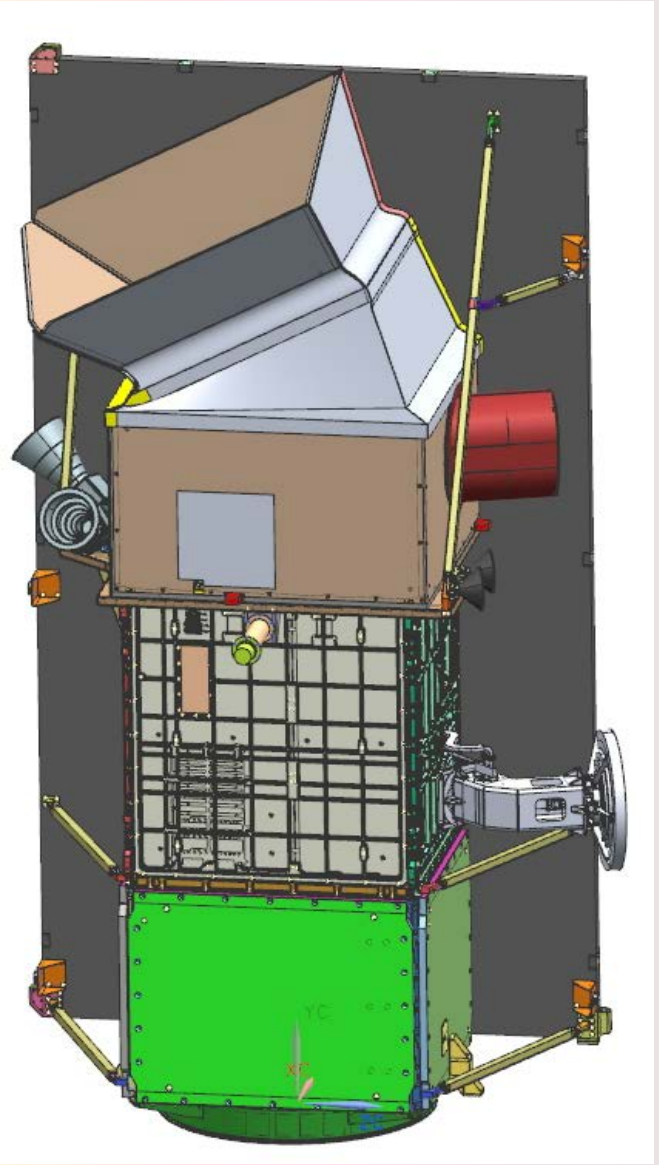
SPACE SEGMENT

The PRISMA satellite will be composed of:

- The Platform (OBDH, Platform Software, TMTC, Electrical Power, Attitude Control, Propulsion, Thermal Control, Structure, Harness)
- The hyperspectral/panchromatic Payload (Optical Head, Main Electronics, Sun Protection System)
- The Payload Data Handling & Transmission, PDHT (DSHA, TXA, XBAA)

Satellite attitude:

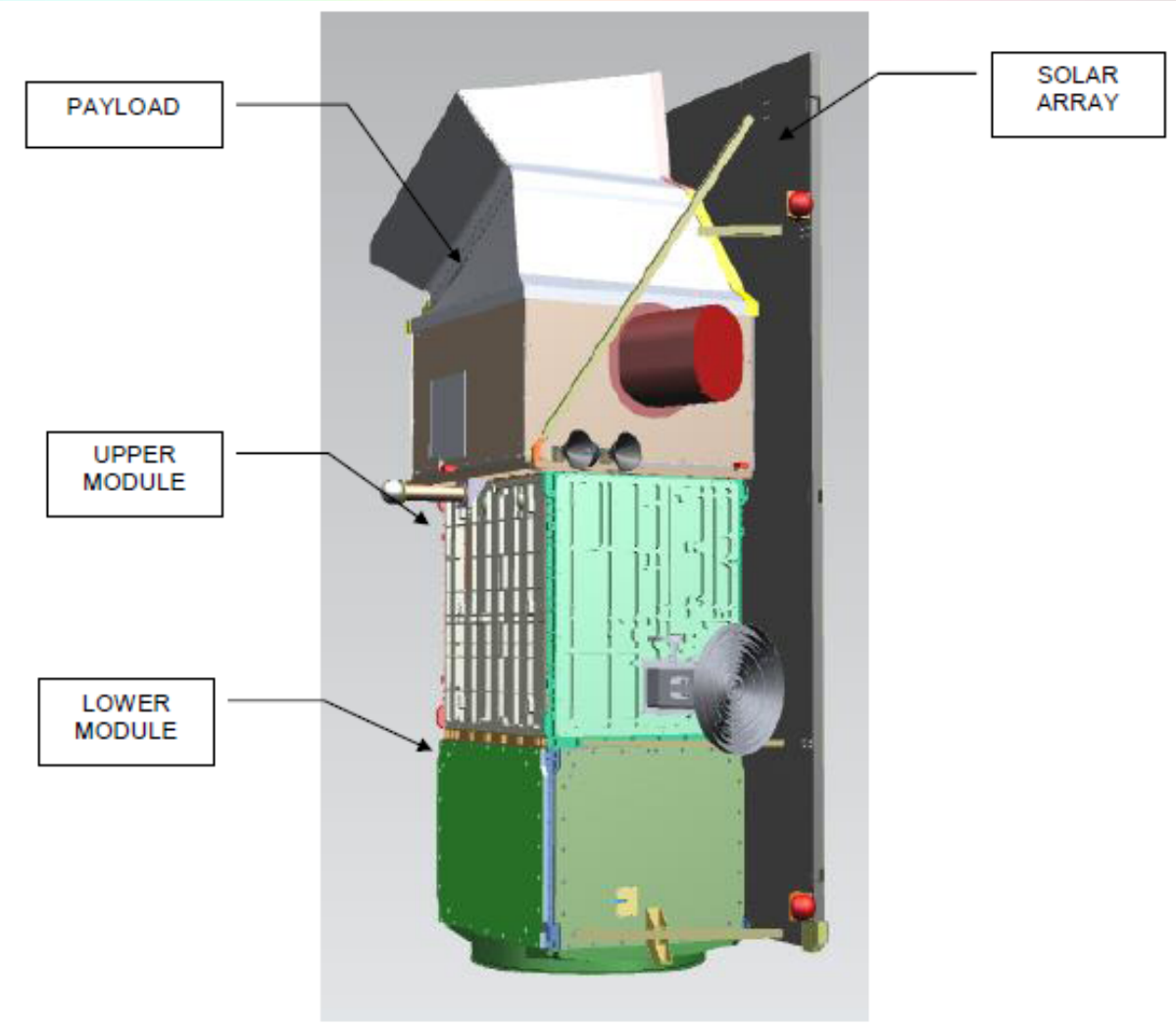
- Nominally sun pointing
- Fine nadir pointing only during images acquisition and download



PRISMA Platform

The PRISMA Platform will provide all the resources required by the payload and by the system in order to satisfy the mission objectives. It will be composed of several subsystems:

- OBDH
- EPS
- TM/TC – S BAND
- ACS
- Propulsion
- Structure
- Thermal S/S
- Harness



Platform's S/S (1/4)

OBDH:

The On Board Data Handling Subsystem is in charge of performing the **on board operative and control functions** of the satellite.
It will be composed of several functional module, including in particular the Board Computer, that is the main computer for the satellite management. It controls all the OBDH internal functions and external interfaces.

EPS:

The Electrical Power Subsystem is in charge of managing the **generation, storage and distribution of the electrical power** needed by the spacecraft subsystems.

It is composed of the following main elements:

- Solar Generator - a fixed solar panel which supplies the spacecraft during the nominal sun pointing attitude
- Battery - two Lithium-Ion battery packs which supplies the spacecraft avionics during eclipse periods and during the attitude acquisition phase
- Power Conditioning and Distribution Unit (PCDU) - in charge of converting and distributing the power delivered by either the Solar Array or the single Li-Ion Battery

Platform's S/S (2/4)

TM/TC – S BAND S/S:

The **telecommunications tasks** are demanded to the S-band TM/TC subsystem.

It is composed of:
- two transponders
- two antennas

ACS:

The Attitude Control Subsystem is in charge of **managing the satellite attitude**.

It is made up by:
- software, running on the on board computer,
- a set of sensors and actuators (four reaction wheels, three magnetic torquers, two sets of star and sun sensors, two set of gyro, two three-axes magnetometers, two GPS receivers)

The algorithms implemented in the ACS SW is able to guarantee the required pointing accuracy, stability and agility.

Platform's S/S (2/4)

TM/TC – S BAND S/S:

The **telecommunications tasks** are demanded to the S-band TM/TC subsystem.

It is composed of:
- two transponders
- two antennas

ACS:

Agility:

PRISMA satellite shall be able to manoeuver in order to capture two images at a maximum distance of 1000 km in a single pass (from worst case left to right side looking and viceversa).

Platform's S/S (3/4)

PROPULSION S/S:

To meet the orbit injection correction, orbit maintenance and de-orbiting requirements, PRISMA is equipped with a **monopropellant Hydrazine**, blow-down mode propulsion system.

The initial orbit correction and the periodic orbit maintenance (routine "Orbit Correction Phases") will be managed by the flight dynamics function of the MCC (Mission Control Centre) and by the SCC (Satellite Control Centre).

Structure S/S:

The satellite structure consists in a frame made of **tubes and reinforcing side panels** (principally **shear-resistant**) - Aluminium HoneyCombs and Carbon Fibre reinforced Plastics.
A dedicated structure is foreseen to (mechanically) connect the fixed solar panels, the magnetometers and the antennas to the satellite.

Platform's S/S (4/4)

TCS:

The satellite Thermal Control Subsystem is **mainly passive** (with the use of heaters and termostats) and it is realised by placing the most dissipating devices on radiating surfaces.
Dedicated thermal control will be implemented for:

- Li-Ion battery,
- payload detectors
- propulsion subsystem.

HARNESS S/S:

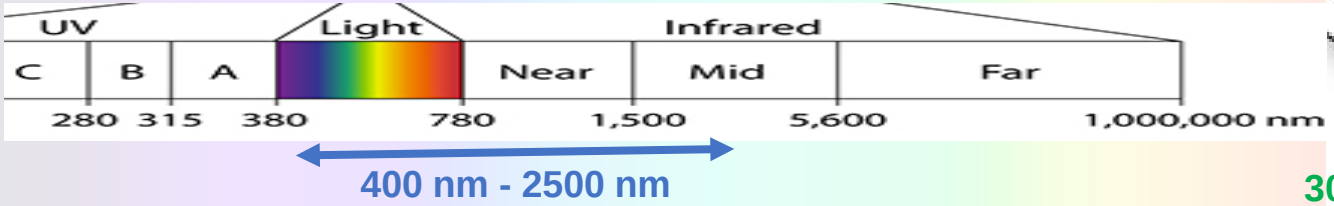
The FM harness provides the **electrical connections** between all electrical and electronic equipment and guarantees the proper electrical interconnection during launch and in-orbit mission.
The subsystem includes also the interconnections relevant to thermal hardware (heaters supply and thermistors acquisition).
Adequate distribution and separation of power, signal and RF Harness shall be ensured.

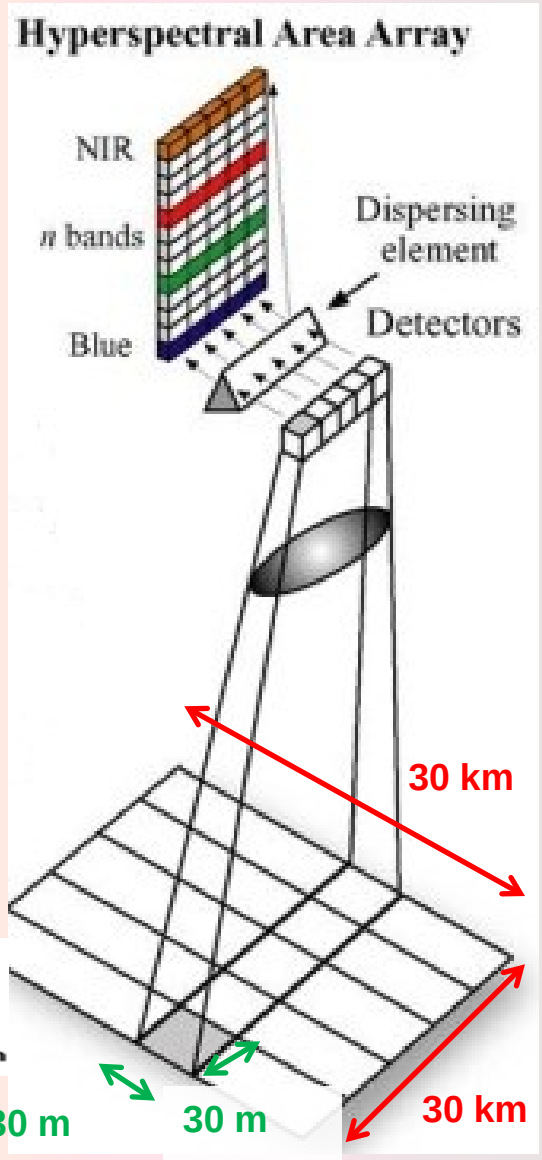
PRISMA Payload (1/2)

The PRISMA Payload will be a **hyperspectral/panchromatic camera** with VNIR (Visible and Near-InfraRed) and SWIR (ShortWave InfraRed) detectors.

- Imaging Spectrometer: able to acquire in a continuum of spectral bands ranging from 400 to 2500 nm
- medium resolution Panchromatic Camera (PAN)

The two sensors allow to perform observations based on recognizing the **geometric** characteristics of the observed area and, at the same time, to determine the **chemical-physical characteristics** of the targets of interest in the scene.





PRISMA Payload (2/2)

The payload operates with a **Pushbroom scanning** concept:

The "instantaneous" spectral and spatial dimension (across track) of the spectral cube are given directly by the 2-D detectors, while the "temporal" dimension (along track) is given by the satellite motion.

The main P/L **subsystems** are the:

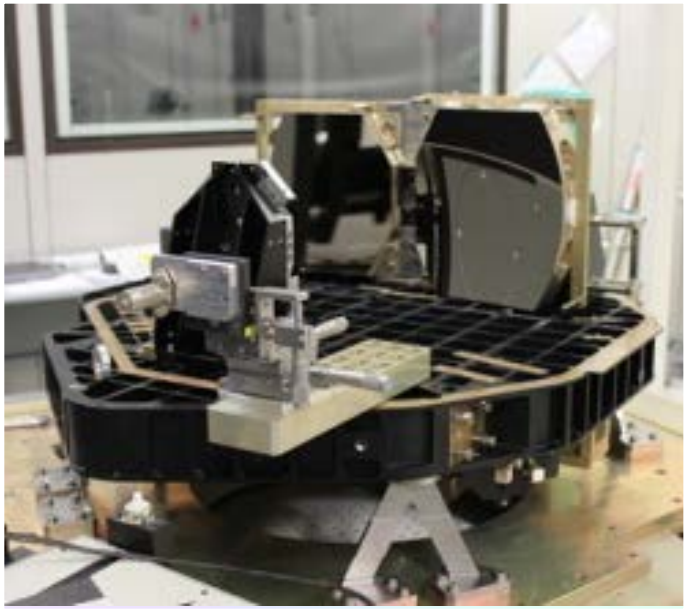
- Hyperspectral/PAN **Optical Head** (OH)
- **Main Electronics** (ME)
- **Sun Protection System** (SPS)

KEY PAYLOAD TECHNICAL FEATURES

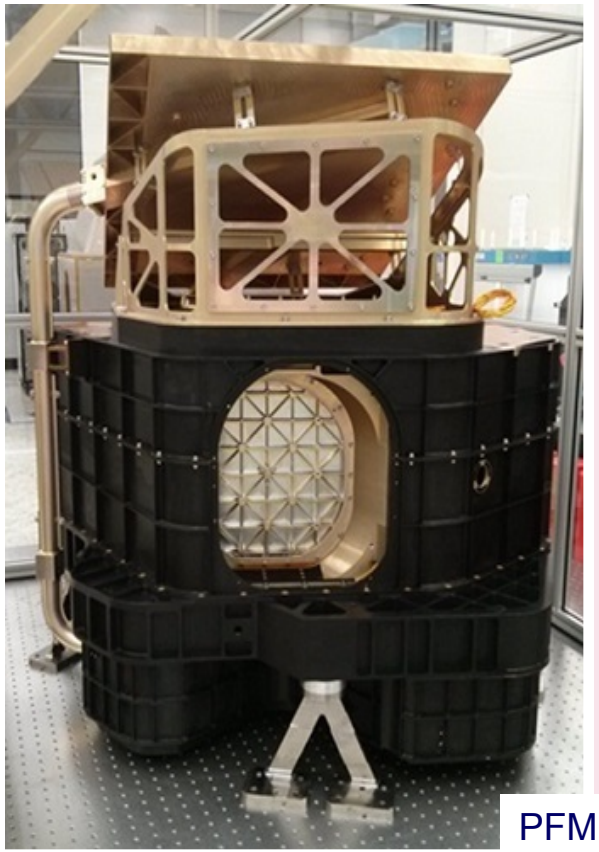
Swath / FOV	30 km / 2.77°
Ground Sampling Distance (GSD)	HYP: 30 m PAN: 5 m
Spatial Pixels	HYP: 1000 PAN: 6000
Pixel Size	HYP: 30 x 30 µm PAN: 6,5 x 6,5 µm
Spectral Range	VNIR: 400 – 1010 nm SWIR: 920 – 2505 nm PAN : 400 – 700 nm
Spectral Sampling Interval (SSI)	≤ 10 nm
Spectral Width (FWHM)	≤ 10 nm
Radiometric Quantization	12 bit
VNIR SNR	> 200
SWIR SNR	> 100
PAN SNR	> 240
Absolute Radiometric Accuracy	> 5%
Spectral Bands	66 VNIR 173 SWIR
Data processing	Lossless compression with compression factor 1.6 Near lossless compression
Cooling system	Passive Radiator

P/L S/S: OH

The Hyperspectral/PAN Optical Head (OH) collects the incoming radiation through a telescope and disperse it through two spectrometers that convert photons to electrons by means of appropriate detectors, amplify the electrical signal and convert it into bits.



PFM Optical Head
(Open view, TMA side)



PFM Optical Head
(closed with cover)

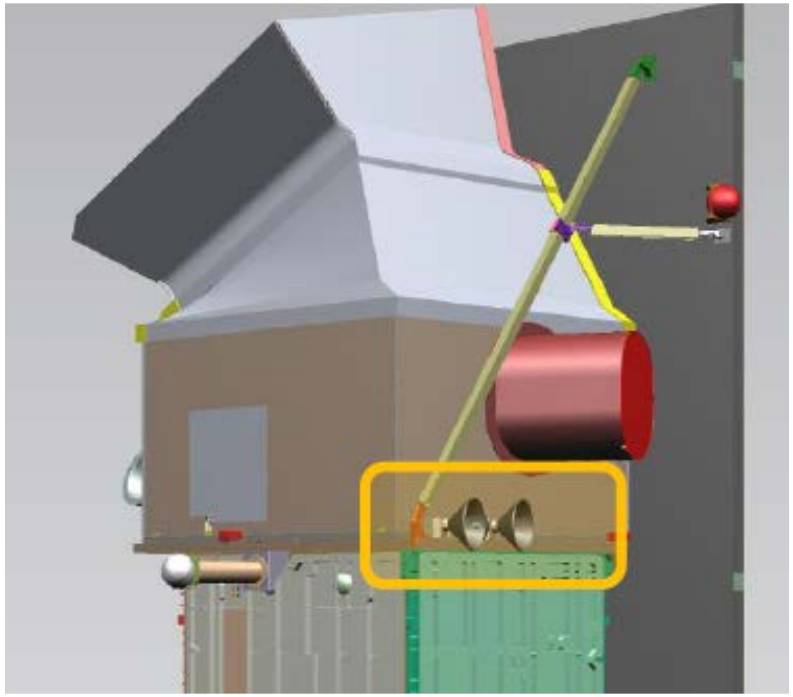
P/L S/S: ME

The Main Electronics (ME), based on a redundant subassembly architecture, is devoted to the control of the instrument and to handle the bit stream representing the spectral images up to the interface with the spacecraft transmitter. It has electrical interface with Payload OH and with spacecraft.

ME EM PL Side
ME Total Weight 12kg
ME Dimensions: 254.2x298x240 mm

P/L S/S: SPS

The Sun Protection System (SPS) is an autonomous system, directly connected to the payload ME and independent from the spacecraft, that is meant to activate a recovery reaction in case of failure of AOCS so to avoid direct exposition of the payload telescope FoV to the solar flux .



SPS accommodation on PRISMA S/C

PRISMA PDHT

The Payload Data Handling and Transmission (PDHT) will **manage all the Data handling and Transmission** of data generated by the Instrument on-board of the satellite:

- store
- format
- encrypt
- transmit

} to ground the payload data

The PDHT is designed to operate in different **modes**:

- ❑ acquiring data from Payload and storage into memory
- ❑ keeping stored data into memory for future download when not in ground station visibility
- ❑ playback of stored data for transmission to ground
- ❑ simultaneous data acquisition from Payload instrument and transmission to ground of previously stored Payload instrument data
- ❑ near real time transmission of currently acquired Payload instrument data to ground.

GROUND SEGMENT

The PRISMA Ground Segment (GS) is responsible for **managing the PRISMA mission** in terms of interfacing the **users** and processing their requests; preparing and upload (daily) to the satellite the acquisition **plan**; data archiving and delivery of the data **products**; controlling and monitoring the **satellite**.

The GS is geographically distributed in Italy and shall use:

- **X-band** downlink for the image and ancillary data (ASI **Matera** Space Geodesy Centre)
- **S-band** link for communication of telemetry and command data with the spacecraft (**Fucino**).

GS Subsystems

The PRISMA GS is organized in **different subsystems** for assuring successful mission operations:

- the Satellite Control Centre (**SCC**), for monitoring and controlling the satellite;
- the Flight Dynamics System (**FDS**) which takes care of orbit/attitude operations;
- the TT&C Station providing the S-Band link service between the satellite and the GS;
- the Mission Control Centre (**MCC**) providing the mission planning and related tasking sequences generation;
- Image Data Handling System (**IDHS**), in charge of receiving, processing and archiving/delivering the PRISMA data and products;
- a dedicated communication local network (**WAN/LAN**) that implements the connections between the different GS entities in a secure, reliable and efficient way.

PRISMA PRODUCTS

L0

(Hyperspectral / PAN) - formatted data product with appended metadata, including ancillary data and file formatting information – for archiving purposes only and available only for selected users (e.g. key data parameters update, calibration verification, etc.)

L1

(Hyperspectral / PAN) - radiometrically corrected and calibrated ToA spectral radiance data.

L2

Geolocated At-ground Spectral Radiance Product (Hyperspectral / PAN) – obtained by applying atmospheric correction

Geolocated At-surface Reflectance Product (Hyperspectral / PAN) – including cloud optical thickness, aerosol optical thickness and water vapour map Product

Geocoded version of the geolocated at-surface reflectance products (Hyperspectral / PAN)

IDHS and HSIS

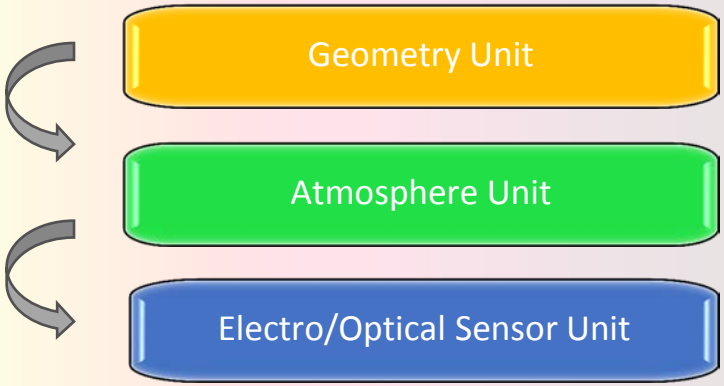
The Image Data Handling System includes the following elements:

- Centro Nazionale Multimissione (CNM)
- L0 Processing
- L1 Processing
- L2 Processing
- Hyper-spectral Image Simulator (HSIS)

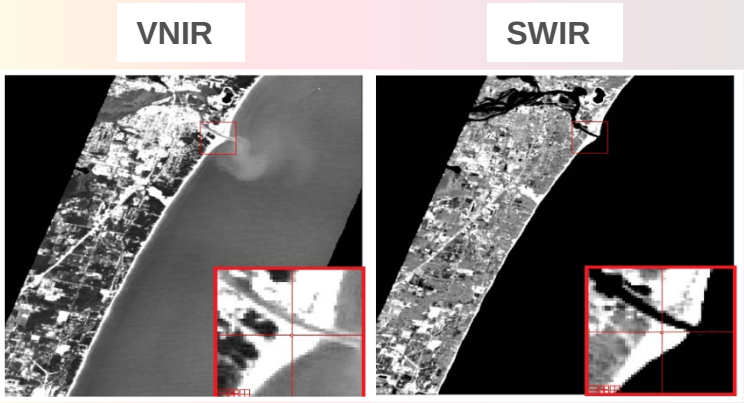
HSIS: produces simulated PRISMA-like imagery in the spectral range of interest, integrating into a single tool all the relevant knowledge about the instrument, the radiation source, the atmosphere and the observed scene.

HSIS can be used at several stages to support products validation.

- L1: comparison of HSIS input TOA radiance and L1 Product ToA radiance (produced starting from HSIS output data)
- L2: comparison of a synthetic test scene of surface reflectance given in input to HSIS with that obtained by the L2 processor (produced starting from HSIS output data)



HSIS output example



CONCLUSIONS

- PRISMA is an innovative hyperspectral Italian Earth Observation mission
- The system will be able to provide (Hyperspectral / PAN) data:
  - with different processing levels (up to L2d)
  - with a daily acquisition capacity up to 223 images corresponding to 200000 km^2
- Tanks to the aforementioned system characteristics, the PRISMA data result very useful to support key applications in the field of:
  - agriculture
  - geology
  - water quality
  - soil
  - vegetation monitoring
  - risk management support and environmental monitoring (fires, landslides, volcanic and seismic hazard)
- Currently PRISMA is in the development phase of the program
- The launch is scheduled for mid 2018 with VEGA launcher.
- Along with the system deployment, a number of scientific activities, including dedicated workshops, with the involvement of researchers in different applicative fields, are being activated (see also PRISMA web site:

  http://prisma-i.it, http://prisma-i.it/index.php/en/events/conferences-and-workshops)
- The deployment activities include the development of Hyper-spectral Image Simulator (HSIS) that can be used to support the Cal/Val WG in the products validation.

Thank you for your attention

For any further information, please contact the Program Manager:

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Keep you informed about PRISMA at http://prisma-i.it