
# PRISMA

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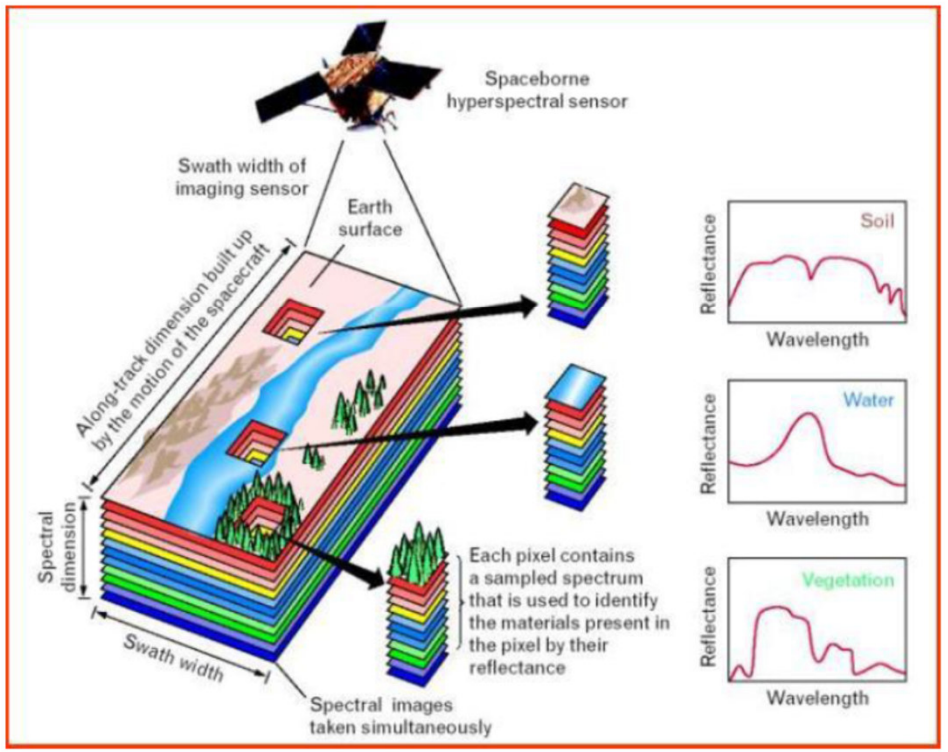
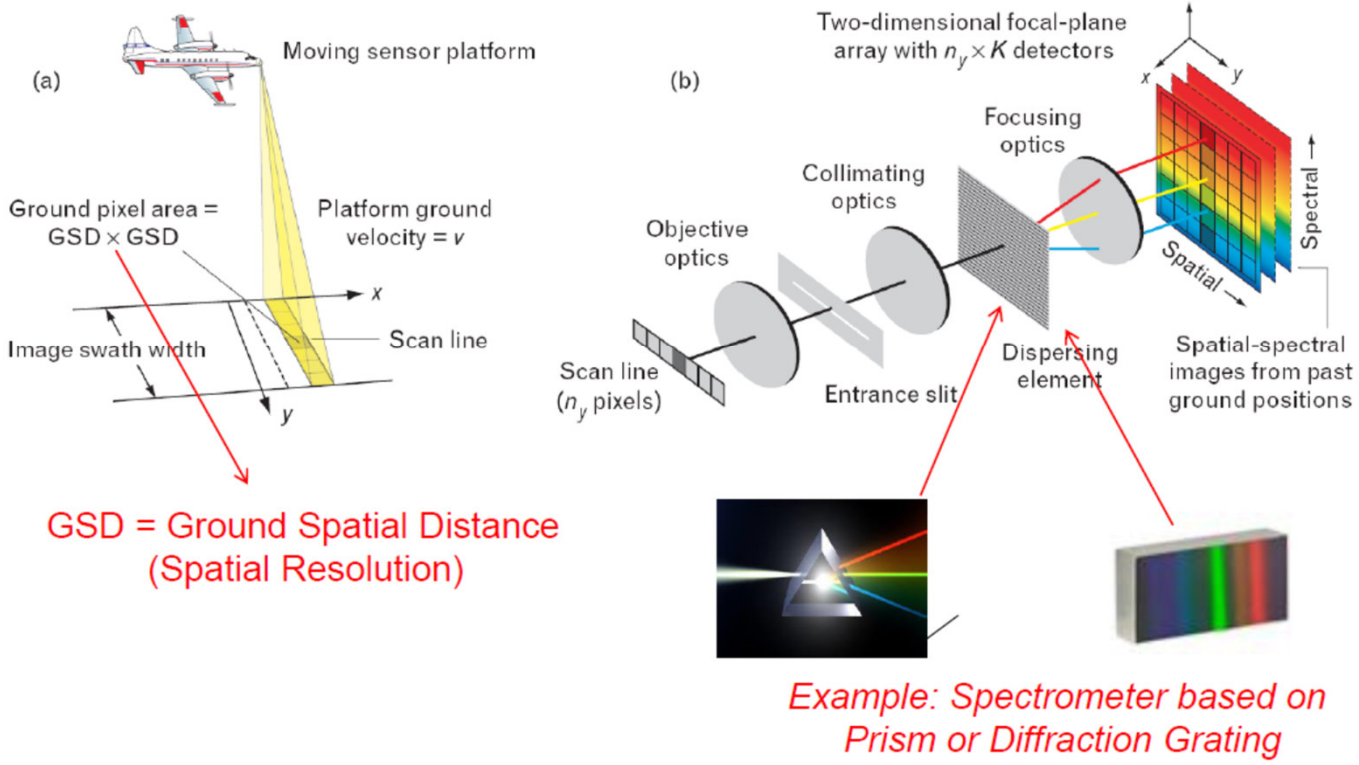
**Leonardo**

# HYPERSPECTRAL «PUSHBROOM» Acquisition

The Hyperspectral Technique is based on the acquisition through an electrooptical sensor of a ***"Spectral Cube"*** containing both spatial and spectral information of the area target.



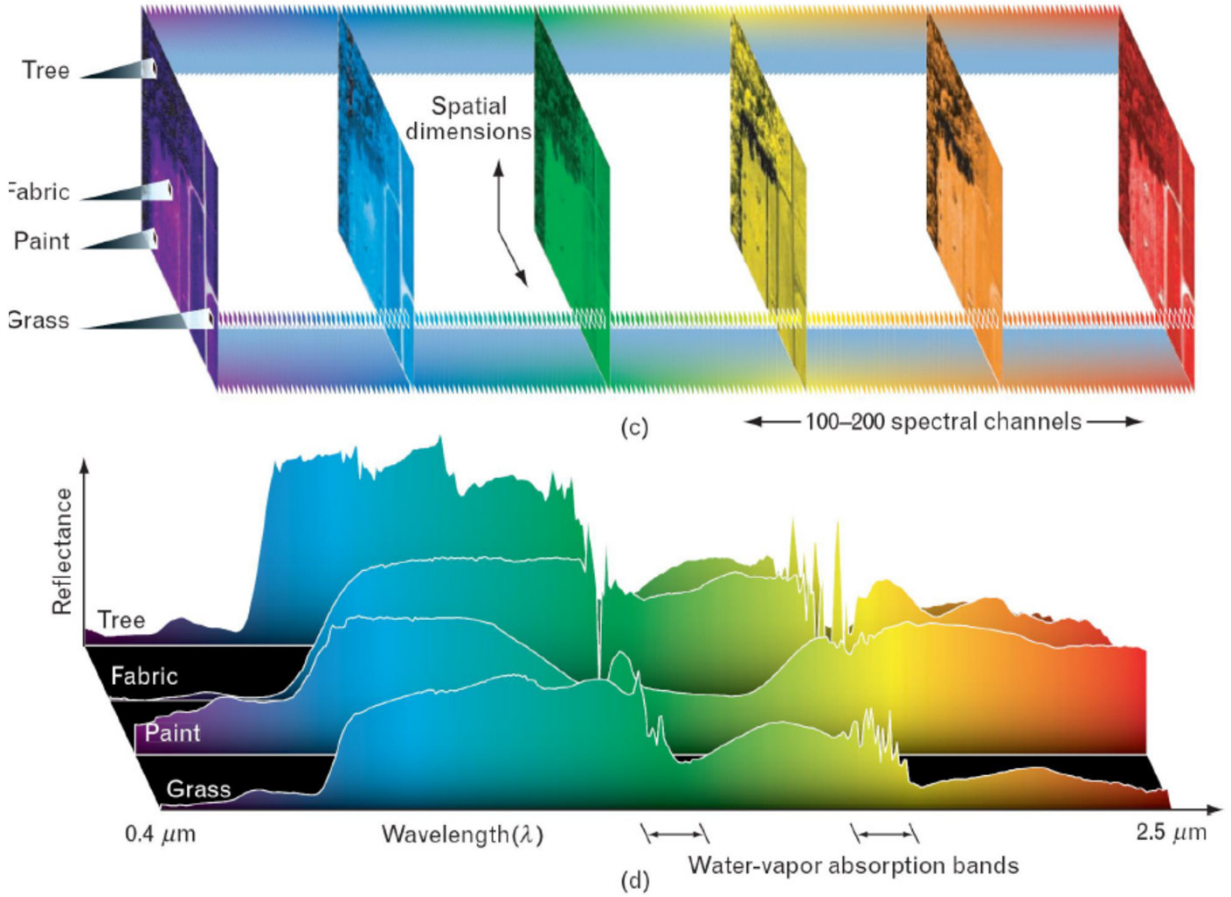
# **HYPERSPECTRAL** «PUSHBROOM» Acquisition




GSD = Ground Spatial Distance
(Spatial Resolution)

*Example: Spectrometer based on Prism or Diffraction Grating*

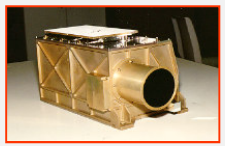
# **Material** identification



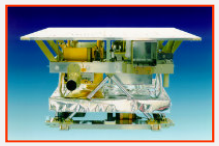
# PRISMA: a long run in Leonardo since the early 90s on the road of Multispectral and Hyperspectral Instruments

1990 2000 2010 2020 2025

*Planetary exploration*



VIMS (Cassini)



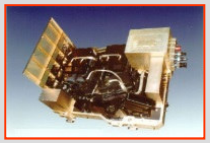
VIRTIS
(Rosetta, VEX, Dawn)

JIRAM
(JUNO)

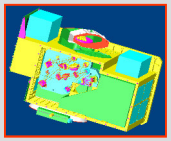
VIHI
(Bepi Colombo)

MA-MISS
(ExoMars)

*Earth Observation*

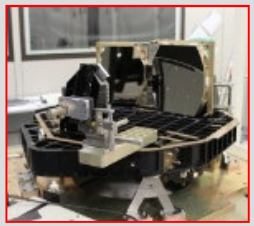


GOME1 (ERS2)



HYPSEO

GOME2 - METOP



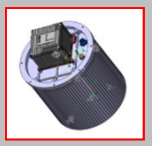
PRISMA

*Airborne Sensors*

VIRS

SIM.GA 1

SIM.GA 2

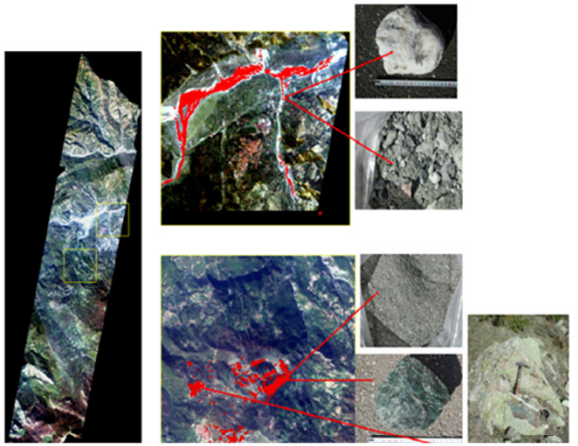


SPHYDER

# PRISMA Mission Objectives and applications

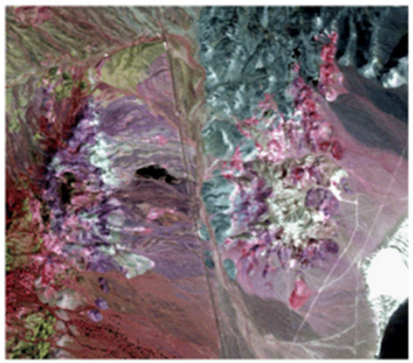
PRISMA provides information about:

- environmental changes at a global level;
- the impact of human activities on ecosystems;
- natural resources for their management and environmental sustainability.

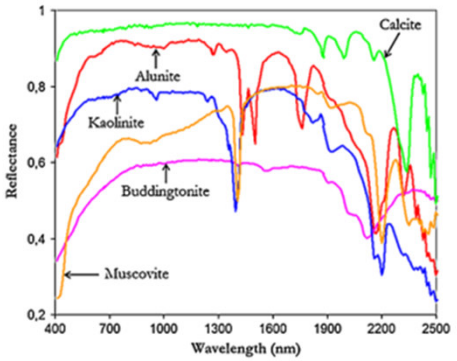


Applications for PRISMA products include monitoring of:

- Geology
- Agriculture and Forestry
- Urban areas
- Water resources
- Natural hazards



(a)



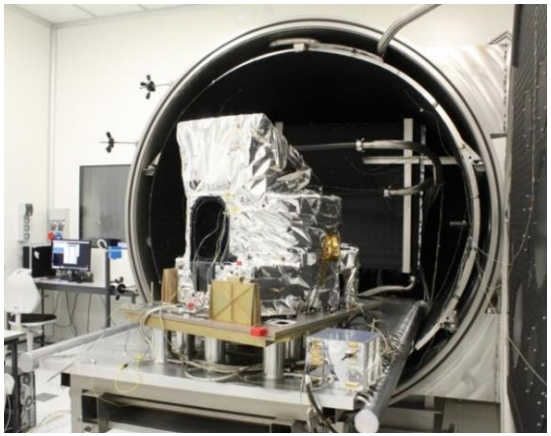

(b)

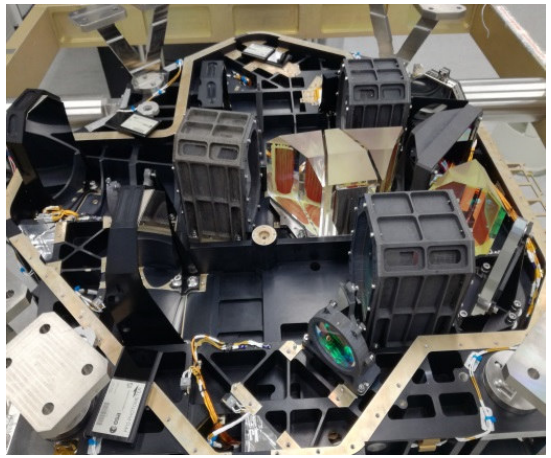
# PRISMA: What is PRISMA innovative for?

The PRISMA Payload is a hyperspectral imager characterized by high Hyperspectral capabilities in terms of **SNR**, **spectral and spatial resolution** and **radiometric accuracy**.

The parallel acquisition of higher spatial resolution Panchromatic images allows enhancing of the Hyperspectral images.

The Optical Head also includes an in-flight Calibration Unit. In-fact, besides nominal Earth Observation, the Payload also offers several in-flight calibration options, aimed at maintaining stable performances during its operative life (5 years).

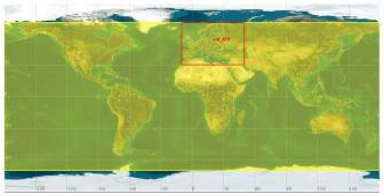


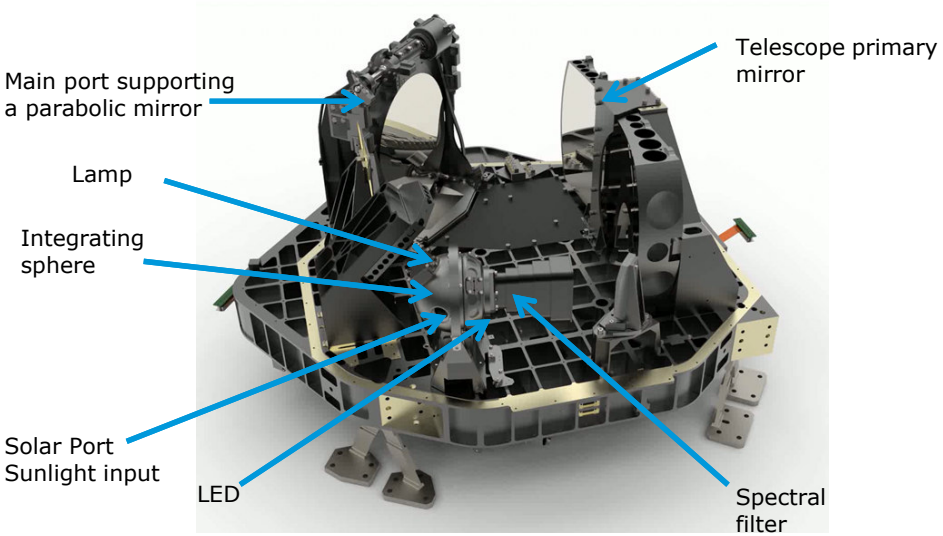


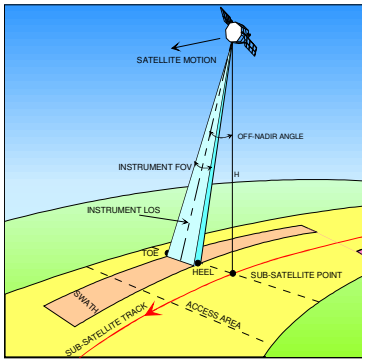
# PRISMA: Payload Characteristics

| | |
|---|---|
| Acquisition method | **Pushbroom**<br>Acquisition Frame = 30m x 30km => 4,31msec<br>Uninterrupted acquisition up to 1800km |
| Image acquisition area | Longitude: 180°W - 180°E<br>Latitude: 70°S - 70°N |
| Relook time | 29 days (7 days considering rolling) |
| Roll angle | **±20 deg** |
| Cooling system | Passive (in order to avoid vibration) |

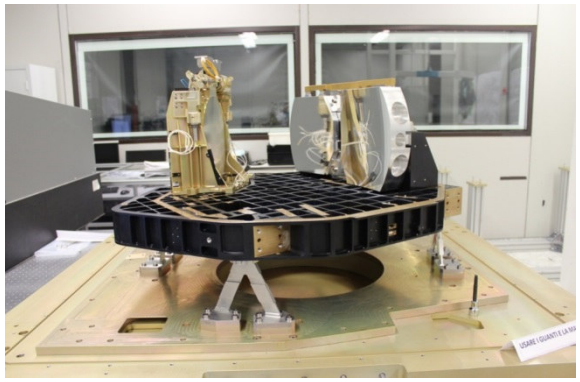
| | |
|---|---|
| Swath | 30 Km |
| GSD | Hyperspectral: 30 m / PAN: 5 m |
| Spectral Range | **VNIR: 400 – 1010 nm** (66 spectral bands) |
| | **SWIR: 920 – 2500 nm** (174 spectral bands) |
| | PAN : 400 – 700 nm |
| Orbit altitude | 620km |
| Orbit period | 97 min |
| Mass | ~200kg |

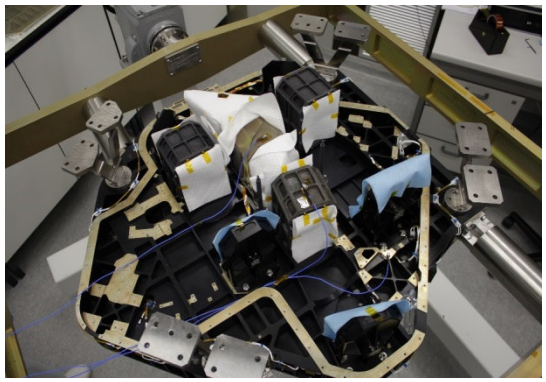


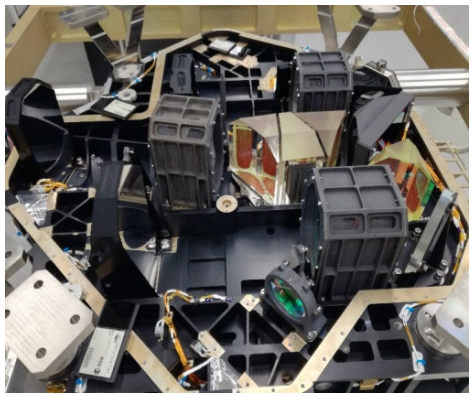


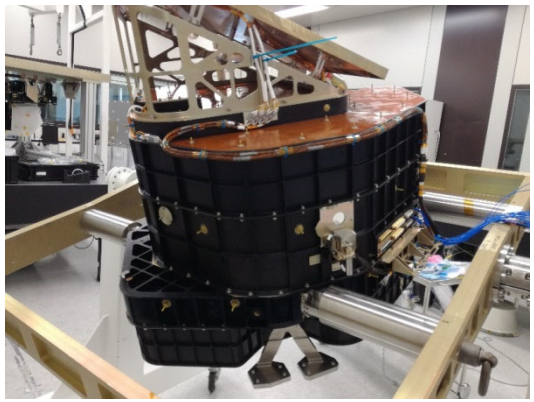



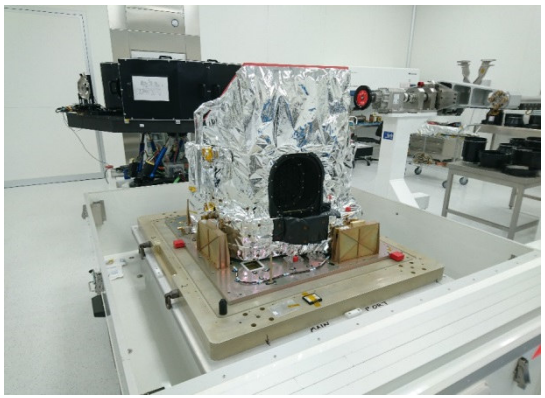
# PRISMA: Integration & Test phases in Leonardo

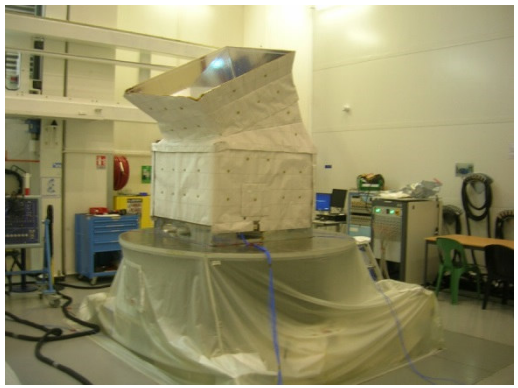




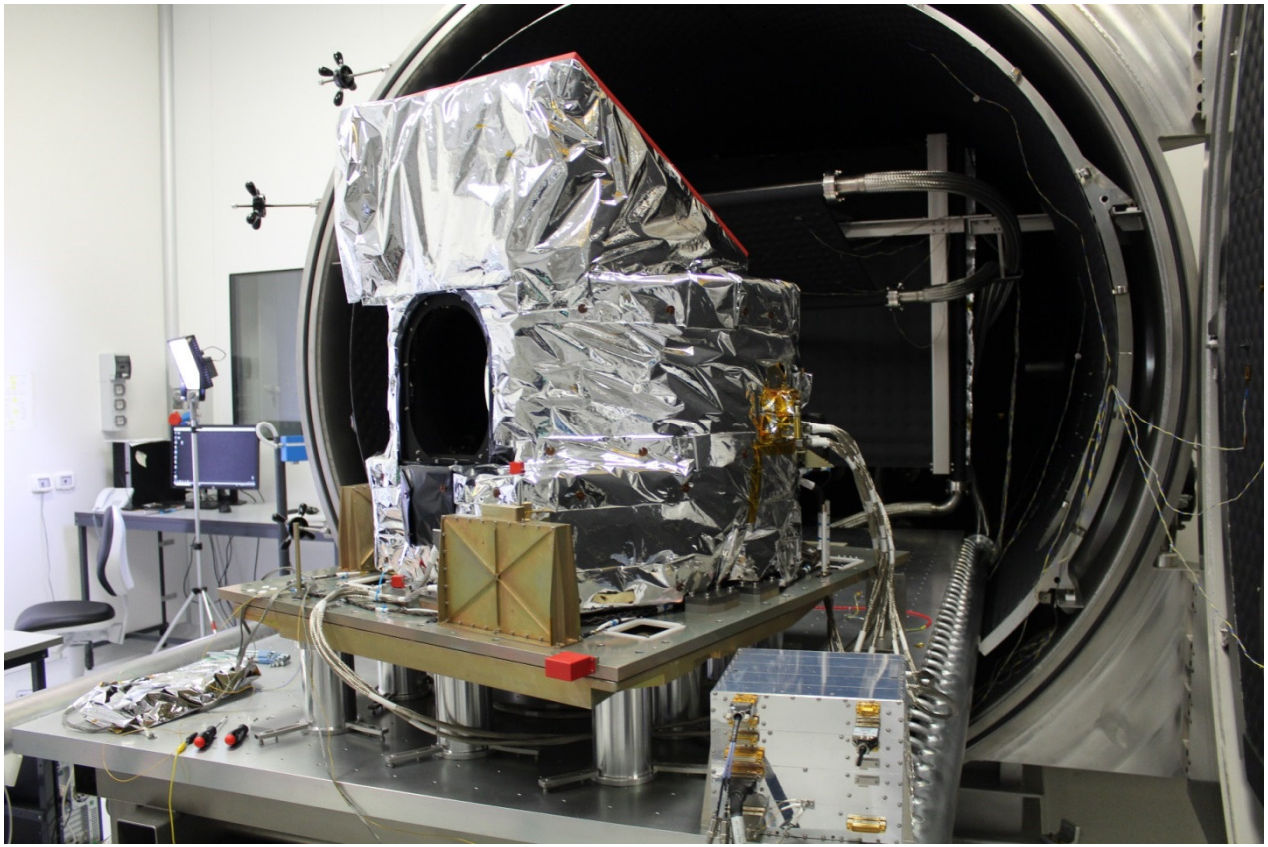




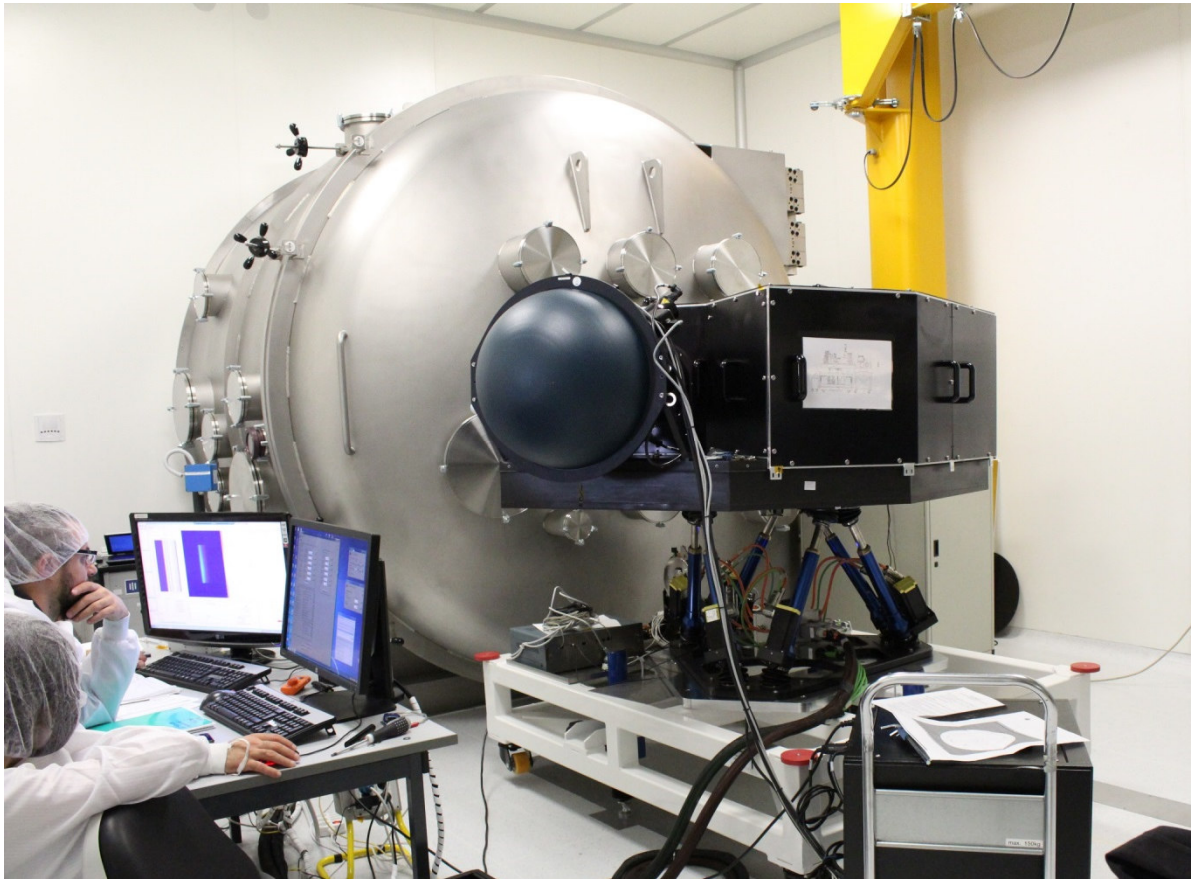




# PRISMA: Integration & Test phases in Leonardo (thermal vacuum campaign)



# PRISMA: On-ground calibration phase



# PRISMA: In-flight condition

## Launch date

March, 22nd 2019 02:50 CET
First telemetry: March, 24th 2019

## Operative date

Fully operative in orbit from end January of 2020

The Payload has been designed and manufactured by Leonardo, as part of a consortium including OHB-I, mission Prime, and operating under the authority of the Agenzia Spaziale Italiana.

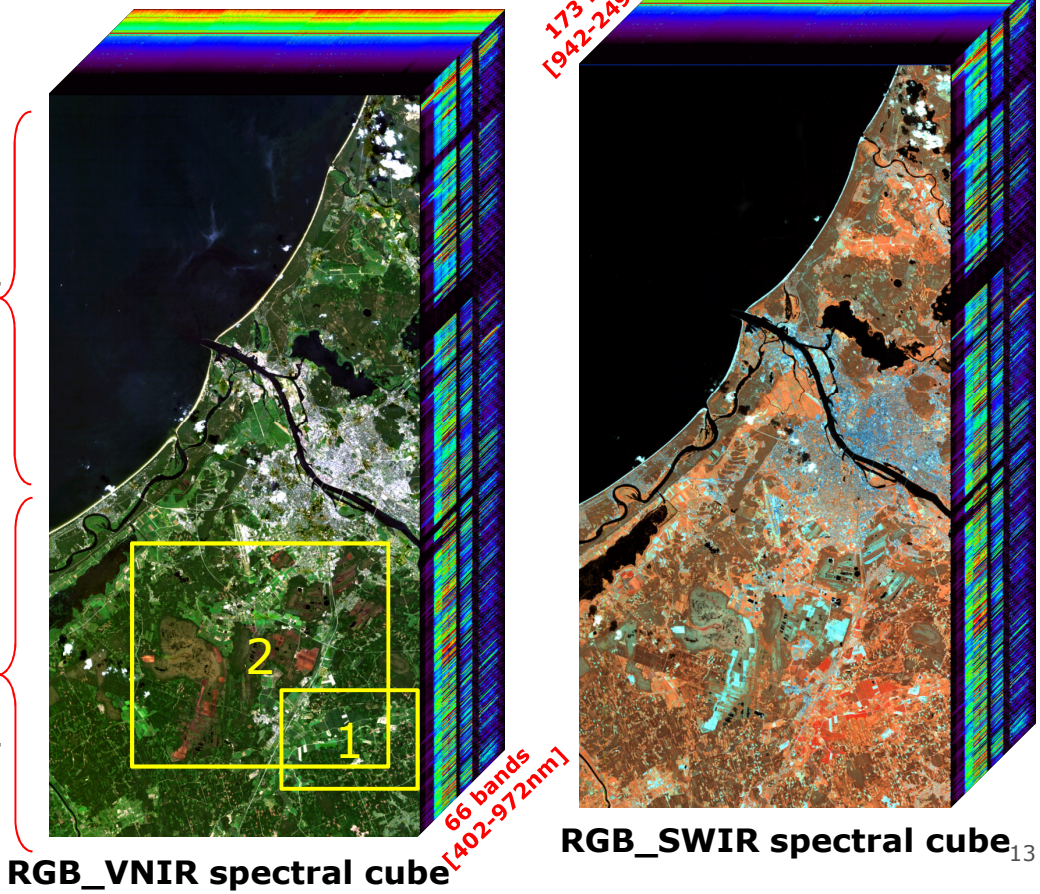
# PRISMA: **Lettonia – Riga Strip acquisition**

**Over a strip of acquisition of two 30x30km spots, two agriculture prone-areas were selected:**

**PRS_L2C_STD_2020061909433 6_**

**1 – Green fields**
**2 – Iron-bearing Bare Soils**

**PRS_L2C_STD_2020061909434 0_**



# PRISMA: **Vegetation Biomass & Health analysis**

Analysis carried out by means of «**Narrowbands Spectral Indices**» combining VNIR & SWIR spectral bands sensitive to specific bio-geo-physical parameters

- Remote sensing provides a considerable potential for estimating Vegetation health at local to regional and global scales. Several spectral vegetation indices (VI) and algorithms are investigated.
- Narrowband greenness VIs are intended for use with imaging spectrometers. They are combinations of reflectance measurements sensitive to the combined effects of foliage chlorophyll concentration, canopy leaf area, foliage clumping, and canopy architecture.
- One area where narrowband greenness VIs are useful is "precision agriculture".
- Most of these VIs use reflectance measurements in the red and near-infrared regions to sample the "red-edge" portion of the reflectance curve. The "red-edge" is a name used to describe the steeply sloped region of the vegetation reflectance curve between 690 nm and 740 nm that is caused by the transition from chlorophyll absorption and near-infrared leaf scattering. Use of near-infrared measurements allows estimation of the total amount of green material in the column.
- Making narrowband measurements in the "red-edge" allows these indices to be more sensitive to smaller changes in vegetation health than the broadband greenness VIs.

# PRISMA: **Vegetation Biomass & Health analysis**

- In this investigation the following Spectral Indices are shown:

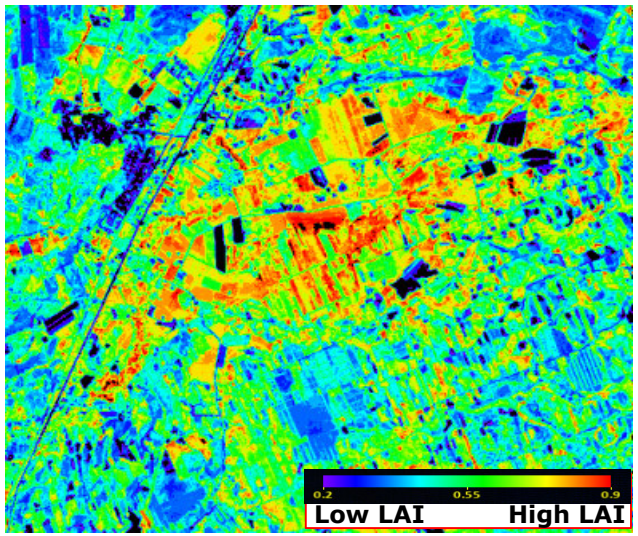
  - **MNTVI2** (Modified Triangular Vegetation Index2) as considered a good predictor of green **Leaf Area Index**
  - **NDNI** (Normalized Difference Nitrogen Index) as designed to estimate the relative amounts of vegetation **Nitrogen content**
  - **FMR** (Ferrous Minerals Ratio) as a band ratio (SWIR/NIR) highlights iron-bearing minerals

In particular: **Leaf Area Index** (LAI) and **Nitrogen Index** are important key bio-physical metrics in estimates of primary production, agricultural yield forecasting, precision agriculture, ecosystem analysis, forest management and climate models to characterize grassland growth and conditions.

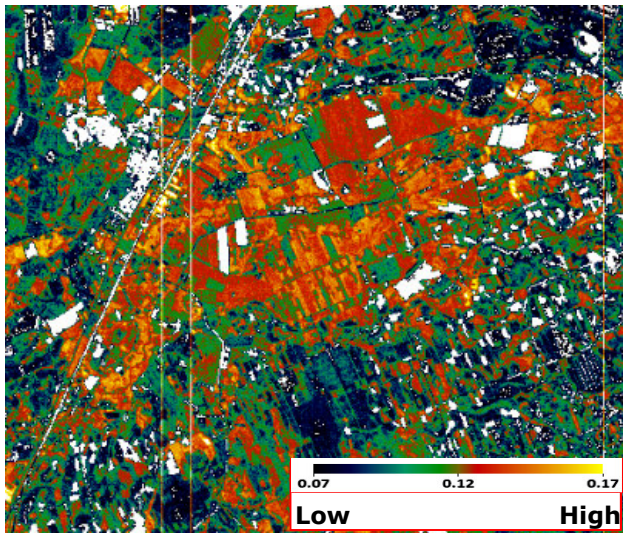
- **LAI** is an index of the photosynthetic capacity of the plant community.
- **Nitrogen** is an important component of chlorophyll present in high concentration in vegetation is growing quickly.

# PRISMA: **Lettonia - Results Maps**

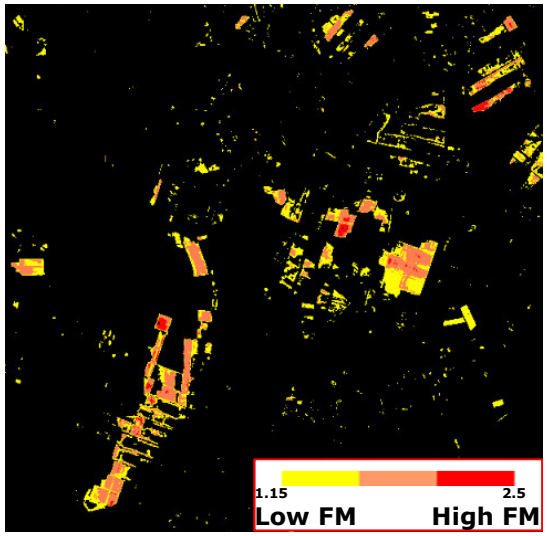
## Modified Triangular Vegetation Index2 (MTVI2) Map




## Normalized Difference Nitrogen Index (NDNI) Map




## Ferrous Minerals Ratio (FMR) Bare Soil Map




(source: Data / Information generated by Leonardo under an ASI License to use. Original PRISMA product - © ASI - 2021)

$$MTVI2 = \frac{1.5[1.2(\rho_{800} - \rho_{550}) - 2.5(\rho_{670} - \rho_{550})]}{\sqrt{(2 * \rho_{800} + 1)^2 - (6 * \rho_{800} - 5 * \sqrt{\rho_{670}}) - 0.5}}$$

$$NDNI = \frac{\log\left(\frac{1}{\rho_{1510}}\right) - \log\left(\frac{1}{\rho_{1680}}\right)}{\log\left(\frac{1}{\rho_{1510}}\right) + \log\left(\frac{1}{\rho_{1680}}\right)}$$

$$Ferrous\ Minerals\ Ratio = \frac{SWIR}{NIR} \quad \frac{1.55 - 1.75nm}{0.76 - 0.90nm}$$

# Thank you for your attention

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