The Hyperspectral PRISMA Mission and its first results

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Italian Space Agency

Presented by
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National EO hyperspectral Mission fully funded by ASI.
PRISMA - Contract signed between ASI and an Italian Industries Consortium led by OHB Italia and Leonardo
Mission conceived as a
- Pre-operational and technology demonstrator
- Focus on
  - Space qualification of PAN/HYP payload
  - Development and production of PAN/HYP products up to Level 2d
**PRISMA Mission Overview**

**Space Segment**
- One small Satellite

**Ground Segment**
- Fucino: MCC (Mission Control Center) / SCC (Satellite Control Center)
- Matera: IDHS (Image Data Handling System)

**Launch Segment:** VEGA

**PRISMA Launch**
22nd March 2019
02:50 CET

**Platform**
- **Payload**, consisting in a Hyperspectral / Panchromatic instrument (derived from HypSEO mission)
- Payload Data Handling and Transmission unit (**PDHT**)
PRISMA Mission Overview

- PRISMA P/L operates with a Pushbroom scanning concept.
- It records the radiation reflected from the Earth surface (spectral cubes) in 400nm – 2505nm spectral window
  - PAN range
  - 240 bands in VNIR / SWIR (partial overlap)
  - High spectral Resolution (much better of 14 nm)
PRISMA Mission Overview

MISSION
Orbit LEO SSO, 620km, 10.30 LTDN
Lifetime 5 years
Coverage Worldwide
Primary Mission mode User driven (on-demand)

SYSTEM CAPACITY
Swath 30 km, GSD: 30 m HYP, 5 m PAN
Data volume daily > 200.000 km² on all the 430/29 orbits/day
Daily products generation daily processing of 200 hyperspectral scenes (30 km x 30 km) up to level 2d product.

SYSTEM LATENCIES
Revisit time < 29 days
Re-look time < 7 days

SPACE SEGMENT
Single Satellite
Mass (Dry) 827 kg (202.5 kg Payload mass included)
Geometric Dimensions Height, about 3 m
Width x depth. about 1.9 m x 1.1 m

GROUND SEGMENT
MCC/SCC Mission & Satellite Control Centre: Fucino
IDHS includes:
Centro Nazionale Multimissione (CNM)
L0/L1/L2 Processing
Hyper-spectral Image Simulator (HSIS)

LAUNCH SEGMENT
VEGA Dedicated launch

Swath 30 Km
GSD Hyperspectral: 30 m / PAN: 5 m
Spectral Range

| SNR | SWIR: > 100:1 (>360:1 at 1550nm) |
| PAN: > 240:1 |
Spectral Width ≤ 14.5 nm
PRISMA Mission Overview

**PRISMA PRIMARY AREA OF INTEREST**

Latitude 70°S ÷ 70°N

Longitude 180°W ÷ 180°E

**Mission Highlight**

**PRIMARY MODE – USER DRIVEN**

Data Delivery based on user requests on areas of interest

- **Very urgent requests**
  - Submitted by ‘special users’ and direct managed by the mission manager

- **Primary requests**
  - CALVAL sites
  - Nominal requests from all registered users
  - Subject to priority level

- **Background requests**
  - Generated to fill system resources still available after planning of users requests

**Satellite attitude**
- Nominally sun pointing
- Nadir pointing only during images acquisition and download

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The dataset is organized in a Cube format, i.e. a 3D dataset.

**Level 0 (Hyperspectral / PAN)**
- formatted data product with appended metadata, including ancillary data and file formatting information (Archived data) in proprietary format

**Level 1 (Hyperspectral / PAN)** radiometrically corrected and calibrated radiance data in physical units
- Top-of-Atmosphere Spectral Radiance
- Cloud mask
- Sun-glint Mask
- Calibration and characterization data
- Classification Mask

**Level 2b Geolocated at Ground Spectral Radiance Product (Hyperspectral / PAN)**

**Level 2c Geolocated At-surface Reflectance Product (Hyperspectral / PAN)**
- Aerosol Characterization Product (VNIR)
- Water Vapour Map Product (Hyperspectral)
- Cloud Characterization

**Level 2d Geocoded version of the level 2c products (Hyperspectral / PAN)**

L1 and L2 product are disseminated in HD5 format
The combined PAN/Hyperspectral data acquisition allows to perform both the observation of the geometric characteristics and of the chemical-physical characteristics of the targets of interest.

The PRISMA hyperspectral products will provide useful information for science investigation and applications in the fields of Earth Observation for terrestrial and aquatic ecosystems, or for natural resource monitoring and management support.

Prisma will provide a stronger contribute in supporting the implementation, monitoring and evaluation of the Sustainable Development Goals (SDGs) in the framework of the 2030 Agenda for Sustainable Development adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future.

PRISMA data will be important for supporting the following key applications:

- **Agriculture and Forests**
- **Land use**
- **Inland and Coastal water**
- **Risk Management** (e.g., volcanic, fires, oil spill, hydrology, etc.)
- **Atmosphere and Climate**
- **Geology**
- **Soil**
- **Urban Areas**
- ...
Original contribution to Remote Sensing applications & Significant role in the upcoming international scenario

- PRISMA has been conceived as an Opportunity on HYP data based R&D
  - New Data Processing (methods & techniques enabling new applications or services)
  - New Products (e.g. Data Fusion)
  - Pre-operational downstream services
  - Exploitation Platforms

- National contribution for EU/International EO programs
  - Technology for SHALOM, Copernicus
  - Sinergy with non ASI missions (e.g. FLEX)

- Support to future hyperspectral missions (SHALOM, FLEX, Hyperspectral Copernicus Mission) through PRISMA Data Exploitation
Data Exploitation Strategy

- Science and User Community deeply involved
  - CAL/VAL activities for independent verification of data quality
  - PRISMA Advisory Group for data Exploitation supporting the definition/updating of the mission exploitation scenario
    - Mission performances monitoring
    - Background mission update
    - R&D activities for data exploitation algorithms and pre-operational products
    - Data Policy update (user groups, priorities, new licensing schemes,...)
    - Support to collaborations with other bodies on HYP themes

- Development of a PRISMA Mission Exploitation Platform / PRISMA Toolbox

- Training & Outreach (Workshops, Education events,...)
After the end of the commissioning phase it is foreseen a structured three years CAL/VAL activity, which will be performed on instrumented sites distributed in Italy in support to:

- the performance characterization of the instrument;
- the verification and maintenance of mission performance over time;
- the effective use of data.

A systematic validation process is foreseen both during the commissioning phase and during the operational phase.

The Validation involves the assessment of the accuracy of data and products, over the relevant spatial, temporal and spectral domains.
The test sites have been selected according to the peculiar thematic areas of interest for the mission;

- International test site are still under agreement.

<table>
<thead>
<tr>
<th>Thematic areas</th>
<th>Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Water</td>
<td>Lampedusa, Venezia</td>
</tr>
<tr>
<td>Snow</td>
<td>Torgnon, Plateau Rosa</td>
</tr>
<tr>
<td>Inland water</td>
<td>Lago Trasimeno, Lago di Garda</td>
</tr>
<tr>
<td>Agricultural areas</td>
<td>Grosseto, Basilicata, Tavoliere delle Puglie, Ferrara</td>
</tr>
<tr>
<td>Forests</td>
<td>Lavarone</td>
</tr>
</tbody>
</table>
PRISMA satellite is alive and well, the commissioning phase is actual expected to end in late June 2019

A specific project about the PRISMA data validation is started in parallel to the commissioning, aimed to pursue a fully independent verification of the data quality and proper calibration, during a six month time frame.

The full PRISMA data dissemination will be available not earlier than late summer 2019, under the Data policy rules (already defined and approved by ASI, although not yet marked for public dissemination.)
First results

Hyperspectral Cube Image

Spectra over 5 pixel selected in the image

Overlapping region between VNIR and SWIR
First results

Geographic Area: IVORY COAST
(Yabayo) Channel: PAN
First results

Geographic Area: IVORY COAST
(Yabayo) Channel: VNIR
**Geographic Area:** IVORY COAST (Yabayo) **Channel:** SWIR
Site: Ofanto river and Margherita di Savoia (Puglia, Italy)
Level 2c
**PRISMA natural (visible) RGB**
- Red: 638 nm
- Green: 587 nm
- Blue: 497 nm

The Margherita di Savoia Saltworks are the largest productive saltworks in Italy. The different green colours show the vegetation presence, while the browns indicate poor arable lands or salty/marsh soils.

**PRISMA. High potentiality for classifying the different salt percentages, also measuring single parcel through digital numbers**

Courtesy of E-GEOS
Tested for a preliminary assessment of PRISMA capacity to sense the signal from waters with different levels of salt: PRISMA revealed different gradients of salt concentrations into the water.

First result showed at the event “Salon International de l'Aéronautique et de l'Espace« - Paris-Le Bourget, 18 June 2019
First results

Site: Ofanto river and Margherita di Savoia (Puglia, Italy), Level 2c
PRISMA IRFC -RGB
Red: 638 nm
Green: 587 nm
Blue: 497 nm

The numerous red, reddish and pinkie colour tones easily detect several crop types: wheat, vine, horticultures, greenhouses

PRISMA. Strong capability in agro-forestry classes detection, both by interpretation and semi-automatic recognition, at medium-large scale

Courtesy of E-GEOS
Site: Nevada (Cuprite hill)
Cuprite has been used extensively as a test site for remote sensing instrument validation.
Level 2c
RGB visible:
Red: 638 nm
Green: 587 nm
Blue: 512 nm

Analysis of the spectral profiles of pixels within a reflectance image, and comparison to library spectra of known materials.

In addition to visible RGB, the absorption features of mineral in the wavelength range 2100 – 2300 nm offers a good reference point for comparing image spectra and clay classes.

Kaolite qualitative abundance map
Qualitative analysis with false color rendering.

Courtesy of E-GEOS
Site: Italy, Castel Fusano

Monitoring of PRISMA

To provide information on the vegetation status (evaluation of chlorophyll contents and water content in the various areas).

To provide a precursor sign of fire risk.

First result showed at the event "Salon International de l'Aéronautique et de l'Espace« - Paris-Le Bourget, 18 June 2019
First results

Site Canada, Vancouver, Product: Land Cover Map

First result showed at the event “Salon International de l'Aéronautique et de l'Espace« - Paris-Le Bourget, 18 June 2019

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**Site: Italy, Trasimeno Lake**  
**Product: Turbidity map**

PRISMA detected the clearest waters and identified algae colonies as well.

First result showed at the event "Salon International de l'Aéronautique et de l'Espace« - Paris-Le Bourget, 18 June 2019
PRISMA Data Policy

High level DATA POLICY (ASI-Council of Ministers) for all the National and Public EO Civil & Dual missions

Data Policy of Other national missions

PRISMA Mission Data Policy
Technical and legal principles to regulate access to mission products, in accordance with foreign policy and domestic security:
- Guidelines to implement Data policy principles;
- Licence to use (terms and conditions of the service)

USER CATEGORY
A. ASI as system owner and entity carrying out the maintenance of system in operating conditions and the safeguarding of national security;
B. Domestic Institutional User (Universities, Research centres, Local authorities, Agencies, etc.);
C. International Institutional User (Universities, Research centres, Int. authorities, Agencies, etc.);
D. General users

PRODUCT USES
- Scientific Use: research and study activities;
- Institutional Use: innovative, public utility and non-profit applications;
- Commercial Use: projects with commercial purposes, currently based exclusively on archive data

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PRISMA Mission Data Policy guidelines

Prisma is a scientific and demonstrative mission, the Data Policy is based on the following guidelines:

- Allow a wide use of products in order to validate the technology, maximize the return on investment and support the development of skills in an innovative sector;
- To promote the development of domestic competences, in view of future opportunities at European and international level;
- Promote scientific use and experimentation of innovative application services;
- Allow the development of commercial demonstration services, on the basis of archive data (as actually foressen) and in accordance with the characteristics of the mission.

PRISMA Mission Data Policy fundamental principles

- The user shall be enabled, through a very simple registration / accreditation step, to
  - request new acquisitions and relevant products;
  - obtain products generated on the basis of archive data.
- Products of level 0 will be accessible only to users belonging to Category A (in order to preserve the industrial know-how underlying the development of the mission.
- The new acquisitions request is managed through rights defined in terms of "quota" (maximum quantity of products) and "priority" in access. They are attributed to the user during the accreditation phase, based on the category to which they belong and the intended use of products and they will be applied during the acquisition planning phase.
- Currently there is no access to new acquisition request for commercial users.
- Daily planning should always include the user acquisitions request and enough background / systematic acquisitions. **The balancing of the two components may vary during the life of the mission.**
Economic conditions

CONDITIONS FOR ACCESS AT NO COST TO NEW ACQUISITION AND ARCHIVE PRODUCT

- for users of category A who use the products for institutional purposes;
- for users of category B who use the products for scientific purposes;
- for users of category B who declare institutional-application use and who request products on Italian territory and Italian territorial waters or exclusive economic zone (EEZ);
- To quotas defined in the context of specific initiatives (e.g. Announcement of Opportunities) promoted by ASI, for scientific and institutional-application use.

The purpose of costless access is to encourage the development of new algorithms and applications, the consolidation of existing applications, to obtain any feedback to optimize performance and exploitation of the mission.

An International Open Call based mechanism, capable to deliver data free of charge to International Institutional and Scientific Users will be launched in the next future.
Mission Data access

The end users can access via web to PRISMA mission data (catalogue and new acquisition requests) through a unique access point named CNM Access System (CAS).

PRISMA mission portal is a web based services access for:
- **User registration/accreditation**
- Product request (from catalogue/archive)
- New Image Acquisition Request

Creation of his own profile:
- personal and identification data, product uses, etc
- acceptance of the terms and conditions of the service
- Submission of the registration request

User Access
www.prisma-i.it

http://prisma-i.it/index.php/it/
PRISMA mission portal is a web based services access for:

- User registration/accreditation
- Product request (from catalogue/archive)
- New Image Acquisition Request

**Mission Data access**

**Mission Selection Form**

- **System**
  - PRISMA

**Other links**

- Old CNM Catalog
- Documentation Area

**User Access**

Select the desired parameters and click continue then proceed with ORDER confirmation.
Mission Data access

User Access

PRISMA mission portal is a web based services access for:

- User registration/accreditation
- Product request (from catalogue/archive)
- New Image Acquisition Request

Mission Selection Form

Mission *
PRISMA

Systems *
Select a System...
Select a System...
Catalog
MS 86

Other links
- Old CNM Catalog
- Documentation Area

New Order
New Cal Order

Status filter: ANY

Status
Summary

Due Date
Order Id: 226
12 May
12:00
Number of Programming Requests 1
SUBMITTED

Order Id: 225
12 May
12:00
Number of Programming Requests 2
SUBMITTED

Order Id: 257
18 May
12:00
Number of Programming Requests 6
SUBMITTED

Order Id: 258
21 May
12:00
Number of Programming Requests 1
SUBMITTED
User Access

Users can select some image acquisition parameters:

- SZA
- Off nadir angle
- Validity time window (within one repeating cycle; 29 days)
- Spot (1 single 30x30sqkm) or Strip (up to 7 consecutive spot)
- Maximum cloud coverage
- Image geographic coordinates
  - Spot: image center coordinates
  - Strip: coordinates of a point of the strip and strip the length before and after that point
Validity Time: Time period to achieve a feasible DTO

Point of interest selection alternatives:
- Selection of point of interest on Map Viewer
- Latitude and Longitude editing on entry fields

Area of Interest type alternatives:
- Spot 30 x 30 km
- Stripmap 30 x 60 km
- Stripmap 30 x 90 km
- Stripmap 30 x 120 km
- Stripmap 30 x 150 km
- Stripmap 30 x 180 km
- Stripmap 30 x 210 km

Processing level required:
- L0
- L1
- L2B, L2C, L2D

Multiple programming requests definition is possible
Observation scenario

4 Operational Satellites Cosmo SkyMed
2 Operational Satellites Cosmo SkyMed Second Generation

2 SAOCOM (CONAE)

HYPSEO

PRISMA program

PRISMA operations

SHALOM ASI/ISA

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Earth Observation is recognized as a key instrument to support monitoring actions at local and global scale aimed to ensure environmental sustainability of human activities. A strategic and innovative role is represented by missions such as PRISMA in term of development of new analysis methodologies which involve the capability to observe not only the geometric features but also the chemical-physical ones of the targets of interest.

PRISMA missions allows to observe the whole Earth with a high revisit time, high spatial and spectral resolution. The innovative Hyperspectral sensor acquires image data in hundreds of narrow contiguous bands (240 bands) from the visible to the shortwave infrared. Each individual pixel of the hyperspectral image contains a continuous spectrum of the solar radiation reflected by the surface.

Thank for this first successful results to e-GEOS, LEONARDO, PLANETEK, IREA, UNIMB.
Many thanks in PRISMA!!