Abstract

The Italian Space Agency (ASI) in 2007 have signed a contract for the design, development and deployment of the PRISMA mission. PRISMA stands for "PRecursore IperSpettrale della Missione Operativa" and is the follow-on of previous programs, either national (HypSeo, phase A/B) or international (JHM phase A, in cooperation with Canada) devoted to establish requirements, technologies and conceptual design of such a mission.

The program is starting the C/D phase and has been completely funded by ASI up to the system on-orbit commissioning; the launch is planned for the second half of 2011.

The selected industrial consortium includes all key national industries, which have already acquired specific know-how and expertise for the development of panchromatic/hyperspectral sensors and small satellites.

PRISMA is conceived as a "public good" pre-operational and technology demonstrator mission, focused on the development and delivery of panchromatic/hyperspectral products and the qualification of the panchromatic/hyperspectral payload in space.

1. PROGRAM HIGHLIGHTS

1.1. Context

The Italian Space Agency has identified the "hyperspectral niche" as one of the fields of interest since about one decade.

A dedicated roadmap is being established encompassing:

- Definition of user needs, in cooperation with operational and scientific community
- Development and qualification of "critical technologies"
- System architecture and preliminary design
- System deployment and exploitation

Specific programs (hyperspectral) undertaken so far are:

- Hypseo A/B phase (2002), in National context
- JHM A phase (2006-2007), as cooperation between Italy and Canada
- PRISMA B2/C/D/E1 phase (2008-2011), in National context

Regarding PRISMA follow-on, ASI is open to consider possible cooperation with other Countries.

The prime contractor for the PRISMA mission is an industrial consortium formed by Carlo Gavazzi Space (CGS), Selex Galileo (GA) and Rheinmetall Italia (RHI), that form the industrial core team that coordinates the participation of other major Italian space companies, as subcontractors.

The responsibilities of the core team companies can be summarized as follows:

- CGS: responsible for project management, overall system engineering, design, development and integration of the platform and system AIV activities. In the frame of the Ground Segment, CGS is responsible of the overall data processing in the IDHS of the Level 2 standard products development.
- GA: responsible for design, development, integration, test and calibration of the complete hyperspectral instrument, PAN camera and of its test equipment (MGSE, EGSE and OGSE). For what concerns the platform GA will also supply solar panels, autonomous star tracker sensors for the attitude determination and the on-board power distribution unit (PCDU). In the frame of the Ground Segment, GA will be responsible for the overall Data Processing in the Instrument Data Handling System (IDHS) with direct responsibility of level 0 and level 1 standard products development.

- RHI: responsible for thermo-mechanical engineering of the satellite, development and integration of the structure and thermal subsystem of the platform, platform and payload structural model, launcher interface, satellite thermo-mechanical AIV/AIT including environmental qualification, satellite MGSE and launch campaign. RHI will also supply the solar panel mechanical substrate.

The industrial team also includes major Italian companies, such as Thales Alenia Space, responsible for the PDHT, and Telespazio, responsible for the overall Ground Segment.

1.2. Planning and status

The program has been completely funded by ASI up to the system on-orbit commissioning.

The Kick Off meeting has taken place in January 2008 and the program is now starting the C/D phase; the launch is planned for the second half of 2011.

After the launch, a 3 month in orbit commissioning phase is foreseen. At completion of the commissioning phase, the system will be delivered to ASI.

2. MISSION OVERVIEW

2.1. Mission Objectives

PRISMA is a National program having the followings main objectives:

- Implementation of an Earth Observation pre-operative mission
- In orbit demonstration and qualification of an Italian state-of-the-art hyperspectral/panchromatic technology
- Validation of end-to-end data processing able to develop new applications based on high spectral resolution images
- Capitalization of ASI heritage, considering the Hypseo mission, the Italian-Canadian Joint Hyperspectral Mission (JHM) study.

2.2. Applications domain

The domain of hyperspectral applications is the following:

- Detailed mapping of land cover and agricultural landscapes
- Risk Management Support & Hazard monitoring (fires, landslides, volcanic and seismic risk)
- Quality of inland waters
- Coastal zones and Mediterranean sea
- Carbon cycle monitoring
- Urban functional areas mapping and monitoring
- Atmospheric turbidity: optical and spectral characterization
- Land surface hydrology and water management
- Security
- Desertification

2.3. System Products

The PRISMA Ground Segment will be located at the Geodesy Center in Matera (Italy) and it will include all the facilities (processors, help desk, catalogue, archive, user interface) to support the end users in ordering Standard Products intended to be the systematic basis for the generation of higher level applications products.

The processing is performed starting from raw data and applying the following processing steps.The total latency from acceptance of an order to delivery of product is less than 14 days.

Level 0: Discriminates image, housekeeping and calibration data and provides formatted data product with appended metadata, including ancillary data and file formatting information.

Level 1: Transforms Level 0 data into radiometrically corrected and calibrated radiance data in physical units. This product provides:

- Top-of-Atmosphere Spectral Radiance
- Cloud mask
- Sun-glint Mask
- Calibration and characterization data used
- Classification Mask

Level 2: Transform Top-of-Atmosphere spectral radiance measurements into geophysical parameters

Level 2b: Geolocated at Ground Spectral Radiance Product (Hyperspectral and PAN)

Level 2c:

- Geolocated At-surface Reflectance Product (Hyperspectral and PAN)
- Aerosol Characterization Product (VNIR)
- Water Vapour Map Product (Hyperspectral)
- Cloud Characterization

Level 2d: is the geocoded version of the level 2c products.

2.4. Value Added Products / Applications

Standard Products will be the basis products for the generation of higher level applications products. A Value Added Application Segment (VAS) will be developed to provide level 3 and level 4 products.

Level 3 products are obtained by processing the system products together with the relevant auxiliary input data (e.g spectral libraries) and by using specific algorithms to provide biophysical, biochemical, geophysical, geochemical and environmental products derived from level 2c or level 2d data (classification products, features, concentrations, etc).

Level 4: products are obtained by further elaboration of Level 3 products (e.g. statistical analysis, temporal trends, etc.).

3. SYSTEM OVERVIEW

3.1. System Architecture

The PRISMA satellite, placed in a sun synchronous orbit, will focus primarily on the European area of interest, enabling the download of the data on two ground stations located in Italy. Once the panchromatic/hyperspectral images are downloaded on ground, they are archived and processed up to level 2.

PRISMA System is articulated in the following integrated segments:

- A Space Segment, consisting in a single satellite placed in suitable LEO SSO orbit with an operational lifetime of at least 3+2 years.

  The satellite (see fig. 1) is made up of:
  - a Platform, based on the Italian small satellites standard platform already used on MITA and AGILE missions
  - a Payload, consisting in a Hyperspectral instrument and PAN camera
  - a Payload Data Handling & Transmission (PDHT) recurrent from COSMO-SkyMed

Fig. 1 – PRISMA satellite mock-up

- A Ground Segment, comprising various centres located in Italy (see Fig. 2) and including:
  - A Mission Control Centre (MCC), in charge of mission planning and management
  - A Satellite Control Centre (SCC), in charge of satellite command and control
  - An Instrument Data Handling System (IDHS), in charge P/L data reception, archiving, processing and interface with users

A dedicated launcher will be used to directly inject the Satellite in its final orbit. The baseline is a VEGA launch, as alternative options, other small launchers such as Dnepr, Eurockot, and PSLV are considered in the satellite design.

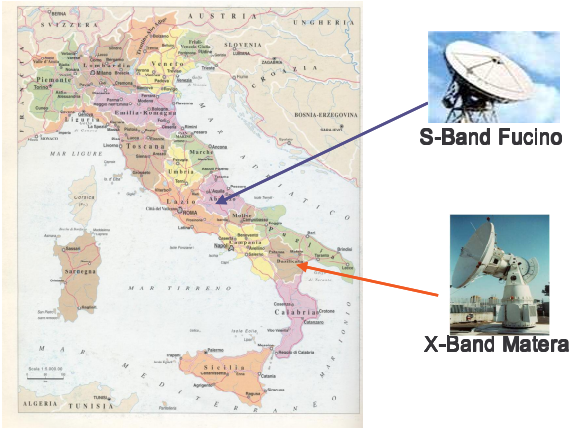

Fig. 2 – Location of PRISMA Ground Centres

3.2. Orbit

The selected orbit for the area of interest (see Fig.) in the baseline configuration is sun synchronous with repeat cycle of 29 days.

- Orbit altitude: 620km
- Inclination: 97.85°
- Local Time of Descending Node: 10.30.
- Daily accesses to the area of interest: usually 3 (daylight only)
- Worst case imaging capability: 85000 km2
- Relook time: 7 days

Fig. 3 – Area of interest

Considering the selected orbit, the daily accesses to the area of interest are usually 6. The average duration of the access to the area of interest is about 8.5 minutes.

3.3. Payload and Data

The PRISMA Payload is composed of an imaging spectrometer (or hyperspectral imager), able to take images in a continuum of spectral bands ranging from 400 to 2500 nm, and a panchromatic camera. The main uses of the instrument are, through on ground processing, to derive information about land cover and agriculture landscape, pollution, quality of inland waters, status of coastal zones and Mediterranean sea, soil mixture, carbon cycle.

The Hyperspectral Instrument is based on a prismatic spectrometer concept. The main features, considering the reference mission orbit are summarized in Table 1.

Instrument Main Requirements	
Swath / FOV	30 km / 2.45°
GSD	Hyperspectral: 30 m PAN: 5 m
Spatial Pixels	Hyperspectral: 1000 PAN: 6000
Spectral Range	VNIR: 400 – 1010 nm SWIR: 920 – 2500 nm
Average Spectral Resolution	10 nm
Radiometric Quantization	12 bit
VNIR SNR	> 200:1 on 400 – 1000 nm > 600:1 @ 650 nm
SWIR SNR	> 200:1 on 1000 – 1750 nm > 400:1 @ 1550 nm > 100:1 on 1950 – 2350 nm > 200:1 @ 2100 nm
PAN SNR	> 240:1
Absolute Radiometric Accuracy	Better than 5%
MTF	VNIR @ Nyquist Frequency > 0.3 SWIR @ Nyquist Frequency > 0.3 PAN @ Nyquist Frequency > 0.2

Table 1 – Instrument main requirements