PRISMA and COSMO-SkyMed demonstration for a Multi-sensor mission

Data Exploitation della missione PRISMA, precursore delle missioni iperspettrali nazionali

ThalesAlenia Space
a Thales / Leonardo company

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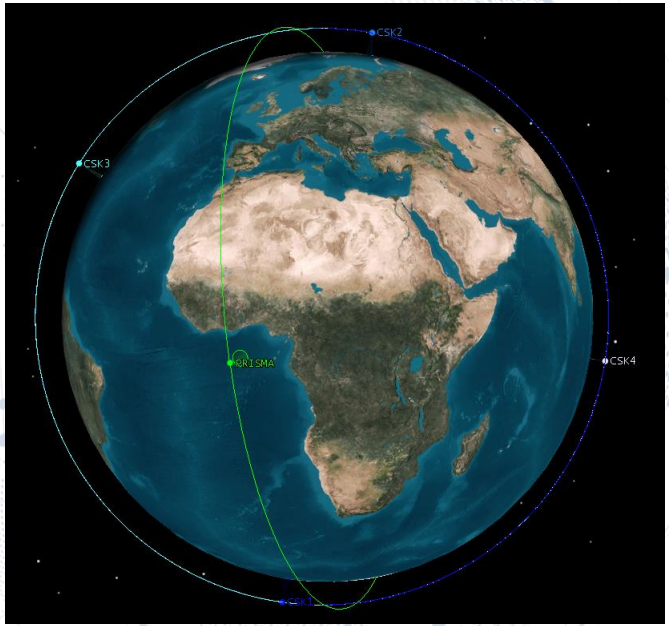
PRISMA and COSMO-SkyMed missions overview

Italy owns actually two Earth Observation missions that will leverage the future concept of multi-sensor data exploitation:

- PRISMA
- COSMO-SkyMed

SSO	PRISMA	COSMO
Orbit altitude	615 km	619 km
Inclination	97.851°	97.86°
LTAN	10:30 a.m.	06:00 a.m.
Repeat cycle	29 days	16 days



Introduction

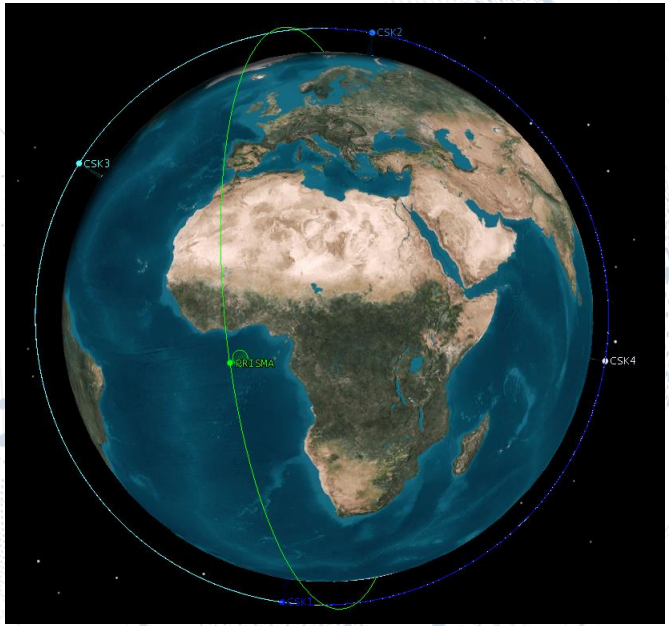
PRISMA and COSMO-SkyMed missions overview

PRISMA (1 sat) will carry a Pancromatic & Hyperspectral sensor

- Pancromatic
  - Resolution 5 m
  - Swath 30 km
- Hyperspectral
  - Resolution 30 m
  - Swath 30 km
  - Spectral Range VNIR & SWIR
  - Specral Resolution ≤ 10 nm

COSMO-SkyMed (4 sat) carries a SAR sensor in X-band capable of

- Spotlight
  - Resolution 1 m
  - Swath 10 km
- Stripmap
  - Resolution 3 m
  - Swath 40 km
- Scansar Wide - Huge
  - Resolution 30 – 100 m
  - Swath 100 – 200 km



Introduction

PRISMA and COSMO-SkyMed missions overview

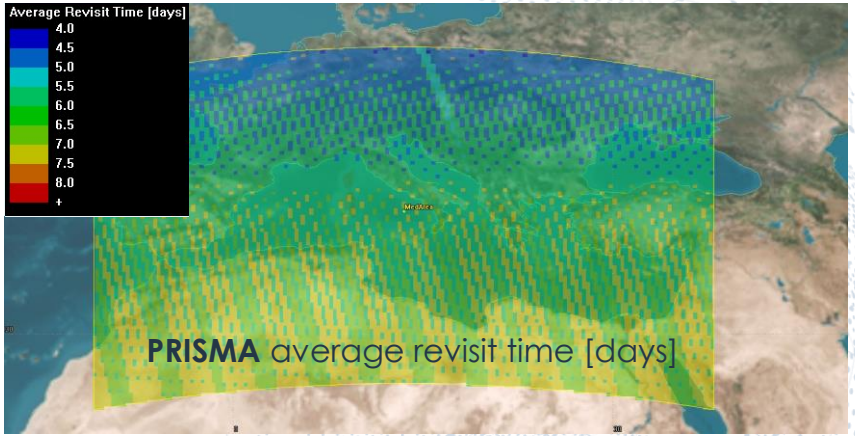
PRISMA relook capabilities have been considered with the following assumptions:

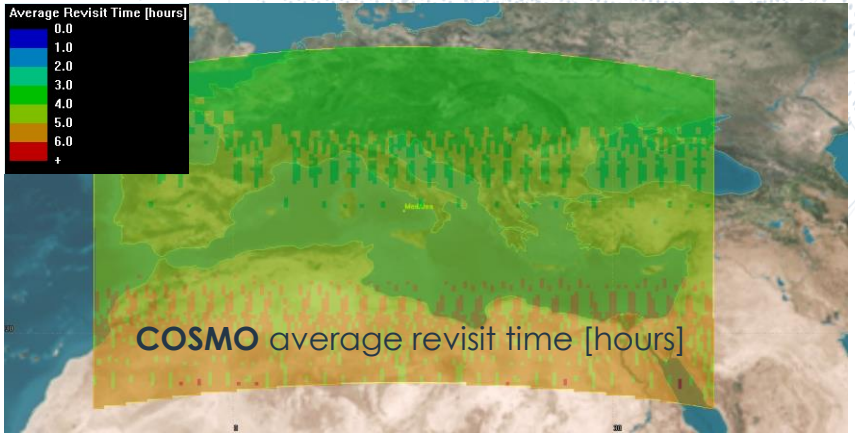
- Access area ± 15° (with roll manouver)
- Solar Elevation Angle ≥ 30°
- Period of Year : Summer

An **average relook** of about 7 days is guaranteed for optical data

COSMO-SkyMed provides a revisit time performance in the order of 6 – 8 hours

<u>At least one COSMO-SkyMed SAR image is available in a short time after each Optical image acquisition</u>





Data Fusion

Data fusion of PRISMA and COSMO-SkyMed products, information content enhancement, multi-sensors synergies

The exploitation of multi-sensor satellite data requires specific algorithms for data fusion to generate added value products that highlight the best features of each sensor

In particular

- Hyper-spectral data provide information related to the **materials** and the **content** of the observed area with low resolution
- SAR data provides information about the **details** and the **structure and shapes** of the scene

Italy will have the opportunity to test data fusion algorithms on its proprietary sensors **COSMO-SkyMed** and **PRISMA**

In the following slides, an example of **PCA (principal component analysis)** data fusion algorithm will be shown using an image over Pavia:

- High resolution image from COSMO-SkyMed
- High resolution image from ROSIS airborne sensor, properly modified to match the resolution of PRISMA data. Pavia hyperspectral data were provided by the Telecommunications and Remote Sensing Laboratory, Pavia University (Italy) at *http://www.ehu.eus/ccwintco/index.php?title=Hyperspectral_Remote_Sensing_Scenes*

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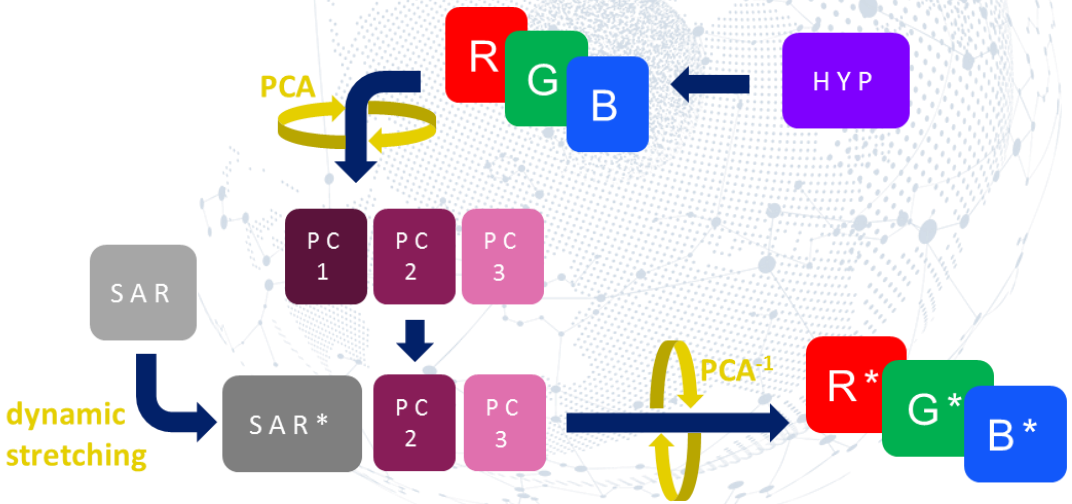
The **PCA (principal component analysis)** data fusion algorithm consists of the following steps:

- Image conditioning: spectral bands are grouped in 3 sets (e.g. spectral averaging)
- PCA transform to image principal components
- SAR image dynamic is stretched and substituted to PC1
- PCA inverse transform to original 3 channels where SAR information improves the geometrical details



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Google Earth ground truth:

Data Fusion

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Pavia Hyperspectral overlay

1 m resolution

Bands are grouped in

- High vawelength
- Mid wavelength
- Low wavelength

Each group is averaged and placed into one of the RGB channels

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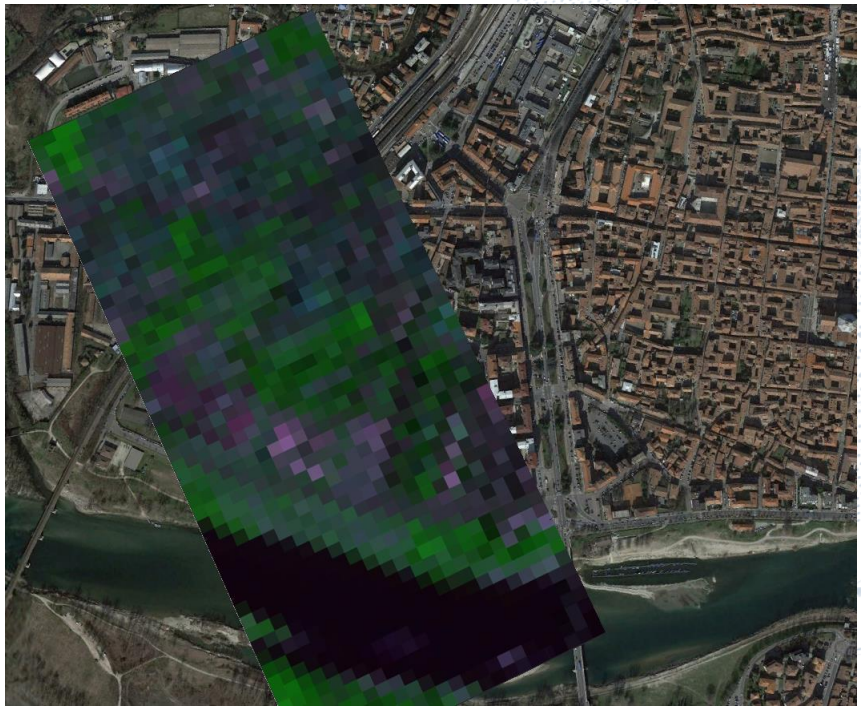
Airborne resolution is degraded to obtain a resolution similar to the expected PRISMA resolution

Image features and shapes are apparently lost



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Pavia SAR image

Resolution is 1 m

Details over the image can be appreciated over buildings and structures like bridges and railways

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Pavia image with PCA algorithm

- Image resolution is improved thanks to the information carried by the SAR sensor
- Details can still be retrieved and can be mapped to materials spotted by the Hyperspectral sensor
- Hyperspectral data offer several possible combinations of bands to be processed to retrieve different type of information

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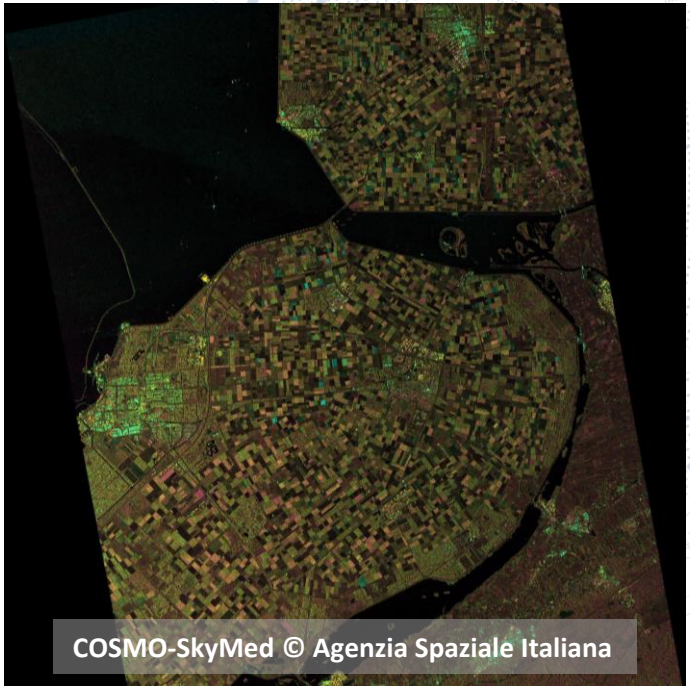
CSK Ping Pong images provide polarimetry capabilities, useful for classification purposes

SAR polarimetry and Hyperspectral imaging are the main space techniques to support agricultural cycles, their cooperation within a unique EO system will provide systematic information about the agricultural field status with even more accuracy



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Orbital configuration

Study of possible orbital configurations for the optimization of multi-sensor Hyperspectral & SAR missions

Data fusion techniques have shown that the exploitation of multi-sensor data is crucial for future Earth Observation applications

In order to improve the service portfolio available to EO data users, it is suggested to take advantage of properly designed constellations of integrated sensors

The orbital configurations (e.g. quasi-interferometric concept) could be envisaged to allow:

- Systematic and consecutive acquisitions by the two sensors
- Improvement of service portfolio

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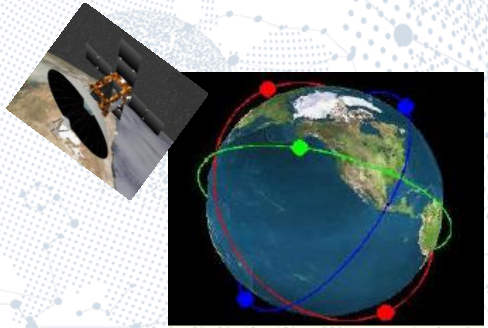
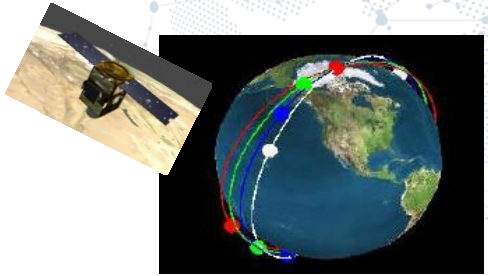
Orbital configuration

Study of possible orbital configurations for the optimization of multi-sensor Hyperspectral & SAR missions

Furthermore SAR and Hyperspectral constellations could be deployed to take advantage of the sensors peculiarities, such as

- Inclined orbits for SAR constellation to frequently monitor a specific Area of Interest, improving the revisit time performance
- Sun-synchronous orbits for Optical constellation to grant global coverage and provision of EO data





Conclusions

Way forward

The combined use of data coming from a SAR and Hyper-spectral sensor (data-fusion) brings added value information to the photo-interpreter exploiting the *peculiarities of both instruments*:

- the **hyperspectral** sensor suffers from low-resolution but carries an insight of the **materials** in the scene
- on the other hand the **SAR** sensor provides a **detailed texture** of the scene to be used as background

Both kind of data can be used for *image classification*, especially including SAR polarimetry.

The combination of such heterogeneous datasets will provide the photo-interpreter with an information content which is *far beyond the sum of the information carried by each single instrument*.

The outcomes of PRISMA mission will pave the way for design of **future constellations** of mixed SAR and Hyper-spectral sensors, exploiting the different access capabilities within the same system, exploring several configurations such as quasi-interferometric observations and formation flying