# Italian Space Agency technologies for the future of Earth Observation.

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Italian Space Agency | Italy

# ASI Earth Observation at glance: Our 8 major objectives

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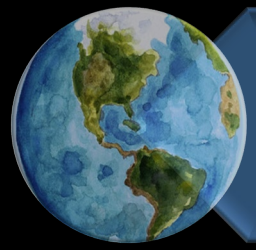


## Earth science and applications

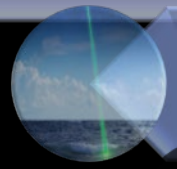
Involve the communities during all the mission development phases (from the concept to the exploitation);
Algorithms and Processors supporting the development of EO National Missions

## Sustain development of new instruments

Radiometers, Quantum Gravimetry, etc..

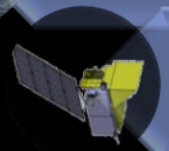
## Achieve autonomy in HR systems

Miniaturized HR Payload and Technology Roadmap



## Consolidating the Lidar capability

Lidar mission and Technology Roadmap



## Strengthen developments in Thermal Infrared

ASI-NASA TIR mission, Miniaturized Payload and Technology Roadmap

## Secure the leadership in Hyperspectral payload

Hyperspectral Next Generation, Miniaturized Payload and Technology Roadmap

## Sustain the Future of Synthetic Aperture Radar

New SAR instruments and constellations (X/L/P Bands) and Technology Roadmap

## Pull users towards our applications and services layers

Facilitate access to data and information and processing capabilities.
National Downstream development Program: Innovation for Downstream Preparation
“MateraLab”: On-Earth and In-Orbit Space Lab (PNRR)

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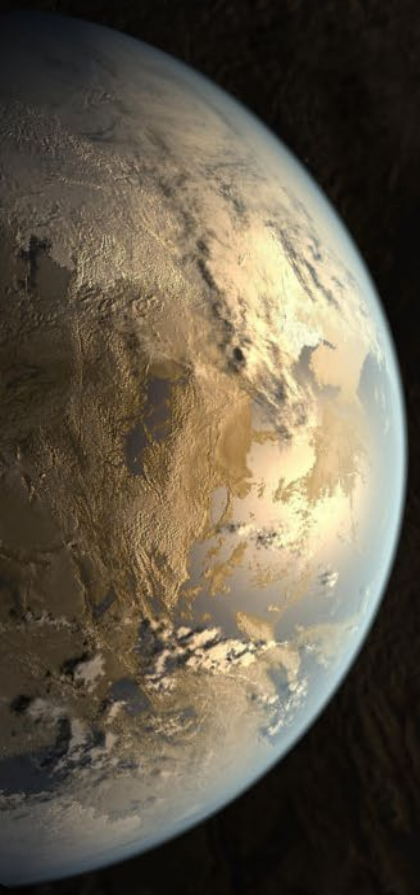
# Technologies for New EO Missions and Payloads



## New Instruments

(supporting National, ESA - Earth Explorer, SCOUT- bilateral mission)

### Microwave Technologies

CRYORAD-FO - GEOSAR - SATCROSS - RADAR SOUNDER 40 MHZ

### Reflective Spectrum Technologies

SISSI – MUSICA

### Quantum Technologies

MOCAST

# Technologies for New EO Missions and Payloads

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## Microwave Technologies

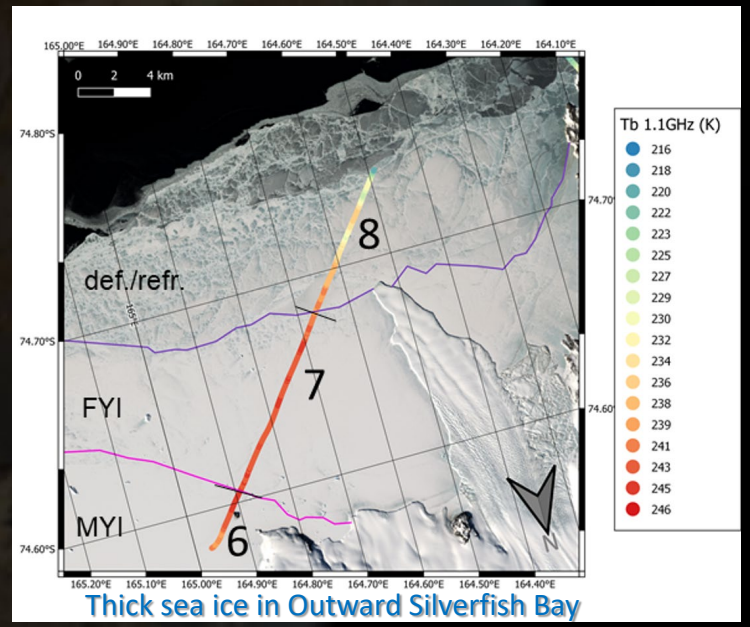
### CRYORAD-FO

**A single satellite hosting a single payload: a wideband, low-frequency microwave radiometer that explores the frequency range 0.4 GHz - 2 GHz with continuous frequency sampling, specifically designed to address scientific challenges in polar regions (Ice sheet Temperature Profile; Sea Surface Salinity; Sea Ice Thickness).**

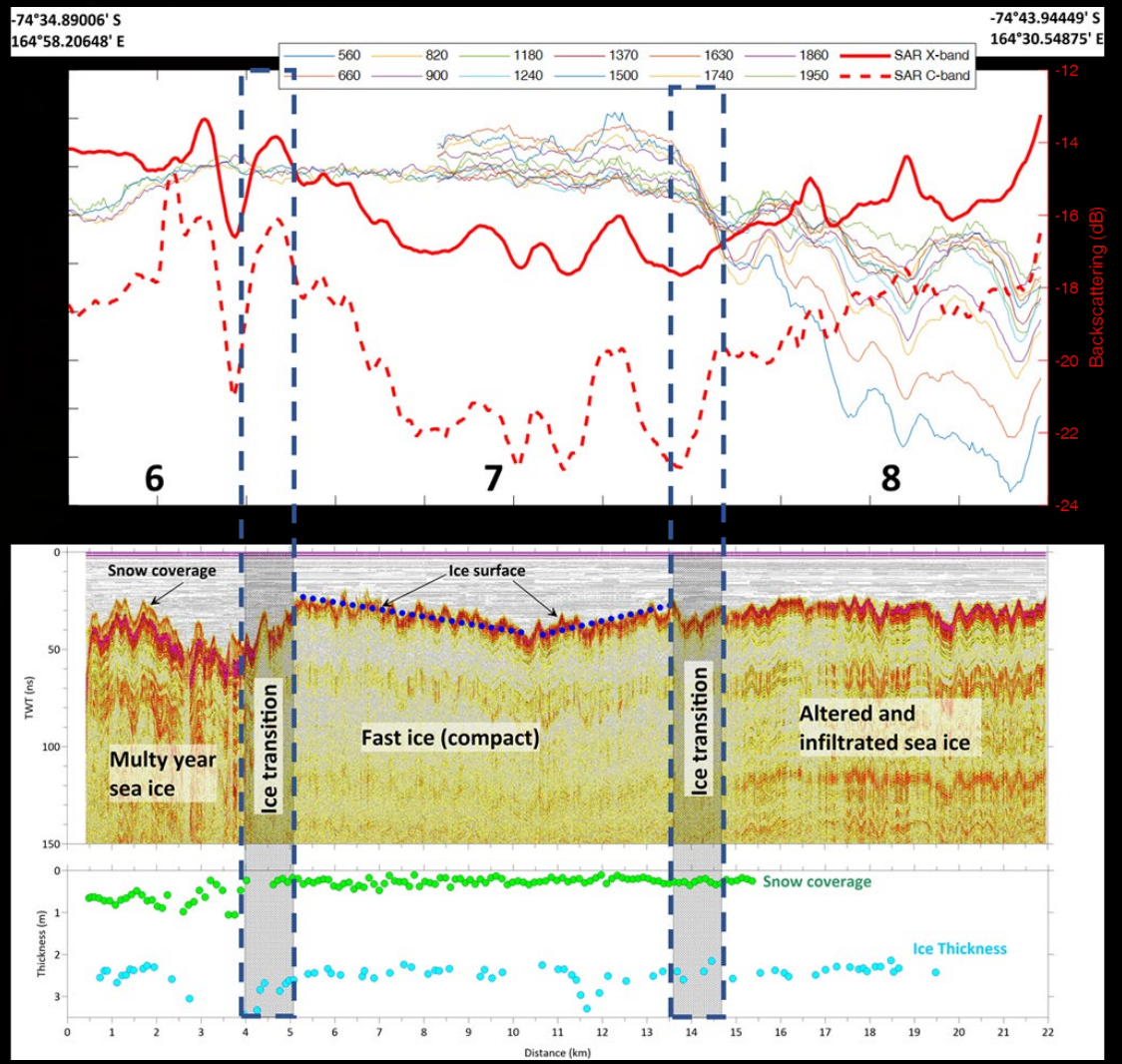
**→ First European instrument prototype**

**→ RFI mitigation in the band of interest.**

**→ Inversion algorithms**




Thick sea ice in Outward Silverfish Bay



# Technologies for New EO Missions and Payloads

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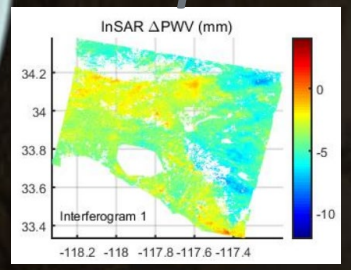
## Microwave Technologies

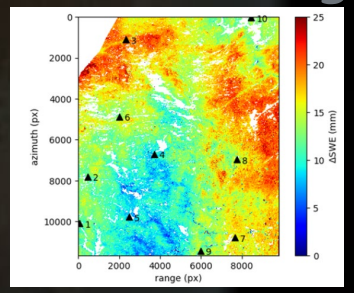
### GEOSAR

- Geosynchronous orbits can have any inclination, whilst Geostationary orbit lie on the same plane as the equator
- Depending on orbit parameters (e.g. inclination and eccentricity), an observer on the ground sees the Geosynchronous satellite in movement covering a 8-shape path
- Geosynchronous satellites are suitable for the applications that require constant coverage of a specific spot on the Earth surface
- Such platform can be equipped with a Synthetic Aperture Radar that requires relative motion with respect to the observation target

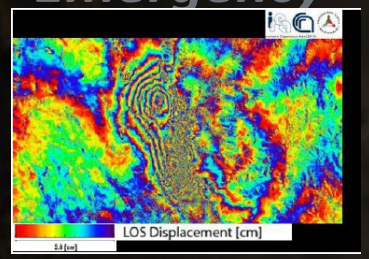
*Atmosphere*



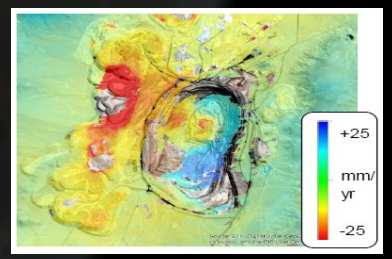

*Climate Change*

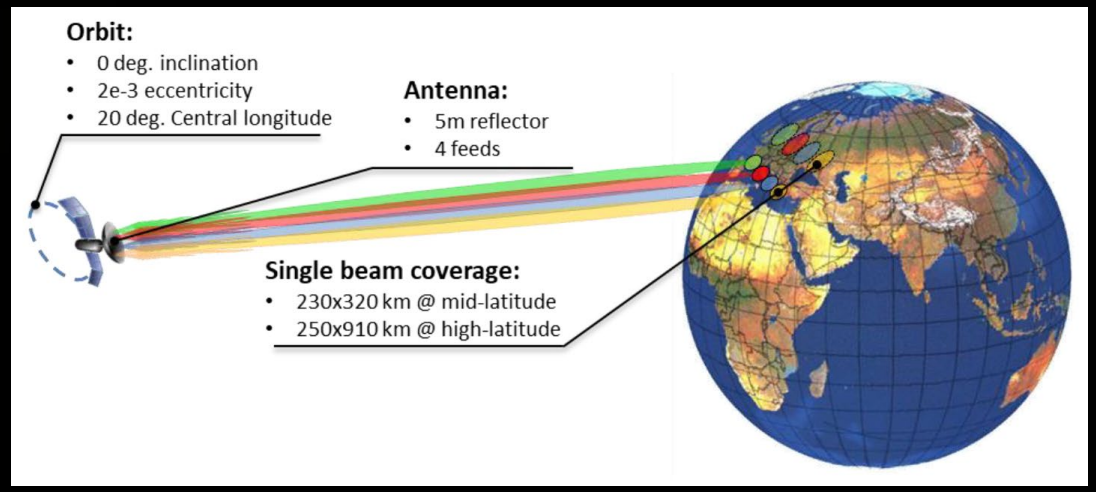



*Emergency*




*Land*



# Technologies for New EO Missions and Payloads

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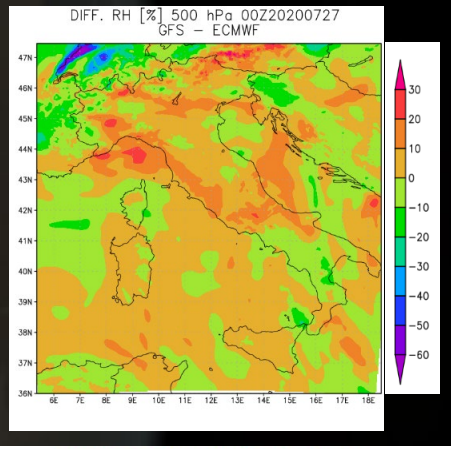
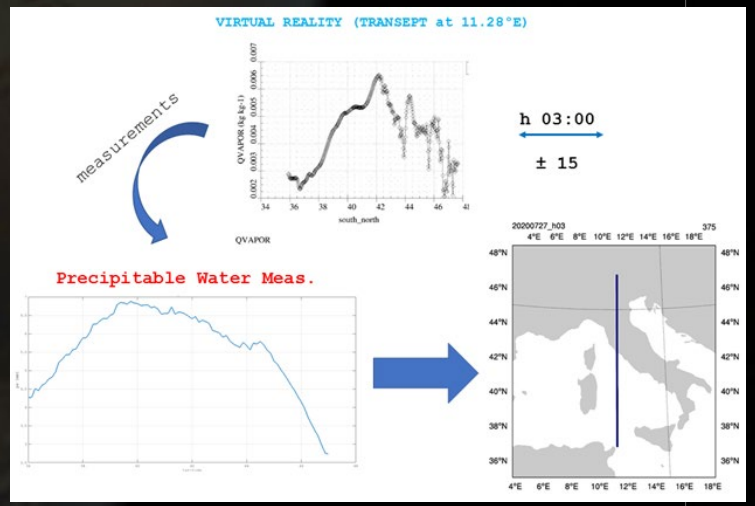
## Microwave Technologies

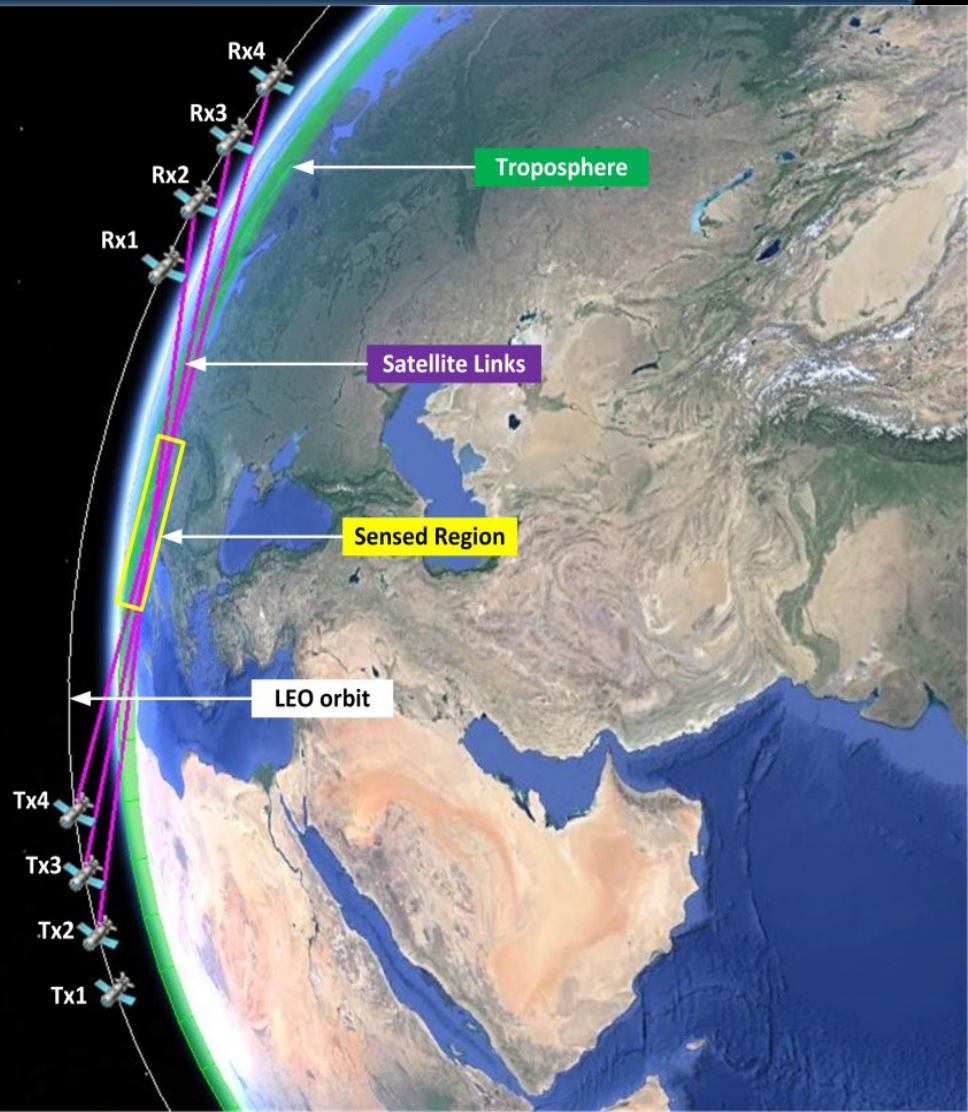
### SATCROSS

**Costellation of LEO nano-sats embarking TX or RX operating in Ku/K band for the estimation of Water Vapor in Troposphere with continuous and global measurement.**

- → NDSA (Normalized differential spectral attenuation) technique
- → Retrieval algorithms
- → E2E simulator and evaluation of NDSA impacts on weather forecast
- → Upgrade of instrument for experimental campaign
- → Definition of Payload functional diagram (RX, TX, antenna)



# Technologies for New EO Missions and Payloads

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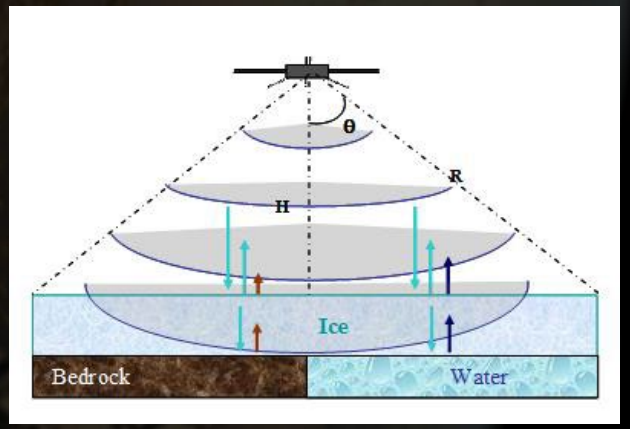
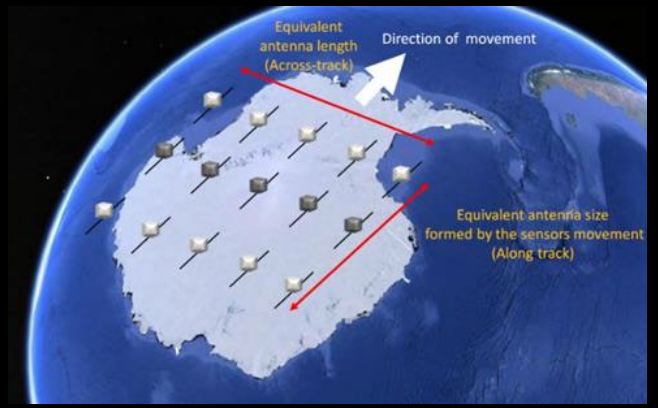
## Microwave Technologies

### RADAR SOUNDER 40 MHZ

- STRATUS is a low-frequency nadir looking radar sounder for probing the subsurface of the Earth (ice and arid/desert areas)
- *Technologies for distributed radar sounding: (i) autonomous control of large constellations of satellites flying in close formation, (ii) distributed and coordinated satellite formation flying using intersatellite communications (iii) distributed architecture and communications and (iv) large synthetic antenna in a distributed architecture*




Carrer,L.,Gerekos,A.,and Bruzzone,L.,"Distributed Radar Sounder System:A Novel Approachto Across Track Resolution Enhancement and Clutter Reduction", International Symposiumon Geoscience and Remote Sensing (IGARSS),Valencia,Spain,23-27July2018

# Consolidating LIDAR capability

- CALIGOLA - Cloud Aerosol Lidar for Global Scale Observations of the Ocean-Land-Atmosphere System
  - Atmospheric monitoring and study of Ocean-Land-Atmosphere System

- Sub-System Technologies: Laser Transmitter, ultra-stable low-weight space telescopes, transmission/receiving optics,
- Opto-mechanical Tecnologies & Processess: stable opto-mechanical assemblies/sub-assemblies/components, glass-to-glass & metal-to-glass bonding processes

# THE MICROWAVES:
## SAR in L and X Band

Focus on:

- COSMO-SkyMed Evolution (Beyond second generation)
- L-Band System
- PLATiNO-1: MONO/BI STATIC X-BAND SAR MISSION

# Future COSMO-SkyMed: Beyond the Second Generation

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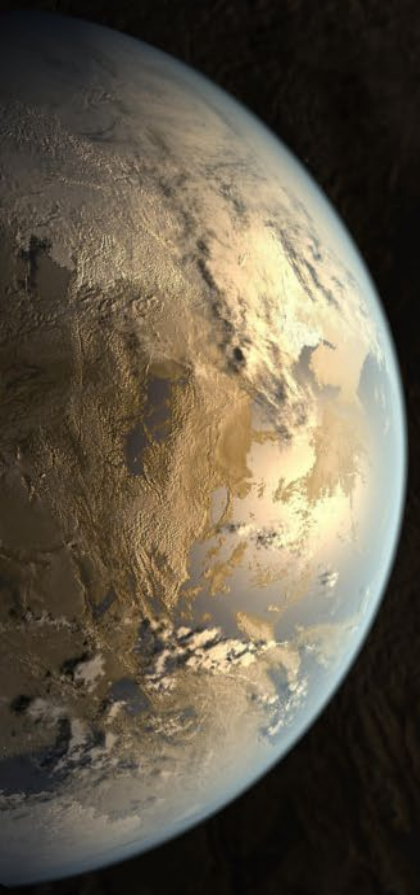

| | CSK | CSG |
|---|---|---|
| | Very High Resolution VHR *(sub-metric)* Governmental Use | Ultra-High Resolution (UHR) Governmental Use |
| SPOTLIGHT | Resolution: 1 m Single Polarization Size 10 km x 10 km Civilian and Defence use | Spot-2 *VHR and Dual Pol.* (**) Sp-2A res. ≤ 0.35 x 0.55 m Swath ≥ 3.1 x 7.3 Km Sp-2B res. ≤ 0.63 x 0.63 m Swath ≥ 10 x 10 Km Sp-2C res. ≤ 0.80 x 0.80 m Swath ≥ 5 x 10 Km Civilian and Defence Use |
| STRIPMAP | Resolution: 3 m Single Polarization Swath Size 40 km Civilian and Defence use | Resolution : 3m x 3m Swath Size Dual Pol 40 km Swath Size QUADPOL 15 km Civilian and Defence use |
| SCANSAR | Resolution: 30 m Single Polarization Swath Size: 100 km or Resolution : 100 m Single Polarization Swath Size: 200 Km Civilian and Defence use | Resolution : 4 x 20 m Double Polarization Swath Size : 100 km or Resolution : 6 x 40 m Double Polarization Swath Size: 200 Km Civilian and Defence use |

*(**) in azimut and range*

## The FUTURE

- New architectures: **a system of systems**
  - **GEO and LEO** elements
  - Multi-Sensor capabilities (**X and L band SAR**)
  - Multi modes: **mono and bi-static SAR**
- Enhanced **performances**
- **Systematic** approach and new **on-demand services**

# PLATiNO-1: The Small SAR mono and bi-static Mission

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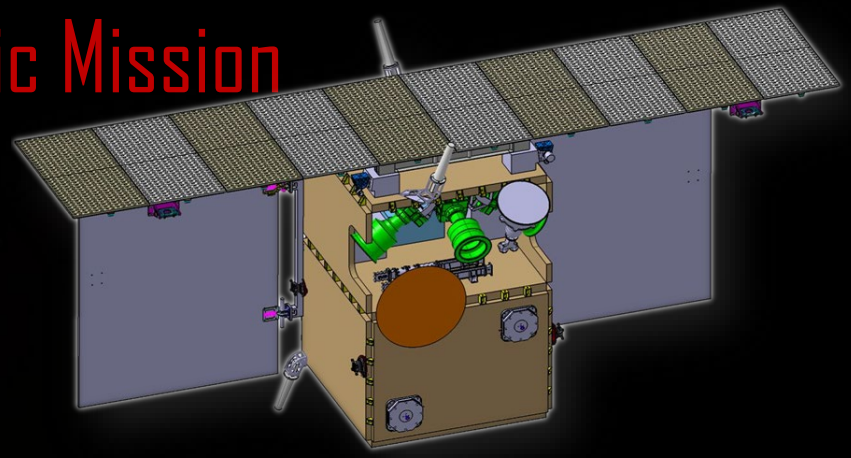


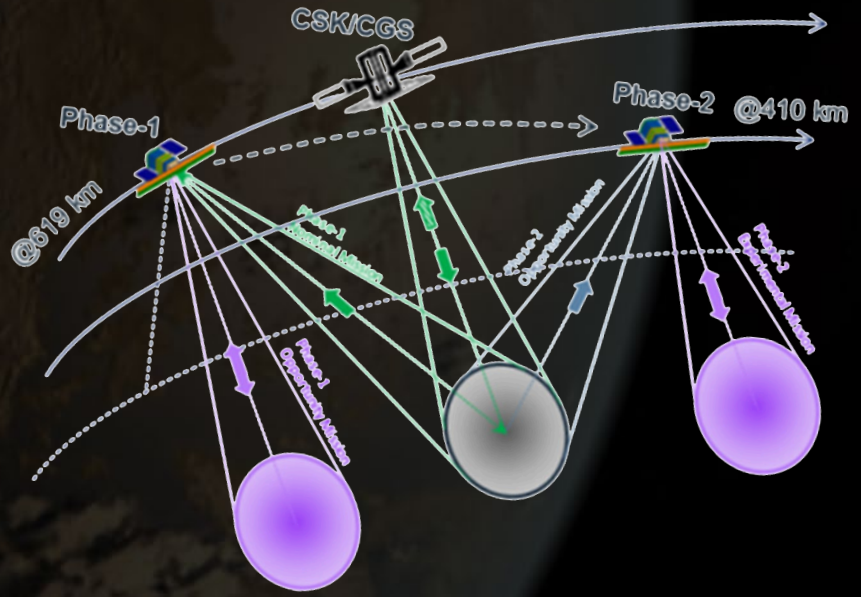
## Mission Phases:

- Phase-1 (@619 km, formation flying with CSK/CSG) 1 year;
- Phase-2 (@410 km, monostatic acquisition) 1.5 years;

## Selectable Formation-Flying configurations:

- Leader-Follower
- Pendulum
- Cartwheel
- Helixmonths

PLT-1 sized to provide the capacity to acquire, downlink and archive images totaling **20000 km2 daily**.




During Phase-1 PLT-1 will mainly work as a receiver acquiring from Earth the signal generated by CSK/CSG

| Bistatic performances (Phase-1) | |
|---|---|
| Altitude | 619 km |
| Swath | 40 km |
| Resolution | 3 m |
| Target Experimental Resolution | 1 m |
| Imaging mode | CSK/CSG Stripmap |
| Continuous stripmap | Up to 1000 km |

| Monostatic performances (Phase -2) | |
|---|---|
| Altitude | 410 km |
| Swath | 15 km |
| Resolution | 3 m |
| Target Experimental Resolution | 1 m |
| Imaging Mode | Stripmap |
| Continuous stripmap | Up to 800km |

# Sustain the future of SAR Systems

- Evolution of Cosmo-Skymed constellation: high resolution, high revisit time, enhanced acquisition capabilities

- SAR technology roadmap
  - GaN and Silicon components
  - Digital and optical beam-forming capabilities
  - Developments to enhance multi-polarization, frequency bandwidth, radiated RF power
  - Photonics components
  - On-board power generation (High efficiency solar cell, deployable and steering solar panels)
  - Edge-computing and early warning capabilities

# THE REFLECTIVE/EMISSIVE BANDS:
## VIS-NIR-SWIR-TIR

Focus on:

- VHR systems
- Hyperspectral imagery in the visible and shortwave infrared;
- Multi / hyperspectral imagery in the thermal IR.

# PRISMA 2nd Generation

PRISMA Second Generation is the future Hyperspectral Italian Mission, to be launched in 2025.

- Entirely Funded by the Italian Space Agency
- Hyperspectral data continuity currently available by the PRISMA system.

SPECS:

- SWATH and SNR: on demand techniques of SWATH enlargement and SNR enhancement on a single pass using the platform agility.
- Acquisition modes: STRIPMAP and SPOTLIGHT.
  I. STRIPMAP image: VNIR/SWIR GSD ≤ 30 m and PAN GSD ≤5 m, swath ≥30 km and indefinite length with a Daily STRIPMAP Imaging Capacity (acquire, downlink and archive) more than 2.000.000 km2.
  II. SPOTLIGHT image (on-demand): VNIR/SWIR GSD ≤10 m and PAN GSD ≤2,5 m, swath ≥30 km and length up to 210 km with a Daily SPOTLIGHT Imaging Capacity (acquire, downlink and archive) more than 200.000 km2.
- Low revisit time (72 h with a maximum off-nadir angle of ± 30° )

# COMPACT PAYLOADS IN THE REFLECTIVE AND EMISSIVE RANGE

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## Very High Resolution (VHR)

| | Readiness: 2024 |
|---|---|
| band | VNIR |
| GSD [m] | 2 x 2 |
| GSD PAN [m] | 0.5 x 0.5 |
| Swath [km] | 8 |
| Spectral Range (nm) | 455-902 |
| # spectral bands | 4 (RGB-NIR) |
| BAND 1 | 490 nm – SNR 154 |
| BAND 2 | 560 nm – SNR 160 |
| BAND 3 | 665 nm – SNR 162 |
| BAND 4 | 842 nm – SNR 110 |
| MTF | VNIR > 0.15<br>PAN > 015 |

## Hyperspectral (HYP)

| | Readiness: 2025 |
|---|---|
| band | VNIR - SWIR |
| GSD [m] | 30 x 30 |
| GSD GMC [m] | 15 x 15 |
| GSD PAN [m] | 5 x 5 |
| Swath [km] | 30 x 210 |
| Spectral Range (nm) | VNIR: 400 – 1010<br>SWIR: 920 – 2500 |
| # spectral bands | >230(VNIR-SWIR) |
| Spectral Resolution (nm) | < 10 |
| VNIR SNR | >200:1 |
| SWIR SNR | >100:1 |
| VNIR GMC SNR | >100:1 |
| SWIR GMC SNR | >50:1 |
| MTF | VNIR/SWIR AT > 0.25<br>VNIR/SWIR CT > 0.25<br>PAN AT > 0.10<br>PAN CT > 0.10 |

## Thermal Infrared (TIR)

| | Readiness: 2024 |
|---|---|
| band | TIR |
| GSD [m] | 40 |
| Swath [km] | 40 |
| Strip [km] | > 100 |
| Accuracy | < 1,5 K |
| Spectral Range | 8 – 12 micron |
| # spectral bands | 4 bands:<br>8.6 - 9.1 - 10.3 - 11.5 (μm) |
| Temperature Accuracy | < 1,5 K |
| NEDT | < 1 K |
| Minimum Detectable Temperature | 250 K |
| Saturation Temperature | 600 K |

# Sustain the future of Reflective/Emissive Systems

- Technology development for future systems towards high resolution and miniaturization of payloads in VIS, HYP and TIR domains

- OPTICAL technology roadmap:

  - Telescopes: lightweight structures, stable opto-mechanical assemblies, new alloys for AM processing
  - Optics: free form optics, large optical systems, mirrors and lenses processing
  - Focal plane technologies: CMOS detectors, advanced thermal management
  - Edge computing, AI-based processing

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# THANK YOU FOR YOUR ATTENTION

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