Italy and Synthetic Aperture Radar: A Perfect Match



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Agenzia Spaziale Italiana

Syntetic Aperture Radar:
A Powerful Tool for Building a Sustainable Future

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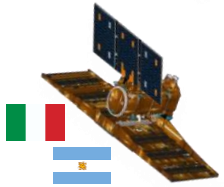
The complexity of SAR is what drives our passion: it's a constant puzzle that keeps us engaged and learning in order to:

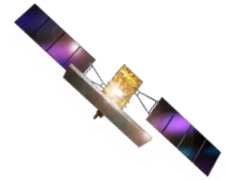
- Sustain the Continuity of the Present and the Ambitions for the Future SAR systems and missions;
- Capture the richness, variety and impact of the latest innovations in SAR, from innovative concept/techniques to technology advancements;
- Support small/micro/nano-satellite SAR constellation targeting complementarity and high revisit times;
- Ensure improvements in well-established techniques and new methodologies in data processing and applications;
- Ensure harmonization and coordination of SAR missions;
- Balancing systematic coverage and disaster response;
- Trade-off between implementation cost and benefits.





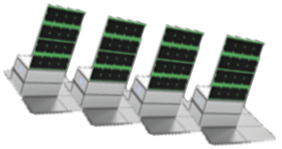


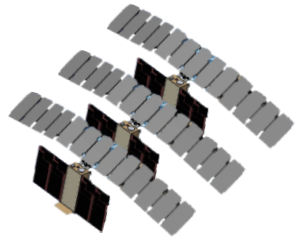








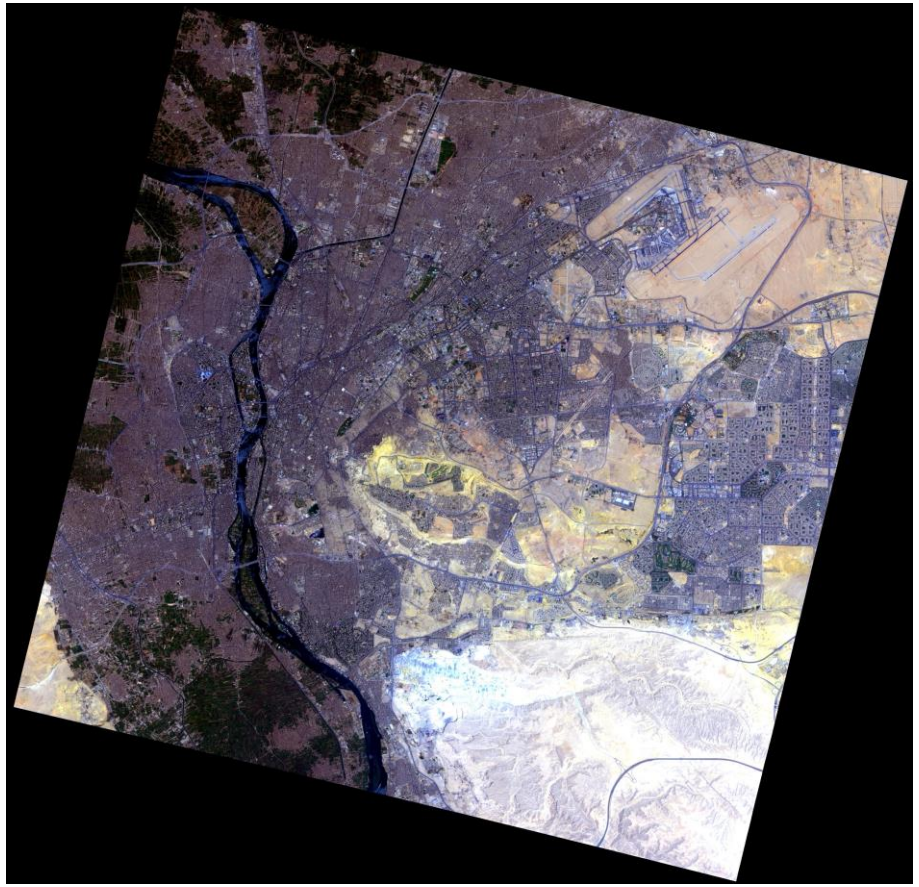




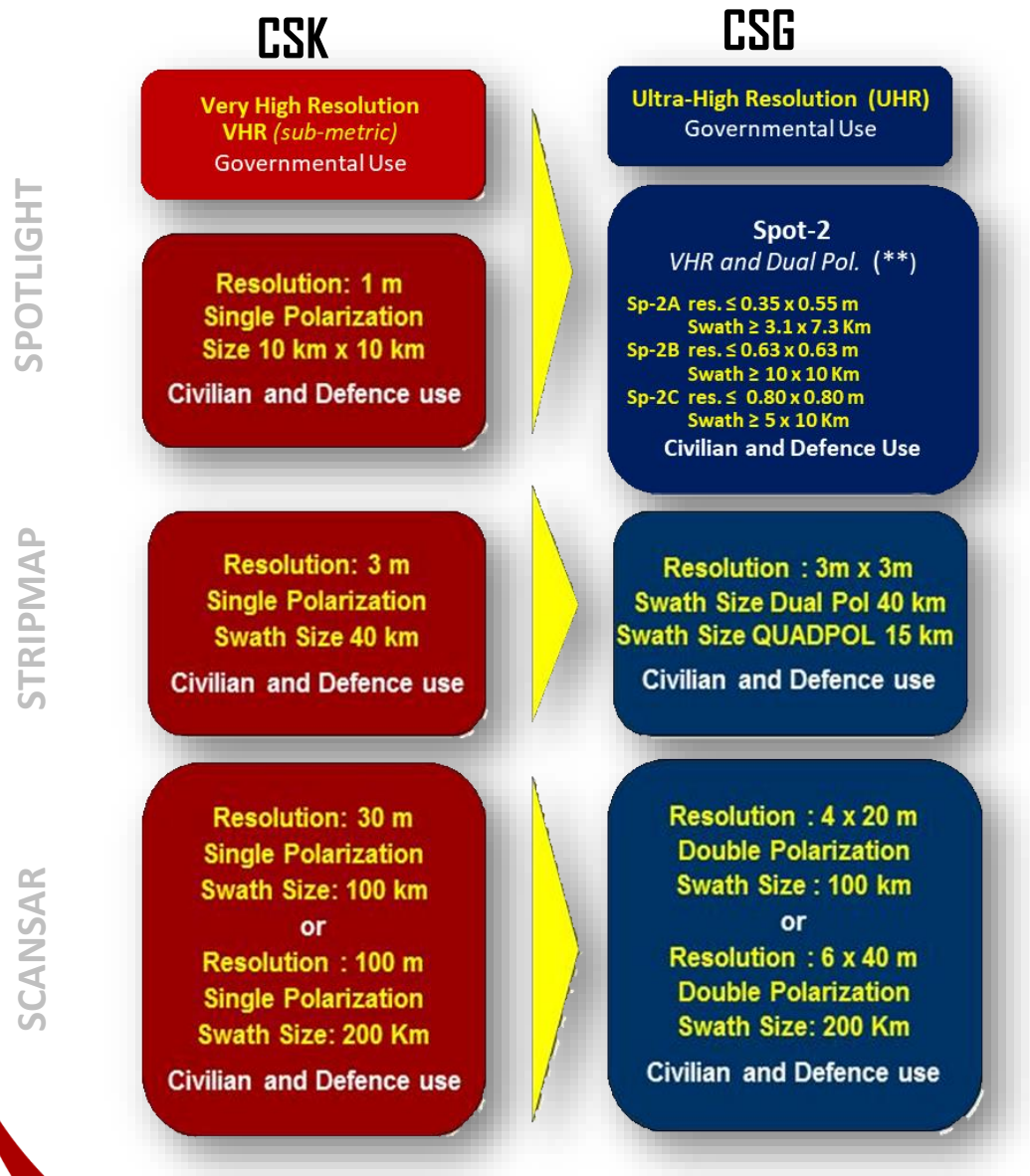
Bridging the Gap: The Downstream, Putting Systems in Action

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- Infrastructure Stability Management and Monitoring
- Sustainable Agriculture and Water Resource Management
- Precision Agriculture
- Smart, Sustainable and Resilient Cities
- Transport management and sustainable mobility
- Combating Drought
- Extreme Events
- Secure Networks
- .....

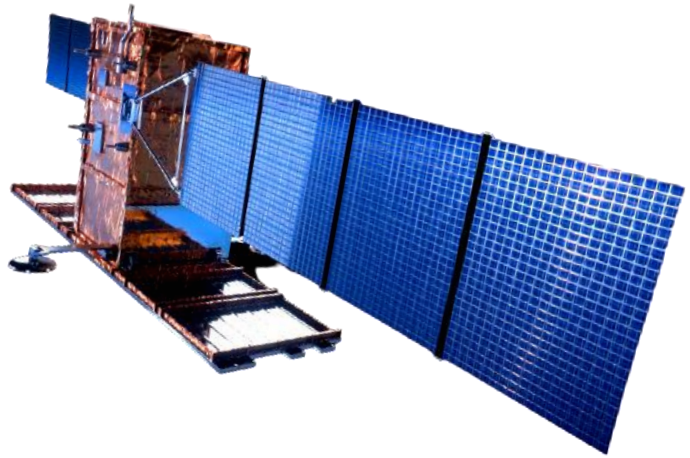


COSMO-SkyMed and Beyond



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 mapping and new on-demand services



SAOCOM – in the frame of SIASGE

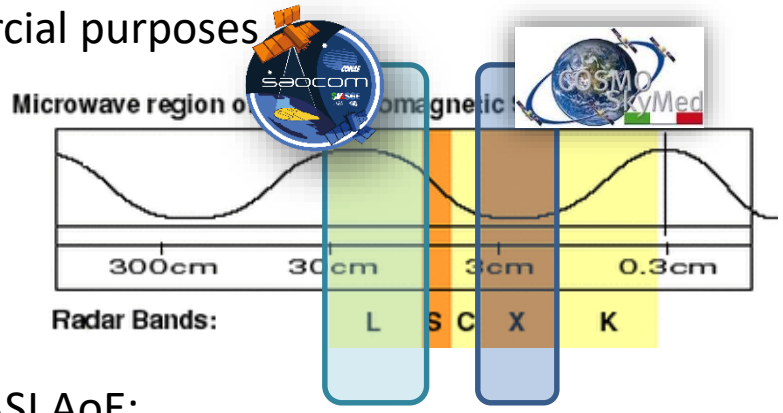
- 2 Argentinian SAOCOM satellites (1A and 1B) with an L-Band SAR sensor onboard. Same orbit of COSMO-SkyMed satellites.

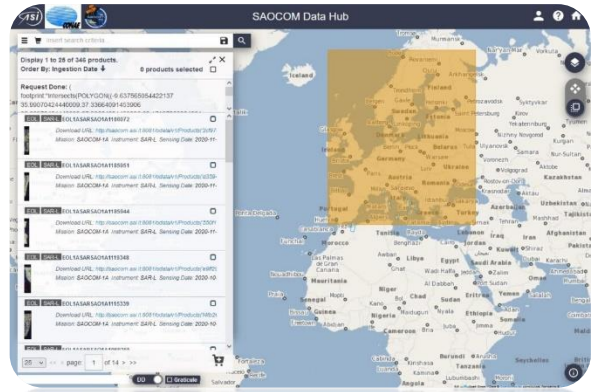
- ASI has full utilization rights on its Area of Exclusivity AoE (approximately all the Europe territory).
- Users:

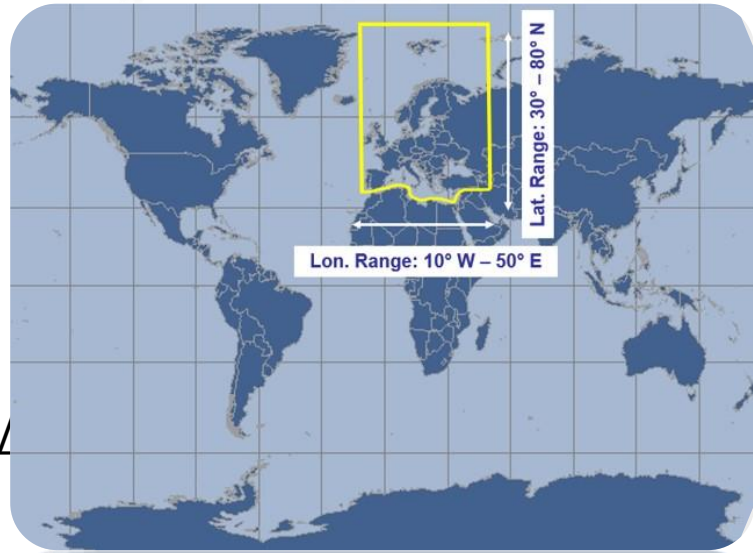
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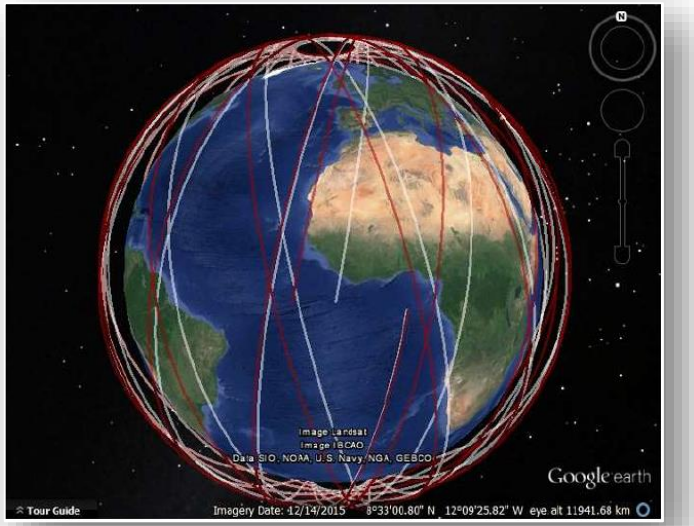
- Access to data on ASI AoE:
- 1. Registration following the instruction at: https://www.asi.it/en/earth-science/saocom/
- 2. Access through the ASI SAOCOM Portal https://saocom.asi.it

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SAR in LOW FREQUENCY BANDS

National L-band SAR mission – Fase A Study

- Develop mission concepts and operational scenarios, exploiting also bistatic acquisitions and small satellites;
- Identify L-band SAR payload configurations, in synergy with other L-band missions (e.g. SAOCOM, ROSE-L, NISAR);
- Identify synergies between with other multi-frequency SAR missions.
- Realize an infrastructure able to inherit, improve and maximize the re-use of knowledge, assets, infrastructures and functionalities developed by ASI as part of the EO missions.



FIELDS of APPLICATIONS

- Geohazards;
- Global Elevation Model in L-Band
- Land use and Land Use Change, Forestry and Agriculture
- Security
- Sea and coastal area applications
- Arctic and Cryosphere



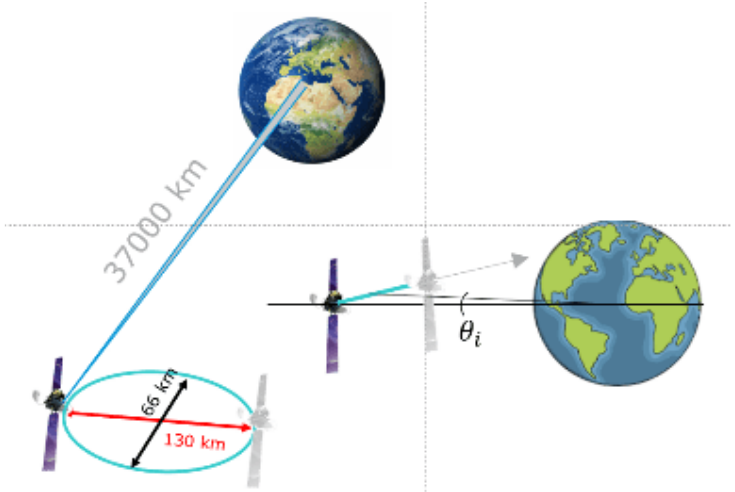
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GEOSAR - a GEOSYNCRONOUS SAR MISSION

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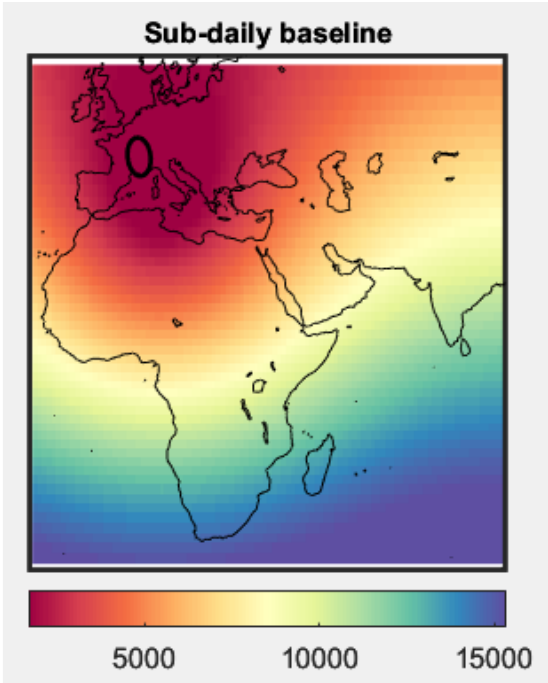
The BENEFITS

- Super-continental access / imaging
- All-weather-all-day continuous observations
- Huge swaths
- Immediate data download and exploitation



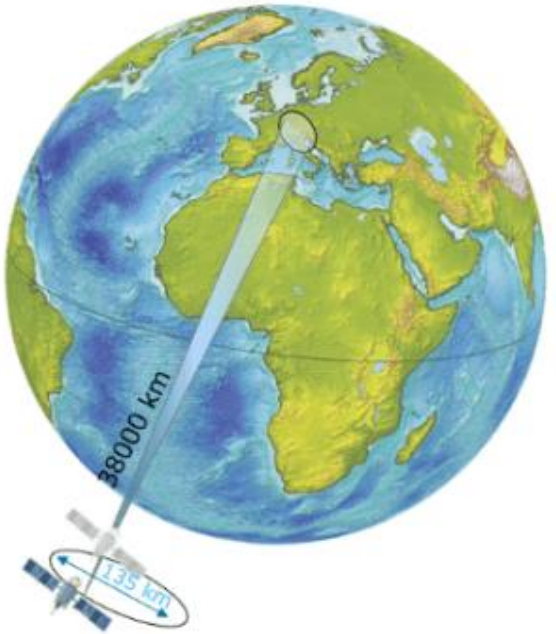
FIELDS of APPLICATIONS

- Suited for short term, large scale:
- interferometric phase: water-vapor, ground motion
- interferometric coherence: change mapping
- backscatter: soil moisture for hydrological forecast, melt/froze



Main CONCEPTS and CHALLANGES

- ITU regulation for geostationary satellites (box in longitude limited to ±0.1° and in latitude limited to ±15°)
- Orbit design (eccentricity of e=0.0008 for ITU box, orbit inclination of 0.005º and Bn=0)
- Interferometric requirements (orbit tube radius of 2-8 km)
- Control strategy to maintain box and shape

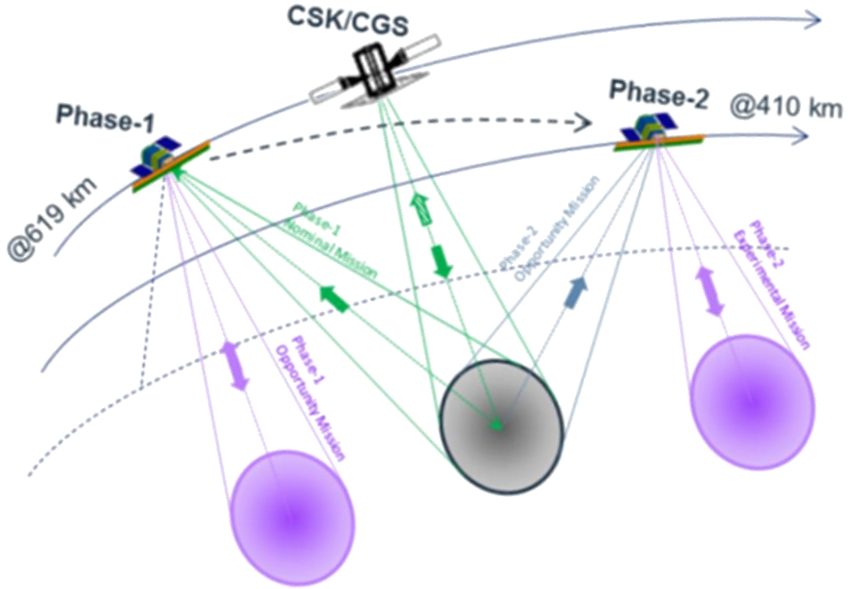


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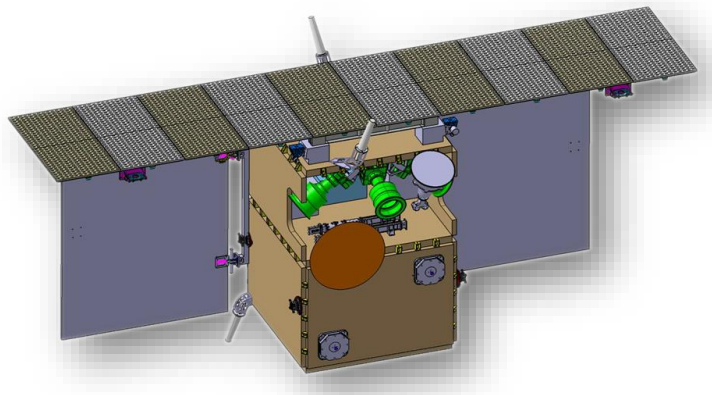
PLATiNO-1 – SAR Mission-X band

Mission timeline:

- Commissioning (LEOP and Commissioning) 3 months;
- Phase-1 (@619 km, formation flying with CSK/CSG) 12 months;
- Re-orbit phase (orbit transfer) 6-8 months;
- Phase-2 (@428 km, monostatic acquisition) 1.5 years;
- De-orbiting phase 6 months.



- PLT-1 shall be sized to provide the capacity to acquire, downlink and archive images totaling 20000 km2 daily.
- Launch date: end of 2025 (TBC)



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

Bistatic performances (Phase-1)	
Altitude	619 km
Swath	40 km
Stripmap Resolution	3 m
Spotlight Resolution	1 m
Continuous stripmap	Up to 1000 km

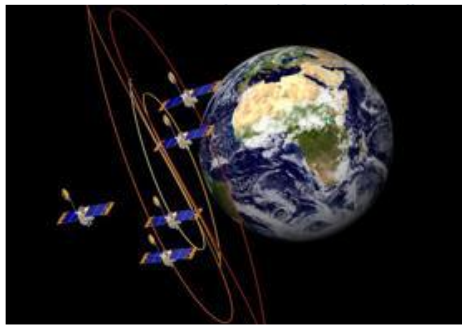
Monostatic performances (Phase -2)	
Altitude	428 km
Swath	15 km
Stripmap Resolution	3 m
Spotlight Resolution	1 m
Continuous stripmap	Up to 800km

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RODIO mission study

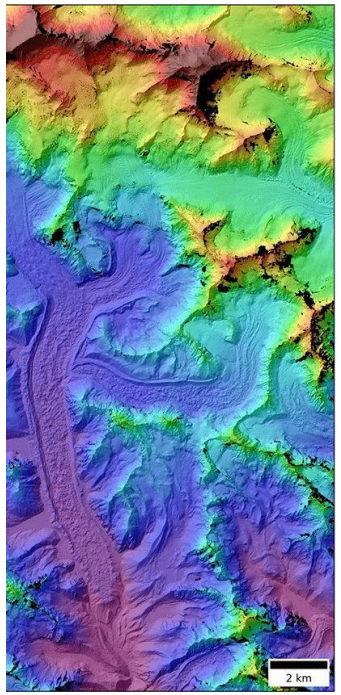
RODIO - Radar for Earth Observation by synthetic aperture DIstributed on a cluster of cubesats equipped with hightechnology micro-propellers for new Operative services

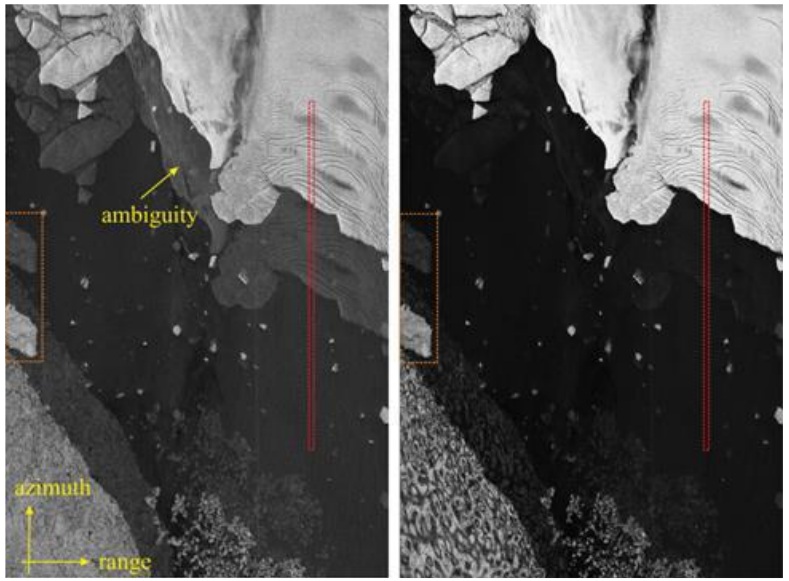




- It empowers PLATiNO-1 (PLT-1) scopes and application fields, consisting of a cluster of 4 CubeSats flying in formation among them and with PLT-1 at about 410 km altitude.

- Each CubeSat embarks a receiving-only X-band SAR instrument able to collect bistatic echoes exploiting PLT-1 as an opportunity illuminator.





	1 CubeSat	4 CubeSats
Resolution	5 m x 5 m	5 m x 5 m
NESZ	< - 9 dB	< - 13 dB
ASR	< - 5 dB	< - 15 dB

Along-track distance from PLT-1	50-90 km
Along-track cluster size	< 600 m
Cluster orthogonal baseline	< 400 m

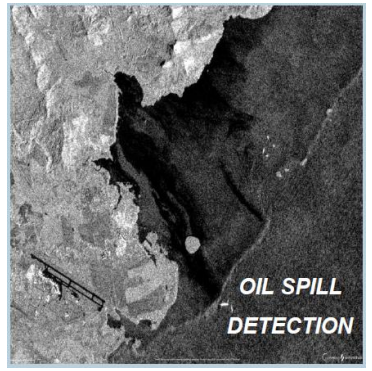
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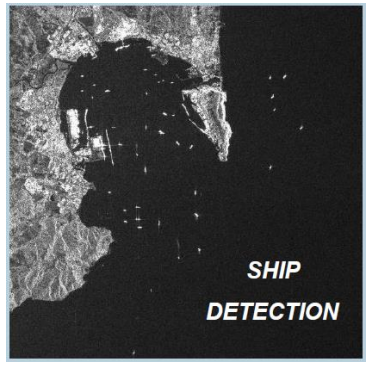
SATURN mission study

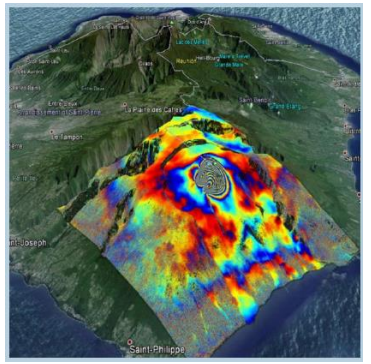
SATURN - Synthetic AperTureradar cUbesatfoRmationflyiNg

» Demonstration mission of a mini-swarm of 3 CubeSats in close formation on a LEO SSO, incorporating Multiple-Input-Multiple-Output (MIMO) technology for EO.

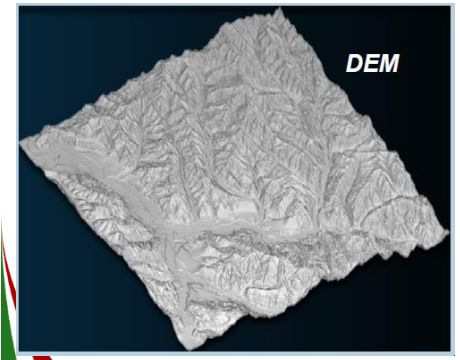
» Aim: overcome limitations of SAR imaging on CubeSat-sized satellites by combining data collected by multiple satellites in close formation to produce high-performance SAR images.

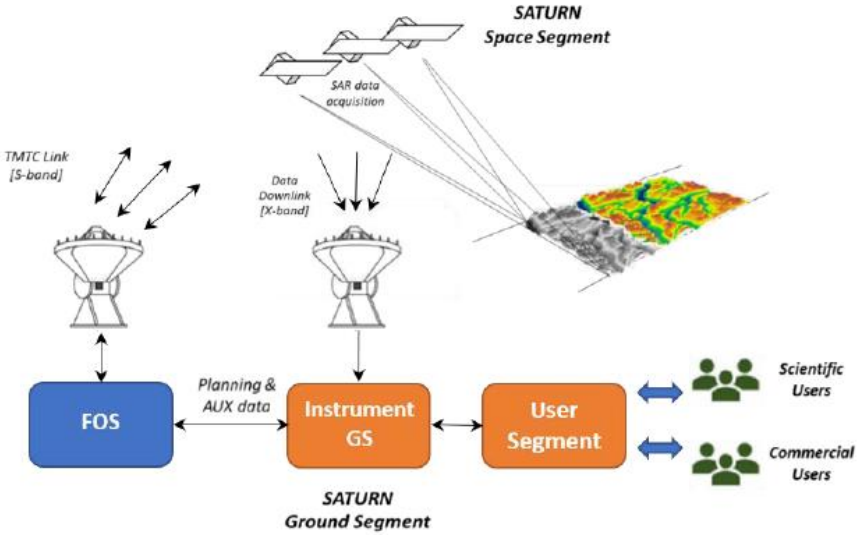






Mission Phase	Target/Application	Performances
Demonstrative Swarm 3 CubeSat M³ in along-track train configuration	SAR imaging of highly reflective targets: - *Manmade* - *Urban & Peri urban* - *Maritime Surveillance* - *Ship Detection* - *Oil Spillage*	*Image Size:* 30 x 50 km *Resolution:* 5 x 5 m *High Resolution:* 1.5 x 1.5 m
Enhanced Swarm Multiple Swarm trains on the same orbital plane	- Single Pass Interferometry - Landslides	*Image Size:* 30 x 50 km *Resolution:* 5 x 5 m *High Resolution:* 1.5 x 1.5 m *Interferometry*
	- Ship detection of wide Swath	*Image Size:* 360 x 50 km
Full Constellation Multiple Enhanced Swarm trains on different orbital planes	High Resolution, High Sensitivity Imaging for Near-Real time applications: - Maritime Surveillance over open sea - Emergency management	*Image Size:* 30 x 50 km / 360 x 50 km *Resolution:* 5 x 5 m *High Resolution:* 1.5 x 1.5 m *Interferometry*





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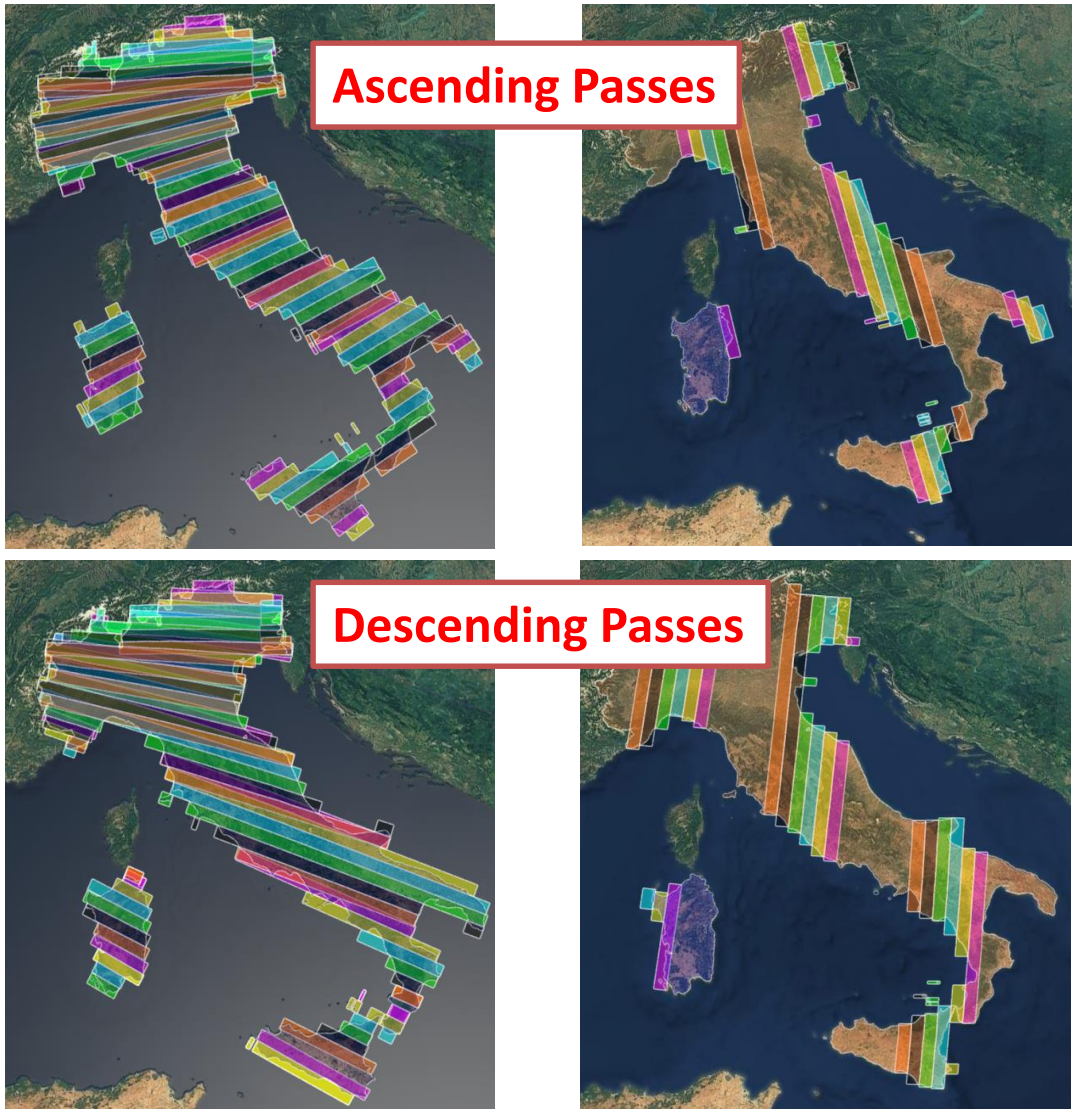
IRIDE NIMBUS-SAR

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6-day coverage of nearly all the Italian territory

Satellite 1 Satellite 2 Satellite 3
Satellite 4 Satellite 5 Satellite 6

MIO case (49°) **SSO case**



Parameter of the NIMBUS/IRIDE sub-constellation	Present Value
Number of satellites	6 + 6
Orbital altitude range	490-550 km
Orbital inclination range	43° / 49°
Swath width extension range **Stripmap mode**	25-28 km
Spatial resolutions (az – ground rg) **Stripmap mode**	2.7 m – 2.7 m
Radar Wavelength	X-Band (λ ~ 3.1 cm)
Looking mode	Right/Left

A **Second NIMBUS batch, in a left-looking acquisition mode (43°),** guarantees a complementary view and it would further enhance the 3D deformation mapping capability.

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CONCLUSIONS

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- Sustainability to be ensured with innovative SAR concepts (as GEOSAR, RODIO and SATURN) and technologies (as PLT-1 and COSMO-SKYMED)
- Sustainability to be exploited with small-satellite SAR constellation and techniques (as RODIO and SATURN)
- Sustainability to be analyzed as harmonization of SAR missions (SAR modes, data products) in view of a System of-Systems architecture (as CSK and CSG, SAR-L National Mission, IRIDE)
- Sustainability to be ensured with operations coordination between SAR missions to support multi-frequency imaging, coverage, and revisit (as SIASGE program, SAR-L National missions).
- Sustainability to provide balancing systematic coverage and disaster response (as GEOSAR and COSMO-SKYMED Mission)
- Sustainability to be exploited and ensured in terms of trade-off between implementation cost and benefits (as SAR-L and PLT-1)

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