

Advancements and future plans for multistatic SAR at the Italian Space Agency

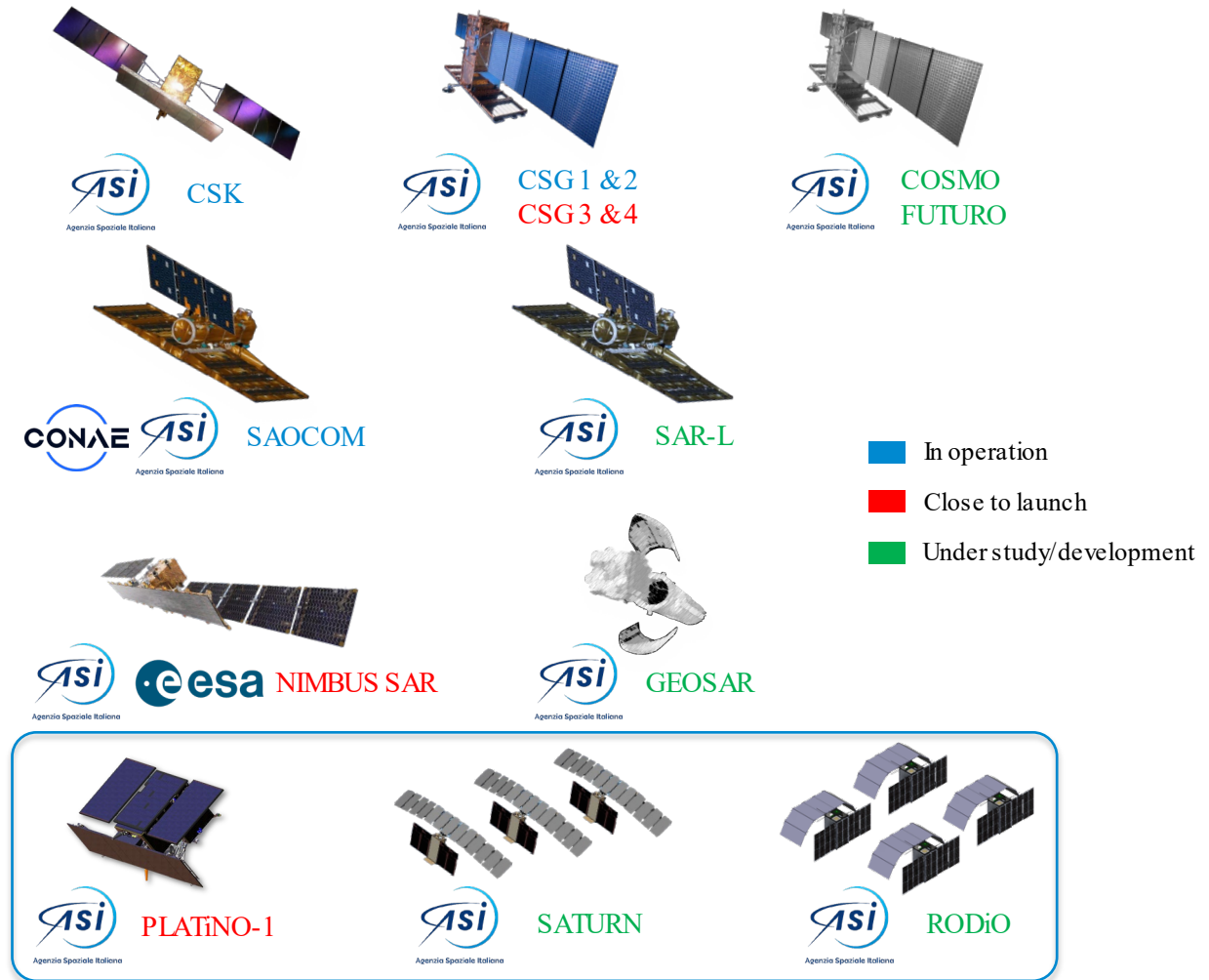
ASI – Italian Space Agency
Earth Observation Office

Giovanni Paolo Blasone, Giuseppe Leccese, Simona Zoffoli

Multistatic Radar Workshop 2025, Milan, Italy
19 June 2025

Italian Space Agency – Current and Future SAR Missions

- First, Second and Future Generation of COSMO-SkyMed, CSG 3 & 4 satellites adding to constellation
- IRIDE - NIMBUS SAR, medium inclined orbit constellation
- National L-band SAR mission, continuity with SAOCOM, state-of-art performance and possible bistatic component
- GEOSAR mission, persistent monitoring and fast response for emergency applications
- **PLATINO-1**, mini-satellite X-band monostatic and bistatic SAR mission
- **SATURN** & **RODiO**, in-orbit demonstration of MIMO D-SAR and bistatic/multistatic D-SAR by CubeSat formations

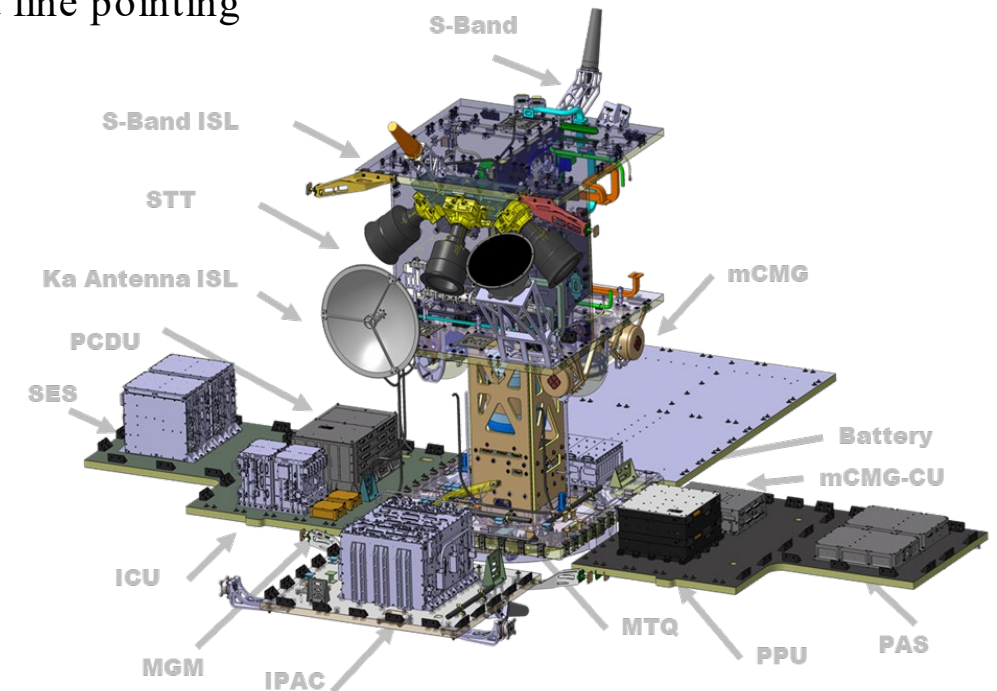


PLATiNO Program – Platform Overview

PLATiNO is a modular multipurpose mini-satellite platform characterised by high level of configurability and scalability

- **Electric propulsion** subsystem base on Hall effect thrusters for enhanced orbit control and manoeuvring capability
- **High on-board power** available thanks to multiple solar arrays configurations and high-capacity batteries
- **Advanced communication** subsystem with electronic steering X-band antenna for high data ret downlink
- **State-of-art AOCS** with mini-CMG and star trackers for high agility and fine pointing

Parameter	Value
P/L allowable volume	Up to 800 x 800 x 1000 mm ³
P/L allowable mass	Up to 100 kg
P/L power consumption	Up to 150 W (avg) 750 W (peak)
S/C launch mass	350 kg
S/C available power	Up to 1.3 kW (peak)
S/C envelope	800 x 800 x 1700 mm ³
Solar array layout	Fixed panel + deployable wings
Delta-V	Up to 800 m/s
TT&C	S-band, up to 1 Mbps
PDHT data rate	X-band, up to 500 Mbps
PDHT data storage	Up to 2 Tb
Lifetime	Up to 5 years



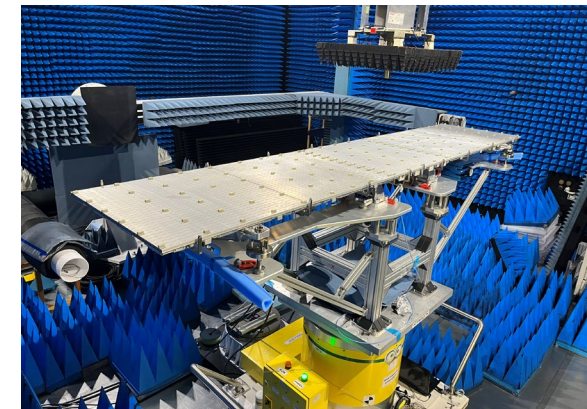
PLATiNO-1 – Mission and SAR Instrument

PLATiNO-1 mission will embark a compact and lightweight X-band SAR payload

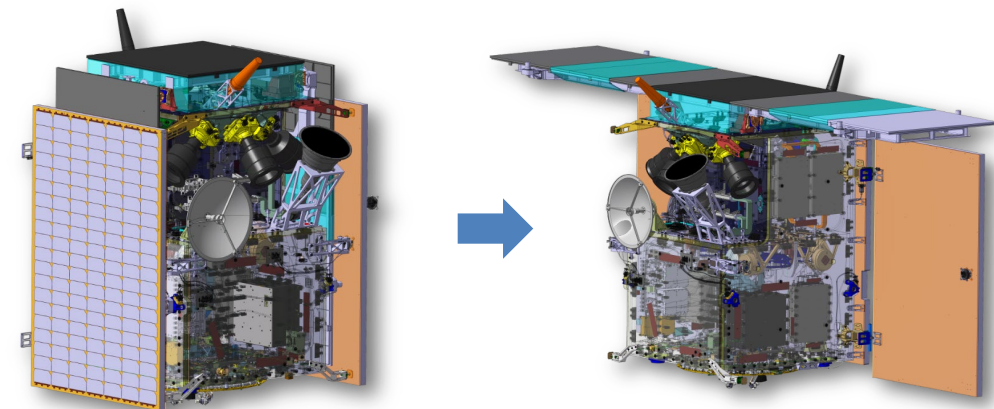
- Slotted waveguide deployable planar antenna
- High gain GaN solid state power amplifier (SSPA)
- Stripmap and Spotlight acquisition in V-pol
- Active mode for monostatic acquisitions
- Passive Rx-only mode for bistatic acquisitions exploiting CSG transmission

The mission is completing Phase D with launch foreseen by Q1 2026

Parameter	Value
Frequencybandwidth	9.4 GHz ÷ 9.8 GHz
Polarization	VV
Tx peak power	1000 W
Tx duty cycle	Up to 15%
Antenna size	3.4 m x 0.7 m
Science data link (HSSL)	Up to 2 Gbps
DC power consumption	≤ 750 W
P/Lmass	90kg



PLT-1 slotted waveguide SAR antenna



PLATiNO-1 – Mission Operational Profile (1/2)

PHASE-1 (1 year)

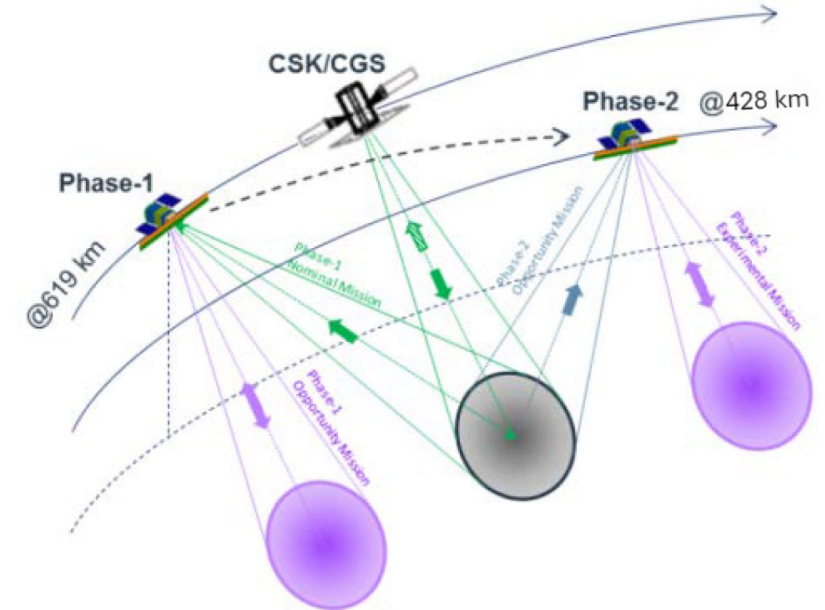
PLT-1 in a large leader-follower formation with CSG satellite @619 km altitude

Constant large along-track baseline: 100 km
(possibility to extend up to 350 km under evaluation)

Nominal: Bistatic Stripmap mode exploiting CSG transmissions

Opportunity: Monostatic Stripmap mode

Experimental: Monostatic Spotlight mode



Imaging mode	Swath width	Ground res.	NESZ	Access region
Stripmap bistatic @619km	40 km	3 x 3 m	< -15 dB	20-40 deg
Stripmap monostatic @619km	15 km	3 x 3 m	< -9 dB	20-40 deg
Spotlight monostatic @619km	5x5 km	1 x 1 m	< -5 dB	24-40 deg

	Phase-1	Phase-2
Orbit type	SSO dawn-dusk frozen	
Average altitude	619 km	428 km
Eccentricity	0.001185	0.001090
Inclination	97.8646°	97.0662°
Semi-major axis	6997.7 km	6788.7 km
Repeat cycle	16 days	2 days
Orbits per day	14.8125	15.5

PLATiNO-1 – Mission Operational Profile (2/2)

Repositioning (6-8 months) from 619 km altitude to 428 km altitude orbit

PHASE-2 (1.5 years)

PLT-1 in a 2-days repeat cycle orbit @ 428 km altitude (TBC)

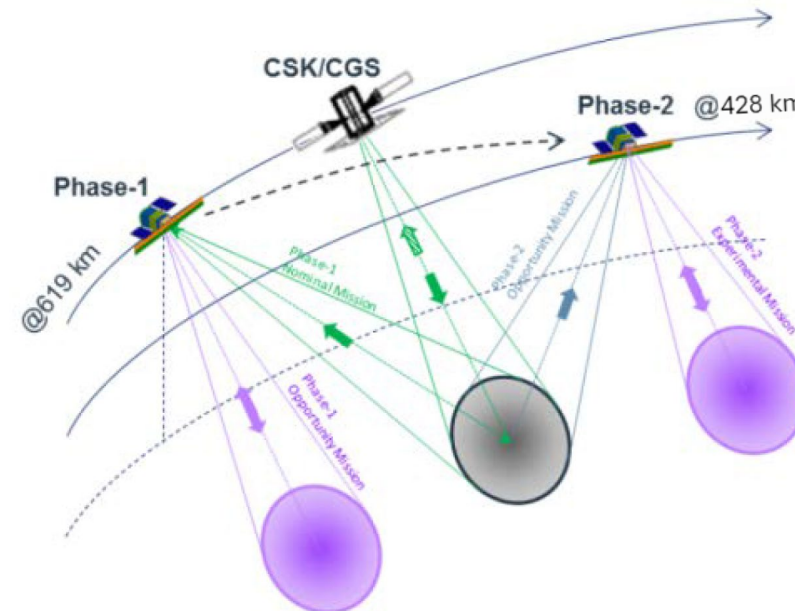
Bistatic opportunities when in conjunction with CSG satellite (12 every 16 days)

Nominal: Monostatic Stripmap mode

Experimental: Monostatic Spotlight mode

Opportunity: Bistatic Stripmap mode exploiting CSG transmissions

Delta anomaly manoeuvres to modify bistatic geometry over multiple passes on same test site or to remap the ground track of PLT-1 to new test sites



Imaging mode	Swath width	Ground res.	NESZ	Access region
Stripmap monostatic @428km	15 km	3 x 3 m	< -13 dB	20-40 deg
Spotlight monostatic @428km	5 x 5 km	1 x 1 m	< -10 dB	24-20 deg

	Phase-1	Phase-2
Orbit type	SSO dawn-dusk frozen	
Average altitude	619 km	428 km
Eccentricity	0.001185	0.001090
Inclination	97.8646°	97.0662°
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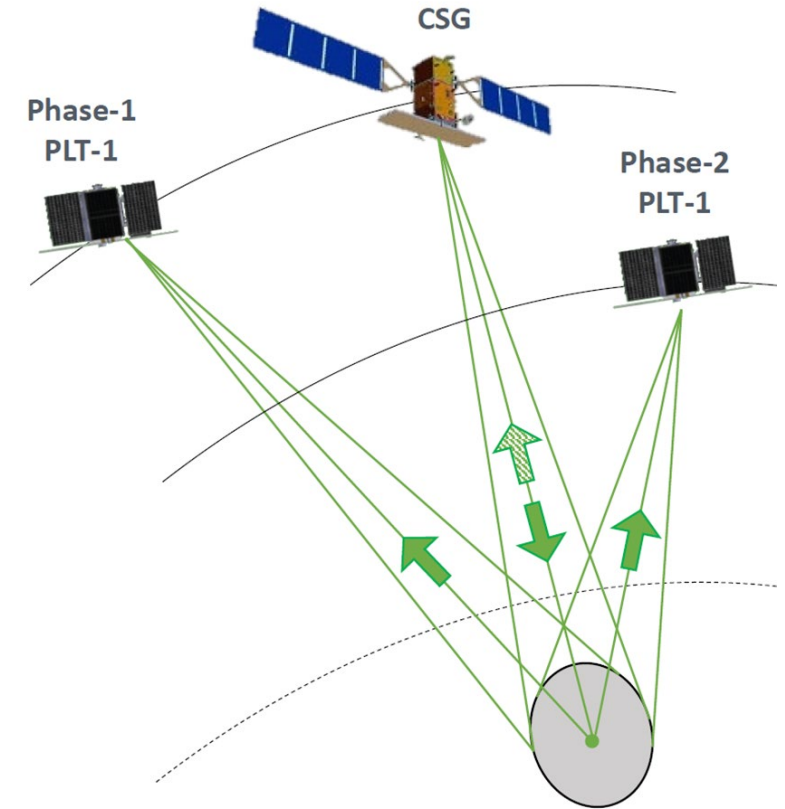
PLATiNO-1 – Experimental Opportunities

PLT-1 will provide systematic acquisition and analysis of bistatic SAR images with a wide range of large baseline configurations

Opportunity to experiment a variety of observation and processing techniques that leverage the long baseline bistatic scenario and to increase the SRL of the related Earth observation products

The multi-angular perspective of simultaneously acquired monostatic and bistatic SAR images is expected to enhance the information content that can be retrieved from the observed scene, benefiting several applications, including

- land cover
- solid earth
- ocean and marine
- risk management and security

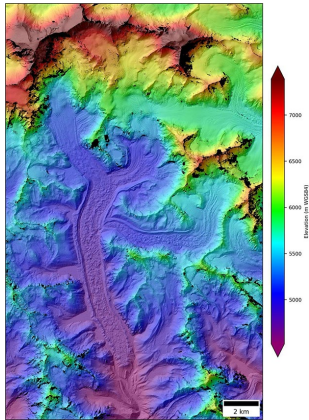


PLATiNO-1 – Enabled Products and Applications

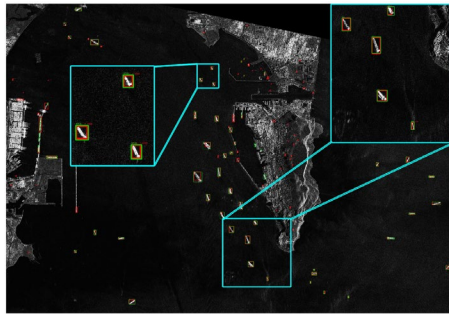


Incoherent combination of monostatic-bistatic acquisitions

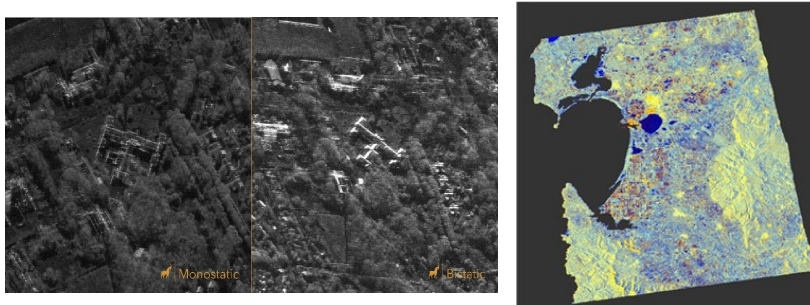
Radargrammetric DEM



Maritime target detection and velocity estimation

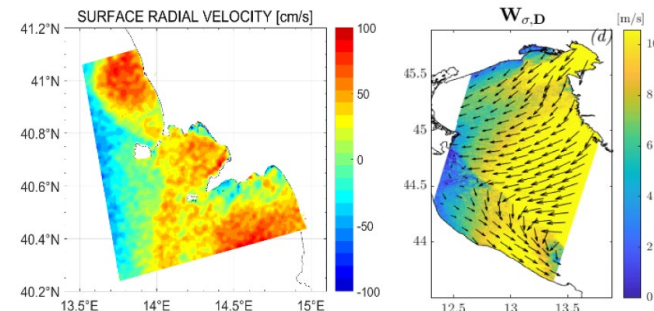


Target classification and land cover analysis



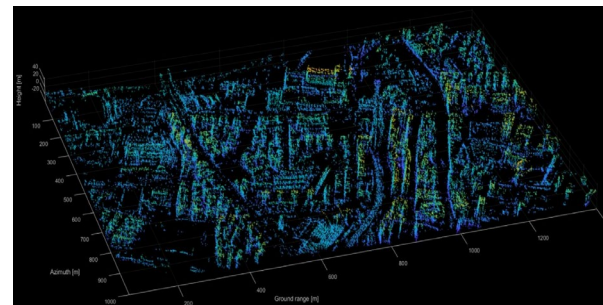
Spectral analysis of monostatic-bistatic pairs

2D field of sea surface currents and wind



Diffraction tomography

3D maps of urban areas



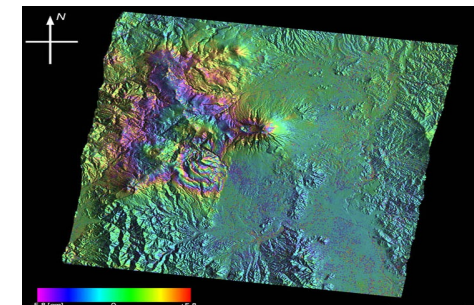
Passive sensing

RFI localisation and image denoising



Bistatic differential SAR interferometry

Full 3D vector of ground displacement



SATURN: Overview

Objectives

- ✓ demonstrate MIMO D-SAR technique
- ✓ provide high-resolution SAR data with CubeSats

Applications

- ✓ maritime monitoring (baseline):
 - ship detection
 - oil spill detection
- ✓ land monitoring (on demand):
 - landslides
 - floods

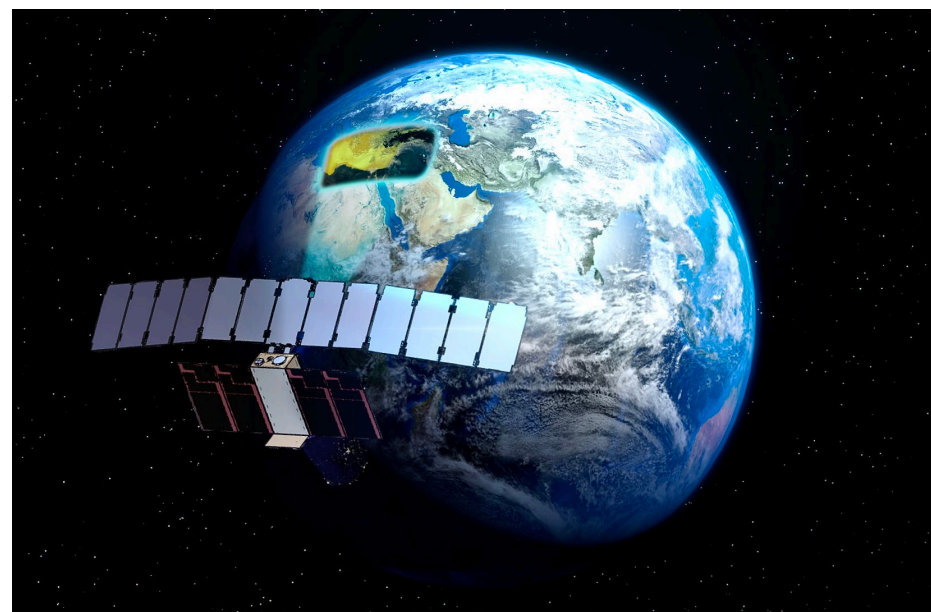
Status

- ✓ completed PDR
- ✓ under phase CDE1 contract signature

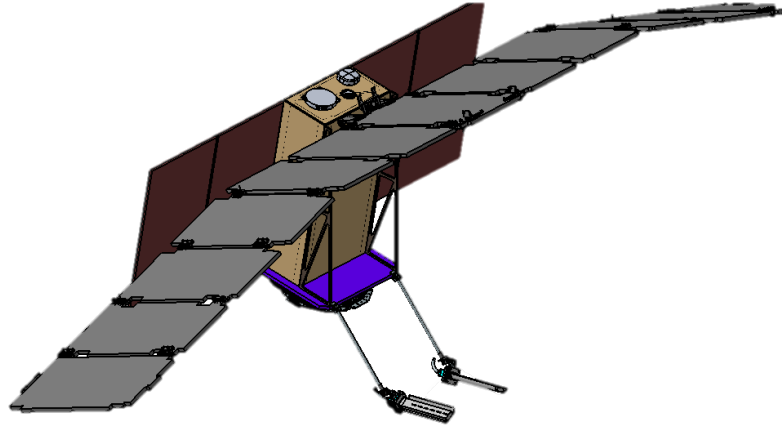
*Formation flying of 3
miniaturized active SAR antennas*



AIRBUS

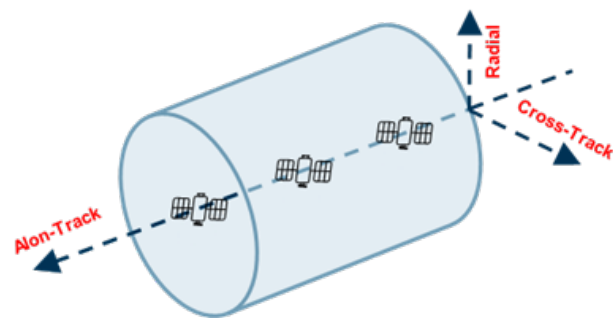


SATURN: Mission and System Design



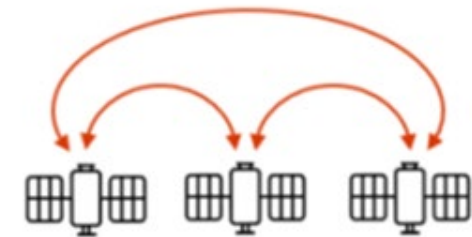
Number of satellites	3
Form factor	16 U
Orbit	SSO @ 480 km with LTDN 6 AM
SAR band	X
SAR antenna type	Reflect-array
SAR antenna panels	13
Formation type	Along-track
Resolution	$1.5 \div 5$ m
Range swath	$30 \div 40$ km
Azimuth swath	$33 \div 50$ km
NESZ	$-5 \div -15$ dB
Ambiguity level	< -15 dB

Distinct SAR Stripmap options to provide different levels of image performance



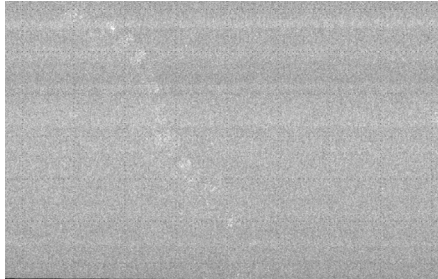
Along-track formation with 200 m relative distance

Inter-satellite link for coordinated formation management



SATURN: MIMO Technology and Constellation Roadmap

Single CubeSat

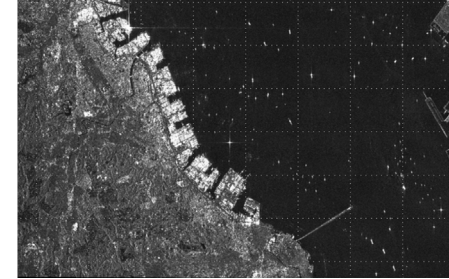


MIMO image recombination



No Doppler aliasing
Enhanced SNR

3 CubeSat swarm



1) Demonstration swarm

- ✓ minimal MIMO formation in along track

2) Multiple swarms on the same plane

- ✓ increase performance in image resolution and SNR

3) Multiple orbital planes

- ✓ increase in revisit time/coverage

Increase in system resilience



RODIO: Overview

Objectives

- ✓ demonstrate bistatic D-SAR techniques
- ✓ provide high-resolution SAR data with CubeSats
- ✓ demonstrate autonomous formation flying

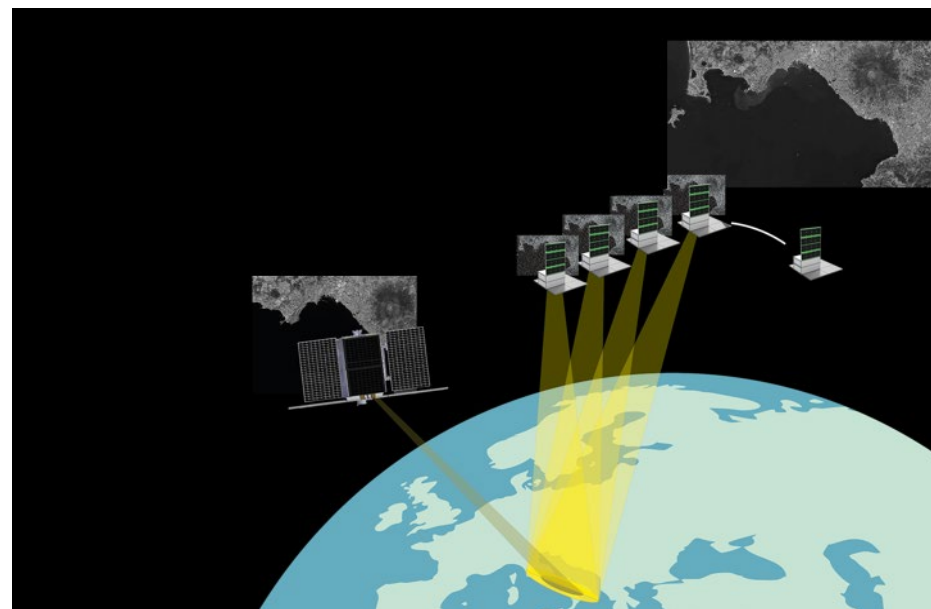
Applications

- ✓ maritime monitoring
- ✓ land monitoring
- ✓ civil protection
- ✓ safety

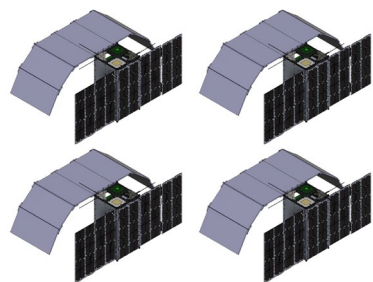
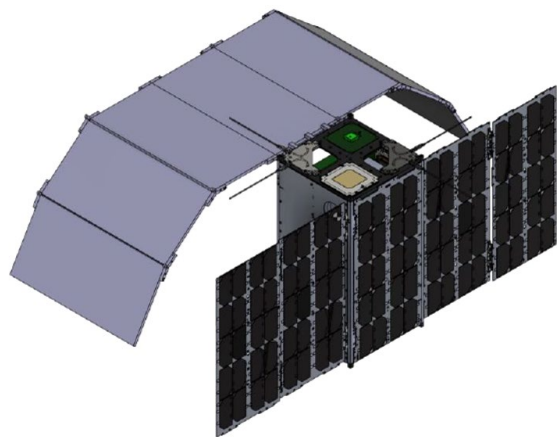
Status

- ✓ completed PRR
- ✓ under phase B contract signature

*Formation flying of 4
miniaturized passive SAR antennas
exploiting PLT-1 as illuminator*

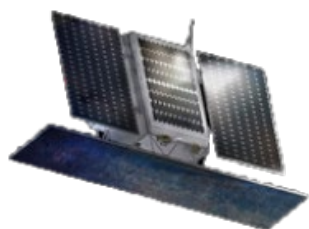


RODIO: Mission and System Design



RODiO CubeSat cluster

- ✓ SAR receiver antennas
- ✓ Along track cluster size < 600 m
- ✓ Cluster orthogonal baseline < 400 m



PLATiNO satellite

- ✓ SAR illuminator of opportunity
- ✓ Along-track baseline 50-90 km

Number of satellites

4

Form factor

16 U

Orbit

same of PLT-1 in operational phase 2

SAR antenna type

reflectarray

SAR antenna band

X

SAR antenna panels

7

Formation type

short cross-track baseline cluster in long baseline formation with PLT-1

Resolution

< 5 x 5 m

Range swath

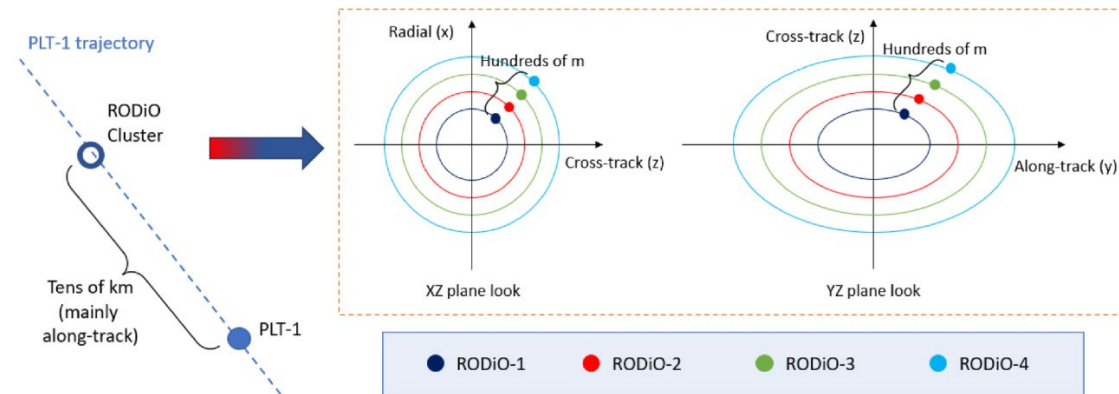
> 15 km km

NESZ

< -13 dB

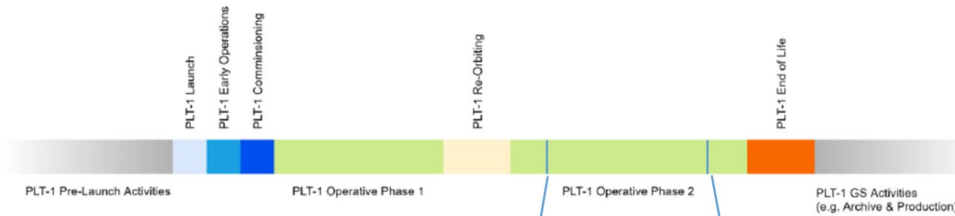
Ambiguity level

< -15 dB



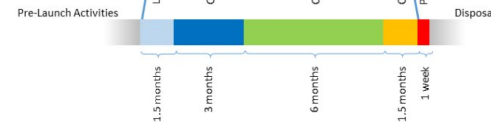
RODIO: Concept of Operations and Payloads

PLT-1



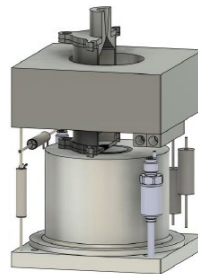
During PLT-1 Operative Phase 2

RODiO



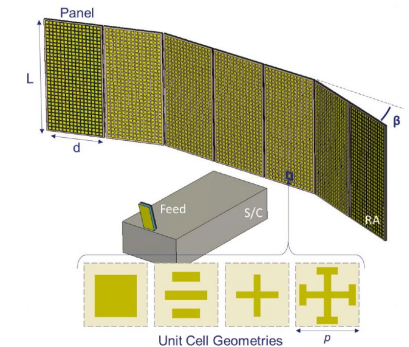
- ✓ LEOP
- ✓ Commissioning
- ✓ Operative Phase 1
- ✓ Operative Phase 2
- ✓ passivation

Payload 2:
Hybrid Propulsion System



Cluster reconfiguration: one escaped CubeSat to form an additional cross-track baseline of 30 km

Payload 1:
SAR Reflectarray Antenna



THANKS FOR YOUR ATTENTION

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