ESA SAR Missions and Activities: Status and Plans

Second Workshop on International Coordination for Spaceborne Synthetic Aperture Radar

28 September 2022

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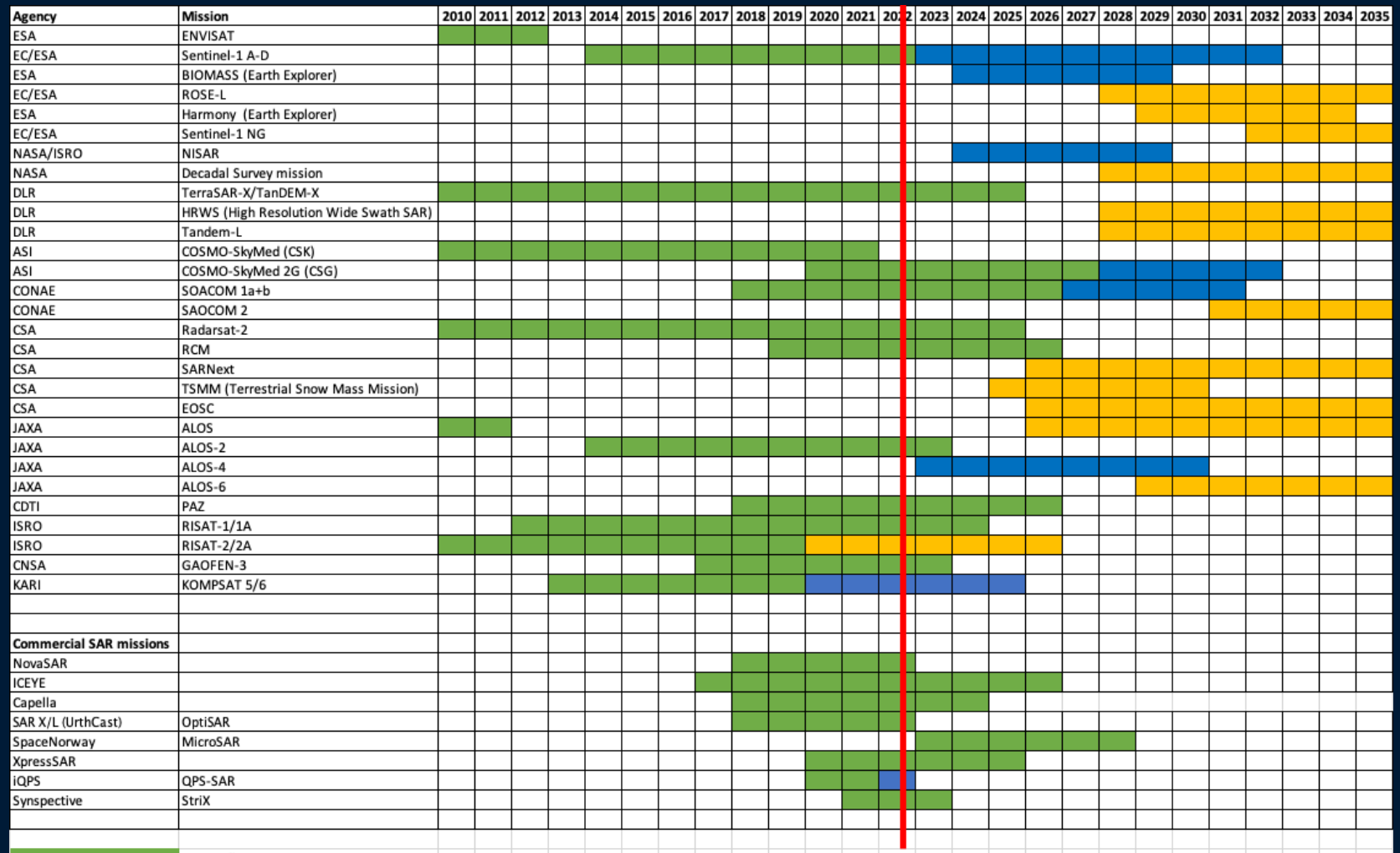
ESA Develops world-class EO systems with European and global partners to address Scientific & Societal challenges


Agency
Mission
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035
ESA ENVISAT
EC/ESA Sentinel-1 A-D
ESA BIOMASS (Earth Explorer)
EC/ESA ROSE-L
ESA Harmony (Earth Explorer)
EC/ESA Sentinel-1 NG
NASA/ISRO NISAR
NASA Decadal Survey mission
DLR TerraSAR-X/TanDEM-X
DLR HRWS (High Resolution Wide Swath SAR)
DLR Tandem-L
ASI COSMO-SkyMed (CSK)
ASI COSMO-SkyMed 2G (CSG)
CONAE SOACOM 1a+b
CONAE SAOCOM 2
CSA Radarsat-2
CSA RCM
CSA SARNext
CSA TSMM (Terrestrial Snow Mass Mission)
CSA EOSC
JAXA ALOS
JAXA ALOS-2
JAXA ALOS-4
JAXA ALOS-6
CDTI PAZ
ISRO RISAT-1/1A
ISRO RISAT-2/2A
CNSA GAOFEN-3
KARI KOMPSAT 5/6
Commercial SAR missions
NovaSAR
ICEYE
Capella
SAR X/L (UrthCast) OptiSAR
SpaceNorway MicroSAR
XpressSAR
iQPS QPS-SAR
Synspective StriX
Past or flying SAR missions
Missions approved (and being built)
Missions planned (but not funded)

Sentinel-1 Mission Status Highlights

- Sentinel-1A, launched on 3 April 2014 (8.5 years ago), **has reached its design lifetime of 7 years of operations**:

  https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-1/First_Copernicus_satellite_exceeds_design_working_life

- **End of mission of Sentinel-1B satellite declared in July 2022**, following a major anomaly on the power sub-system that occurred on 23 Dec 2021
- The **Sentinel-1B de-orbiting** strategy is being analysed, the start of the disposal phase is planned once the Sentinel-1C commissioning phase will be completed
- **Sentinel-1A is fully operational** and remains key for many Copernicus Services and users worldwide in the operational, scientific, commercial domains
- Sentinel-1 contribution to **emergency activations** continues to be very high (about once a week in average), for flood monitoring in particular
- **Sentinel-1A is operated close to its full mission capacity** (i.e. difficulty to accommodate additional observations)
- Planned **launch of Sentinel-1C: from mid-April to mid-July 2023** on VEGA-C
- Discussions on-going with the European Commission and Arianespace for a **Sentinel-1D launch in the 2024-2025 timeframe**

Sentinel-1 Mission Status Highlights

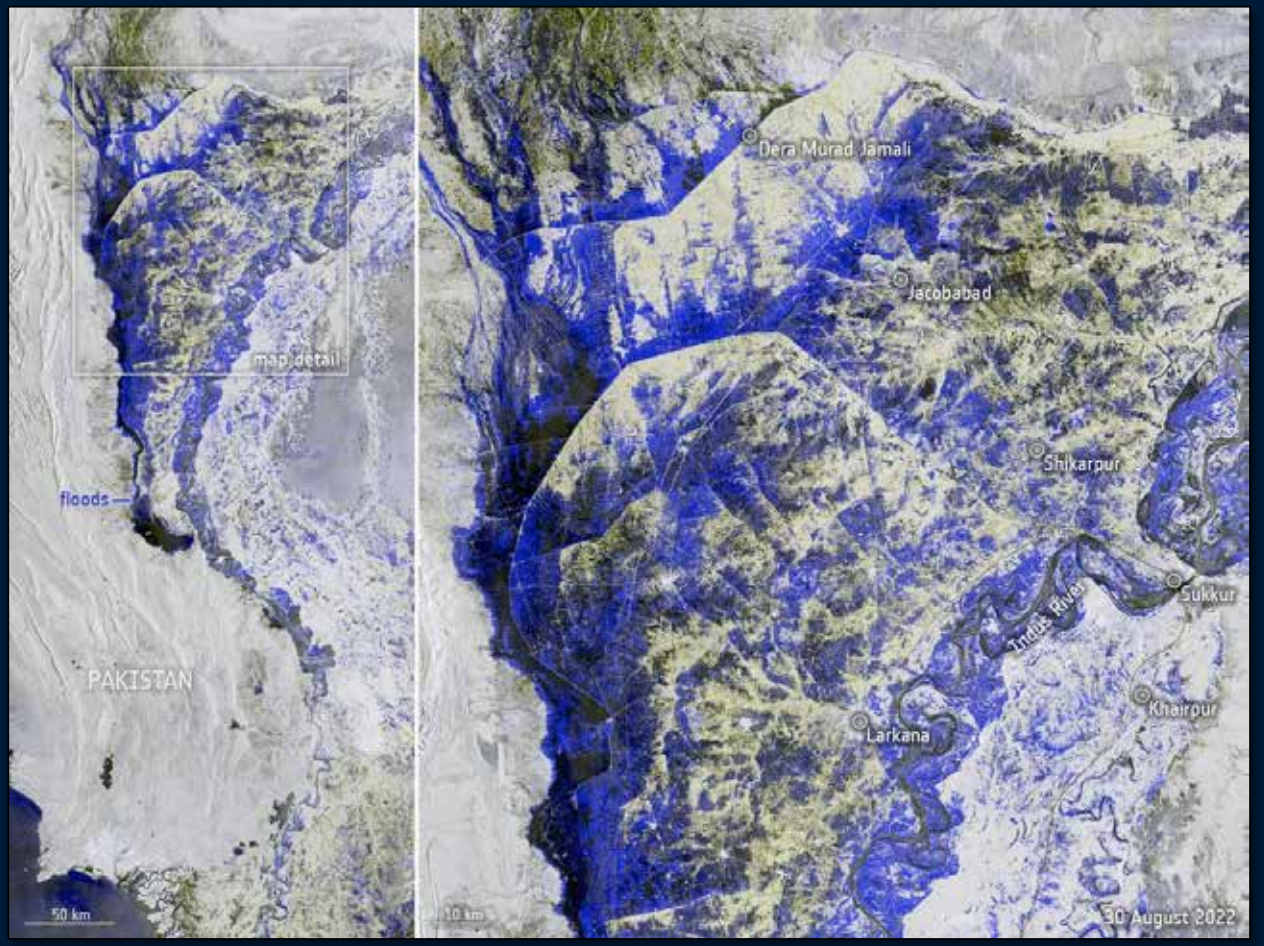
Sentinel-1A fully operational

Catastrophic floods in Pakistan

Heavy monsoon rainfall – ten times heavier than usual – since mid-June 2022, has led to a large part of the country being underwater

Flood map based on Sentinel-1A data acquired on 30 August 2022

https://www.esa.int/ESA_Multimedia/Images/2022/09/Pakistan_inundated



RADD (RAdar for Detecting Deforestation) Alerts - based on dense Sentinel-1 time series

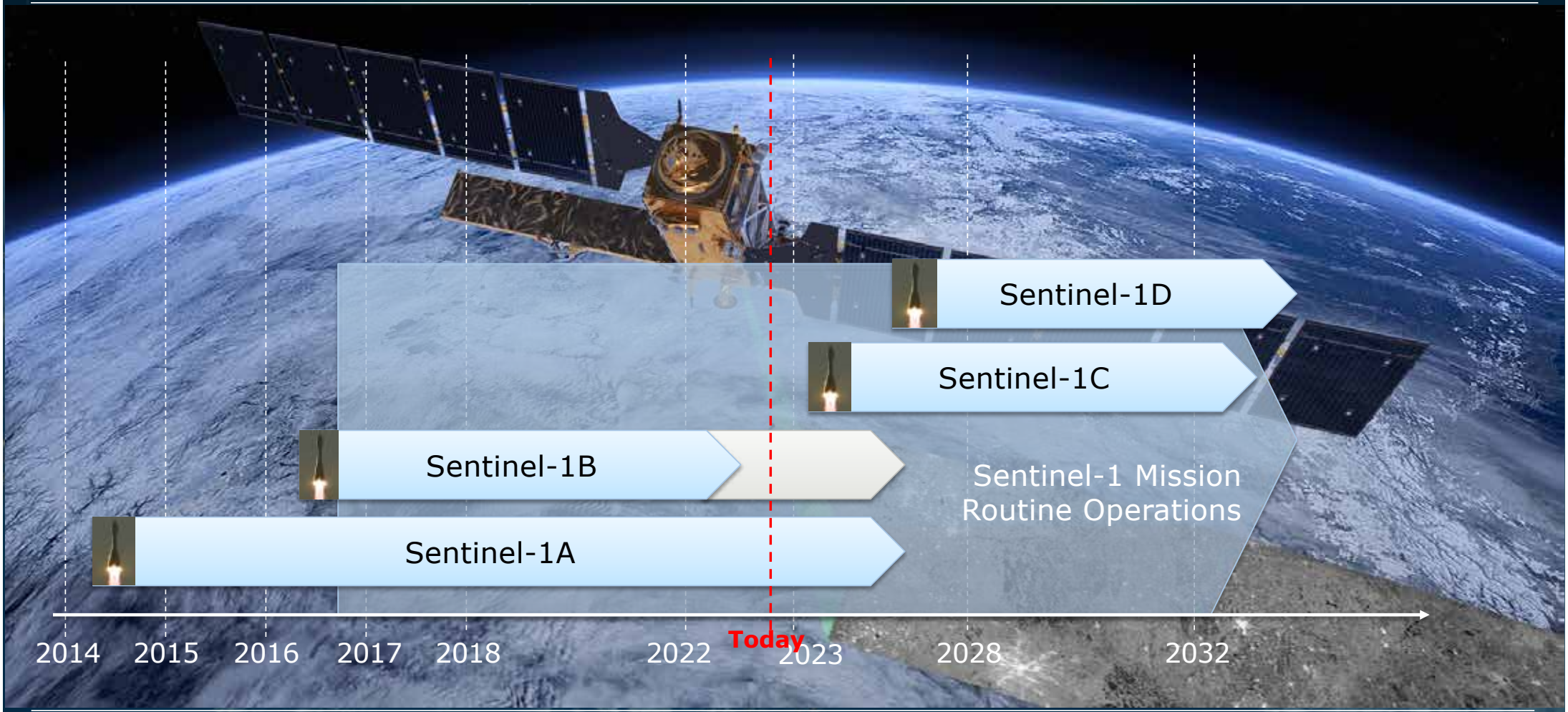
Central African Republic
RADD Alerts 2019 –2021
Selective logging

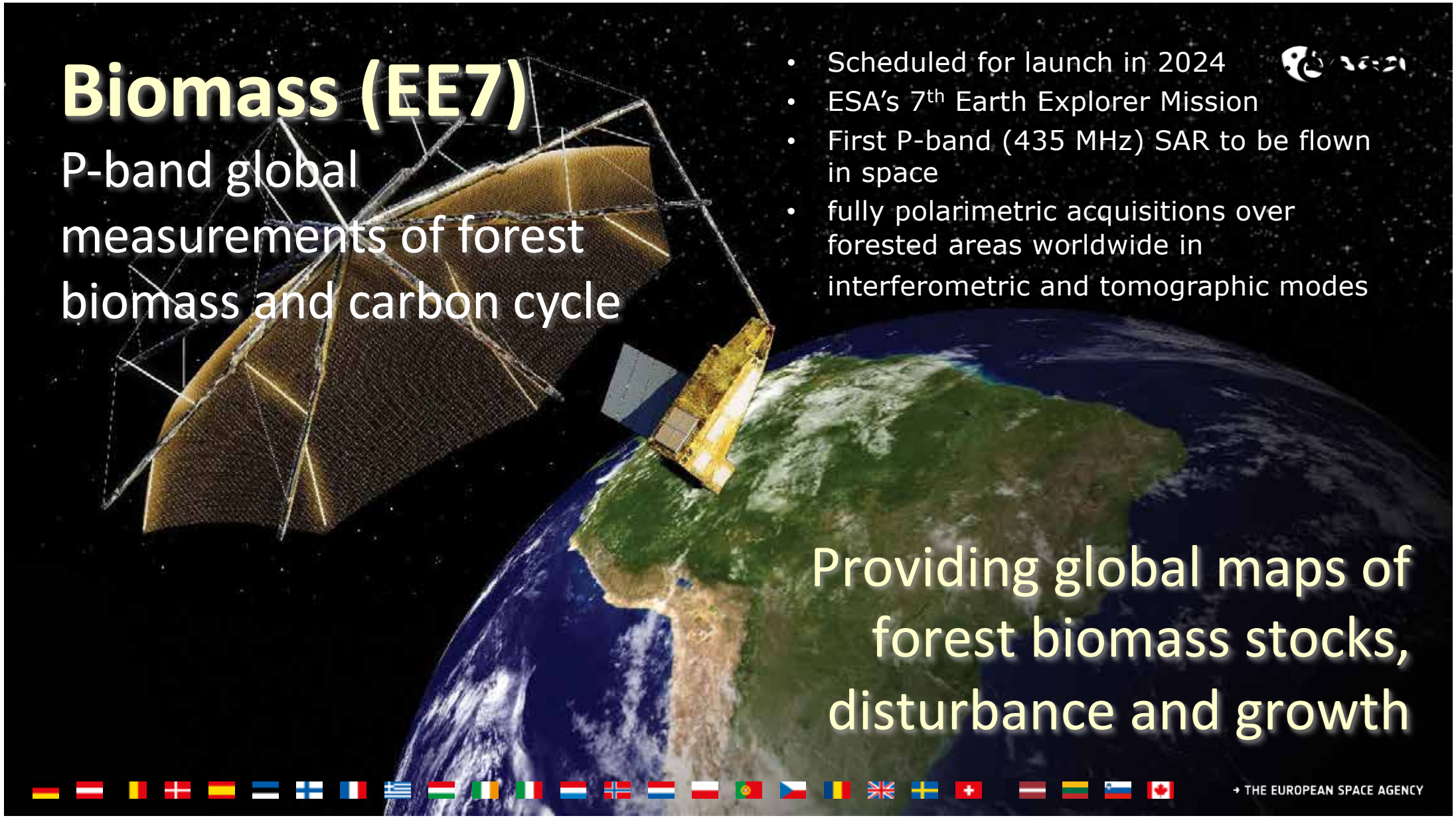
Credit: Pieter Moonen

http://radd-alert.wur.nl

Reiche et al.(2021), ERL

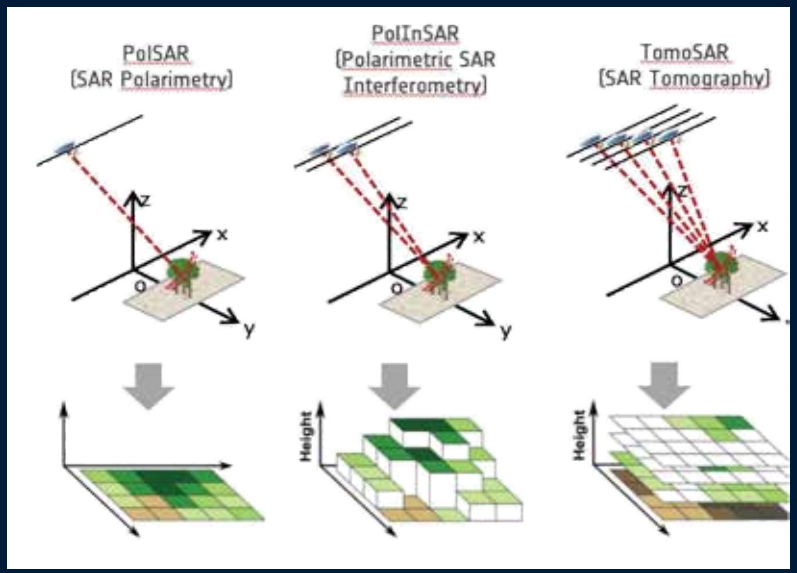
Sentinel-1

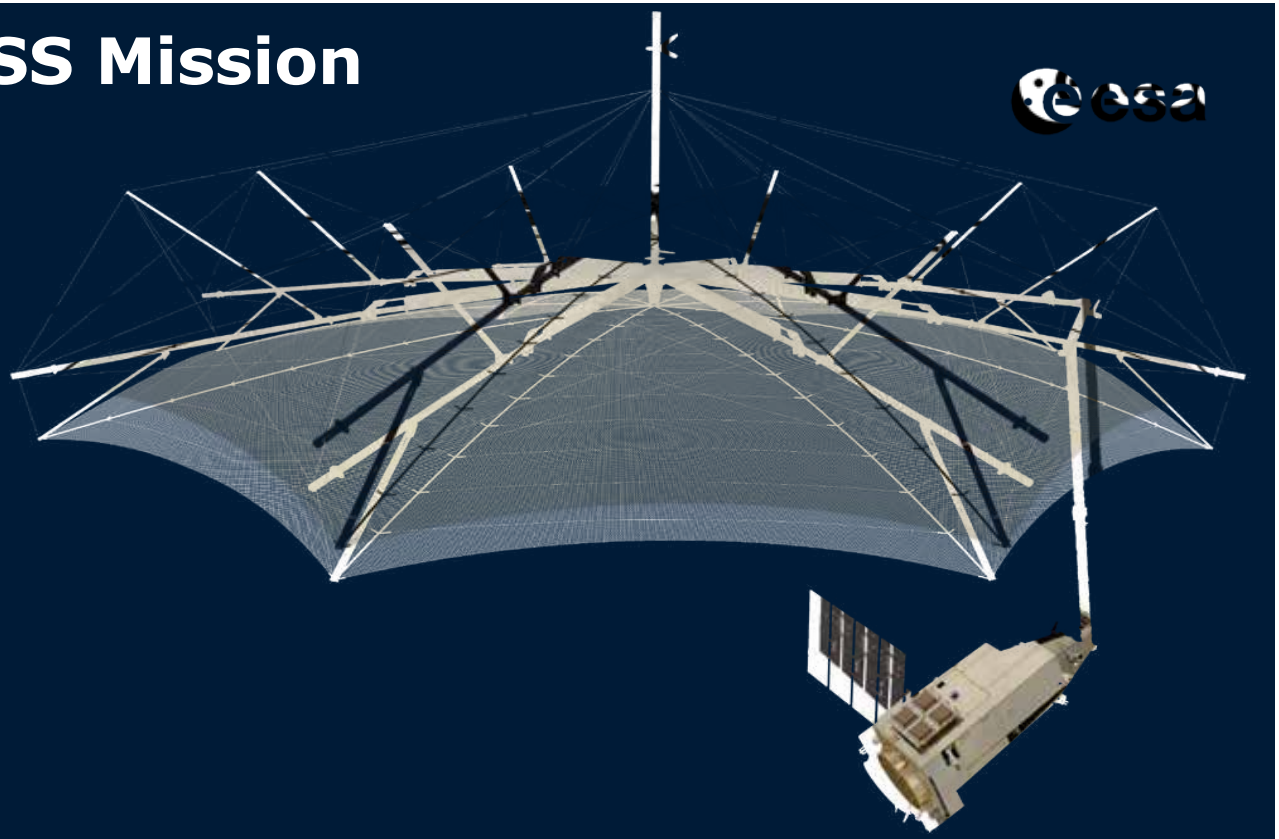

Sentinel-1D
Sentinel-1C
Sentinel-1B
Sentinel-1A
Sentinel-1 Mission
Routine Operations
2014
2015
2016
2017
2018
2022
Today
2023
2028
2032


Biomass (EE7)
P-band global measurements of forest biomass and carbon cycle
• Scheduled for launch in 2024
• ESA's 7th Earth Explorer Mission
• First P-band (435 MHz) SAR to be flown in space
• fully polarimetric acquisitions over forested areas worldwide in interferometric and tomographic modes
Providing global maps of forest biomass stocks, disturbance and growth
→ THE EUROPEAN SPACE AGENCY

BIOMASS Mission

- 12 metres projected aperture reflector (focal length: 7.8m)
- Fully linear polarimetric left-looking stripmap mode SAR
- 3 swaths, obtained by satellite roll steering, total swath ~150 km
- Dual-polarisation Feed Array patches





- Tomographic phase: 7 acquisitions; Interferometric phase: 3 acquisitions
- Centre frequency: 435 MHz, total bandwidth: 6 MHz

Earth Explorer #10: Harmony

Studying small-scale motion & deformation fields

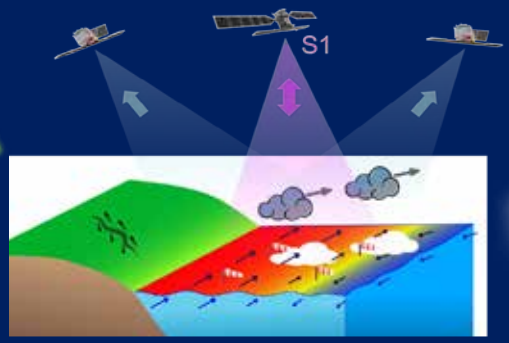
Mission approved by ESA Member States on 22 Sept 2022 !

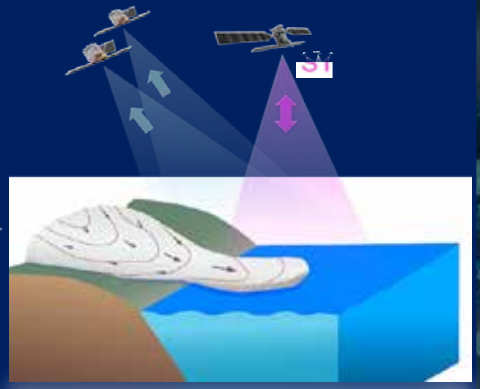
Expected launch 2029

Two passive receiving antenna satellites

Bi-static SAR + TIR instruments, in stereo and close formation with Sentinel-1, demonstrating synergies between ESA's EO research missions and EU Copernicus missions

Two satellites flanking Sentinel-1 in stereo or close flight formations

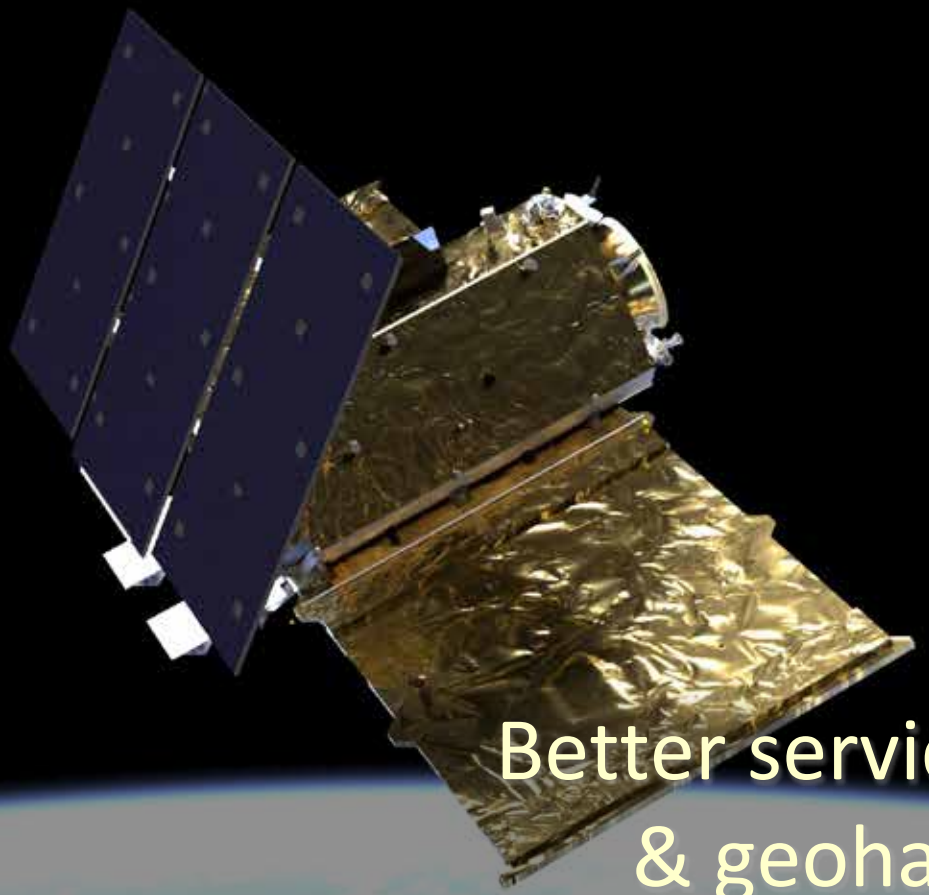




Observing movement in ocean, solid Earth, cryosphere, height-resolved clouds and SST for improved understanding of Ocean circulation patterns, Ice dynamics & mass balance, 3D deformation fields in land topography, Ocean-atmosphere boundary layer

ROSE-L

L-band SAR system for Europe & the World



Better services for disasters & geohazards, forests & agriculture management

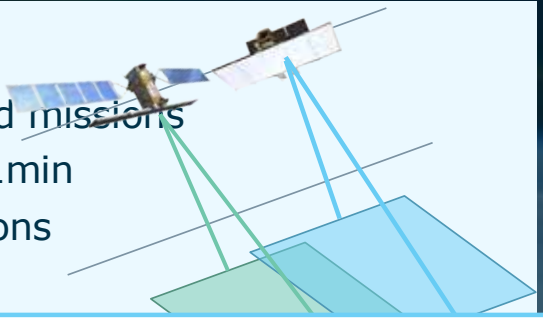
Expected launch A 2028 / B 2030

→ THE EUROPEAN SPACE AGENCY

ROSE-L Mission Requirements Highlights

Synergy with Sentinel-1

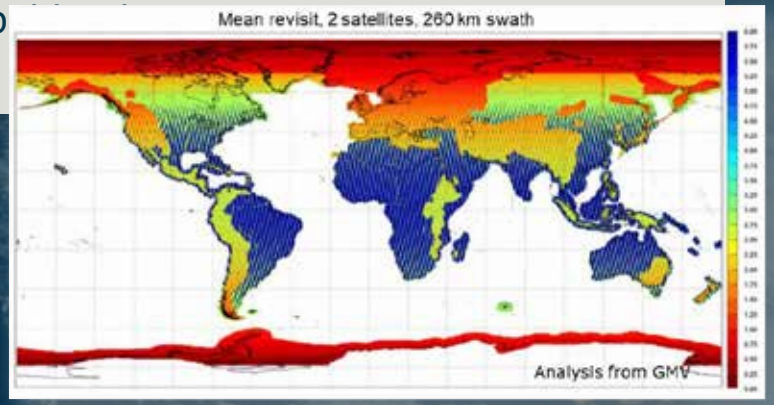
- Continuous operations without gaps with current and future Copernicus C-band missions
- Support collocated acquisition with Sentinel-1 with a temporal baseline up to 1min
- The ground swath shall be sufficient to cover the swath of Sentinel-1 acquisitions
- Repeat cycle shall be a maximum of 6 days



Moving towards a **System of Systems concept** and enhanced information products

Coverage and Operations

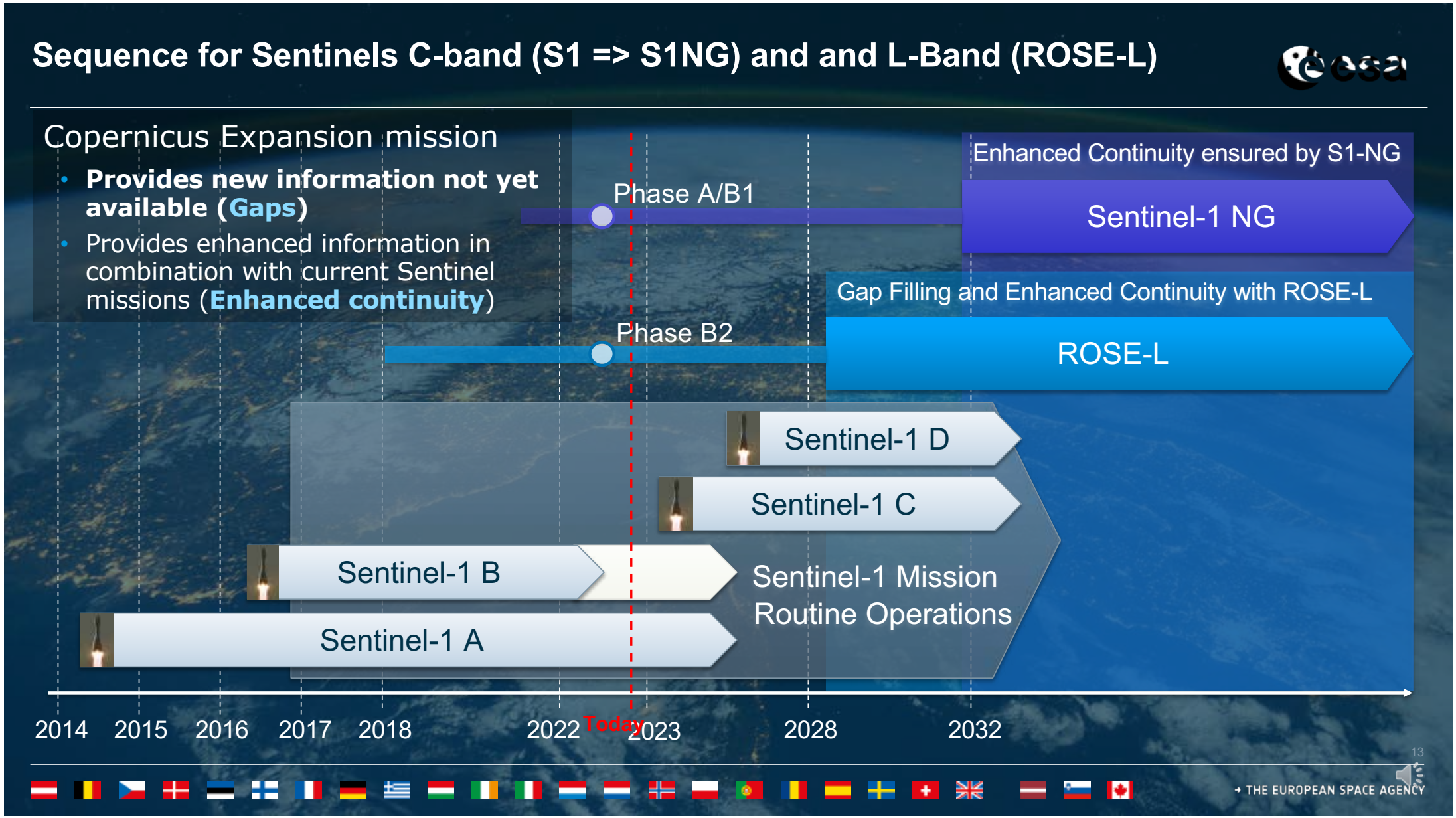
- Global coverage (except for South pole) and systematic acquisitions
- Revisit of 1 day for the Arctic, 3 days for Europe and 6 days for Glob
- Data latency of 10 min for maritime monitoring and 200 min Global



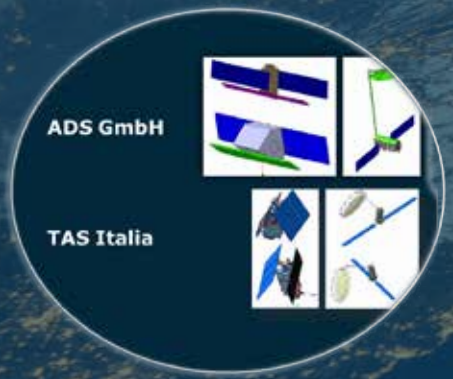
SAR Imaging and Performance

- Resolution equal or higher than 50 m2
- Noise Equivalent Sigma Zero ≤ -28 dB on wide-swath modes
- Support linear Dual-Pol (DP) and Full/Quad-Pol (QP) acquisitions
- Support Wave Mode products for ocean monitoring
- Optimized bandwidth for ionosphere correction (e.g. split-band

Sequence for Sentinels C-band (S1 => S1NG) and and L-Band (ROSE-L)



Sentinel-1 NG Highlights



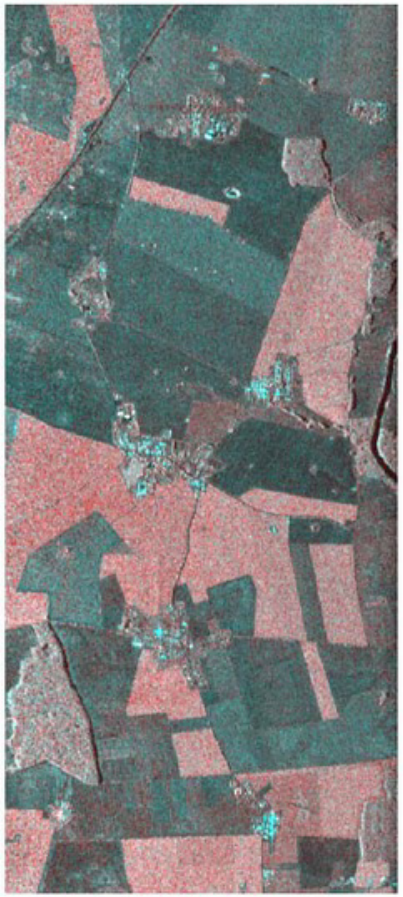
OBJECTIVES

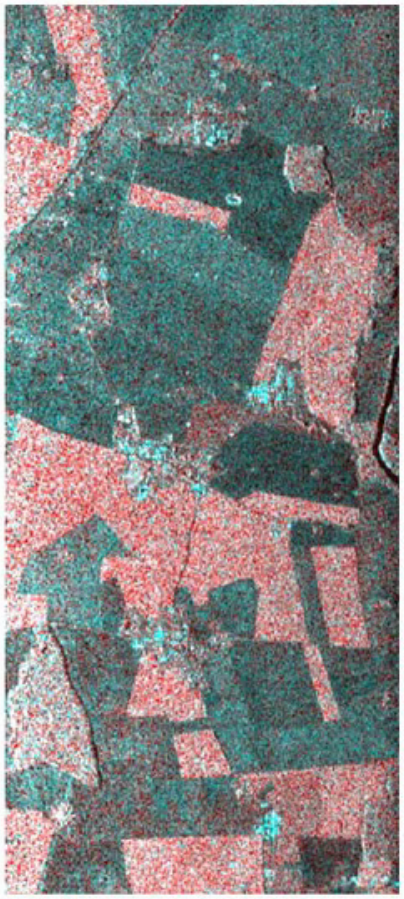
- *Ensure continuity* and expansion of services and applications relying on Sentinel-1
- *Enhance* existing services and applications
- *Enable* new application developments building on improved performance and observation gaps (e.g. resolution, revisit and others)

MISSION PERFORMANCE REQUIREMENTS

- Performance shall be equal or better than Sentinel-1 FG
- Revisit: 3 days Global, 0.5 days Arctic and sea ice
- Resolution ≤ 25 m^2
- NESZ ≤ -26 dB
- Dual-Pol and Quad-Pol capability
- Large swath ~300km or greater

Next Generation Imaging





Airborne highres (8 looks) S1 NG 25m² (4 looks) S1 IWS 100m² (4 looks)

- Higher resolution a cross-cutting user requirement from Copernicus Services
- Sentinel-1 NG expected to provide 25m2 resolution (5m x 5m) compared to 100m2 (5m x 20m) for Sentinel-1 FG

E-SAR data for ESA AgriSAR campaign with Sentinel-1 simulation in stripmap and IWS mode. Color coding is RGB: HV-HH-HH. Stripmap resolution is the same as S1-NG, although with higher NESZ (DLR)

New Dimensions in EO Data

Big Data Challenges

3 days of ESA EO data dissemination

Copernicus
2+ PB/week

Data Integration

IAAS

SAAS

Digital Solutions

Onboard processing

Artificial Intelligence

Quantum Computing

Process Automation

Digital Twins

Machine Learning

Challenges in dealing with huge EO Data Dimensions

MAAP - Mission Algorithm and Analysis Platform

→ ***It's a Virtual open and collaborative environment built in collaboration between ESA and NASA that…***

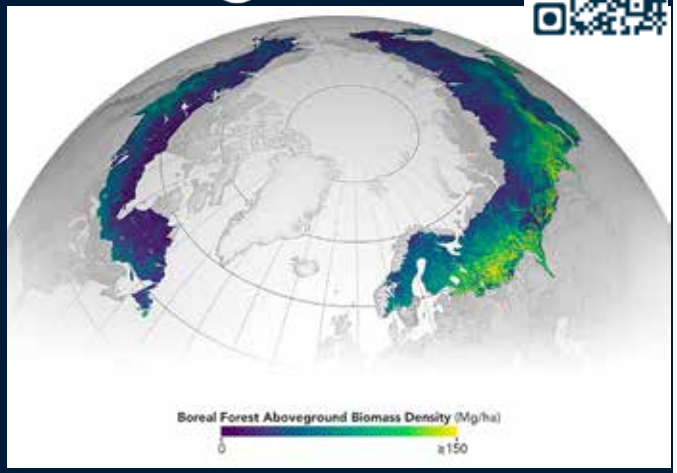
Enables researchers to easily discover, process, visualize, and analyse large volumes of data.

Provides tools and infrastructures to bring data into the same coordinate reference frame to enable comparison, analysis, data evaluation, and data generation.

Provides a version-controlled science algorithm development environment that supports tools, co-located data, and processing resources.

Addresses intellectual property and sharing issues related to collaborative algorithm development and sharing of data and algorithms.

scimaap.net



Boreal forest biomass density mapped at 30 m for 2020 with ICESat-2 & Landsat-8, generated on the MAAP

biomass

NISAR
NASA - ISRO SAR Mission

GEDI
ECOSYSTEM LIDAR

Sentinel User Preparation (SUP) ESA Initiative

Activity in collaborative synergy with the EC

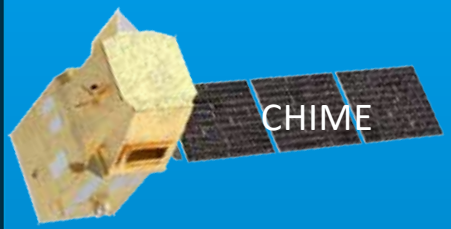
- Enable the rapid integration of new Copernicus Expansion & NextGen datasets into operational working practices by:
  - building the necessary expertise in various science and application domains and sectors (academia, value adding companies) to prepare future downstream services.
  - ensuring readiness for rapid uptake by end-users and stakeholders

a) ROSE-L dedicated exploitation techniques consolidation and SAR multi-band perspective

b) Multi-mission Thematic-driven innovative application products

Thematic driven (e.g. agriculture) multi-mission coordination efforts

- International coordination: SAOCOM and JAXA ALOS Palsar
- User consultations: LPS22, Fringe, SeaSAR, PolInSAR



- International coordination: ASI, DLR, NASA, JAXA.
- User consultations: EARSeL, WHISPERS, 2nd Int. Workshop
- Ongoing projects.

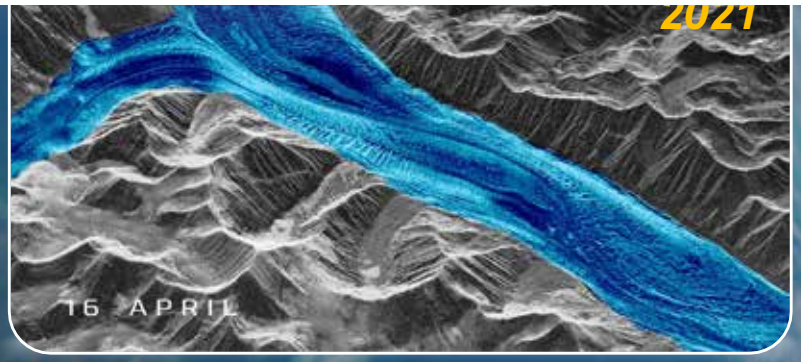
- International coordination: NASA, CNES, ASI.
- European Ecostress Hub
- ET4FAO

ESA EO Supporting New Space

Daily movement of stockpiles at Rotterdam port

InCubed

Challenge of European New Space Development



2021

Third Party Missions

ESA and International Collaboration in the SAR domain

- ESA-NASA Joint Programme Planning Group (JPPG)
- Multi-mission Algorithm and Analysis Platform (MAAP) with NASA
- ESA-NASA coordinated assessment of SAR commercial missions
- Joint ESA-NASA-JAXA EO Dashboard
- ESA-JAXA cooperation on cooperation using SAR satellites in Earth Science and Applications
- ESA-CSA - Sentinel-1/Radarsat Constellation Mission (RCM)
- ESA-CSA Joint Study on Next Generation of Legacy SAR Capabilities
- CONAE - SAOCOM data access & PUMAS & BIOMASS cooperation with SAOCOM
- Collaboration with ESA member States (COSMO-SkyMed, SAR-X, TerraSAR-X) via ESA Earthnet and Copernicus Contributing Missions Programmes
- And growing ….

Challenges of continuing and further developing international collaborations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