Overview and preparation status of ESA’s Earth Explorer 7 Biomass mission

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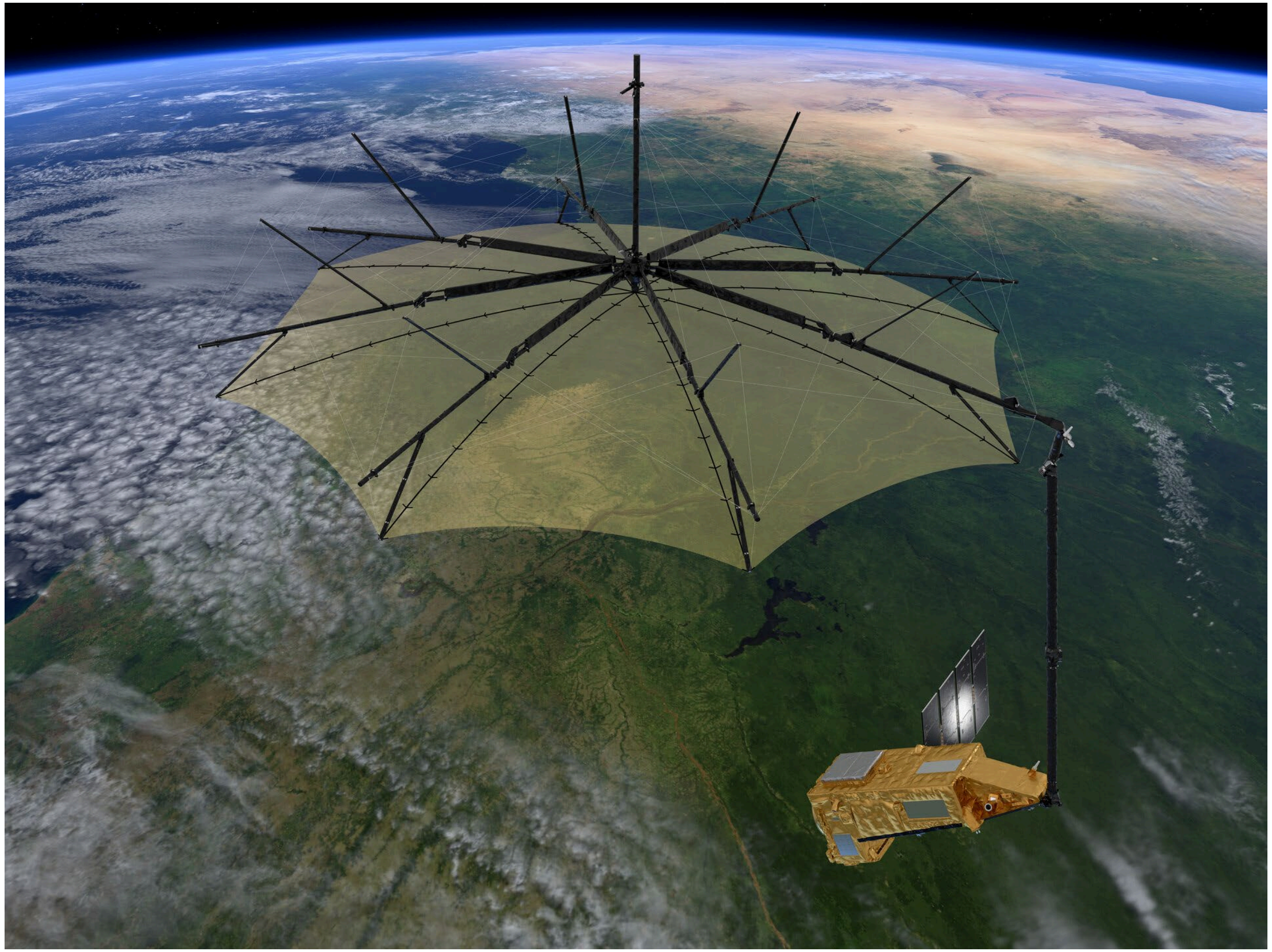
Overview

- Biomass mission objectives
- Key mission requirements
- Mission operations concept
- Biomass system architecture
- Current status & outlook



Biomass mission summary

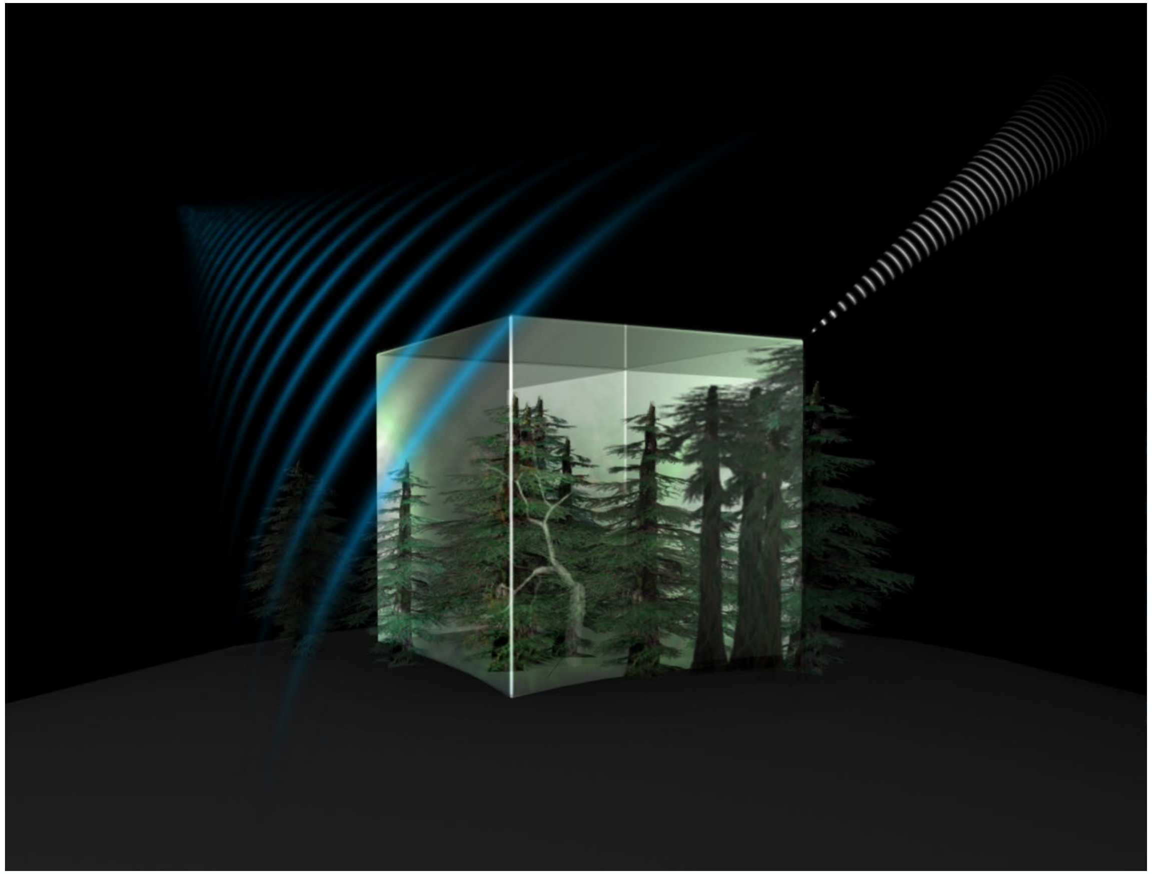
“to take stock of the biomass in the world’s forests and to monitor its evolution”

Primary objectives: determination of

- forest biomass
- forest height
- vegetation disturbances and re-growth

Secondary objectives:

- imaging of sub-surface geology in deserts
- mapping the topography under dense vegetation
- measurements of glacier and ice sheet velocities



What information will we get from Biomass

Above-ground biomass (tons / hectare)

- 200 m resolution
- 1 map every ~9 months during INT phase
- global coverage of forested areas outside SOTR areas
- accuracy of 20%, or 10 t ha^{-1} for biomass < 50 t ha^{-1}

Upper canopy height (meter)

- 200 m resolution
- 1 map every ~9 months during INT phase
- global coverage of forested areas outside SOTR areas
- accuracy of 20-30%

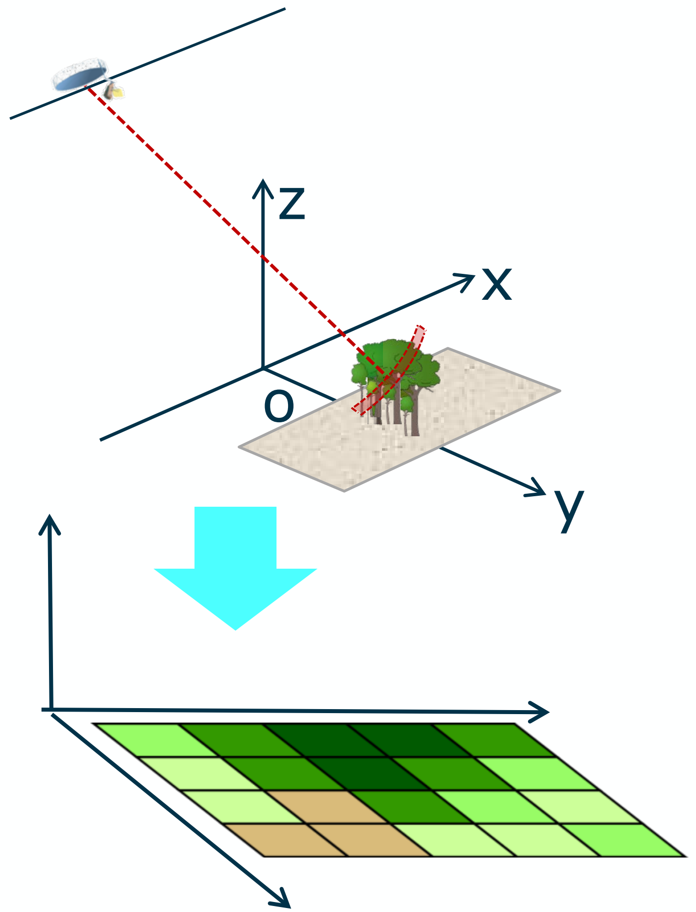
Areas of forest clearing (hectare)

- 50 m resolution
- 1 map every 6 months for 4 years
- global coverage of forested areas outside SOTR areas
- 90% classification accuracy

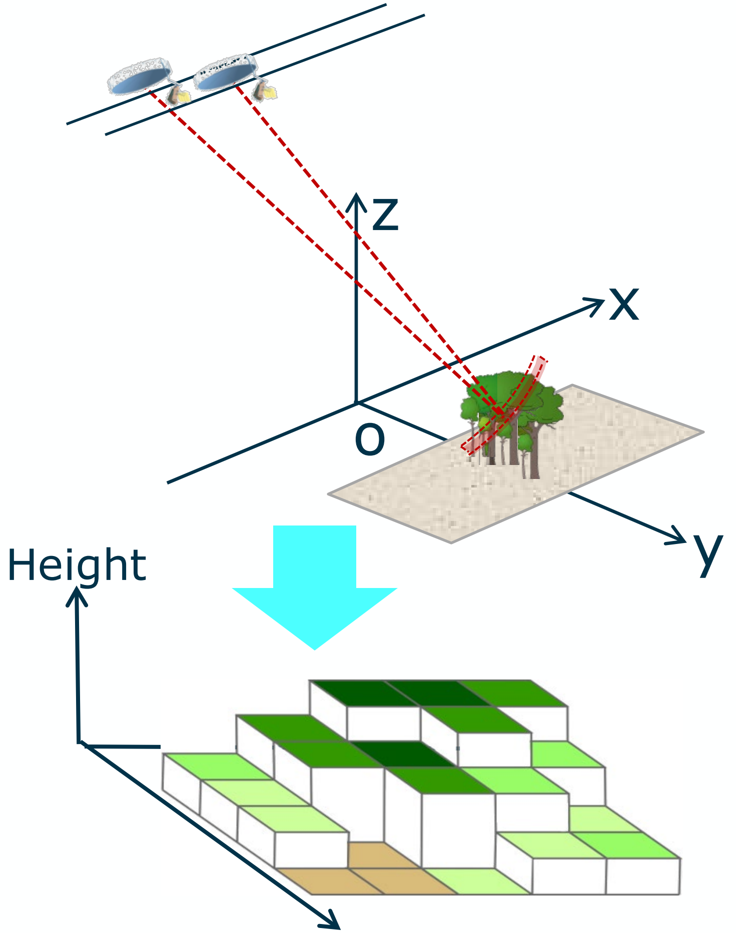
BIOMASS can operate with a resolution of ~55m in range

Biomass SAR observation capability

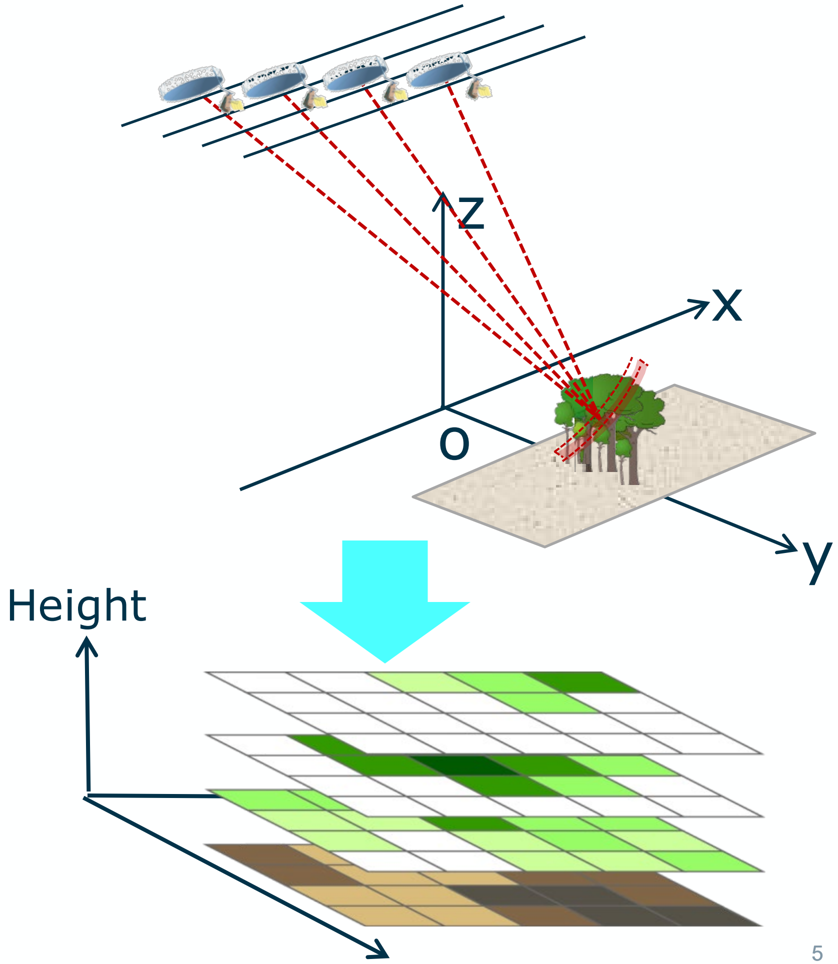
PolSAR
(SAR Polarimetry)



PolInSAR
(Polarimetric SAR Interferometry)



TomoSAR
(SAR Tomography)



Key mission requirements

Fully polarimetric P-band SAR

- P-band backscatter has the highest sensitivity to biomass compared to other wavelengths and displays a high temporal coherence over repeat passes; however
  - using P-band for space applications poses significant challenges as P-band signals are highly susceptible to ionospheric distortions.
  - due to the large wavelength and large antenna diameter, there are currently no test facilities which would allow satellite antenna E2E performance testing on ground. This requires to rely on a dedicated antenna pattern characterisation in orbit.
- To achieve the required L2 product performances the system has to comply to high accuracy polarimetric and radiometric requirements
- SAR working in quad-pol mode which requires acquisition of the scattering coefficients in each of the different linear polarisation combinations, i.e. HH, VV, HV & VH ([H]orizontal, [V]ertical in transmit and receive).

Two mission phases employing multi-pass interferometry

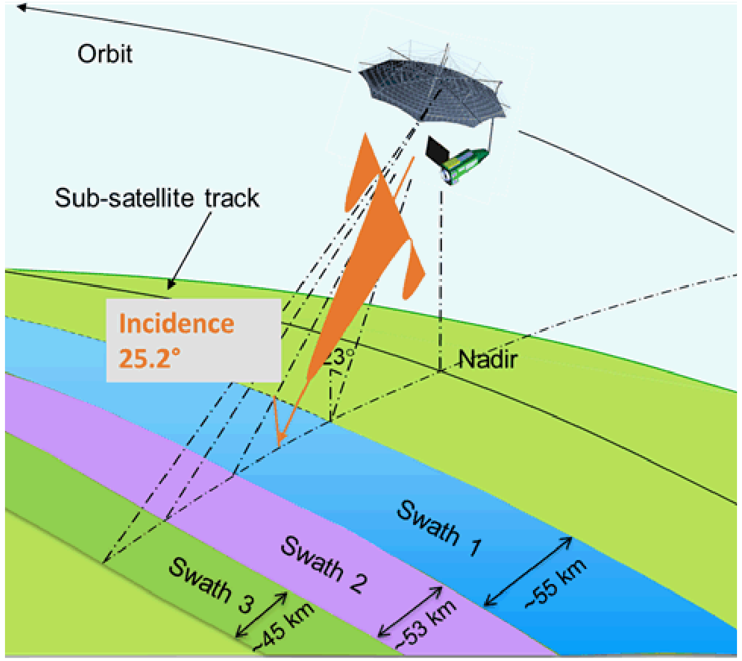
- controlled inter-orbit distances (baselines) between successive revisits to the same site

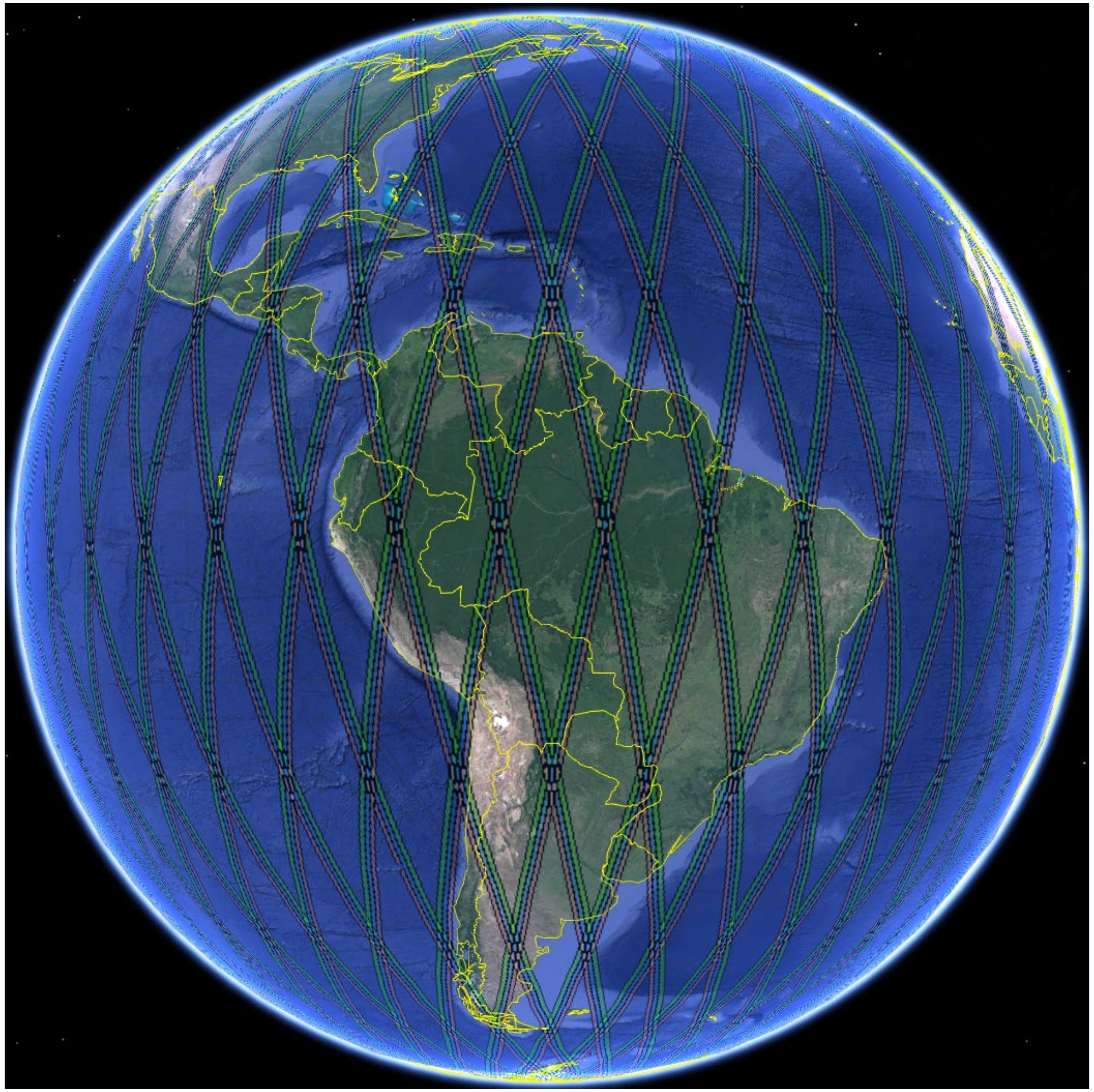
•Tomographic phase: observations with 6 3-day baselines (7 acquisitions)

•Interferometric phase: observations with 2 3-day baselines (3 acquisitions)

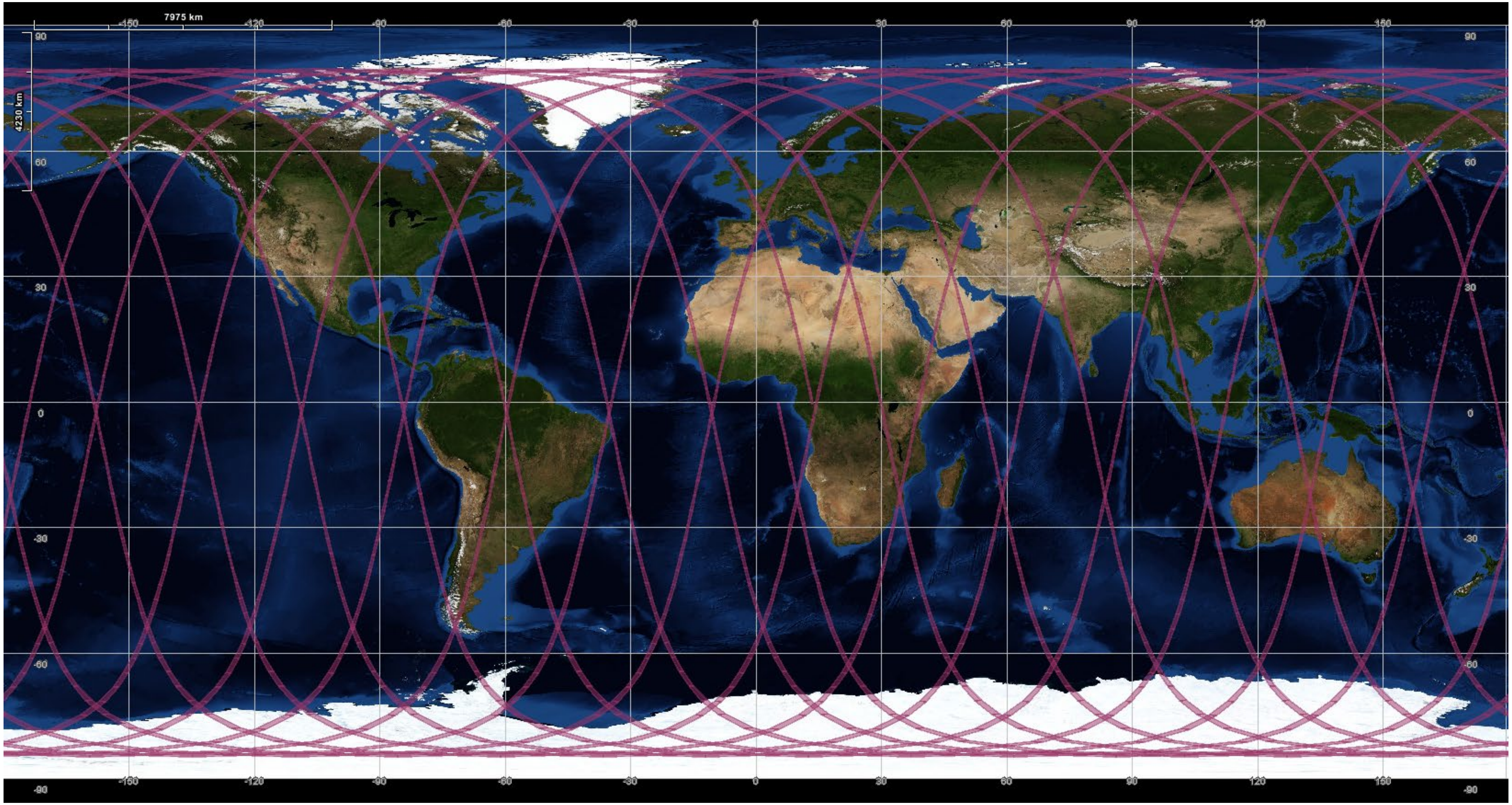
Key mission characteristics

- Sun-synchronous 666 km dawn-dusk orbit
- 3-day repeat / 44 orbits
- Small East-West drift to implement baselines
- Stripmap mode operation @6MHz bandwidth
- Satellite roll for swath access (**left**-looking)
- Satellite repositioning manoeuvre after each "major cycle"

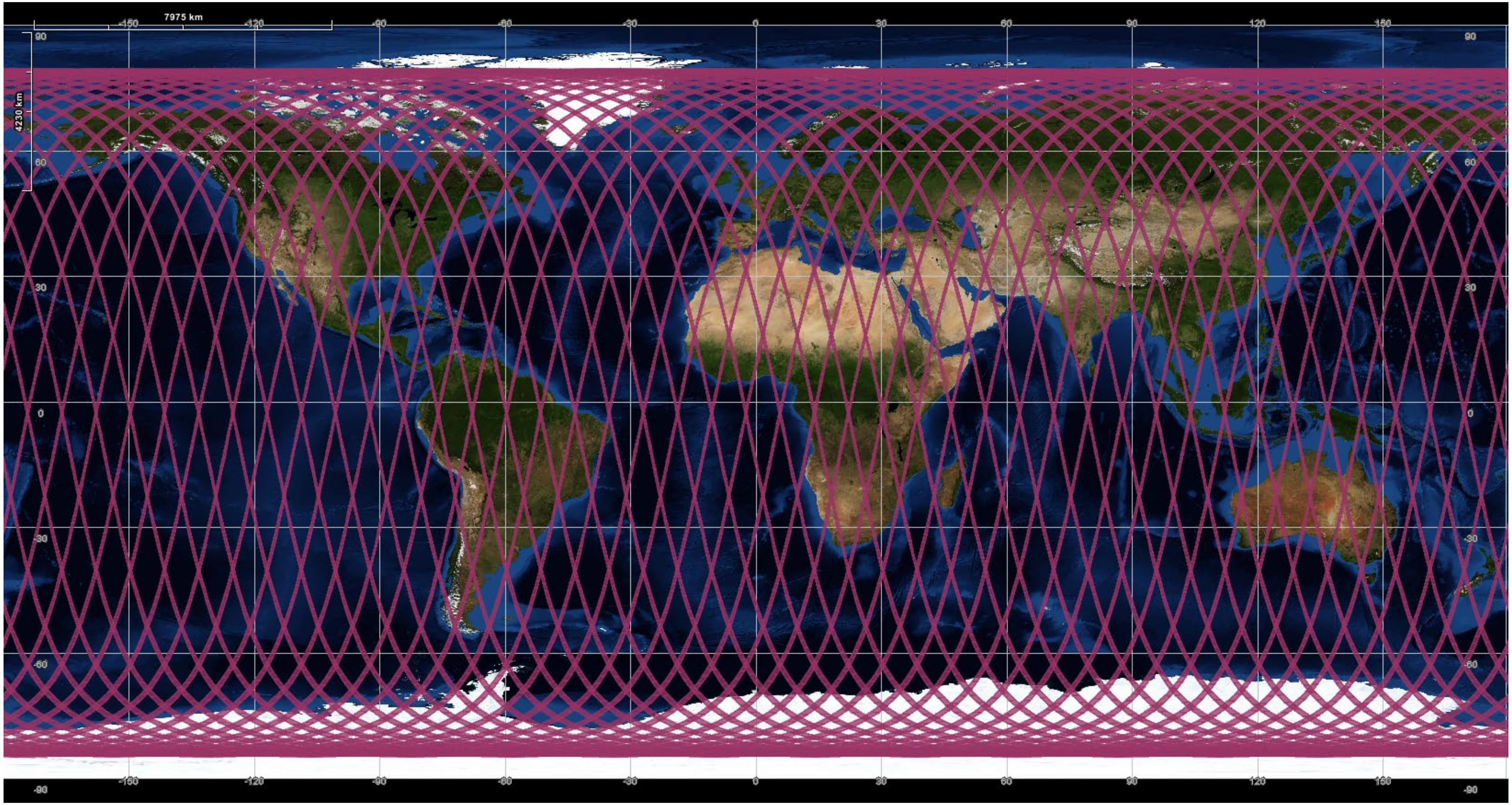




Observation geometry (1 day coverage)

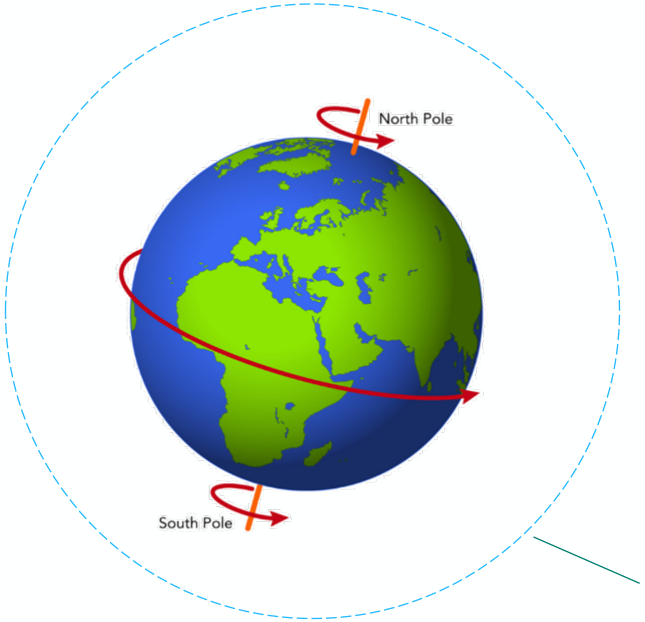


Observation geometry (3 days coverage)

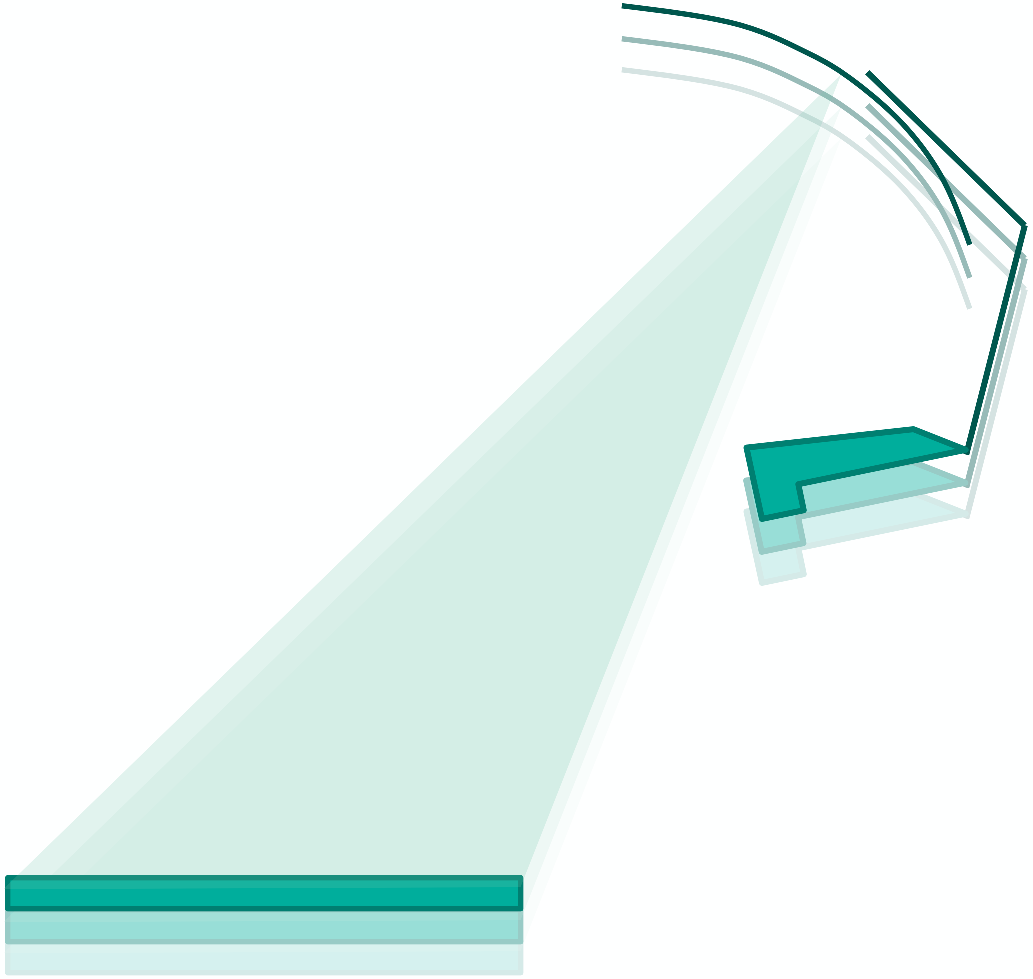


Observation geometry (repeat cycle orbit)

A spacecraft in an orbit with a pure 3 days / 44 orbits, observes exactly same area every 3 days.



3 days / 44 orbits

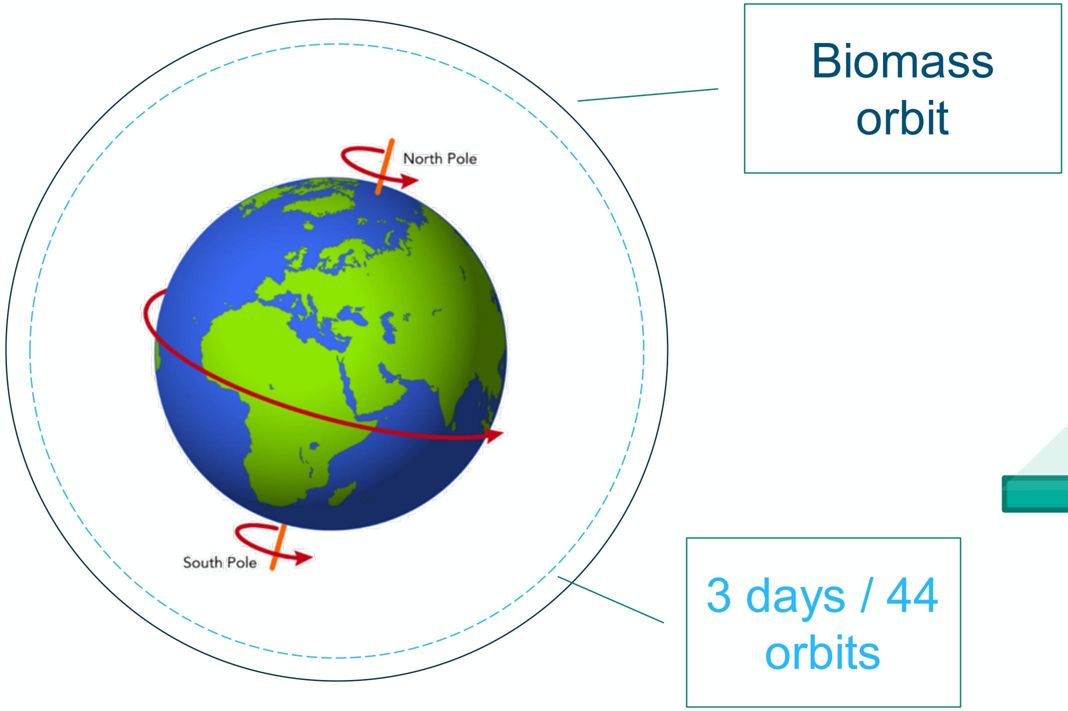


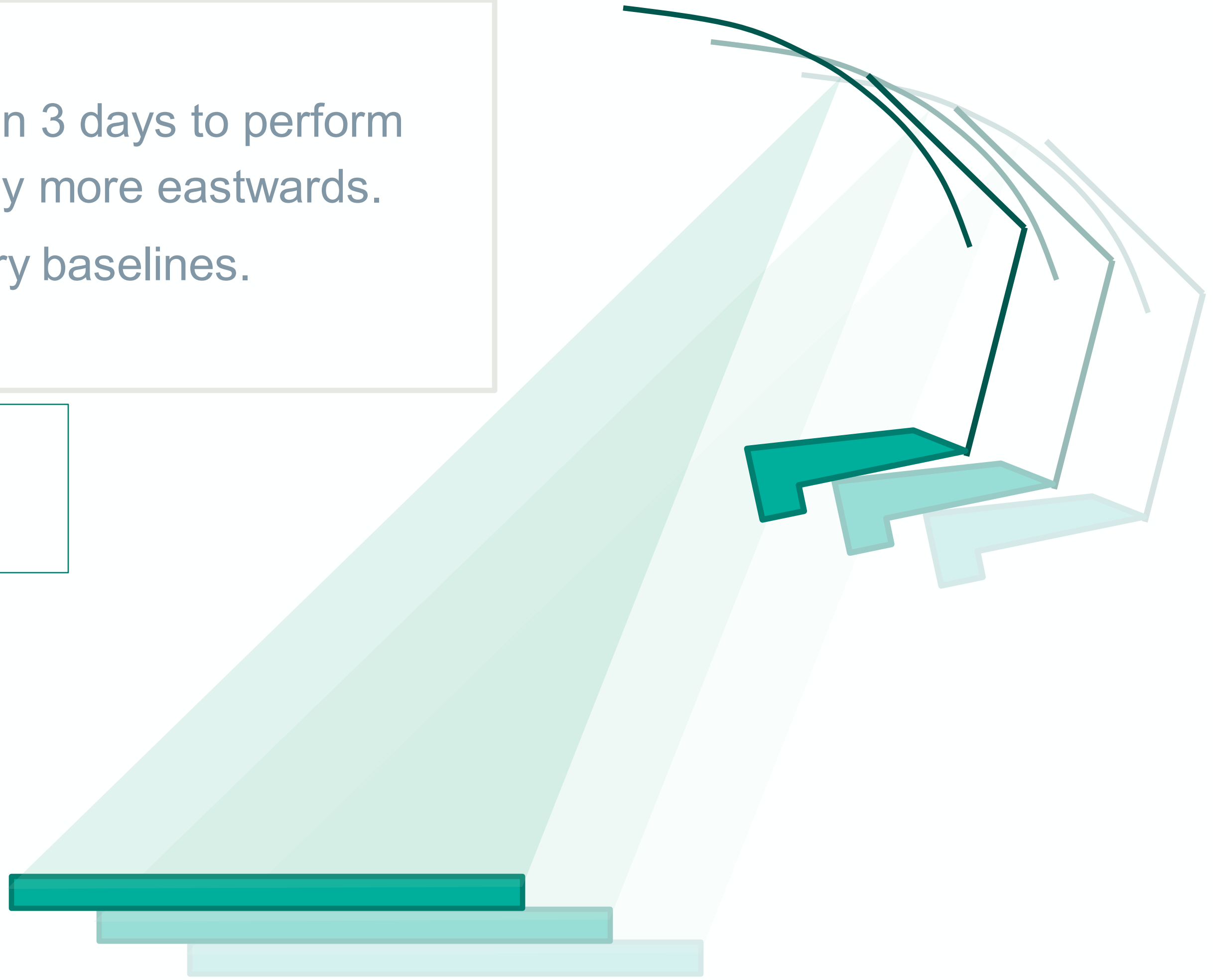
Observation geometry (near repeat cycle orbit)

Biomass will be operated at a slightly higher altitude.

This means that the spacecraft will take a little longer than 3 days to perform the 44 orbits, and the Earth will have time to rotate slightly more eastwards.

This longitude drift is leveraged to generate the necessary baselines.



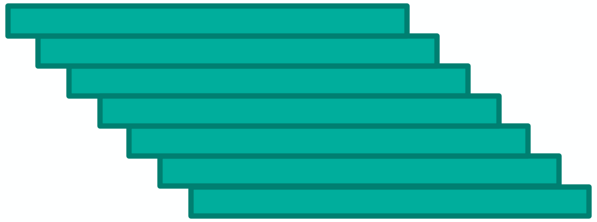


Observation geometry (swath 1)

Tomographic coverage

Interferometric coverage

If Biomass would stay always in its drifting orbit, it would take too long to achieve global coverage.

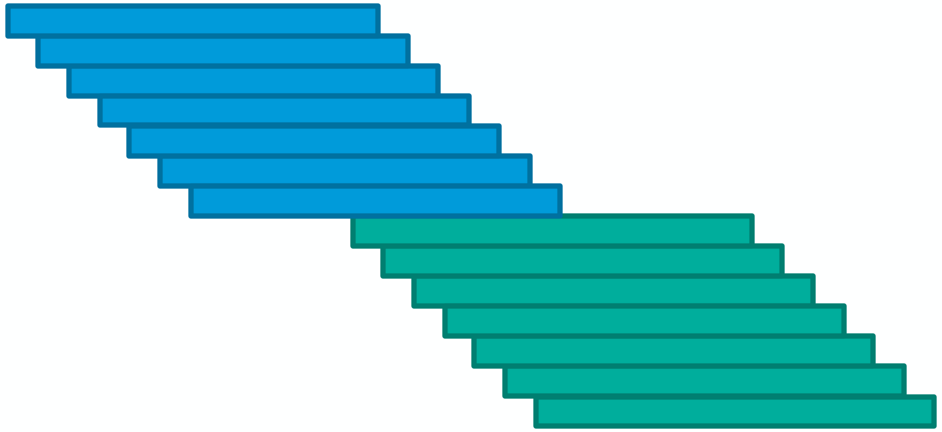


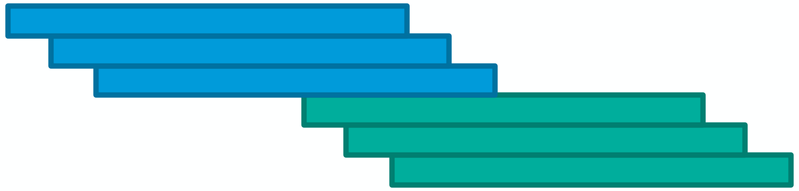
Observation geometry (swath 1 & swath 2)

Tomographic coverage

Interferometric coverage

If Biomass would stay always in its drifting orbit, it would take too long to achieve global coverage.
The solution is to perform a roll manoeuvre to observe the adjacent areas once a full observation stack has been acquired.





Observation geometry (swath 1 & swath 2 & swath 3)

Tomographic coverage

Interferometric coverage

If Biomass would stay always in its drifting orbit, it would take too long to achieve global coverage.
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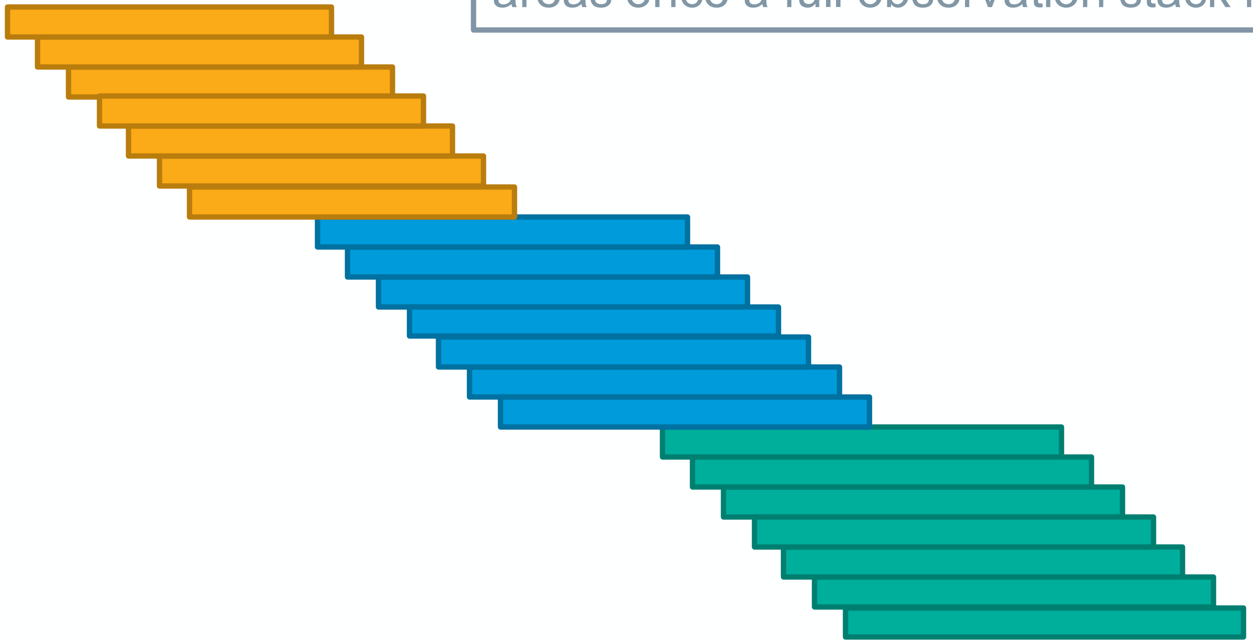
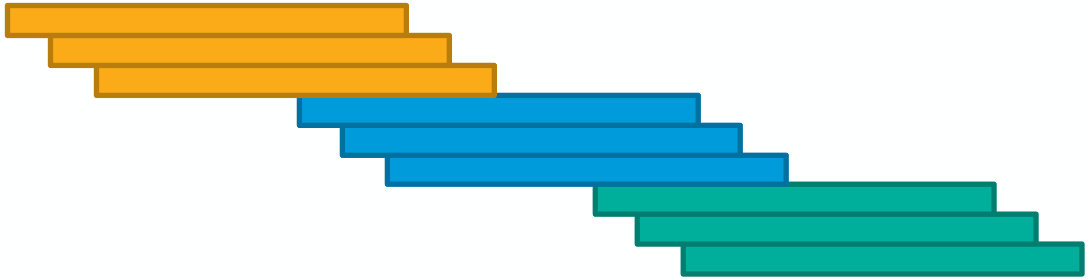
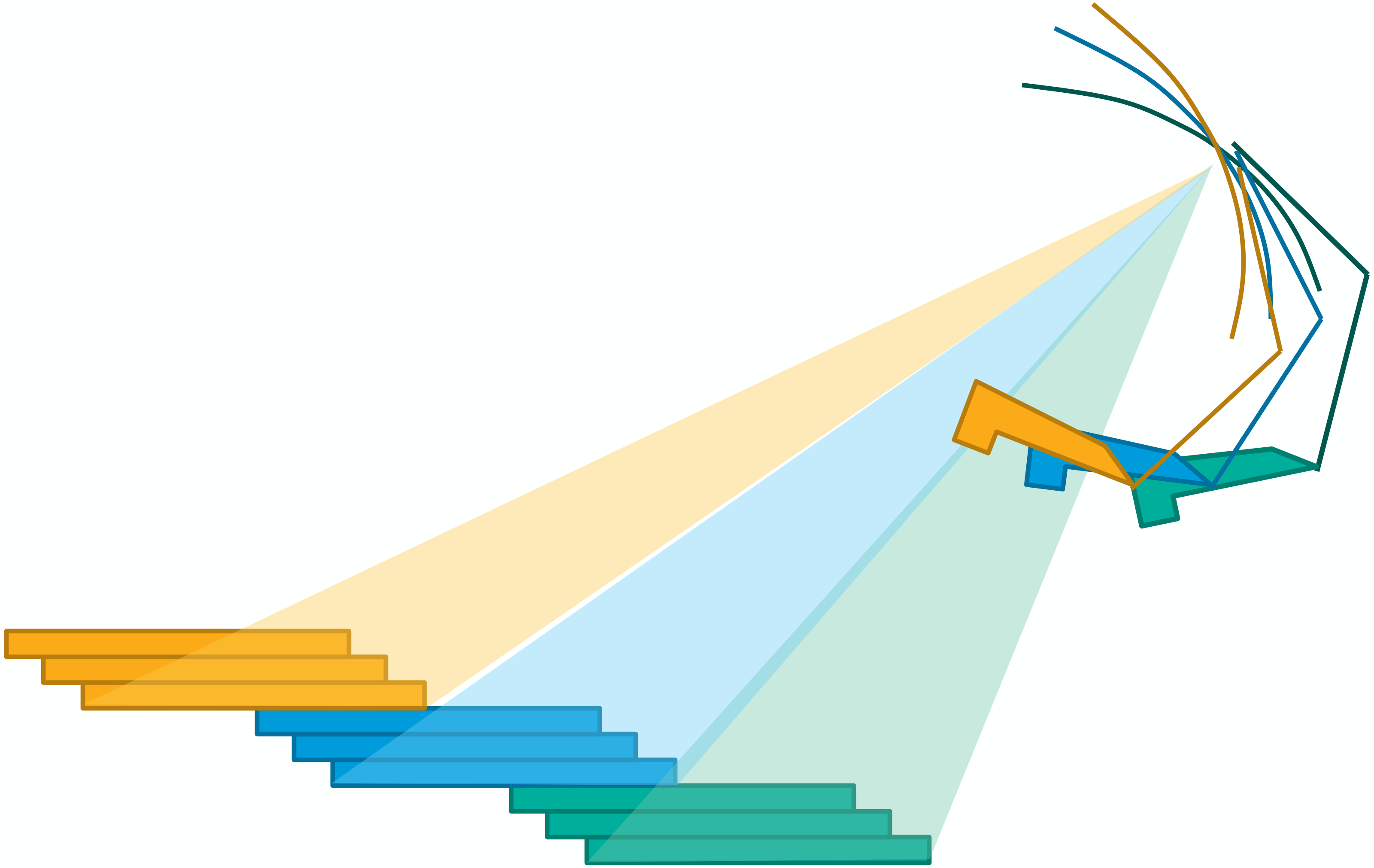


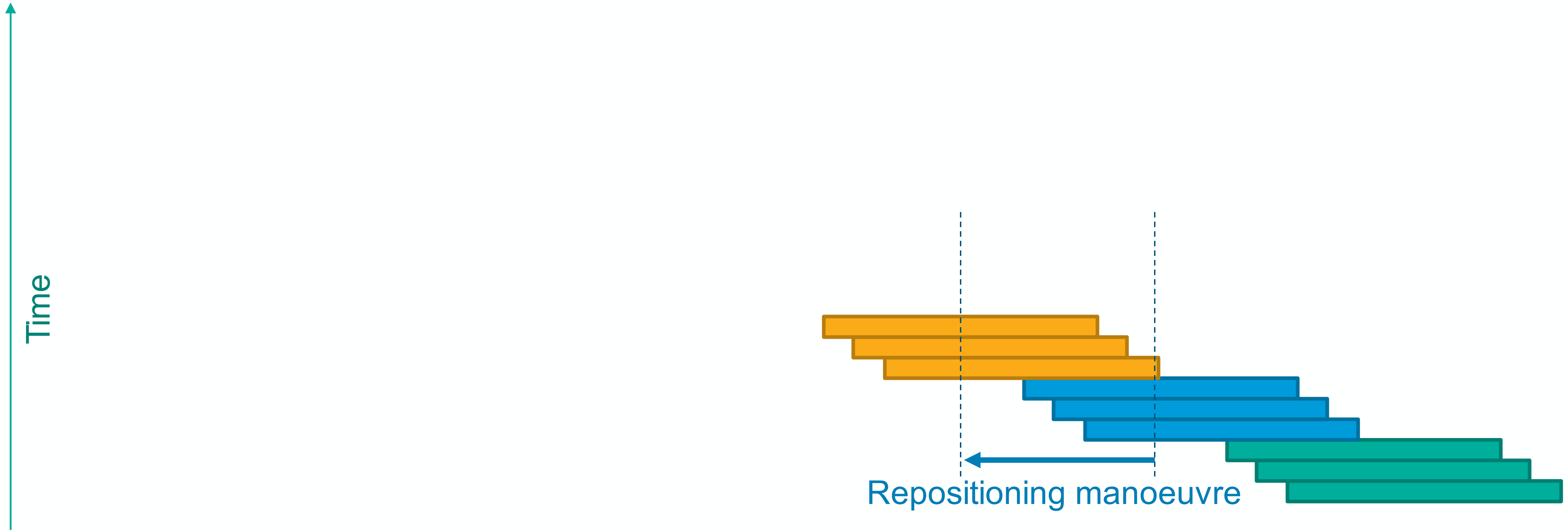


Observation geometry (swath 1 & swath 2 & swath 3)



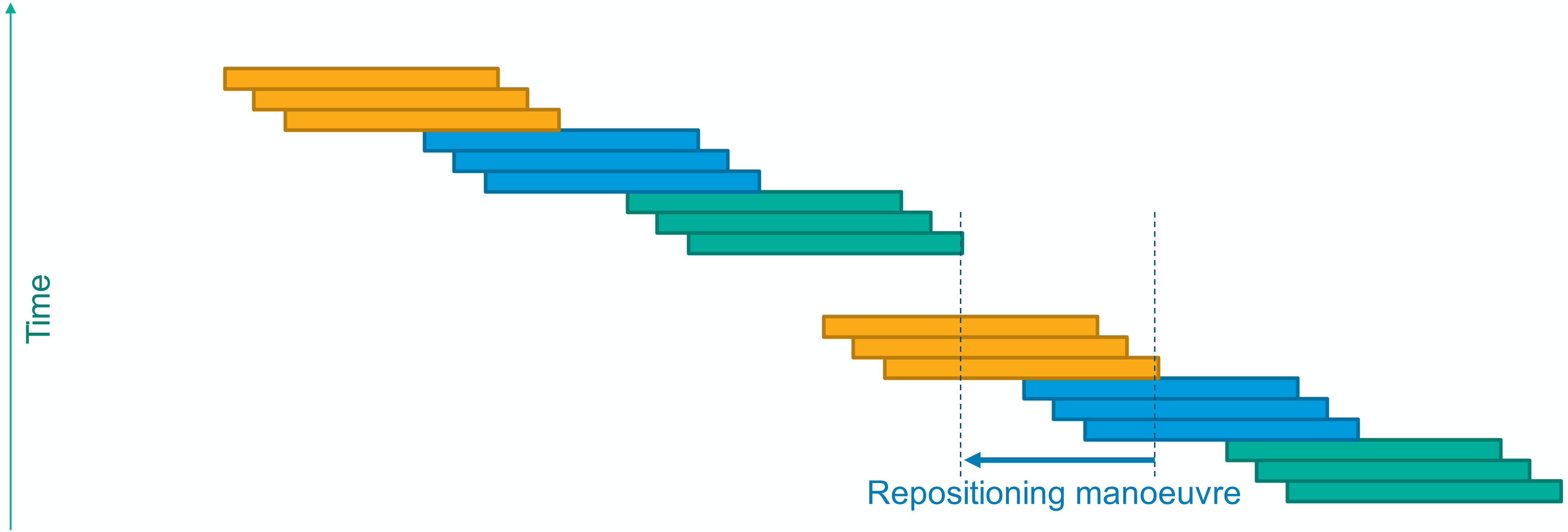
Satellite repositioning manoeuvre

But there is a limit to the possible incidence angle of the observations. Thus, at the end of the observations with the 3 swaths, Biomass raises its orbit so that the longitude drift rate increases.

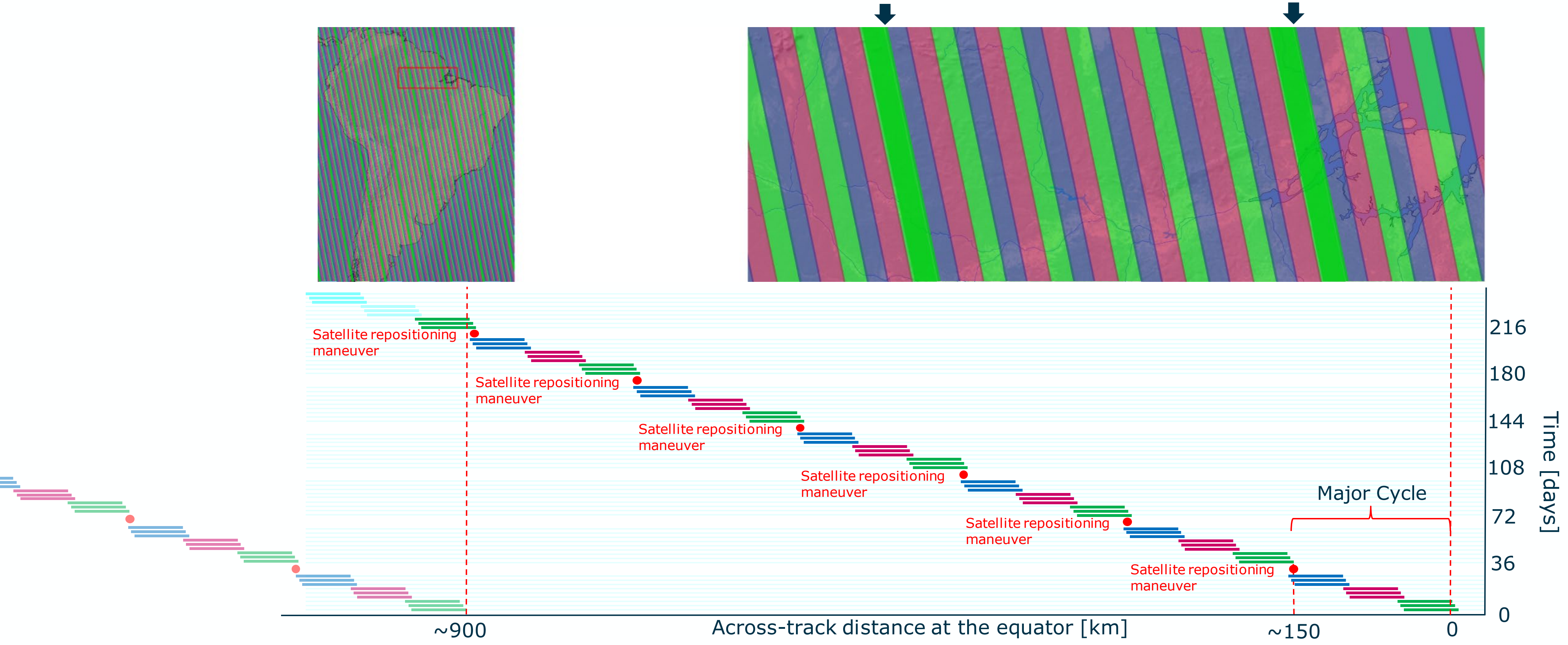


Satellite repositioning manoeuvre

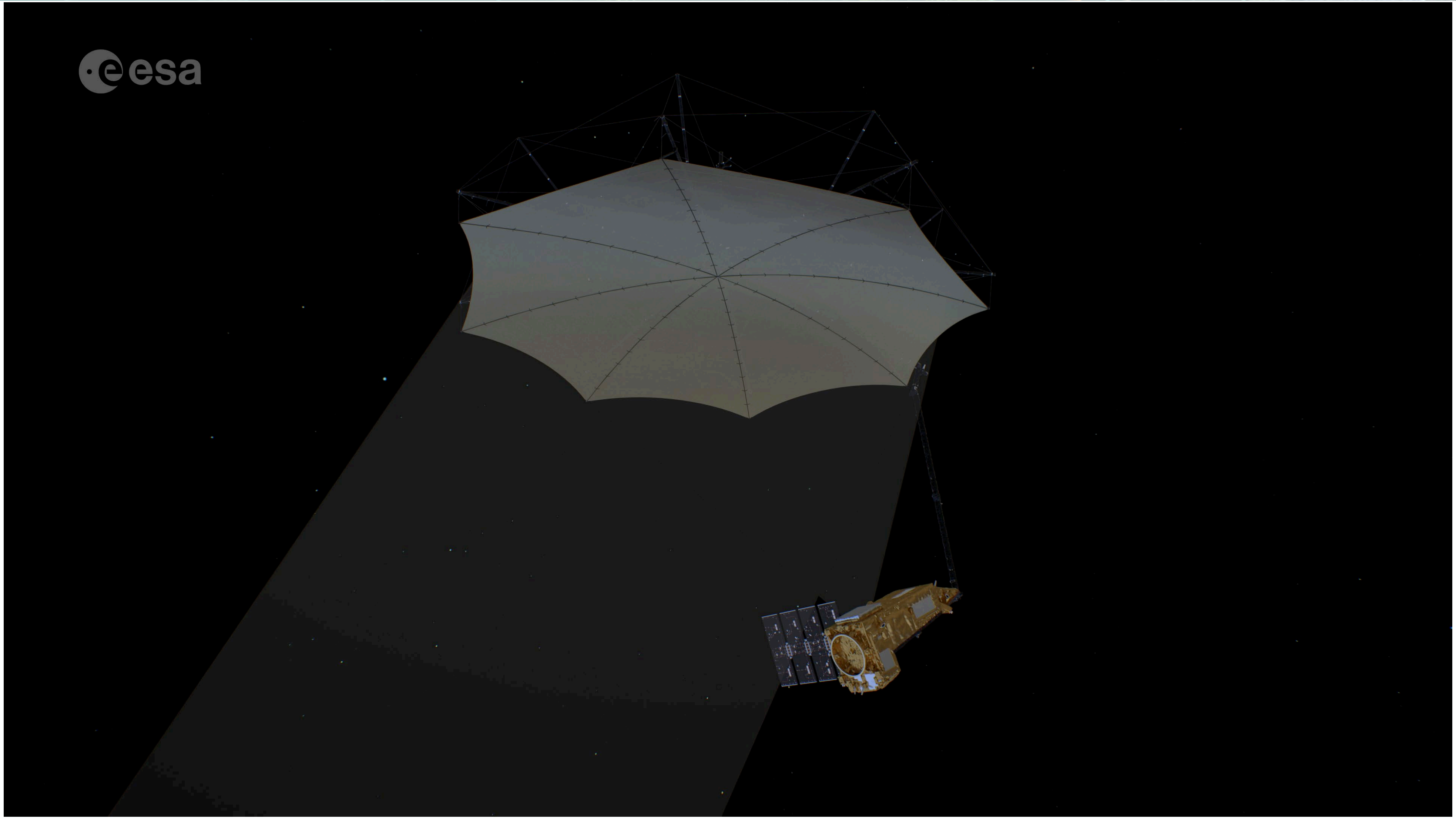
But there is a limit to the possible incidence angle of the observations. Thus, at the end of the observations with the 3 swaths, Biomass raises its orbit so that the longitude drift rate increases.
Once the drift is sufficient, the spacecraft returns to its nominal orbit and a new cycle begins.



Putting the pieces together

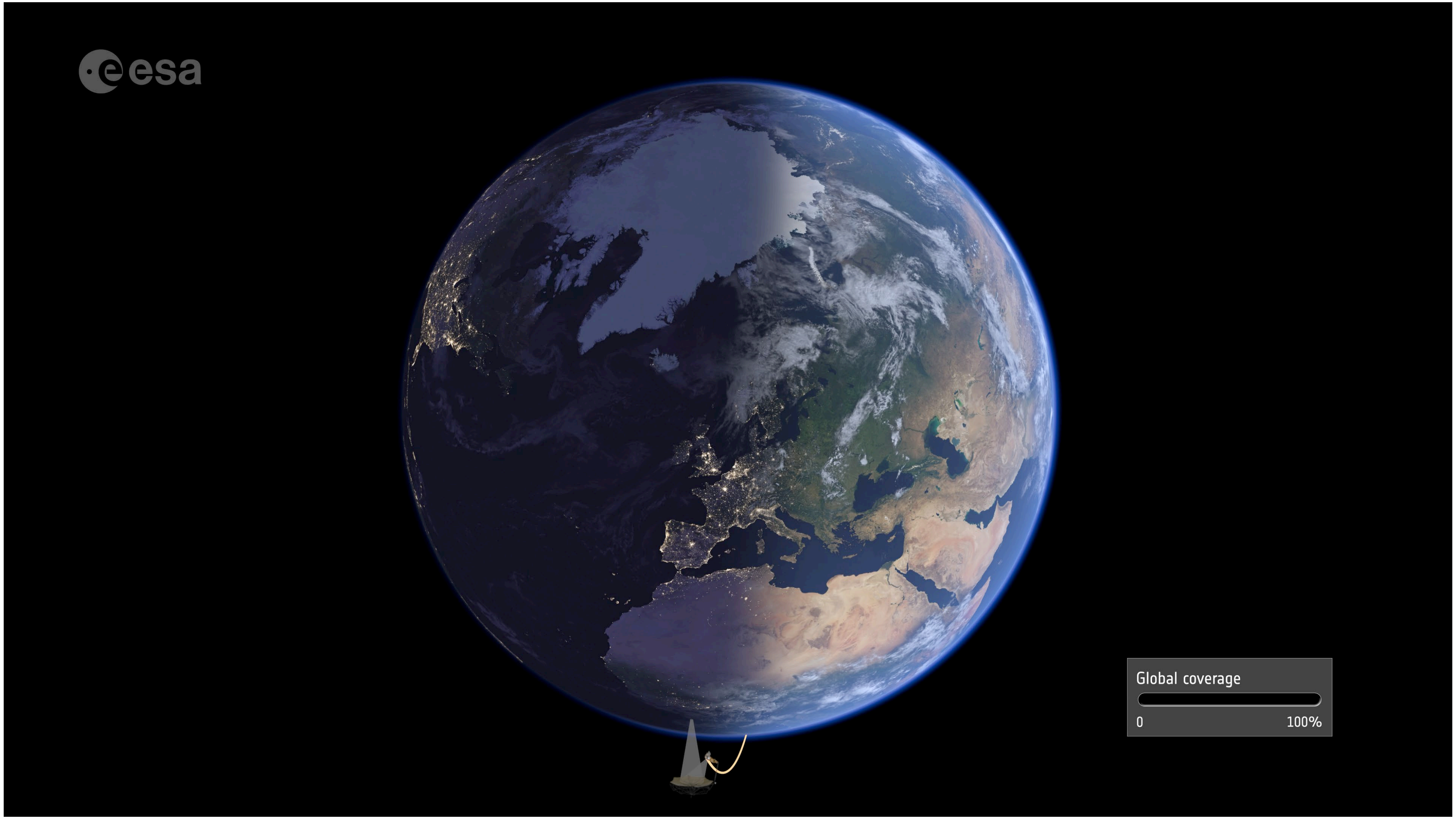


As a video is worth more than a thousand words...



https://www.esa.int/ESA_Multimedia/Missions/Biomass/

Polar coverage



https://www.esa.int/ESA_Multimedia/Missions/Biomass/

Ground Segment Overview

The Ground Segment is composed of the major elements:

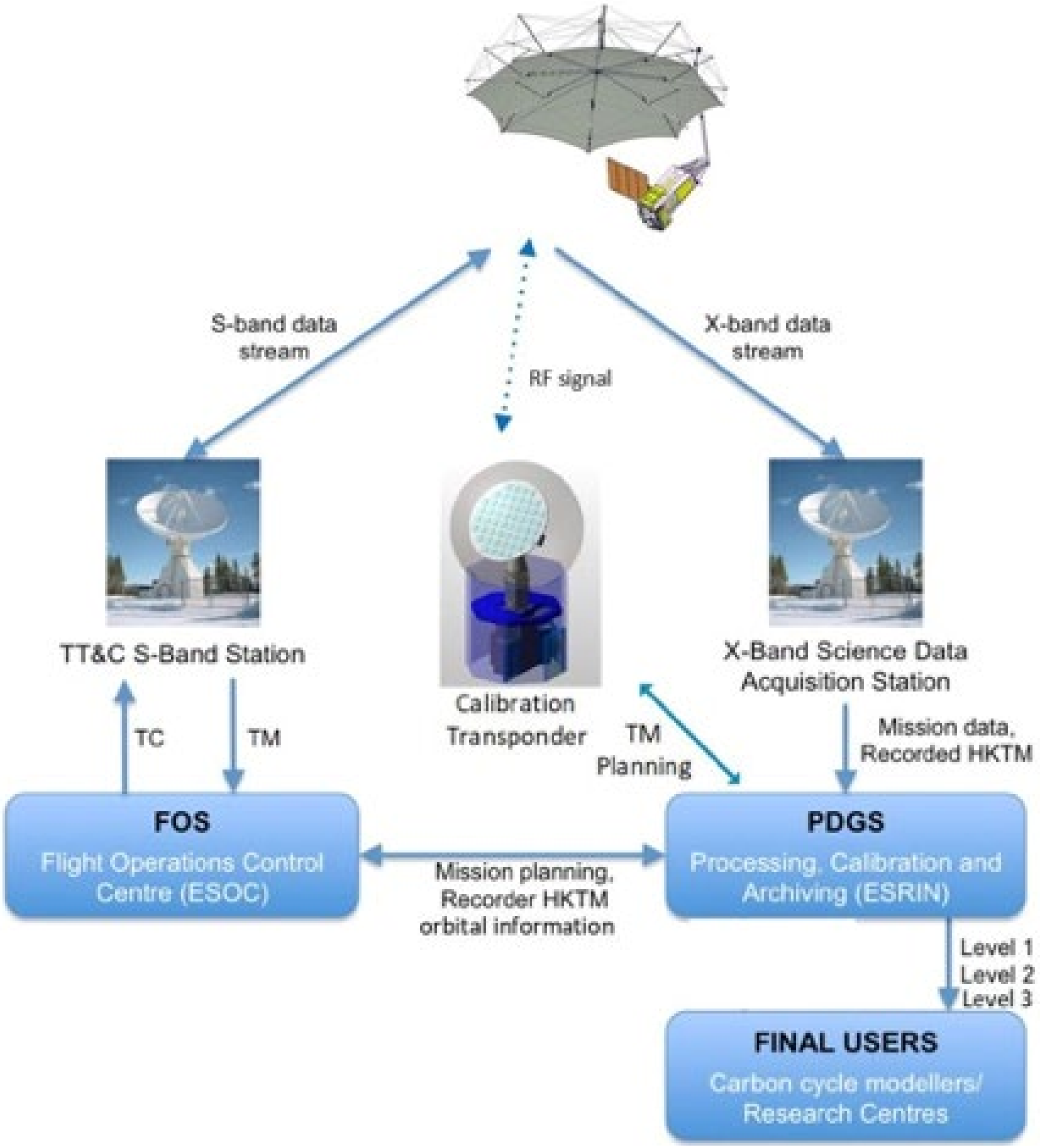
Flight operation segment / FOS
monitoring and operating the Biomass mission:

- TMTC communication with the spacecraft
- mission planning
- satellite control and status monitoring
- orbit and attitude determination
- on-board software maintenance

Payload Data Ground Segment / PDGS
implementing all science data functions:

- payload and X-band activities planning
- science data / X-band data acquisition
- payload data processing, quality control, archiving
- provision of data access and user services

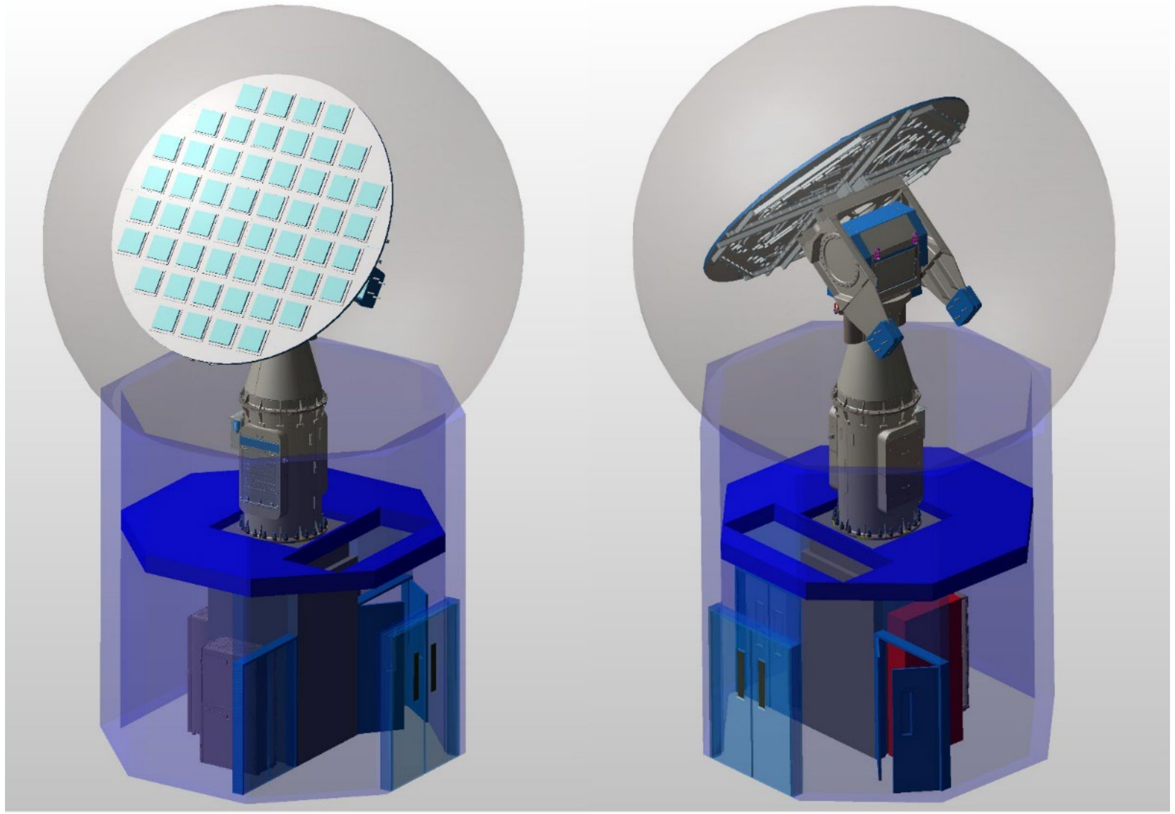
Biomass Calibration Transponder / BCT
- located in Western Australia, ESA's New Norcia Site
- Antenna diameter: 4.9 m



Polarimetric Active Radar Calibrator (PARC)

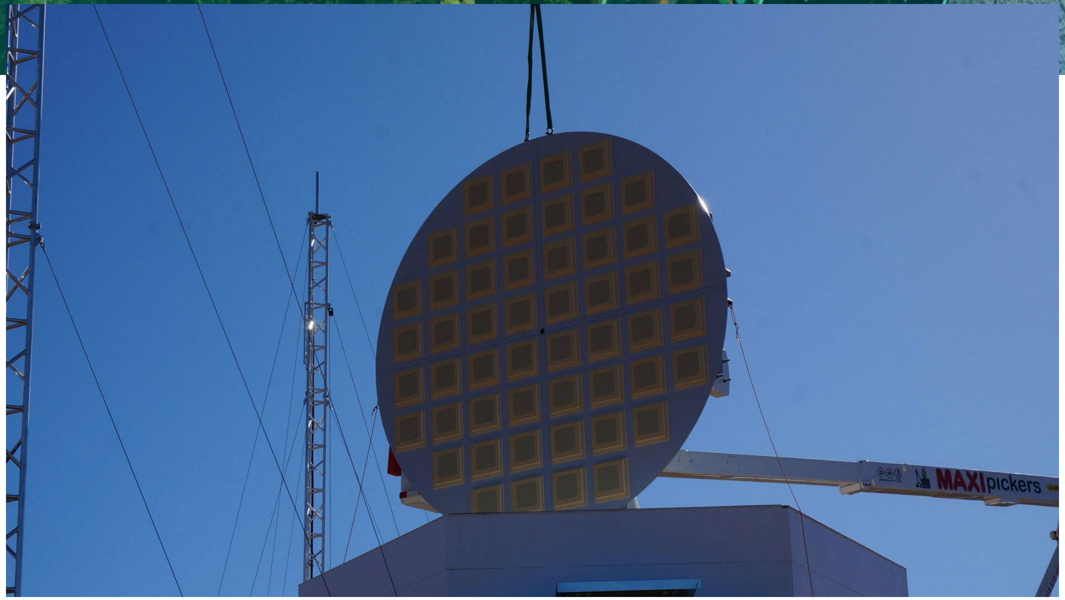
- first of its kind active, fully polarimetric P-band transponder, four independent polarimetric signature matrices
- satellite tracking in Azimuth/Elevation: ensure consistent measurements with maximum transponder antenna gain
- control & microwave sub-system including microwave sub-system, digital sub-system
- transponder calibration sub-system, supporting the transponder external calibration

Feature	Description
Antenna design	2D array with a 4.8 diameter. 4 quarter composed by 13 patches each (10 active)
Antenna Beam	12 deg HPBW. Gain 22.7 dBi
Simulated RCS	85 dB(m^2) with an uncertainty < 0.2 dB (1σ)
Gain stability	< 0.1 dB (1σ) over the entire mission lifetime
Sensitivity	Capability to detect PFD > -90 dBm/m^2
Cross-Polar isolation	< 40 dB (1-way) in both Tx and Rx
Channel Imbalance	< 0.1 dB (1σ) in amplitude and < 0.77 deg (1σ) in phase, including the antenna (2-way)
Signal to Multipath Ratio	> 43.5 dB
Steering	Azimuth and Elevation. Biomass tracked during the overpass
Absolute pointing error	< 0.5 deg (3σ) azimuth and elevation combined
Calibration	Internal calibration network (I-CAL) + External calibration disk with a known RCS (Ex-CAL)
Operational Modes	3 operational modes that can be run in any combination (details in the next slide)

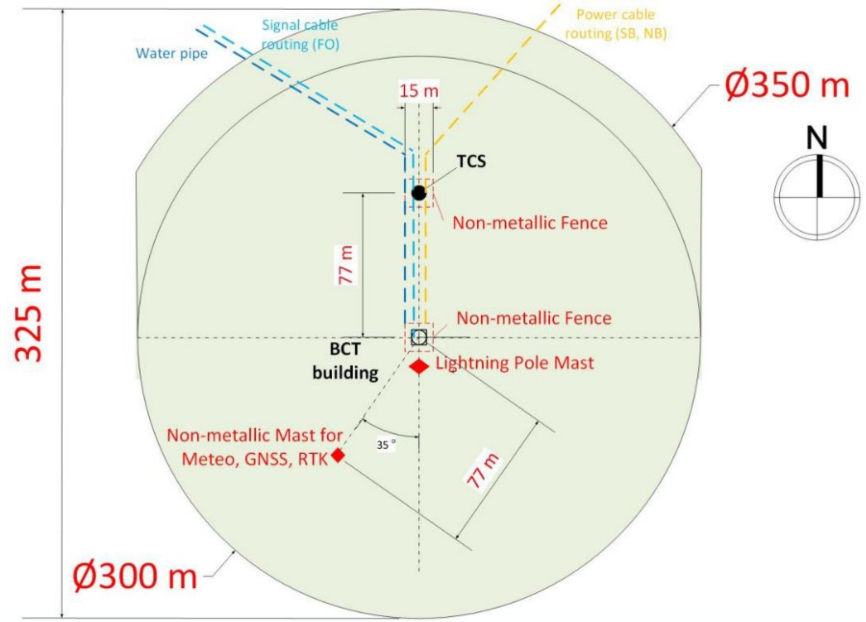


Courtesy of C-CORE

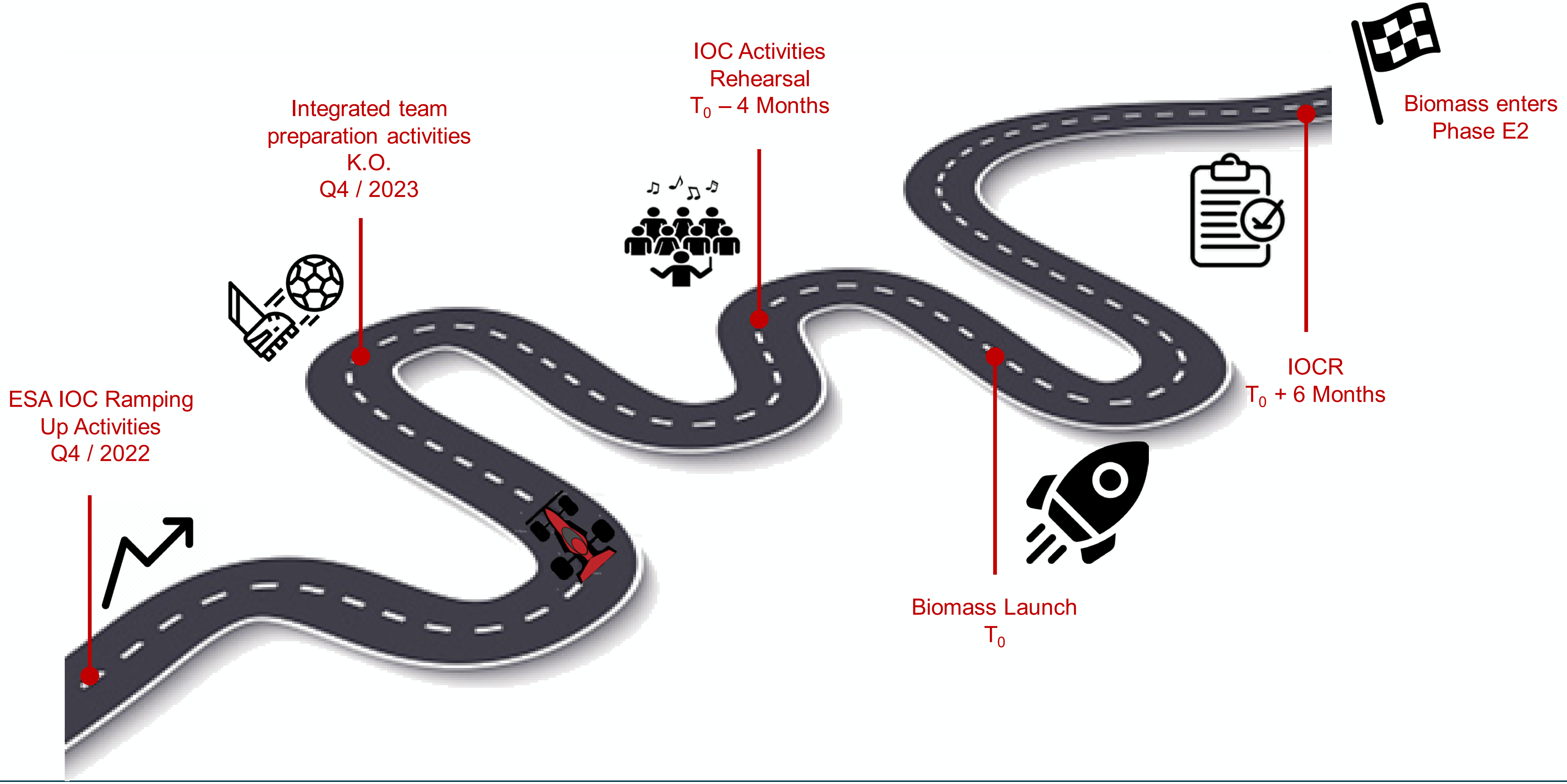
PARC deployment



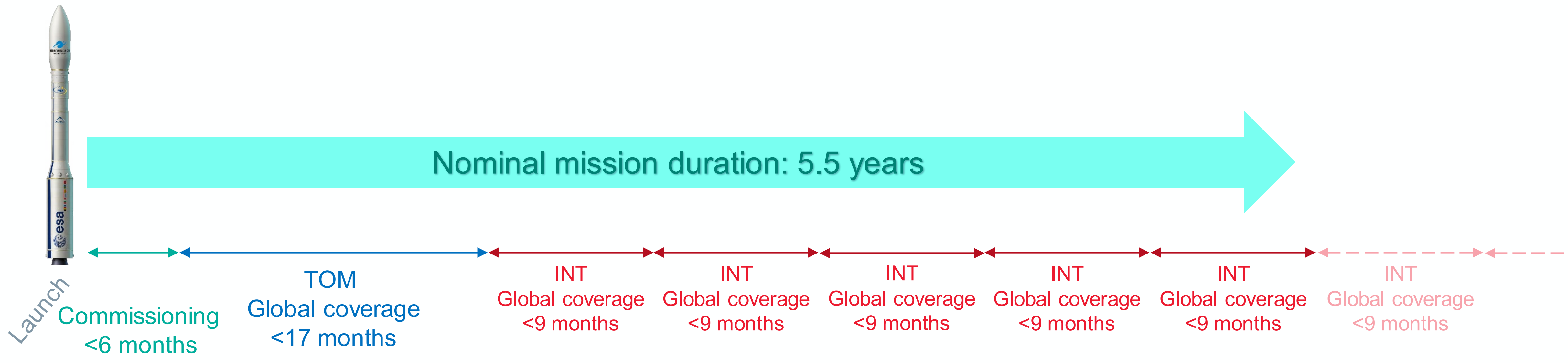
Courtesy of Airbus UK and C-CORE



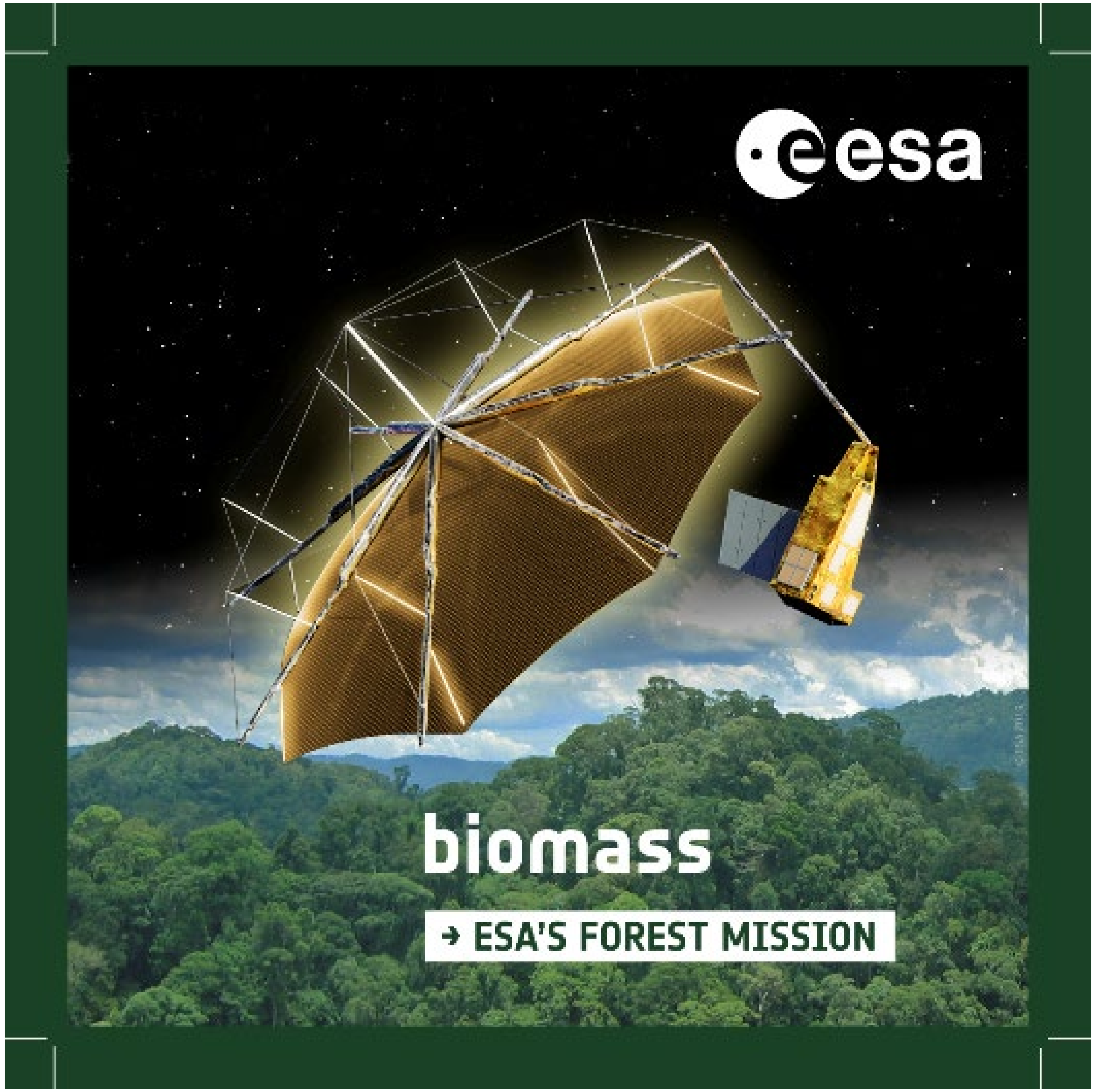
The road to Phase E2: Biomass' exploitation phase



Mission timeline



Artist's impression vs. real hardware



The fully assembled satellite on the shaker in January 2023

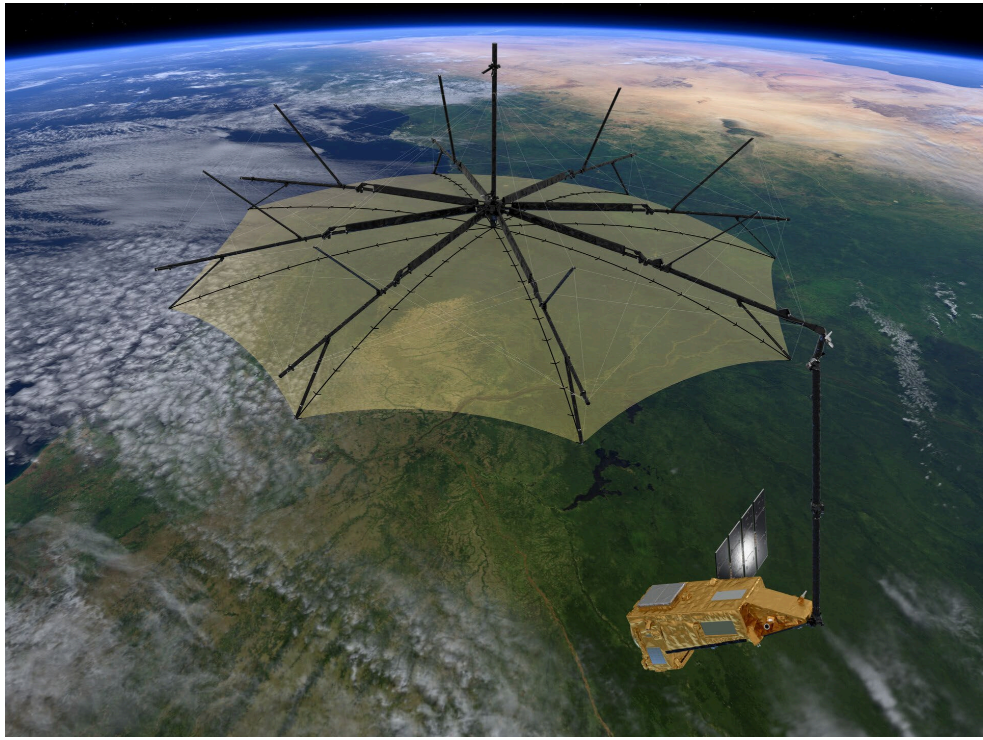
Biomass Assembly, Integration & Testing

Outlook

Open issues:

- Biomass has recently been moved from VEGA to VEGA-C
- Late delivery of Power Amplifier Subsystem

> ➢ Satellite passed part of the final environmental test campaign
> ➢ All other remaining work is off the critical path



Key upcoming milestones:

- Power Amplifier Subsystem PFM available: **December** 2023
  - Missing element for instrument completion
  - Duration to launch readiness is 10-12 months
- Continuation of environmental test campaign (TBTV, EMC etc): **Q2 2024**
- QAR start: **August/September 2024**
- **Launch Readiness: Q4 2024**

Announcement BioGeoSAR-2023

8th International Workshop on
Retrieval of Bio- & Geo-physical Parameters from SAR Data for Land Applications
Rome, Italy 15-17 November 2023

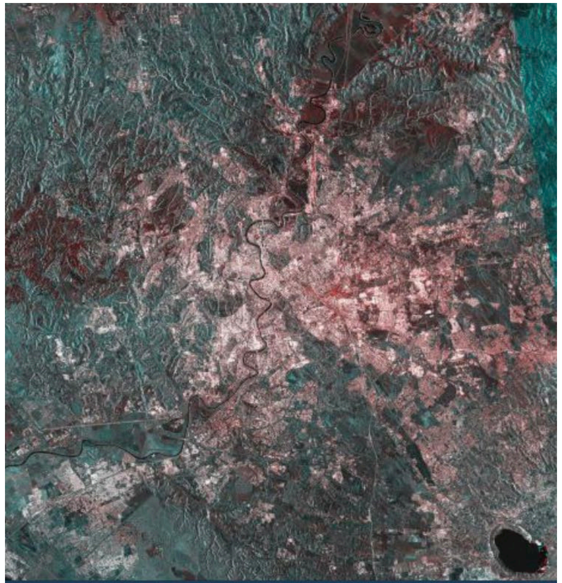
SAPIENZA
UNIVERSITÀ DI ROMA

Organised around the following main themes:

- *Land-use and classification*
- *Agriculture*
- *Soil and hydrology*
- *Forestry*
- *Ice and snow*

Abstract submission closing 18 September

http://biogeosar.esa.int



ANNOUNCEMENTS AND CALL FOR ABSTRACTS

Abstract submission opening	**July 2023**
Abstract submission closure	**18 September 2023**
Notification of acceptance	**October 2023**
Registration opening	**July 2023**
Issue of preliminary programme	**October 2023**
Issue of final programme	**at the workshop**
Workshop dates	**15–17 November 2023**

REGISTRATION AND ABSTRACT SUBMISSION

Further information and guidelines regarding the registration and abstract submission can be found on the workshop website at :

http://biogeosar.esa.int