Biomass, a polarimetric interferometric P-band SAR mission

M. Arcioni, P. Bensi, M. Fehringer, F. Fois, F. Heliere, N. Miranda, K. Scipal

Fringe 2015, ESRIN

27/03/2015

The Biomass Mission

1. Biomass was selected as ESA's 7th Earth Explorer and will be launched in 2020

2. Biomass' primary objectives:
   a. Measure biomass
   b. Measure forest height
   c. Measure forest disturbance

Secondary objectives:
a. Subsurface geology mapping
b. Ice flow measurement

3. **BUT Biomass applications will go beyond biomass**
   a. **Full polarimteric SAR**
   b. **Interferometric orbit**
   c. **Tomographic mission phase**

Design Drivers

- Cover high biomass forest
- Single Satellite Mission (repeat pass interferometry)

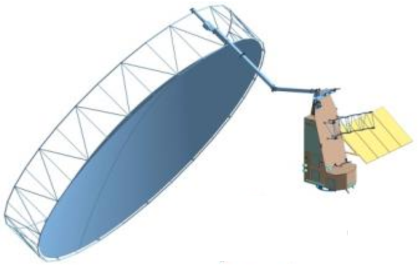
→ Low frequency **435MHz (**~69 cm**):**
  - for PolSAR sensitivity to high biomass
  - for high POLINSAR coherence.

→ Large swath (coverage)

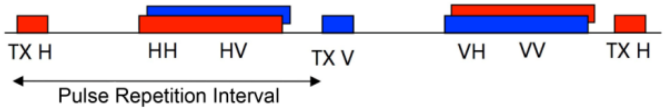
→ Good performance isolation, resolution, ambiguity

→ Large antenna (11m-12m)

→ Vega compatible



SPACE SEGMENT
Single Spacecraft
Mass: ~1200 kg
Power: ~1500 W



- Full polarimetric mode of operation
- Interferometry

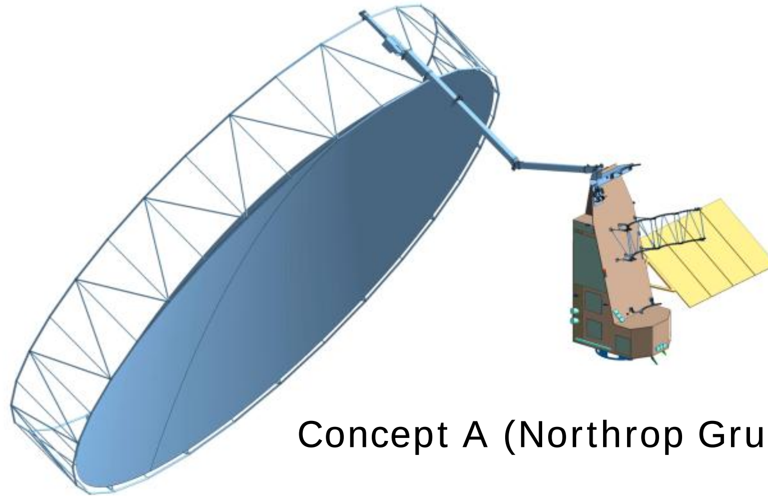
→ **Stripmap mode, satellite roll for beam repointing**

→ Radiometric stability, bias

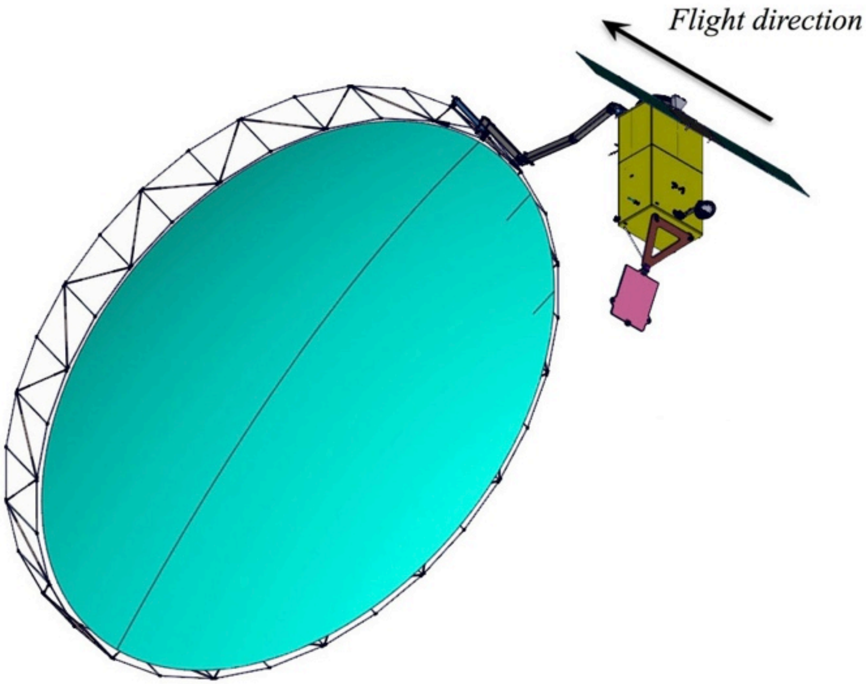
→ **Calibration (internal and external calibration)**

The Biomass Mission – Sat. configuration

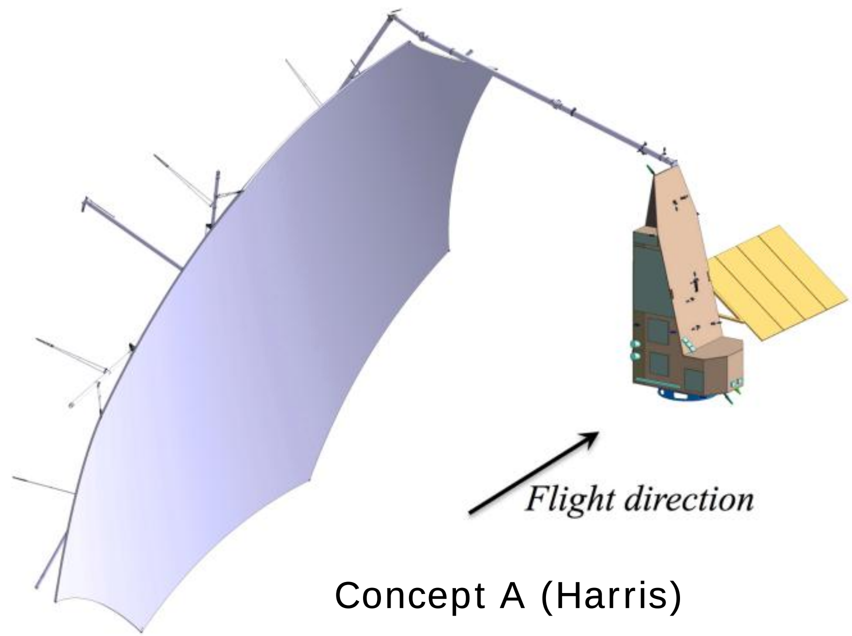
1. Fully polarimetric P-band SAR
2. Interferometric Orbit
3. Tomographic Phase
4. Systematic global acquisitions
5. Launch 2020



Concept A (Northrop Grumman)



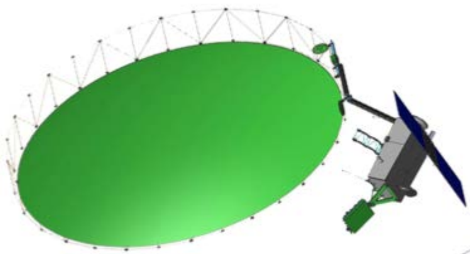
Concept B (Northrop Grumman)

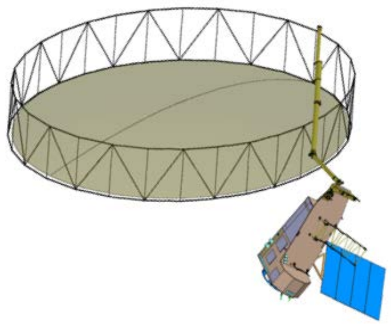


Concept A (Harris)

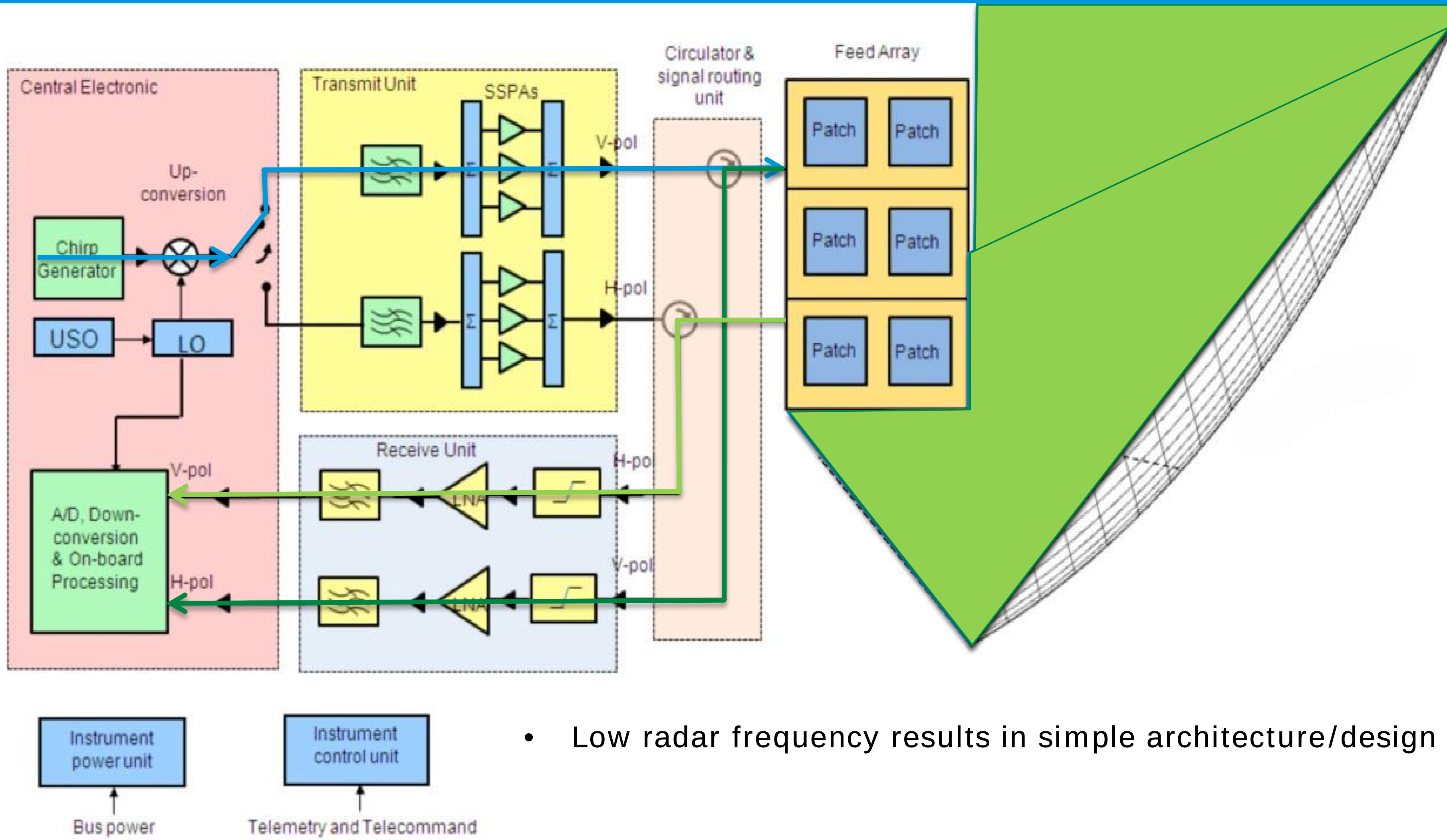
BIOMASS Requirements

Parameter	Requirement
Instrument type	P-band full polarimetric SAR
Centre frequency	435 MHz (P-band)
Bandwidth	6 MHz (max ITU allocation)
Incidence angle (near)	Threshold: 23°; Target: 25°
Cross-talk	≤ -30 dB
Spatial res. (≥ 6 looks)	≤ 60 x 50 m (range x azimuth)
Noise equivalent $\sigma 0$	≤ –27 dB
Total ambiguity ratio	≤ -18 dB
Radiometric stability	0.5 dB RMS
Abs. radiometric bias	1.0 dB
Dynamic range	35 dB





Payload Functional Architecture



- Low radar frequency results in simple architecture/design

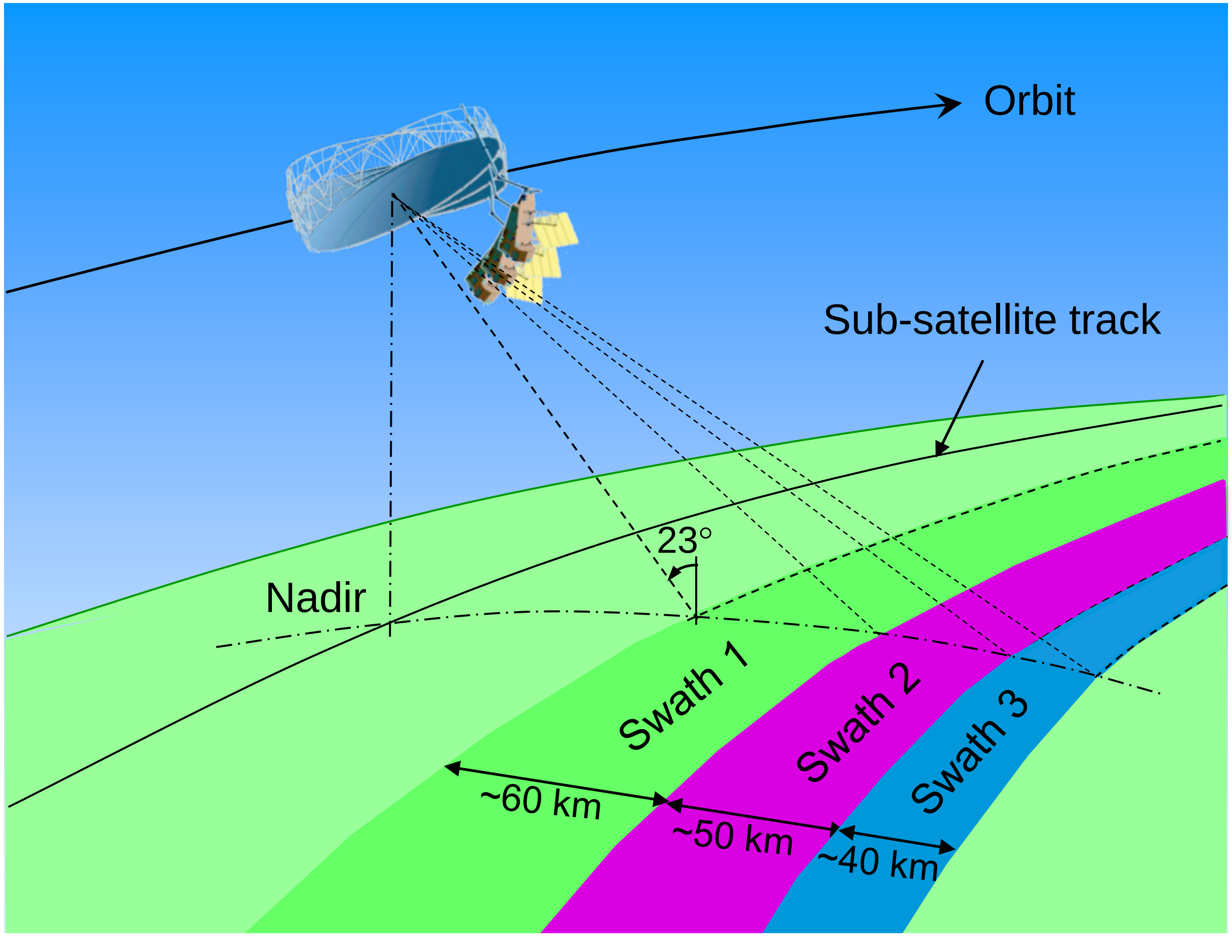
Simple Stripmap Acquisition Mode

Biomass features a single acquisition mode:

- Stripmap mode with a single antenna beam

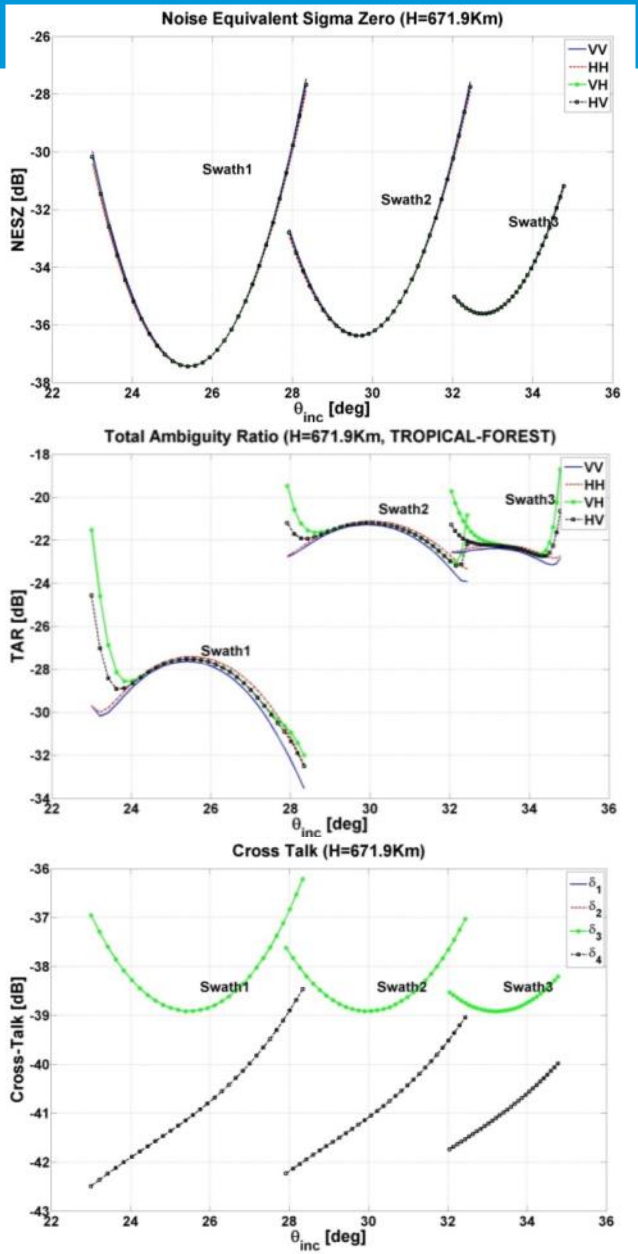
Gap-less global coverage requires beam steering capacity:

- Satellite roll for beam repointing
- Total swath access of 150km



System performance at Level 1B

Key Parameters	Requirement	Concepts A and B
Sensitivity (NESZ)	≤ -27 dB	≤ -27 dB ✔
Total Ambiguity Ratio	≤ -18 dB	≤ -18 dB ✔
Geometric Resolution	≤ 60m x 50m	≤ 60m x 50m ✔
Effective Number of Looks	≥ 6	≥ 6 ✔
Radiometric Stability	≤ 0.5 dB	≤ 0.35 dB ✔
Absolute Radiometric Bias	≤ 1.0 dB	≤ 0.45 dB ✔
Crosstalk	≤ -30 dB	≤ -30 dB ✔
Dynamic Range	35 dB	35 dB ✔



Calibration approach

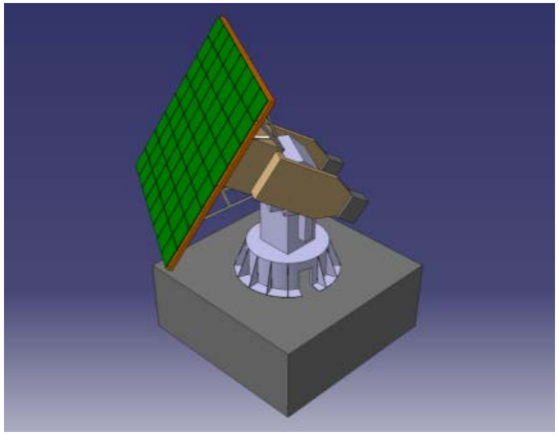
Achievement of the radiometric performance requirements is ensured by:

- *On-ground characterisation* of the Biomass payload prior to launch
- *Internal calibration* to monitor the power level and gain of the radar electronics
- *External calibration* using transponders for the characterisation of the end-to-end radar measurement chain

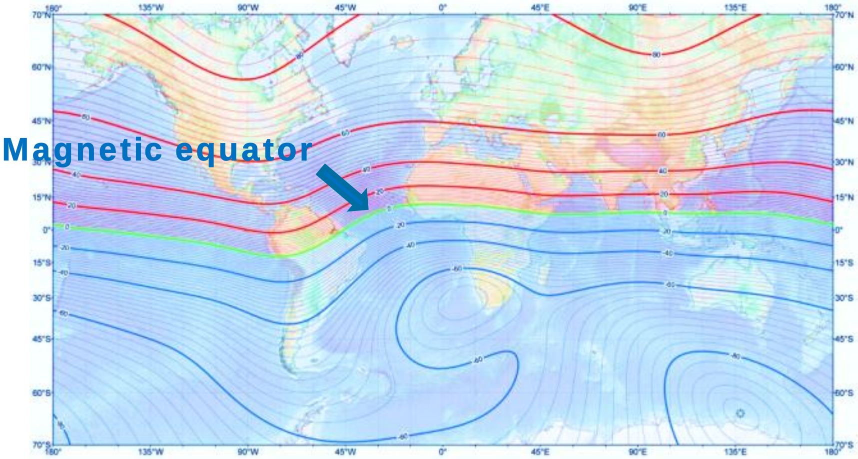
Transponder concept:

- Polarimetric with a single 4 m × 4 m planar antenna (re-generative with time-delays), mechanical satellite tracking, receive function and polarisation agility

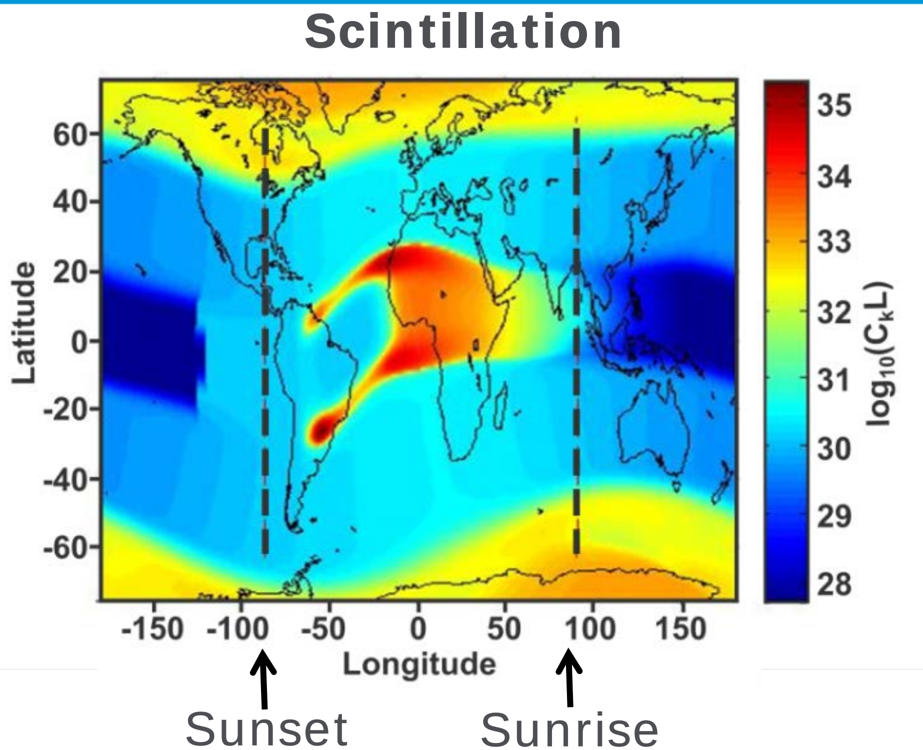
One transponders placed on the magnetic equator and one at higher latitudes



Transponder concept



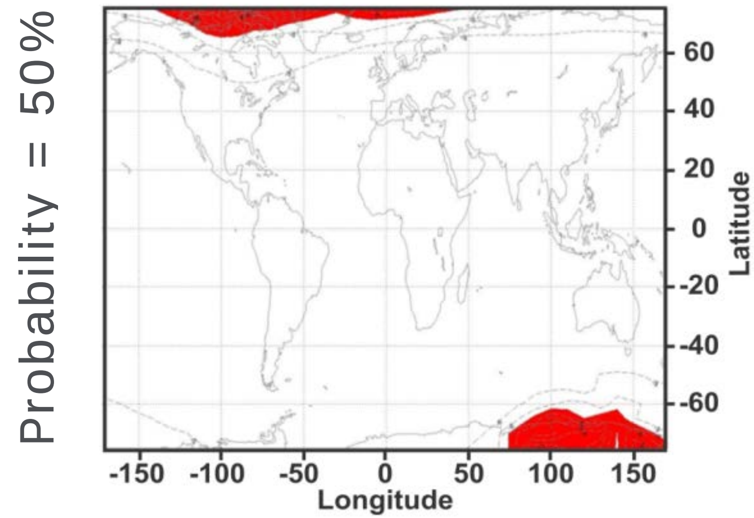
Ionosphere Impact: Scintillations



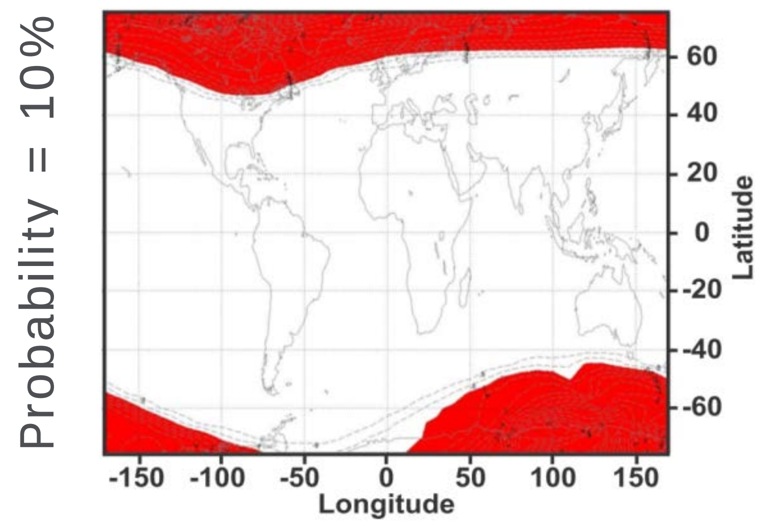
Scintillation causing defocussing, loss of contrast and phase disturbance

The dawn-dusk orbit avoids the severe equatorial conditions, but not the auroral zone.

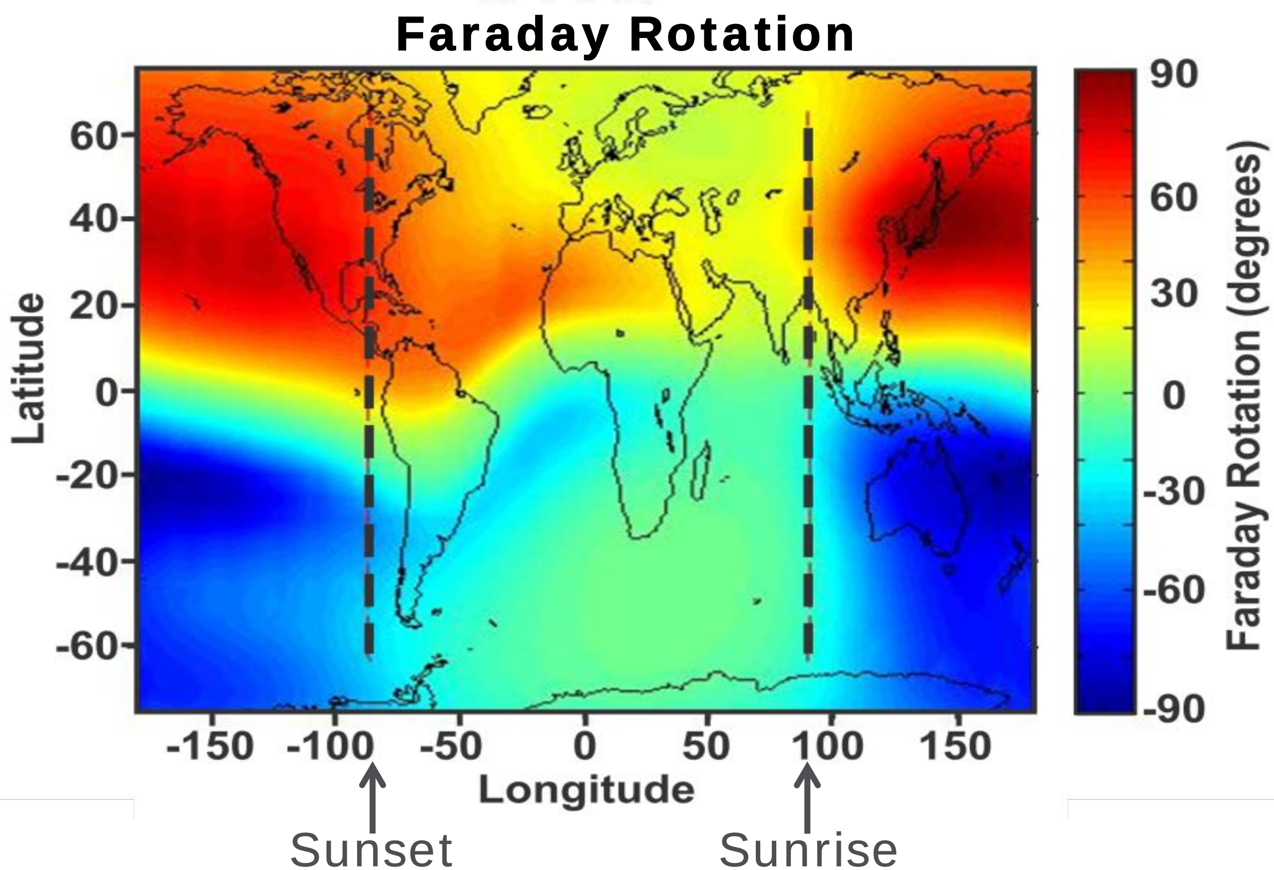
Correction of moderate scintillation is foreseen at several level



Degradation region, median solar conditions

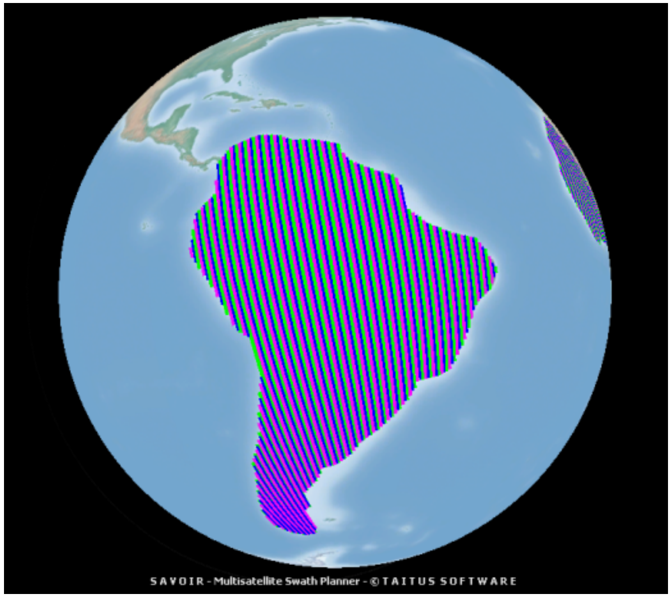


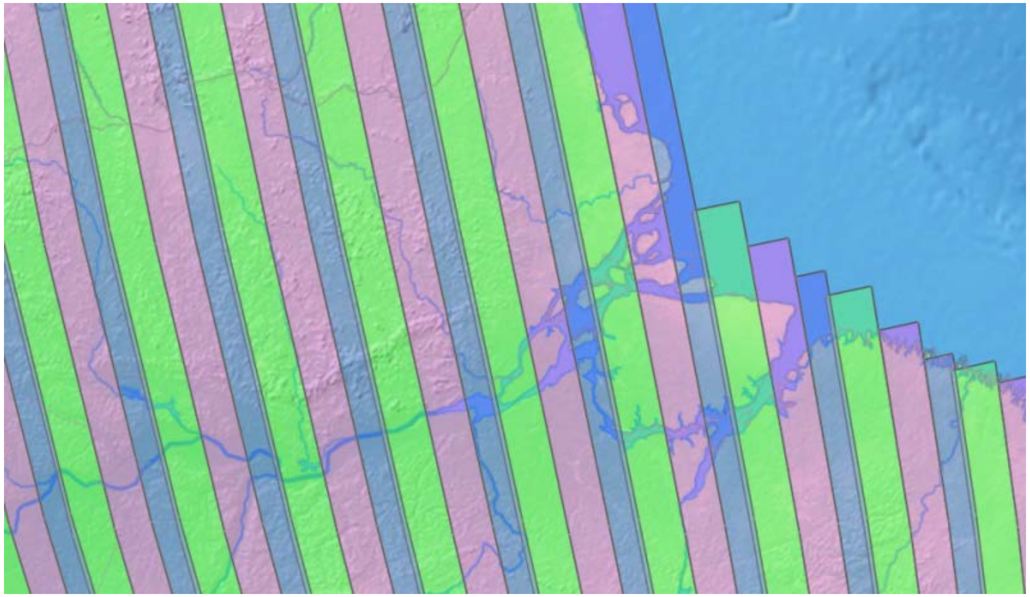
Ionosphere Impact: Faraday rotation

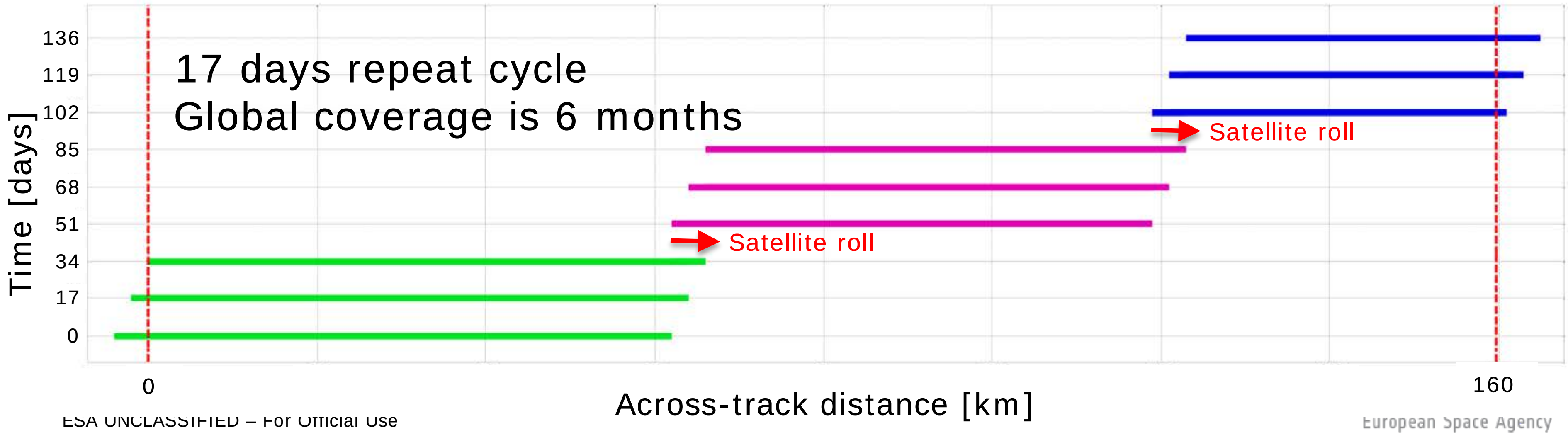


- Faraday rotation corrupts polarimetry
- Can be corrected to better than 1º using the Biomass polarimetric data themselves
- Total Electron Content is measured, allowing Biomass to measure ionospheric structure

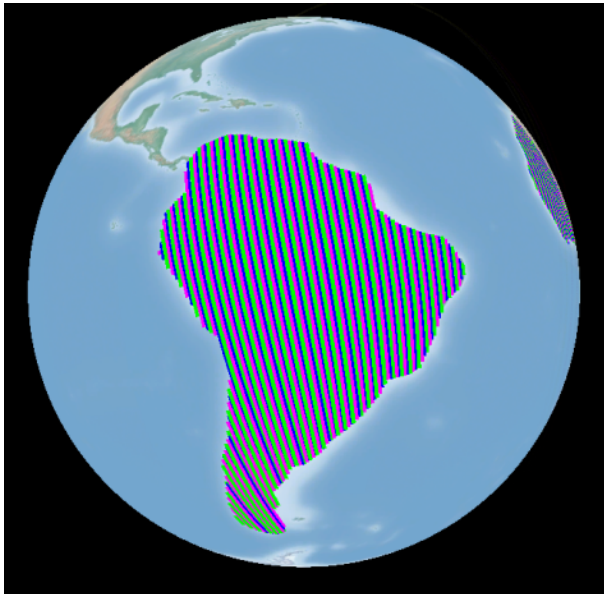
Coverage Strategy (Interferometry phase)

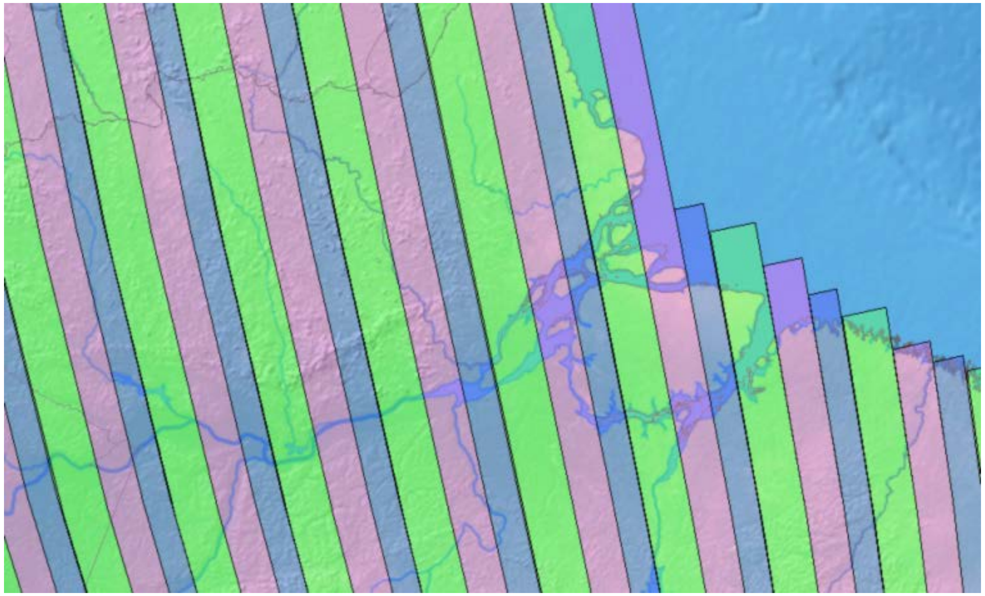


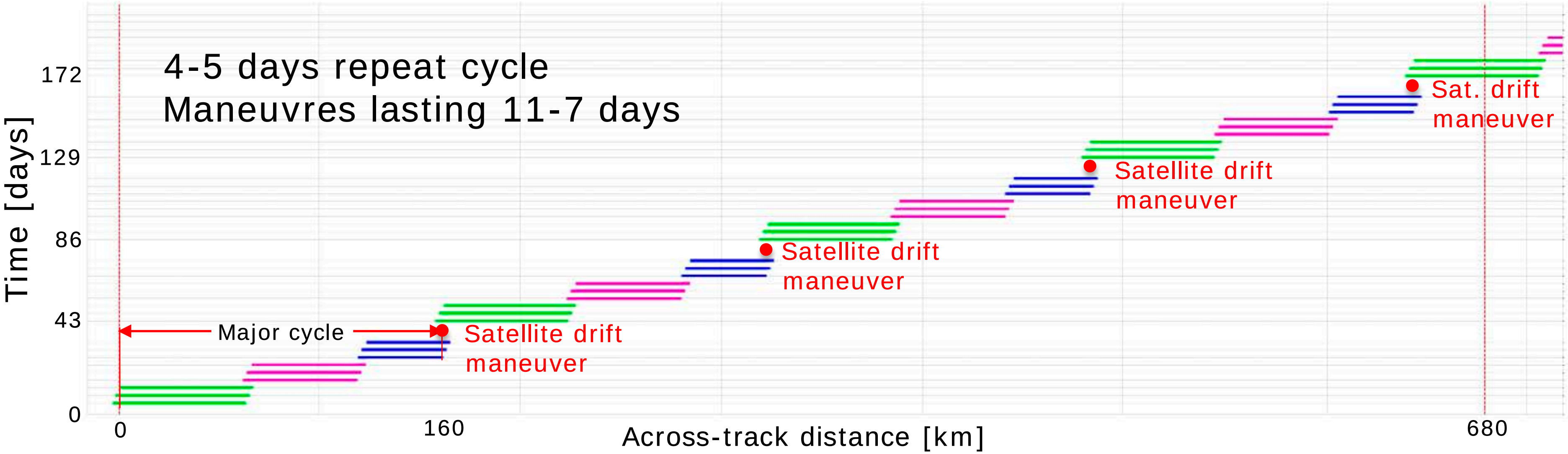




Reducing the repeat cycle time

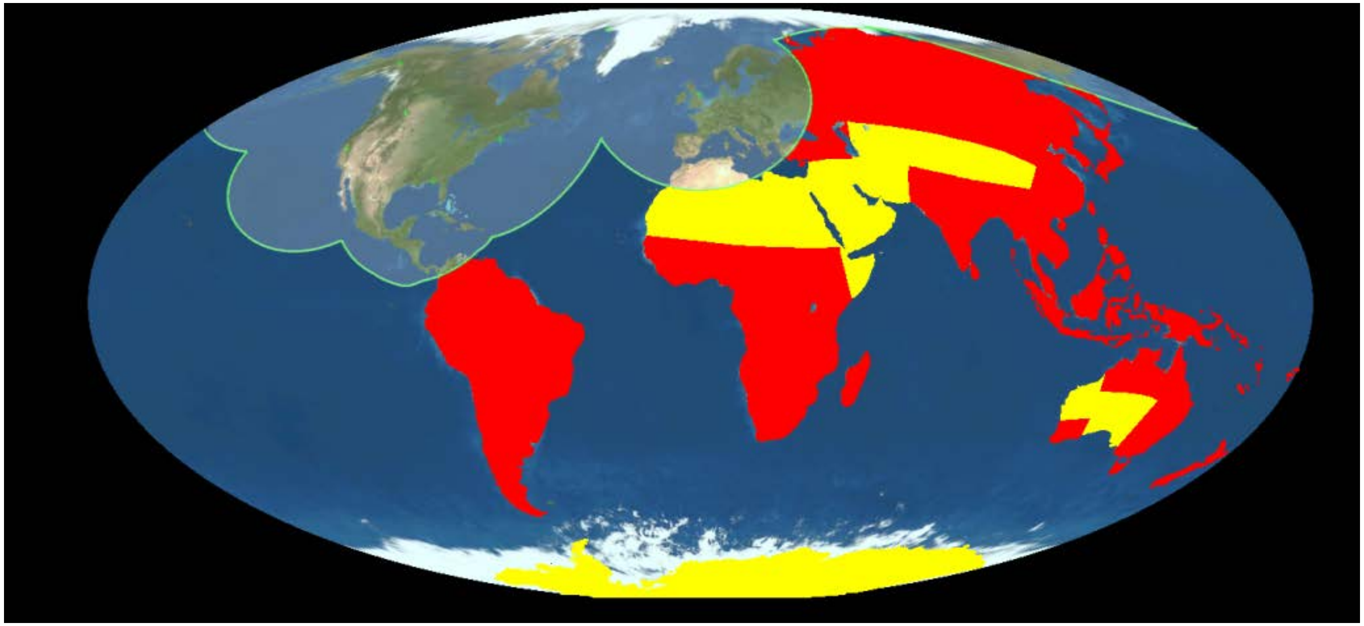






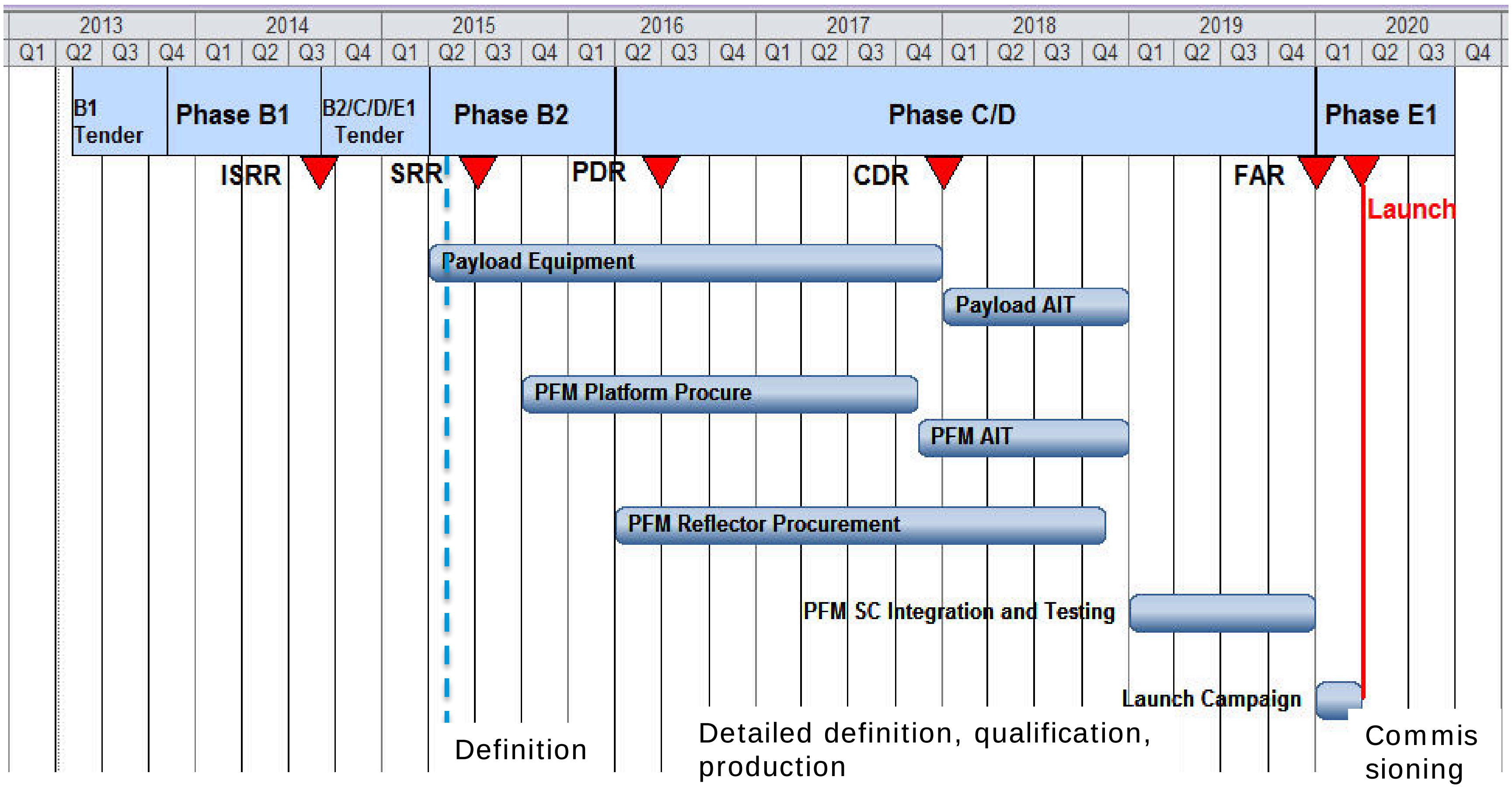
Coverage

1. Acquisition mask restricted by US Space Objects Tracking Radar (SOTR)
2. Systematic Pre-Programmed Acquisitions (for red areas), yellow areas will be acquired on a best effort basis.
3. Complete coverage in both ascending and descending passes
4. Two mission phases:
   - **TOM** Tomography with 7 acquisitions for a given location (1st year)
   - **INT** Interferometry with 3 acquisitions for a given location (2nd-5th year)



(Red = Primary objective coverage mask, Yellow = Secondary objective coverage mask)

Biomass development schedule



Summary

1. Biomass is the first P-band and first radar tomographic space mission; it is a true Earth Explorer.

2. The new unique vision of the Earth from Biomass will extend beyond forests.

3. Large potential for interferometric applications.

4. Issues to be considered:
    a. Ionosphere
    b. Low bandwidth of 6 MHz

Backup

Example: Biomass Exploitation Platform → *a very preliminary approach*

L1 → L2 → L3
ESA source codes
Other L2 & L3 algos

Specific handling tools

etc...

Biomass MAG major involvement in Phase B/C/D

Institutional infrastructures
Commercial ICT providers

Biomass Exploitation platform

EO software	ICT resources	EO data In-situ data

Biomass mission community

Biomass mission data (ph. E/F)

Other SAR data (test sites):
- ERS/Envisat SAR
- Sentinel-1
- ALOS PALSAR
- Radarsat 1/2
- SAOCOM

Campaigns data
- e.g. AfriScat, TropiScat

In-situ data:
- To be defined

Concept to be further elaborated for Biomass mission during 2015