The ESA BIOMASS Mission

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Credit: AOES Medialab

Presentation Outline

- The ESA Observation program
- The BIOMASS mission
  - Scientific Objectives
  - Technical concept
  - Support activities
- Synergies with DESDynI
- Conclusions

ESA Earth Explorers

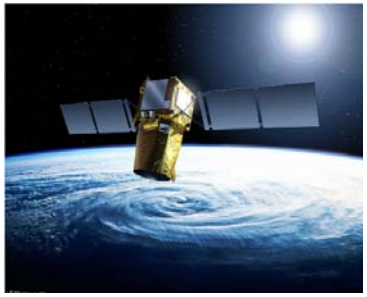
BIOMASS

GOCE

Gravity Field and Steady State Ocean Circulation Explorer

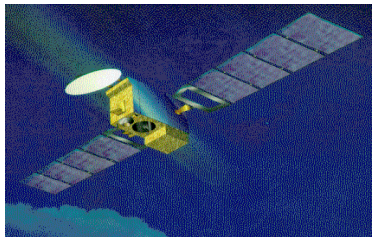
ADM-Aeolus

Atmospheric Dynamics Mission



EarthCARE

Cloud, Aerosols & Radiation Explorer



Earth Explorer 7

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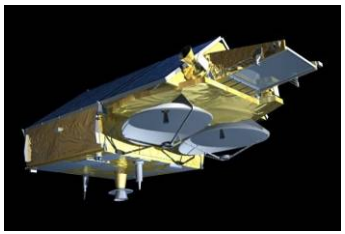
Core

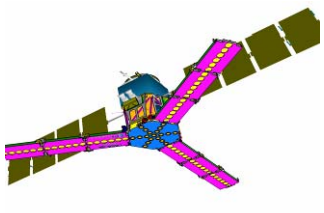
2005 2006 2007 2008 2009 2010 2011 2012 2015

Opportunity



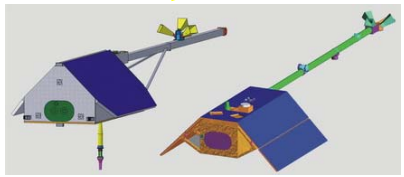
Cryosat 1 & 2

Sea Ice thickness and Ice sheet topography



SMOS

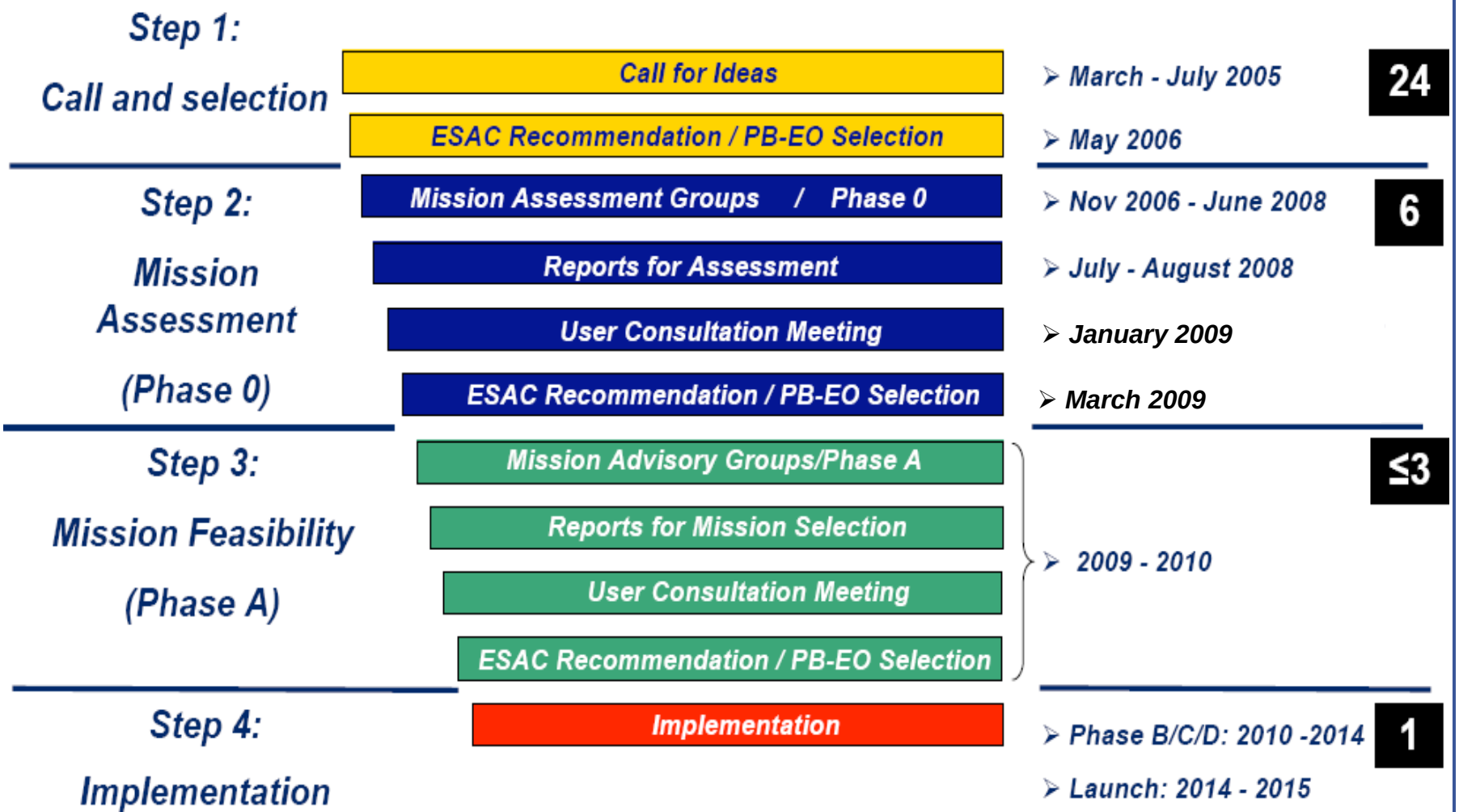
Soil Moisture and Ocean Salinity



Swarm

Geomagnetic field survey

The selection process



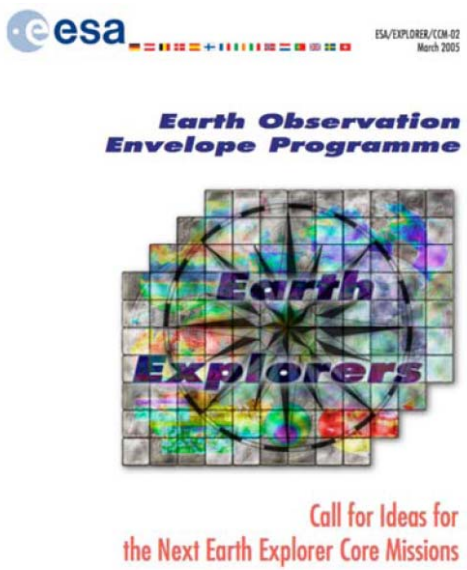
Ceiling Cost Range: 200 - 220 M€ at 2007 e.c.

Excluding ESA internal Cost, Mission Operation Cost and Science Support Activities

The Next Earth Explorer

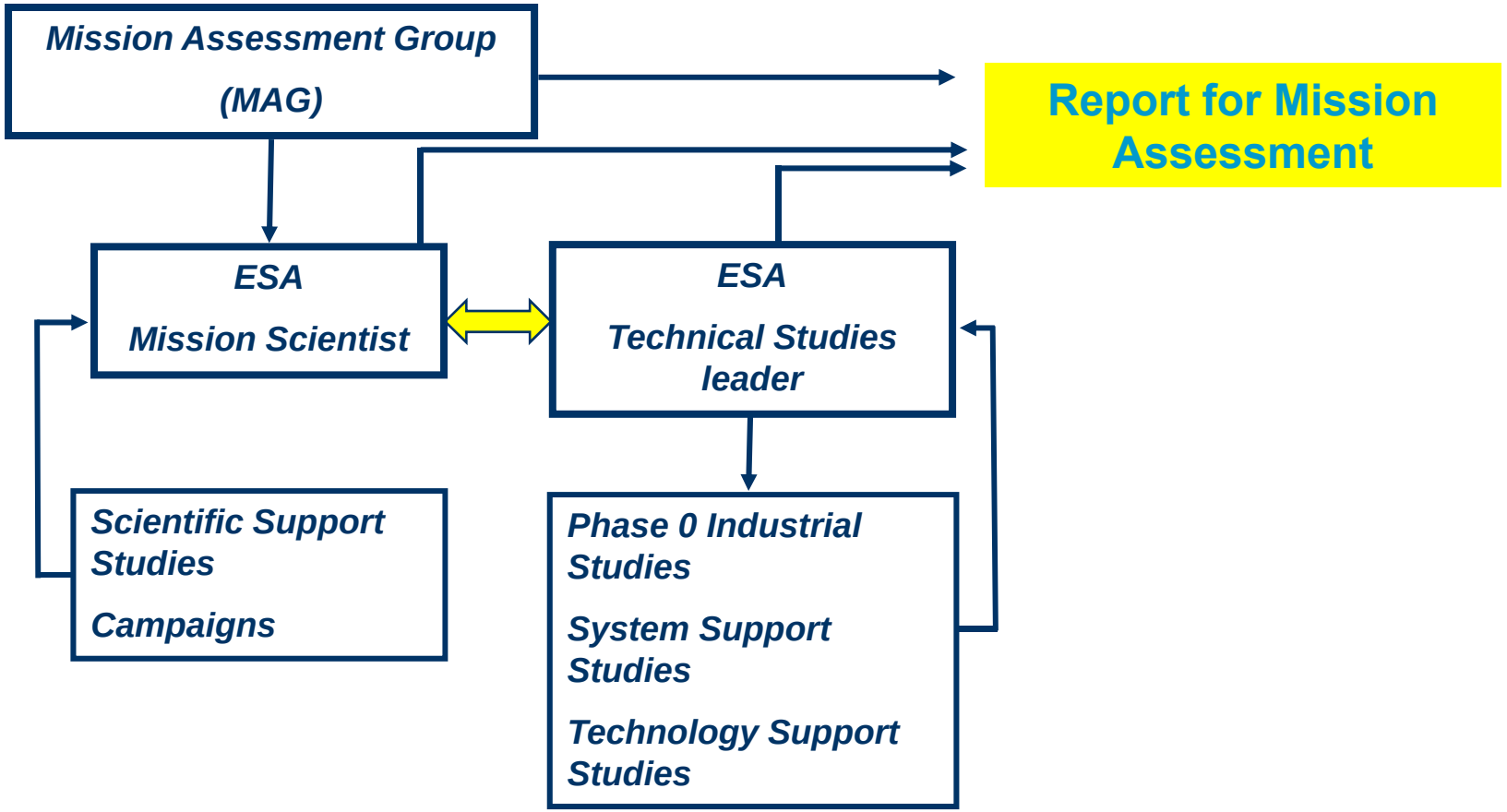
Call for ideas issued in 2005

- Science priorities
  - The Global Water Cycle
  - **The Global Carbon Cycle**
  - Atmospheric Chemistry
  - The Human Element
- 24 proposals evaluated
- 6 Candidate Missions selected for further study
  - **BIOMASS:** BIOMASS Monitoring Mission for Carbon Assessment
  - **TRAQ:** TRopospheric composition and Air Quality
  - **PREMIER:** Process Exploration through Measurements of Infrared and millimeter Emitted Radiation
  - **FLEX:** Fluorescence Explorer
  - **A-SCOPE:** Advanced Space Carbon and Climate Observation of Planet Earth
  - **CoRe-H20:** Cold Regions Hydrology High-resolution Observatory
- Expected launch 2014-2015



BIOMASS Phase-0 Organisation

- Reports for Assessment provide updated mission details (scientific, technical)



Mission Assessment Group

- Mission Assessment Group
  - Help define the scientific objectives
  - Advice on mission concept
  - Support writing of report for assessment
  - Meetings approx. 3 times/year

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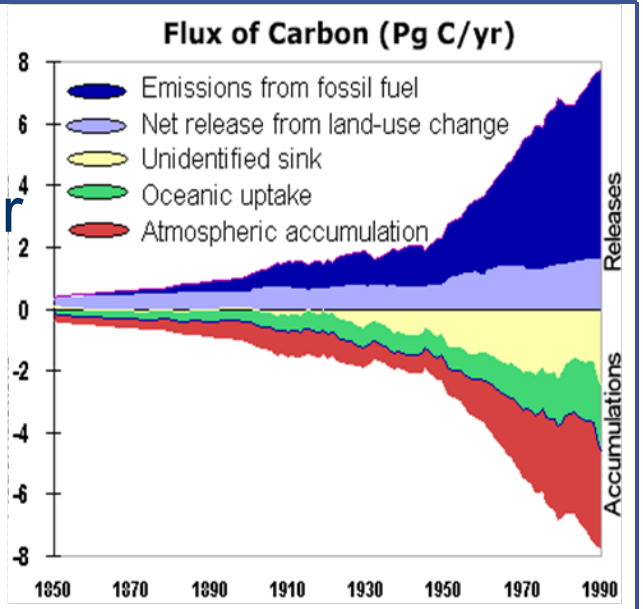
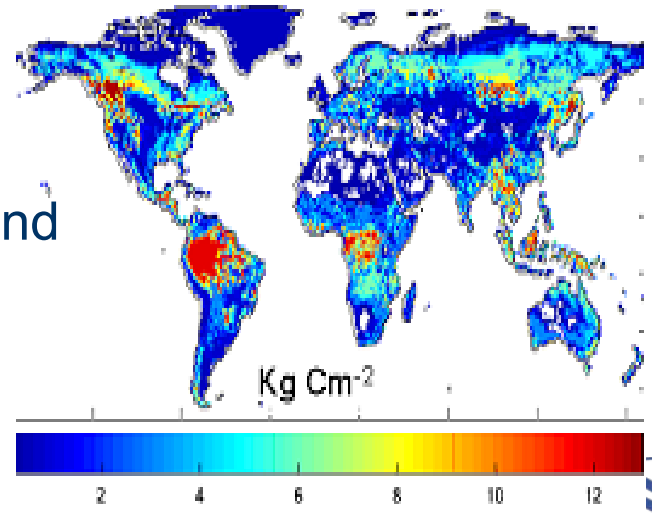
BIOMASS Mission objectives

- Improved understanding and quantification of land contribution to global carbon cycle
  - Quantify flux of carbon from land use change
  - Greatly improved modelling of terrestrial carbon cycle
- Objectives achieved through
  - Gridded high-resolution global estimates of **above ground biomass**
  - Monitoring and quantification of **forest disturbance** and **recovery**
  - Monitoring and quantification of **wetland areas and forest inundation**
- Additional objectives related to opportunity for spaceborne P-Band SAR images
  - Mapping subsurface structures, polar regions,
  - Mapping subsurface geomorphology in arid zones

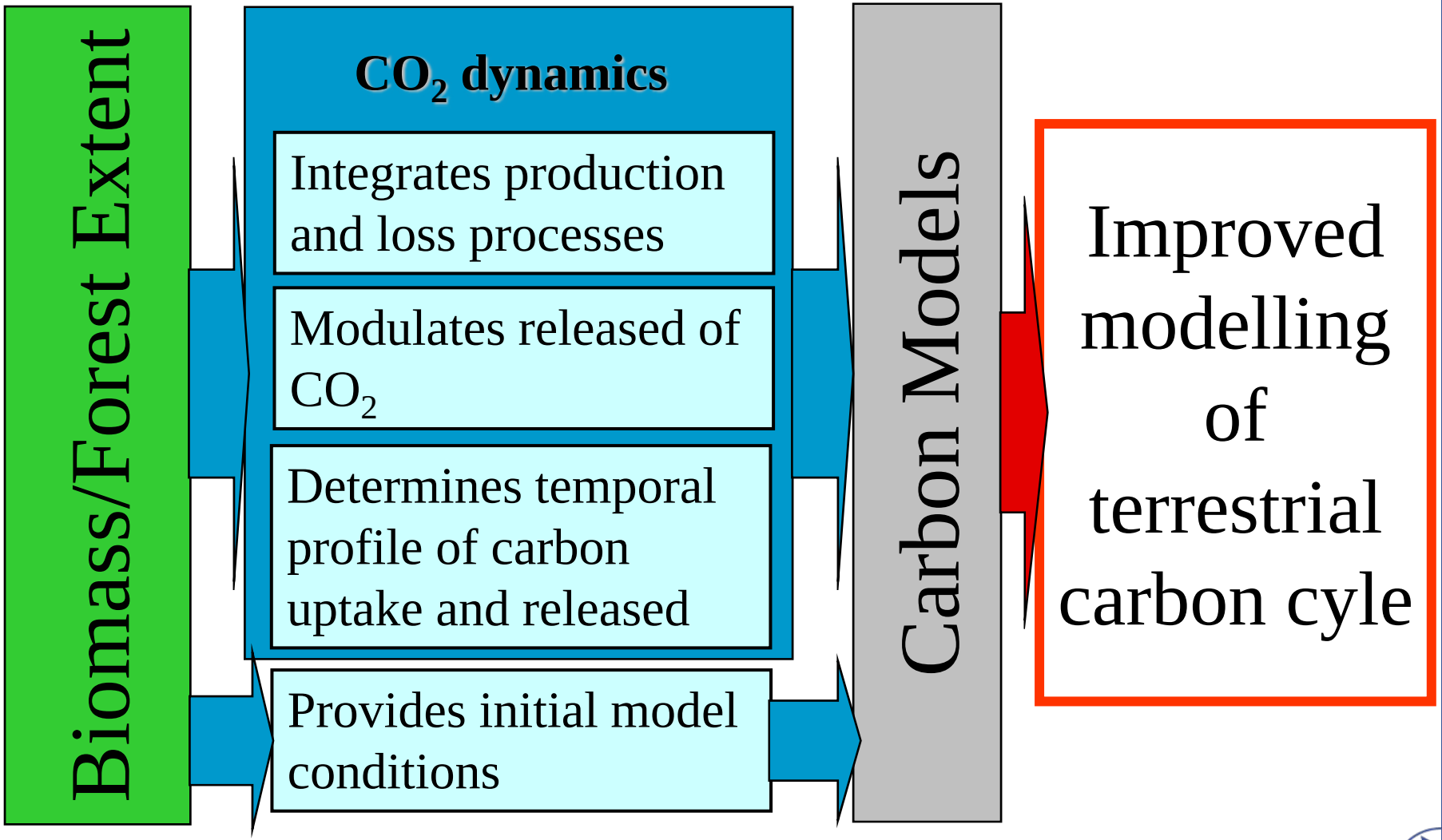
Scientific Background

- Terrestrial contribution to the global carbon cycle poorly understood
- Forest biomass information critical for inventory of CO2 stocks and fluxes
  - Fluctuations in total forest biomass provide immediate feedback on CO2 release
  - Provide initial condition for biophysical models
  - Biomass changes with time integrator of CO2 production and loss processes
- No consistent source of biomass suitable for climate models
  - National reporting *not spatially explicit* and with unspecified errors
  - Only 1 gridded low-resolution mono-temporal dataset compiled from country/sample plot information (Olson map)



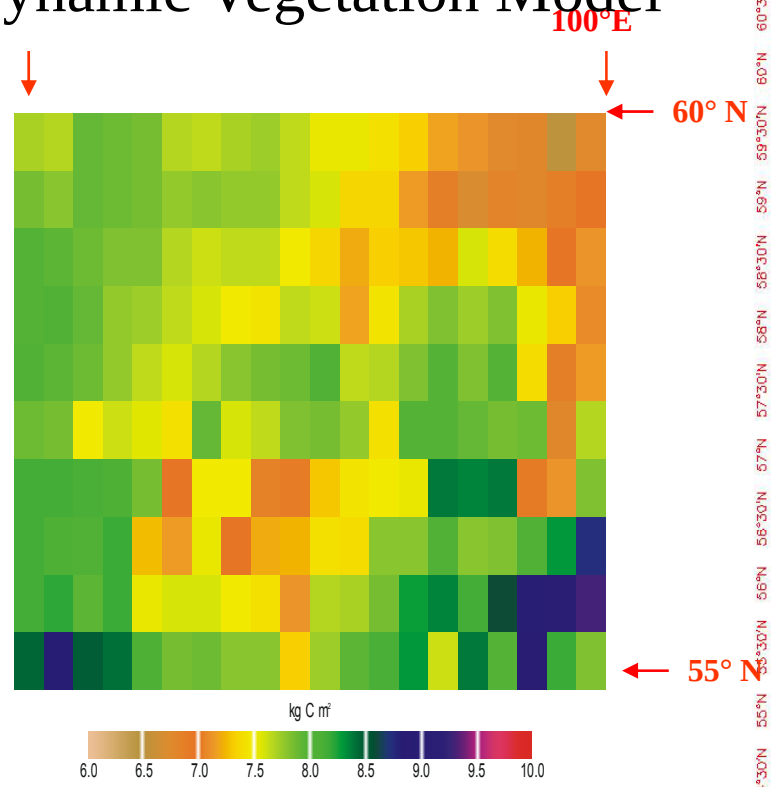


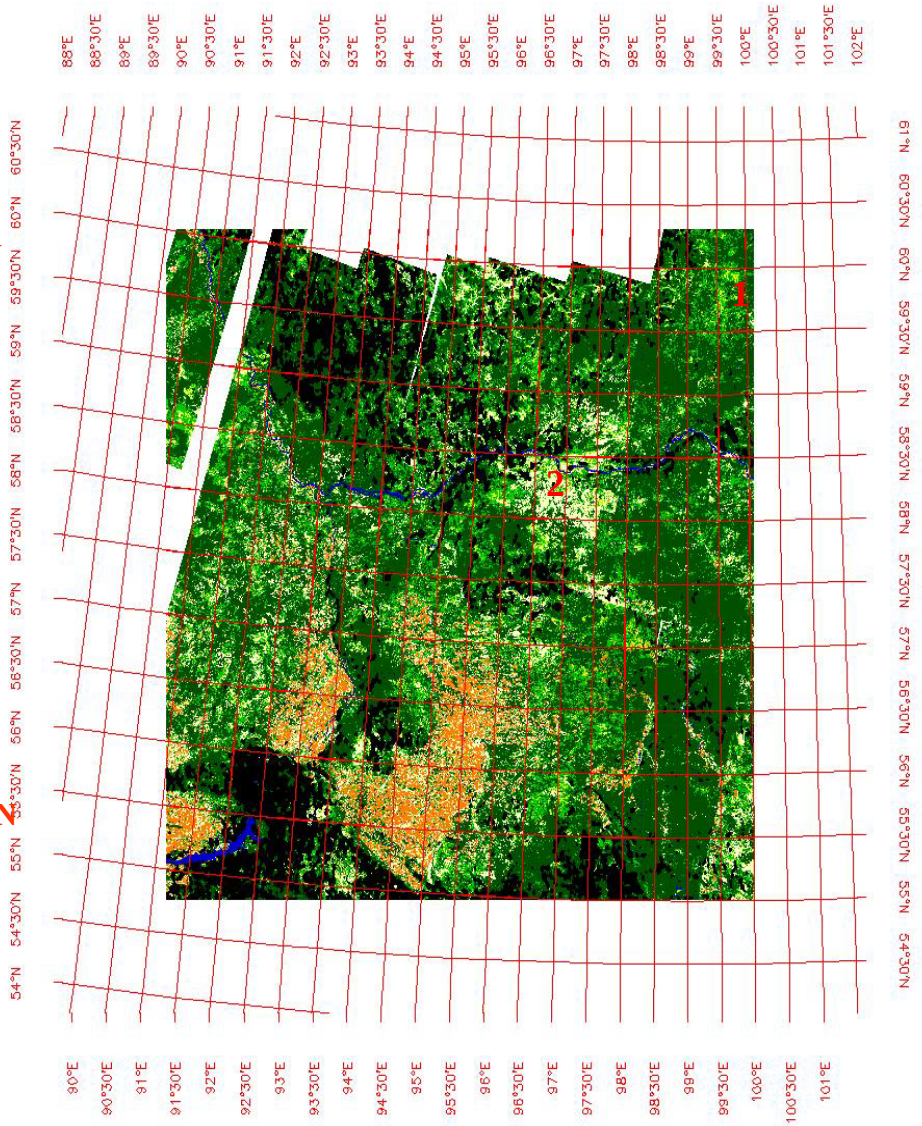
Use of biomass information in CO_2 models



Biomass information within carbon models

Biomass predicted by Global Dynamic Vegetation Model





Biomass map derived from SAR measurements

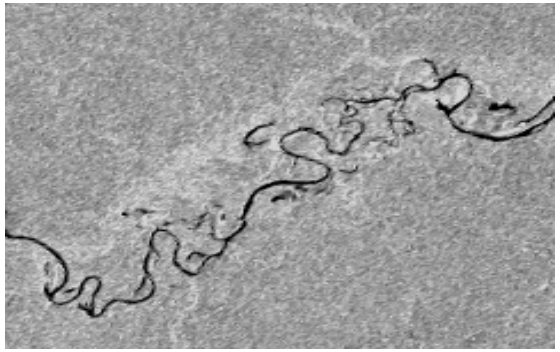
Le Toan et al, 2004

Forest wetland extent

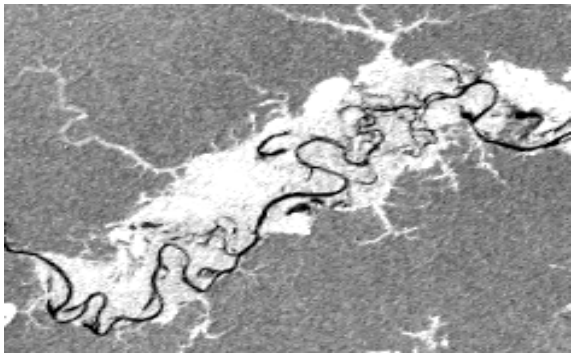
- Methane strong contributor to global warming
- Extent and temporal evolution of floodplain under forest canopy not well known

Varzea Dry Season

Varzea Wet Season



P-band backscatter

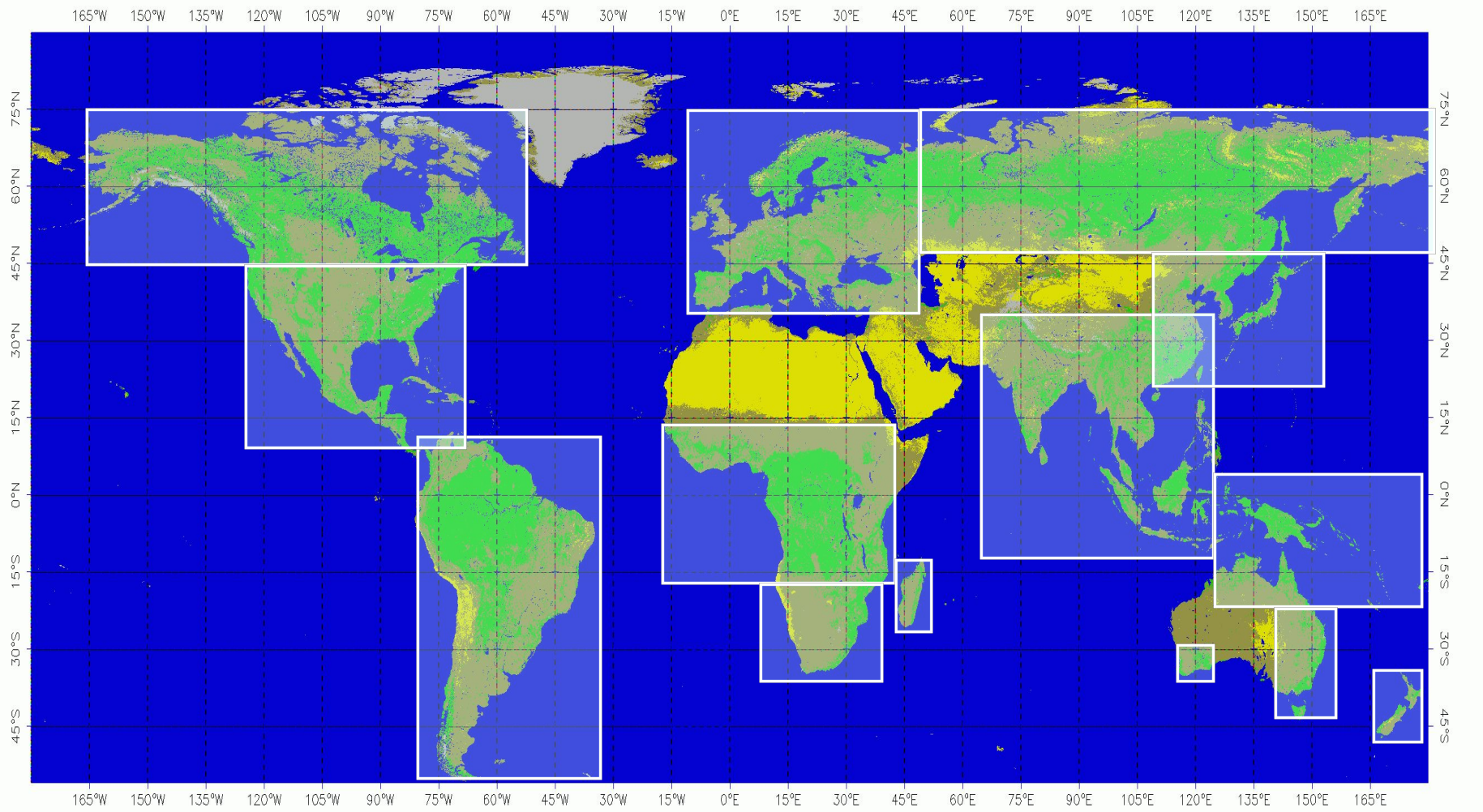


P-band backscatter

BIOMASS mission requirements

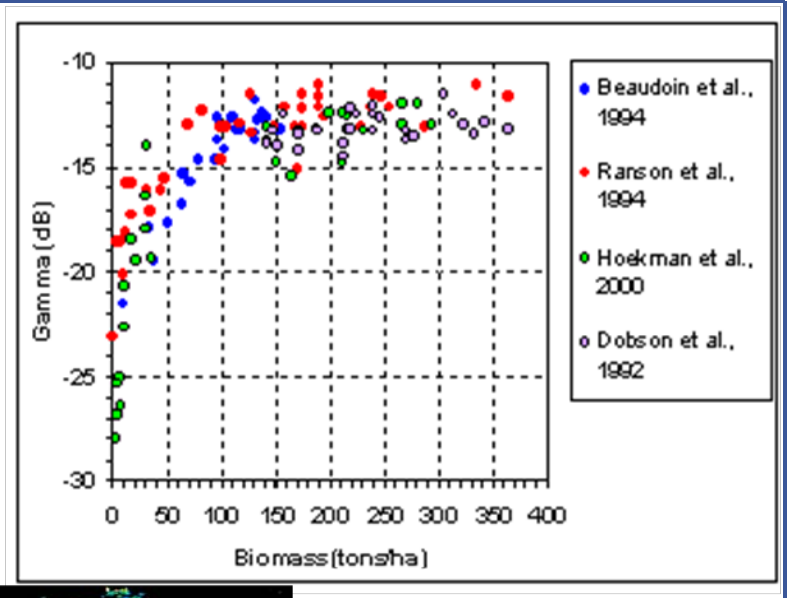
Information Product	Mission Requirements
Forest Biomass (above ground)	• 20% accuracy • 100-300m resolution/16 looks • 2 biomass maps/year • Polarimetric Interferometric mode • Global coverage of forests
Forest Disturbance	• Maps of disturbed area with 10% classification accuracy • 100m resolution/16 looks • 1-2 forest disturbance maps every 2months • Global coverage
Forest Regrowth	• Biomass information 20% accuracy • Biomass rate of change – 20% accuracy • 100-200m resolution/16 looks • 2 revisits/year • Global coverage with focus on tropical forests
Forest seasonal floods	• Inundation area information – 10% classification accuracy • 100m resolution/16 looks • 1 revisit/month during flood season • tropical forests (main target) + boreal wetlands (secondary target) for methane emission

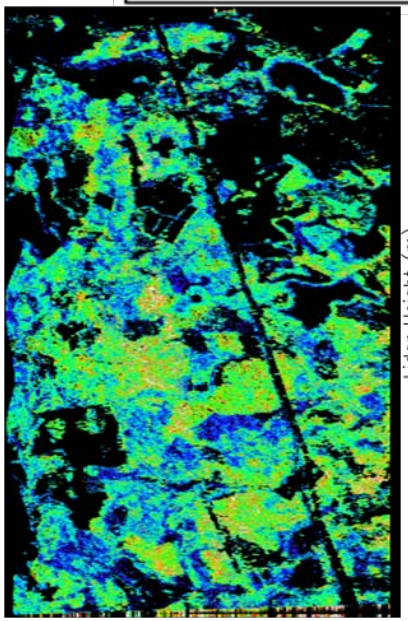
BIOMASS Coverage

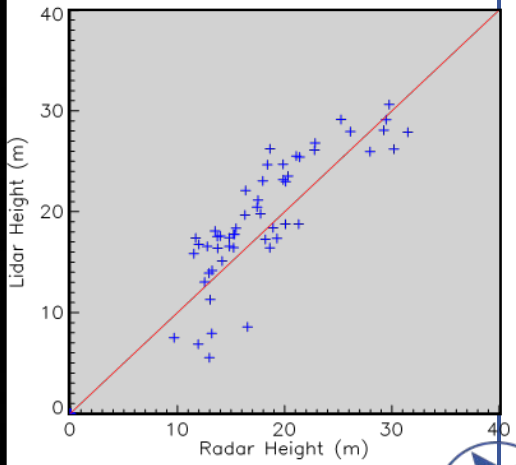


Achieving the BIOMASS requirements

- Global forest biomass estimates to be derived using three different techniques
  - Exploitation of biomass-intensity relationship at P-Band
  - Forest height retrieval using Polarimetric-Interferometric techniques
  - Classification using polarimetric signature
- Final product may combine intensity and forest height information
- Interpretation and validation of biomass products and algorithms supported by tomographic mission phase



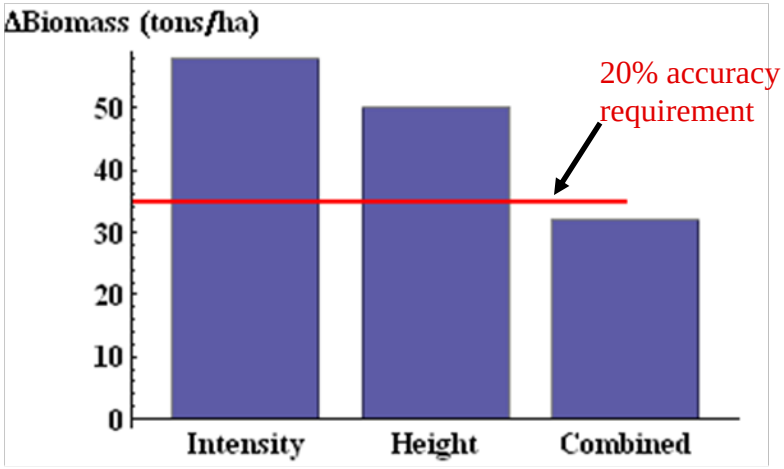




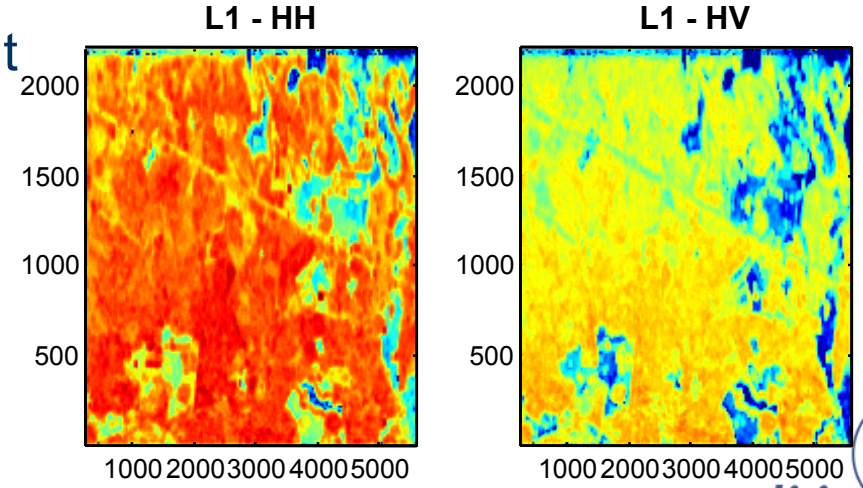
Achieving the BIOMASS requirements

- Mission implemented using two phases (Main Phase, Tomographic Phase)
- Main Phase (98% of time)
  - dedicated to mapping of forest biomass, recovery and flooding
  - to support intensity and polarimetric interferometry
- Tomographic phase (2% of time)
  - 10-12 baselines – short revisit time
  - Identify the sources of the radar signal
  - Validate intensity/PolInSAR techniques

2007 BioSAR Campaign – Boreal Forest



Tomographic Product
Power scattered from ground



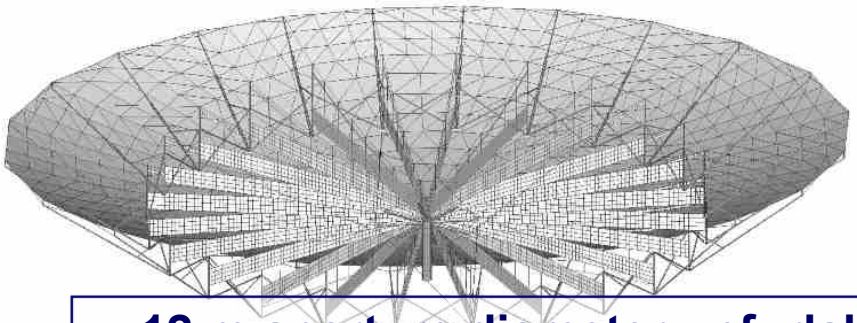
Technical Concept

- ESA Industrial study running from April 2007 to September 2008 to define P-Band SAR payload and mission characteristics
- Mid-term review held in Dec.2007: no major show-stoppers identified

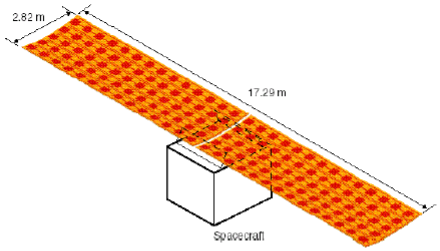
Instrument Type	P-band Synthetic Aperture Radar (SAR)
Centre Frequency	435 MHz (P-Band)
Bandwidth	≤6 MHz
Polarisation	Full Polarimetry/Compact pol.
Data Acquisition	Single Pass/Repeat Pass polarimetric interferometry
Spatial Resolution	≤ 50 x 50m (4 looks)
Swath Width	≥ 100 km
Noise Equivalent σ_0	≤ 27 dB (T), -30 dB (G)
Absolute Radiometric Calibration	≤ 1 dB
Radiometric Stability	≤ 0.5 dB

Technical Concept

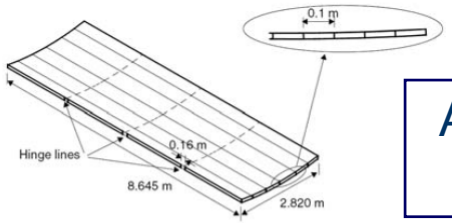
- At P-Band. antenna area of 50 to 100 m^2 would be required !



12 m aperture diameter unfurlable reflector built by Thales Alenia Space and Russian NPO EGS

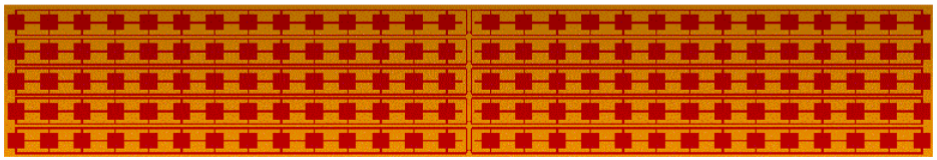


Deployed antenna

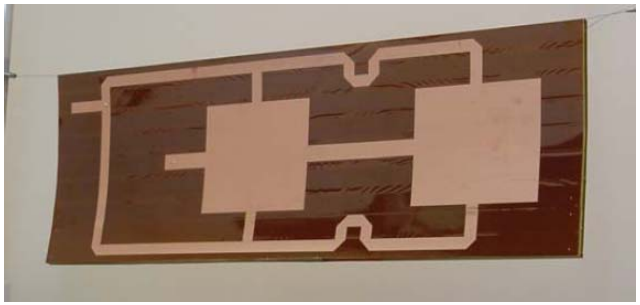


Mechanical design of one-wing

Astrium's **FLATS** antenna concept (17.29 m × 2.82 m)



Full Antenna realised as 2-wings of a FLATS design

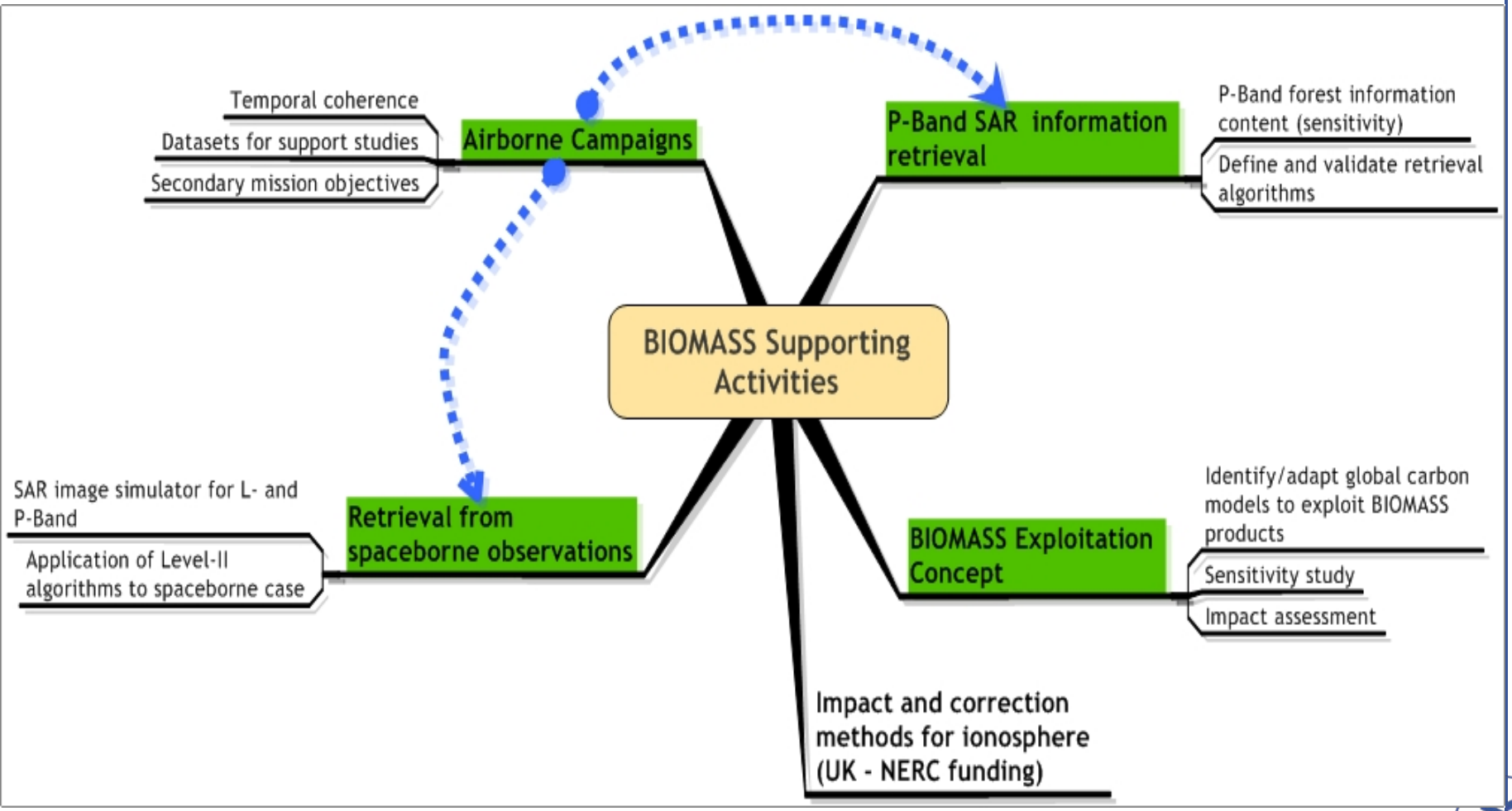


Mid-Term Review - Baselines

	Deployable Flat Array	Reflector
Antenna Aperture	Length 17.9m Height 4.5m	Diameter 12m
Surface	80 m^2	113 m^2
ITU	Compliant with tapering	Compliant with tapering
Gain	27.4 dB	32.5 dB
RF peak Power	600 Watts	500 Watts
PRF	1700Hz-1800Hz	3600Hz-3800Hz
Total Swath	80 km (STRIPMAP)	55-60km (STRIPMAP) 110km (SCANSAR 2 swaths)
Coverage time	35 days	45-50 days (STRIPMAP) 25 days (SCANSAR)
Resolution	≤50 mx50 m (≥ 4 looks)	≤ 50mx60m (≥ 4 looks)
NeSigma0	-30dB/-26.5dB	-31dB/-28dB
Total Ambiguity Ratio	<-20dB	<-20dB
Data Rate Instrument	80 Mbit/sec (5 bits)	133 Mbit/sec (8 bits)

BIOMASS Supporting Activities

- Several scientific supporting activities have been initiated to better define the overall mission concept

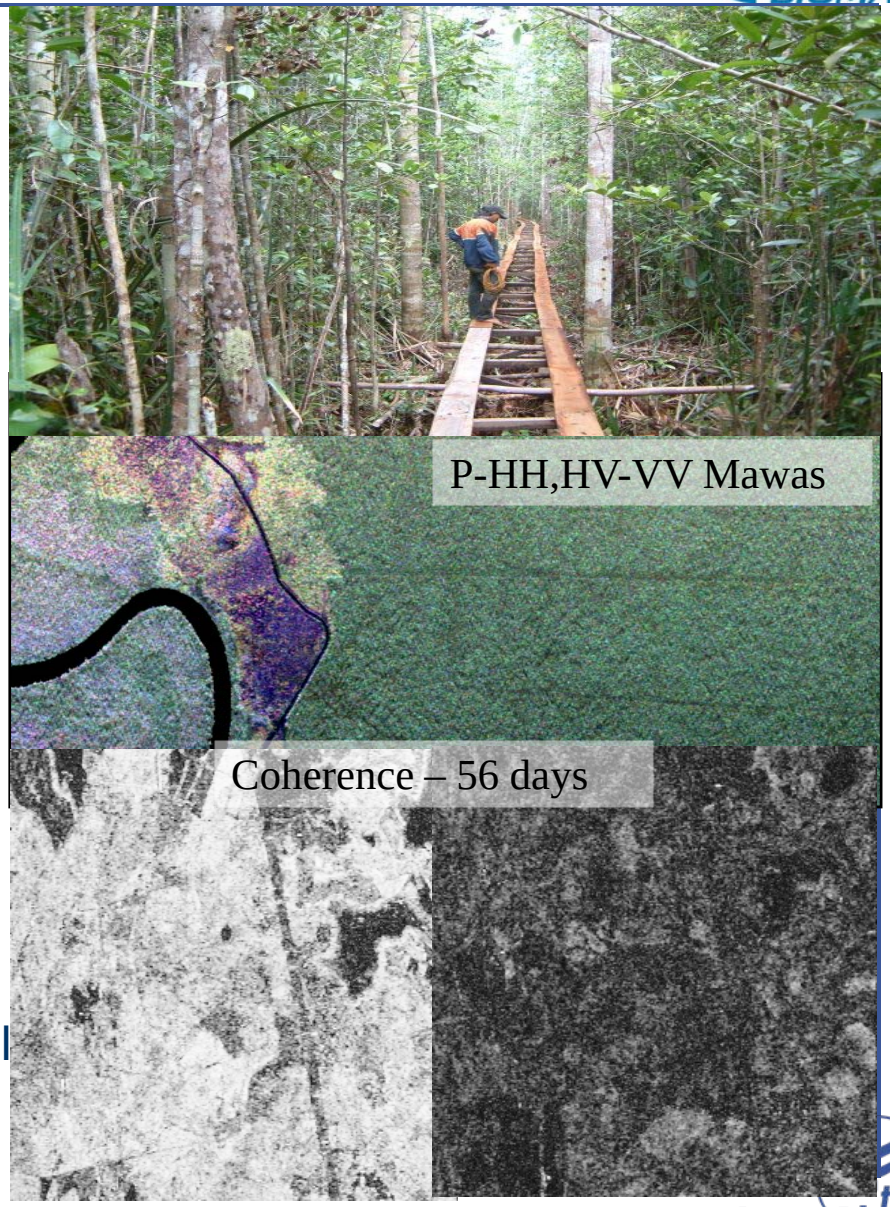


Synergies and Collaboration

- Scientific collaboration
  - MAG expected to consult with user community
  - Scientific support studies
  - Documented airborne campaign datasets
- Forest Biomass constellation ?
  - Cross-validation of products e.g. radar forest height P- and L-Band and lidar forest height
  - Exploit advantages of each mission e.g. lower resolution BIOMASS product with higher-resolution DESDynI products
- Programmatic collaboration
  - Always most difficult (funding cycles often incompatible with mission development milestones)
  - BIOMASS design stand-alone but participation from other agencies not excluded
  - Start of Phase-A in March 2009 (assuming selection) would provide ideal opportunity

ESA Campaigns

- Active airborne SAR campaigns underway to address BIOMASS mission definition
- Consolidated datasets from ESA airborne campaigns accessible to scientific community
- Category 1 proposal required
  - http://eopi.esa.int/esa/esa and click on ESA Campaigns link
- Existing campaign datasets of interest to the SAR community
  - TreeSAR 2003 (DLR E-SAR, Traunstein test site SE Germany)
  - Indrex-2 2004 (DLR E-SAR, Tropical forests and plantations, Kalimantan Indonesia)
  - BioSAR 2006 (DLR E-SAR, Boreal forests in Sweden)



Conclusions

- BIOMASS represents a dedicated mission to:
  - Quantify flux of carbon from land use change
  - Greatly improved modelling of terrestrial carbon cycle to improve our understanding and quantification of land contribution to global carbon cycle
- Mission objectives to be achieved through provision of consistent global information on forest biomass, forest disturbance and recovery and seasonal forest flooding retrieved using long-wavelength SAR (P-Band current baseline)
- Final decision on build and launch expected in 2010