



# The VEGETATION Programme



Federal Office for  
Scientific, Technical  
and Cultural Affairs  
Belgium

EUROPEAN COMMISSION





# **RATIONALE TO DEFINE AN EARTH OBSERVATION MISSION ON THE BIOSPHERE**



# GENERAL CONTEXT

**Both needs and knowledge of the end users are pushing towards new strategies for providing useful products**

- ensure widespread availability of basic measurements**
- provide elaborated products with capacity of rapid integration in information flow of users**
- adapt systems for long term and evolving continuity**
- design mechanisms for transfer from experimental to operational missions**

**After the Atmosphere (Meteorology) and Ocean communities, the Biosphere community, both for Application and Science, has recently become structured to express its needs with support of large programmes or international institutions**



# BIOSPHERE :

## Informations to be provided

### □ Spatial distribution of vegetation

- ◆ acreages or cartography,
- ◆ variability and/or structure related to environment :
  - climatic and topographic factors,
  - human activities

**LAND COVER**  
**LAND USE**

### □ 'Vegetation state' : through biophysical parameters

- ◆ as input to empirical relationships for assessment or predictions,
- ◆ as 'control points' for models :
  - to validate description of processes
  - to update parameters to refine prediction

**YIELD**  
**PREDICTION**  
**INTERACTIONS &**  
**CLIMATE IMPACT**  
**STUDIES**



# General characteristics of optimal measurements

## □ For spatial description :

- ◆ local scale : spatially accurate identification of land cover can generally be obtained through few measurements and acquisition dates
- ◆ regional and continental scales : use of medium resolution (>100m) usually needs time series and high resolution sampling

## □ For description of 'vegetation state' :

- ◆ repetitive measurements on vegetation canopies/soil and on the driving factors of their evolution to characterise
  - energy and water exchanges,
  - basic biophysical processes at different scales both in space and time
    - leaves, plants, homogeneous populations, ecosystems,
    - hours, days, weeks, year,...

**Due to basic physics, solar reflection and IR emission still give the most direct determinations for vegetation state parameters.**



## Basic systems for present needs

- **Solar reflection (0.45 -2.3  $\mu$ ): structure(growth/ecosystem) & photosynthesis**
  - ◆ Mid morning sun synchronous
  - ◆ Daily coverage to accomodate for cloud cover and get almost weekly useful measurements
  - ◆ Multiscale : for continental-global coverage and zoom capability (at some dates)
  - ◆ Selection of measurements based on:
    - structural and absorption properties ( $\ll 10 \lambda$ )
    - needs for some corrections (atmosphere, directional effects?)
  
- **IR emission (3.5 - 12  $\mu$ ) : energy and water exchanges**
  - ◆ Need for some access to diurnal variation
  - ◆ Daily coverage ...
  - ◆ Multiscale as above + Emissivity effects
  - ◆ Selection of measurements mainly based on needs for corrections :  
emissivity and atmosphere

**TECHNICALLY ADAPTED SYSTEMS are PLANNED for the NEXT DECADE**

**VEGETATION IS ONE OF THEM**



# THE VEGETATION MISSION



# Needs for a VEGETATION system

- ❑ **Use of Earth observation data in operational or pre-operational programmes increases for**
  - . monitoring the environment,
  - . global change studies,
  - . management of productions (agriculture, forestry...)
  - ◆ in particular, for the European Commission :
    - in Research and Development programmes
    - for sectorial policies
- ❑ **Data quality and availability (especially on the long term) is becoming a major limitation, even for basic measurements.**
- ❑ **Consequences :**
  - ◆ Strong need for an operational and basic data source
  - ◆ Develop Observation Systems driven by users needs and not only by technology development
  - ◆ Aim at overall self-sustainability for long term availability
  - ◆ Through a full test case, identify mechanisms for leadership of user community in such space projects



# Main missions for Vegetation monitoring

- Surface parameters :**  
to describe spatial and temporal distribution of radiative properties
- Vegetation resources :**  
monitor productions (agriculture, forestry, grasslands...)
- Biosphere processes :**  
understand and modelize functioning of ecosystems, their interactions with the atmosphere and with human activities

## **COMMON STRATEGY :**

**document processes at different scales,  
for spatial and temporal aspects.**



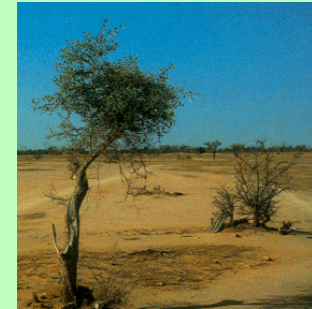
## Agriculture

- Monitoring and prediction of crop productions
- Impacts of drought, frost, flood, disease...
- Agroclimatological stratification



## Forestry

- Monitoring deforestation
- Impact of human activities (slash & burn....)
- Influence of tropical, temperate and boreal forests on global changes

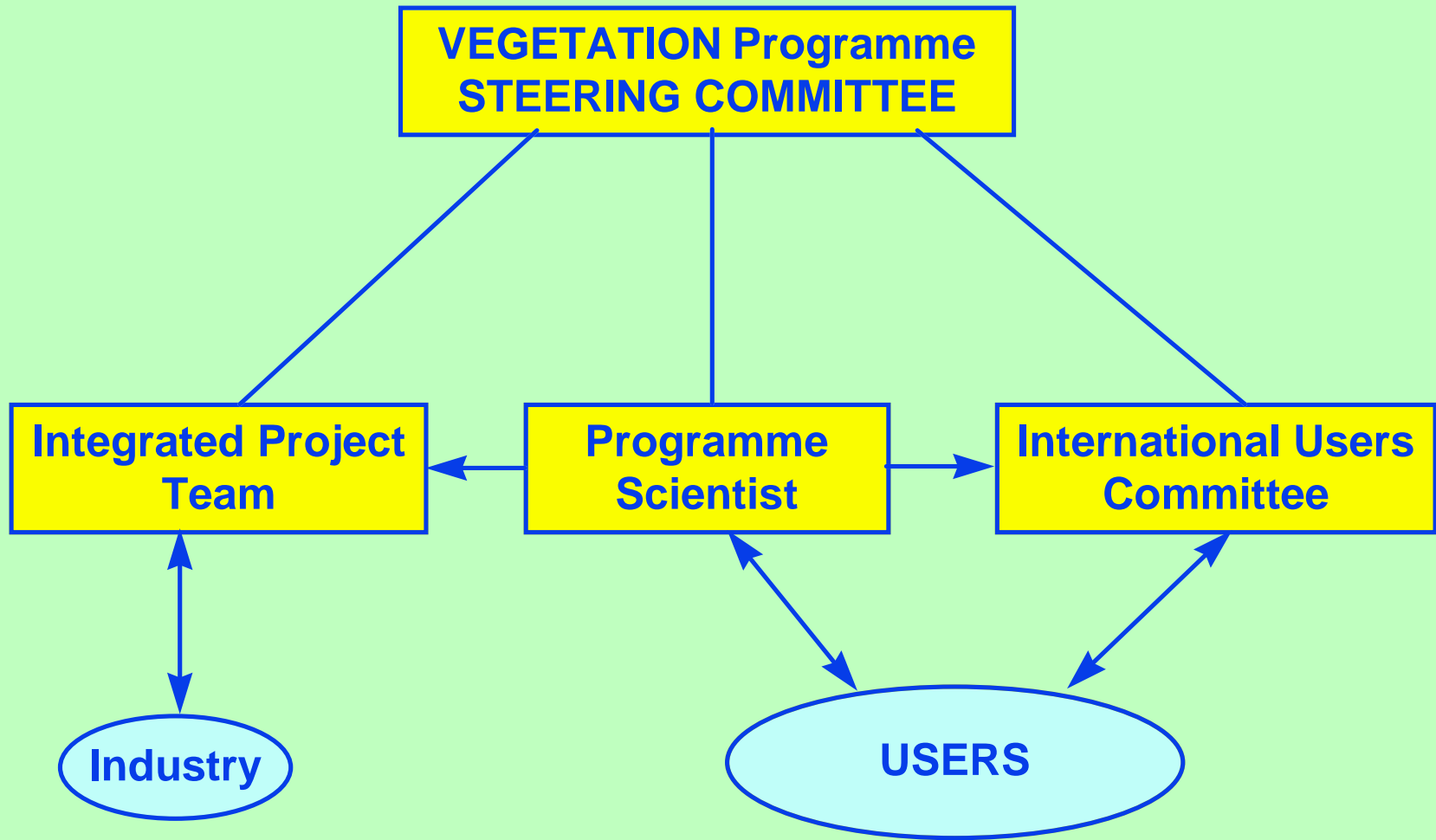


## Environment

- Land cover / land use
- Impact of population increase
- Understanding of biosphere processes
- Interaction with atmosphere and climate (energy, gas, water exchanges...)



# PROGRAMME ORGANISATION





# Organisation & Responsibilities

## Steering Committee

(Partners of the Programme)

Supervises the entire Programme and elaborates guidelines for the executive entities.

## International Users Committee

Defines mission and product specifications,  
Provides recommendations during development  
Prepares the *VEGETATION Preparatory Programme*  
Proposes orientations for evolutions

Partners representatives,  
International Programmes  
representatives,  
Experts

## Programme Scientist

Coordination between IUC and IPT,  
Management of the *Preparatory Programme*

User  
Community

## Integrated Project Team

Maître d'Oeuvre : CNES (F)  
In charge of management for development and integration

Industrial  
Development



# Composition of IUC

- Chairman from EC : JP Malingreau (SAI/JRC)**
- Secretary = Programme Scientist (CNES)**
- Representatives of partners (2 per national partner + 2 for EC)**
- Representatives of important international programmes or institutions :**
  - ◆ **IGBP (represented by IGBP-DIS)**
  - ◆ **FAO (M Bied Charreton)**
  - ◆ **GVMI (S Briggs UK)**
  - ◆ **MODIS Science Team (EOS) (A Huete US)**
- Experts**
  - ◆ **S Dech (Germany), A Lobo (Spain), J Van Genderen (The Netherlands), T Häme (Finland), J Pereira (Portugal), E Lioubimtseva (Russia), J Eidenshink (USA),**
- Invited**
  - ◆ **IPT representative (system manager) + as needed**



## KEYWORDS

- ADAPTED** to biophysical studies
- OPERATIONAL** for end users
- ROBUST & BASIC** measurements
- LONG TERM** and **EVOLUTIVE**

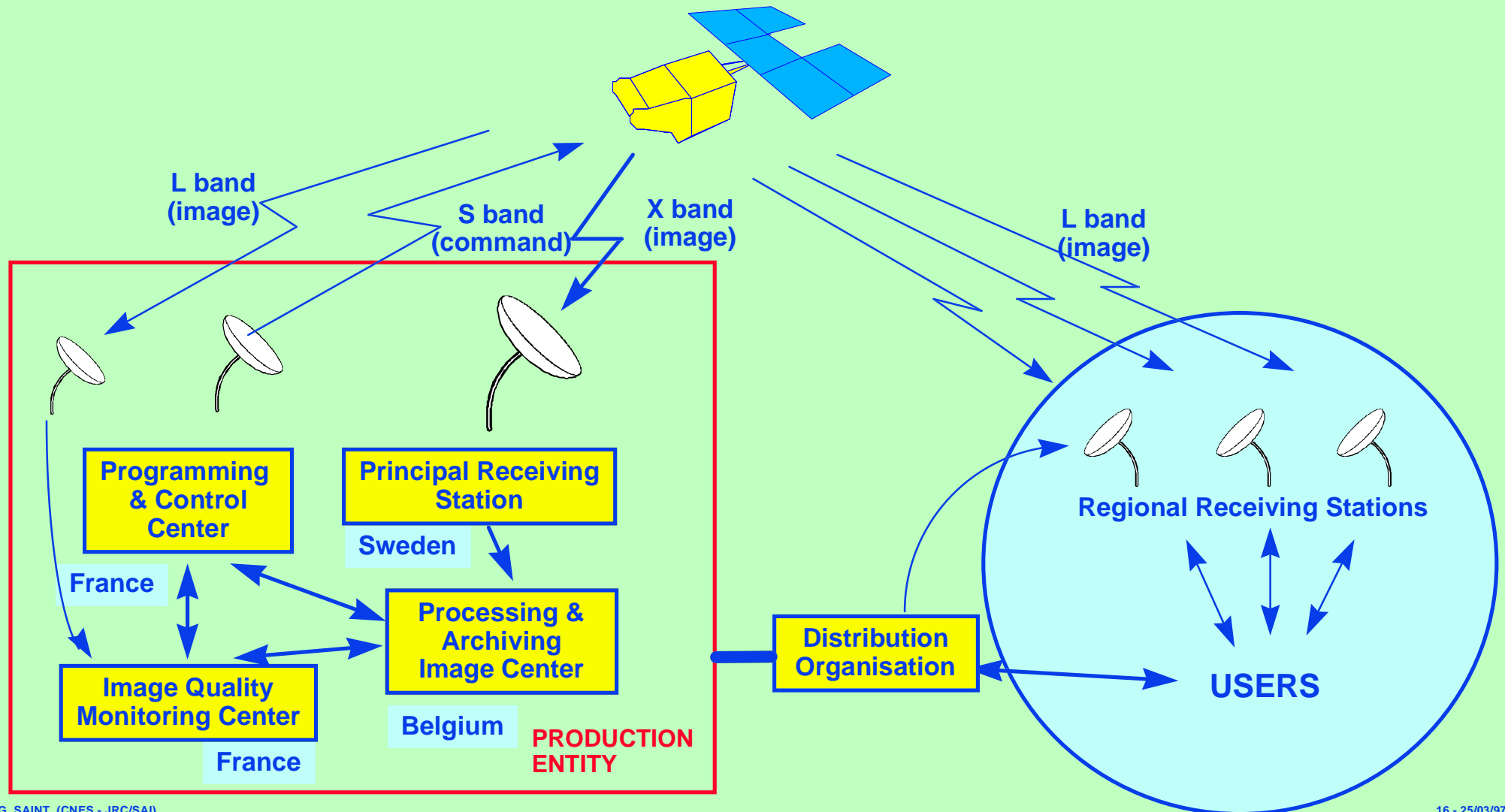


# MISSION REQUIREMENTS

- Time scales :** High revisit capability,  
Long term acquisition  
Archive
- Spatial scales :** wide FOV  
zoom capability
- Observability :** spectral bands  
both for information and correction
- Accuracy :** radiometric calibration  
geometric quality



# OVERALL SYSTEM STRUCTURE





# DETAILED CHARACTERISTICS



# TECHNICAL CHARACTERISTICS

## □ Radiometry

### ◆ Four spectral bands

- |        |                           |                    |                           |
|--------|---------------------------|--------------------|---------------------------|
| • Blue | 0.43 - 0.47 $\mu\text{m}$ | Near InfraRed      | 0.78 - 0.89 $\mu\text{m}$ |
| • Red  | 0.61 - 0.68 $\mu\text{m}$ | ShortWave InfraRed | 1.58 - 1.75 $\mu\text{m}$ |

### ◆ Calibration

- interband and multitemporal : better than 3%
- absolute : better than 5%

## □ Geometry

### ◆ Spatial resolution 1km in the entire field of view

### ◆ Off nadir observations up to 50°

### ◆ Distorsions :

- |                     |          |                         |          |
|---------------------|----------|-------------------------|----------|
| • multispectral     | < 0.1 km | multitemporal           | < 0.3 km |
| • absolute location | ~ 0.5 km | registration with HRVIR | < 0.3km  |

## □ Operations

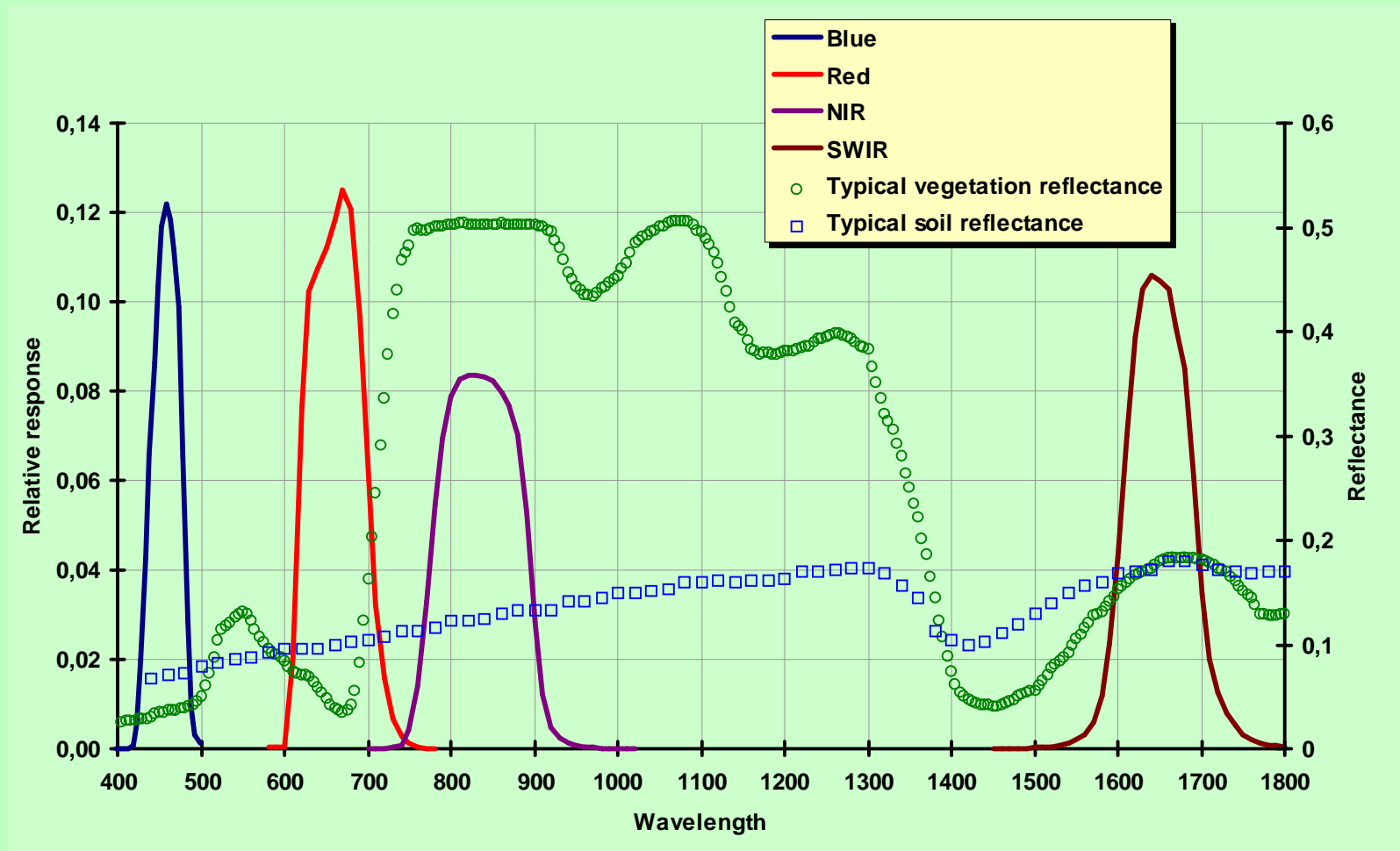
### ◆ Global coverage almost everyday on land areas

### ◆ Central archiving and processing through onboard solid state memory and X band downlink to one principal receiving station

### ◆ Regional receiving stations (L band downlink)



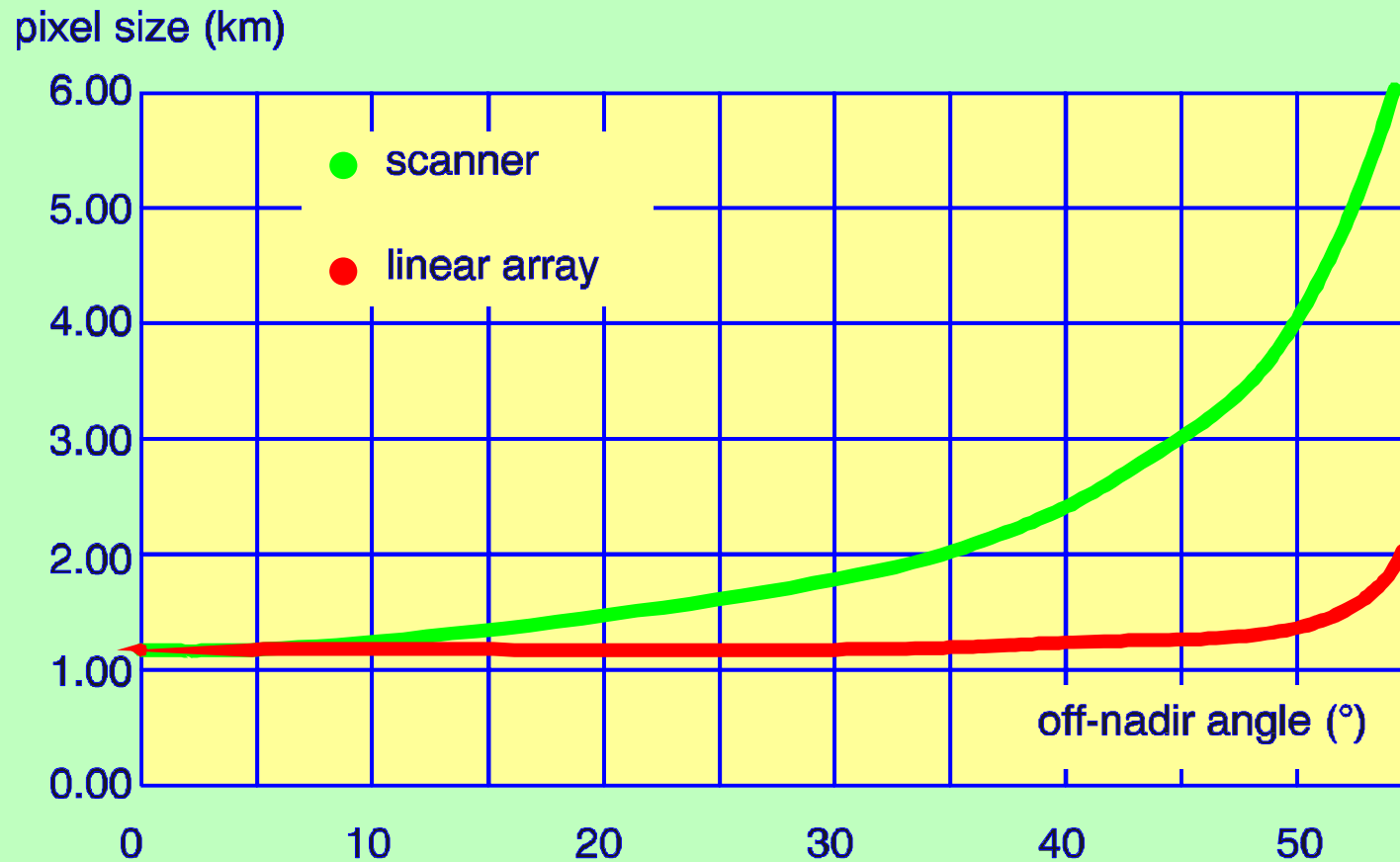
# Spectral Responses





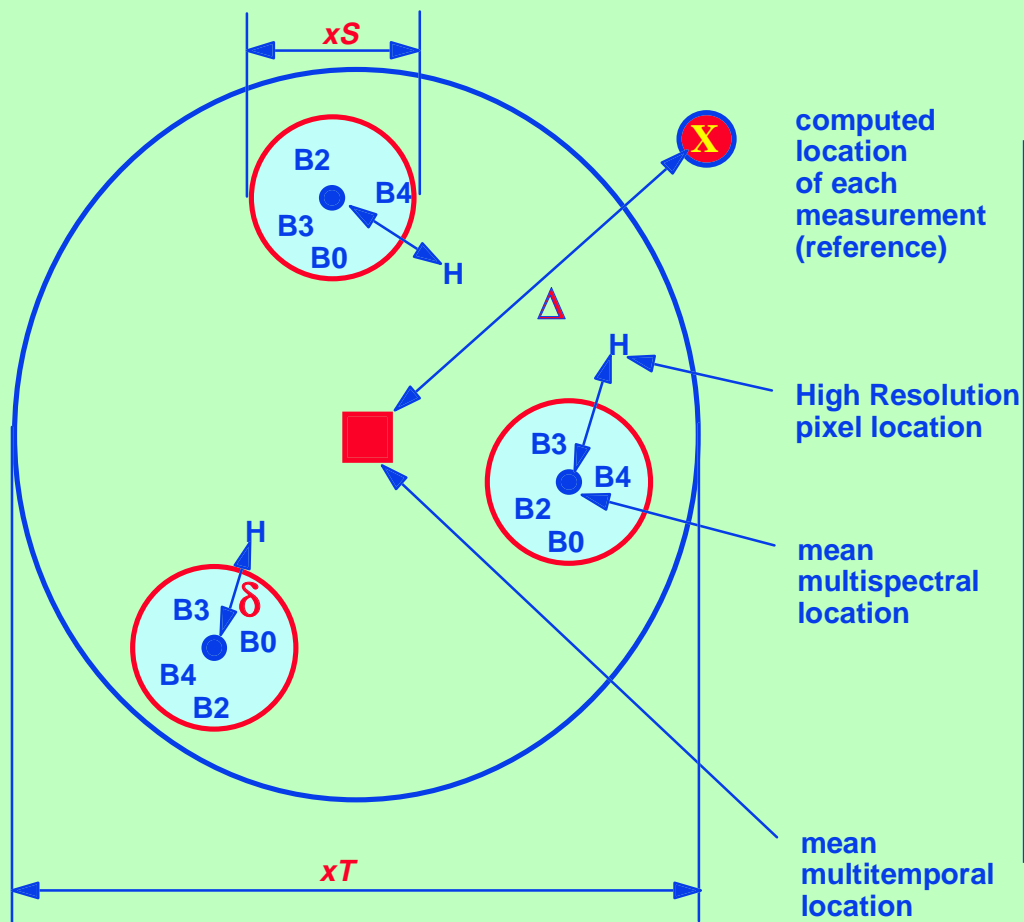
# SPATIAL RESOLUTION VARIATIONS

Resolution comparison between linear array and scanner :





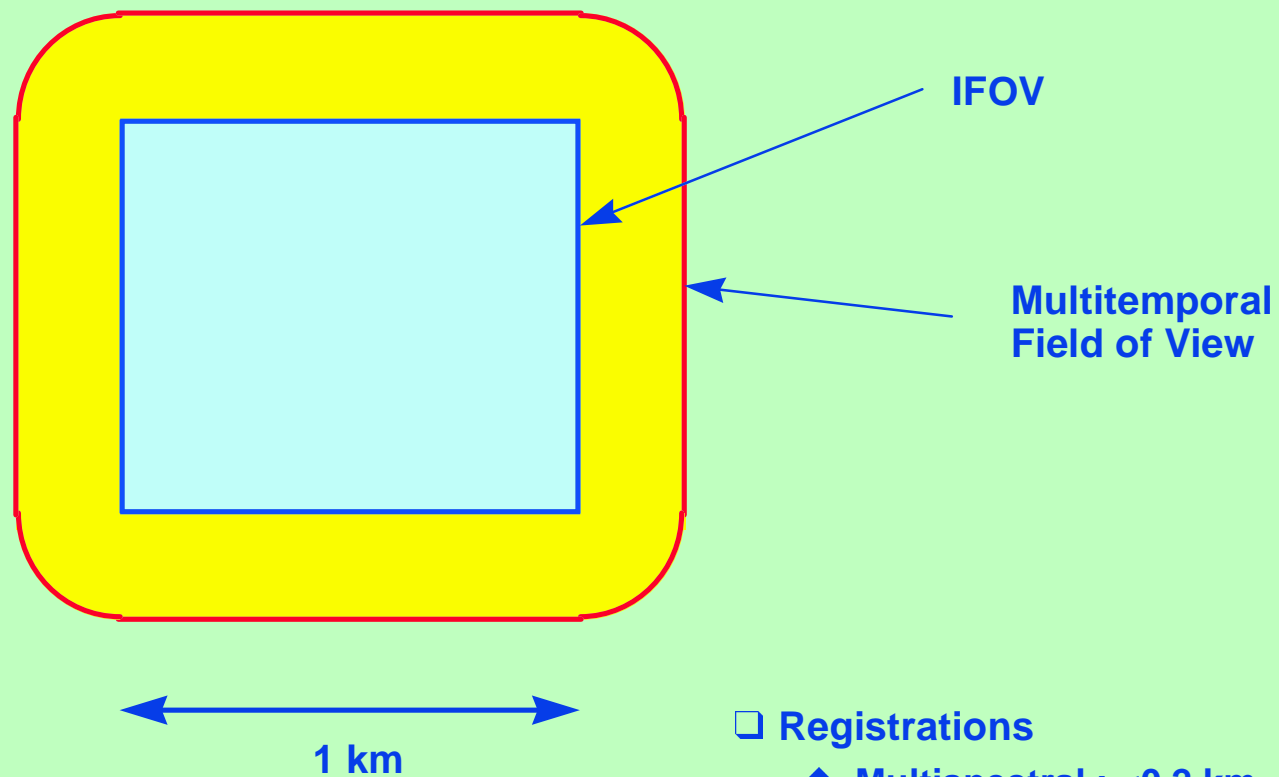
# GEOMETRY : SPECIFICATIONS



Specifications	
multispectral registration $xS$ :	$\ll 0.3$ km objective : 0.1 km
collocation $\delta$ :	$< 0.3$ km
multitemporal registration $xT$ :	$< 0.5$ km, objective : 0.3 km
absolute location $\Delta$ :	$< 1$ km, objective : 0.5 km



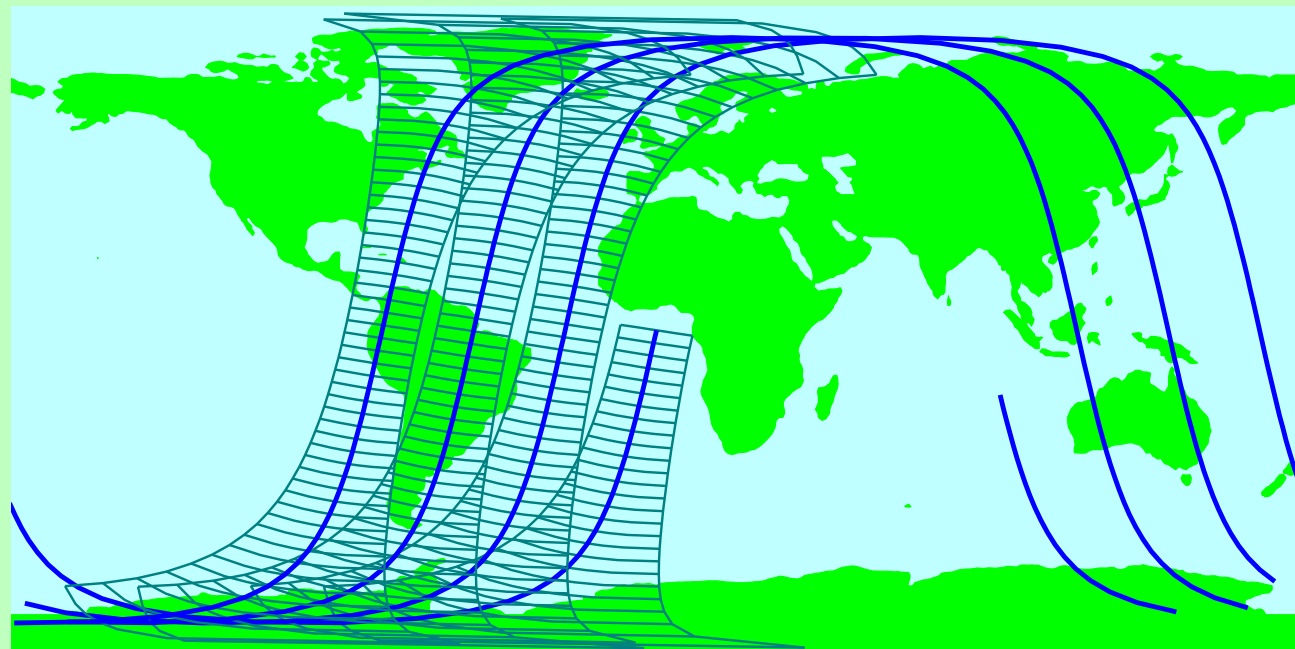
# GEOMETRIC : EXPECTED ACCURACY (Beg. 96)



- Registrations
  - ◆ Multispectral :  $<0.2$  km
  - ◆ Multitemporal :  $<<0.5$  km for one year
- Absolute location  $<0.8$  km



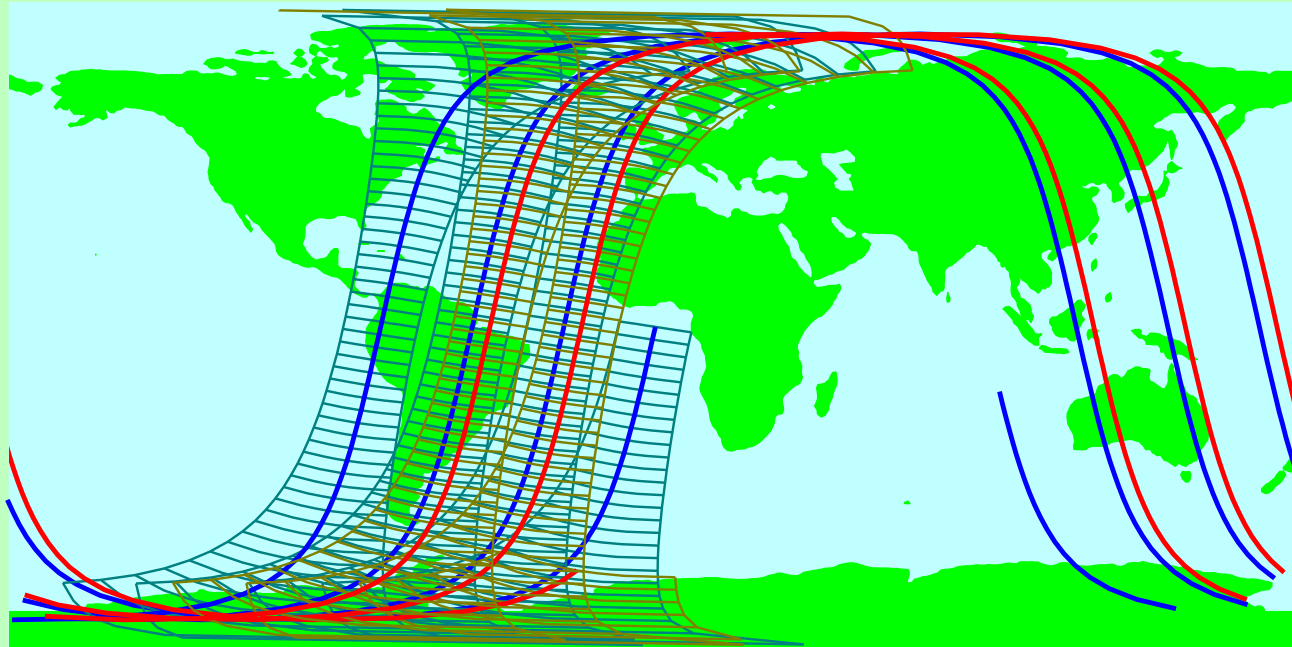
## Coverage (1)



26 days SPOT cycle

3 orbits on day 0

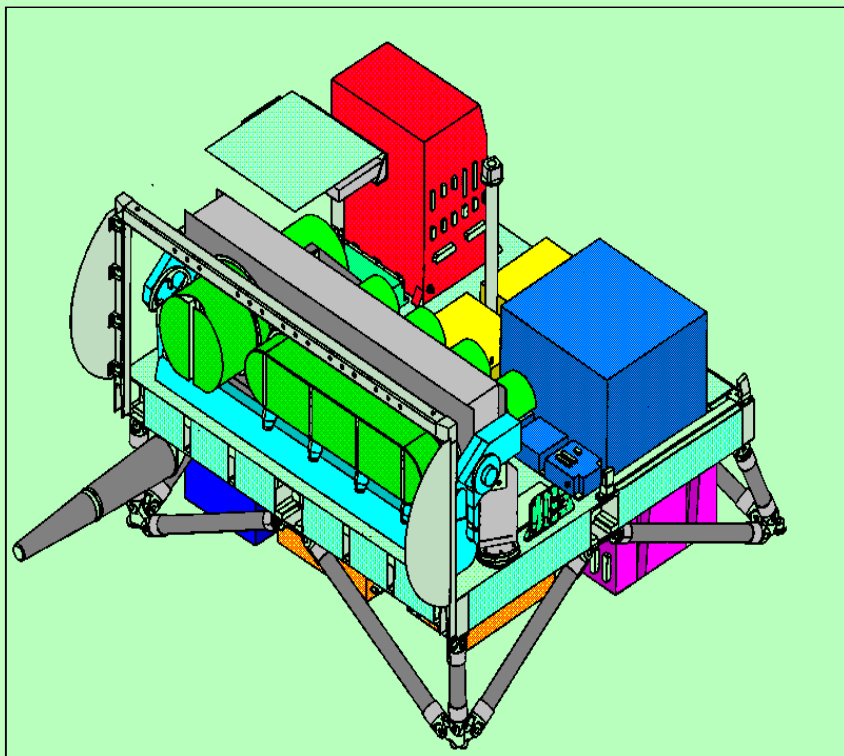
## Coverage (2)



3 orbits on day 0 and 2 orbits on day 1



# PAYLOAD CHARACTERISTICS



## SYSTEM

**MASS :** 160 kg  
**SIZE :** 0.7 x 1.0 x 1.0 m<sup>3</sup>  
**POWER :** 150 W  
**On-board MEMORY :** 2.25 Gbit

## IMAGE

**SPECTRAL BANDS :** Blue - Red - NIR - SWIR  
 (Red, NIR and SWIR identical to HRVIR ones)  
**CODING :** 10 bits  
**OPTICS :** telecentric lenses  
**F.O.V. :** 101° (ground swath = 2250 km)  
**DETECTION :** CCD line array  
**RESOLUTION :** 1.165 X 1.165 km<sup>2</sup>

## TRANSMISSION

**.GLOBAL ( X-BAND )**

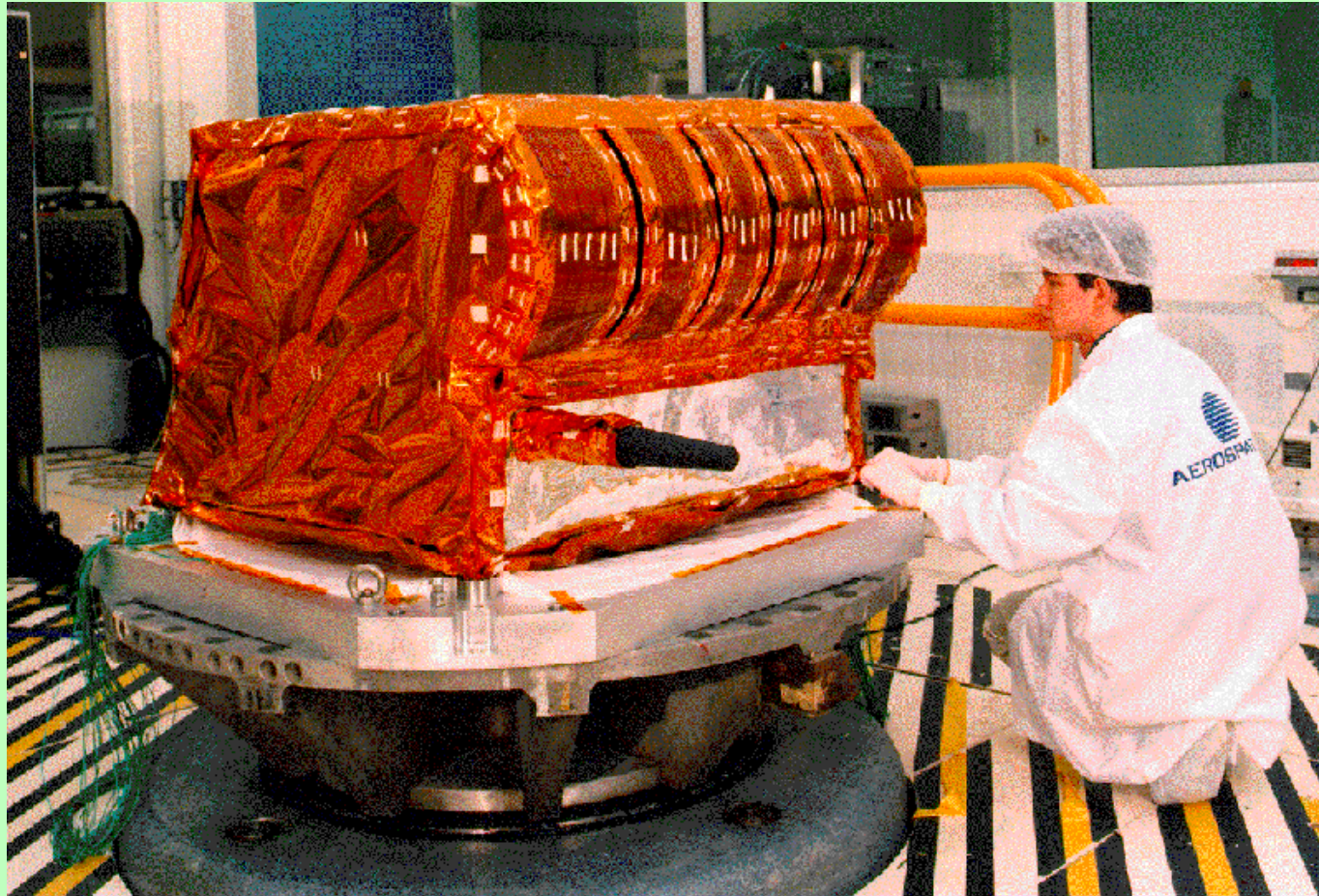
<b>FREQUENCY</b>	8.15 GHz
<b>POWER</b>	3 dBW
<b>DATA RATE</b>	3.4 Mb/s

**.LOCAL ( L-BAND )**

<b>FREQUENCY</b>	1.70 GHz
<b>POWER</b>	5.7 dBW
<b>DATA RATE</b>	1 Mb/s



# STRUCTURAL & THERMAL MODEL





# PRINCIPLES for PRODUCT DEFINITION

## Products available from Ground Processing Segment

- ◆ defined and adapted specifically to the use in vegetation studies,
- ◆ capabilities to adapt
  - to "important" projects
  - to evolution (18 months - 2 years)
- ◆ compatibility with HR products should be maximum,

## Products available from secondary receiving stations

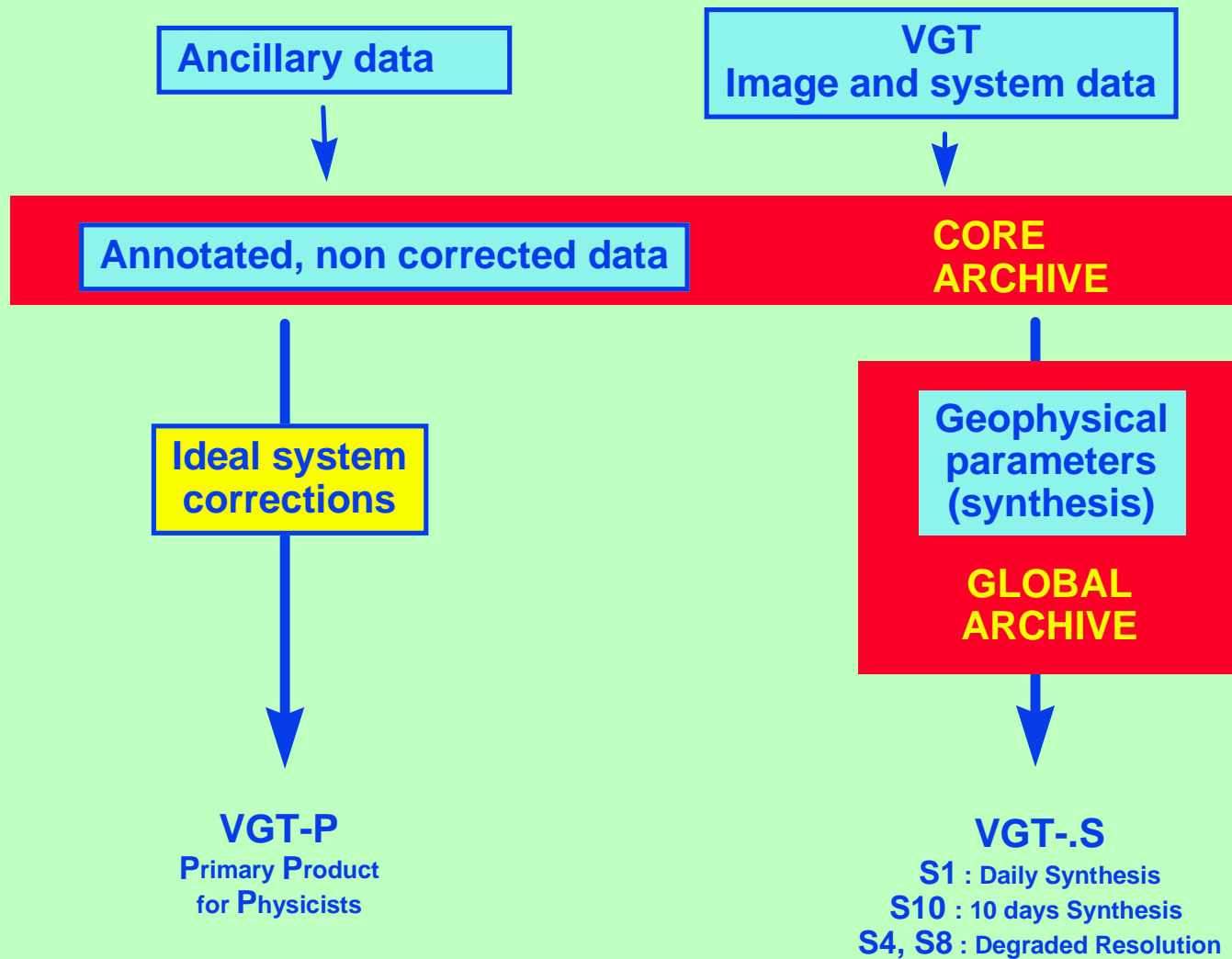
- ◆ no specification given but high compatibility recommended
- ◆ ? : possibility to provide requirements , software package

## Other data sets

- ◆ not available as current products but retain capabilities to provide other data sets (i.e. raw data) under special agreement



# STANDARD PRODUCTS





# VG-T-P

## □ Goals

- ◆ nature and quality designed for physical studies
  - TOA reflectances
  - provide direct multitemporal registration
  - as much coherence as possible with existing high resolution product
  - annotation with ancillary data or metadata
- ◆ ideal instrument (mission specifications)
  - data reference to segments of orbital path

## □ Geometric projection

- ◆ small set of projections (coherent with projections available for High Resolution data)



## VGTS.

### □ Goal :

- ◆ provide synthesis of corrected data for end-vegetation users with coherence to other data sets
  - two types of synthesis :
    - daily
    - decade : full resolution and degraded resolution (4 & 8km)
  - capability to evolve from selection of best measurement in the period to computed representative parameter
  - surface reflectances,
  - some derived surface parameters
    - should be widely known and accepted (i.e. NDVI)
    - capability to add new parameters in evolution of the system
  - data reference to geographic areas



# L band transmission

- ❑ **Image data to be transmitted in real time for HRPT-like regional receiving stations**
  - ◆ operation modes still to be defined to take into account onboard technical constraints and resources
  - ◆ parameters for telemetry acquisition and image correction made available through appropriate means
- ❑ **Telemetry parameters**
  - ◆ Antenna : low-gain cardioid towards Earth center
  - ◆ EIRP : +31dBm at zenith, +33 dBm at 5° elevation angle
  - ◆ Minimal ground flux : -99 dBm/m<sup>2</sup> at zenith, -108 dBm/m<sup>2</sup> at 5° elevation
  - ◆ Central frequency : 1704.0 MHz, RF bandwidth : 2MHz, Polarization : RHCP
  - ◆ Modulation : BPSK
  - ◆ Bit rate : 510 kb/s, symbol rate : 1.02 Mchips (convolutional encoding R=1/2, k=7)
- ❑ **Typical ground station :**
  - ◆ 1.8 m antenna, G/T > 4dB/K at 5° elevation angle
  - ◆ pointing error < 2° (included total margin)
  - ◆ demodulator losses < 1.5 dB
  - ◆ total margin 3.3dB at 5° elevation angle for a Bit Error Rate of 10<sup>-6</sup>



# DATA POLICY

- **High level principles defined by the Cooperation Agreement as a result of the investment done by the partners of the programme and more particularly in the case of the Commission,**
  - ◆ **preferential treatment (if possible free or nominal price) for scientific research programmes carried out or sponsored by the partners including the member states of the European Commission,**
  - ◆ **reduced price for operational application programmes carried out under the responsibilities of the partners (national partners and services of the European Commission),**
  - ◆ **all other users of VEGETATION data will be given access to its products and associated services at market prices, with a view to generate incomes and cover a portion of the operating costs.**



# EXPLOITATION PHASE

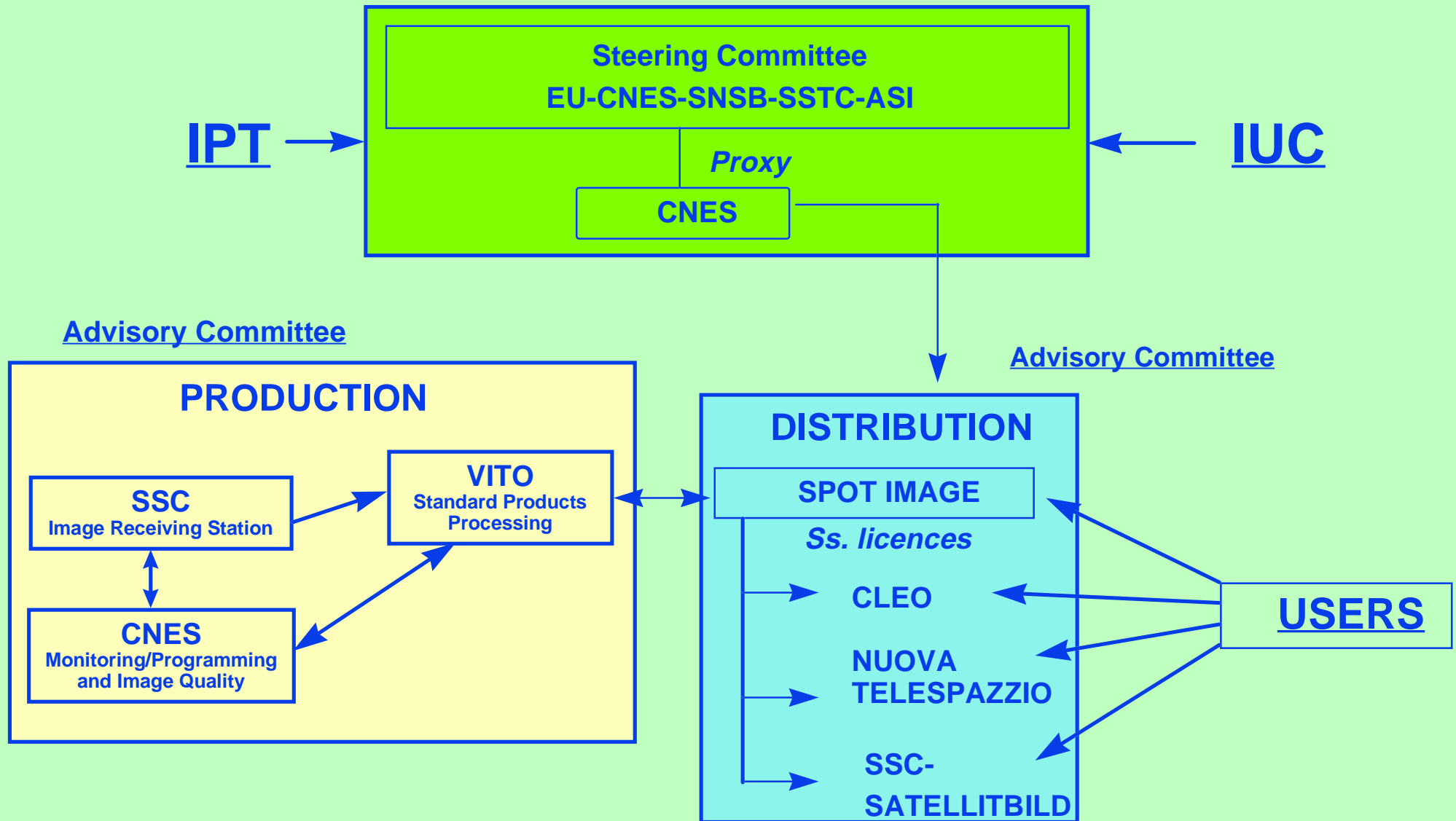
## PRINCIPLES

- Exploitation scheme : efficient, cost effective, reliable
- Respect of the guidelines defined by the Parties
- World-wide marketing approach
- Standard VEGETATION products as defined in the mission specifications
- Data policy :
  - ◆ Non discriminatory access
  - ◆ Principles as defined in the Cooperation Agreement
  - ◆ Will be enforced by the partners towards the distribution organisation
- Financial flow with an objective of selfsustainability of the VEGETATION system in the long term

 Preparation of an Exploitation Agreement



# Exploitation Structure





## EVOLUTION

- Ensure continuity of service with same basic principles :
  - ◆ end users product availability,
  - ◆ multiscale approach
  - ◆ accuracies (stability on the long term for both radiometry and geometry)
  - ◆ regional and global access
  
- Provide enhancements *at the pace of users needs* :
  - ◆ for the next systems improve ground reflectance determination :
    - correct atmospheric and directional effects
    - decrease gap between spatial resolutions (...)
    - characterise directional properties ?

**Next opportunity under discussion between partners :  
SPOT 5 / 2002**



# PREPARATORY PROGRAMME

## Objectives :

- ◆ stimulate interest of a broad community of potential users,
- ◆ prepare for an efficient integration of VEGETATION data sets into projects.

## Considered as a component of the Programme with funding allotted : 2MECU

## Domains for investigations :

- ◆ support to development or improvement of applications using VEGETATION data
- ◆ R&D on the use of VEGETATION specific features,
- ◆ improvement on standard products.

## Conducted under responsibility of IUC

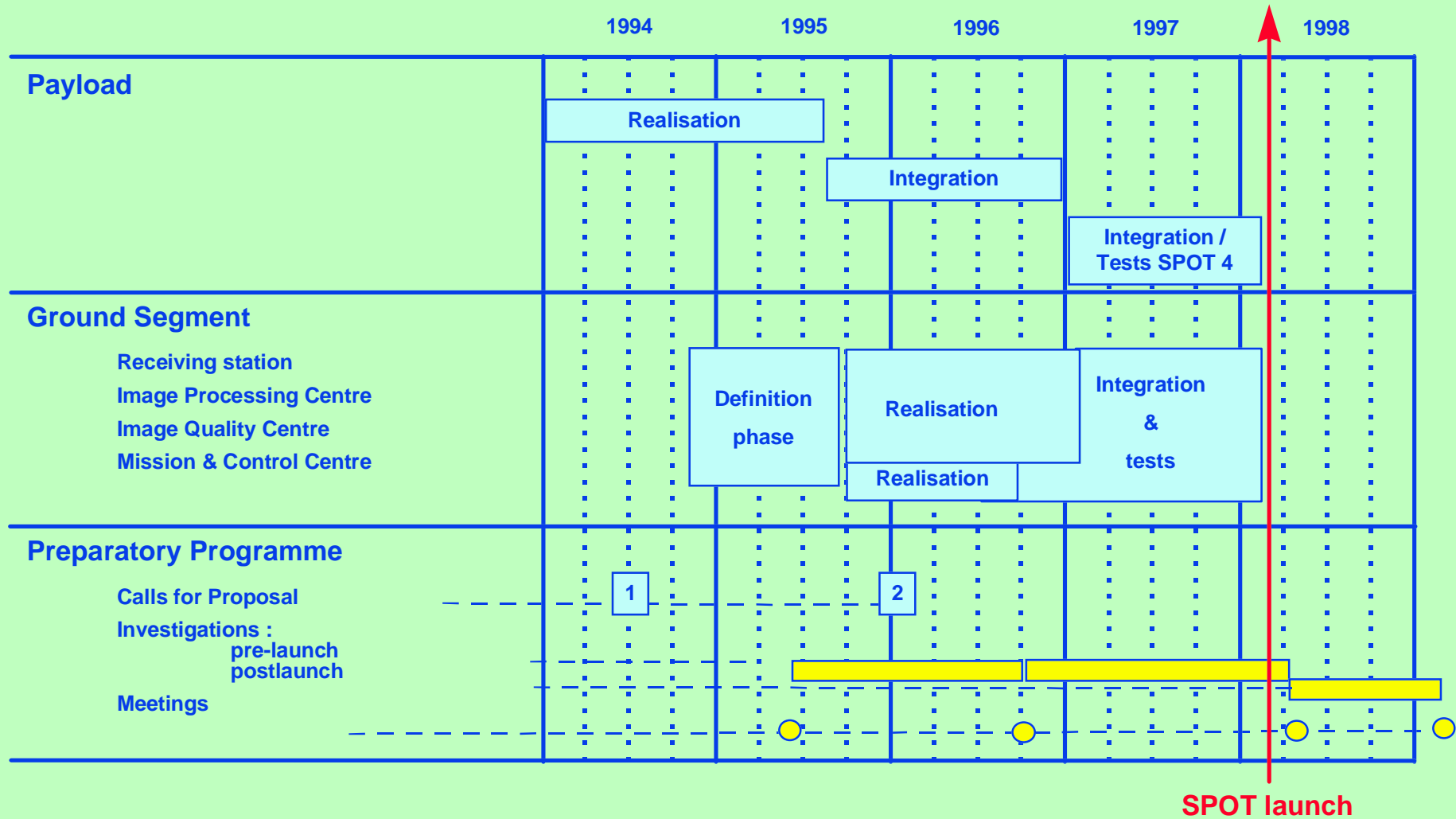
## 32 investigations selected after 2 Calls for Proposals

- ◆ Principal investigators from various countries (Europe, USA, Canada, Brazil, China...)
- ◆ Investigations on a wide range of ecosystems (from tropical to boreal ecosystems)
- ◆ Diversity in thematic domains (agriculture, forestry, rangelands, global change research...)

## Results available through publications, meetings, Internet...



# PLANNING





# Specific merits of VEGETATION

- Basic measurements for identification of land cover and assessment of its conditions,
- Accuracies for radiometry and geometry (Minimum Mapping Unit criterium)
- Multiscale approach using simultaneous High Resolution data,
- Acquisition frequency adequate to follow changes of vegetation canopies (from weeks to years)
- Continuous and global monitoring through :
  - ◆ centralised archiving and processing,
  - ◆ regional receiving stations,
- Operational and long term system for end users,
- Launch opportunity end-97 and SPOT series follow-up



## Contact with VGT-IUC

❑ Email : *iuc.vegetation@jrc.it*  
*gilbert.saint@cnes.fr*

❑ Internet / World Wide Web  
*<http://www-vegetation.cst.cnes.fr:8050/>*

*or through <http://ewse.ceo.org/>*

**for:**

- ◆ Information on the programme,
- ◆ Reference documents : Mission & Product Specifications
- ◆ Newsletters,
- ◆ Examples, illustrations,
- ◆ VEGETATION Preparatory Programme :
  - Calls for Proposals,
  - Results when available