cnes

CENTRE NATIONAL D'ÉTUDES SPATIALES

ORFEO Preparatory Program

S. CHERCHALI
CNES (DCT/SI/AP)

---

cnes   **ORFEO Preparatory Program**   ORFEO
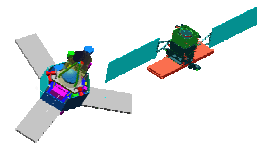
- *Objectives* :
  - To define evaluate and prepare adequate future **Services**
  - To prepare **Users** to develop their own routine processes
    - *"in very close cooperation with the final users"*
    - *"at ORFEO level to give the best answer"*
- *Two complementary approaches*
  - **Thematic** : 55 users (mainly from institutions)
    - Better understanding of the users needs in terms of services
    - Better understanding by the users of the performances and system limitations
  - **Methodology :** About 50 researchers from 25 institutes
    - Definition and development of tools for the operational exploitation of the images :
      - High volume of data's : Automatic processing mandatory
      - Processing techniques to be adapted to the new kind of visible objects
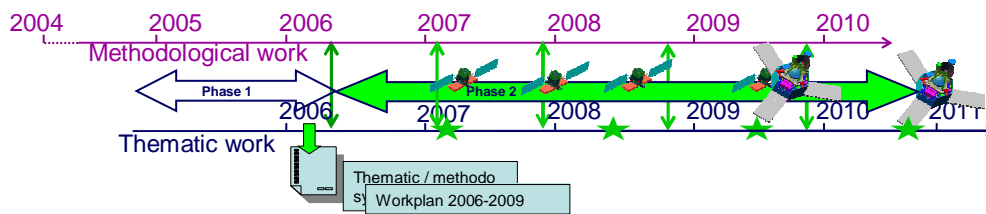
→ New **Tools for Interpretation**, *new algorithms*
→ **Applicative Processing Chains** *(Automatic or semi-automatic)*

ORFEO Preparatory Program

- **Two phases :**
  - Phase 1 : Identification of **users needs** (Services, Value-added Products, Tools)
    Identification of methodology **state of the art**
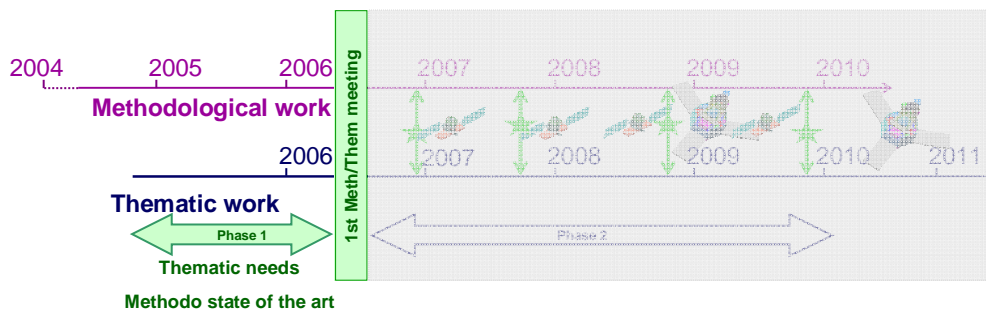 - Phase 2 : Services & tools **development**, **validation** through feasibility studies

We are now in Phase 2 of the ORFEO Preparatory Program

2004   2005   2006   2007   2008   2009   2010

Methodological work

Phase 1   Phase 2

2006   2007   2008   2009   2010   2011

Thematic work

Thematic / methodo
sy Workplan 2006-2009

Phase2 objectives :	Demonstrate the capacity of ORFEO data for development of **New Services**
	Facilitate ORFEO users tasks, thanks to **Specific Tools** :
	ORFEO ToolBox, Applicative Chains

ORFEO
Phase 1 : Program progress

- **Phase 1 :**
  - **Thematic activities : Identification of needs in terms of products, services, tools and proposition of thematic feasibility studies**
  - **Methodology activities : State of the art; R&D and research; assessment of technical readiness of "priority functionalities" as defined by thematic groups.**

2004   2005   2006

Methodological work

2006

Thematic work

1st Meth/Them meeting

2007   2008   2009   2010

2007   2008   2009   2010   2011

Phase 1   Phase 2

Thematic needs

Methodo state of the art

ORFEO - Phase 1 : Thematic Activities
Composition of the Thematic WG

1- **Ocean & Coastal zone**
2- **Risks & Humanitarian aid**
3- **Cartography**
4- **Geology & Geophysics**
5- **Hydrology**
6- **Forest**
7- **Agriculture**
8- Defence

Thematic WG mission:

• Expression of convergent users needs

• Specification of value-added products&services

• Feasibility tested through pratical studies

Belgian experts are present in 5 WG
Austrian, Spanish and Swedish experts have recently integrated 5 WG

Spot Image representatives are present in 5 WG

ORFEO - Phase 1 : Thematic Activities
Product data sheet

■ **General description, objectives**
■ **Technical specification**
  ◆ **Information required (nomenclature, spatial accuracy, precision level)**
  ◆ **Ancillary data required**
  ◆ **Surface and scale of elementary product**
  ◆ **Format**
■ **Operational constraints assessment**
  ◆ **Temporal constraints, delay between request and data reception, …**
■ **Yearly acquisitions evaluation**
  ◆ **nb km², geographical location, …**

→ **More than 150 Product data sheet expressed**

cnes

ORFEO

■ **Example of Product data sheet** – **WG Risks & Humanitarian aid**

FICHE PRODUIT ORFEO

GT « Risques, Interventions rapides en cas de crise, Aide Humanitaire »

Type de Risque : MOUVEMENT DE TERRAIN	Phase : PENDANT CRISE

Nom du produit : SUIVI Mouvement de Terrain, Séisme

Objectif recherché (3 lignes):
Mettre en évidence les zones touchées par le mouvement de terrain
Définir les zones touchées occupées par l'activité humaine (habitat, agriculture) et le niveau d'atteinte
Figer éventuellement un dispositif opérationnel terrestre

Spécifications techniques du produit

Contenu en information et précision associée :

Information recherchée, nomenclature...
- o Image
- o Zone du séisme mouvement de terrain
- o Définir les zones formant une étendue d'eau suite au sinistre (modification du MNT)
- o Déterminer les ressources de lutte : points d'eau naturels et artificiels (citernes) zones de poser hélicoptères, zones de repli de population
- o Définir les contraintes : habitat isolé, établissements de plein air, lieux de rassemblements de personnes, accès pour évacuation, et détermination de l'impact du feu : destruction, sinistré, comptage
- o Visualiser le dispositif de lutte : engins terrestres, zones d'épandages de retardant coloré

Précision
5 m en x,y

Surface géographique à couvrir (ou plage de surfaces)
Zone touchée

---

cnes

ORFEO

■ **Example of Service/Product data sheet** – **WG Risks & Humanitarian aid**

Fiches du GT2

Dernière mise à jour le 15/09/2005

- Fiche DDSC n°1 Grands Evénements
- Fiche DDSC n°2 Tremblement de Terre
- Fiche DDSC n°3 Secours à personnes
- Fiche DDSC n°4 Inondations
- Fiche DDSC n°5 Feux forêts
- Fiche DDSC n°6 Risque technologique
- Fiche EMA Inondations 1
- Fiche EMA Inondations 2
- Fiche EMA Inondations 3
- Fiche ERM carte crise
- Fiche ERM carto base
- Fiche ERM plannification deminage
- Fiche ERM refugies
- Fiche ERM risque deminage
- Fiche MNR n°1 Zones inondées
- Fiche MNR n°2 Hauteur d'eau
- Fiche MNR n°3 Durée d'immersion
- Fiche MNR n°4 Zones tempêtes
- Fiche MNR n°5 Dégâts urbains tempête
- Fiche MNR n°6 Dégâts forêts tempêtes
- Fiche SDIS 83 FF Avant
- Fiche SDIS 83 FF Pendant
- Fiche SDIS 83 FF Apres
- Fiche SDIS 83 MAREE BLANCHE
- Fiche SDIS 83 MAREE NOIRE AVANT
- Fiche SDIS 83 MAREE NOIRE PENDANT
- Fiche SDIS 83 MNT MNE
- Fiche SDIS 83 MNT MNE CRISE
- Fiche SDIS 83 MVT TERRAIN SEISME
- Fiche Sertit geo coule de boue
- Fiche Sertit geo glissement terrain
- Fiche Sertit geo tremblement terre
- Fiche Sertit geo volcan
- Fiche Sertit hyd met inondations 1 extension
- Fiche Sertit hyd met inondations 2 dynamique
- Fiche Sertit hyd met inondations 3 impact
- Fiche Sertit hyd met tempete cyclone
- Fiche Sertit nat anthro feux foret
- Fiche Sertit nat anthro indus

Slide 9

cnes — ORFEO - Phase 1 : Thematic Activities
Synthetic products by Thematic WG — ORFEO

- **What is useful : Example of WG Ocean & Coastal zone**

Required observations	Thematic / rationale
Vessel position	Security (1), Direct or chronic pollution (2)
Coastline delineation	Environmental monitoring
Survey of benthic typologies	Environmental monitoring, preservation of the biodiversity
Water composition in coastal areas	Survey of water quality
Cartography of coastal habitats	Preservation of the biodiversity
Mapping of artificial infrastructures at coast	Pressure on the environment
Oil pollution detection and follow-up	Environmental monitoring, regulation
Nomad tourism mapping	Pressure on the environment, security
Nomad moorings mapping	Pressure on the environment, security
Land use on the MPD	Pressure on the environment, regulation
Characterisation of areas to be classified as "espaces remarquables"	Pressure on the environment, regulation

Slide 10

cnes — ORFEO - Phase 1 : Thematic Activities
Common Needs from product sheets — ORFEO

- **VERY FREQUENT REQUESTS**
  - **Product in local cartographic projection**
    - Compatible with GPS
  - **Product generation can request the use of several images**
    - Coming from different satellites system
    - Having different resolution
  - **Product generation can request the use of others kind of data**
    - Aerial photo
    - Existing data base
    - Ground truth
  - **At this scale, 3D analysis is necessary**

cnes

ORFEO - Phase 1 : Thematic Activities
Common Needs from product sheets

ORFEO

■ **VERY FREQUENT REQUESTS**

  ◆ **At this resolution, we want to detect, recognize and identify «objects »**

    • What « object » ? : linked to the priorities of the Work Group

  ◆ **We want to estimate some « attribute » of the requested « objects »**

    • « Attribute » can be :
      – Geometrical attribute : localisation, dimension,…
      – Content attribute : type of material, …
      – Quality attribute : object destroyed or not, …
      – Relational attribute : object related to another one (networks)

---

cnes

ORFEO - Phase 1 : Thematic Activities
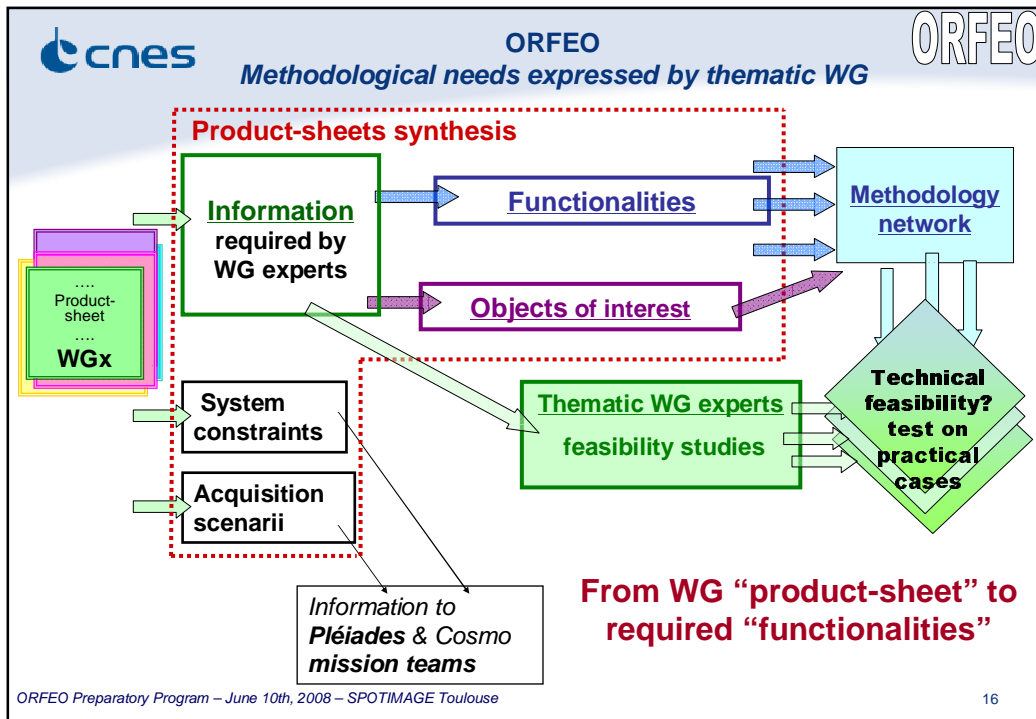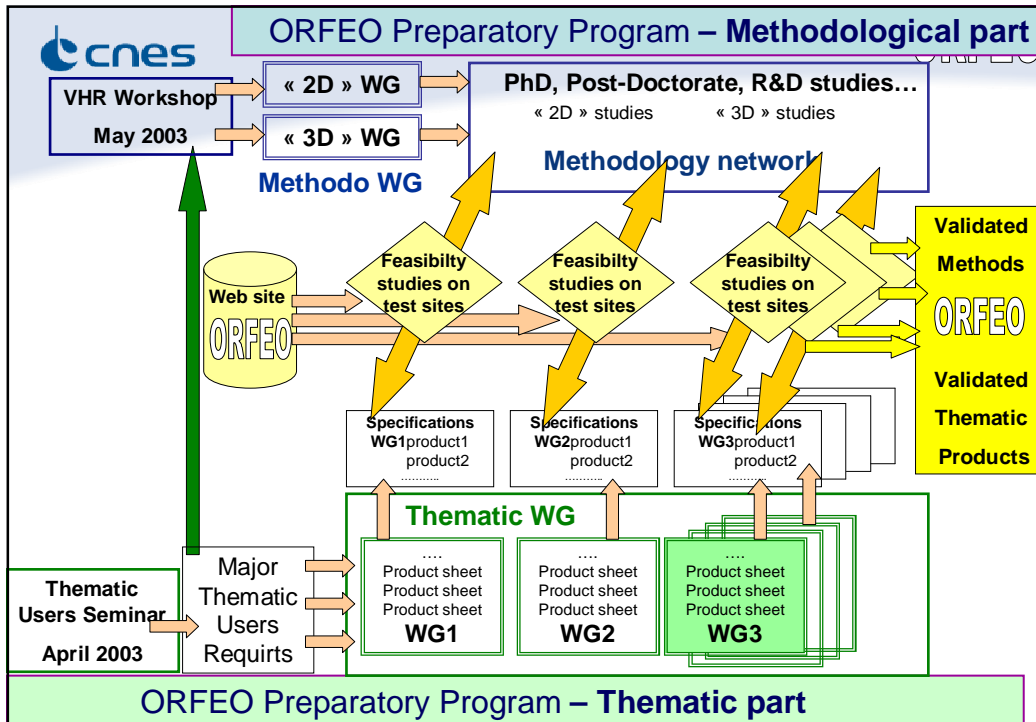**Common Needs from product sheets**

ORFEO

■ **VERY FREQUENT REQUESTS**

  ◆ **What has changed?**

    • Affected areas, objects impacted by a disaster
    • New construction or infra structure
    • Forest exploitation
    • New equipments in coastal areas
    • Agricultural practices
    • Water content or volume

⨁ cnes　　　ORFEO - Phase 1 : Thematic Activities
Common Needs from product sheets　　　ORFEO

■ **VERY FREQUENT REQUESTS**

  ◆ **Communication aspects are important**

  ◆ **What about the radar data?**

    • Access conditions, costs, programming condition, time delivery, ...

  ◆ **Interferometric possibilities**

⨁ cnes　　　ORFEO - Phase 1 : Methodology Activities
Summary　　　ORFEO

■ **State of the art and methodological hints from April's 2003 "Users workshop"**

  ◆ **Organization: 7 workgroups**

    • 2D
      – Multiscale, ancillary data
      – HR X-SAR
      – From pixels to objects
      – From objects to scenes
    • 3D
      – Optical 3D in urban areas
      – Deformations
      – SAR 3D

■ **June 2005 methodological meeting**

  ◆ **Goals update and refinement : "Functionality-oriented" workplan**

■ *Present document :*

  ◆ *About 100 pages*

  ◆ *More than 200 bibliographic references*

  ◆ *Released in January 2006*

ORFEO Preparatory Program – **Methodological part**

« 2D » WG
VHR Workshop
May 2003
« 3D » WG
Methodo WG

PhD, Post-Doctorate, R&D studies…
« 2D » studies   « 3D » studies
Methodology network

Web site
ORFEO

Feasibilty studies on test sites
Feasibilty studies on test sites
Feasibilty studies on test sites

Validated Methods
ORFEO
Validated Thematic Products

Specifications WG1 product1 product2
Specifications WG2 product1 product2
Specifications WG3 product1 product2

Thematic WG

Thematic Users Seminar April 2003

Major Thematic Users Requirts

Product sheet Product sheet Product sheet WG1
Product sheet Product sheet Product sheet WG2
Product sheet Product sheet Product sheet WG3

ORFEO Preparatory Program – **Thematic part**

ORFEO
Methodological needs expressed by thematic WG

Product-sheets synthesis

Product-sheet WGx

Information required by WG experts

Functionalities

Objects of interest

Methodology network

System constraints

Acquisition scenarii

Thematic WG experts feasibility studies

Technical feasibility? test on practical cases

Information to *Pléiades* & Cosmo *mission teams*

From WG "product-sheet" to required "functionalities"

cnes   ORFEO - *Methodological needs expressed by thematic WG*
Objects and functions relating to a theme
ORFEO

Risk Objects
- Burnt areas
- Gas tanks
- Ploughlands
- Military camps
- Cars
- Shelters
- Log jams
- Wetlands, burnt areas, areas cleared of brushwood,
- ....

Agricultural Objects
- Crops
- Row formations
- Grassed borders
- Slash-and-burn agriculture
- Winter vegetation
- ....

Geological Objects
- Faults
- Terraces
- Lava flow
- ....

Geological Functions
- Centimetric 3D displacements
- Set of correlated surface measurements
- ...

Agricultural Functions
- Soil humidity
- Roughness
- Variability of soil properties
- Agricultural practices
- Surface changes
- Health indicators
- Quantitative and qualitative estimation
- ....

Hydrology Objects
- Saturated areas
- Hydrogr. network
- Major & low-water bed
- .....

Risk Functions
- Calculating water levels
- Duration of flooding
- Depth of snow
- ....

Hydrology Functions
- Soil moisture content
- Soil roughness ...

cnes   ORFEO - *Methodological needs expressed by thematic WG*
Objects and functions relating to a theme
ORFEO

Cartographic Objects

Cartographic nomenclature at 10.000e, 25.000e   BD Carto, Scan25, BD Topo
- Networks
- Industrial area
- Commercial area
- Housing
- .....

Sea and Coastline Objects
- Sand
- Seagrass beds
- Rocks
- Coral
- Ships
- Colour of water
- Oil discharge
- Anchorage zones
- Sea defense breakwater
- ...

Forest Objects
- Forest stands
- Isolated trees
- Lanes
- .....

Cartographic Functions
- DEM (urban 3D models)
- Alert / 3D changes
- Surface measurements
- DTM, slopes, orientations
- Virtual reality
- ....

Sea and Coastline Functions
- Speeds and headings (ships)
- Surface currents
- Wave directional spectrum, sea state
- Swell: height, direction, length of wave
- Wind speed and direction
- ....

Forest Functions
- Tree recognition
  - Type, height, top
  - Estimation of damage
  - Budbreak, senescence, abnormal change in reflectance
  - Exposure (derived from DTM)
  - ...

	Thematic studies started (optical and radar)						Total/GT
	end 2004	end 2005	2006	2007	2008	AO CSK 08	
GT1 / Sea & Coastline		3				3	6
GT2 / Risks & Humanitarian aid		2	1			1	4
GT3 / Carto. & Town planning		2	2		1	3	8
GT4 / Geology & Geophysics	1		1			4	6
GT5 / Hydrology		2		2	1	1	6
GT6 / Forest			1			2	3
GT7 / Agriculture	1	4				4	9
GT8 / Security & Defense				2		6	8
Total studies					26	24	50

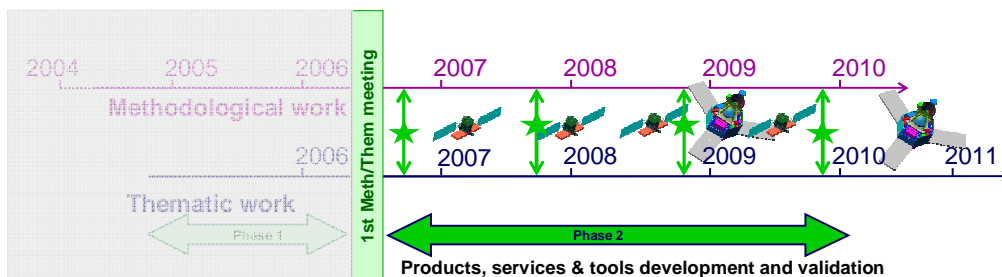**26 studies** **started since 2004** (http://smsc.cnes.fr/PLEIADES)

Most of them use QuickBird or Ikonos images as input data

2 use Pléiades simulated data; 1 use Cosmo-like images (on 4 sites)

Preference to studies requiring CSK & Pleiades data : **CSK AO in april 2007**

ORFEO experts have contributed to this AO : 24 studies presented

---

- **We are now in Phase 2 of the ORFEO Preparatory Program**
- **Phase 2 :**
  - **Services & tools development, validation through feasibility studies**

cnes ORFEO - *Methodological needs expressed by thematic WG*
Generic Functionalities to develop
ORFEO

■ **Methodological needs expressed by thematic WG → Functionalities to develop**
  ◆ **Main "geometric" functionalities**
    • **Images superposition : Optical / Optical**, Optical / SAR, **SAR / SAR**
    • **Image / map and image / geographical database superposition**
    • Localisation**,** ortho-rectification, projection in the local geographical reference system
    • **Correlation map – Distortion calculation (3D)**
    • **DTM & DEM**
    • **3D navigation (at t, t+Δt….**
  ◆ **Radiometry: Reflectance estimation (atmospheric correction, calibration, radiative transfer model ….)**
  ◆ **Objects of general interest (VHR object Database)**
  ◆ **Information extraction**
    • **Objects recognition (specific list to be built)**
    • **Specific land cover classification (burnt areas; flooded areas..)**
    • Change detection between 2 or more images, **optical/SAR : damaged areas identification**
    • **Change detection for some identified and recognized objects**
    • Identification of some specific land cover classes (specific list to be built)
    • **Calculation: water height, flood duration, …**
      **   snow height, …**
    • Vectorization of areas

---

cnes ORFEO - *Methodological needs expressed by thematic WG*
Objects of general interest
ORFEO

■ **NETWORKS AND INFRASTRUCTURES**
  ◆ **Road networks**
    • With or without asphalt surfacing
  ◆ **Railways**
  ◆ **Hydrographic networks**
  ◆ **Built-up areas, buildings**
  ◆ **…**
■ **LANDSCAPE**
  ◆ **Plots**
  ◆ **Access roads**
  ◆ **Drainage canals**
  ◆ **Hedgerows**
  ◆ **Ditches**
  ◆ **Forests**
  ◆ **Glaciers**
  ◆ **Trees**
  ◆ **Vines**
  ◆ **Orchards**
  ◆ **Permanent grasslands**
  ◆ **…**

■ **...**

cnes
Object database development using VHR images

■ **Development of a predefined object catalogue**
- ◆ **Catalogue can be a support**
  - • for algorithmic tests of extraction information tools
- ◆ **Catalogue interesting different themes considered in Orfeo Preparatory Programme**
  - • Sea & Coastal areas
  - • Risk & Humanitarian aid
  - • Geology & Geophysics
  - • Hydrology
  - • Forest
  - • Agriculture
  - • Cartography & town and country planning
- ◆ **Information sources**
  - • QuickBird images used as basic information in Orfeo thematic studies
  - • Reports and presentations prepared by the thematic groups
  - • Thematic studies reports

---

cnes
Object database : Attributes concerning some objects of general interest

■ Networks and infrastructures: Attributes:
- ◆ **Road networks**   **Type of surfacing, width**
- ◆ **Railways**
- ◆ **Hydrographic networks**   **Connections**
- ◆ **Built-up areas, buildings,**   **Type: dense, residential, commercial, hospitals,**
  ….   **Geometry: perimeter, volumes, facets**
- ◆ **Car parks**   **Outline, type of surfacing**
- ◆ **Bridges**   **Local width**
- ◆ **Dykes**   **Length, width**
- ◆ **….**

> *The « **VHR ORFEO** Database » integrates most of these objects, from the QuickBird images or Pléiades simulations on the thematic test sites*

ORFEO
ORFEO ToolBox - Presentation

- **Goals: make easier the**
  - ◆ **development of new algorithms,**
  - ◆ **their validation,**
  - ◆ **their capitalisation**
  - ◆ **development of tools for the users of the ORFEO system**
- **CNES is responsible for specification and validation**
- **Source code available for the labs, the users and the AVC**
- **AO won by CS**

- **Input from the methodology group**
  - ◆ **Regular updating of the "Synthesis document"**
  - ◆ **Feedback on the use of the OTB**
  - ◆ **Feedback on the use of simulation data**

ORFEO - ORFEO ToolBox
Development

-

TB development must focus on "priority functionalities"

-

dentification of "priority functionalities" depending on several parameters :

- **1- Functionalities required by thematic users**
- **2- Technical feasibility**
- **3- Technology readiness, quoted from 1 "research on basic technology" to 9 "fully operational"**
  - R1   R4   R7   R9
- **4- OTB perimeter :**
  - **generic functionalities**
  - **existing legal engagements, © and licences (DIAPASON, Medicis, …)**
- **5- Financial and human means**

■ **Pre-processing functionalities** (geometry and radiometry)

  ◆ **Image/Image registration**

  Basis postulate : final accuracy highly dependent on DTM quality

  • Visible/Visible :
    – **Spot5 / PHR** : Readiness level 7 (**R7**)
    – **PHR / PHR** :   at ground level : **R7**
                                        at 3D level : **R4** (3D model, multiple viewings…)
    – **PHR / QB or Ikonos**:   at ground level : **R7**
                                        at 3D level : **R4** (3D model, multiple viewings…)
  • Radar/Radar :
    – **ERS, Envisat / CSK** : **R7**
    – **CSK / CSK** :   at ground level : **R7**
                                        at 3D level : **R4**
    – **CSK / TerraSAR, SARLupe** (?) at ground level : **R7**
                                        at 3D level : **R4**
  • Visible / Radar : CSK/PHR, CSK/Spot5, ERS-Envisat / PHR, ERS-Envisat/Spot5
    – At ground level : **R6**
    – At 3D level : **R2**

■ **Processing functionalities (information extraction)**

  ◆ **Object Detection (only on optical images)**
    • Learning from "examples DB" (adapted to *elementary* objects):
      – **Some examples of objects** from Thematic WG lists : docked ship, sea breakwater, bridges, stadiums, isolated house, isolated tree, agricultural silo
      – **Existing tools adapted to Spot5 data** (CNES R&D), to be integrated into OTB
      – **Tools to be tuned to PHR images** for integration into OTB: **R6**   with *PHR objects DB to be built* and *thematic studies* for testing it !
    • Detection using geometric model of objects (for *simple* geometric objects):
      – **Some examples of objects** from Thematic WG lists : road and railway networks, hydrographical network, large building in industrial or commercial areas, airport tracks, dykes, agricultural plots, structured orchards
      – **R&T studies funded by CNES (INRIA, CMLA)** (very complex methods) **R4**
      – **Integration into OTB is foreseen** but will not be easy nor rapid
    • Spatial reasoning (for *complex* or *composite* objects) :
      – **Some examples of objects** from Thematic WG lists : airport, campground, residential area, commercial area, sports complex, cemetery, nuclear power plant, refugees camp, hospital ?, mass human gathering?, car parks, …
      – At the present time, **no scientific team working on this topic** in ORFEO framework
      – **Thesis scheduled end 2006 at CNES R2 R3**

■ **Processing functionalities (information extraction)**

- **Change detection**
  - Change indicators / Alarms ("Surface" approach)
    - Visible /Visible : **R6 R7**
    - Radar / Radar: **R6 R7**
    - Visible/ Radar : work to be done ! **R2 R3**
  - Change indicators / Alarms ("Object" or "3D" approach)
    - Work to be done ! **R2 R3**
- **Change characterisation**
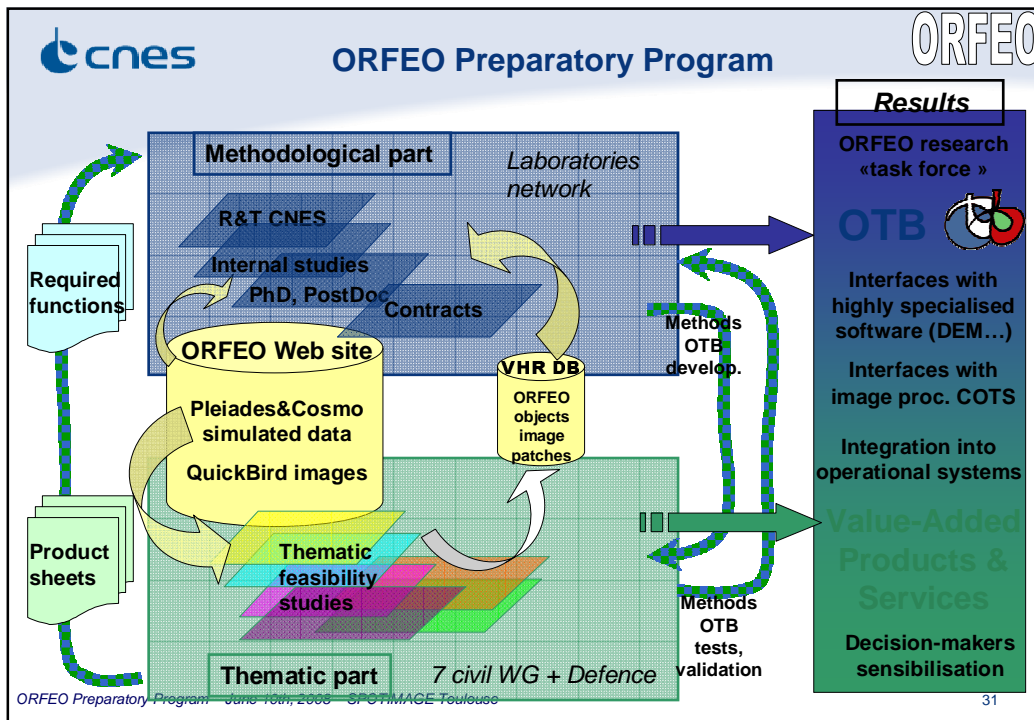 - Characterisation of damages, building/destruction, … ? R2 R3
- **Change quantification**
  - Very specific to the type of change.
  - For ground movements, with Visible or Radar : R6 R7
  - In majority of other cases … R2 R3

■ **Processing functionalities (information extraction)**

- **Land Cover Classes extraction**
  - Segmentation and Classification (supervised, non supervised)
    - **Several existing tools adapted to Spot5 data**
    - **Tools to be tested to PHR images** before integration into OTB (shadows, heterogeneity, hidden faces…) : **R6 R7** (Thematic studies)
    - **Development of new classification tools ?**
      Work to be done ! **R2**

Results

ORFEO research «task force »

OTB

Interfaces with highly specialised software (DEM…)

Interfaces with image proc. COTS

Integration into operational systems

Value-Added Products & Services

Decision-makers sensibilisation

Methodological part

Laboratories network

R&T CNES

Internal studies

PhD, PostDoc   Contracts

ORFEO Web site

Pleiades&Cosmo simulated data

QuickBird images

VHR DB

ORFEO objects image patches

Required functions

Product sheets

Thematic feasibility studies

Thematic part

7 civil WG + Defence

Methods OTB develop.

Methods OTB tests, validation

ORFEO Preparatory Program
Conclusion

- **The approach adopted during the preparatory programme for use has a twofold purpose:**
  1. **Check whether the data can meet the specified requirements ?**
  2. **Simplify the production of specified information requirements**

- **Point 1.** is covered by supplying DATA (simulated images) to the EXPERTS, for performing feasibility studies
- **Point 2.** is being covered by the "general tools" from CNES R&T and results of preparatory programme (link with methodology groups, OTB…)

- **Requirements expressed by the 8 thematic WG will drive**
  - **the "methodology" experts and the CNES R&D programme**
  - **the feasibility projects, in each thematic WG**

ORFEO Preparatory Program

- **ORFEO Web site:**
  http://smsc.cnes.fr/PLEIADES/

- **Regularly updated :**
  - Program information: planned meetings, minutes….
  - Methodology documentation
  - Thematic documentation
  - Access to images

- **Additional data, new presentation of WG product-sheets, WG Synthesis reports, …**