

The Pléiades Optical High Resolution Program

- Introduction : overall context
 - System description
 - Development status

Genesis of the Program

- End of the 90's CNES made some preliminary studies on the need of a constellation of satellites providing high resolution and multi spectral data under the name of "Pléiades".
- During the same period the Italian Space Agency performed the same analysis under the name of "COSMO-Skymed"
- France and Italy converged on the need to serve Civilian users (Institutional and Commercial) and Defence users with optical and radar capabilities
- An Inter Governmental Agreement has been signed beginning of 2001 at the level of chiefs of Government to establish a joint program named ORFEO

The Inter Governmental Agreement

- Define the responsibility of both countries
 - ♦ Optical component including two satellites with the related ground segment under the leadership of CNES – The “Pléiades” program
 - ♦ Radar component including four satellites with the related ground segment under the leadership of ASI – The “COSMO-SkyMed” program
- Recall the dual objectives
 - ♦ Accomplishment of civilian / commercial users needs in term of operational capacity, rapid access to the data, adequate image availability, competitiveness of the services
 - ♦ Protection of defence interests in term of security and priority of mission requests
- Define the principles of resources sharing, data ownership and distribution, policy

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Cooperation within the Pléiades Program

- Taking benefits of the well established cooperation within the Spot program with Belgium and Sweden and within the Helios program with Spain, a multi partners cooperation has been set up with
 - ♦ Sweden *Swedish National Space Board*
 - ♦ Belgium *Federal Office for Space Policy*
 - ♦ Spain *Instituto nacional de Tecnica Aeroespacial*
 - ♦ Austria *Osterreichische Forschungsforderungesellschat*
- Each country will have access to a % of Pléiades resources in term of satellite tasking and in term of image production for institutional and non commercial use. Their quota of access proportional to their funding participation to the Pléiades program.

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Access to the Resources and Data Policy

■ **Two ways to access the system**

◆ **Through the defense channel**

- Cooperating defences may have a direct access to the satellites and the capabilities to receive and process the data on dedicated sites for defense high priority request
 - 50 requests maximum per day for 2 satellites (among 700)

◆ **Through the Civil Channel**

- For the other users, responsibility of tasking, data reception, processing, archiving and distribution is given to a Civilian Operator

■ **Data Policy**

- ◆ **CNES is the holder of the copyright**
- ◆ **Licence to use granted to defence, cooperating countries and institutional users for non commercial use**
- ◆ **Full and exclusive licence for data under the responsibility of the Civilian Operator**

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Access to the Resources through the Civil Channel

■ **Civil Channel operated by a Civilian Operator**

◆ **Through a « Public Service Delegation »**

◆ **Resources are allocated**

- 40% for Institutional bodies and cooperating countries for Institutional bodies and cooperating countries
- 60% for commercial use

■ **Spot Image chosen after an European Call for Tender in July 2004**

◆ **Delegation signed in December 2007**

■ **Mission of Spot Image**

◆ **Development tasks**

- To develop the Civil Centre

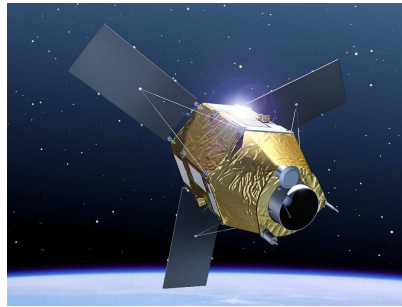
◆ **Operational tasks**

- To take into account users needs and elaborate the programming
- To receive and archive the data and update the catalogue
- To process and deliver the products,
- To promote Pléiades

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Pléiades Main Mission Requirements

- **Revisit Capability**
 - ◆ Daily accessibility to any point on the globe
- **Improved access image delay**
 - ◆ Better than 36 hours between image request and image delivery in nominal mode
 - ◆ 24 hours in very urgent mode
- **Large coverage capability**
 - ◆ Around 30 000 km² per orbit
 - ◆ Average area of more than 2 500 000 km² over a year including weather statistics (cloud free images).
- **Image characteristics**
 - ◆ 0.7 m Pan resolution at nadir
 - ◆ four XS bands (blue, green, red, near IR) with 2.8 m resolution at nadir
 - ◆ 20 km swath at nadir



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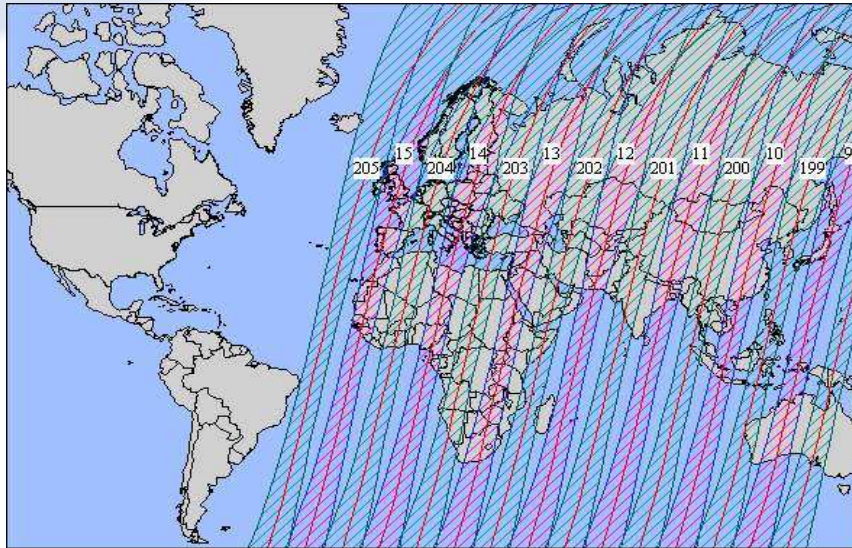
Orbit and Accessibility

- **Orbit:**
 - ◆ Sun-synchronous, phased and quasi-circular at 698 km,
 - ◆ 26-day cycle, crossing the descending node at 10:30 local time,
 - ◆ 180° offset between the two satellites.
- **Revisit :**
 - ◆ With one-satellite and a viewing angle of 47°: 2 d days revisit
 - ◆ with 2 satellites and a viewing angle of 43°: daily revisit

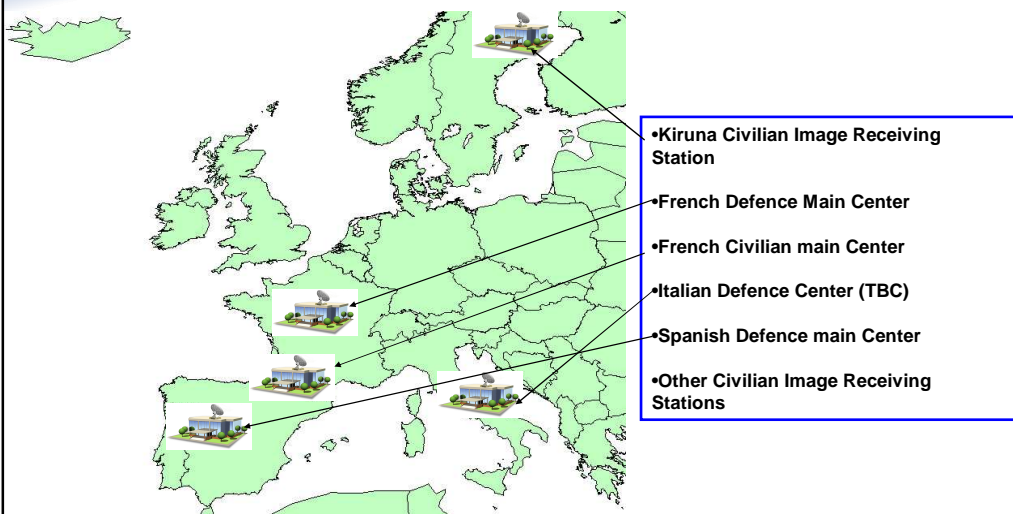
Viewing angle	1 satellite	2 satellites	resolution
5°	26 days	13 days	0,7 m
20°	7 days	5 days	
30°	5 days	4 days	1 m
50°	2days	1 day	2,25 m

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Daily access at 30° for 2 satellites



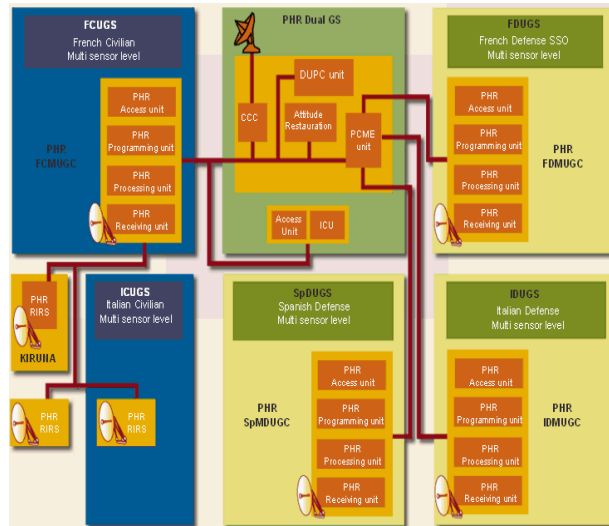
The Pléiades System



The Ground Segment

Each user centre includes

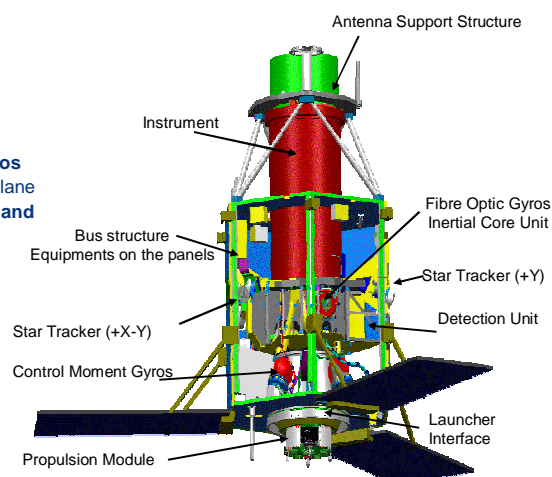
- ◆ X band antenna in charge of satellite acquisition and 3 demodulation channels
- ◆ Image Processing Unit in charge of Inventory, Catalogue, Archive and Images production
- ◆ Programming Unit for managing the users requests
- ◆ Set of access unit to browse the image catalogue, submit requests and receive the ordered products



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The Pléiades satellites

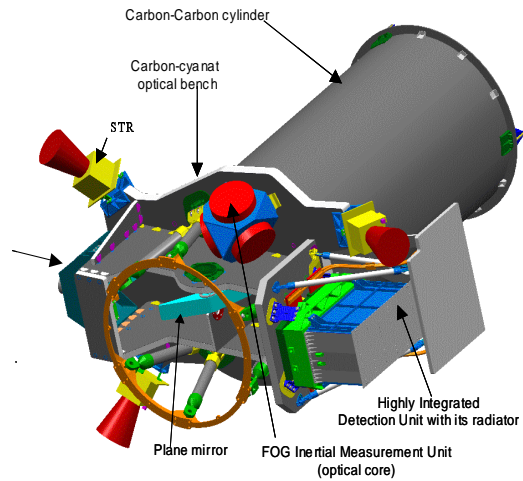
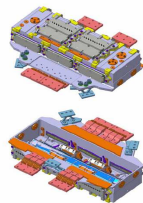
- **Mass 1 ton**
- **Power**
 - ◆ Lithium-ion batteries
 - ◆ Rigid AsGa solar panels – 1.5 kW
- **AOCS**
 - ◆ High Agility with 4 Control Moment Gyros
 - 5°/6.5s, 10°/10s, 60°/25s in roll-pitch plane
 - ◆ High image quality with 3 star sensors and Fibre Optic Gyros
- **Image telemetry: 465 Mbps X band**
- **Mass memory: 600 Gbits EOL**
- **Pointing Accuracy <200 m**
- **Image location Accuracy <10m**



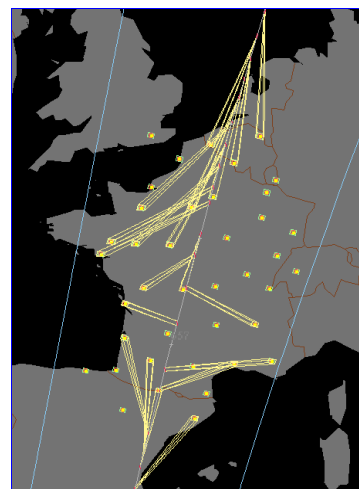
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- **High satability instrument**
 - ◆ Fine sensor heads mounted on the instrument for maximum geometrical quality accuracy
- **Telescope**
 - ◆ Korsch type combination
 - ◆ Primary mirror size 650 mm
 - ◆ Focal length 12,9 m
- **Detection**
 - ◆ PA 5 TDI 6000 X 13 Microns
 - ◆ XS 5 CCD 1500 X 52 Microns with four lines for the four colours

- B0 (blue): 430-550 nm
- B1 (green): 490-610 nm
- B2 (red): 600-720 nm
- B3 (NIR): 750-950 nm

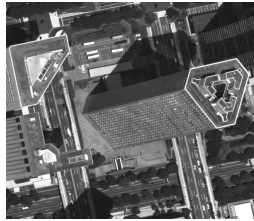


- **Up to 450 images per day and per satellite**
 - ◆ In a 50° cone around vertical (30° with all performances)
 - ◆ High agility permits to minimize conflicts between users
- **Commercial mission over Europe:**
 - ◆ 40 targets to acquire, each with a diameter of 15 km, spread over an area of 1000 x 1000 km².
 - ◆ 20 targets acquired in a single pass with a viewing angle of +/- 30° thanks to agility



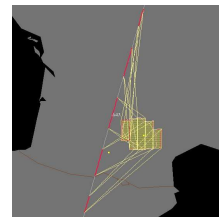
■ Simultaneous stereo capacity with 1 satellite on 1 pass

B/H	Stereo length	Tri -stereo length
0.1	25 km	-
0.2	80 km	25 km
0.4	195 km	80 km
0.6	315 km	135 km
0.8	350 km	201 km
1	350 km	260 km



■ Coverage capacity with 1 satellite on 1 pass

Coverage wide	Authorized access	Segment length
80 km (4 strips)	Up to 20°	110 km
	Up to 30°	205 km
120 km (6 strips)	Up to 20°	45 km
	Up to 30°	110 km



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■ Raw image **System characterisation**

- ◆ 5 bands, decompressed data
- ◆ Detector normalisation performed on board
- ◆ System level location performance

■ Perfect Sensor **Value-added processing**

- ◆ Equivalent to a regularly sampled raw Image delivered by a perfect sensor
 - Distorsion, attitude, orbit and datation correction
 - MTF enhancement : deconvolution and denoising
 - XS/Pa fusion, true or false colour
- ◆ System level MTF for PA of 0.2 (.07 at instrument level) with a signal to noise ration better than 90
- ◆ Product Sampling : 0,5m
- ◆ Image location better than 10m

■ Orthoimage **GIS**

- ◆ Corrected with DTM from SPOT 5 HRS mission or other DTM
- ◆ Improved location performance thanks to DTM



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System Products

■ Mosaics

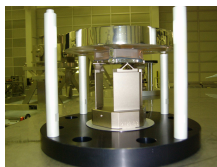
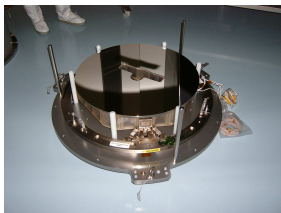
- ◆ lateral multi-band mode acquisition : ortho images stitched together to generate a single product.
- ◆ Mosaics look as a single image :
 - no geometric discrepancies
 - no radiometric discrepancies



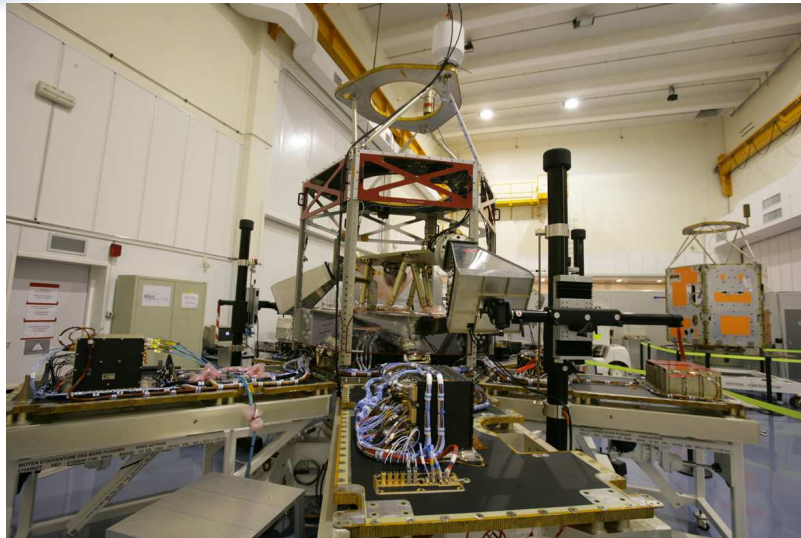
Development status

 **Satellite: some achievements**

- Integration operations on the Focal Plane have been achieved satisfactorily end of 2007.
 - ◆ After 16 months delay due to XS filters anomalies
- Flight mirrors have been delivered end of April 2006 and have performed excellently.



- Two buses delivered



Flight telescopes undergoing integration in Thales Cannes premisses.

Satellite: major milestones

- Instrument delivery : September 2008
 - ◆ with very good measured performances
- Start of satellite AIT (instrument assembly on MQV bus) : september 2008
- Satellite delivery : early November 2009
- Launch :
 - ◆ Pléiades 1 : January 2010
 - ◆ Pléiades 2 : 15 months later



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Measured Performances

- MTF_{inst} : Instrument Modulation Transfer Function
- MTF_{inst} : System Modulation Transfer Function after processing (MTF enhancement by deconvolution + denoising)

	PA	B0	B1	B2	B3
Spécifications	SNR=90 $MTF_{inst}=0.08$ $MTF_{sys}=0.20$	SNR=111 FTM=0.38	SNR=107 FTM=0.36	SNR=107 FTM=0.34	SNR=155 FTM=0.32
Mesures TAS 04/08 (valeurs moyennes)	SNR=165 $MTF_{inst}=0.14$ $MTF_{sys}=0.30/0,40$	SNR=148 FTM=0.38	SNR=152 FTM=0.36	SNR=154 FTM=0.34	SNR=188 FTM=0.32

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■ *Why such a program ?*

- ♦ New capabilities of ORFEO : optical and radar system
- ♦ Need of processing techniques adapted to the new visible objects
- ♦ Necessity to assist photo interpretation with automatic processing

■ *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”