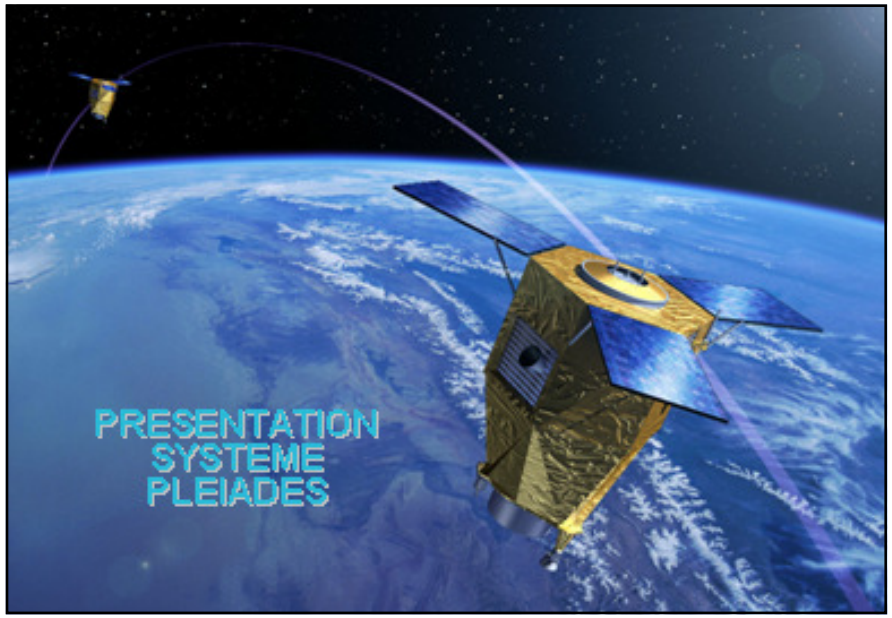



cnes

- Introduction :
- Pléiades System
- Pléiades Status
- The Pléiades  Data distribution
- The FFG Cnes Cooperation Agreement

## Introduction : overall context

- **Pleiades is developed in the frame of the ORFEO program**
- **ORFEO program**
  - Metric resolution earth observation system
  - Cooperation between Italy and France
    - Intergovernmental agreement signed in January 01
  - Dual system developed for civil and defence needs
    - Protection of defence interests in term of security and priority of mission requests
    - Accomplishment of civilian / commercial users needs in term of operational capacity, rapid access to the data
  - Federation of two components
    - Cosmo-SkyMed :
      - radar component radar developed by ASI
    - Pléiades :
      - optical component developed by Cnes In cooperation with Austria 1%, Belgium 4%, Spain 3%, Sweden 3%



## 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 Aerospacial***
  - **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 being relevant to their funding participation to the Pléiades program.**

## Access to the Resources

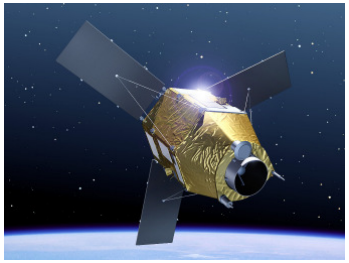
- **Two ways to access the system**
  - Defense channel
    - For cooperating defenses : direct access to the satellites for defense high priority request
    - For Pléiades : 50 requests maximum per day for 2 satellites (among 700)
  - Civil Channel
    - For the other users, responsibility of tasking, data reception, processing, archiving and distribution is given to a Civilian Operator
    - For Pléiades : 40% of the resources for institutional bodies of cooperating countries
- **Data Policy**
  - CNES is the holder of the copyright
  - Licence to use granted to defence, institutional users of cooperating countries for non commercial use
  - Full and exclusive licence for data under the responsibility of the commercial operator

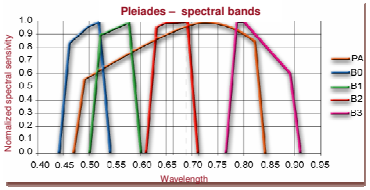


# The Pleiades System

## 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 per satellite
  - Average area of more than 2 500 000 km² over a year (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





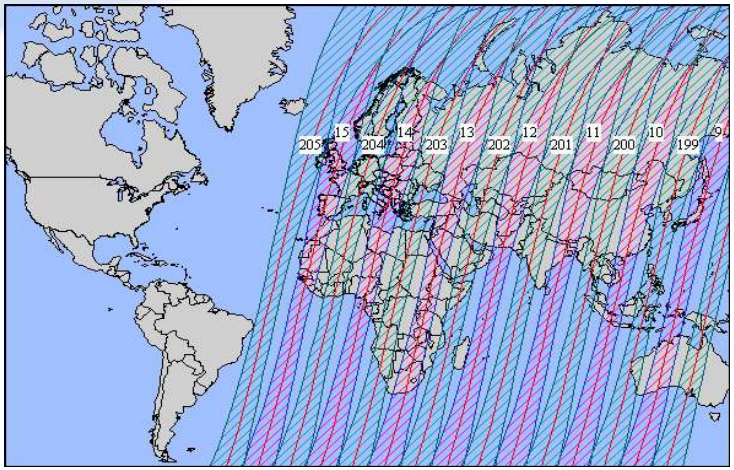



## Orbit and Accessibility

- **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 days revisit
  - with 2 satellites and a viewing angle of 43°: daily revisit

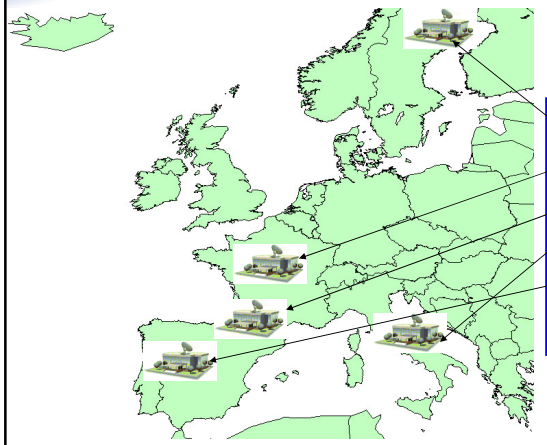
| Viewing angle | 1 satellite | 2 satellites | resolution |
|---|---|---|---|
| 5° | 26 days | 13 days | **0,7 m** |
| 20° | 7 days | 5 days | |
| 30° | 5 days | 4 days | **1 m** |
| 50° | 2days | 1 day | **2,25 m** |

## Daily access at 30° for 2 satellites





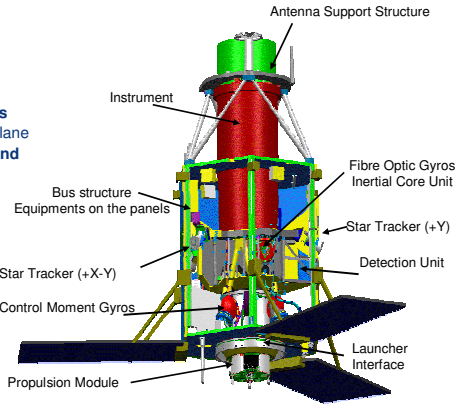

## The Pléiades System



- Kiruna Civilian Image Receiving Station
- French Defence Main Center
- French Civilian main Center
- Italian Defence Center (TBC)
- Spanish Defence main Center
- Other Civilian Image Receiving Stations

## The Pléiades satellites

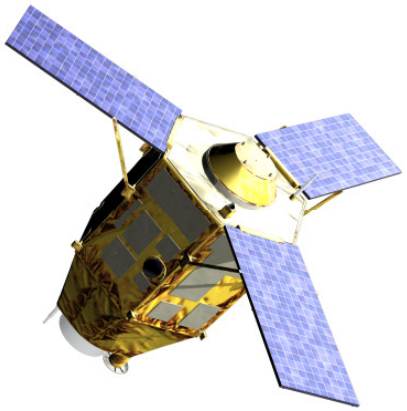
- **Mass 1 ton**
- **Power**
  - **Lithium-ion batteries**
  - **Rigid AsGa solar panels – 1.5 kW**
- **AOCS**
  - **High Agility with 4 Control Moment Gyros**
    - 5°/6.5s, 10°/10s, 60°/25s in roll-pitch plane
  - **High image quality with 3 star sensors and Fibre Optic Gyros**
- **Image telemetry: 465 Mbps X band**
- **Mass memory: 600 Gbits EOL**
- **Compression: wavelets (average Panchro = 2.5 bits par pixel)**
- **Pointing Accuracy <200 m**
- **Image location Accuracy <10m**






## PLEIADES HR satellite

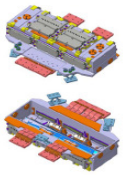
- **Mass: 1000 kg**
- **Power subsystem**
  - lithium ion batteries
  - Rigid solar panel AsGa (triple-jonction) 1,5 KW
- **AOCS**
  - 4 Control momentum Gyros
  - 3 Star trackers (SED 36)
  - gyro FOG
  - DORIS/DIODE navigator
- **Image telemetry 450 Mbps**
- **Mass memory: 600 Gbits**
- **Compression: wavelets** (average Panchro = 2.5 bits par pixel)

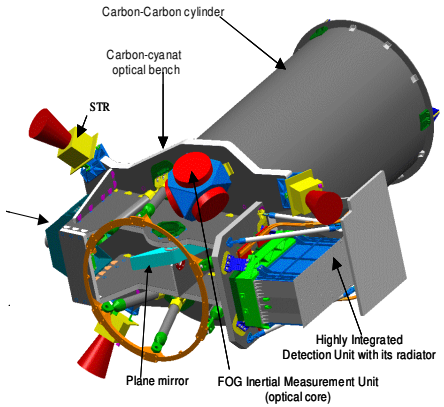


# The Pléiades Instrument

- **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

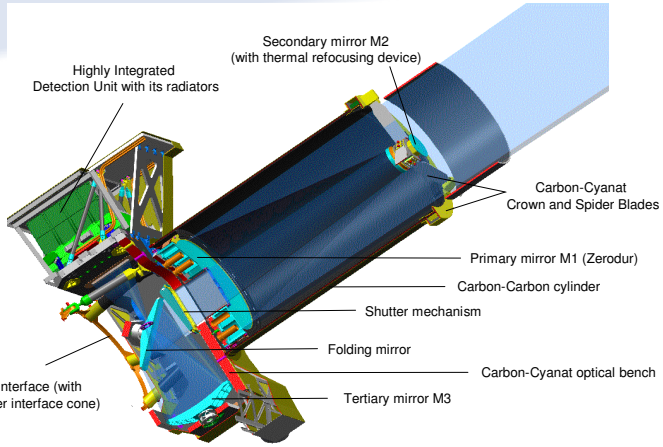
| | |
|---|---|
| B0 (blue): | 430-550 nm |
| B1 (green): | 490-610 nm |
| B2 (red): | 600-720 nm |
| B3 (NIR): | 750-950 nm |








# Instrument Exploded View



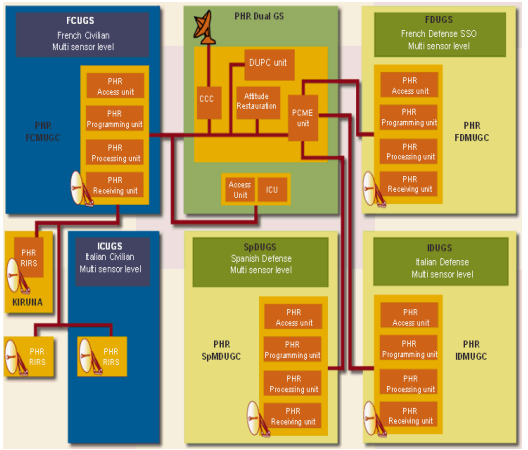
# Ground Segment

- **User ground segment**
  - A centre from which the operator can provide access to users, prepare schedules, receive, process and archive data and also generate satellite imagery products.
  - FDUGS: French Defence User Ground Segment (Creil, France).
  - FCUGS: French Civilian User Ground Segment (Spot Image Toulouse + Kiruna).
  - SpDUGS : Spanish Defence User Ground Segment (Torrejon, Spain)
- **Dual ground segment (Cnes) :**
  - The part of the ground segment in which satellite scheduling and operation take place.
  - DUPC: Dual Use Programming Command (carries out scheduling and produces the satellite's work programme).
  - CCC: Control and Command Centre (manages the satellite).
  - ICC: Image Calibration Centre (responsible for monitoring image quality).



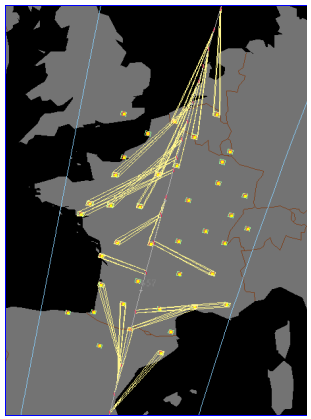
# The Ground Segment

- **Each user centre includes**
  - **PHR Receiving Unit : 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**



## Mission performances

- **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

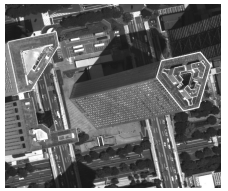


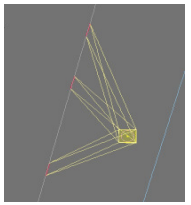


## Mission performances

- **Simultaneous stereo capacity with 1 satellite on 1 pass**

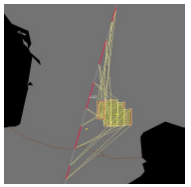
| B/H | Stereo length | Tri -stereo length |
|---|---|---|
| 0.1 | 25 km | - |
| 0.2 | 80 km | 25 km |
| 0.4 | 195 km | 80 km |
| 0.6 | 315 km | 135 km |
| 0.8 | 350 km | 201 km |
| 1 | 350 km | 260 km |

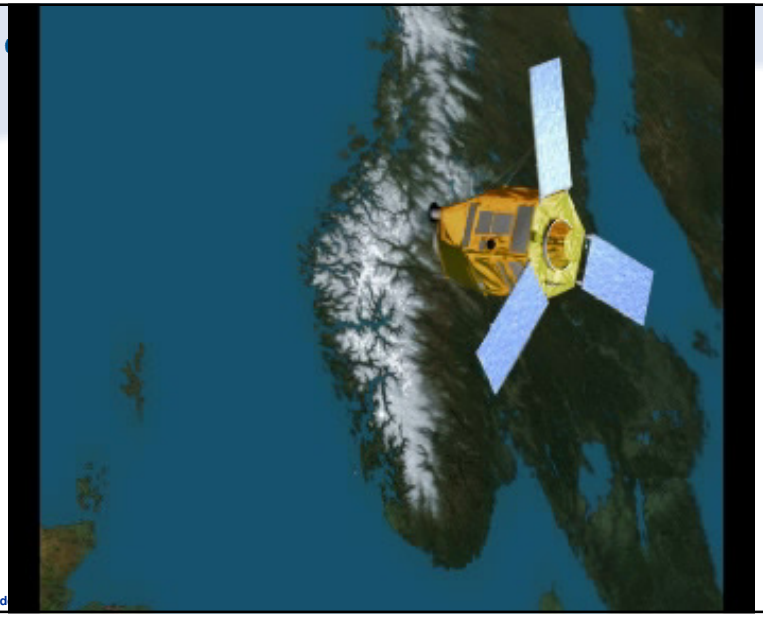




- **Coverage capacity with 1 satellite on 1 pass**

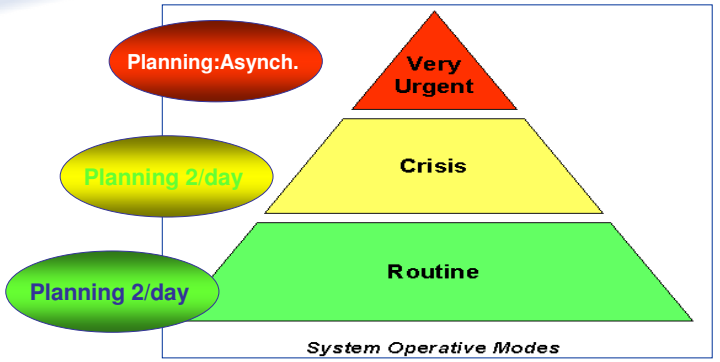
| Coverage wide | Authorized access | Segment length |
|---|---|---|
| 80 km (4 strips) | Up to 20° | 110 km |
| | Up to 30° | 205 km |
| 120 km (6 strips) | Up to 20° | 45 km |
| | Up to 30° | 110 km |



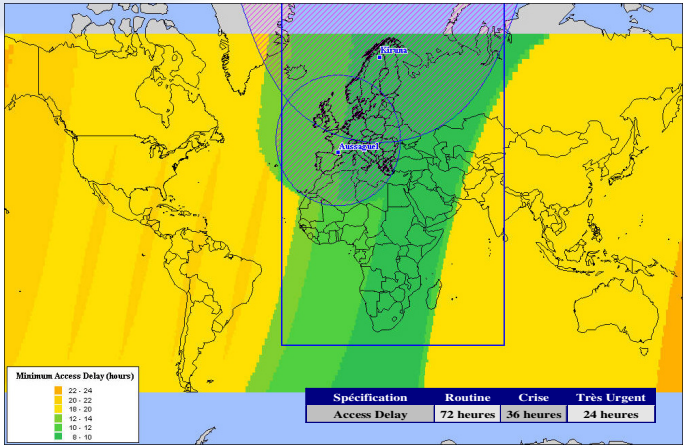




## Response Time



## Response Time

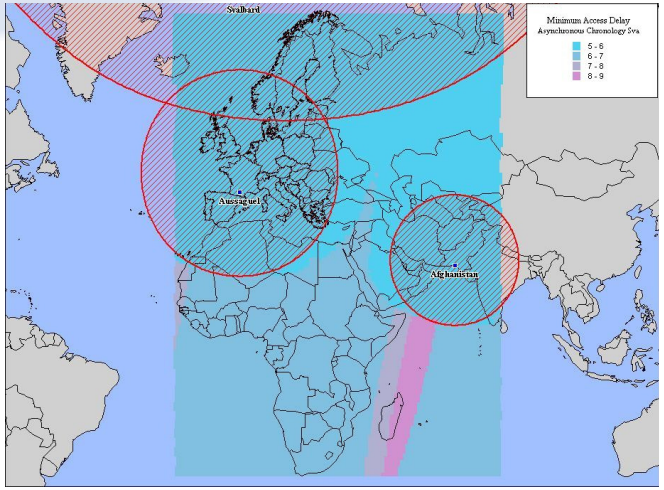



| Spécification | Routine | Crise | Très Urgent |
|---|---|---|---|
| Access Delay | 72 heures | 36 heures | 24 heures |

Routine and Crisis Mode

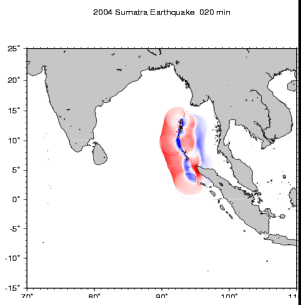


## Response Time in Very Urgent Mode



## TSUNAMI 26/12/2004

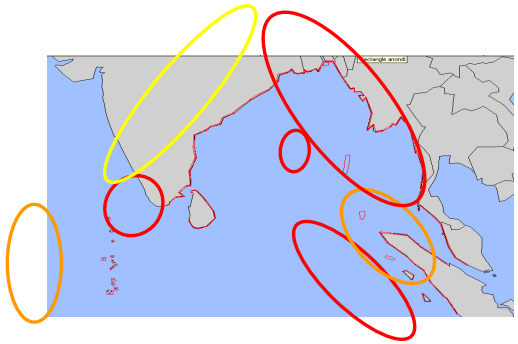
- **Earthquake**
  - **Time:**
    - 00:58:53 (UTC)
    - 07:58 epicentre local time.
- **Tsunami** (in epicentre local time)
  - **08:30 (roughly): reaches Sumatra**
  - **09:00 (roughly): reaches Thailand, Myanmar (ex-Burma) and Bangladesh**
  - **10:00 (roughly): reaches Sri Lanka**
- **Pleiades: 10:15**
  - **Could only have acquired images of the zone if it had been programmed *by chance* to do so. (Spot 2, Jason and some other satellites took images of the zone by pure chance.)**



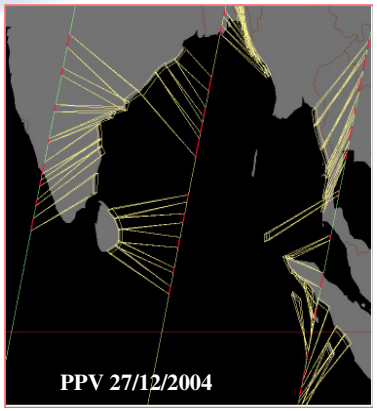


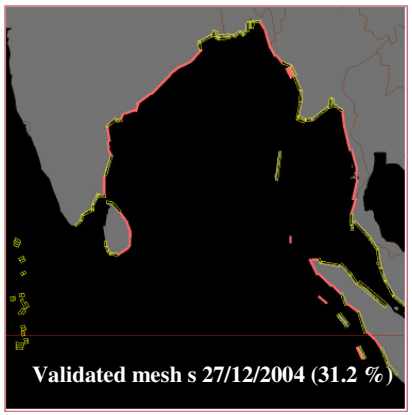

## Programming for the Tsunami

- **Programme received: 26/12/2004**
  - **Mission: to acquire images of the entire damaged coastal zone**
  - **Absolute priority given to this programme**
  - **Decreasing weights by zone: red > orange > yellow**



## Acquisitions on 27/12



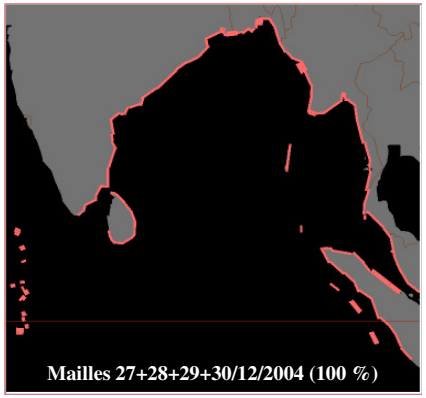

- The agility of Pleiades facilitates the acquisition of the coastal zones



## Receiving and processing data

- Most urgent data:
  - Received at Kiruna
    - 27/12 around 07:00 UT
  - Sent by network to Toulouse
    - 27/12 around 08:00 UT
  - Images available
    - 27/12 around 09:00 UT
- The rest of the data were received directly at Toulouse
  - Reception around 10:00 UT
  - Processing
  - Images available around 11:00 UT

## Acquisition capability example 2004 Tsunami




| DATE | Mailles à acquérir | Mailles validées | % | TOTAL cumulé |
|---|---|---|---|---|
| 27/12 | 125 | 39 | 31.2% | 31.2 % |
| 28/12 | 71 | 36 | 28,8% | 60 % |
| 29/12 | 39 | 33 | 26,4% | 86.4 % |
| 30/12 | 17 | 17 | 13,6% | 100 % |
| TOTAL | | 125 | 100% | |



## System Products

- **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

## Rapid Mapping Using Pléiades Images


**Communication network**

**Vegetation**

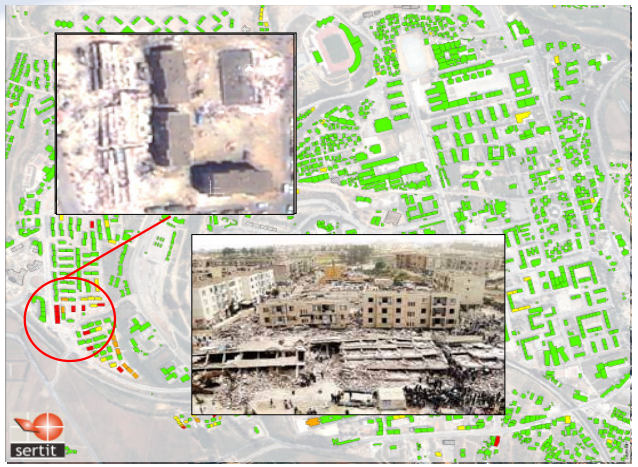
**Buildings**

**Rapid mapping using only from Space Data**



## Impact Maps Using Pléiades Images

**Simulation made using Quick Bird images over Boumerdes**




**22/04/2002 image**

**23/05/2003 image**

**Image comparison = Damage assessments with various level**

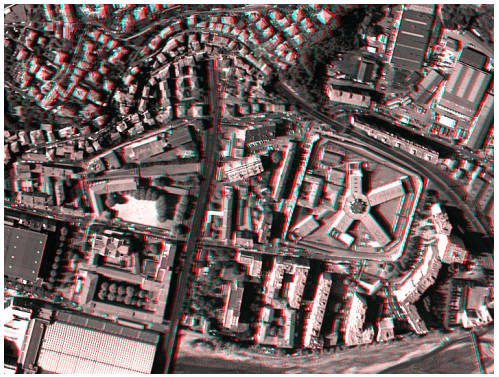
## Products

- **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



## Stereo pairs and triplets

- One pass stereo pair :
  - Low B/h for interpretation comfort in urban areas
  - For DTM Production from a « perfect sensor » stereo pair
  - High level Ortho-images produced from stereo triplets
- example :



# Pléiades status

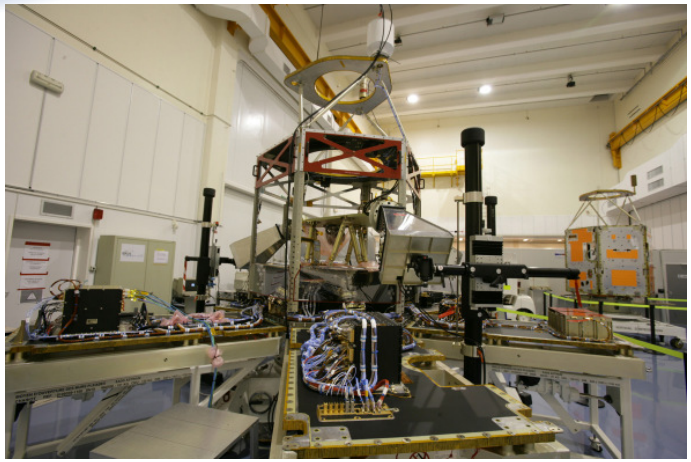
B Boissin



## Pleiades status

- **Satellite**
  - **Instrument**
    - **Major anomaly on filters in front of multispectral flight detectors**
      - Detection unit integration was interrupted during 16 months : now fixed
      - Integration operations on the Focal Plane have been resumed and processed satisfactorily
    - First Instrument delivered in July 2008
  - **Bus**
    - **The 2 buses have been delivered**
  - **Satellite**
    - **Start of satellite AIT (instrument assembly on MQV bus) : September 2008**
    - **First 6 days system test with ground segment in january**
    - **Thermal vacuum test ended**
    - **Satellite delivery : early November 2009 with good confidence**

## Satellite: some achievements

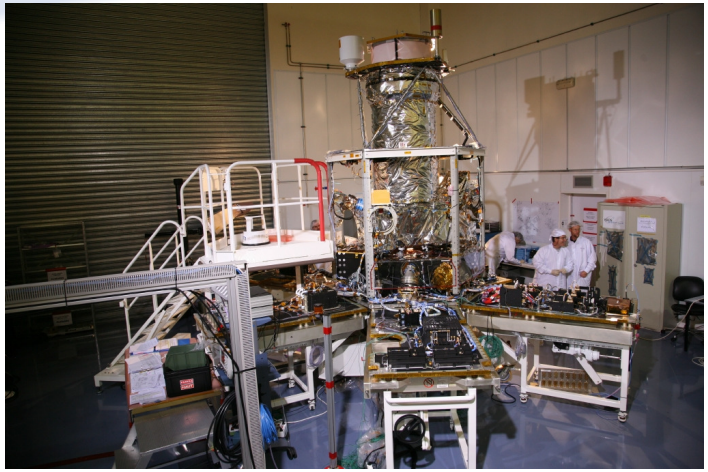




## Satellite: some achievements

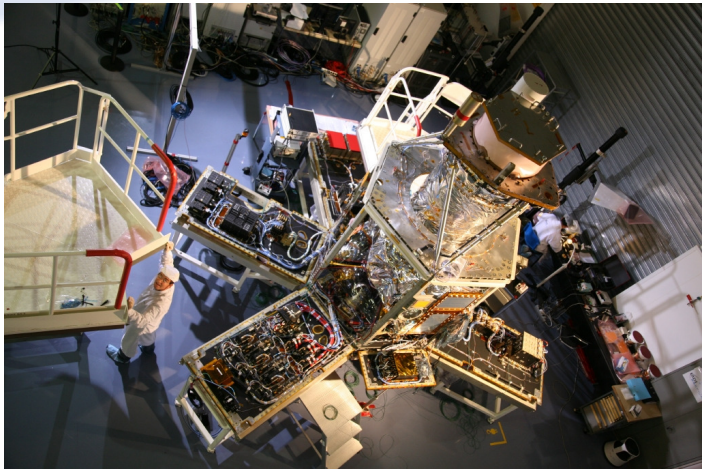
***Flight telescopes undergoing integration in Thales Cannes premisses.***

## Satellite: some achievements





## Satellite: some achievements



## Satellite: some achievements

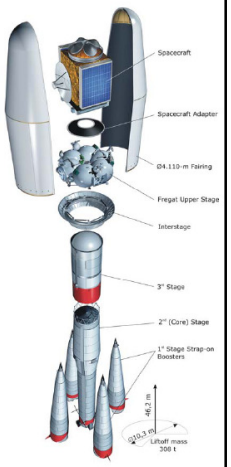


## Ground segment & System tests

- **Ground Segment**
  - **Command Control Center integrated in Cnes**
  - **Programming Chain & Imaging chain:**
    - First version delivered and OK used fir integration of users ground segment
  - **User Ground segment (French Defense FDUGS, Spanish Defense SpDUGS, Spot Image FCUGS)**
    - First versions accepted end of 2008 “in factory”
    - Integration on site will start in July2009
- **System test**
  - **System Technical Qualification**
    - January 2009 - July 2009
  - **System Operational Qualification**
    - July 2009-December 2009
  - **In orbit acceptance**
    - 2 months after launch

## Launch

- **Launch contract with Arianespace (awarded Dec. 2004) for two launches (Pléiades 1 and 2)**
- **Launch from Kourou SOYOUZ 2.1.a launcher,**
- **Contractual Launch period :**
  - Dec. 2009 to May 2010 for pléiades 1,
  - 15 mois later for Pléiades 2






## Image Simulations with measured performances Comparison with Specification

## Simulation parameters

- $MTF_{inst}$ : 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<br>$MTF_{inst}$=0.08<br>$MTF_{sys}$=0.20 | SNR=111<br>FTM=0.38 | SNR=107<br>FTM=0.36 | SNR=107<br>FTM=0.34 | SNR=155<br>FTM=0.32 |
| Mesures TAS 04/08 (valeurs moyennes) | SNR=165<br>$MTF_{inst}$=0.14<br>$MTF_{syst}$=0.30/0,40 | SNR=148<br>FTM=0.38 | SNR=152<br>FTM=0.36 | SNR=154<br>FTM=0.34 | SNR=188<br>FTM=0.32 |





# Pléiades Data Distribution



## Access to the Resources

- **Pléiades is a dual system**
- **Two ways to access the system**
  - Defence channel
    - High priority requests for cooperating defence : direct access to the satellites
      - **Grading and selection performed by defences**
      - **50 requests maximum per day for 2 satellites (among 700)**
  - Civil Channel
    - For the other users, responsibility of tasking, data reception, processing, archiving and distribution is given to a Civilian Operator
    - Various levels of civil priorities
      - **Grading and selection performed by a civil operator**
    - 40% of the resources for institutional bodies of cooperating countries
    - 60% for commercial use

## Access to the Resources through the Civil Channel

- **Mission of the Civil Operator**
  - **Development tasks**
    - To develop the Civil Centre
  - **Operational tasks**
    - To operate the Civil Channel
    - 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
- **Full and exclusive licence for data under the responsibility of the Civil Operator**
  - **Specific requirements to serve Institutional Users at a preferential price**

    "Operational cost + a limited margin"



## Authorized Institutional Users

- **Institutional bodies**
  - Public services, défense, public research establishments administrations, universities, regional and local entities
  - for non commercial use
- **Two categories**
  - **Category 1**
    - Agreed institutional users (End Users) of states funding system development
    - Pleiades: France, Austria, Belgium, Spain and Sweden
    - ORFEO: Italy and France
  - **Category 2**
    - European institutional users

## Data Policy

- **Licensing for agreed Authorized Users**
  - Right to use and modify Protected Products only for Authorized Institutional Users own needs
  - Right de produce Derivative products
  - Right to exchange Protected Products authorized between Authorized Institutional Users
  - Re distribution or sell forbidden
- **Copyright**
  - CNES for Pléiades is the holder of copyright, attached to Data and Protected Products under
  - This does not preclude Authorized Institutional Users from being the holder of distinct copyright on a Derivative Product



## Pléiades
## Civil Data Distribution

- **Civil Operator**
  - After an European Call for Tender in July 2004
    - Spot Image chosen
  - Spot Image Proposal
    - Received end of March 2006
  - Delegation signed in December 2007
- **Prices for Authorized Institutional Users Category 1**

| Engagement d'achat annuel | produits km² | 20 000 8 000 000 | 10 000 4 000 000 | 6 000 2 400 000 | 3 000 1 200 000 | 1 000 400 000 |
|---|---|---|---|---|---|---|
| prix au km² | | 2,5 € | 3,2 € | 3,7 € | 4,2 € | 4,6 € |
| prix unitaire | | 1 000 € | 1 280 € | 1 480 € | 1 680 € | 1 840 € |