The Pléiades System

Introduction: the overall context
Pléiades System
Pléiades Status
Data Distribution
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

- 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  Österreichische Forschungsförderungsgesellschaft

- 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 is equal to their funding participation to the Pléiades program.
The Pleiades System
Pléiades Main Mission Requirements

- **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

- **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**
  - In average 160 000 km² (400 images) per satellite and per day
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

<table>
<thead>
<tr>
<th>Viewing angle</th>
<th>1 satellite</th>
<th>2 satellites</th>
<th>resolution</th>
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<tbody>
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<td>5°</td>
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<td>13 days</td>
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<td>4 days</td>
<td>1 m</td>
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<td>50°</td>
<td>2 days</td>
<td>1 day</td>
<td>2,25 m</td>
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</table>
Daily Metric Coverage
**Ground Segment**

- **Dual ground segment (Cnes):**
  - Final scheduling and operation
    - Dual Use Programming Command
      - Merging civil and defense programming
    - Control and Command Centre
      - Satellite Control and monitoring
    - Image Calibration Centre

- **User ground segments**
  - Operator center ensuring
    - Interface with users,
    - Scheduling
    - Image reception, cataloging and archiving
    - Production, data dissemination
  - Various centers
    - French Defence User Ground Segment (Creil, France).
    - Spanish Defence User Ground Segment (Torrejon, Spain)
    - French Civilian User Ground Segment (Spot Image Toulouse + Kiruna)
Each user centre includes:

- 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
- Access units to browse the image catalogue, submit requests and receive the ordered products
The Pléiades satellites

- Designed for an high agility and stability
  - Mass 1 ton
  - Compact satellite with low inertia Power
  - Rigid satellite with fixed solar array
  - Attitude control system
    - High Agility with 4 Control Moment Gyros
      - 5°/6.5s, 10°/10s, 60°/25s in roll-pitch
    - High image quality with 3 star sensors and Fibre Optic Gyros

- Pointing Accuracy <200 m

- Image location Accuracy <10m

- Image telemetry 450 Mbps
- Mass memory: 600 Gbits
- Compression: wavelets
  - (average Panchro = 2.5 bits par pixel)
The Pléiades Instrument

- High stability 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
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 metric resolution (viewing angle of +/- 30°) thanks to agility
Mission performances

■ Simultaneous stereo capacity with 1 satellite on 1 pass

<table>
<thead>
<tr>
<th>B/H</th>
<th>Stereo length</th>
<th>Tri-stereo length</th>
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<tbody>
<tr>
<td>0.1</td>
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<td>350 km</td>
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</table>

■ Swat enlargement with 1 satellite on 1 pass

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<tr>
<th>Coverage wide</th>
<th>Authorized access</th>
<th>Segment length</th>
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<tbody>
<tr>
<td>80 km (4 strips)</td>
<td>Up to 20°</td>
<td>110 km</td>
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<td>Up to 30°</td>
<td>205 km</td>
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<td>120 km (6 strips)</td>
<td>Up to 20°</td>
<td>45 km</td>
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<td>Up to 30°</td>
<td>110 km</td>
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■ Possibility to follow a cost line or a river
ORFEO Preparatory Program             Brussels  March 4 2010
Acquisition simulation: 2 satellites

- Includes other customers’ programming requests (tasking conflicts).
- 10% cloud coverage or less
- 15° incidence angle or less
- 75,000 sq. km to cover, in 11 separated areas (« départements »)

Collection achieved within 2 months (June 7th - August 3rd)
Access delay

- Delay between the latest order end the product delivery

Specified in the three specified modes

- Routine
  - Tasking twice a day, every day (6h00 tu and 19h00 tu)
- Crisis
  - Idem with absolute priority over an area.
- Very urgent mode
  - Asynchronous mode with absolute priority over an area.

<table>
<thead>
<tr>
<th>Spécification</th>
<th>Routine</th>
<th>Crise</th>
<th>Très Urgent</th>
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<tbody>
<tr>
<td>Access Delay</td>
<td>72 heures</td>
<td>36 heures</td>
<td>24 heures</td>
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</table>

Spot Image asked Cnes to improve the access delay and funded this improvements

- With 3 plans per day
- With direct tasking capability
Specified system access delay

Routine and Crisis Mode

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Minimum Access Delay (heures):
- 22 - 24
- 20 - 22
- 18 - 20
- 16 - 14
- 12 - 14
- 10 - 12
- 8 - 10
Acces delay improvement (1)

- **Improvement funded by Spot Image**
  - Ability to take in account Urgent programming up to 4 hours before collection

- **Chronology : 3 Plans/ day**
  - **Morning plan**
    - Optimisation over Europe Africa
  - **Afternoon plan**
    - Optimisation over America
  - **Evening plan**
    - Optimisation over Asia

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**Japan local time >**

| 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
Acces delay improvement (2)
Direct tasking

Funded by Spot Image
- Plan uploaded at the beginning of the visibility of a receiving station
- Just before imaging the pass
- Image downloaded just after the image acquisition
Perfect Sensor  Value-added processing
- Equivalent to a regularly sampled 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
- **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
Rapid Mapping Using Pléiades Images

Communication network

Vegetation

Buildings

Rapid mapping using only from Space Data
Pléiades status
Pleiades status

■ Satellite
  ♦ Satellite delivered: 12\textsuperscript{nd} November 2009
  ♦ Second satellite
    • Second Instrument delivered in November 2009
    • In integration
    • Test sequence will start in March 2010

■ Ground Segment
  ♦ Command & control ground segment: delivered
  ♦ User Ground segment delivered

■ System
  ♦ System Technical Qualification
    • Acquired beginning of January 2010
  ♦ System Operational Qualification
    • Will start 6 months before launch
  ♦ In orbit acceptance
    • 2 months after launch
Launch date

- Launch contract with Arianespace (awarded Dec. 2004) for two launches (Pléiades 1 and 2)

- Launch from Kourou with SOYOUZ launcher,

- Launcher qualification: second quarter of 2010

- Contractual slot:
  - First satellite slot: October 2010-December 2010

- Second satellite will be ready for a launch one year after
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
■ CNES
  - Owner of the system
  - Holder of the copyright
  - In charge of the operation of the Civil Channel

■ Defense Ministry
  - Owner of the data acquired by the Defense Channel
  - With a specific license protecting the Civil Operator
Pleiades Civil Operator
“Civil Channel operation”

■ Public Service Delegation
  ✷ Stress is put on Public service of the cooperating countries (France, Austria, Belgium, Spain and Sweden, Italy and France)
  ✷ Eligible parties (Institutional Users of the cooperating countries)
    • services publics, défense, administrations, instituts, universités, établissements de recherche, les entités régionales et locales agissant dans leur mandat de service public, …
    • For non commercial use

■ Resources are allocated
  • 40% for Institutional bodies of 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 and fund the Civil Centre
- To fund system improvements

**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
Service Public Delegation principles

- Full and exclusive licence for data under the responsibility of the Civil Operator

- In return of this license
  - Spot Image pays
    - The operation of the civil channel including the space segment
    - A fee to Cnes proportional to its turnover
  - Spot Image serves Cooperating Countries Institutional Users at a preferential price: “Operational cost + a 4% margin”
Cannes seashore
A lot of things to see but still one year to wait
Thank you for your attention