Pléiades days
Alain Gleyzes
• Pléiades is the optical component in the frame of the ORFEO program (intergovernmental agreement between France and Italy)
• Dual system designed for civil and defense needs
• Submetric optical Earth observation system developed by CNES In cooperation with

  - Sweden        Swedish National Space Board
  - Belgium       Federal Office for Space Policy
  - Spain         Instituto nacional de Tecnica Aerospacial
  - Austria       Österreichische Forschungsforderungesellschaft
PLEIADES MAIN MISSIONS

- Defense
- Civil Security
- Cartography
- Risks & crisis management

- Hydrology
- Renewables ressources
- Geology
- Coastal management
TWO SATELLITES IN ORBIT WITHIN 11.5 MONTHS

Launch: PHR1A 17th December 2011
In flight acceptance: March 2012

PHR1B: 2nd December 2012
February 2013
- Number of orbital revolutions (PHR 1A + 1B) : >19 000
  ~ 844 000 000 km
- Number of CMG maneuvers (PHR 1A + 1B) : ~900 000
- Number instrument ON/OFF (PHR 1A + 1B) : ~53 000
- Number of image segments* in Pléiades catalog : 358 700
- Covered surface : 276 500 000 km²
  * Average segment size = 38km x 20km
- Volume of files in archive : 214,190 T bytes
  (2 781 682 files)
Pléiades has entered the International Charter Space and major disasters

- A First activation in July 2012
- >20 activations since launch

Pléiades constellation already benefits to users from Russian federation, Niger, Madagascar, France, Philippines, Haiti, Iran, Chile, Argentina, China, Germany and international organisations
PLEIADES
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
- Data coded on 12 bits
- Product is resampled @ 0.5m to improve robustness to ground processing

Revisit Capability

- Daily accessibility to any point on the globe (with 2 satellites)

Improved access image delay

- Better than 24 hours between image request and image delivery in nominal mode
- 1 hour, with Direct Tasking …

Large coverage capability

- In average 600 images per satellite and per day
Suez Harbor – Daily Monitoring

Egypt, 2013
Suez Harbor – Daily Monitoring
Egypt, 2013, February 15
Suez Harbor – Daily Monitoring
Egypt, 2013, February 16

© CNES – Distribution Spot Image / Astrium Services
Suez Harbor – Daily Monitoring
Egypt, 2013, February 17
Suez Harbor – Daily Monitoring
Egypt, 2013, February 18
Suez Harbor – Daily Monitoring
Egypt, 2013, February 19
PLEIADES SATELLITE

A new concept compared to Spot
A small and very agile satellite to improve operational capability and minimize the conflicts between users

Designed for an high agility
Compact <1000 kg satellite with low inertia
Rigid satellite with fixed solar array
Attitude control system with powerful CMG actuators

Designed for an high image quality
High stability instrument with high precision sensor heads mounted on the optical bench for maximum geometrical quality accuracy (star trackers, Inertial Measurement Unit (FOG))
sensors
Autonomous navigation with the DORIS/DIODE system
Image geolocation governed by attitude determination
● 3 star trackers
● 4 Fiber Optical Gyrometers
● All active in nominal configuration

actuators
Instrument agility is obtained through a set of 4 gyroscopic actuators (control moment gyros or CMGs)
CMG on ball-bearings,
kinetic momentum: 15 Nms

agility (roll and pitch):
5 in 8 seconds
10 in 10 seconds
60 in 25 seconds
PLÉIADES INSTRUMENT

Korsch type telescope
focal length = 13 m
input diameter = 65 cm
A flexible, modular and high-performance ground segment

4 users’ centers
- 2 Defense centers in Creil and Torrejon
- 1 civilian center in Toulouse operated by Astrium Geo
- 1 main receiving station in Kiruna

A set of Regional image Receiving Stations deployed by Astrium Geo
- Japan, China, Canada ...

One dual ground segment operated by CNES
- One dual programming and control center
- One image quality center
CHRONOLOGY

Morning plan: Optimisation over Europe Africa
Afternoon plan: Optimisation over America
Evening plan: Optimisation over Asia
MISSION PERFORMANCES

High agility is a must to
minimize conflicts between users
select the most important images
take into account cloud coverage forecast
access to different acquisition modes

- stereo pairs
- stereo triplets
- single pass mosaics
- follow linear targets
Three pictures on Makkah Royal tower clock acquired by Pléiades 1B every 90sec in a single pass to see the minutes needle moving!
HOW AGILE IS PLEIADES?

- during commissioning we pushed Pleiades to its limits…
- we were able to acquire in a single pass up to 30 images of the same target.
- Stacking them into a single movie gives an idea of what “persistent vision” could be.

- ISS with ATV cargo Edoardo Amaldi was captured by PLEIADES 1A during its commissioning.
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Relative egalization

- Pléiades 1B over Antarctic

No egalization | launch coefficients | coefficients jan’13
Direct visual impact on the images
Detectors line of sight calibration is essential for a good PanSharpen product.
Major improvement on the PAN-SHARPENED PRODUCT

Instrument MTF is much better than its requirements

In particular the XS channels have a very high MTF which brings some aliasing. That aliasing was present also in the Pan sharpened product.

➔ A new Pan sharpen processing algorithm was deployed in the ground segment beginning 2013.
For both satellites, in orbit commissioning lasted 2 months with all performances much better than the requirements.

The instruments and satellites performances are excellent

<table>
<thead>
<tr>
<th>Image Quality criteria</th>
<th></th>
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<tbody>
<tr>
<td>Localization CE90 (with accurate attitude and for 30 off nadir pointing)</td>
<td>6.5 m</td>
</tr>
<tr>
<td>PAN/XS registration in XS pixels (90%)</td>
<td>0.16</td>
</tr>
<tr>
<td>XS/XS registration in XS pixels (90%)</td>
<td>0.15</td>
</tr>
<tr>
<td>Planimetry in PAN pixels (90%)</td>
<td>0.44</td>
</tr>
<tr>
<td>Altimetry for a stereo pair with a b/h of 0.15 (RMS)</td>
<td>1 m</td>
</tr>
<tr>
<td>PAN MTF @ nyquist frequency</td>
<td>0.14</td>
</tr>
<tr>
<td>PAN SNR @ radiance 100 W/m²/µm/sr-1</td>
<td>162</td>
</tr>
<tr>
<td>Absolute calibration accuracy</td>
<td>5 %</td>
</tr>
<tr>
<td>Multi-temporal calibration accuracy</td>
<td>1 %</td>
</tr>
<tr>
<td>Inter-Pleiades accuracy</td>
<td>2 %</td>
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</tbody>
</table>
MNT extraction from Pléiades stereo images gives excellent results:

Here, an example on Everest and Cairo
- $B/h = 0.09$.
- 3D modelling by line of sight intersections (generation of a cloud of 3D points)

Usage of stereo triplets
- Allows to see hidden faces
- Increases altimetric accuracy:
  - 1.5 m with two images
  - 1 m with stereo triplet
SYNTHESIS

Pléiades system is fully operational

- Mission is uninterrupted and availability is close to 100%.

Image quality, reactivity, acquisition capacity are excellent

→ With Pléiades system, Europe and France in particular, have entered the restricted circle of organisms who master the civilian very high resolution imagery.

CNES is preparing the future

→ OTOS is a demonstrator of technologies needed for EHR imagery
→ As with Pléiades, the post Pléiades program will be very challenging and the support of the institutional and scientific community will be essential to justify the investment.