CNES micro satellites program

Ref. : SSC06-IV-2

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20th Annual Conference on Small Satellites
August 14-17, 2006 - Utah State University · Eccles Conference Center · Logan, Utah, USA
MYRIADE goal

- Permit realization of low cost, reduced development time missions
  - More opportunities for scientific missions
  - Realization of “exploratory” missions.
- Application domains
  - Sciences
  - Telecommunications
  - Technology demonstration
  - Pre operational, service demonstration
- Take advantage of piggy back launch opportunities (ASAP Ariane V)
MYRIADE system definition

- **Satellite bus**
  - Standard functional chains and equipment (AOCS, data handling, communications, power, On board Software)
  - Mathematical models: AOCS, mechanical, thermal, power
  - Integration and test: support equipment, procedures.

- **S Band Ground station network**
  - Toulouse, Kiruna, Hartshobitshoek, Kourou, Kerguelen

- **Data transmission network**

- **Micro satellite common operation center**
  - Located in CNES Toulouse,
  - Permits to control up to 5 missions, 8 satellites simultaneously

- **X band station**

- **System Validation bench**
  - Digital simulation of satellite dynamics and environment

- **System data base**

- **Operations**
  - Trained teams and validated procedures.
MYRIADE satellite characteristics

- Mass and dimensions
  - 110 to 150 kg, 50 to 70 kg available for payload
  - 60 cm x 60 cm x 80 cm + extension and appendages

- Independent payload module

- Pointing: compatibility with
  - Earth pointing
  - Sun, inertial pointing

- Orbit
  - Low Earth orbit: 600 to 1000 km, various inclinations
  - Geo Stationary Transfer orbit (reduced life time)

- Operational performances
  - Life duration: 1 year initial extended to 3 years
  - No reliability or availability requirement.
### MYRIADE bus performances

<table>
<thead>
<tr>
<th></th>
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<th>Fine mode (Star tracker + reaction wheels)</th>
<th>Coarse mode (magnetic control)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AOCS accuracy</strong></td>
<td>&lt; 0,05 °</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>&lt; 5°</td>
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<tr>
<td><strong>Power</strong></td>
<td>200 W</td>
<td>Steerable Solar generator.</td>
<td>Triple junction AsGa cells</td>
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<tr>
<td><strong>Telecommunications</strong></td>
<td>TM: 625 kbits/s</td>
<td>S- Band, CCSDS</td>
<td></td>
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<tr>
<td></td>
<td>TC: 20 kbits/s</td>
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<tr>
<td></td>
<td>16,8 Mbits/s</td>
<td>X-Band, High rate TM</td>
<td></td>
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<tr>
<td><strong>Mass memory storage</strong></td>
<td>16 Gbits</td>
<td></td>
<td></td>
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<tr>
<td><strong>Propulsion (option)</strong></td>
<td>80 m/s</td>
<td>Hydrazine, 4 x 1 N thrusters</td>
<td></td>
</tr>
<tr>
<td><strong>GPS (Option)</strong></td>
<td>&lt; 1 µs</td>
<td>Fine datation and position measurement</td>
<td></td>
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<tr>
<td></td>
<td>&lt; 5 m (3D)</td>
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</table>
• Original development was conducted by CNES
• Partnership agreement established with ASTRIUM and ALCATEL Space companies
  • Both companies were involved in the development effort,
  • Both companies may commercialize the product
• CNES remains design authority
• CNES develops national scientific applications
• ASTRIUM and ALCATEL develop government and commercial applications
• Production
  • Common set of contractors / subsidiaries was defined and shared by CNES and ASTRIUM and ALCATEL
  • AIT activities conducted by each entity.
• Operations
  • conducted by CNES
In flight mission 1 - DEMETER

■ Mission
- Science: electromagnetic perturbations of the ionosphere and high atmosphere, in relation with volcanic eruption and earthquakes.
- Technology: test of in orbit autonomous control system
- In flight validation of MYRIADE

■ Payload
- Electrical and magnetic sensors
- Plasma and particles sensors

■ Launch
- June, 28th, 2004 from Baikonour (DNEPR)
- SSO, 710 km

■ Status
- In operation
In flight mission 2 - PARASOL

**Mission**

- Characterize the radiative properties and micro physics of aerosols and clouds.
- Analyze contribution of aerosols to climate and interaction between clouds and aerosols.
- Part of the A-Train

**Launch**

December, 18th, 2004 from Kourou (ASAP Ariane V)
SSO, 700 km
PARASOL: in flight results

**Payload:**
- Multi band camera. 15 spectral bands in the range 443 nm to 910 nm
- 32 kg, 50 W
- FOV: 43° (along the track) x 51°
-IFOV (pixel): 6 x 7 km

**Status**
- In operation (3 years)
  Recurrent payload permitted a development in 3 years
In flight mission 3 - ESSAIM

- Constellation of 4 satellites
  - French ministry of defense
  - Exploratory Communications application

- Developed by ASTRIUM

- Launch
  December, 18th, 2004 from Kourou (ASAP Ariane V)

- Status
  - In operation (3 years)
Mission in development - PICARD

■ Mission: Sun observation
- Measurements of sun characteristics: diameter, irradiance, differential rotation, and analysis of correlation between these values. Application: influence of sun on earth climate
- Helio seismology.

■ Payload
- 60 kg, 70 W
- CCD telescope: measurement of sun diameter with relative accuracy: 5 mas
- Set of radiometers and photometers.

■ Launch
- March, 2009
- SSO, 18h00 A.N 710 km

■ Status
- Phase C in progress
Mission in development – Micro Scope

- **Mission: Fundamental physics**
  - Assessment of equivalence principle (with accuracy < $10^{-15}$)
  - Drag free satellite

- **Payload**
  - 2 differential electro static accelerometers
  - Electrical thrusters

- **Launch**
  - Mid 2010
  - SSO, 18h00 A.N 750 km

- **Status**
  - Phase C in progress
Mission in development by industrial partners

Mission developed for the French ministry of defense

❖ SPIRALE:
  • Prime is ALCATEL Space
  • 2 observation satellites placed on GTO orbit
  • Launch: 2008

❖ ELISA:
  • Prime is ASTRIUM
  • Constellation of 4 communications satellites placed on LEO orbit
  • Launch: 2010

Commercial mission

❖ ALSAT
  • Prime is ASTRIUM
  • LEO earth observation satellite with high resolution.
Mission in preparation - TARANIS

Mission:
- Study of sprites over atmosphere (impulsive transfers of energy between Earth environment and space)
- Effect on the atmosphere

Payload:
- 30 kg, 30 W
- Cameras and photometers
- X and γ detectors
- Electron detectors
- Electrical and magnetic field sensors.

Launch
- Orbit: SSO, 650 km
- 2011

Status
- Phase A concluded
- Realization decision expected.
Mission: Sun observation
- Observation of solar flares and Coronal mass ejections.
- Cooperation with China.

Payload:
- Imaging telescope: Lyman Alpha, visible (coronograph)
- High energy burst spectrometers X and $\gamma$
- Infra red camera
- 70 kg, 75 W

Launch
- 2011 (Before solar max: 2012)
- SSO, 18h00 A.N  700 km

Status
- Phase O completed
- Phase A decision expected
Lessons learnt

Keys for achieving low cost

- Large variety of missions considered for the definition phase.
- Small size =>, reduced launch cost, launch as piggy back
- Use of standard, off the shelf existing on board equipment
- Early R and T effort for specific equipments (OBC, transmitter)
- Controlled utilization of COTS components
- No reliability, availability requirement
  - No redundancy,
  - Satellite turns to safe mode upon not easily recoverable fault detection
- Re-use or limited adaptations of existing ground segment design (PROTEUS heritage)
- Operations
  - limited to standard labor time (5 days/week, day time)
  - automation of daily sequences
- Generic definition permits reduced validation effort for new missions.
Lessons learnt

■ Early commitment of European space companies (ALCATEL, ASTRIUM)
  - Unique product: design, industrial organization
  - Adapted to commercial applications
  - Industrial constraints were considered.

■ Development effort was under estimated.
  - 6 years from program decision (1998) until first satellite launch (2004)
Lessons learnt: availability evolution

■ Early faults appeared on DEMETER
  - Corrected by SW modification and upload
  - PARASOL affected by Star tracker moon blooming: now corrected.

■ Availability: now close to 100% (> 95 %).
Conclusion

- MYRIADE made the demonstration of:
  - its capacity to accommodate a wide range of missions.
  - Its competitiveness: realization of low cost missions with high return
- Partnership between CNES and industrial companies ASTRIUM and ALCATEL is a success
- Development duration remains above expected (4 years vs 2 as targeted): payload usually critical.
- 6 satellites in orbit
  - cumulated life time: 10 years with no failure
  - Performances higher than specified
- 10 satellites in development