

MAX Atelier
Formation Flying Mission

IAP Paris
23 Mars 2004

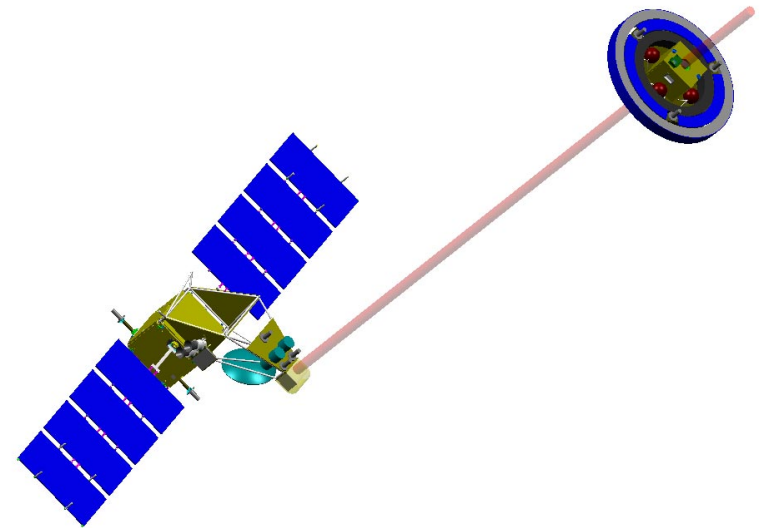
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Alcatel Space Cannes

▼ Mission requirements

- Main performances
- Orbit / Launcher
- Duration

▼ Formation Flying Fleet

- Lens Spacecraft descriptio
→ Architecture
- Detector Spacecraft descri
→ Architecture



▼ Metrology

- Global Principle
- RF and Optical Metrology Description
- Fine Metrology implementation
- Verification philosophy

▼ Actuation

- Actuation Survey
- Cold Gas Description

▼ AOCS Modes

- Preliminary Modes Description

▼ Manoeuvres

- Deployment
- Collision Avoidance
- Retargeting
 - Classical target
 - Sun option

▼ Mission requirements

□ System Requirements recall

→ Lens and Detector separated by 86 m

→ System Accuracy +/- 0.1 cm lateral, +/- 0.1 m axial

→ *Formation Flying Accuracy +/- 100 microns cube*

→ Absolute Pointing error : 15 arcsec

▼ Mission requirements

□ System Requirements recall

→ Out of Radiations belts

→ Lens : 150kg of crystals, diam 2.23 m

→ Lens : thermoelastic stability required < 15 arcsec

→ Detector : 60 kg including shielding, 40 W , passive cooling (85K)

→ Mission duration : 2 years min (50 targets, 15 days per target)

→ SUN Target

▼ Mission requirements

□ Orbits

→ LEO Orbit

- main drawback differential forces due to gravity gradient

→ MEO Orbit

- main drawback : radiations

→ GEO Orbit

- drawback : still partially in radiations belts

→ 3 days Orbit (81 330 km)

- no radiations belts
- small perturbation / if inclined orbit : no eclipse
- Kick off stage mandatory for the estimated launch mass

→ L2 Lagrangian point

- no radiations / very small perturbation / no eclipse /

▼ Mission requirements

□ Orbits

- Final trade off to be performed between

- 3 days Orbit and L2 Orbit

- Main parameters
 - Total Launch cost Kick stage or not ?
 - Visibility 27 h every 40 hours for 3 days orbits
 - Visibility 6 h per day for L2 orbits

▼ Two Spacecrafts concept

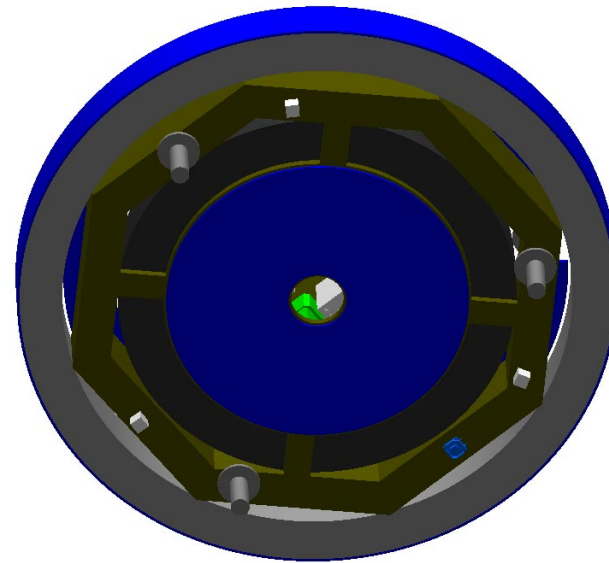
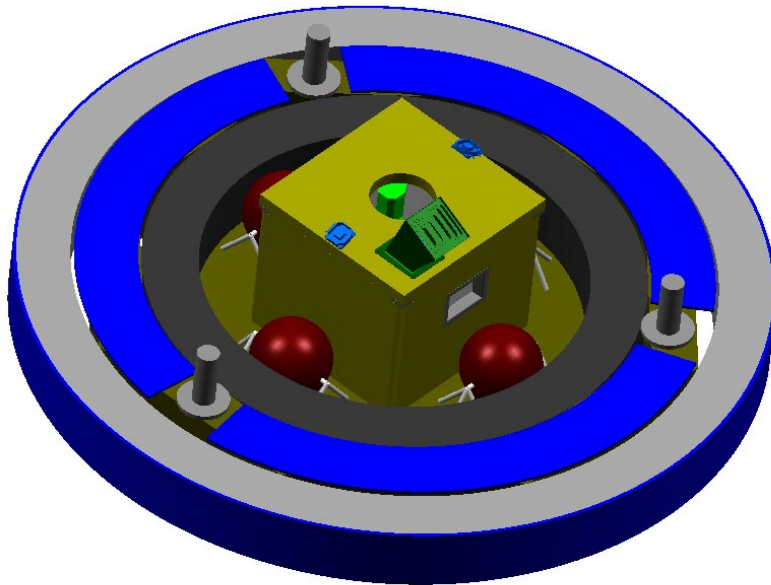
□ Lens spacecraft

- Main part : crystals (150 kg) mounted on a GAIA like torus with high thermoelastic intrinsic stability
- Microsat Myriad like ensures the control

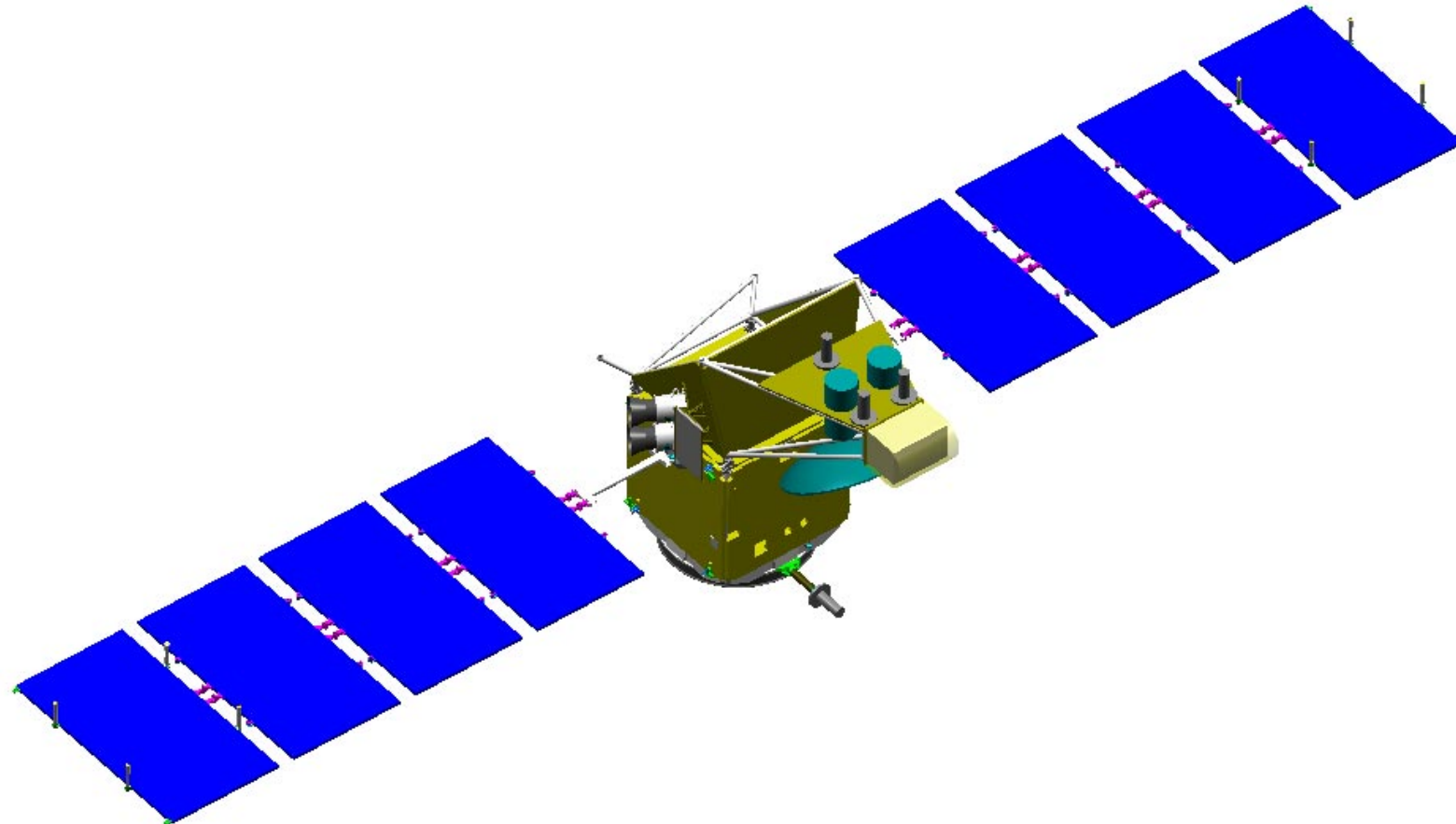
□ Detector spacecraft

- Main part : Detector mounted on an arm 1 meter away from Proteus
- Main spacecraft : Proteus Standard
- Detector Spacecraft ensures the main part of the mission
 - Detector accommodation , data processing and storage
 - Communication with the Earth
 - Formation , FDIR and Manœuvres management
 - Main metrology part accommodation (optical)
 - Bi propulsion : classical hydrazine and cold gas

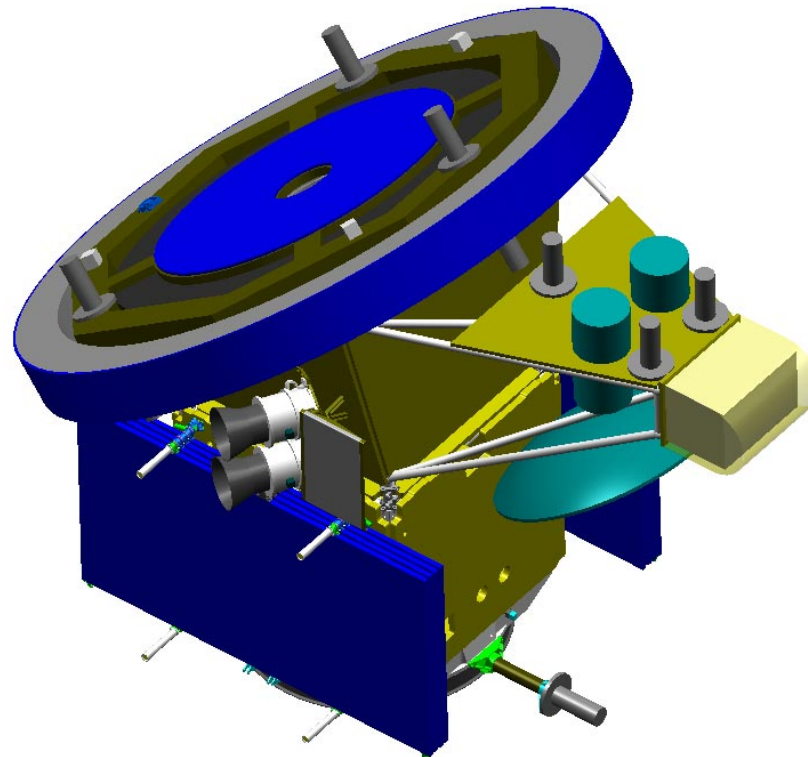
▼ Lens spacecraft accommodation



▼ Detector spacecraft accommodation



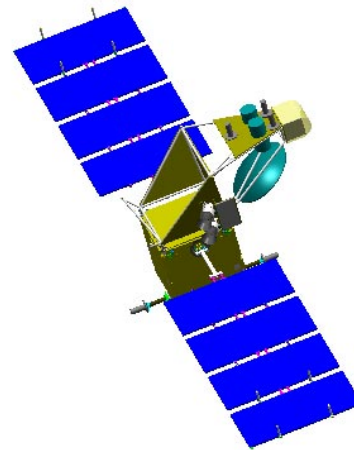
▼ Composite accommodation



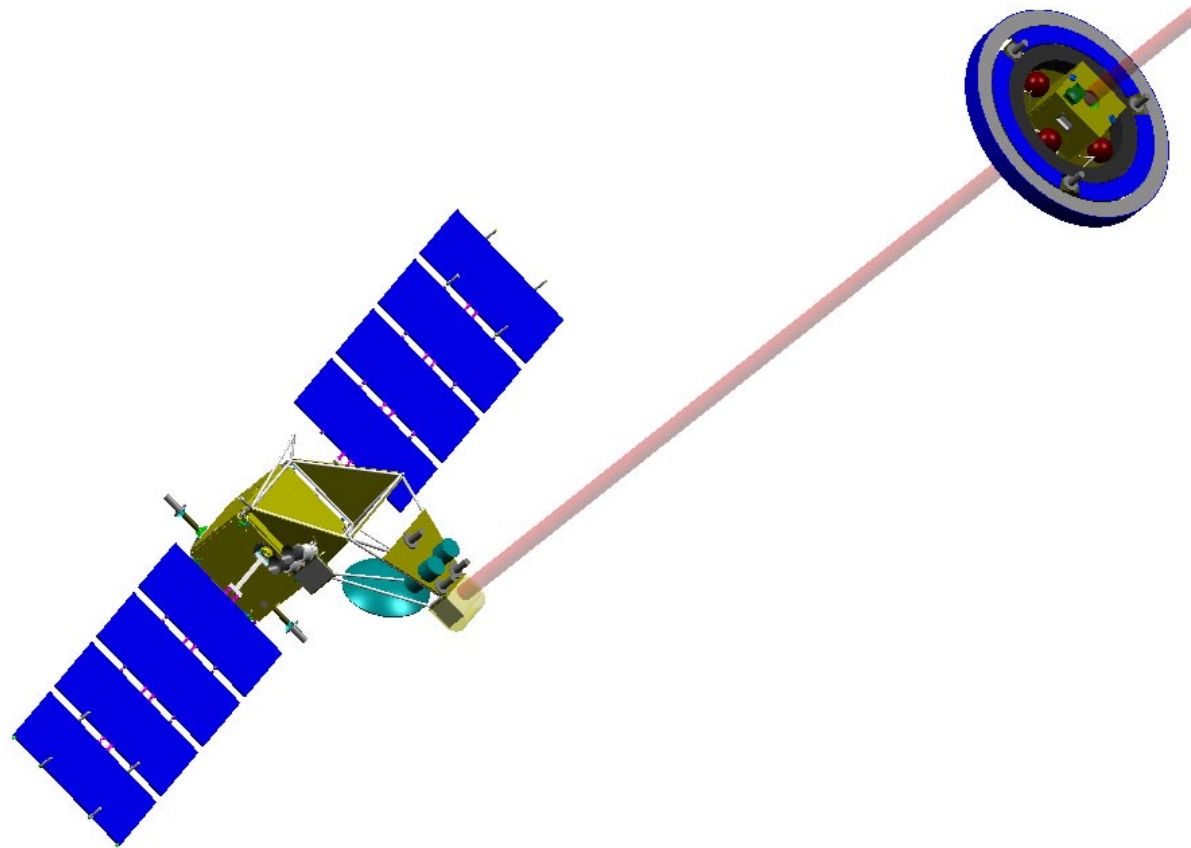
▼ Launcher Accommodation



▼ Formation



Formation



▼ Metrology Logic

□ Three steps based

- **RF Coarse Metrology used for deployment , anticollision and coarse preliminary pointing**
 - **Technology totally mastered by Alcatel Space**

- **Coarse Metrology pointing in conjunction with Startracker**
 - **Innovative concept from Alcatel allowing to reach extended performances based on a divergent laser**

- **Fine Metrology pointing (in order to demonstrate Formation Flying capacity even if not mandatory for Max Mission)**
 - **Extensive experience from Alcatel for Optics and Interferometry**

▼ Metrology Verification

□ Direct Internal verification through the three steps

→ RF / Coarse Optical / Fine Optical

□ Indirect Verification through

→ Dedicated camera

→ Dedicated Gamma Ray source through central hole

Actuation Market

| | PPT | Colloid | FEEP | Cold gas | Comments |
|---|--|---------|------|----------|--|
| Propellant mass & volume | + | + | ++ | -- | Linked to Isp value |
| Capacity to deliver very low and precise thrusts and impulses | + | ++ | ++ | - | |
| Power consumption | - | - | -- | ++ | |
| Complexity | - | - | - | + | |
| Cost | - | - | - | ++ | |
| Maturity/experience | - | -- | + | + | PPT experience exists outside Europe (US and especially Russia). Colloid propulsion has never flown. |
| Lifetime | + | + | + | - | Cold gas limitation due to high propellant mass/volume and to gas leakage |
| Sum | - | - | ++ | ++ | |
| Particular constraints | Contamination of surfaces, Changes in electrical environment and charging of the spacecraft. | | | | |

PPT : Pulsed Plasma Thruster

▼ Manoeuvres

- Anticollision / Deployment
- Retargeting
- Precision Flying

▼ MAX Space Segment

- ❑ Formation Flying based on two standard spacecrafts
- ❑ High Scientific Return
- ❑ Formation Flying demonstration up to fringe acquisition
- ❑ Alcatel will allow thanks to its unique experience both in standard platform (PROTEUS and Myriad), RF Navigation, Optical Payloads and extensive Interferometry experience to develop and consolidate this very innovative mission