



CENTRE NATIONAL D'ÉTUDES SPATIALES

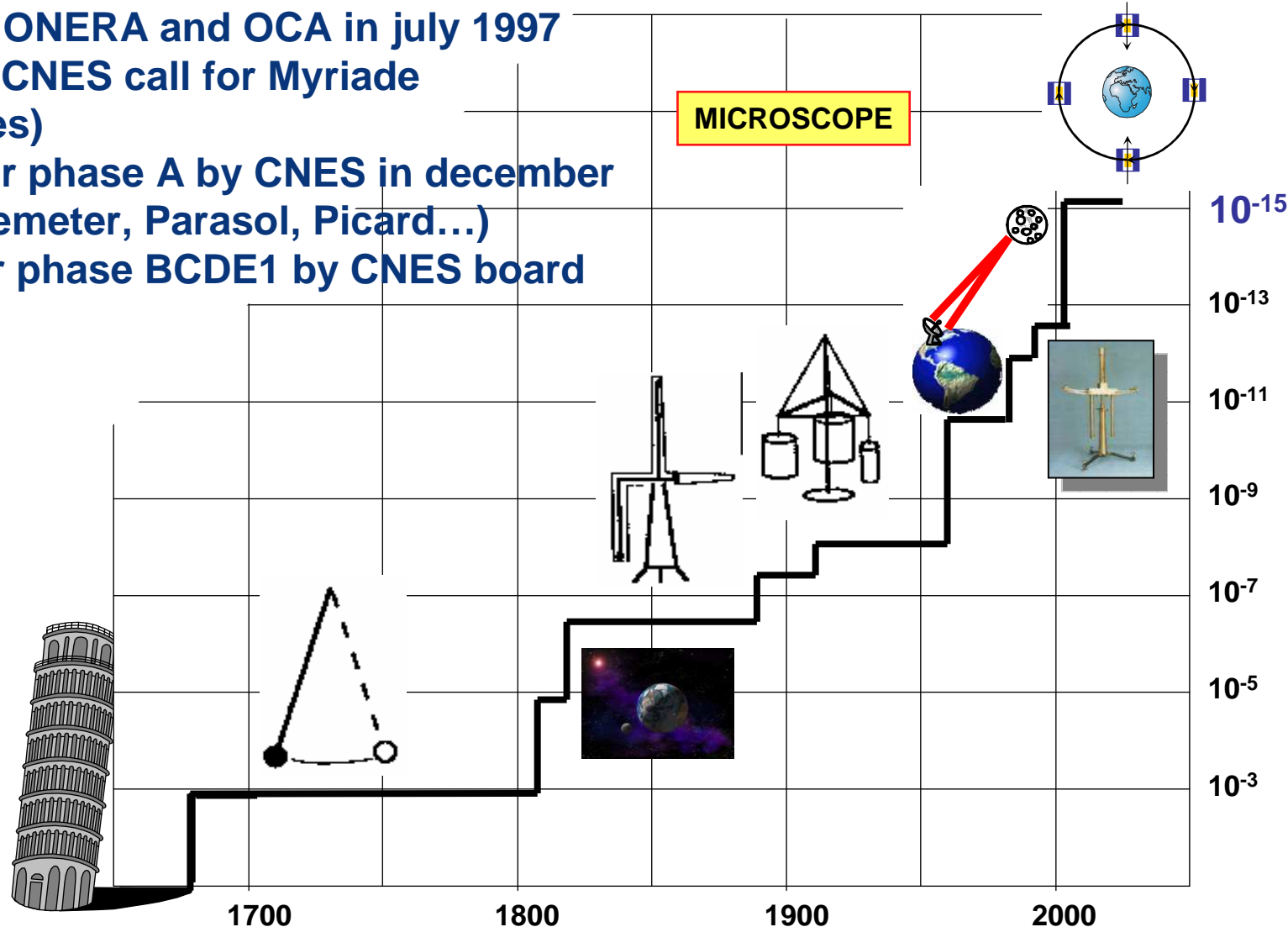
Microscope status at CNES

Sylvie Léon-Hirtz CNES DSP/EU
19 sept 2011

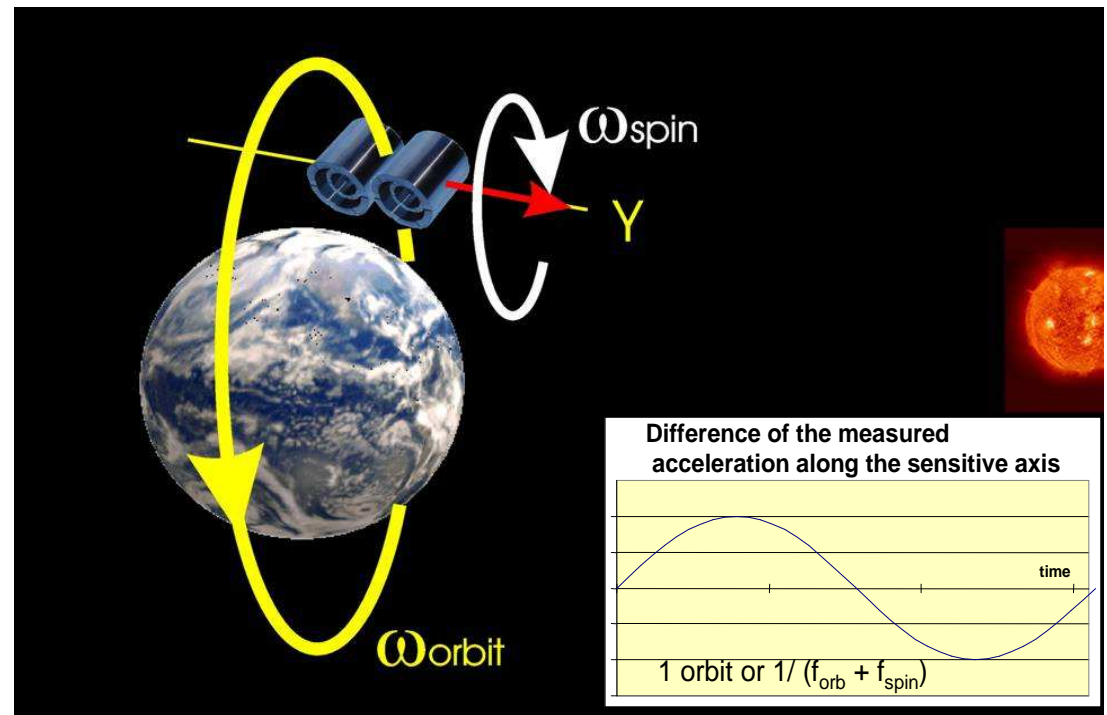
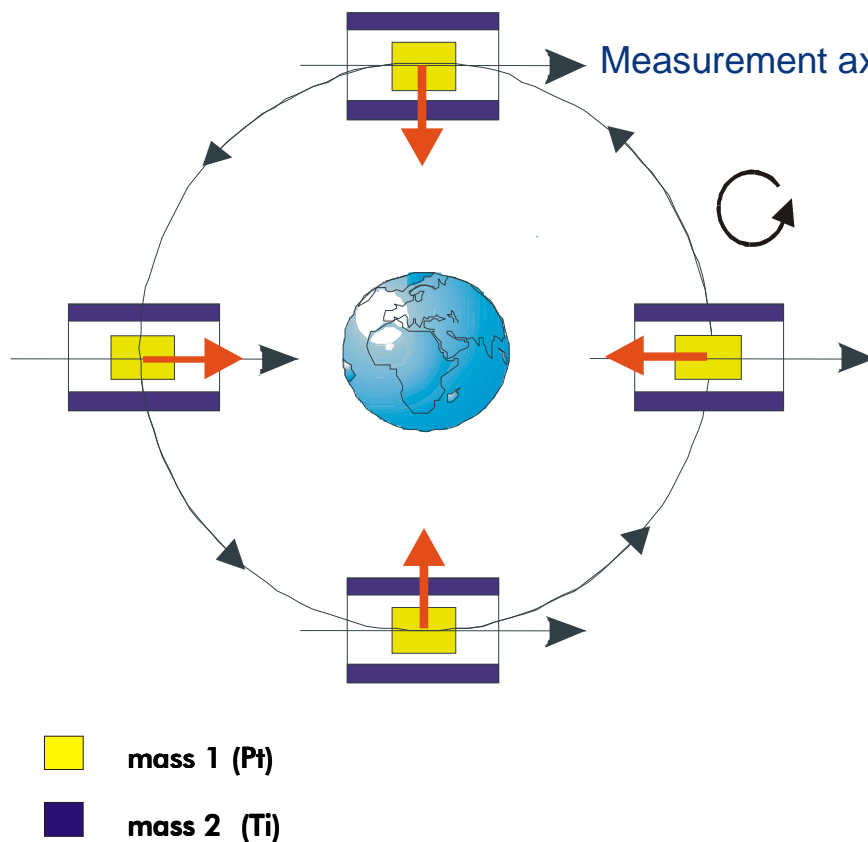
$$\delta = \frac{m_{g2}}{m_{I2}} - \frac{m_{g1}}{m_{I1}}$$

- Proposal by ONERA and OCA in July 1997 (response to CNES call for Myriade microsatellites)
- Selection for phase A by CNES in December 1999 (after Demeter, Parasol, Picard...)
- Decision for phase BCDE1 by CNES board 24 June 2004

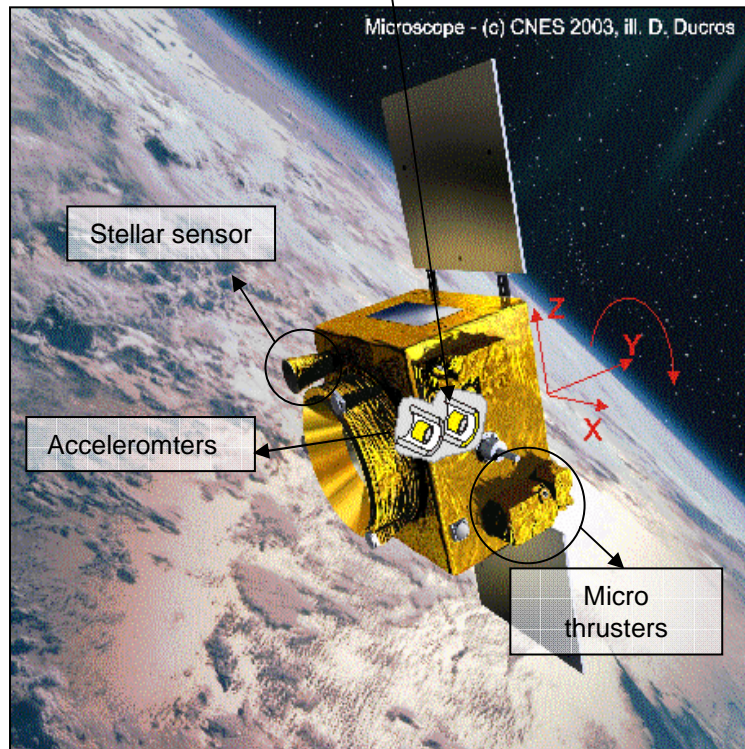
2011?



- 2 masses of different compositions in free fall
- Environment : free of perturbations, (drag-free satellite)
- Duration of measurement :
120 orbits in inertial mode, 20 in spin mode
- **Signal : phase & frequency defined**



Electrostatic differential accelerometers :
2 masses controlled on the same orbit ($< 10^{-11}\text{m}$)



Satellite and payload are tightly connected :
performance group

MYRIADE Microsatellite : 2 m³–280kg–120 W

Payload 35 kg, 40 W

Orbit : quasi polar sun-synchronous 6h-18h

Altitude : 720 km

Excentricity $< 5 \times 10^{-3}$

Mission duration : 12 months

Inertial and spin modes ; 3 values of Fep

2 main functions of the satellite :

Fine attitude control :

stellar sensor + angular measurement of the accelerometer

Drag free control :

**translation measurement of the accelerometer
+ micro-thrusters (0-150 μN)**

Myriade microsatellite

- ♦ CNES : prime for system and satellite
- ♦ ONERA : prime for instrument (funded by CNES) and Scientific Mission Center (funded by ONERA)
- ♦ OCA : scientific analysis

European cooperation :

- ♦ ESA/Space Science : provides the micropropulsion system
 - CNES response to ESA call for proposal and approval of ESA/SPC : 2000
 - ESA-CNES agreement : 2001, FEEPs Cs ; 2009, swap to Cold Gas
 - Steering committee ESA-CNES-DLR-ONERA-CNRS/INSU-ZARM
- ♦ Germany (funded by DLR) :
 - ZARM/ Bremen university : performance group ; free fall tests of the accelerometers
 - PTB : providing, fine machining and metrology of the proof masses
- ♦ Performance group CNES-ONERA-OCA-ZARM :
 - Performance budget, sensibility to parasitic forces, mission scenarios, calibration, data analysis..



■ Technical status :

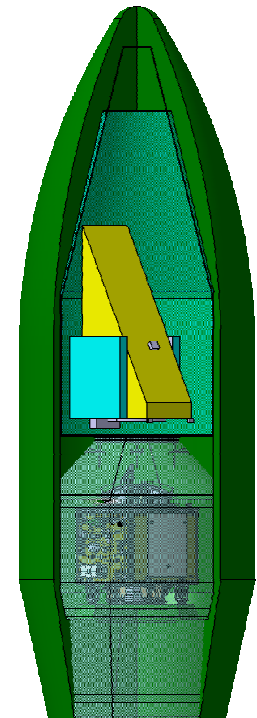
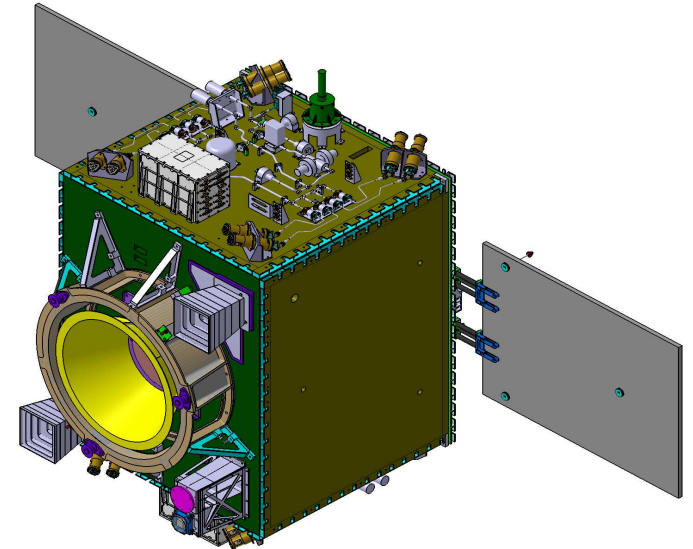
- Satellite (PDR march 2011) : ready for implementation; large part of FM equipment already available
- Payload : sensor unit under qualification & part of FM electronics

■ Remaining action

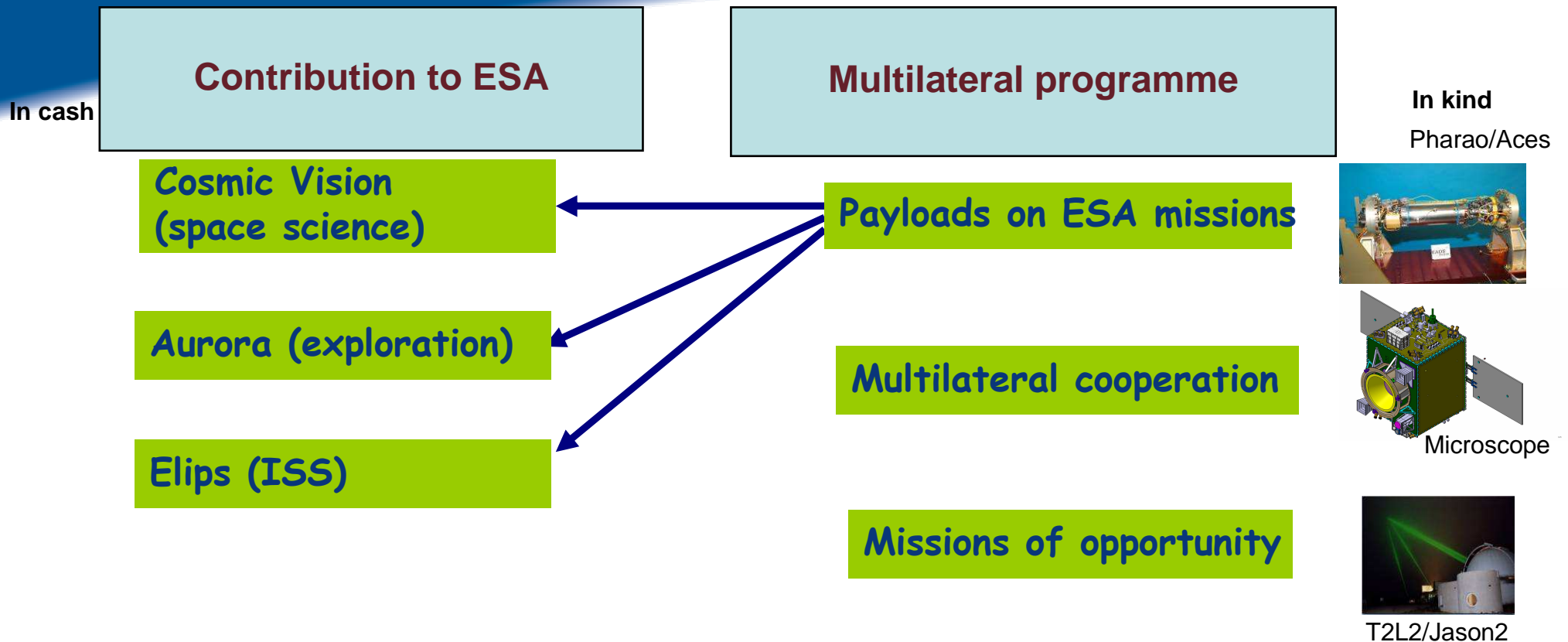
- ◆ Launcher: double launch on 6h/18h SSO orbit

■ But science programme is overloaded

- ◆ overcost of Microscope and other on-going projects
- ◆ new projects in competition, extension of exploitation



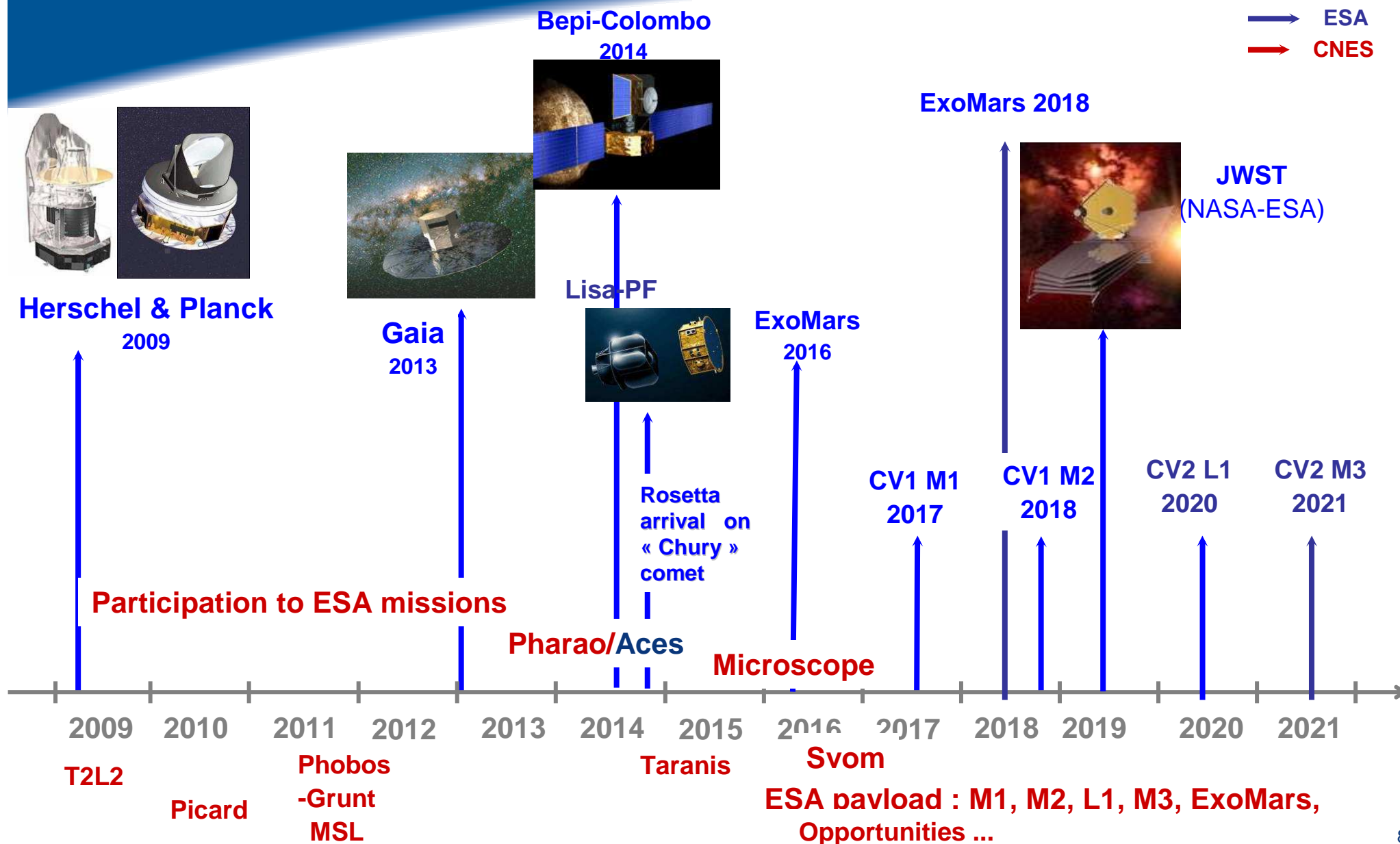
cnes budget for space science



Payloads on ESA missions = participation to Cosmic Vision missions, to EXOMARS, PHARAO/ACES on ISS

Multilateral cooperation = mini and microsatellites COROT, PICARD, TARANIS, MICROSCOPE, SVOM.

Missions of opportunity = payloads T2L2/Jason-2, STEREO, PHOBOS-GRUNT, MSL-2011, ...



ESA Cosmic Vision 2005

Roadmap for Fundamental Physics in space ESA 2010

<http://sci.esa.int/fprat>

« Our recommendations for future free flyer missions are summarized as follows:

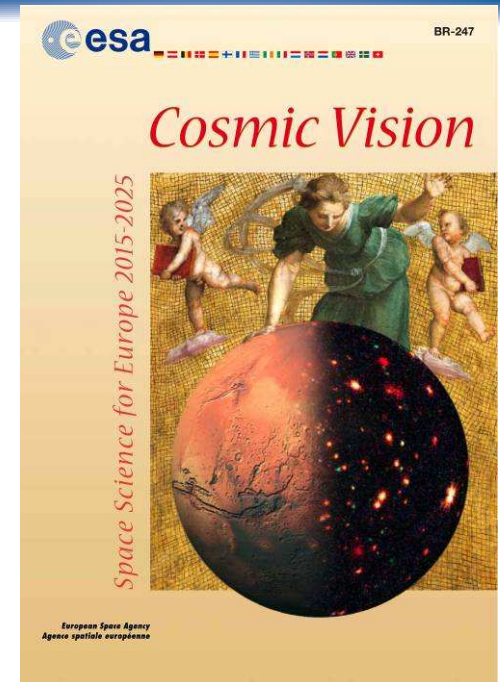
1/ It is of vital importance to the field of fundamental physics that the missions presently approved (LISA Pathfinder, ACES and MICROSCOPE) are launched with no further delay..... »

CNES séminaire de prospective mars 2009

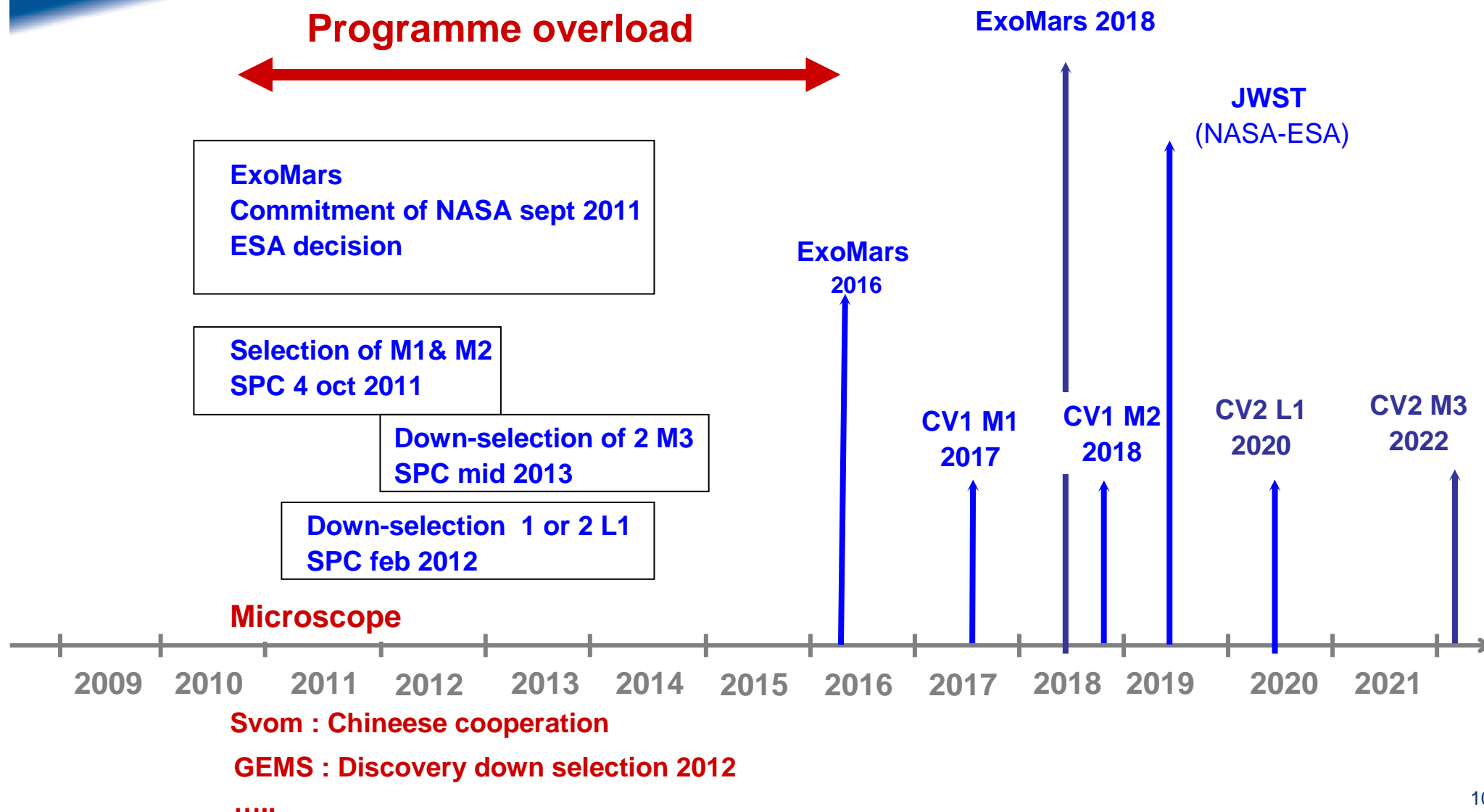
<http://www.cnes.fr/web/CNES-fr/8673-st-seminaire-de-prospective-scientifique-2010.php>

CPS Microscope recommendation 16 june 2011

The scientific challenges are still more urging than in 2004 and reinforce the interest of the Microscope project.



Programme overload

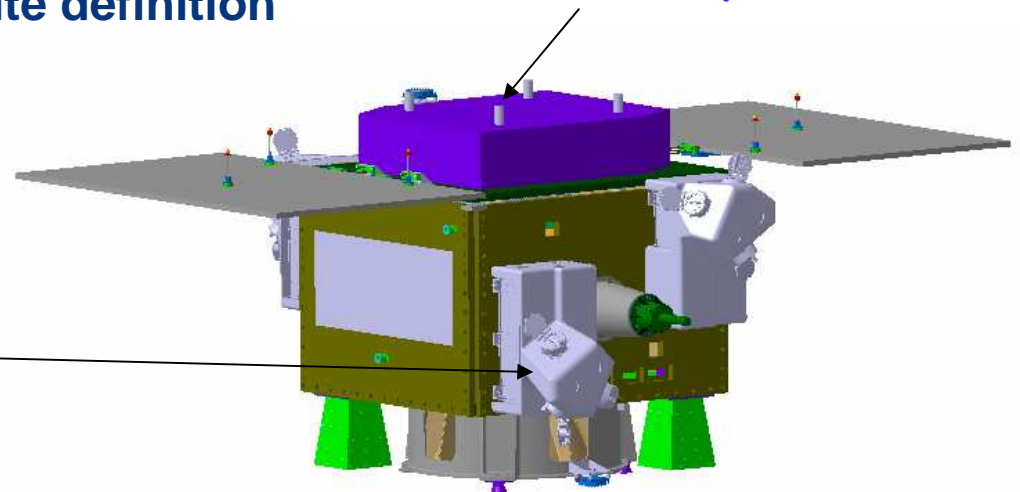


a number of changes in the project => overcost

- PDR feb.2006:approval of the satellite definition

Micropropulsion
FEEPs Cs (Lisa PF)

Deorbitation system



- But lack of maturity of the FEEPs Cs

- ♦ Approval of phase C/D for payload only (CNES board 5 april 2007)
- ♦ Search for alternate solutions for the micropropulsion system with ESA : 2006-2009
- ♦ Redefinition of the satellite, impact on performances, delay

- New regulations :

- ♦ Addition of a deorbitation system (avoid space debris)
- ♦ European launchers

- New project organisation (sub-contracting), new method for risk estimate

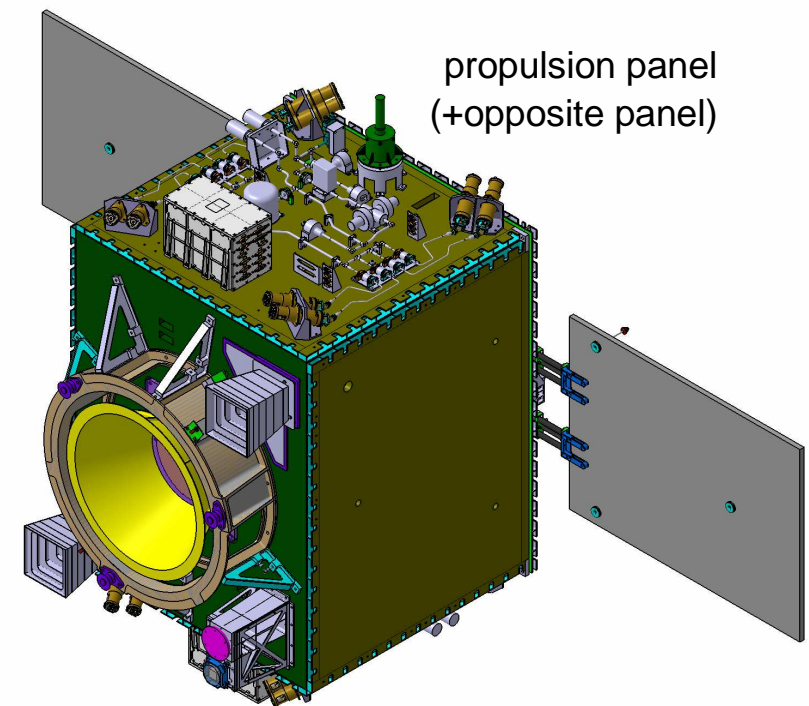
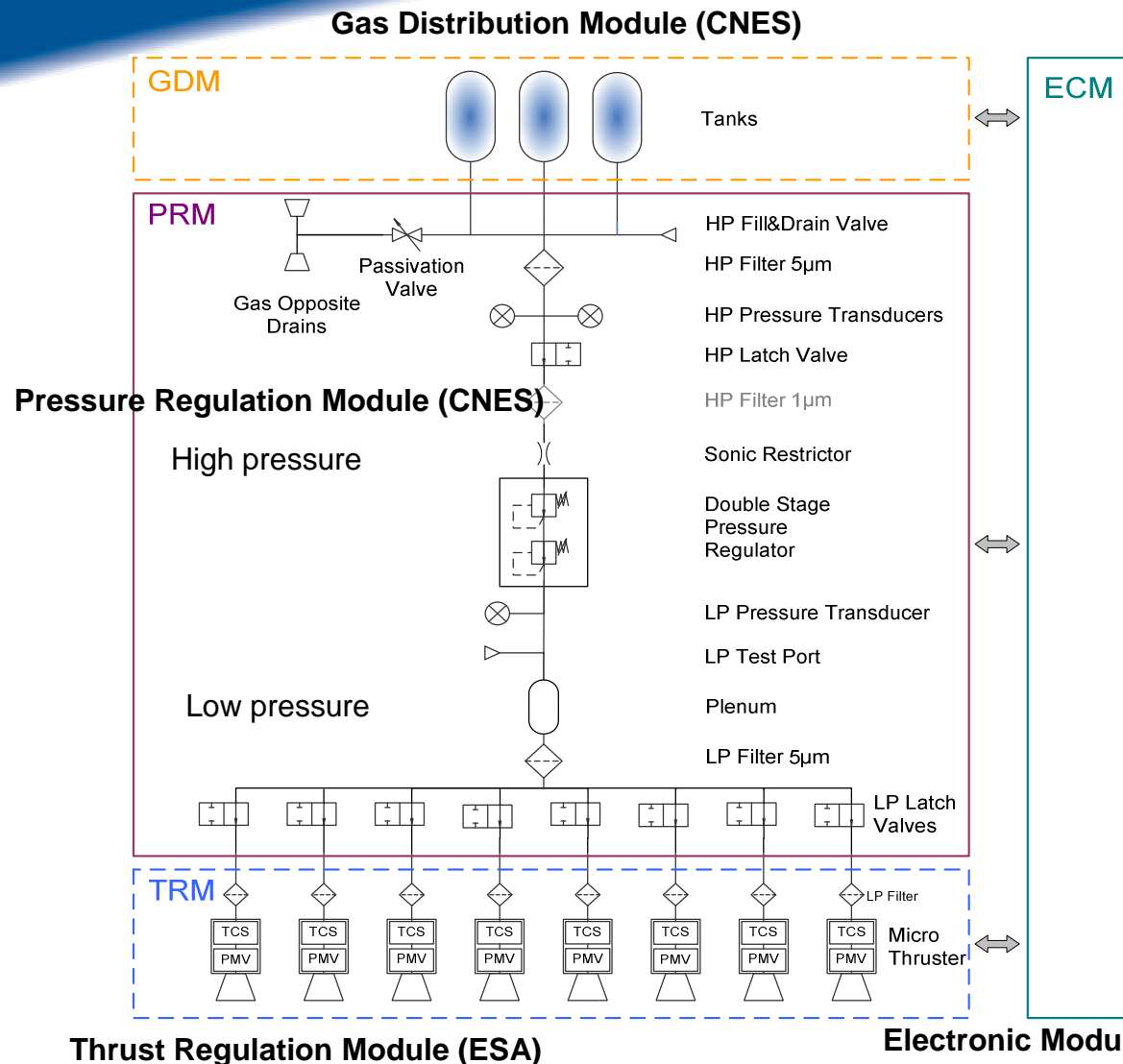
specific

generic

- Agreement with ESA to swap to Cold Gas Propulsion System (Gaia) instead of Electric Propulsion System (Lisa PF).
Sharing of responsibility in order to stay in the agreement cost cap (5M€ 2001).
- Delta-PDR successfully concluded with new satellite design (March 2011).
- Micro Propulsion Subsystem : phase B1 funded by CNES and performed by TAS-I in order to prepare the procurement with ESA (ESA/IPC 7oct 2010). But ESA ITT still on hold (waiting for CNES decision)
- Pressure Regulation Module designed by CNES and ready to enter procurement phase (waiting for CNES decision).
- Mission performances very deeply assessed by the ONERA/OCA/ZARM/CNES working group.

CNES : CGPS development,
qualification & validation ;
provision of tanks & pressure
regulation module

ESA : provision of micro thrusters &
electronics + performances





Satellite : a lot of equipments already procured

■ Myriade standard equipment

- ◆ Procured : reaction wheel, RX/TX, antennas, Sun Sensors, MAG, MTB, battery, OBC

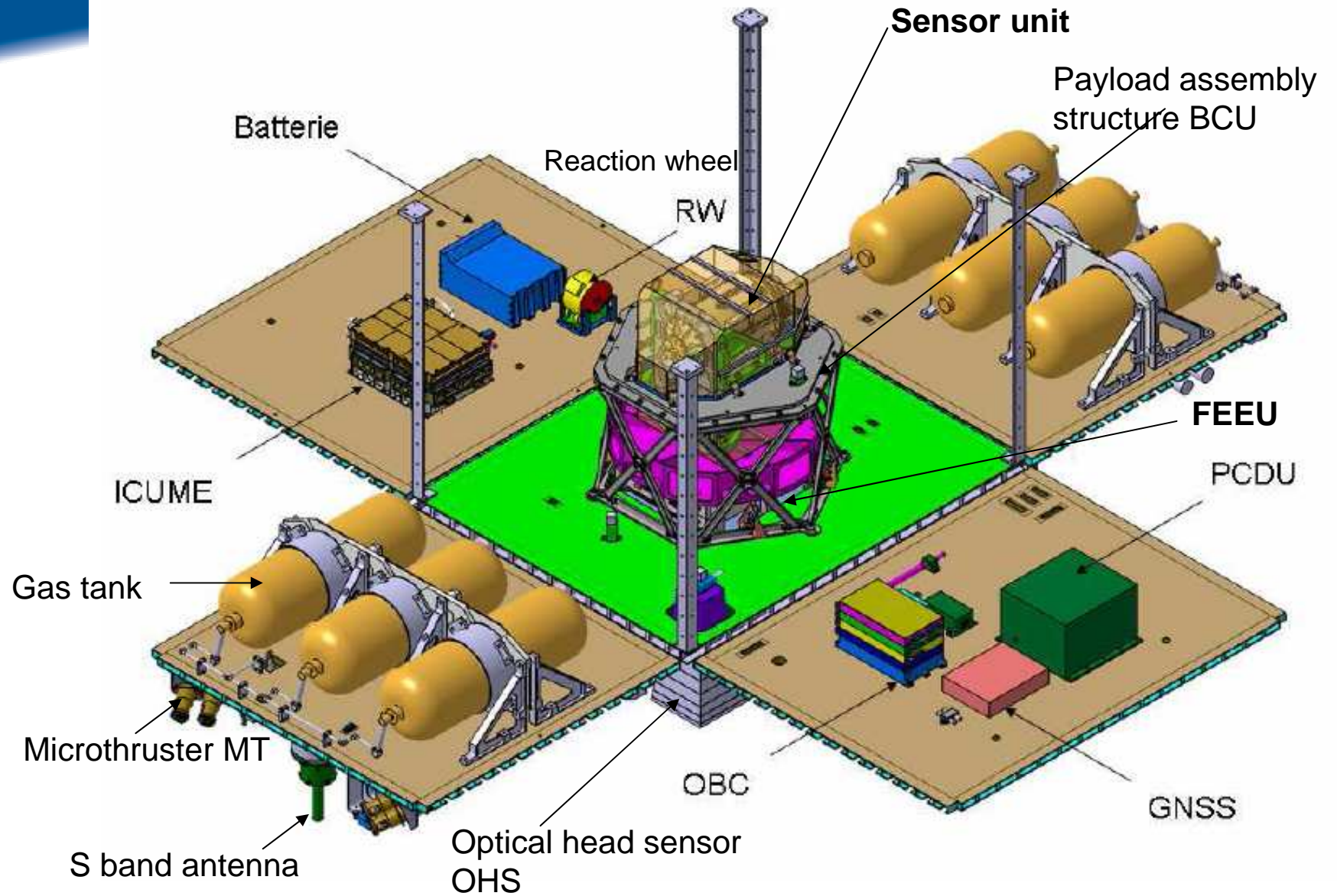
- ◆ To be adapted : PCDU, STR *

■ Satellite specific equipment

- ◆ Delivered : Payload structure (PFM)
- ◆ To be adapted : Platform structure, **
Solar Generator, harness
- ◆ Under development (PDR fall 2011) :
deorbitation system ***

+ Ground segment and operation fully re-using the existing Myriade facilities

Chaîne fonctionnelle	Equipements	Statut
Structure	1 structure « P/F » ¹ **	Spécifique Microscope
Contrôle thermique	thermistances, réchauffeurs, bilames	Equipement Myriade
	MLI	Spécifique Microscope
Alimentation électrique	1 GS avec articulations et pyros **	Equipement Nouveau
	1 batterie	Equipement Myriade
	1 PCDU *	Equipement Myriade
RF	2 Antennes bande S	Equipements Myriade
	2 boîtiers Rx/Tx	Equipements Myriade
	1 coupleur	Equipements Myriade
	Harnais RF	Myriade adapté
Gestion bord	1 OBC	Equipement Myriade
	1 Logiciel de vol	Adapté de Myriade
SCAA	1 SST à deux têtes *	Equipement Myriade
	3 SAS	Equipements Myriade
	1 magnétomètre 3-axes	Equipement Myriade
	3 Magnétocoupleurs	Equipement Myriade
	1 RW + 1 amortisseur	Equipement Myriade
	CGPS +son logiciel de vol	Spécifique Microscope
Chaîne électrique	1 harnais électrique **	
	2 µswitches	Equipement Myriade
GNSS	1 boîtier récepteur	Equipements nouveau
	2 Antennes GPS	Equipements existant
	1 coupleur	Equipements existant (AC)
	Harnais RF	Equipements existant (AC)
Dispositif de désorbitation	***	Spécifique Microscope



CPS (scientific programme committee) 16 june 2011

■ Situation :

Considering the new cost within the tight financial budget of CNES for space science, it seems that it is no longer possible to fund the whole project.

■ Recommendation of CPS :

- ♦ reaffirms that testing the Equivalence Principle is fundamental
- ♦ encourages CNES to seek all the solutions in order to achieve Microscope, in particular by coming together at the highest level with ESA and DLR partners, and finding a new cost adjustment.

■ Instruments :

- ♦ Opportunity payload (MSL, GEMS...) < €20 Million

■ Missions (payload, satellite, launch, operations) :

- ♦ Microsatellite (Taranis, Microscope, ..) €120-150 Million
- ♦ ESA M mission : 450 ESA+ 150 member states (payload, operations) = € 600 Million
- ♦ ESA L mission ; 850 ESA + payload = €1000 Million
- ♦ ExoMars: ESA € 1000 Million + payload (member states)
- ♦ JWST : > \$ 8000 Million

(Ground equipment

- ♦ telescope (ALMA, ELT) : € 800 à 1000 Million + operations
- ♦ LHC : € 7500 Million)

The project is technically ready for implementation.
But CNES decision has been postponed, due to overload of CNES programme and to Microscope overcost.

The project is on hold. Most urgent :

- CNES:
 - Payload contract rider?
 - Procurement of ITAR elements? (part of CGPS, platform structure, solar generator, IDEAS)
- ESA: CGPS ITT (Invitation To Tender)?

Next steps :

- Payload : end of qualification
- Discussion with partners (ESA, DLR)
 - propulsion system
 - launcher
- CNES CPS 16 october

