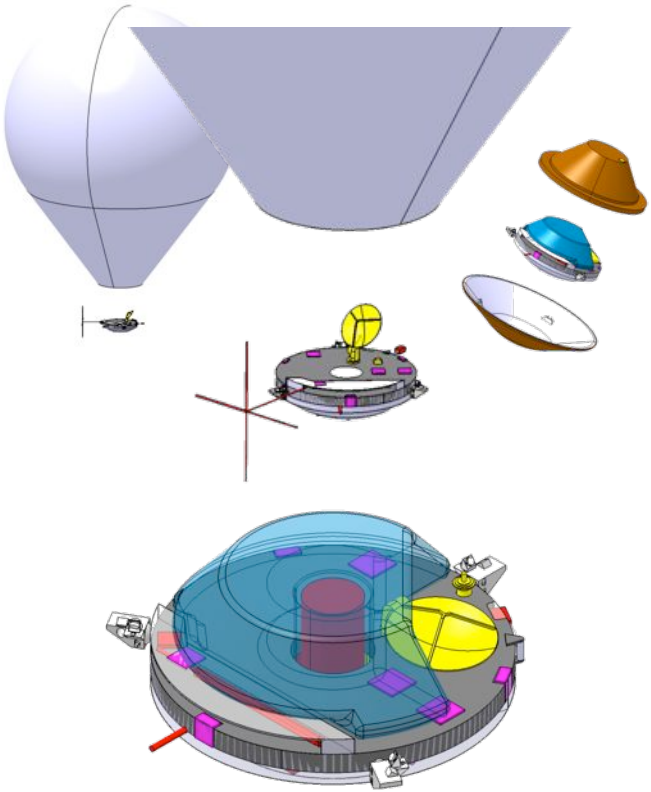
ESA Robotic Science Missions Overview



P. Falkner,
Planetary Exploration Studies Section
Advanced Studies and Technology Preparation Division
European Space Agency

10th ASTRA Workshop, ESTEC, 11. Nov. 2008

Contents

Science Missions

- Overview
- Focus Future CV missions

Exploration Missions

Conclusion

Overview

	Sun	Solar System	Astrophysics	Fundamental
Operations	SOHO [1995] Ulysses [1990]	Venus Express [2005] Rosetta [2004] Mars Express [2003] Double Star [2003] Cluster [2000] Cassini-Huygens [1997]	INTEGRAL [2002] XMM-Newton [1999] Hubble [1990]	
Implementation		BepiColombo	Herschel [2009] Planck [2009] Gaia JWST	LISA Pathfinder [2010]
Assessment	Solar Orbiter			
Completed		SMART-1 [2003] Giotto [1985]	ISO [1995] Hipparcos [1989] EXOSAT [1983] IUE [1978] Cos-B [1975]	
Future Missions	Cosmic Vision 2015 - 2025: M-class study missions: Cross-Scale, Euclid, Marco Polo, PLATO, SPICA L-class study missions: Laplace/EJSM, LISA, TandEM/TSSM, XEUS/IXO			

Call for mission proposals:	Mar 2007
Proposal selection:	Oct 2007

M-class

- **Marco Polo**: Near-Earth asteroid sample return
- **Cross Scale**: Coupling in plasmas between different physical scales
- PLATO: Planetary Transits and Oscillations of Stars
- EUCLID: ESA's mission to map dark energy
- SPICA: Europe contribution (JAXA's Space IR Telescope)

L-class

- **Laplace/Tandem**: Jupiter or Saturn system exploration
- IXO: International X-ray Observatory
- *LISA:* *Laser Interferometer Space Antenna*

- Important selection criterion: TRL >= 5 by end of Definition Phase
- Competitive mission selection process (M-class and L-class missions)

- ESA Internal assessment studies: Nov. 2007 – Dec. 2008
- Industrial assessment studies: Jul. 2008 – Sep. 2009 (M-class)
- Instruments assessment studies: Sep. 2008 – Aug. 2009 (M-class)

- Industrial assessment studies: Jul 2009 – Dec 2010 (L-class)
- Instruments assessment studies: May 2009 – Nov 2010 (L-class)

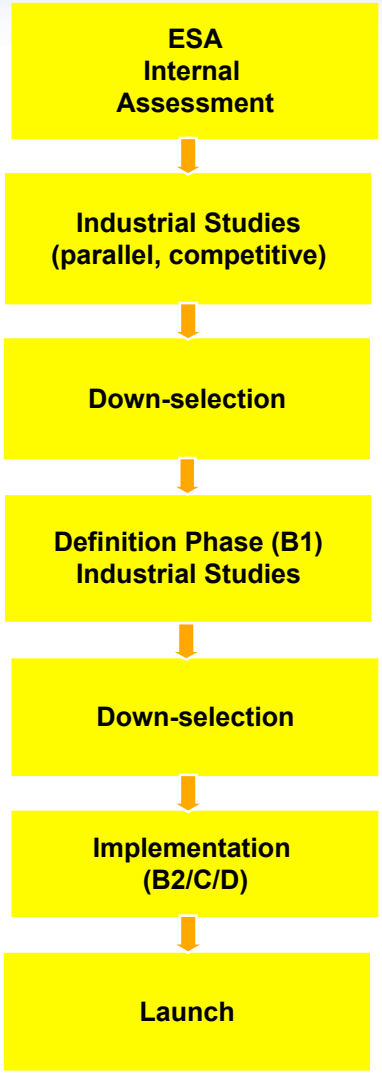
- Internal review and synthesis: Sep-Oct 2009 (M-class)
- Down-selection (SSWG/SSAC): End 2009

M-class candidates:

- Definition Phase (B1) - 3 (tbc) candidates: 2010 – 2011
- Implementation phase (B2/C/D) - 2 missions: 2012 – 2017/2018
- **Launch- 2 missions: 2017/2018**

L-class candidates:

- Laplace / Tandem down-selection (ESA/NASA) Jan. 2009
- Assessment Phase (3 candidates) 2009-2010
- Definition Phase (B1) (2 candidates): 2011-2012
- Implementation phase (1 mission): 2013 – 2020
- **Launch: 2020 (TBC)**



Marco Polo (M-class)

Programmatic

- M-class mission (300 M€ CaC, excl. science P/L), launch 2017

Science

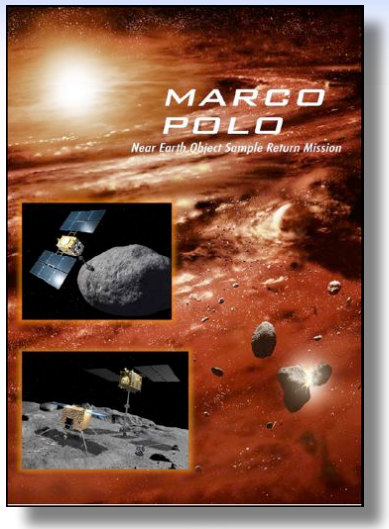
- ~30 gram Sample Return from primitive Asteroid (C or D-type)
  e.g.: UQ 1989 (C-type), ~760m diameter, 0.67 AU x 1.16 AU

Space Segment

- Launch with Soyuz -1B (Aug. 2017)
- Chemical Transfer (typ. 3.2 year), Δv = 482 m/s, Earth-Venus GA-transfer
- Arrival: Dec. 2020 – 1.6 year stay time (observation, sampling)
- Landing on target at full daylight
- Return: Nov. 2023, Δv = 529 m/s, Venus GA
- Entry: v = 11.8 km/s, 11 MW/m2, ~76 kg entry capsule (ERC)
- 3 axis stabilized S/C, mass = 1.191 kg (wet)
- Sampling based on coring principle (some ExoMars heritage)

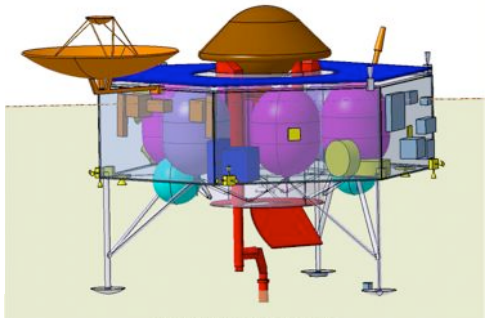
Payload

- **Focus on sample return**
- cameras, microscope (close-up image), laser altimeter, VIS/NIR spectrometer, Neutral Particles, Radio Science, APXS,…



CV-proposal
Marco Polo

Re-entry capsule



Spacecraft Design

Robotic arm for sampling

Marco Polo (M-class)

Technology

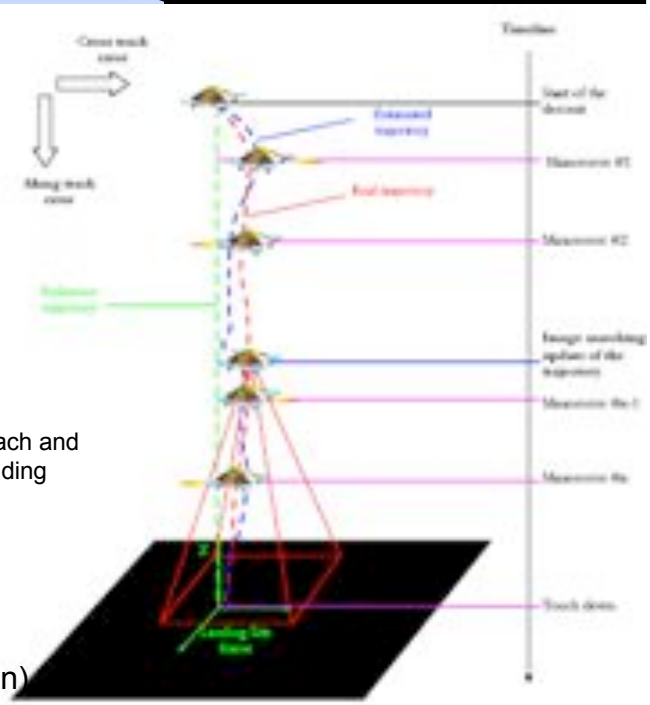
- Guidance and Navigation at small body, including GNC for safe landing
- Landing and operations on surface at low gravity
- Sampling mechanism and transfer system
- Re-entry 12.5 km/s

Status

- ESA internal CDF study completed. Report Issued (328 pages).
- Industrial Studies – running (Final Review ~Sep. 2009)
- Technology Plan approved (ESA's E2E harmonisation)

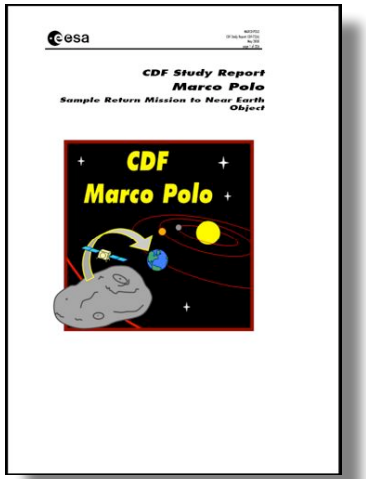
International collaboration

- JAXA, NASA (details under discussion)
- In case of JAXA lead: More challenging target (e.g.2001 SG286/Wilson-Harrington)



Approach and Landing

Marco-Polo Sample and Transfer System

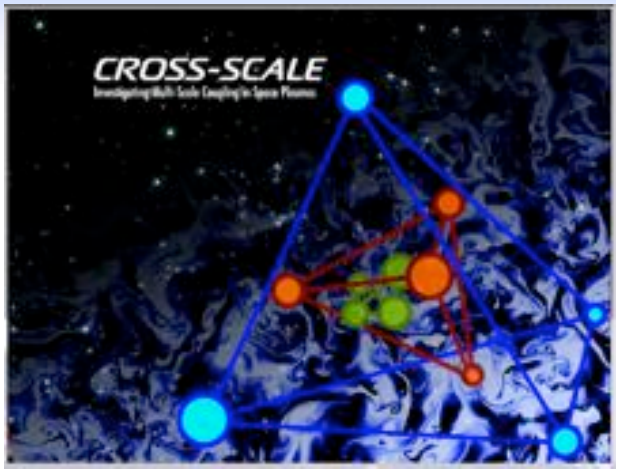


CDF Report Marco Polo

Cross Scale (M-class)

Programmatic

- M-Class Mission (300 M€ CaC, excl. science P/L), launch 2017

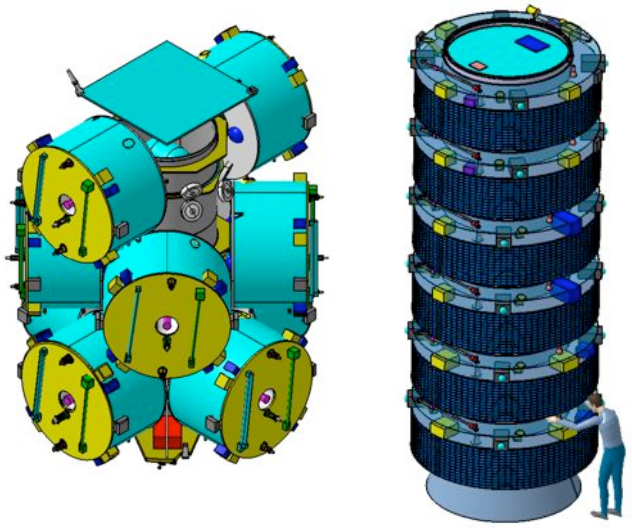


Science

- To study plasma processes (turbulence, reconnection, shocks) on multiple scales simultaneously

Space Segment

- Minimum 7 S/C in nested tetrahedra, optimum 12 S/C on 3 scales:
  (1) Electron scale (2-100km), (2) Ion scale (50-2.000km), (3) Fluid scale (3.000-15.000km)
- Slightly adopted payload per scale (~25 kg per S/C)
- Spinning S/C with ~15 rpm
- Orbit: 10 R_E x 25 R_E (optimum science, low radiation, no debris problem) constellation passes through bow shock, magnetotail and magnetopause
- Orbital period: 104 h Orbit Inclination: 14 degree, multiple visit of "Tailbox"
- Launch on Soyouz-2b (7 S/C on single launcher)
- S/C design: identical for all scales to keep NRE*-cost low
- Main trade: dispenser / stacked configuration



Trade: Dispenser or Stacked configuration

Payload:

- DC Magnetometer (MAG)
- Electric Field sensor with double wire booms (E2D)
- Electron Electrostatic Analyser (EESA)
- Ion Composition analyzer (ICA)
- Active Spacecraft Potential Control (ASP)

AC search coil magnetometer (ACB)
Electron Density Sounder (EDEN)
Ion Electrostatic Analyzer (IESA)
High Energy Particle Detector (HEP)

Note (*): NRE=non recurring engineering

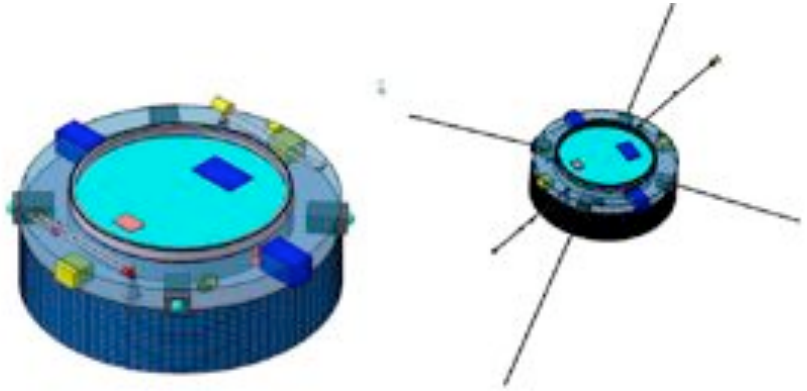
Status

- ESA internal CDF study completed. Report Issued. (304 pages).
- Industrial Studies – running (Final Review: Jul. 2009)
- In parallel: Instrument Studies (10) by instrument proposers
- No major critical technology development required
- **Announcement:** Workshop on Cross-Scale Coupling in Plasmas
  Università della Calabria, Rende (Cosenza) – Italy, 9. -11.March 2009

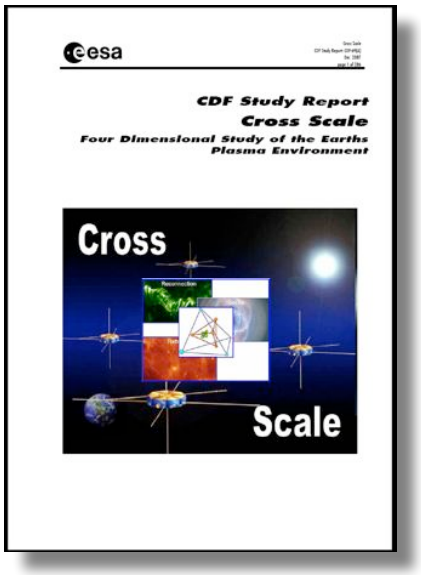
Wire-boom deployment unit

International Collaboration

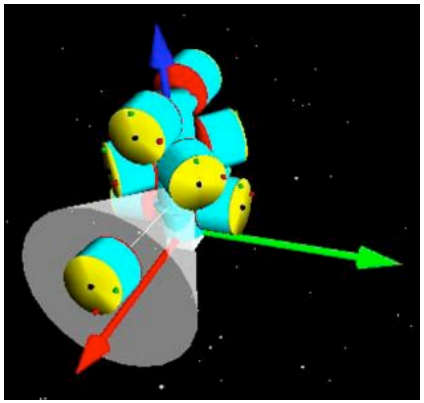
- JAXA (Scope), NASA and CSA - members included in Study Science Team



Spacecraft in stowed and deployed configuration



CDF Report Cross Scale



S/C deployment simulation
(dispenser based)

Tandem – Titan Saturn System Mission (TSSM)

Programmatic

- L-class mission (650 M€ CaC, excl. science P/L), launch 2020
- Close NASA cooperation (Outer Planet Flagship missions)
- ESA: In-situ elements (ISE) & NASA: Titan Orbiter carrying ISE's
- Balloon Technology from CNES

Science

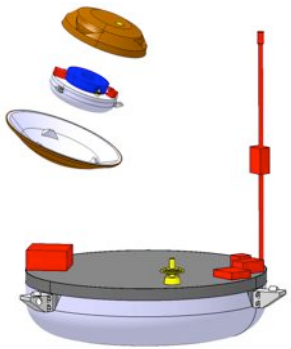
- Saturn System science, Titan in-situ science (atmosphere, surface, lake)

Space Segment

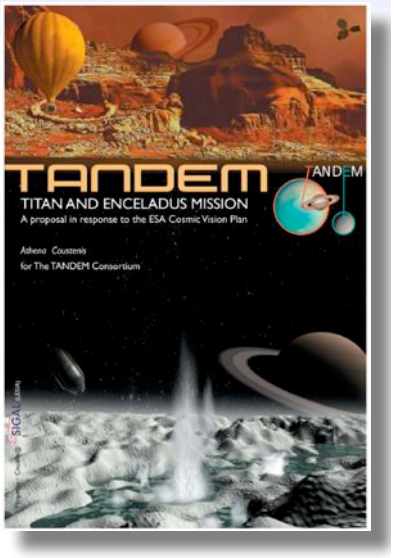
- Launch by NASA, Orbiter carrying ISE's (up to 800 kg)
- Release of ESA insitu-elements after SOI at 3rd Titan fly-by
- Montgolfier: 599 kg (24 kg P/L), targeted at mid latitude (20° N), power MMRTG
- Short lived (battery) lander: 190kg (27kg P/L), northern polar lakes (Kraken Mare)

Payload

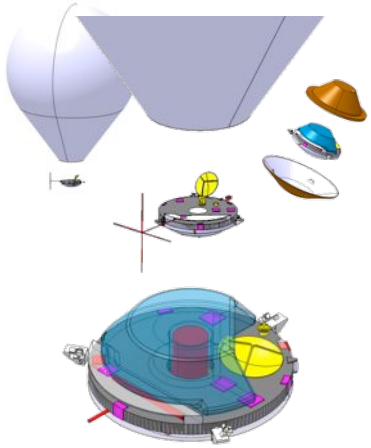
- **Montgolfier:** Camera, Imaging spectrometer, ASI, Radar, Radio Science, Electric environment package, Magnetometer, Chemical Analyzer
- **Lander:** Chemical Analyzer, Radio Science, ASI& Meteo, Acoustic sensor, Imager Radio/Spectrometer, Liquid Science package



Short life lander



CV-proposal Tandem

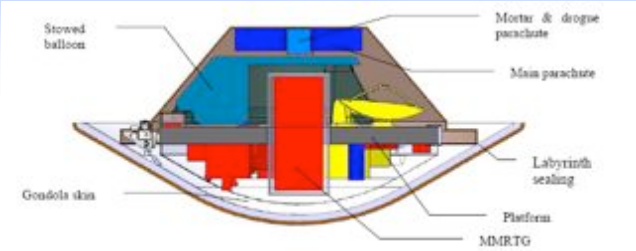


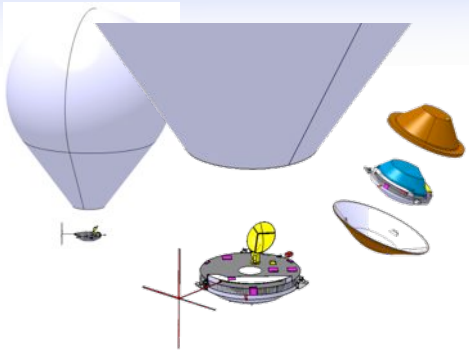
Montgolfier

Tandem – Titan Saturn System Mission (TSSM)

Technology

- Balloon (CNES) – material & inflation
- Balloon Gondola and P/L accommodation
- Late Integration of MMRTG
- Small Lander (integration)



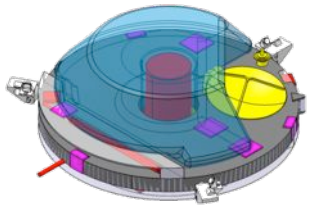


Status

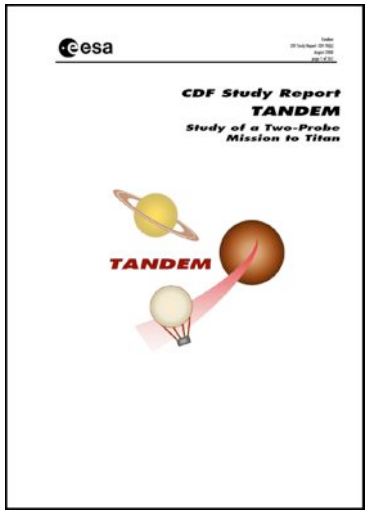
- ESA internal CDF study completed. Draft report under review (363 pages)
- **Preparation of ESA/NASA down-selection** between Jupiter & Saturn ⇨ Jan. 09

International collaboration

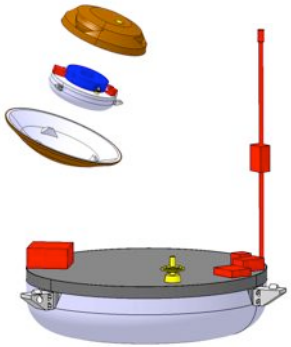
- Strong ESA/NASA collaboration



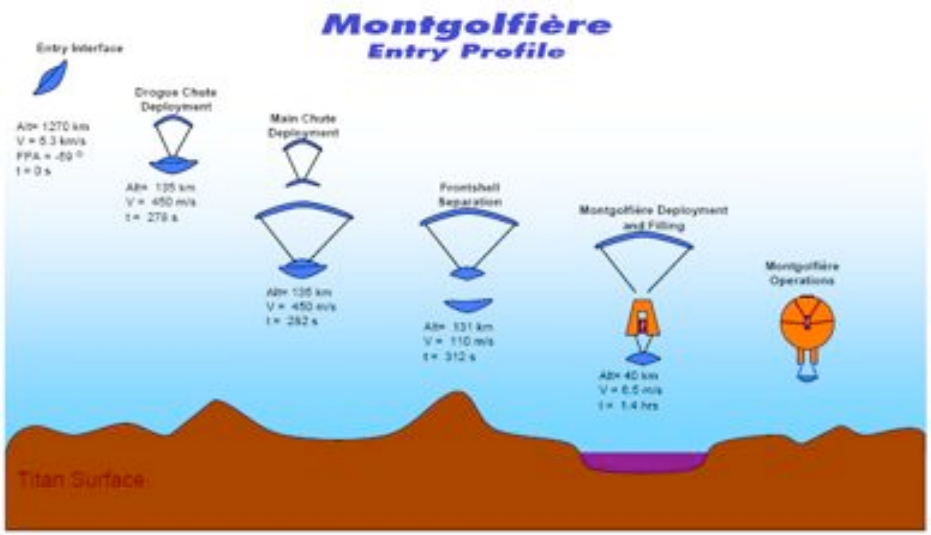
Montgolfier



CDF report - Tandem



Short life lander



LaPlace – Europa Jupiter System Mission (EJSM)

Programmatic

- ESA-JGO: L-class mission, (650 M€ CaC, excl. science P/L), launch ~2020
- Close NASA collaboration (Outer Planet Flagship missions) (JEO)

Science

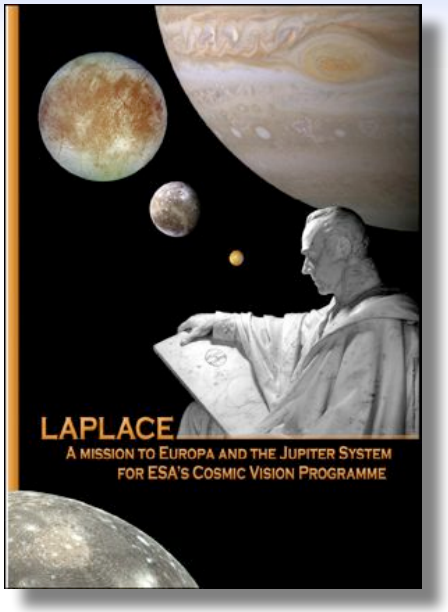
- Jupiter System Science (atmosphere, magnetosphere), focus: Callisto and Ganymede (JGO)
- Jupiter System Science, focus: Europa, IO (NASA-JEO), Jovian Magnetosphere (JAXA-JMO)

Space Segment (ESA, Jupiter Ganymede Orbiter (JGO))

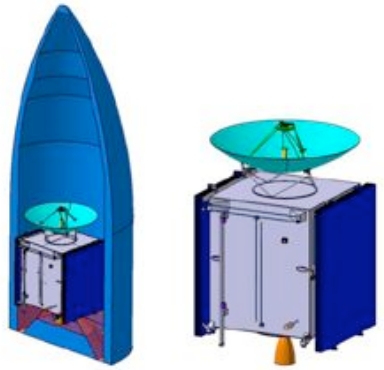
- Launch: Ariane 5 (CSG) 2020, Transfer: 5.9 y (6.5y) VEEGA-type, no deep space manoeuvre
- Arrival: 2026, Jupiter insertion (12.5R_J x 224 R_J) with Ganymede Gravity Assist
- Jupiter tour with multiple fly-bys at Callisto and Ganymede (low altitude, typ. 200 km)
- (1) Callisto resonant orbit, (2) Ganymede elliptical orbit (200x6000km), (3) Ganymede circular orbit (200 km)
- **Avoidance of high radiation** ⇨ JGO stays <100krad (8mm) total dose, 80kg shielding mass
- 3-axis stabilized S/C, dry mass (wet)= 1254kg (3480kg)
- **Solar power** (540W_{EOL}), array = 52 m^2, LILT technology, no concentrators, no RTG or RHU
- Chemical propulsion (total Δv = 2467m/s + 445m/s navigation)

Payload (~80kg science instruments)

- Imager, Vis/NIR/TIR/EUV/FUV Spectrometers, Radar sounder & sub-mm wave sounder, Micro-Laser-Altimeter, MAG + Plasma package, Radio-Science



CV-proposal Laplace



JGO = Jupiter Ganymede Orbiter

Technology

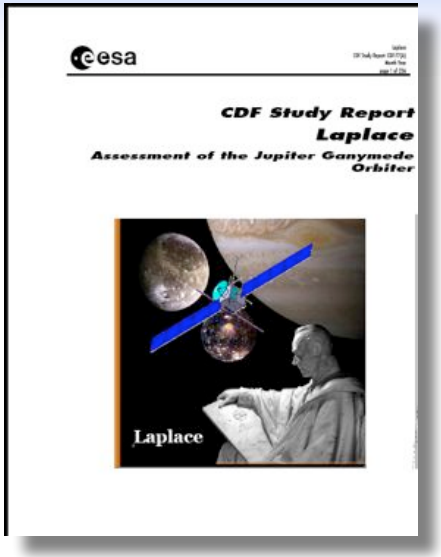
- Radiation hardening and tolerance
- Improved Environmental modelling
- Tailored shielding
- Solar Cell Technology (LILT)

Status

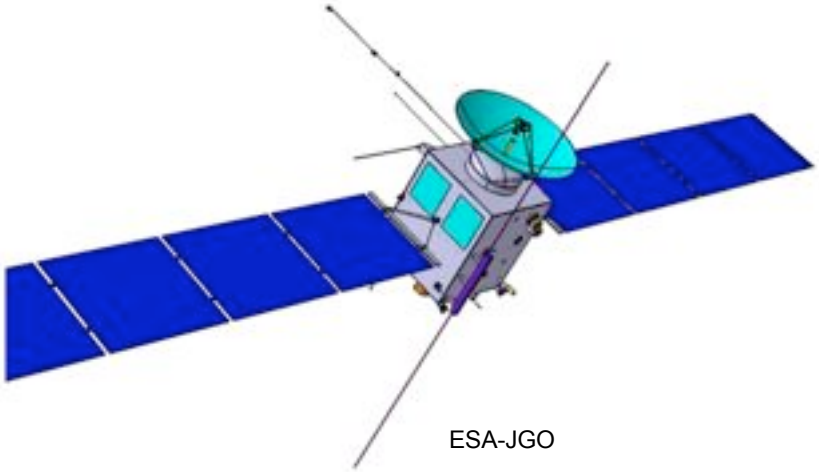
- ESA internal CDF study completed. Draft report under review (236 pages).
- **Preparation of ESA/NASA down-selection** Jupiter / Saturn ⇨ Jan. 09

International collaboration

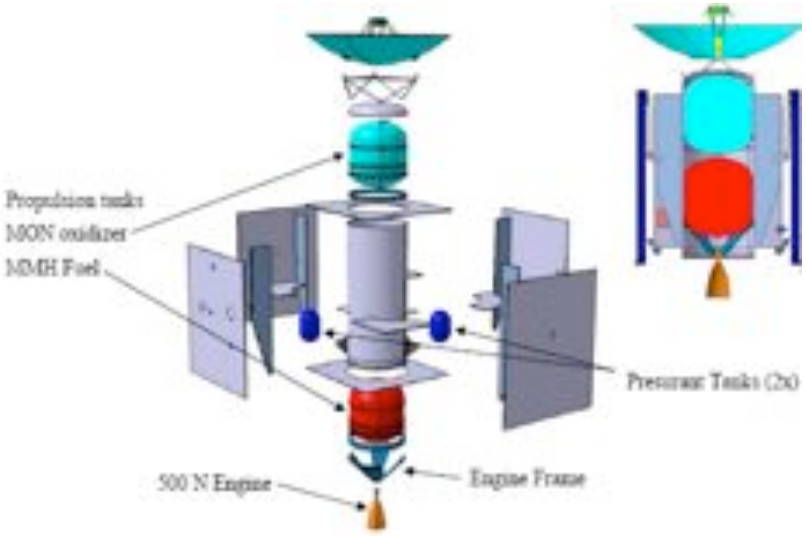
- strong ESA/NASA collaboration
- possibly JAXA (JMO) and Russia (lander)



CDF report - Laplace

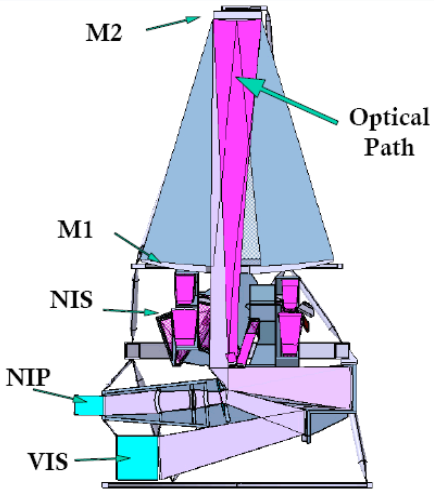


ESA-JGO

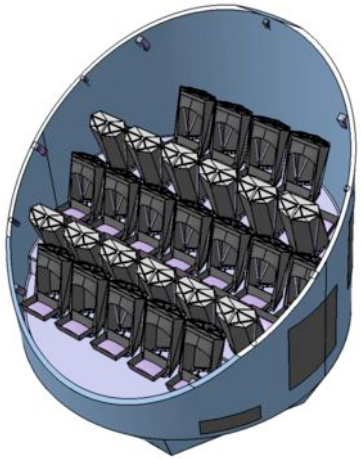


ESA-JGO

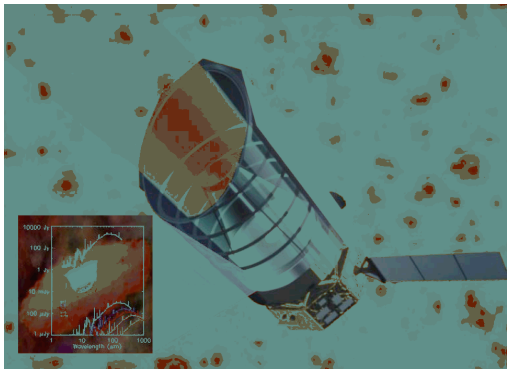
M-class



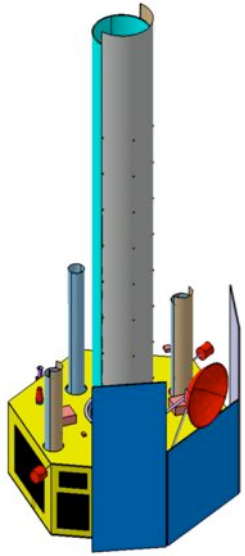
EUCLID



PLATO



SPICA – IR Telescope



XEUS / IXO (L-class)

Main R&A_Technology:

Deployable structures: as alternative to FF to achieve long focal lengths, interesting also for radar deployment / antenna deployment (exploration).

- ExoMars - See Session 3 & Session 4

- Future missions – Proposal to PB-HME done
  - Needs confirmation & depends on LoR
  - Optional Programme
  - Mars Sample Return (MSR) as long time goal (vision) > 2020
  - Intermediate missions (IM) for technology demonstration in close collaboration with US
  - Technology development roadmap under definition
    ⇨ rich on robotic technologies

Future Cosmic Vision missions:

- Marco Polo (Near Earth Asteroid Sample Return)*
- Insitu Elements (Montgolfiere and lander) for Tandem TSSM**

⇨ require most interesting robotics and automation technology

Future Exploration missions:

- under definition

⇨ will require a extensive set of robotics and automation technology

Note *: subject to down-selection for M-class missions end 2009
Note **: subject to down-selection between Jupiter and Saturn Mission Jan 2009

End