Cosmic Vision 2015-2025
Technology Plan

Industry day, Estec 21 November 2008

Directorate of Science
and Robotic Exploration

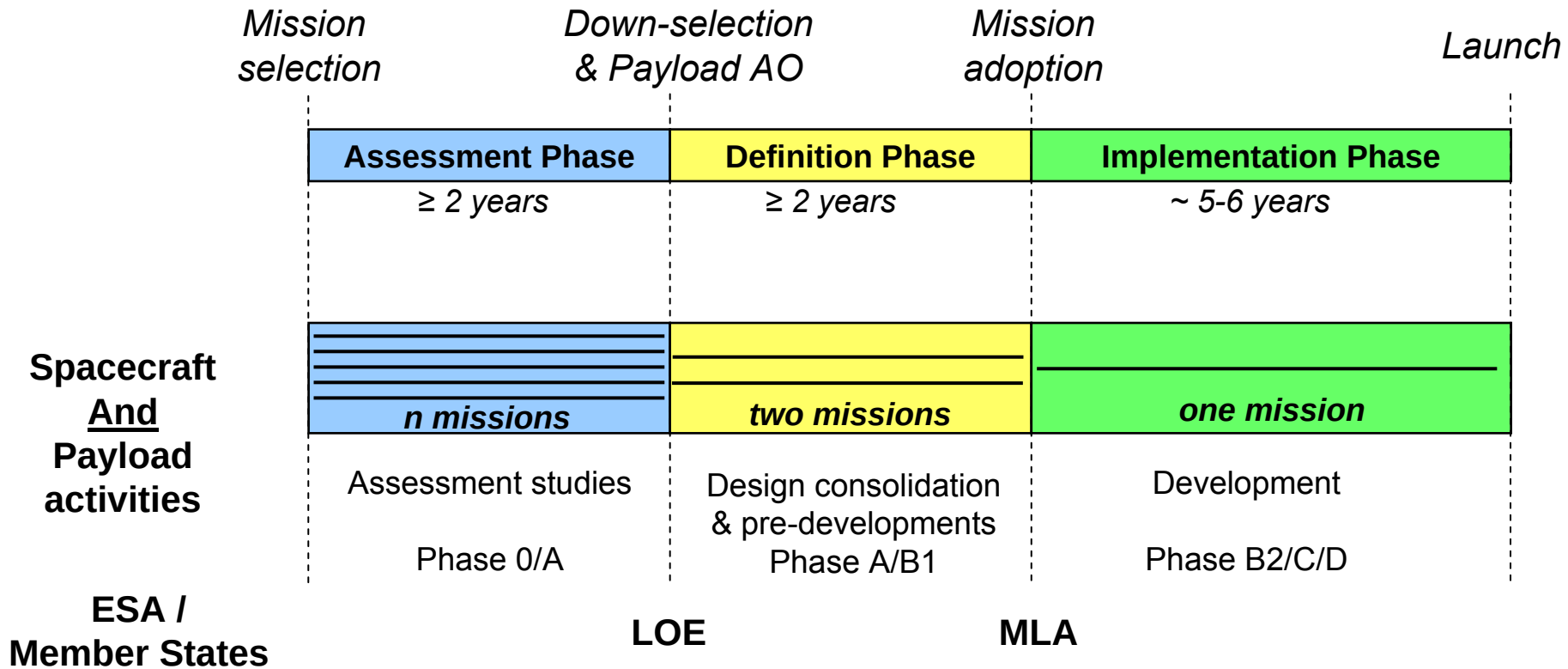
Agenda

1- Status of Cosmic Vision Plan	10:00 - 10:40
General Status - F.Safa	
2- Overview of M-Class missions	10:40 – 11:30
Solar Orbiter – Ph.Kletzkine	
Cross-Scale, Marco-Polo – P.Falkner	
Plato, Euclid – N. Rando	
3- Overview of L-Class missions	11:30 – 12:10
IXO mission – N.Rando	
LISA – A.Gianolio	
Outer Planet Mission – P.Falkner	
4- Technology Development Plan Implementation	12:10 – 12:30
Implementation procedures – M.Bavdaz	
Implementation schedule – M.Bavdaz	

General Status

Mission Assessment Phase

First slice of Cosmic Vision Plan: Six M-Class and three L-Class missions are being assessed



more on cosmic vision: http://sci.esa.int/science-e/www/area/index.cfm?fareaid=100

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M class missions

- **Six missions studied**
  - ✓ Five from CV 2015-2025 first Call: Euclid, Plato, SPICA, Marco-Polo & Cross-Scale
  - ✓ Solar Orbiter now included in CV slice 1

- **Current progress is compatible with a M-mission down-selection end 2009/early 2010 and a launch in 2017/2018**
  - ✓ Phase 0 completed for all M missions. All industrial studies completed in Sept 09,
  - ✓ Technology Plan (TDP) in place for ESA and in progress for Member States on instrumentation
  - ✓ Technical readiness status vs 2017-2018 launch: should be achievable, based on Phase 0 ESA studies

- **Budget compatibility: The overall CV budget envelope (~ 900 ME) can reasonably accommodate two (or more) M missions**
  - ✓ Will be further consolidated by the end of the Assessment Phase, following consolidation of Member State contribution on the Payload

M missions: Short term schedule

- **Industrial studies**
  - ✓ Funded by ESA General Study Programme (GSP)
  - ✓ All studies are organised in three phases
    - Design trade-offs & baseline selection (Phase 1)
    - Detailed design (Phase 2)
    - Programmatic (Phase 3, 1 month)
  - ✓ Mid-term (baseline selection): Dec 08-Jan 09
  - ✓ Study completion: Sept 2009

- **National Payload Studies**
  - ✓ Instrument national studies are made in parallel with industrial studies
  - ✓ Interface with the Study Science Team, Industry and Instrument teams ensured by ESA

L class missions

- **Three L-missions are being studied: Outer Planet mission (Laplace or Tandem), IXO and LISA**
  - ✓ Phase 0 completed for all L missions,
  - ✓ Technology Plan (TDP) in place for ESA and in progress for Member States on instrumentation
  - ✓ Slower progress than for M missions, due to international context, technical complexity and “primary” between Laplace/Tandem: Industrial studies not yet started, call for Instrumentation studies not yet issued.
- **Technical readiness status vs 2018 launch: Not demonstrated**
  - ✓ Poor for Outer Planet missions and IXO, based on Phase 0 ESA studies and TDP elaboration.
  - ✓ Subject to LISA Pathfinder success in-orbit and to satisfactory technology development progress for LISA.
- **Budget compatibility: None of the missions can be afforded within the overall CV budget envelope, without international collaboration.**

L missions: International collaboration scheme and constraints

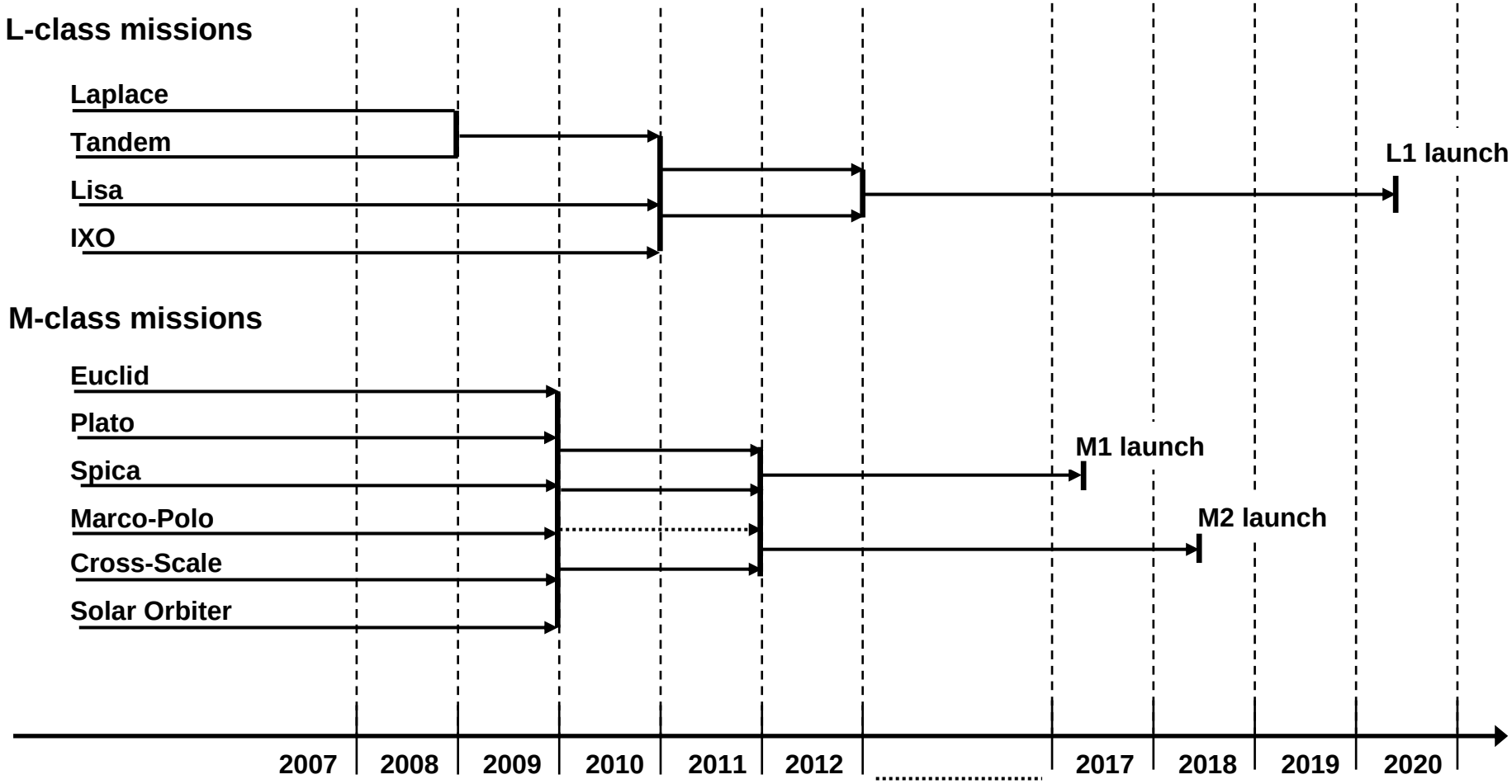
- **The three L missions are today foreseen in collaboration with the United States, and in addition for some with Japan**
  - ✓ Was the case for LISA: ESA/NASA mission
  - ✓ Was the case for Outer Planet Missions
  - ✓ Recent evolution for XEUS, re-named IXO (International X-ray Observatory)
  - ✓ But NASA budget constraints are not compatible with L-mission launch before 2020

- **Target launch date for L1 mission is now 2020**
  - ✓ Realistic schedule vs budget and technology preparation
  - ✓ The Outer Planet down-selection (Jupiter or Saturn) is confirmed for beginning 2009 and will be jointly done by ESA/NASA

L missions: Short term schedule

- **IXO Phase 0 (ESA study):** **Oct-Nov 08**
- **Laplace/Tandem down-selection:** **Jan 09**
- **IXO and Outer Planet studies (all dates preliminary)**
  - ✓ Invitation to Tender: April-May 2009
  - ✓ Industrial Studies: July 2009-Dec 2010
  - ✓ Call for Instrument studies: Feb-March 09
- **L1 mission down-selection:** **beginning 2011(tbc)**

Cosmic Vision timeline summary



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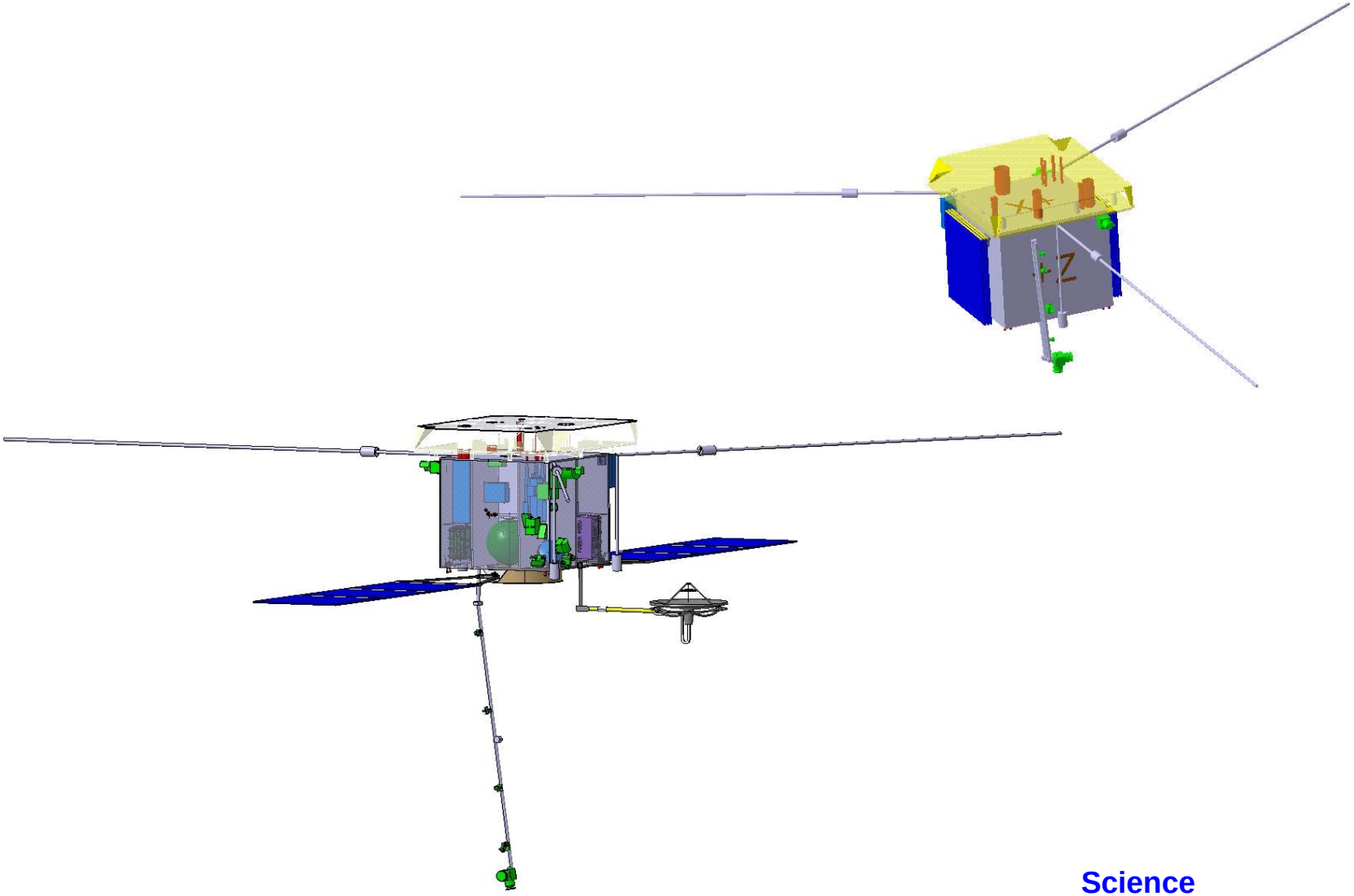
Overview of M-class missions

Current Industrial Work

- Preliminary Definition Phase B1 initiated in March 2008.
- Astrium Ltd, with Astrium GmbH and Alenia.
- Design Definition of Spacecraft, Heat Shield, Instrument Accommodation, **Definition of Technology Development Activities**.
- Programmatics, BepiColombo equipment re-use, Equipment Requests for Information, Schedule, Costing.
- Preliminary Requirements Review scheduled in Dec. 2008.
- System Requirements Review scheduled in Fall 2009.
- Slightly re-directed to fit **Cosmic Vision milestones**: down-selection end 2009, Phase B2/C/D start in January 2012, **target launch in January 2017.**

Spacecraft Baseline



Spacecraft Critical Items

- SOLAR GENERATOR
  - ✓ Hot case sized by temperature and solar flux
  - ✓ Cold case sized by far-sun power demand
    => New, dual-side design needed
    Heritage from BepiColombo? (Array / PVA / Cell / diodes etc)
- HIGH GAIN ANTENNA
  - ✓ Inherited from BepiColombo but must be adapted (Pointing Mechanism, coating, mounting frame), higher mass than originally budgeted
  - ✓ Crucial for critical data downlink. MUST BE FOLDED REPEATEDLY.
- HEAT SHIELD with its BAFFLES, DOORS, MECHANISMS
  - ✓ Openings, interfaces, diaphragms, materials - Already well underway
- AOCS SENSORS and FDIR ITEMS
  - ✓ Sun Sensors, adapted Star Trackers, specific FDIR
- THERMAL CONTROL MATERIALS
  - ✓ Heritage from BepiColombo? (HTMLI / Heat Pipes etc)
- HIGH SOLAR FLUX TEST FACILITY
  - ✓ Moderate size, to check filters, materials, interfaces and local effects

Payload Critical Items

- HEAT REJECTING ENTRANCE WINDOW
  - ✓ Development already well underway (ESA CPT)
  - ✓ To be continued: IR coating cycle life improvement, mounting frame design, qualification testing higher mass than originally budgeted
  - ✓ Crucial for thermal control of instrument and whole spacecraft
- DETECTORS
  - ✓ Some development underway (commercial visible-light APS under ESA CTP; EUV detectors under ESA TRP)
- POLARIZERS
  - ✓ Space application of LCVRs, getting going
- OTHER ITEMS
  - ✓ Very instrument and design specific (e.g. specific ASIC), not underway yet, expected to be covered by Instrument teams

Cross Scale (M-class)

Science

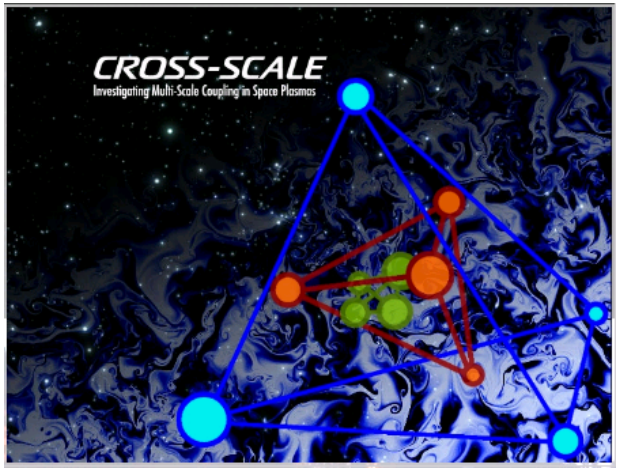
- To study plasma processes (turbulence, reconnection, shocks) on multiple scales simultaneously

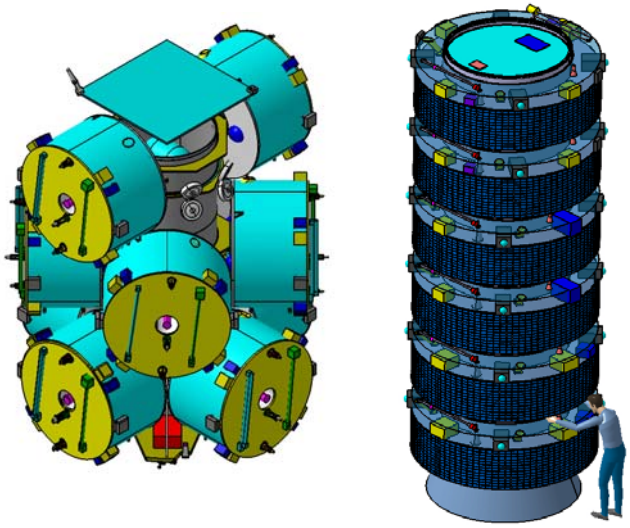
Space Segment

- 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)
- Launch on Soyouz-2b (single launch)
- 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"
- S/C design identical for all scales to minimise non-recurring costs
- Main trade-off: dispenser / stacked configuration

Payload: provided by Member States





Trade: Dispenser or Stacked configuration

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Cross Scale (M-Class)

Technology

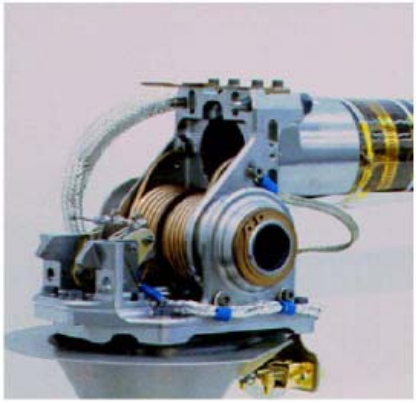
- No major critical technology development required

Assessment Status

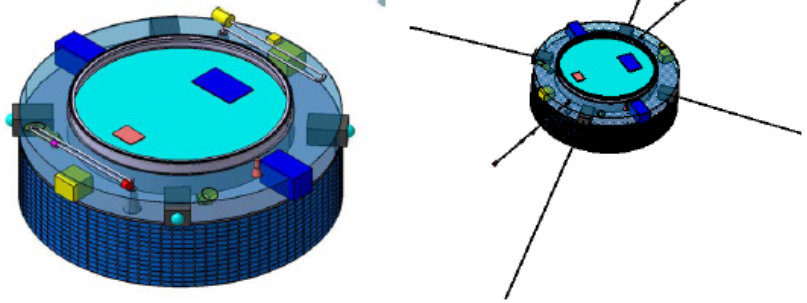
- ESA Phase 0 study completed.
- Industrial Studies – 2 parallel contracts running (TAS-F and Astrium-UK, Final Review Jun. 2009)
- In parallel: National funded Instrument Studies (10) by instrument proposers

International Collaboration

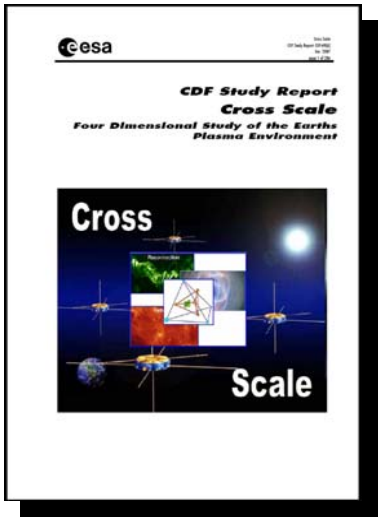
- JAXA (Scope), NASA and CSA

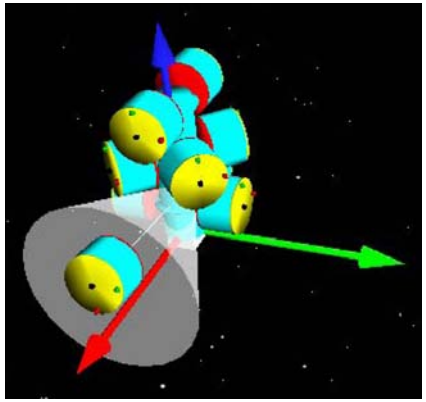


Wire-boom deployment unit



Spacecraft in stowed and deployed configuration





S/C deployment simulation (dispenser based)

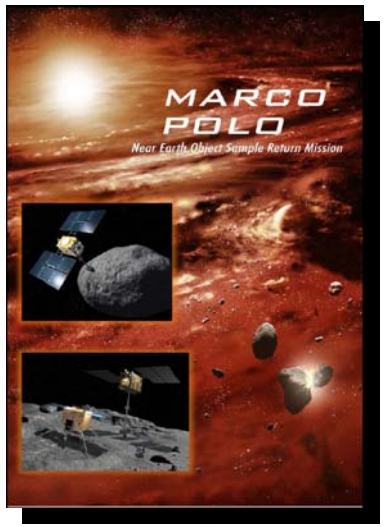
Marco Polo (M-class)

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

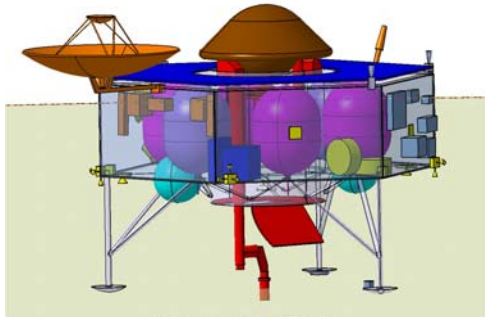
Space Segment

- Goal: Minimum possible 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)



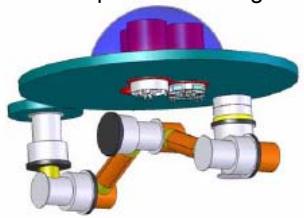
CV-proposal
Marco Polo

Re-entry capsule



Spacecraft Design

Payload: Focus on sample return



Robotic arm for sampling

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Marco Polo (M-class)

Technology

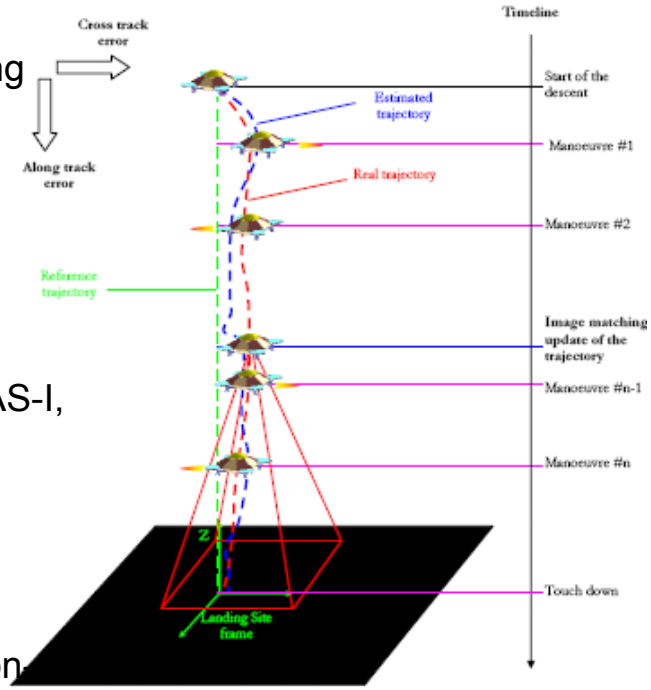
- Guidance and Navigation at small body, including GNC for safe landing
- Landing and operations on surface at low gravity
- Sampling mechanism and transfer system
- Re-entry up to 12.5 km/s

Status

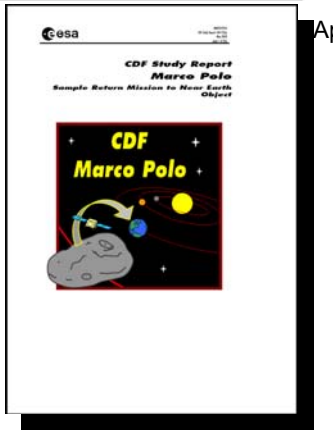
- ESA Phase 0 study completed.
- Industrial Studies – 3 parallel contracts running (Astrium UK, OHB, TAS-I, Final Review ~ Sep. 2009)
- National funded P/L studies in parallel (23 proposals received)

International collaboration

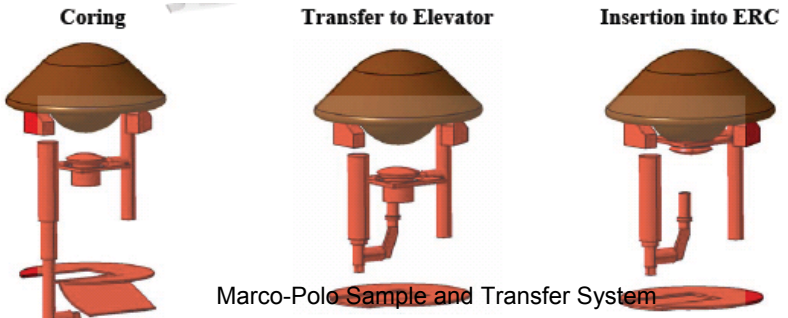
- Under elaboration, could be with JAXA,
- In case of JAXA lead: More challenging target (e.g.2001 SG286/Wilson-Harrington)



Approach and Landing



CDF Report
Marco Polo



Marco-Polo Sample and Transfer System

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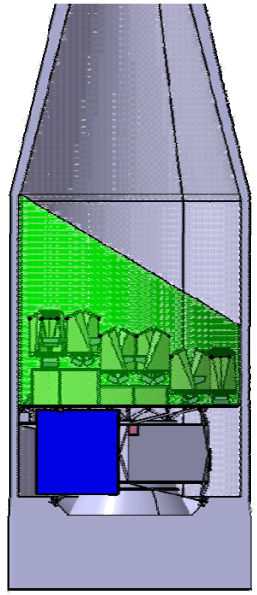
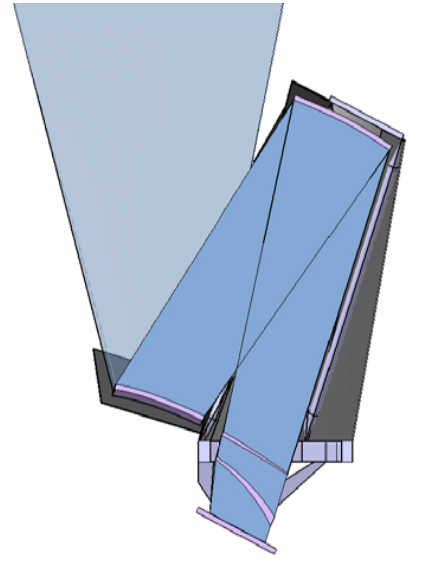
- **Industrial system studies:**
  - ✓ Two parallel contracts, Astrium-F & TAS-I

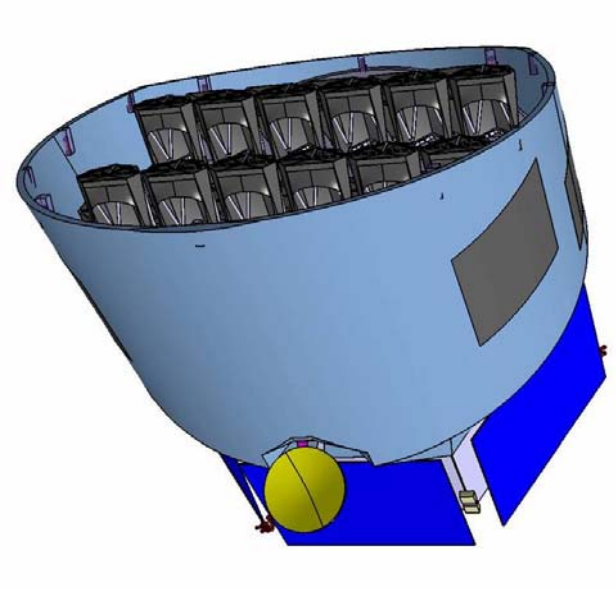
    ‘*Staring mode*’ baseline from ESA study:
  - ✓ Two fields of view explored (e.g. 3 yrs + 2 yrs)
  - ✓ SF2-1b launch, direct transfer to L2
  - ✓ 28 identical telescopes
  - ✓ Total collecting area ~0.3 m^2, FOV > 550 deg^2
  - ✓ 4 CCD’s / focal plane (compatible with realistic detector procurement constraints), 3.5k x 3.5k, 18 um pixel
  - ✓ Early procurement of CCD’s required in 2010

- **National instrument studies:**
  - ✓ Single consortium in place
  - ✓ Work on instrument design, performance analyses and on board data reduction



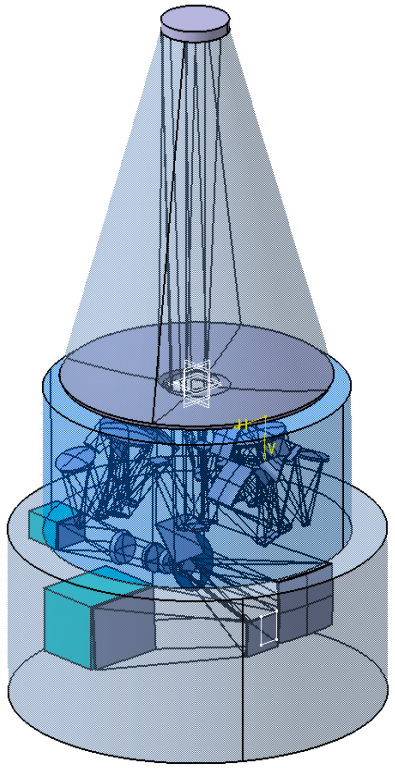
- **Relevant technology activities in the current plan**
  - ✓ High processing power DPU (onboard processing of science data)
  - ✓ Optimised high speed, high dynamic range CCD.
  - ✓ High speed, 16 bit CCD signal processor / ADC.





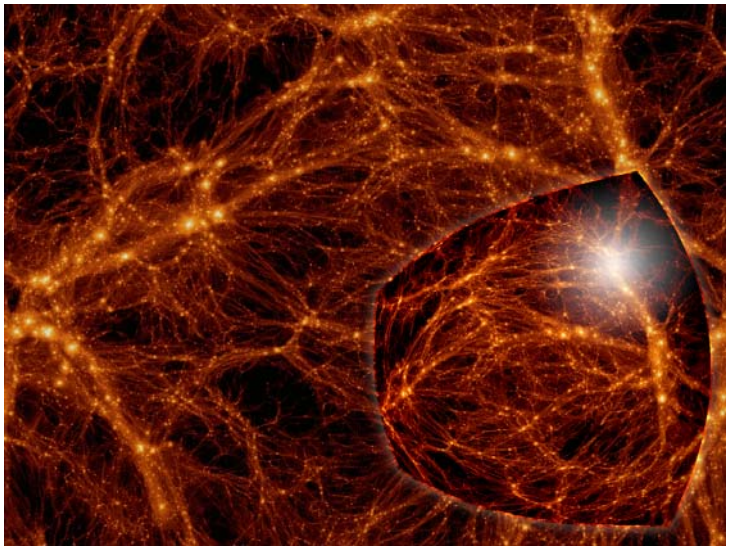
- **Industrial system studies:**
  - ✓ Two parallel contracts, Astrium GmbH & TAS-I.
  - ✓ Feature 1.2 m telescope.
  - ✓ Focal plane instruments:
    - VIS path with large focal plane for weak lensing.
    - NIR path for accurate wide-band photometry.
    - NIR path with 3 instruments for high resolution spectroscopy.

- **National instrument studies - Two consortia are in place:**
  - ✓ Euclid Imaging, on the VIS imaging and NIR Photometer channels.
  - ✓ Euclid NIS, on NIR spectrometer channel.

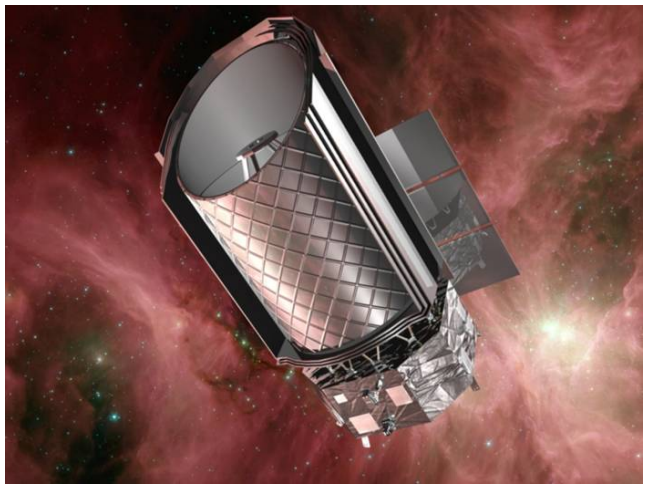


Relevant technology activities in T.D.P.

- ✓ K-band down-link capability from L2 (space and ground segment).
- ✓ CCD radiation characterisation (of relevance to VIS).
- ✓ Digital Micro-mirror Device for multi-object spectrometers (of relevance to NIS, evaluation of commercial component ongoing).
- ✓ NIR/SWIR large format array detector and associated ASIC read-out.



- **JAXA led mission. ESA provision: 3.5 m telescope + SAFARI instrument**
  - ✓ SPICA in “pre-project phase”in JAXA, 2 years Phase A study and review milestones in line with CV15-25 process.

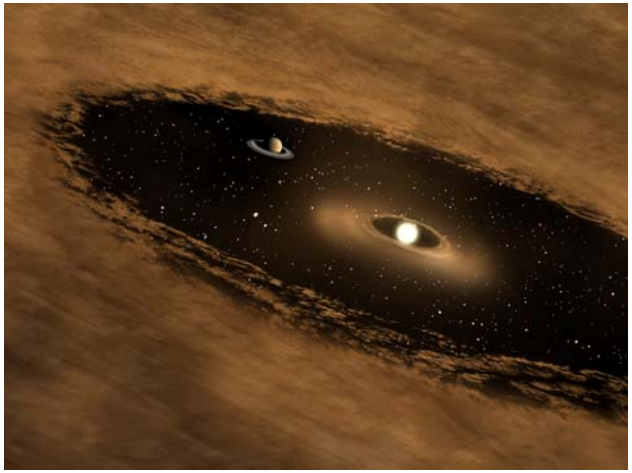


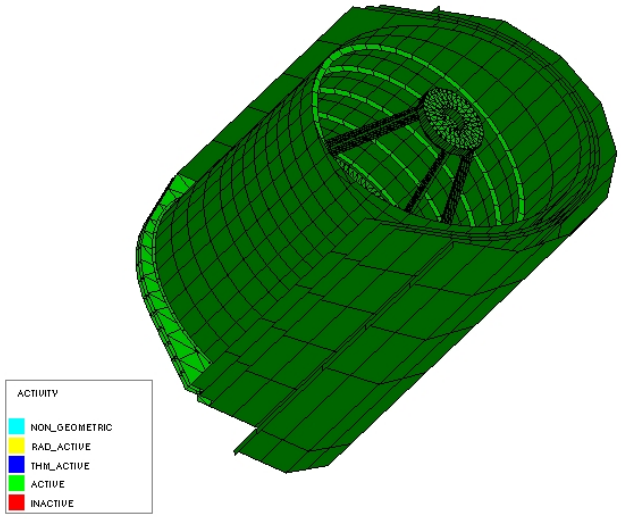
- **Industrial studies on Telescope Assembly:**
  - ✓ Two parallel industrial contracts: TAS-F & Astrium-F.
  - ✓ Baseline design from ESA study: Ritchey-Chrétien design, ~5K operations, 700 kg, re-focussing mechanism at M2, ~ 5 yrs development schedule.
  - ✓ Coronograph related requirements treated as delta to baseline telescope design.

- **SAFARI CDF study (ESA + instrument team) completed**
  - ✓ Four candidates for detector technology, down-selection expected by 2nd half 2009.
  - ✓ Interferometer mechanism to be traded-off.
  - ✓ Instrument hybrid sorption/ADR cooler.
  - ✓ Heat load budget to be consolidated with JAXA.

Relevant technology activities in T.D.P.

- ✓ Focusing mechanism for secondary mirror (3 DOF, operating at 5K).
- ✓ Light-weight mirror demonstrator breadboard (addressing specific critical areas).
- ✓ Telescope Assembly verification & Testing: demonstration of critical areas (e.g. verification of optical performance at representative temperature).

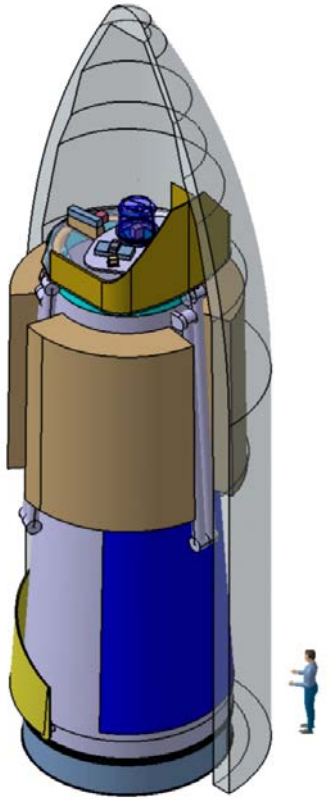




Overview of L-class Missions

- **IXO (International X-ray Observatory) replaces XEUS (ESA/JAXA) and Con-X (US)**
  - ✓ XEUS ESA/JAXA Formation Flying internal study completed
  - ✓ Mission not compatible with available CV budget

- **IXO baseline for ESA/NASA/JAXA joint study:**
  - ✓ Single large X-ray mirror assembly, HEW 5 arcsec
  - ✓ Deployable bench for reaching ~20-25 m focal length
  - ✓ Main instruments: Wide field imager, high resolution non-dispersive
  - ✓ spectrometer and dispersive spectrometer using X-ray gratings
  - ✓ Compatibility with Ariane V and Atlas V launchers



- **IXO internal study is just completed, with NASA and JAXA participation**
  - ✓ Industrial studies should start by mid 2009

- **IXO will be the input to both US decadal survey and CV L1 selection**

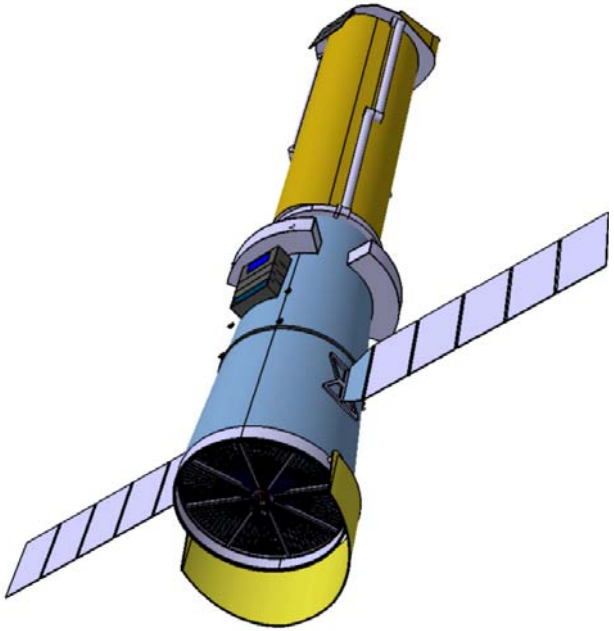
- **ESA/NASA/JAXA respective contributions and roles not yet defined**

Relevant technology activities in T.D.P.

- ✓ Low mass X-ray optics (mission enabling): Si pore optics development and validation, alternative technology using slumped glass
- ✓ Cryogenic coolers (required by Narrow Field Instrument)

Technology Development Plan will be updated according to IXO re-direction and results of ongoing study

- ✓ Deployable structure required to increase focal length (extension mechanisms, deployable shroud).
- ✓ Instrument exchange platform (mechanism).

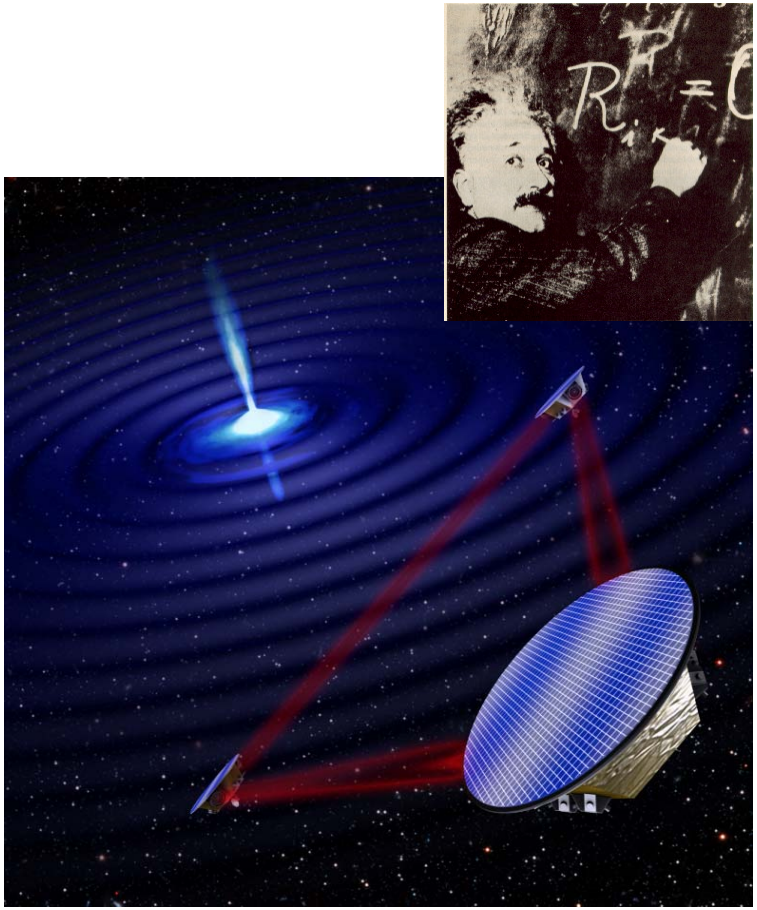


LISA mission

- ✓ ESA/NASA collaboration
- ✓ Measurement of gravitational wave using laser interferometry
- ✓ Constellation of 3 spacecrafts separated by 5 million km

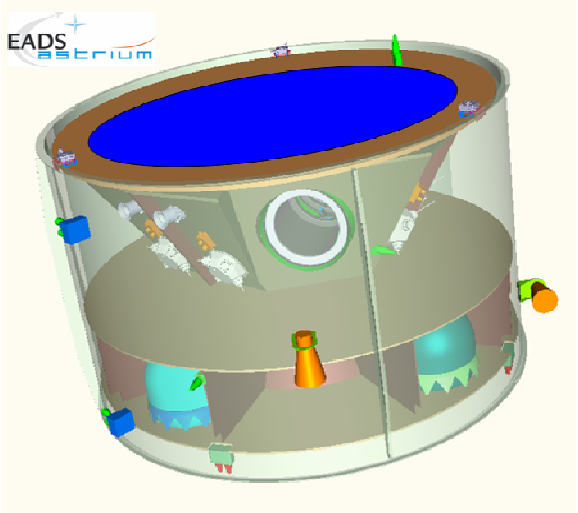
Critical areas

- ✓ 6 drag-free test masses
- ✓ micropropulsion system
- ✓ **interferometrically** measuring variations in distance between couples of test masses at the **picometre** level
- ✓ **LISA Pathfinder technology validation** mission to be launched **in 2010/11**



Technology required by LISA

- Low-noise, high stability mechanisms (point-ahead and optical articulation)
- Highly stable materials for telescope assembly (CFRP, zerodur, inserts …)
- Low-noise electronic components for GRS front-end electronics (voltage references ..)
- Light sources for charge management discharge (LEDs, laser diodes …)
- Metrology system
- High-power laser system (1-2 W EOL, redundant)
- Outgassing & contamination issues
- Micropropulsion (lifetime characterization)

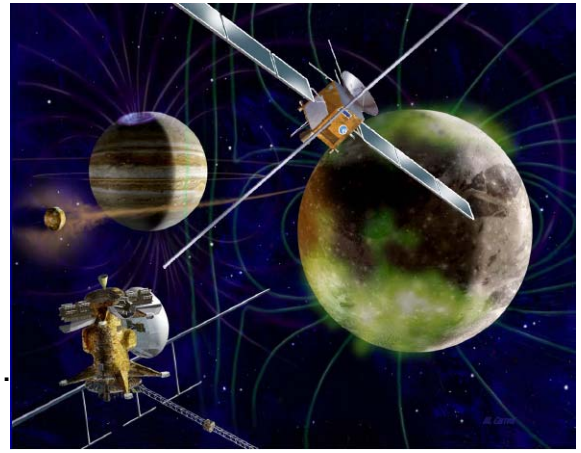


LISA technology

- **The majority of LISA technology will be flight-validated by LISA Pathfinder (LPF)**
- **Main differences w.r.t. LPF:**
  - ✓ lower operative frequency band (10^{-3} to 10^{-4} Hz)
  - ✓ Interferometry (polarizing vs. non polarizing)
  - ✓ Laser output power
  - ✓ Material stability (CFRP, ZERODUR …)
- **Workshop on technology will be organized in Jan/Feb 2009 for consolidating Member State involvement**
- **CTP activities will be issued in 2008/2009**

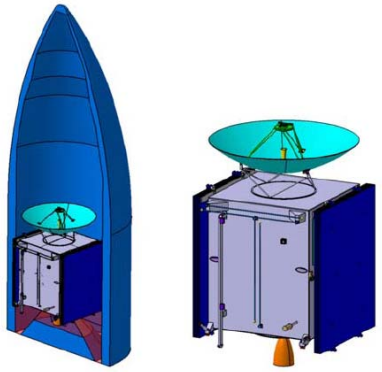
ESA/NASA Outer Planet candidate mission

- ESA: Jupiter Ganymede Orbiter (JGO), Jupiter System Science (atmosphere, magnetosphere) with focus on Callisto and Ganymede
- NASA: Jupiter Europa Orbiter (JEO). Jupiter System Science with focus on Europa, Io (NASA-JEO)



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, nationally provided

JGO = Jupiter Ganymede Orbiter

Technology

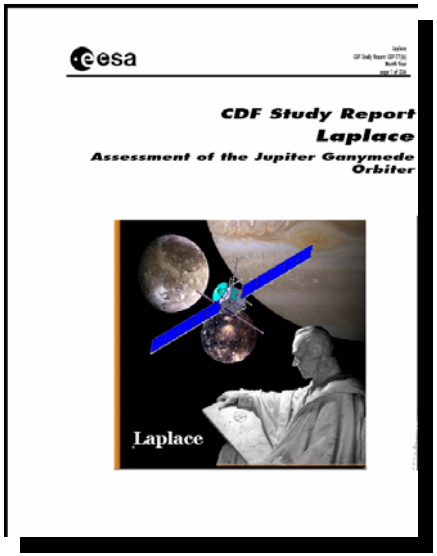
- Radiation hardening and tolerance / tailored shielding
- Improved Environmental modelling
- Solar Cell Technology (LILT)

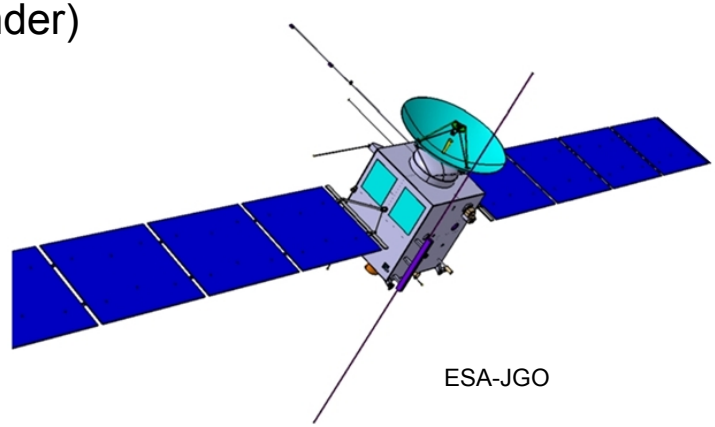
Status

- ESA and NASA Phase 0 studies completed.
- ESA and NASA individual & joint reports completed
- ESA/NASA down-selection Jupiter / Saturn ⇨ Jan. 09
- Industrial Studies: start in ~ May/Jun 09

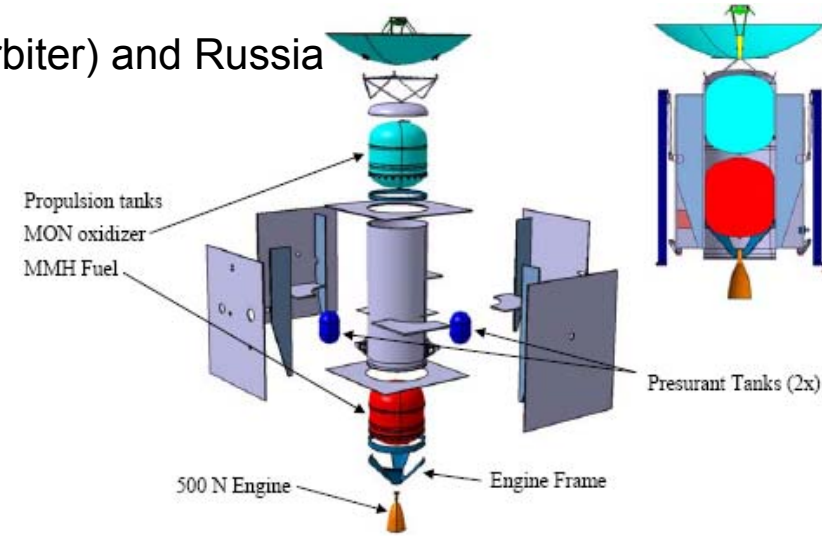
International collaboration extension

- possibly JAXA (Jupiter Magnetosphere Orbiter) and Russia (lander)





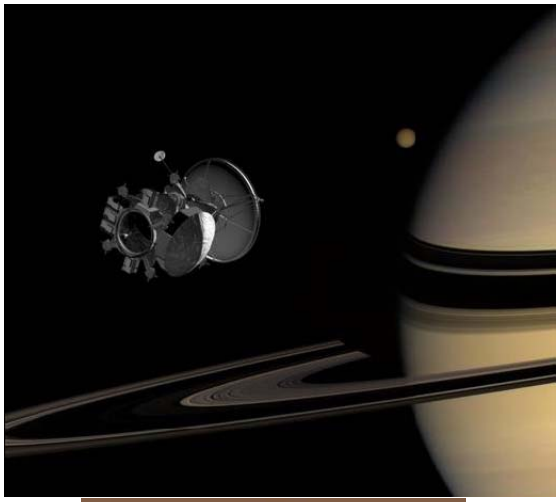
ESA-JGO



ESA-JGO

ESA/NASA Outer Planet candidate mission

- Saturn System science, Titan in-situ science (atmosphere, surface, lake)
- NASA: Titan orbiter carrying In-Situ Elements (ISEs)
- ESA: ISEs, Mongolfiere Balloon and short-live Lander
- Balloon Technology from CNES



Space Segment

- Launch by NASA, Orbiter carrying ISE's (up to 800 kg)
- Release of ESA in situ 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)

Montgolfier

Payload: Nationally provided

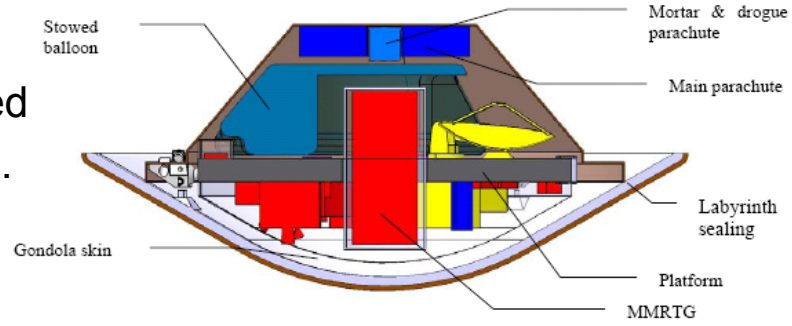
- 24 kg on montgolfiere,
- 27 kg on lander

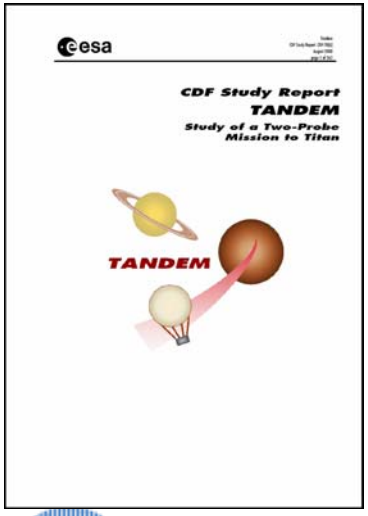
Technology

- Balloon (CNES) – material & inflation

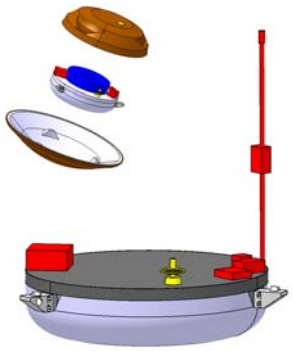
Status

- ESA and NASA Phase 0 studies completed.
- ESA and NASA individual & joint reports completed
- ESA/NASA down-selection Jupiter / Saturn ⇨ Jan. 09
- Industrial Studies: start in ~ May/Jun 09

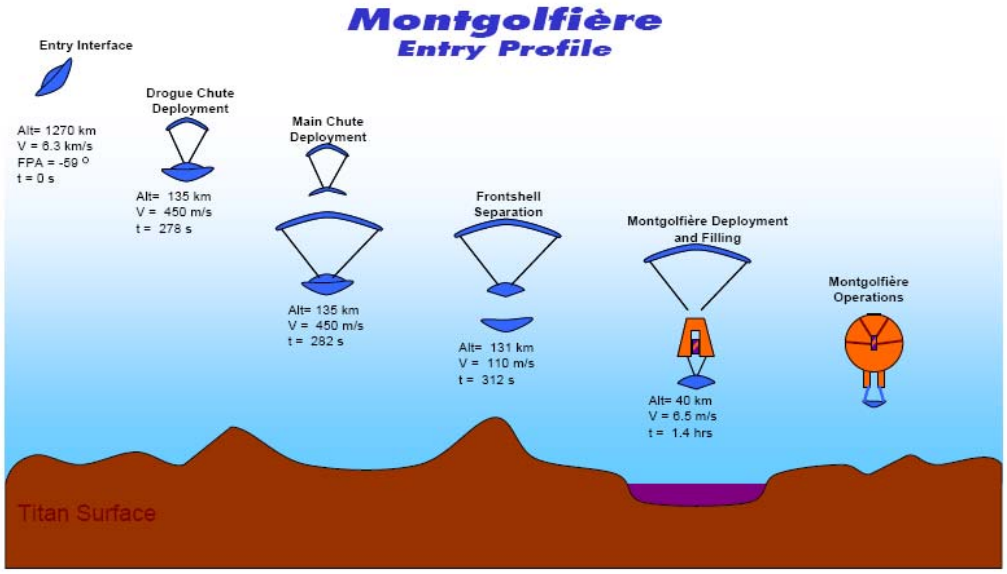




CDF report - Tandem



Short life lander



Technology Development Plan Implementation

Elaboration of CV Technology Plan

- **Comprehensive Technology Development Plan, including ESA activities and National activities on payload**
  - ✓ General objective: TRL ≥ 5 before starting Implementation Phase (B2/C/D)

- **Separation line between ESA and Member States for Astrophysics missions was agreed at June 08 SPC workshop**
  - ✓ Large and complex payload elements that are strongly interleaved with the spacecraft design remain under ESA responsibility. Example: IXO telescope.
  - ✓ Focal plane instruments under Member States responsibility. Example: SAFARI on SPICA
  - ✓ For cryogenic instruments, the last cryogenic stage(s) which are physically embedded in the instrument are assumed to be part of the instrument assembly

- **ESA activities (subject of this meeting)**
  - ✓ Mainly funded by TRP/CTP technology programmes
  - ✓ Work Plan and Procurement Policy approved by IPC in June/September 08
  - ✓ Planning horizon: 3-4 years, up to end 2011
  - ✓ ESA activities for 2008-2009 approved for implementation

- **Payload National activities**
  - ✓ Are being consolidated with the Member States (convergence expected by June 2009)

ESA T.D.P. content

- **Medium Class Missions (M)**
  - ✓ High technology readiness level (supposed TRL ≥ 5, CV mission selection criterion)
  - ✓ On ESA side: No mission specific technology developments before down-selection end 2009. Pre-developments can be envisaged in the development phase, if justified by the development schedule

- **Large Class Missions (L)**
  - ✓ Ambitious long term missions, high technical complexity requiring technology developments
  - ✓ TDAs to be implemented ASAP, aiming at TRL ≥ 5 for the mission adoption

- **Future Science Programme Themes**
  - ✓ Identified from the CV proposals by AWG, SSWG, FPAG in Oct 2007
  - ✓ TDAs to be implemented ASAP, subject to prioritisation by Advisory Bodies,
  - ✓ Technical objective: TRL ≥ 4 by next CV call in 2011, for enabling mission selection

- **Generic Technologies for Future Science Missions**
  - ✓ Multiple-use technologies required for future Science Programme

ESA T.D.P. evolution

- **The activities over 2008-2009 are being implemented**

- **The activities in 2010-2011 are preliminary will be revisited**
  - ✓ Revision expected after M-mission down-selection, beginning 2010

- **More generally, the TDP will be updated regularly for reflecting the programme needs. First update is foreseen by June 09 and should include:**
  - ✓ Revisit of Outer Planet activities following the down-selection
  - ✓ Solar Orbiter complement activities
  - ✓ Activities for preparing the future Exoplanet mission, following the EPRAT working group conclusions

Procurement Policy and Special Initiatives

- **The nominal Procurement Policy is defined in the plan and has been approved by IPC**

- **Some activities can be subject to Special Initiatives for Geo-return re-balance. Countries concerned for 2008-2009: A, CH, N and IRL**

- **For Special Initiatives (S.I.) activities, the nominal procedure is the following:**
  - ✓ Eligibility to S.I. will be explicitly stated in the ITT (cover letter)
  - ✓ The competition will take place as usual, according to best practices and nominal procurement policy
  - ✓ Following the T.E.B. report, a proposal produced by a company belonging to S.I. country can be retained by the Agency, even if not ranked first, *but only if the proposal is technically satisfactory*.

TDP Implementation Plan 1./6 (CTP)

Mission Theme	Reference	Activity Title	PP	Start
IXO	C216-003MM	Bessy X-ray test facilities upgrade plan	DN/S	Q4 2008
IXO	C216-004MM	Development of XEUS Si pore optics and mass production processes	C(1)	Q2 2009
IXO	C216-005MM	Panter X-ray test facilities upgrades	DN/S	Q4 2008
IXO	C216-006MM	XEUS mirror module ruggedizing & enviromental testing Ph. II	C	Q4 2009
LISA	C207-009PW	GRS Front End Electronics characterization for LISA	C(2)	Q2 2009
LISA	C207-010EE	Compact low noise magnetic gradiometer	C(1)	Q4 2008
LISA	C207-011PW	Charge Management System for LISA	C(2)	Q1 2009
LISA	C207-012PW	Opto-mechanical stability characterization for LISA	C(2)	Q4 2008

TDP Implementation Plan 2./6 (CTP)

Mission Theme	Reference	Activity Title	PP	Start
LISA	C207-013PW	Metrology system for LISA	C(2)	Q1 2009
LISA	C207-014PW	High-power laser system for LISA	C(2)	Q2 2009
LISA	C207-016PW	Outgassing and Contamination characterization for LISA	C(2)	Q3 2009
Several	C201-030ED	High processing power DPU based on high rel. DSP	C(2) *	Q4 2008
Several	C220-032MC	15K Pulse Tube cooler	C	Q2 2009
Several	C222-034QC	CCD radiation characterisation	DN/S	Q4 2008
Several	C223-035QM	Characterisation of ultra-stable materials at cryogenic temperature	C	Q2 2009

*** Subject to Special Initiative TBC**

Directorate of Science
and Robotic Exploration

TDP Implementation Plan 3./6 (TRP)

Mission Theme	Reference	Activity Title	PP	Start
Laplace Tandem	T201-002ED	Latch up protection for COTS (Commercial, off-the-shelf) digital components	C *	Q1 2009
Laplace Tandem	T201-003ED	Low mass SpaceWire	C(1)	Q4 2008
Laplace Tandem	T201-004ED	DAREplus (Design Against Radiation Effects) ASICs for extremely rad hard & harsh environments	DN/S	Q4 2008
Laplace Tandem	T203-006EP	Stirling Engine Radioisotopic Power System Requirement Study	C	Q4 2008
Laplace Tandem	T203-007PA	Novel Low Power Radioisotope Power Generator	C	Q1 2009
Laplace Tandem	T203-008PA	Optimized electrical power conversion for RHU based systems.	C	Q1 2009
Laplace Tandem	T204-009EE	Radiation Effects on Sensors and Technologies for Cosmic Vision SCI Missions (REST-SIM)	C(2)	Q1 2009
Laplace Tandem	T222-015QC	Radiation characterisation of RT digital CMOS technology	C(2)	Q4 2009
Laplace Tandem	T222-016QC	Radiation hard memory	C(2)	Q2 2009

*** Subject to Special Initiative TBC**

Directorate of Science and Robotic Exploration

TDP Implementation Plan 4./6 (TRP)

Mission Theme	Reference	Activity Title	PP	Start
Laplace Tandem	T222-017QC	Radiation Tolerant analogue / mixed signal technology survey and test vehicle design	C *	Q1 2009
Laplace Tandem	T222-018QC	Front-end readout ASIC technology study and development test vehicles for front-end readout ASICS	C *	Q1 2009
Laplace Tandem	T222-019QC	Survey of critical components for 1 Mrad power system design including delta radiation characterisation of RH power EEE components	C(1)	Q4 2008
Laplace Tandem	T222-020QC	Radiation characterisation of Laplace/Tandem critical RH optocouplers, sensors and detectors	C(1)	Q4 2009
Laplace Tandem	T223-021QM	Characterisation of radiation resistant materials Phase 1	C(2)	Q1 2009
IXO	T216-022MM	Large area X-ray window development.	C(1)	Q3 2009
IXO	T216-023MM	Back-up XEUS optics technology Phase 1	C(1)	Q4 2008
IXO	T216-026MM	XEUS mirror module ruggedizing & enviromental testing	C(1)	Q4 2008

*** Subject to Special Initiative TBC**

Directorate of Science and Robotic Exploration

TDP Implementation Plan 5./6 (TRP)

Mission Theme	Reference	Activity Title	PP	Start
Several/ EUCLID	T204-028EE	Solar/interplanetary electron hazards	C(3)	Q1 2009
Several/ Marco Polo	T205-029EC	Autonomous GNC Technology for NEO proximity, Landing and sampling Operations - Phase 1	C	Q1 2009
Several/ BPOL	T207-034EE	Low-loss, low-mass, large lenses with anti-reflection coating	C(1) *	Q3 2009
Several/ Phoibos	T203-035EP	Near-sun power generation: Identification of best suitable thermoelectric converters	C	Q1 2009
Several/ Phoibos	T223-038QM	Materials compatibility for the PHOIBOS mission (high temperature under high UV load)	C(2)	Q4 2008
Several	T204-042EE	Computational tools for spacecraft electrostatic cleanliness and payload analysis	C(1)	Q3 2009
Several	T204-043EE	Rad-Hard Electron monitor	C(1) *	Q3 2009
Several	T204-044PA	Solid-state neutron detector	C(1)	Q4 2008

*** Subject to Special Initiative TBC**

Directorate of Science and Robotic Exploration

TDP Implementation Plan 6./6 (TRP)

Mission Theme	Reference	Activity Title	PP	Start
Several	T212-045GS	X/K band feed	C	Q3 2009
Several	T212-046GS	X/K/Ka band dichroic mirror	C	Q3 2009
Several	T216-047PA	Prototype ASIC development for large format NIR/SWIR detector array.	C(1)	Q2 2009
Several	T216-050PA	Low-noise scintillator detectors for planetary remote-sensing	C(1)	Q4 2008
Several	T217-051MP	Ablation radiation coupling	C	Q3 2009
Several	T217-052MP	Kinetic shock tube for radiation data base for planetary exploration	C	Q4 2008
Several	T220-053MC	Advanced 2K JT cooler	DN/S	Q4 2008
Several	T223-054QM	Development & testing of bonding and coating technologies of high temperature materials (C/C, C/SIC, ablative materials etc.) under extreme conditions	C(2)	Q4 2008
Several	T223-055QM	Materials Charging effects under extreme environments (ultra-low temperatures and high radiation fields)	C(2)	Q4 2008

The End