Future Science Missions

ESA/Portugal industry meeting

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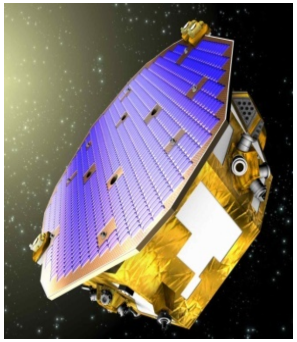
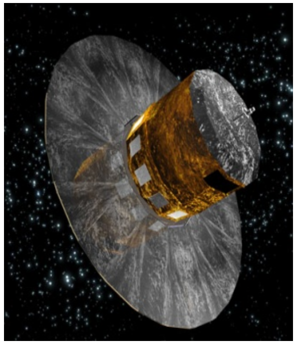
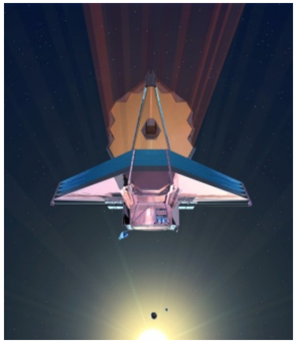
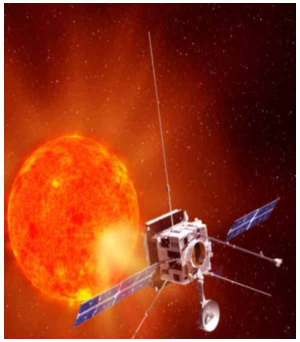
Science programme - introduction

- **Science Programme: mandatory ESA activity**
- **Yearly budget ~ 480 MEUR**
- **Recent launches:**
  - Herschel
  - Planck
- **Projects in implementation phase:**
  - European contribution to JWST
  - GAIA
  - Bepi-Colombo
  - Lisa Pathfinder
  - Solar Orbiter

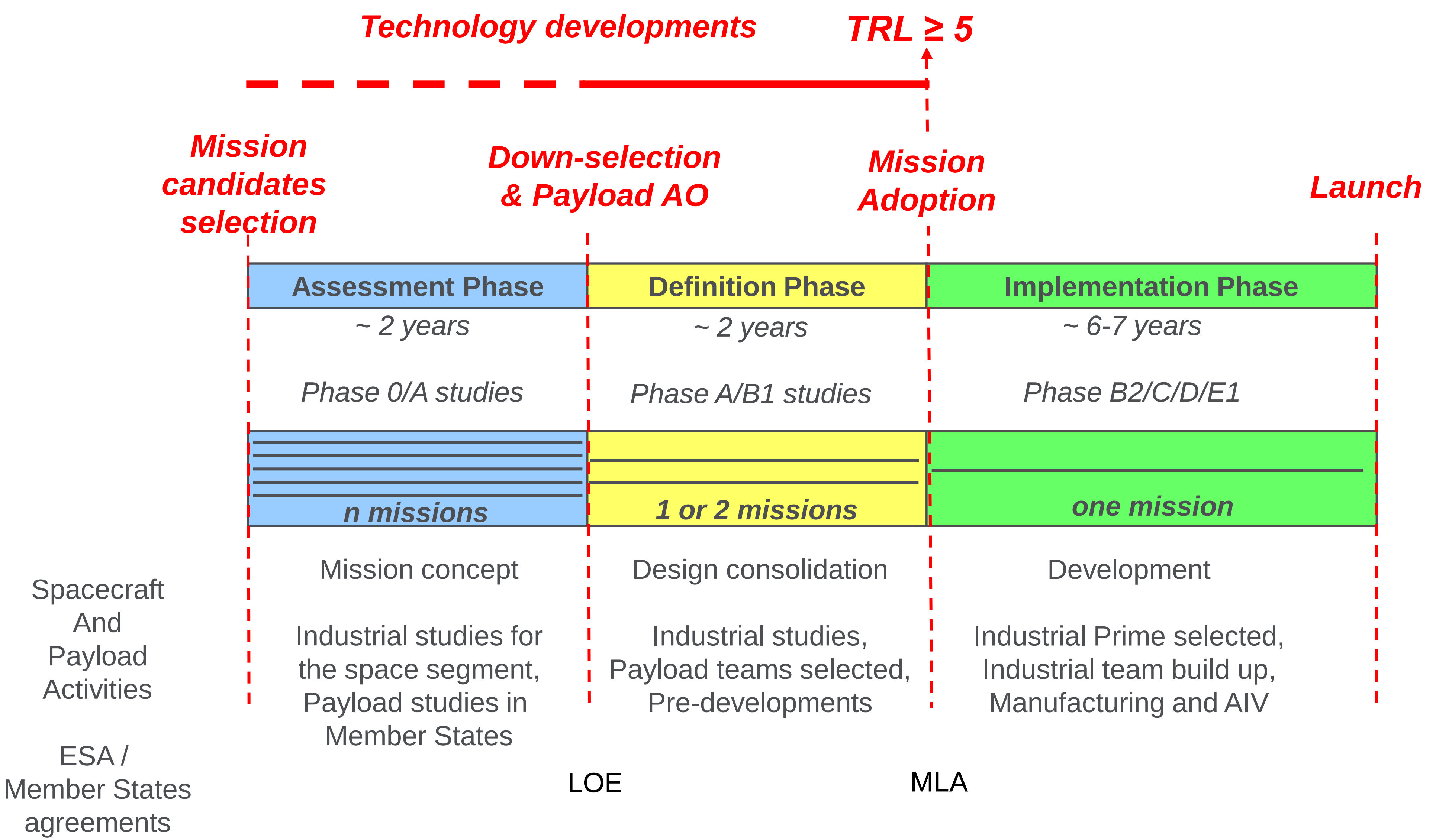


- **Scientific missions important driver for technology developments**
- **Opportunities for industry exist in technology activities, payload contributions and participation in the projects**

Science missions selection and implementation

- **Missions are selected through open Calls (“bottom-up” approach)**
    - 2007: Call for M1/M2 and L1 mission, target launch 2017 (M1), 2019 (M2) & 2022 (L1)
    - 2010: Call for M3 mission, target launch 2022
    - 2012: Call for S missions, target launch 2017
    - 2013: Call for L2 mission (TBC)
- **Three type of missions considered today: L, M and S-missions**
    - **L-Missions:** ~ 2 ESA Science Programme yearly budget, possibly with international partner(s), typically 6 years preparation (Phase 0, A, B1 studies and technology activities), then 7-8 years development (Phase B2/C/D)
    - **M-missions:** ~ 1-1.3 ESA Science Programme yearly budget, ~ 4 year preparation (Phase 0, A, B1 studies and technology activities), then 6-7 years development and launch (Phase B2/C/D)
    - **S-Missions:** Are also being considered, capped to 50 M€. Implementation scheme TBD
- **Science payload: In general, provision through Member States**

Phases for M-missions



Technology Developments in the Science Programme

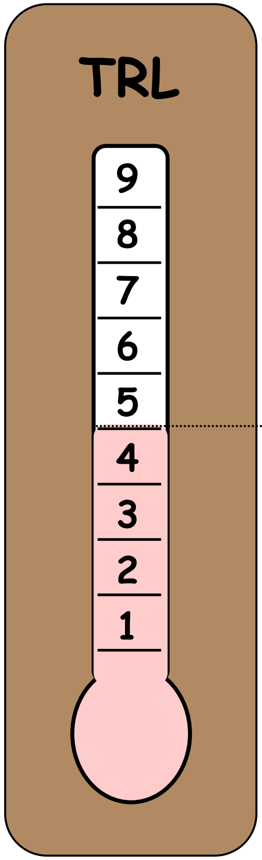
- **Substantial effort is spent for reaching sufficient definition and technology maturity of Science missions**
  - Science technology development budget: ~18-20 M€/year (TRP + CTP)
  - **TRL 5** requested before starting Phase B2/C/D (mission adoption)
- **Technology developments are generally Mission-focused**
  - Work plans are regularly updated for reflecting the Programmes evolution, as a minimum once a year
- **Some generic or long term developments are also implemented for enabling new missions**
  - Generic developments in science missions, for themes identified by the Science Advisory structure
- **Technology plans available**
  - CV TDP: http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=47731

Technology preparation, TRL and risk

esa

	Technology Readiness Levels									
	1	2	3	4	5	6	7	8	9	
	Basic principles observed and reported	Concept and/or application formulated	Analytical / experimental critical function / characteristic proof of concept	Component or breadboard Validation in laboratory environment	Component or breadboard validation in relevant environment	System / subsystem model or prototype demonstrated in relevant environment	System prototype demonstration in a space environment	Actual system completed and "flight qualified" through test and demonstration (ground or space)	Actual system flight proven trhough successfulk mission operations	
TRP										All
CTP										Science
EOEP										EO
ARTES, 345										Telecom
GNSS Evolution										Navigation
FLPP										Launchers
Aurora - MREP										Robotic Expl
Transporation	Slice ISS, includes technology development component									Transportation
Human Expl	Slice ISS, includes technology development component									Human Expl
GSTP										All but Telecom
										Project Phase
Risk if starting phase										B
										C/D

TRL scale and use



TRL 9, in orbit operation

TRL 7-8, qualification & integration in final system

TRL 5- 6, readiness level required for project implementation

TRL 3- 4, basic technology developments, often multi-mission

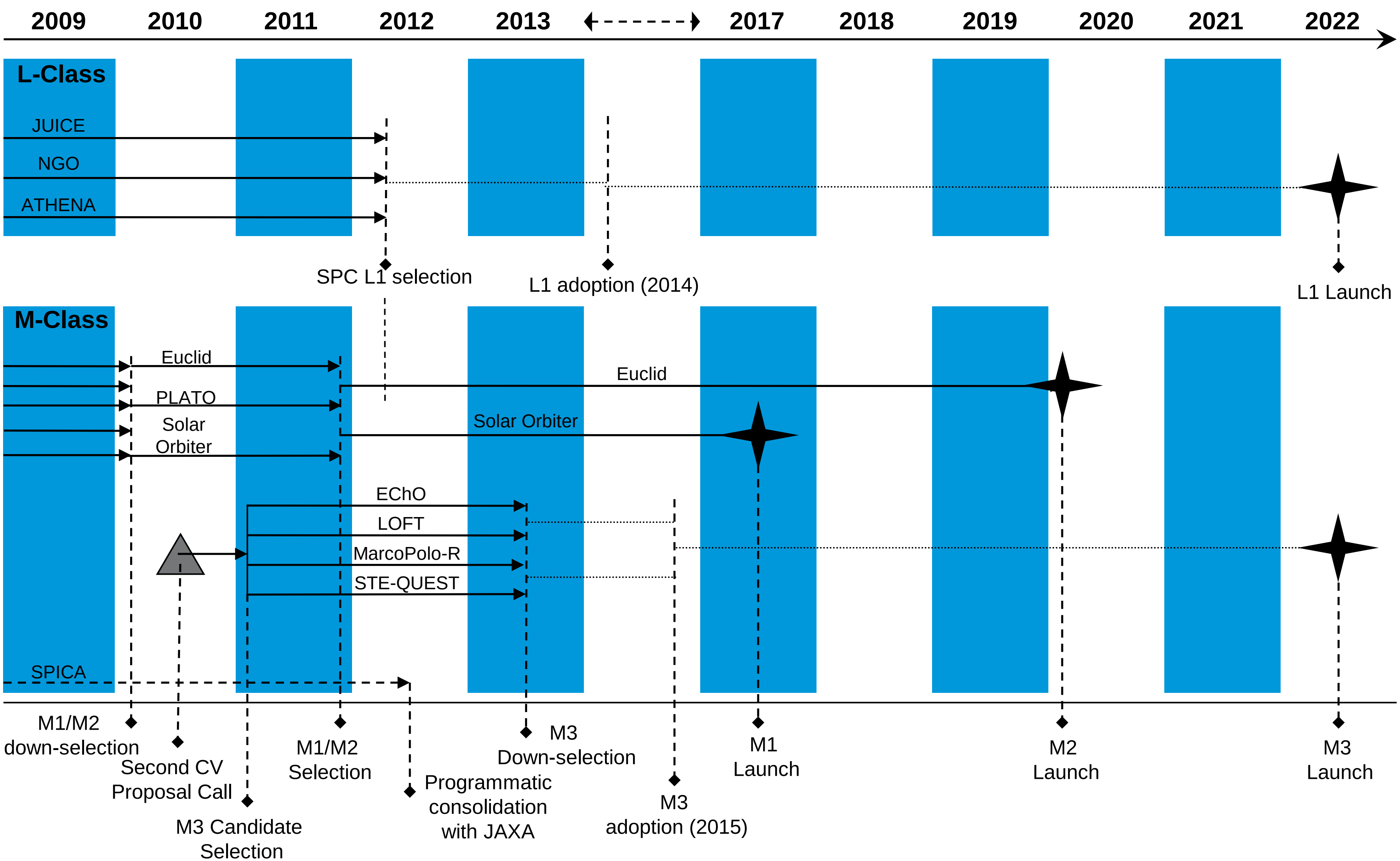
TRL 1- 2, basic research, generally made by institutes

Note: If TRL 5 is not reached, the development schedule is unknown!

When does an element reach TRL 5?

- Mission and Performance requirements established, including operational environment requirements
- Element design available
- Critical functions with low heritage are identified
- Breadboards and tests for demonstrating the critical functions in the relevant environment

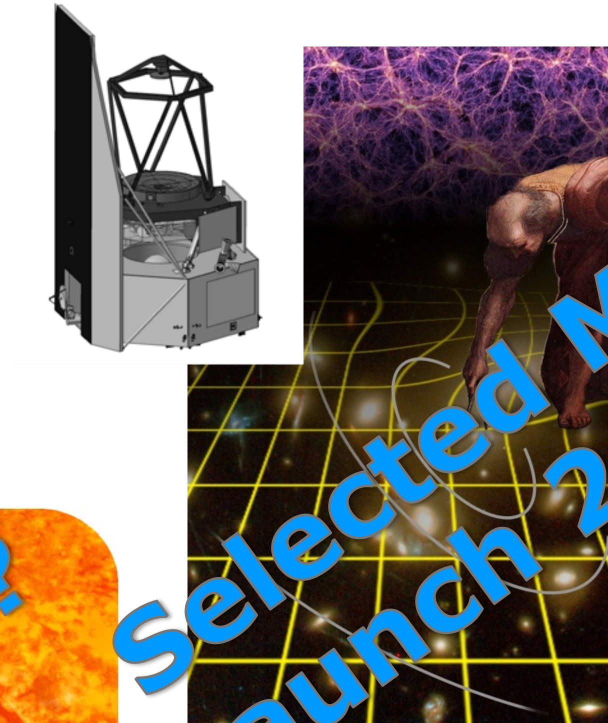
Cosmic Vision Programme timeline



M1 / M2 SPC Selection in October 2011

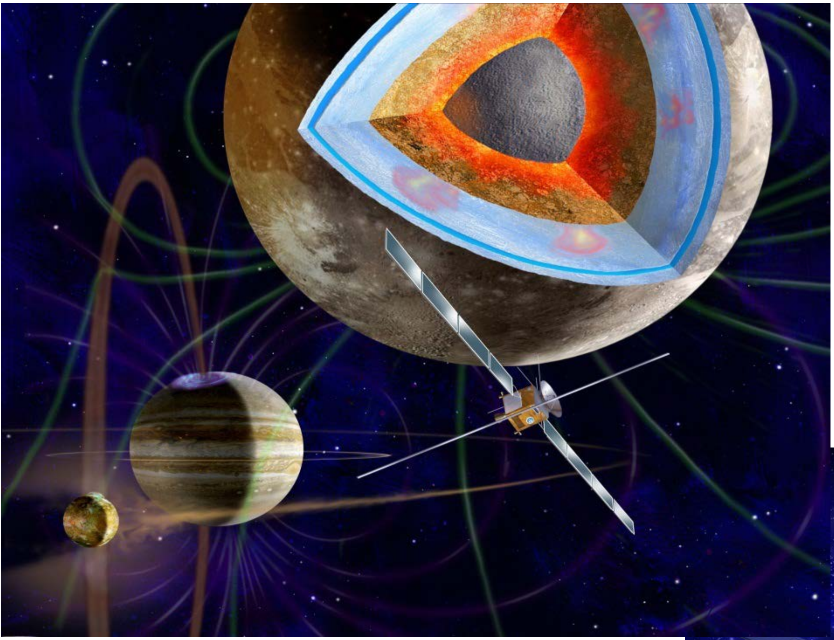
Solar Orbiter
Sun & heliosphere characterization

PLATO
Exoplanet mission

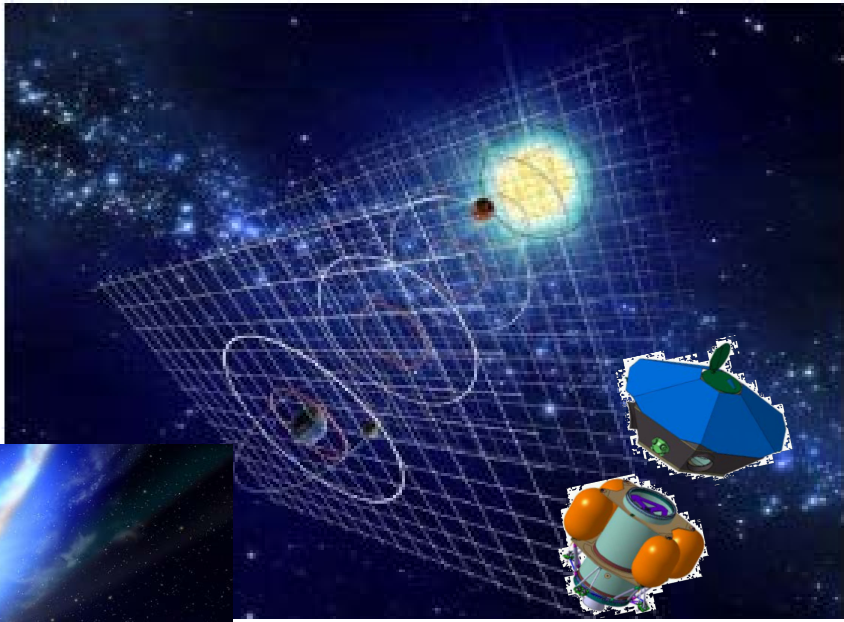


Euclid
Dark energy mission

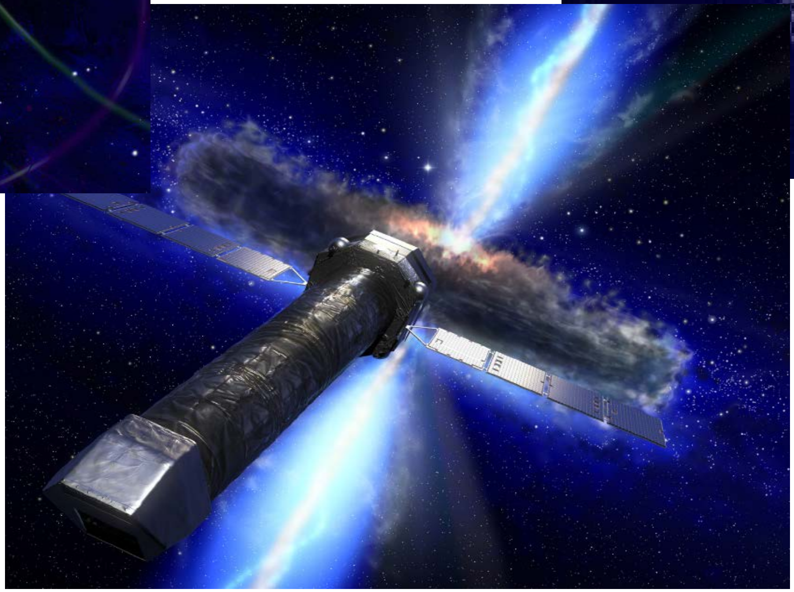
Reformulation of L1 Candidate Missions



LAPLACE -> JUICE



LISA -> NGO



IXO -> ATHENA

L1 missions: General status

- **Reformulation phase is completed for the three L mission candidates**
  - Europe-only or Europe-led missions. Non strategic international collaboration may be envisaged, but with a European back-up
  - Target launch year 2022, target CaC 850 M€ e.c. 2010
  - Was achievable only because of the thorough studies made for the three missions in the last years
- **SPC selection of L1 expected April/May 2012**
- **Next Steps:**
  - Definition Phase A/B1 in 2013/2014
  - Final adoption in 2014/2015
- **Technical details can be found on the ESA web site (Yellow Books): http://sci.esa.int/science-e/www/area/index.cfm?fareaid=107**

M3 mission definition status

Phase 0 was completed for all missions in 2011

- Science Definition Team in place
- Baseline mission concept elaborated using ESA CDF facility and involving the proposers
- Key input documents for the industrial studies have been produced, including Payload Definition Document

Instrument teams kicked off in Dec 2011-Jan 2012

Industrial assessment studies are running

- Parallel contracts for all missions, kicked-off early 2012
- The studies will be completed by Feb 2013

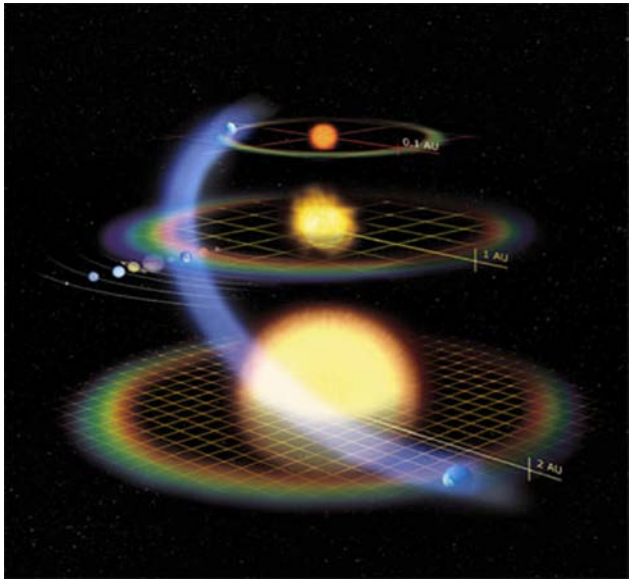
Overall schedule is maintained, down-selection is planned in June 2013

Target launch is 2022

EChO

Science goals:

- Study the physics and chemistry of the atmosphere of know transiting exoplanets around nearby stars using the differential technique of transit spectroscopy.
- From 0.4 to 11/16 μm wavelength
- For ~100 exoplanets:
  - Jupiter size to a few Earths
  - Equilibrium temperatures of 2000 K to 300 K
  - Around F, G, K and M type stars
- Spectral energy distribution will provide information on a number of parameters, including chemical composition and abundances, energy budget, thermal structure, optical albedo, etc

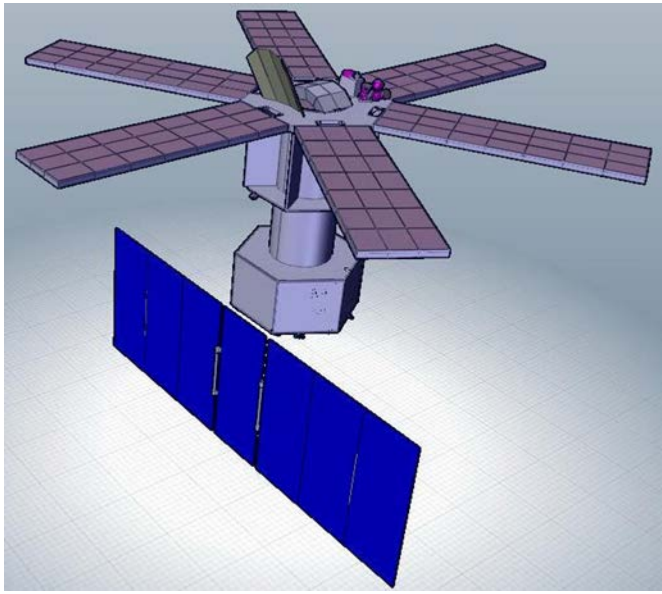


CDF: 20''x20'' FoV, 1.2 m Cassegrain telescope, Spectrometer:7 channels, Resolution (R) between 30 and 300, Vis CCD, HgCdTe at ~30K under 5 μm, Si:As at ~7 K above 5 μm, Photometric stability of $10^{-4}/10^{-5}$ over 10 h

LOFT

Science goals:

- X-ray observatory type mission (2 – 50 keV)
- To study the structure of Neutron Stars and the determination of the equation of state of ultra-dense matter by time-resolved diagnostics,
  and to investigate strong gravitational fields
- To study the X-Ray variability and spectra of different objects, including the early afterglow of gamma-ray bursts, pulsars, bright AGNs, and various others.



Instruments:

- Wide-Field Monitor (WFM) to monitor sources and detect interesting bursts or signals.
- Large Area Detector (LAD) for high time resolution studies

CDF:

- Observatory in 600 km, 5 deg LEO, 4 year mission duration
- 6 LAD panels, 10m2 effective area at 8 keV

Marco Polo-R

Science objectives:

- Earth-based analysis of samples (~ 30-100 grams) returned from a primitive asteroid (nominally1996 FG 3, binary)

CDF: completed in November 2011, main objectives:
→ To lower cost with respect to previous Marco Polo
→ Transfer to target (1996 FG 3, binary)

- Launch with Soyuz-Fregat (2021-2023)
- Architecture: Electric propulsion
- Touch and go sampling
- Parachute-free re-entry (~50kg capsule)

Payload:

- Wide, narrow and close-up cameras, visible/near-IR & mid-IR spectrometer, radio science, total mass: ~ 25 kg

Industry studies will re-assess the whole mission (including target, mission architecture/design and key technologies)

STE-QUEST

Science goals:

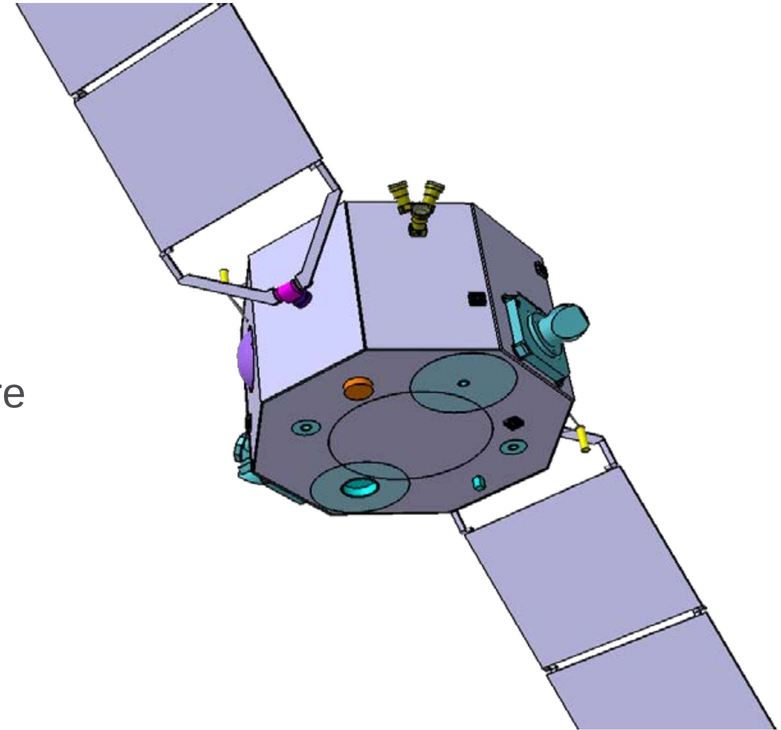
- Measurement of the Earth gravitational red-shift to better than $2 \cdot 10^{-7}$,
- Measurement of the Sun gravitational red-shift to better than $6 \cdot 10^{-7}$,
- Test of the universality of the free propagation of matter waves to an uncertainty in the Eötvös parameter better than $1 \cdot 10^{-15}$.

Instruments:

- Atomic Rb Clock (derived from PHARAO clock)
- Atom Interferometer (AI)

Phase 0 outcome:

- ~16 hour orbit 700 x 51000 km, drifting orbit
- Perigee over 1 Ground Station (GS) in Northern hemisphere
- Apogee visible from 2 GSs



Overview of technology themes in the current Technology Work Plan: L1 missions

L-class Missions		
Mission	Technology area	Future Technology development activities
ATHENA	X-ray Optics	Mirror Module ruggedizing and environmental testing
		X-ray optics mass production processes
		Mirror module performance
		Petal breadboard
		Baffling system, mirror module level
		X-ray test facilities upgrading
	Payload	Instrument read out electronics (cryogenic)
		Entrance windows and filters
		Detector developments – WFI and XMS
		Performance studies, anti-coincidence methods
	Cryogenics	Closed cycle dilution cooler
		Cryocooler chain for TES
JUICE	Components	Radiation hard characterization: Digital components, Memory, Mixed analogue and digital components, On board computer
	Power	LILT solar power systems
	AOCS	Star tracker for high radiation environment
	Payload	Development of compact, highly integrated instrument and subsystem suites
		Radiation effects on payload – shielding, redundancy, rad-hard component solutions etc.
	Penetrator option	Penetrator impactor and surface delivery system study
		Ground demonstration of impact survival of key systems
		Penetrator impactor sub-systems: TMTC, OBDH, thermal, power
		Development of ruggedized low resource payloads
NGO	Payload	Opto-mechanical stability characterization Metrology system High-power laser system Gravitational Reference Sensor Electronics Charge Management
	Propulsion	Micro-propulsion lifetime characterisation
	EMC	Magnetic Gradiometer

Overview of technology themes in the current Technology Work Plan: M missions (1/2)

M-class Missions		
Mission	Technology area	Future Technology development activities
MarcoPolo-R	Re-entry technologies	Development of lightweight ablative material (also in MREP)
		Hypersonic aerothermodynamics/ aerodynamic stability
		Parachute system
		UHF patch antenna
	AOCS	Autonomous GNC for NEO proximity – navigation, landing and sampling operations
		GNC hardware – radar altimeter, multi-beam laser
	Mechanisms	Sample acquisition, transfer and containment
		Earth re-entry capsule spin up ejection (SUEM)
		Landing-touchdown system – landing leg with impact attenuation e.g. crushable materials
Solar Orbiter	Power	Solar array based on Bepi Colombo cell technology
	Thermal	Testing: high solar flux testing, procedures, facilities
		Heat shield materials- high temperature/UV
		Heat shield – feedthroughs, mechanisms
		Heat rejecting filters
	Payload	Various national activities for in-situ and remote-sensing instrument suites
EChO	Mechanisms	Fine steering cryogenics tip-tilt mechanism
	Coolers	Further development of hydrogen sorption Joule Thompson cooler
	Payload	Development of low dark current NIR/MIR wavelength HgCdTe detectors
EUCLID	Communications	K-band downlink – spacecraft and ground station developments
	Propulsion	Cold gas system delta development
	Payload	High dynamic range fast readout CCDs
		Optics: dichroic beam splitter, visible phase plate, grism
		Cryolens development
		Cryomechanisms

Overview of technology themes in the current Technology Work Plan: M missions (2/2)

LOFT	Payload	Large-area Silicon Drift Detectors and ASIC
		X-ray capillary plate collimator
PLATO	Payload	High-speed, high dynamic range CCD
		Refractive telescope breadboard
SPICA (TBC)	Cryogenic Mirror	Lightweight primary mirror demonstrator
		Secondary mirror cryogenic refocusing mechanism –
	Payload	SAFARI: Detector development
		SAFARI: Focal plane read-out
		SAFARI: 50 mK ADR
		SAFARI: Cryogenic mechanisms
		SAFARI: Fourier Transform Spectrometer BB
STE-QUEST	Payload	Development of laser for Rb Clock
		PHARAO microwave source delta dev.
		PHARAO atom tube delta development
		Development and space qualification of high finesse reference optical cavity for MOLO
		Microwave-optical frequency generation using optical frequency comb technology
		Delta Development and space qualification of a frequency generation, comparison and distribution unit
		Development of Laser Source for the Atom Interferometer (AI)
		Development and qualification of a dual-species Rb 85/87 AI Physics Package

How to get involved in the Science Programme technology developments

- **The nominal procedure**
    - Analyse the last version of the Technology Development Plan (TDP)
    - Identify activities matching the company strategy/competence, then submit a bid in response to ESA ITT, where ESA Procurement Policy and constraints are generally defined,
    - Most of the activities are in Open Competition. The bidder must win the competition for getting the contract.
- **Also possible, on a case by case basis**
    - Unsolicited proposal to ESA for some new activity that is matching the Company strategy/competence and some future mission need
    - If ESA interest in the proposal is confirmed, and under some specific conditions – e.g. if the Company country is in severe under-return – a direct negotiation can be sought in view of placing a contract
    - The activity is then anyhow included in the TDP updates for information

Contact points for future missions and technology activities for science and robotic exploration missions

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The End