ESA Science Missions: Plans of the Cosmic Vision Programme

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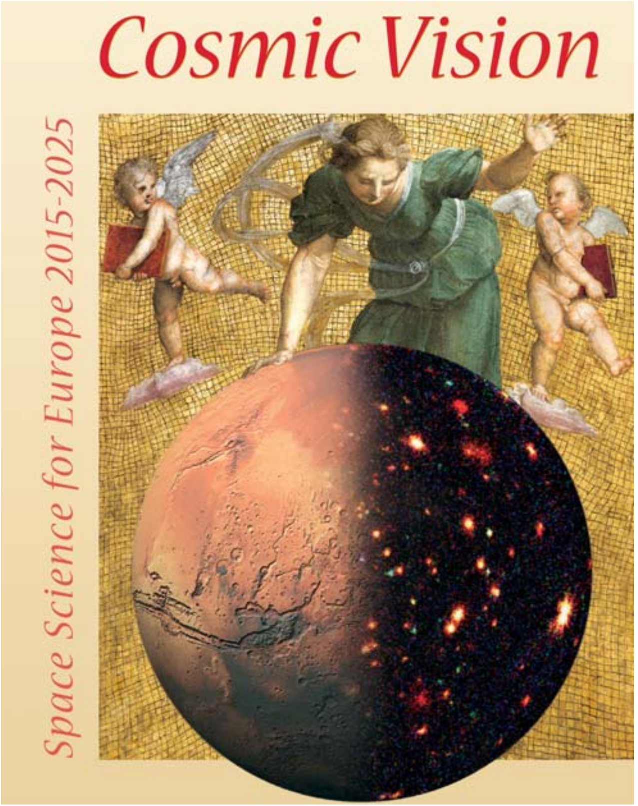
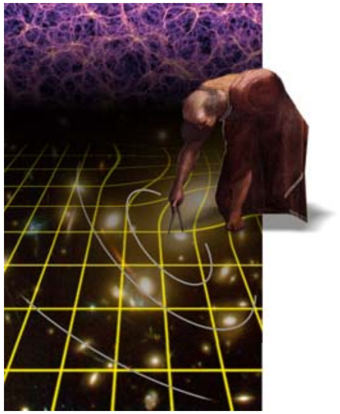
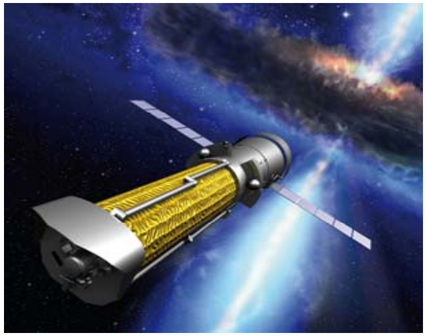
ESTEC
15/03/2011

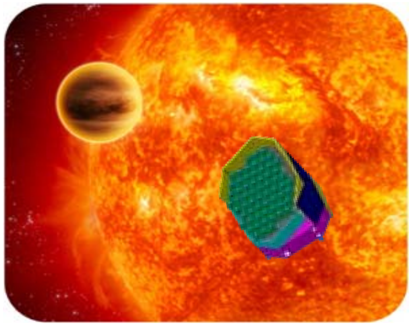


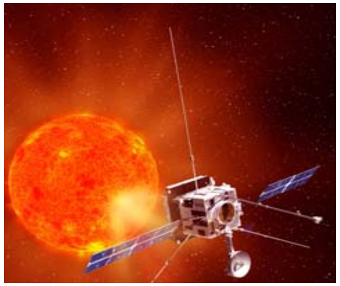
Cosmic Vision Process

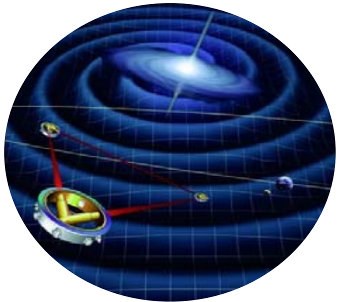
1. Plan covers 10 years, starting from 1st launch in 2017
2. It is divided in 3 “slices” with a ~1 B€ budget each (2010 EC)
3. It foresees a “Call for Mission proposals” for each of the 3 slices
4. First “Call for Missions” was issued in 1st Q 2007
5. 50 proposals received by June 2007 deadline (2x than H2000+)
6. Selection by advisory structure on behalf of scientific community during summer & fall of 2007 → Assessment study (1 year)

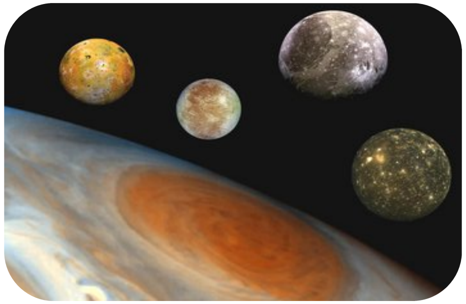




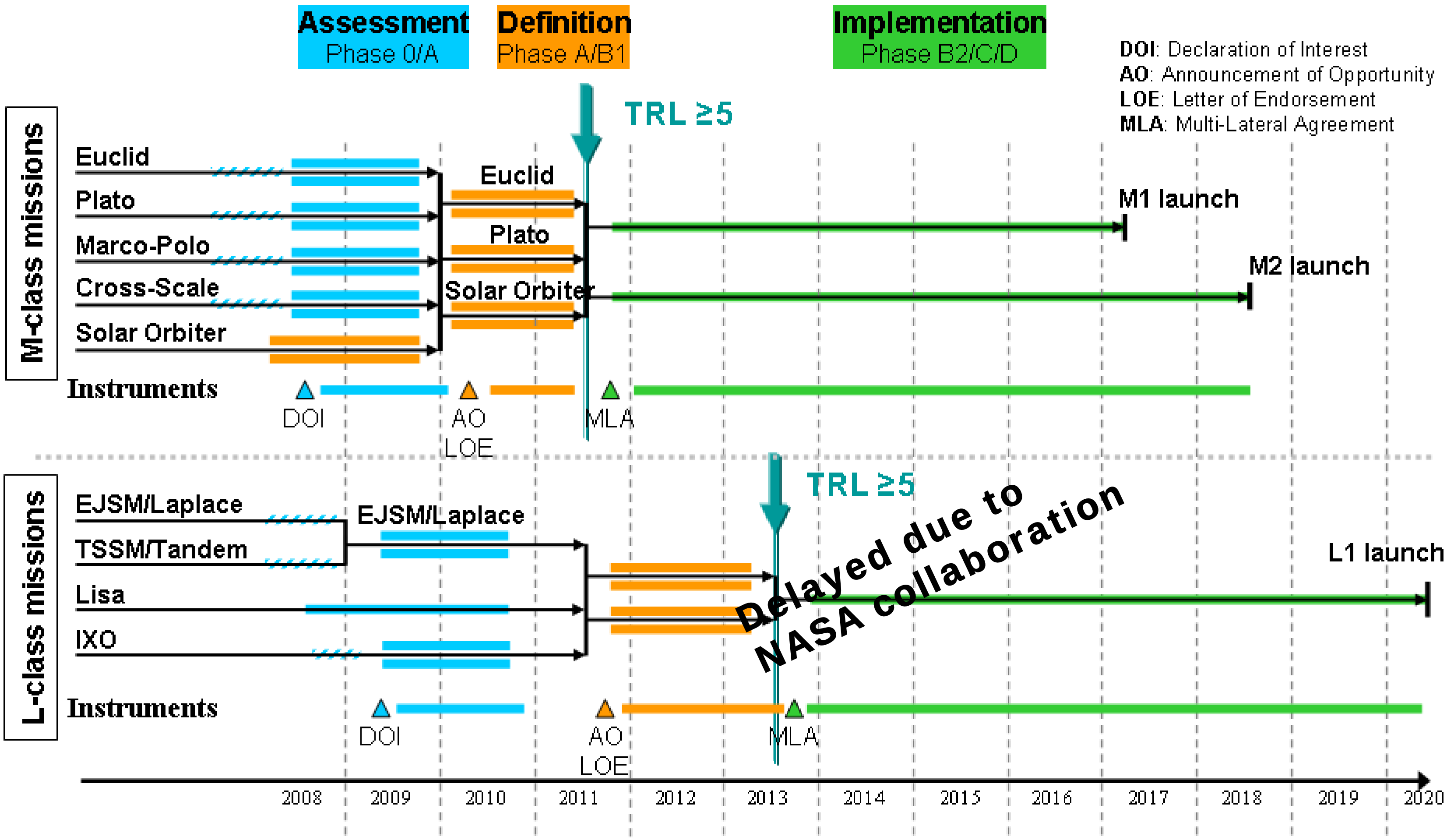








Cosmic Vision Preliminary Planning



Cosmic Vision Slice #2 : M3 Mission

1. Call for M3 Mission (≤ 470 M€) proposals released on 29 July 2010:
    a. 3 December 2010: Proposal deadline (47 proposals)
    b. Dec 2010 – Feb 2011: Proposal evaluation by AWG → SSAC
    c. Feb 2011: selection of 4 M3 missions for Assessment
        - Exoplanet Characterisation Observatory (EChO)
        - Large Observatory For X-ray Timing (LOFT)
        - MarcoPolo-R
        - Space-Time Explorer and Quantum Equivalence Principle Space Test (STE-QUEST)
2. Selection of 2 M3 missions for Definition study (phase A/B1) – end 2012
3. Selection of 1 M3 mission for implementation – End 2015
    a. M1/2 mission candidate which was not selected may compete for M3
4. Launch of M3 mission in 2022

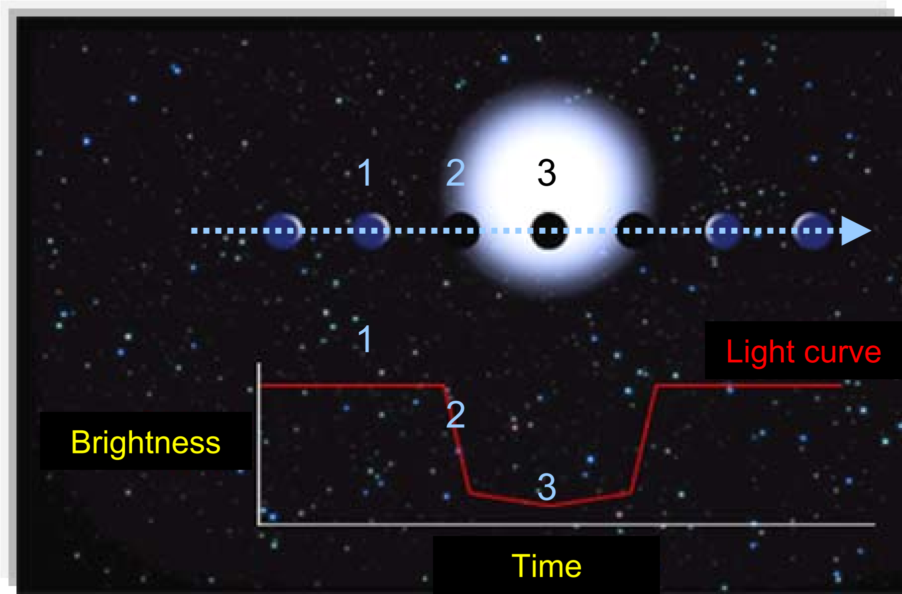
The Medium “M” Mission Candidates

Plato	MarcoPolo-R
Euclid	ECHO
SOLO	LOFT
	STE-QUEST

M1/2: PLATO overview

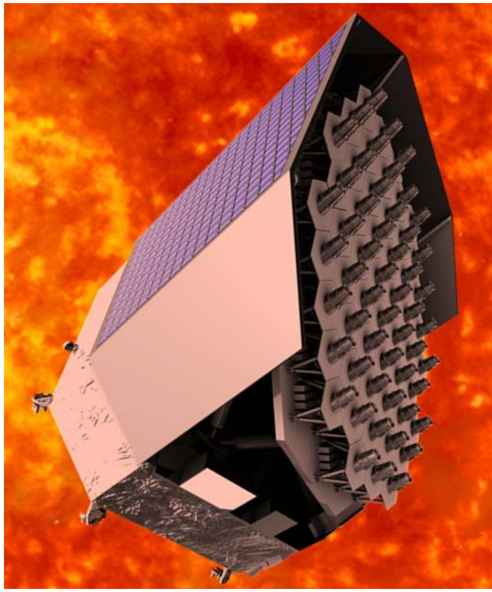
Science objectives:

1. Discover and characterise a large number of close-by **transiting exo-planetary systems.**
2. Perform **seismic analysis** for the exo-planet host stars (stellar evolution and interior processes).
3. Obtain mass, radius, age,... of stars and planets with a precision in the determination of mass and radius of 1% .
4. Observation strategy
   - Observe **many** stars (>20 000); detect ~40 exo-planets
   - With **low noise** level (27ppm)
   - For **2-3 years continuously** to observe multiple transits
   - Observe bright stars (m_V=4-11)
   - Maximize number of observed **bright stars** enabling required ground based follow up observations
   - Maximize Field of View by using overlapping Lines of Sight



M1 / 2 PLATO mission

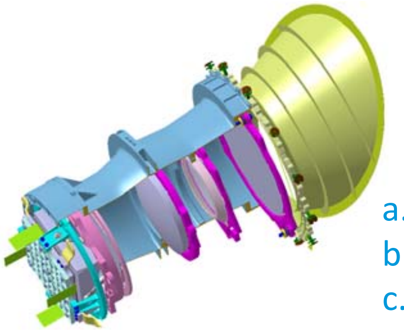
Mission description:



1. Launch by end 2018 from Kourou, French Guyana
2. Soyuz 2-1b with Fregat-MT upper stage
3. Operational orbit: large-amplitude around L2
4. Mission life time is 6 years; all subsystems sized for 8 years in L2
5. Components Technology Readiness Level ≥ 5 before July 2011
6. Max launch mass: 2190 kg with adapter
7. Power ~ 1.7 kW.

Instruments:

a. Maximise both fov (2000 deg^2) and collecting area.
b. 32+2 cameras (32 in full-frame and 2 in frame-transfer mode; 1+1 operating in loop with ACS).
   - 6 lenses/telescope (1 aspheric); radiation resistant
   - 120mm entrance pupil
   - mounted individually on optical bench
   - individual baffles for stray-light rejection and thermal dissipation



a. 4 CCD/camera, each CCD (4510×4510 pix, 18 µm).
b. Spectral range: 500 – 1000nm
c. Telescope nominal working temperature: -80degC

M1/2 PLATO technology

Technology development areas

1. No development for S/C required

2. Payload: Development of optimised CCD for PLATO

Phase 1: 20 July 2010 – 20 June 2011

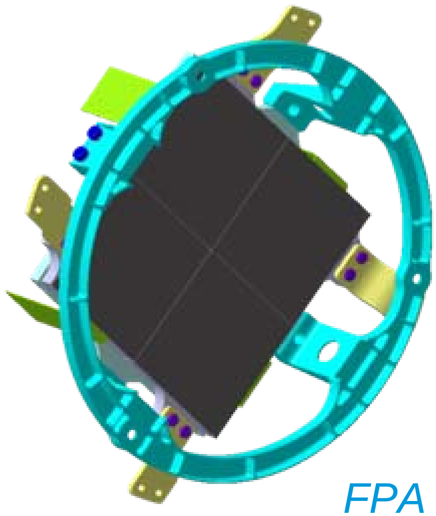
Minimum requirements for activity until June 2011 in view of CV M-class mission down selection:

- CCD design, packaging design, flexi-cable design
- Silicon batches production (5 batches in total)
- Identification of design improvements w.r.t. GAIA to give confidence on production yield extrapolation
- Initial characterization of CCDs on wafers

Phase 2: 21 June 2011 – Feb. 2012

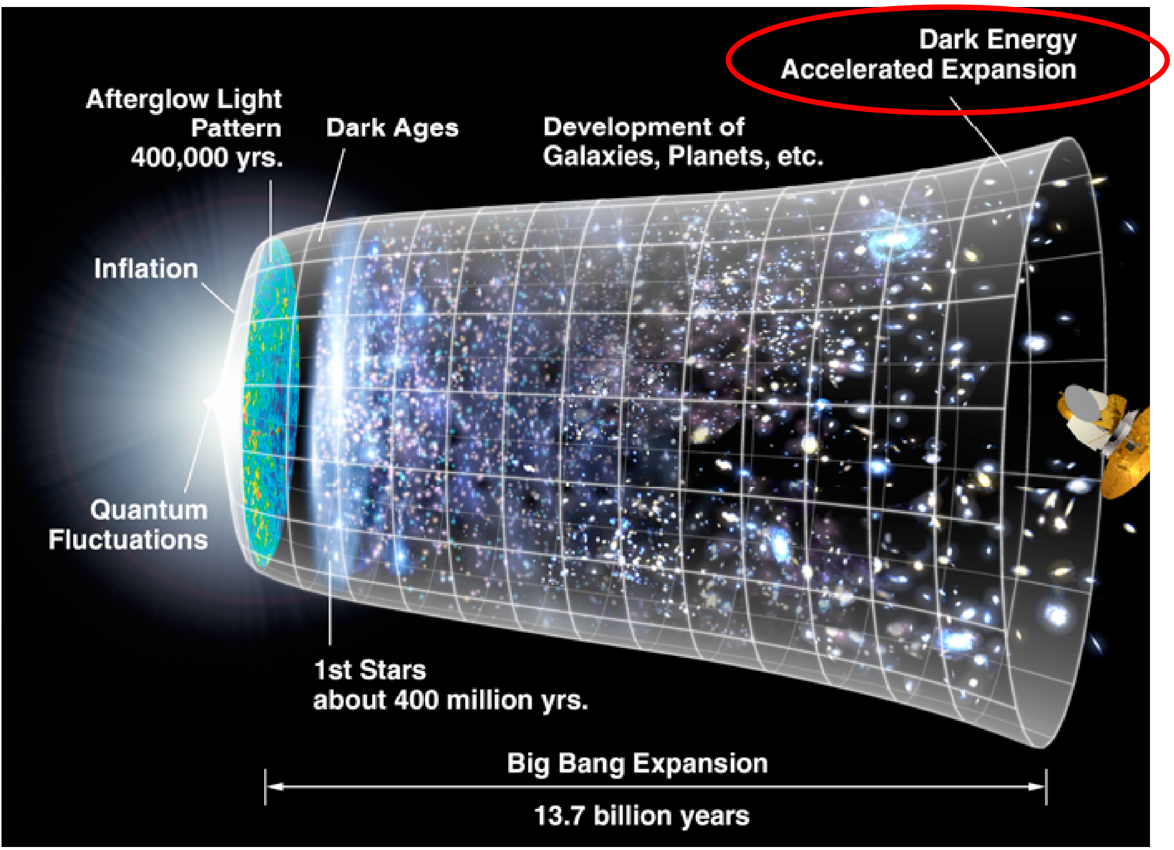
Finalization of development until Feb. 2012, tasks including:

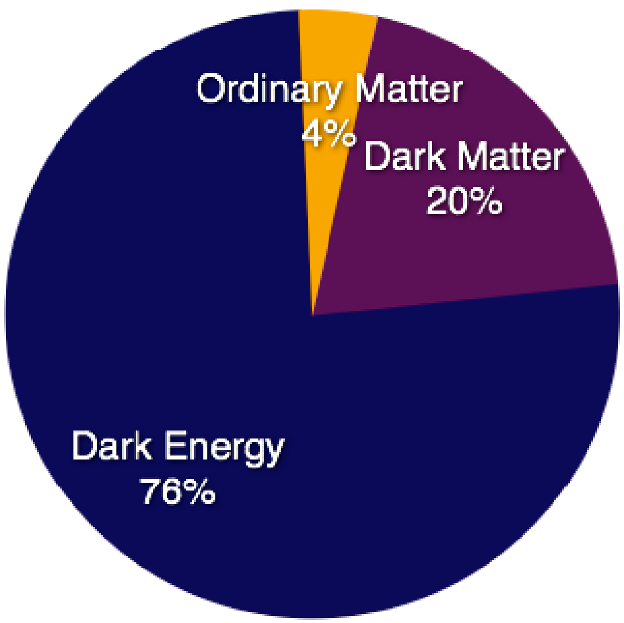
- Back thinning of devices
- CCD packaging
- Testing of the packaged devices
- Plan for flight model mass production


FPA

M1/2: EUCLID science

1. To constrain Dark Energy equation of state parameter w to <1% and its evolution w(z) to < 10 %
2. Uses 2 probes: Weak Lensing & Baryonic Acoustic Oscillations
3. Imaging & spectroscopic survey of entire extragalactic sky

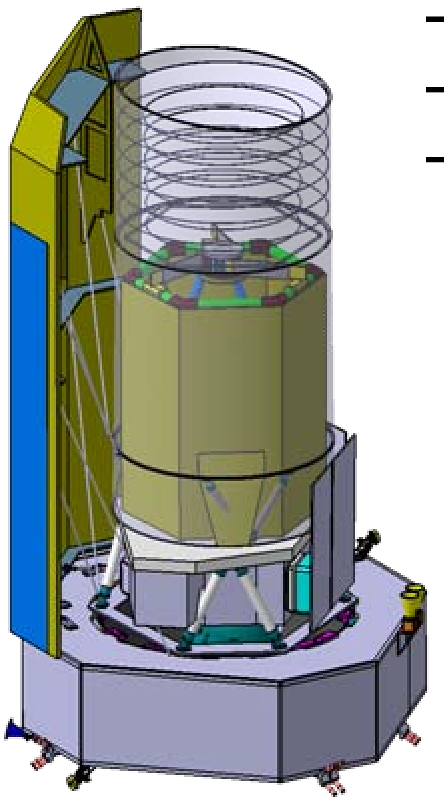


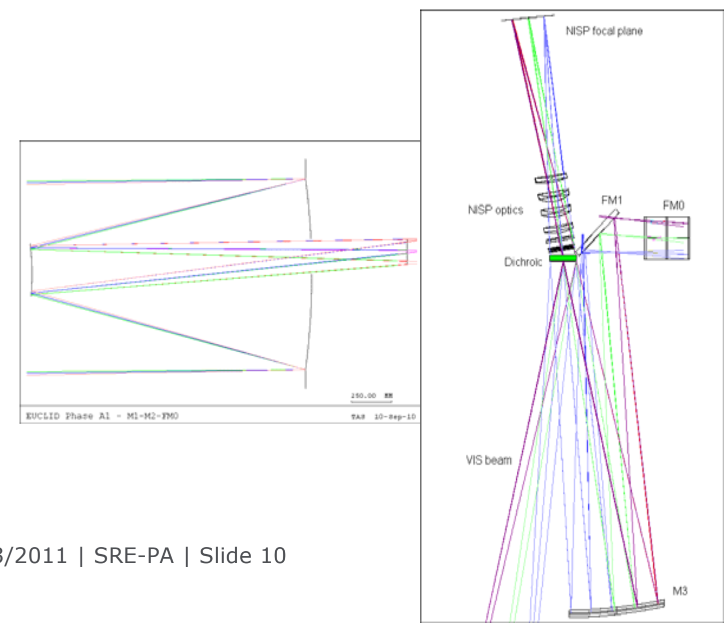


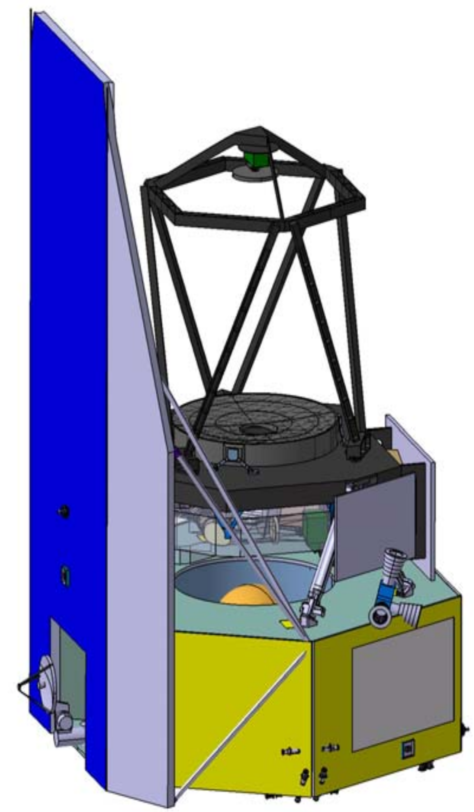
M1/2: EUCLID mission

The EUCLID payload consists of:

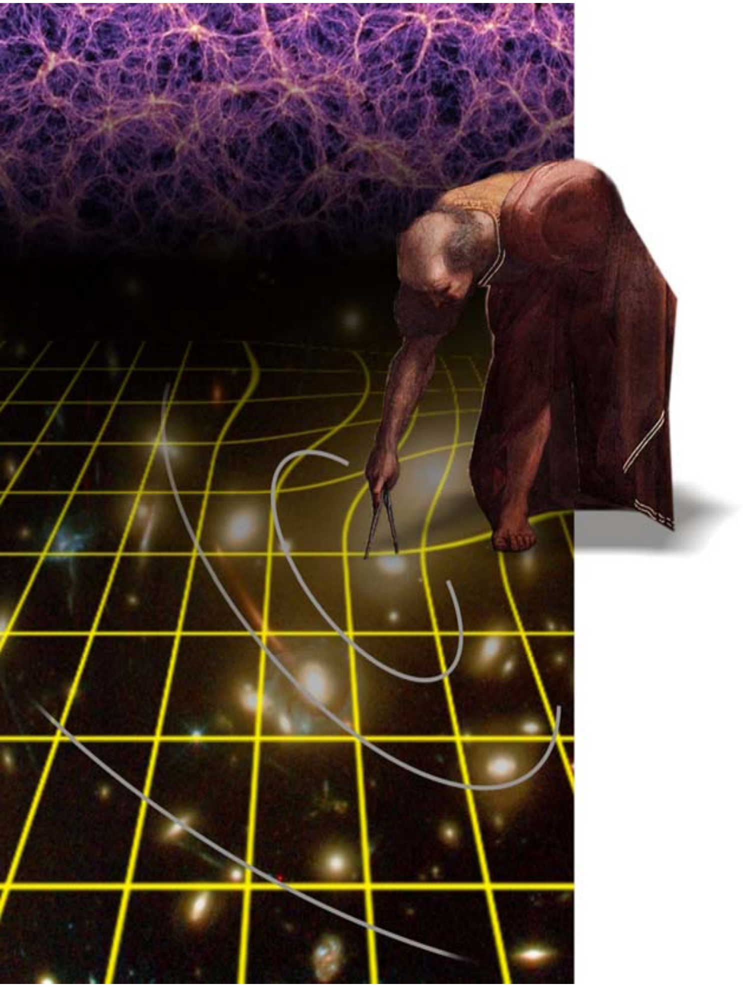
- a 1.2 m diameter telescope,
- a visible imager (VIS),
- a near-IR instrument (NISP)







M1/2: EUCLID technology



Technology activities & pre-developments

- CCD pre-development proceeding

- NIR detector development in Europe pursued as a back-up for Euclid

- Dichroic development

M1 / 2: Solar Orbiter overview

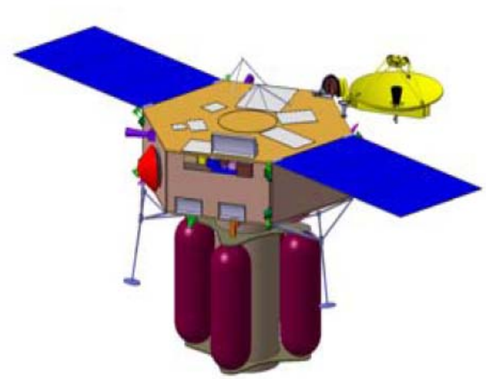
1. To produce images of the Sun at an unprecedented resolution and perform closest ever in-situ measurements
2. Determine in-situ the properties and dynamics of plasma, fields and particles in the near-Sun heliosphere
3. Survey the fine detail of the Sun's magnetised atmosphere
4. Identify the links between activity on the Sun's surface and the resulting evolution of the corona and inner heliosphere, using solar co-rotation passes
5. Observe and characterise the Sun's polar regions and equatorial corona from high latitudes
6. Visible, extreme ultra violet, X-rays
7. Elliptical orbit around the Sun with perihelion as low as 0.28 AU and with increasing inclination up to more than 30° with respect to the solar equator.
8. 6 years lifetime (nominal)

M1/2: Solar Orbiter technology

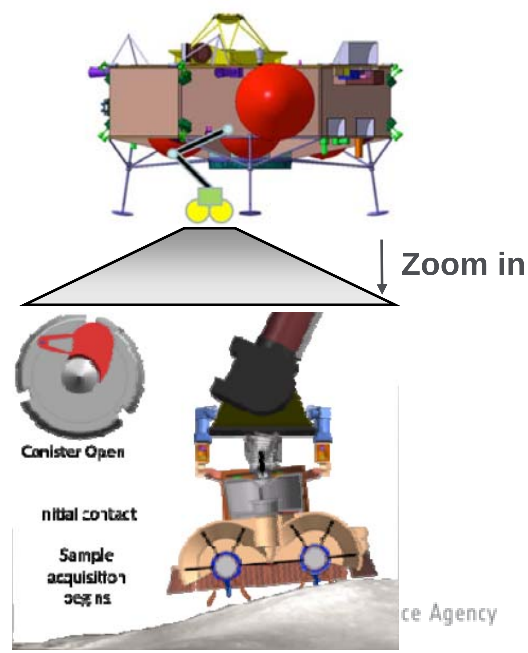
1. Solar generator for High-Intensity-High-Temperature
2. High temperature materials selection/verifications
3. Heat rejecting entrance window

M3: MarcoPolo-R

1. Main science objectives:
    a. Earth-based analysis of samples returned from a primitive asteroid (1996 FG 3, binary)
    b. In-situ characterization of the asteroid

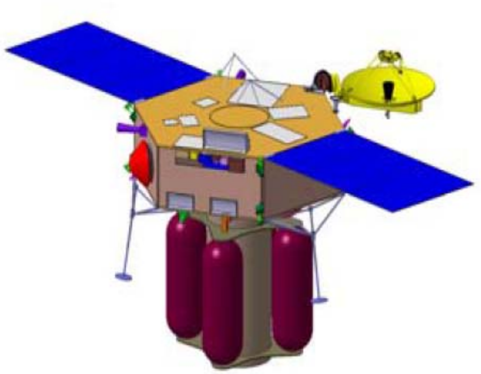


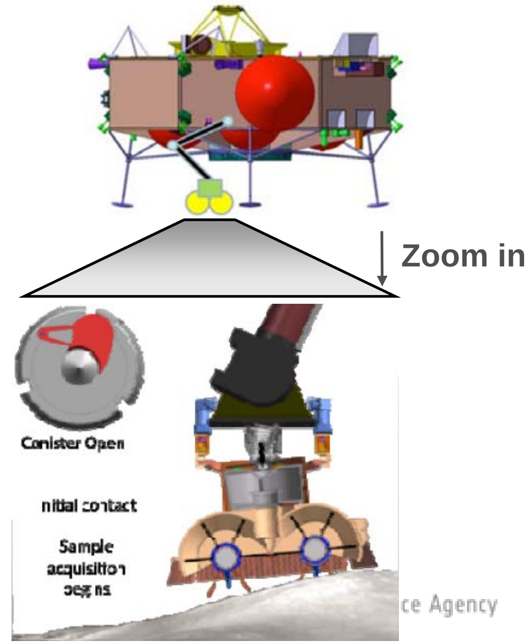
2. Mission profile:
    a. Launch with SF-2B via GTO in 2021 (backup in 2022), Transfer Δv = 2.8 km/s.
    b. Stay time at the asteroid: 8-10 months.
    c. Short asteroid landing (few seconds touch and go) using very fast sampling system.
    d. Distances to the Sun ~ 0.7 AU = Hot environment
    e. Return to Earth in 2029. Earth re-entry velocity: 13.6 km/s



M3: MarcoPolo-R

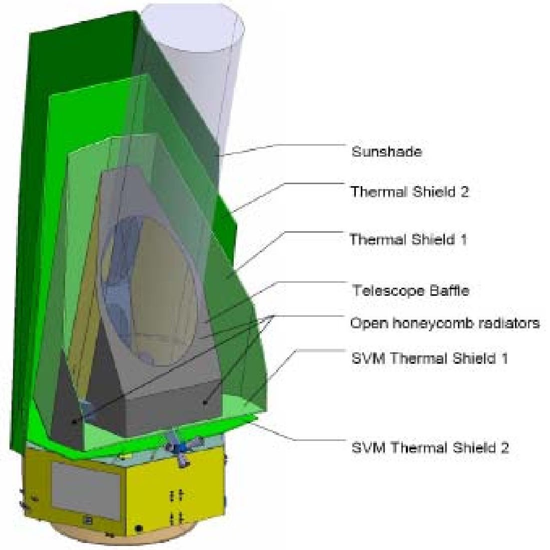
1. Payload:
    a. Baseline: wide-angle & narrow-angle & close-up camera (in-situ images of the sampling location), visible/near-IR & mid-IR spectrometer, neutral particle analyzer, radio science, total mass: 20 kg
    b. Optional: laser altimeter, lander package (camera, LIBS, vis/IR microscope, radar)
2. Technology development area:
    a. Landing/touchdown system (if relevant, depending on selected sampling approach)
    b. Further development of GNC sensors and algorithms
    c. Sample Mechanism
    d. TPS for re-entry

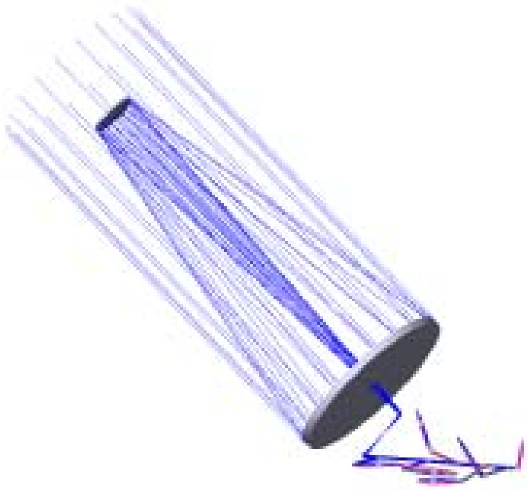




M3: ECHO

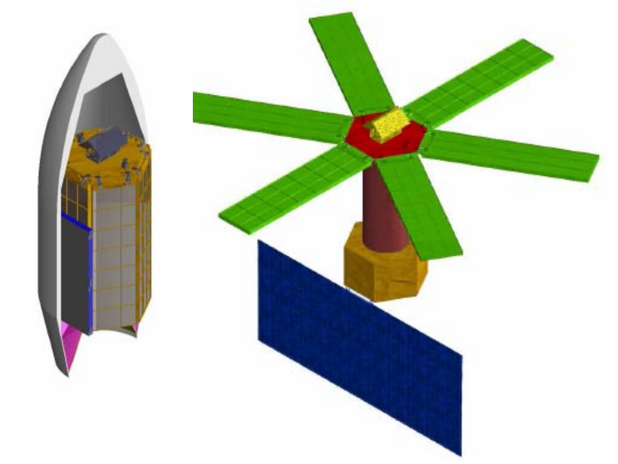
1. Characterisation of already detected exo-planets (50-100 targets) via spectroscopic measurements.
2. SF2-1B launch to SE-L2. Lifetime = 5 yr.
3. SVM + PLM. Total mass ~ 2 ton, power ~ 1.5 kW.
4. Instruments (0.4 – 16 μm):
    a. 1.5 m diameter telescope.
    b. Optical bench and telescope T < 45K (passive cooling).
    c. 1 Vis (science + guidance) + 5 IR channels (HgCdTe) split by dichroic mirrors.
    d. RPE < 20 mas / 10 hr (VIS channel in ACS loop).
5. Technology development areas:
    a. To be defined during assessment study.
    b. Likely to involve MIR detectors.

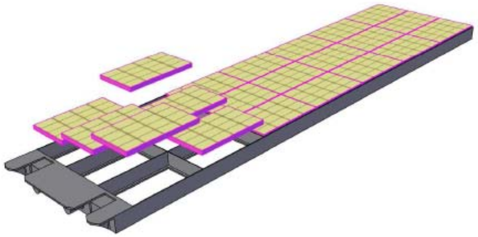




M3: LOFT

1. High-time-resolution X-ray observations (2-30 keV) of rapidly varying objects.
2. VEGA launch to equatorial LEO. Lifetime = 4 yr.
3. SVM + PLM. Total mass ~ 2 ton, power ~ 2 kW.
4. Instruments:
    a. Wide Field Monitor (triggering observations).
    b. Large Area Detector (capillary collimator + SDD).
    c. 6 deployable panels, total of 10m^2: 16 detector/module, 21 module/panel –> total of 2016 detector units.
    d. Deployable panel mechanism (SMOS/SAR heritage)
5. Technology development areas:
    a. To be defined during assessment study.
    b. Likely to involve delta detector and capillary collimator developments.

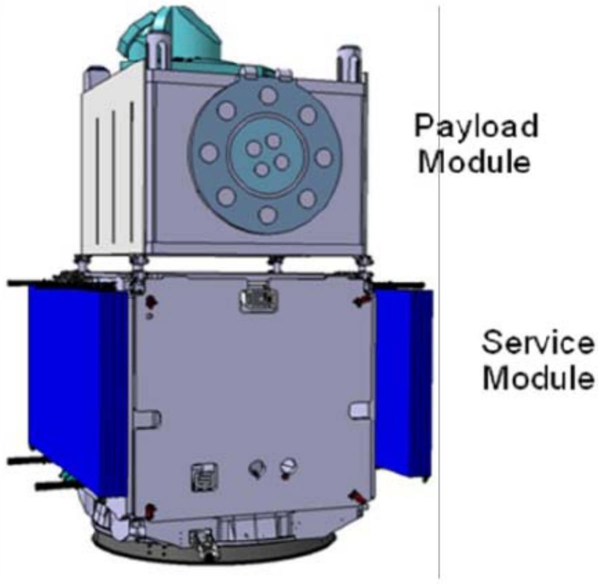




M3: STE-QUEST

1. General relativity confirmation. STE= gravitational red shift. QUEST= equivalence principle.
2. SF2-1B launch to highly inclined HEO. Lifetime = 5 yr.
3. SVM + PLM. Total mass ~ 1-1.5 ton, power ~ 2 kW.
4. Instruments:
   a. Improved cold atom MW clock (upgraded PHARAO/ACES).
   b. Atom Interferometer (EP verification).
   c. Precise orbit determination (GNSS receiver + corner cube reflectors)
5. Technology development areas:
   a. To be defined during assessment study.
   b. Likely to involve delta work on upgraded PHARAO.
   c. Atom Interferometer: significant work required in order to achieve TRL=5 by end of 2014.

STE Satellite



The Large “L” Mission Candidates

IXO

LISA

Laplace/EJSM

L1: IXO overview

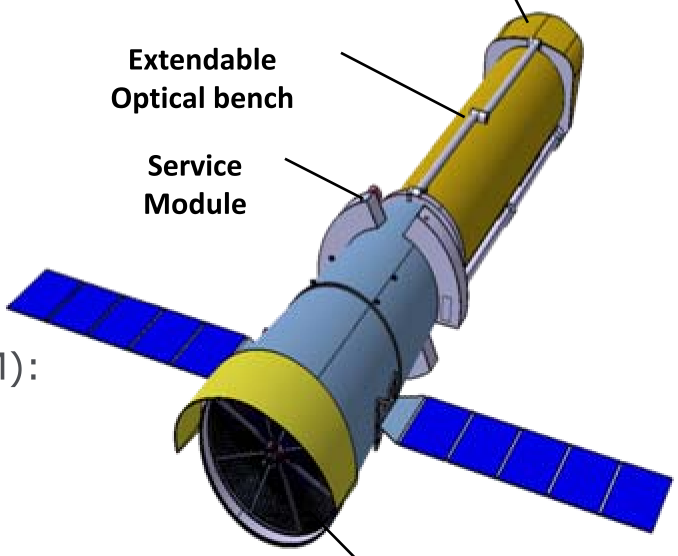
1. A single large aperture X-ray telescope (MA), using:
    a. either the Si pore optics technology.
    b. or the slumped glass technology.

2. Focal length (20 m) achieved via deployable booms (EOB).

3. X-ray Grating Spectrometer always illuminated (IM).

4. Five focal plane instruments on a moving platform (IM):
    a. Wide Field Imager (WFI)
    b. Hard X-ray Camera (HXI)
    c. X-ray Imaging Spectrometer (XMS)
    d. High Time Resolution Spectrometer (HTRS)
    e. X-ray Polarimeter (XPOL)

5. Observatory operating at SEL2 (on a large Halo orbit).



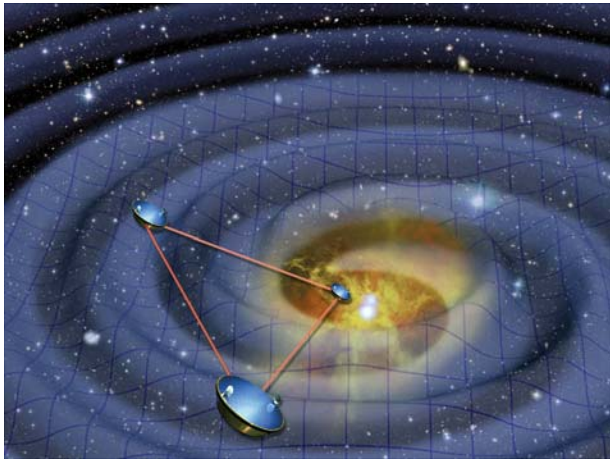
L1: IXO technology

1. IXO platform:
    a. Needs (and risk) mitigated through optimisation of the international cooperation scheme (e.g. NASA deployable bench with flight heritage).
    b. Metrology and mechanisms

2. IXO focal plane instruments:
    a. Nationally funded development activities are ongoing for all instruments.
    b. ESA team is monitoring closely progress through consortia studies.

3. IXO optics (mission enabling element):
    a. ESA strong commitment to next generation X-ray optics.
    b. ESA funded activities addressing both Silicon Pore Optics (baseline) and slumped glass approach (back-up). See next presentations for details.
    c. Independent activity (focused on slumped glass) is sponsored by NASA.
    d. Parallel activities on different technologies allow to further mitigate the risk.

L1: LISA science

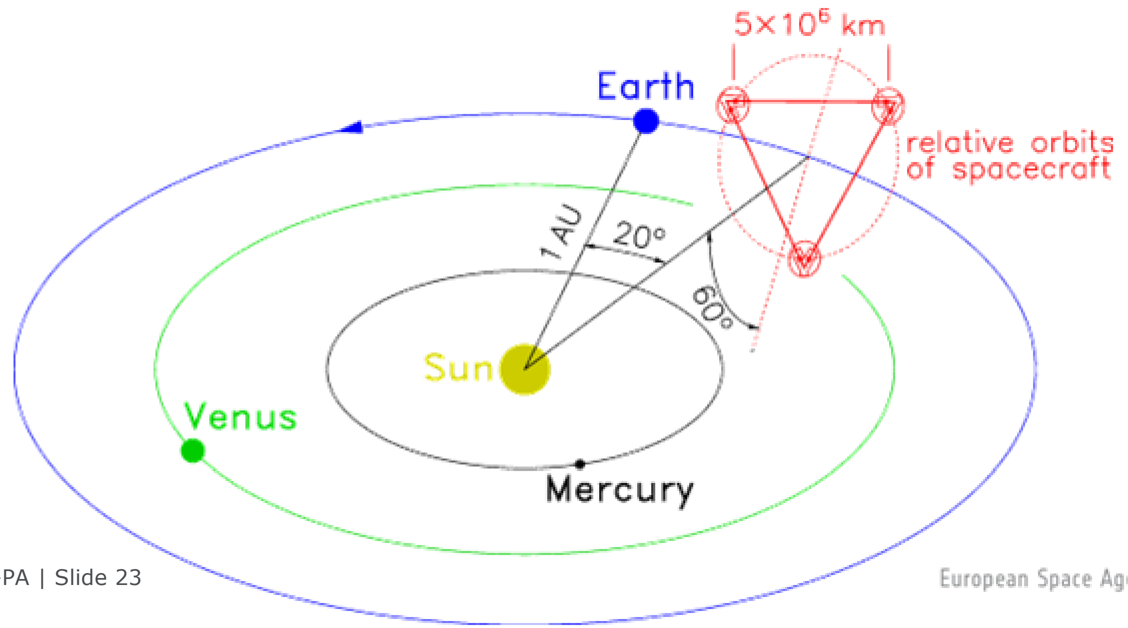


1. Observe BH formation & SMBH (M ~105 ... 108 Mo) mergers out to z > 10 with high (>300) SNR
2. To observe capture of stellar-mass compact objects (BH,NS,WD) into SMBH (“EMRI”)
3. Map space-time geometry near BH & test GR in strong field regime, including “no hair” theorem
4. To observe thousands of compact binaries & map their distribution across the galaxy
5. Measure Luminosity distances to 0.5 % accuracy → accurate cosmology

L1: LISA mission

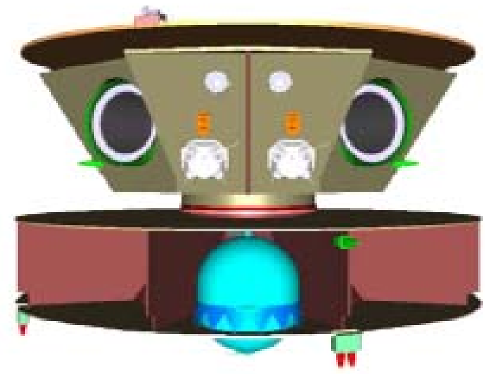
1. Cluster of 3 spacecraft in a heliocentric orbit
2. Trailing the Earth by 20° (50 million kilometres)
3. Equilateral triangle with 5 million kilometres arm length
    a. Measure arm-lengths variations by laser interferometry
    b. Precision of relative variation measurements <0.1 pm

1. Spacecraft shield the test masses from external non-gravitational forces (solar wind, radiation pressure) → TM follow pure geodesic
2. Allows measurement of <u>amplitude</u> and <u>polarisation</u> of GW



L1: LISA technology

1. Optical assembly articulation mechanism
2. Metrology system
3. High power laser system
4. Tuneable laser frequency reference
5. Inertial sensor design
6. Charge management system
7. Low noise magnetic gradiometer
8. Micropropulsion lifetime

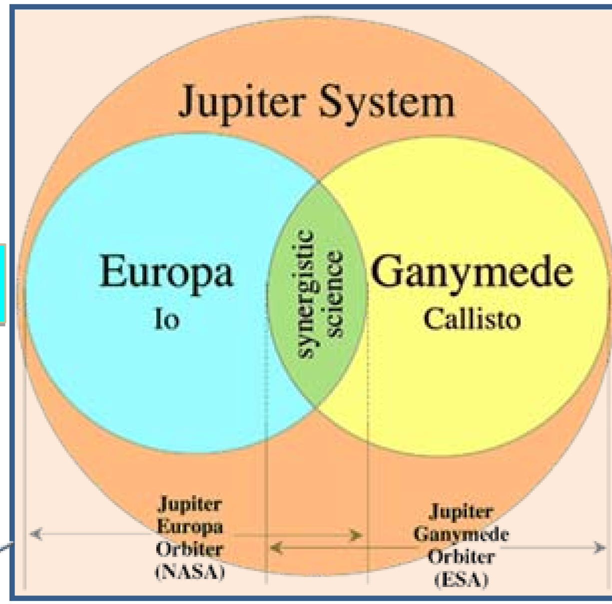


L1: LAPLACE / EJSM science

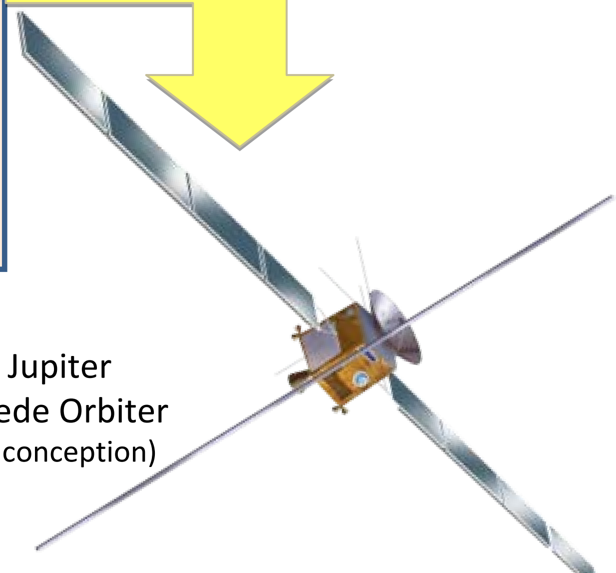
Explore the Jupiter system as an archetype for gas giants.

Explore Europa to investigate its habitability

Characterize Ganymede as a planetary object including its potential habitability



NASA Jupiter Europa Orbiter
(artist's conception)



ESA Jupiter Ganymede Orbiter
(artist's conception)

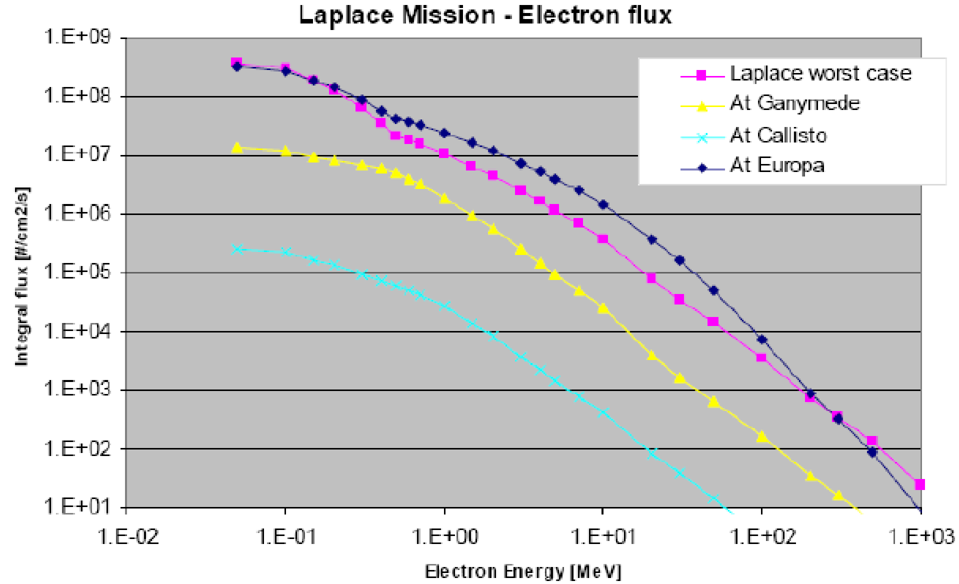
L1: LAPLACE / EJSM mission

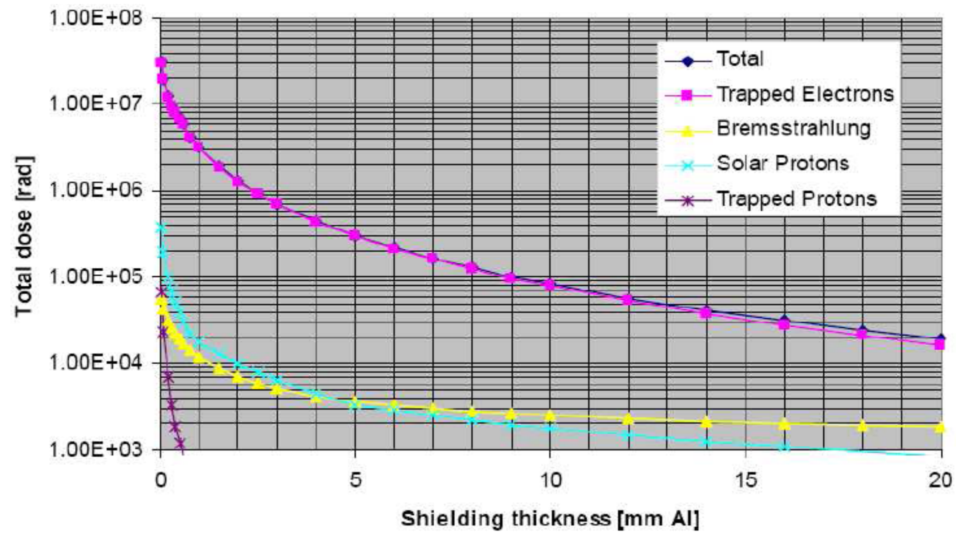
1. NASA and ESA: Shared mission leadership
2. Independently launched and operated flight systems with complementary payloads
   a. NASA-led Jupiter Europa Orbiter (JEO)
   b. ESA-led Jupiter Ganymede Orbiter (JGO)
3. Complementary science and payloads
   a. JEO concentrates on Europa and Io
   b. JGO concentrates on Ganymede and Callisto
   c. Both perform Jupiter System Science
   d. Synergistic overlap
   e. ~11 instruments on each flight system

L1: LAPLACE / EJSM radiation environment

1. Radiation is electron dominated

2. High energies – less efficient shielding





L1: LAPLACE / EJSM technology

1. Solar cells for Low-Temperature-Low-Intensity conditions
2. Radiation tolerant materials (high surface charges, cold)
3. Radiation tolerant components: FLASH, memory, LEON, power converters
4. Latch-up protection for COTS
5. Front-end readout ASIC (radiation tolerance, different frequency domains)
6. DARE+ continuation of development
7. Low mass Space Wire
8. Radiation tolerance of opto-couplers, sensors, detectors
9. Star tracker performance on high radiation environment

Technologies for several missions

1. Strategic developments possibly applicable to several missions

2. Developments related to components (selected list):

    a. High processing power DPU based on high rel. DSP
    b. An On-Board Software Platform for the Next Generation of Infrared Astronomy Missions
    c. High Efficiency Horn Antennas for Cosmic Microwave Background Experiments and Far- Infrared Astronomy
    d. Development of a THz Local Oscillator for Space Science Heterodyne Applications

Conclusions

1. M-class missions are constrained by schedule and allow only limited developments

2. L-class missions additional limited developments accepted
    a. LISA: lasers, drag-free, metrology
    b. IXO: optics, focal plane, metrology
    c. EJSM/Laplace: electronics, materials

3. L-class missions now under review due to recent developments on US decadal surveys outcome and due to NASA budget, specifically
    a. EJSM/Laplace
    b. IXO
    c. LISA