SCIENCE

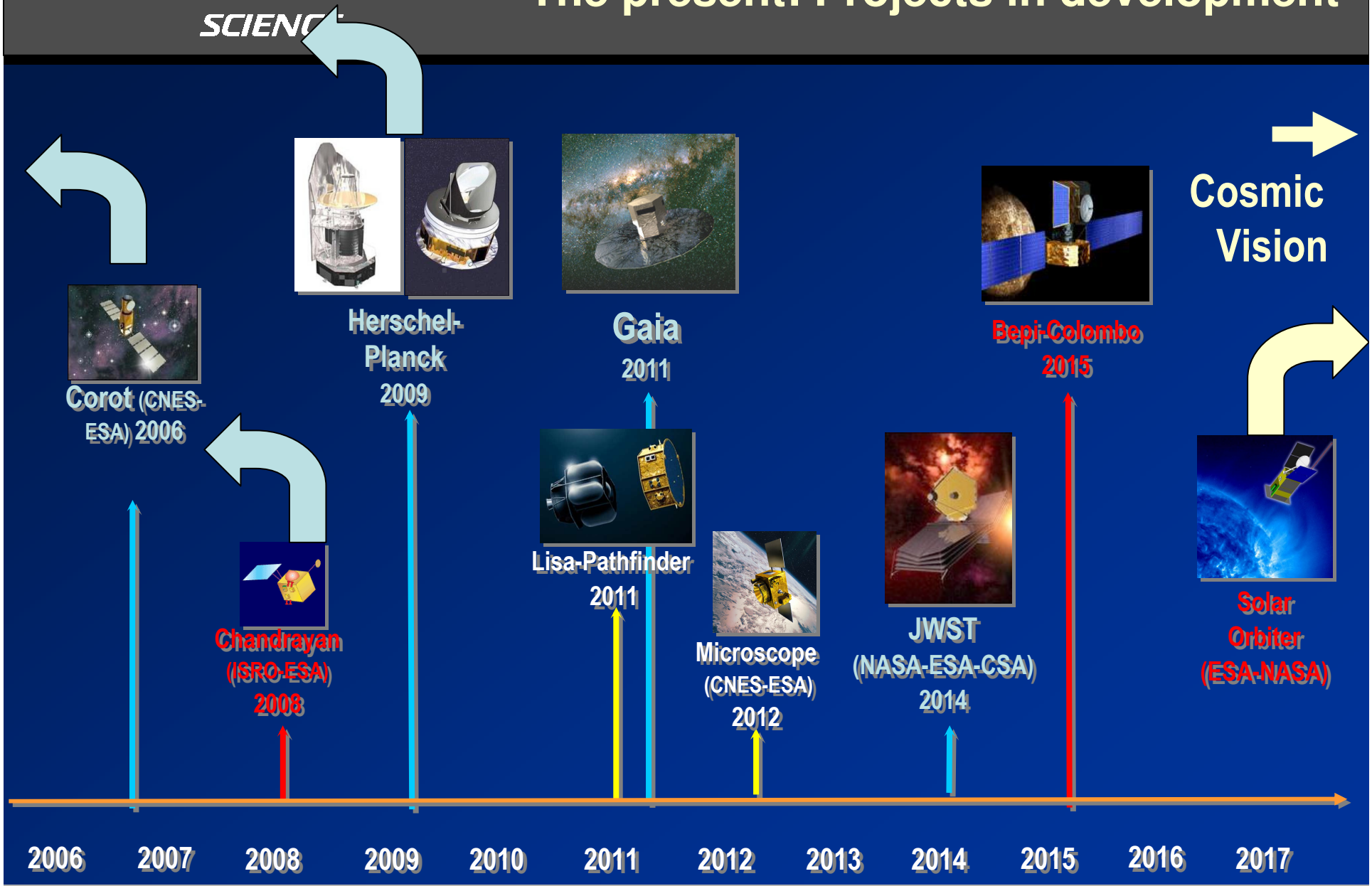
A Perspective for the future:

The ESA Cosmic Vision Programme

Jean Clavel

Head, ESA Astronomy & Fundamental Physics Mission Division

The present: Projects in development



ESA's new long term plan for space science

Cosmic Vision Process

- Plan covers 10 years, starting from 1st launch in 2017
- It is divided in 3 “slices” with a budget of 950 M€ each
- There will be a “Call for Mission proposals” for each of the 3 slices
- First “Call for Missions” issued in 1st Q 2007
- 50 proposals received by June 2007 deadline (2x than H2000+)
- Selection process by advisory structure on behalf of scientific community during summer 2007
- Selection by Space Science Advisory Committee in October 2007

Cosmic Vision process: 1st slice

- The 1st slice initially foresaw 2 launch opportunities:
  - 1 **Medium** size mission in 2017: ESA cost capped at **300 M€**
  - 1 **Large** size mission in 2018: ESA cost capped at **650 M€**
- Payloads funded separately by Member States
- Other combinations possible depending on programmatic evolution

Cosmic Vision: the selection process

- The selection of a given **M** mission is in three steps:
  - Selection of **5** Missions for 1-year **Assessment** Phase (Phase-A)
  - At the end of Assessment Phase, down-selection of **3 M** missions for 2-years **Definition** phase (Phase-B)
  - At the end of Definition phase, down selection of **1 M** mission for 5-7 years **Implementation & launch** (Phases C/D)
- The selection of an **L** mission is similar but …

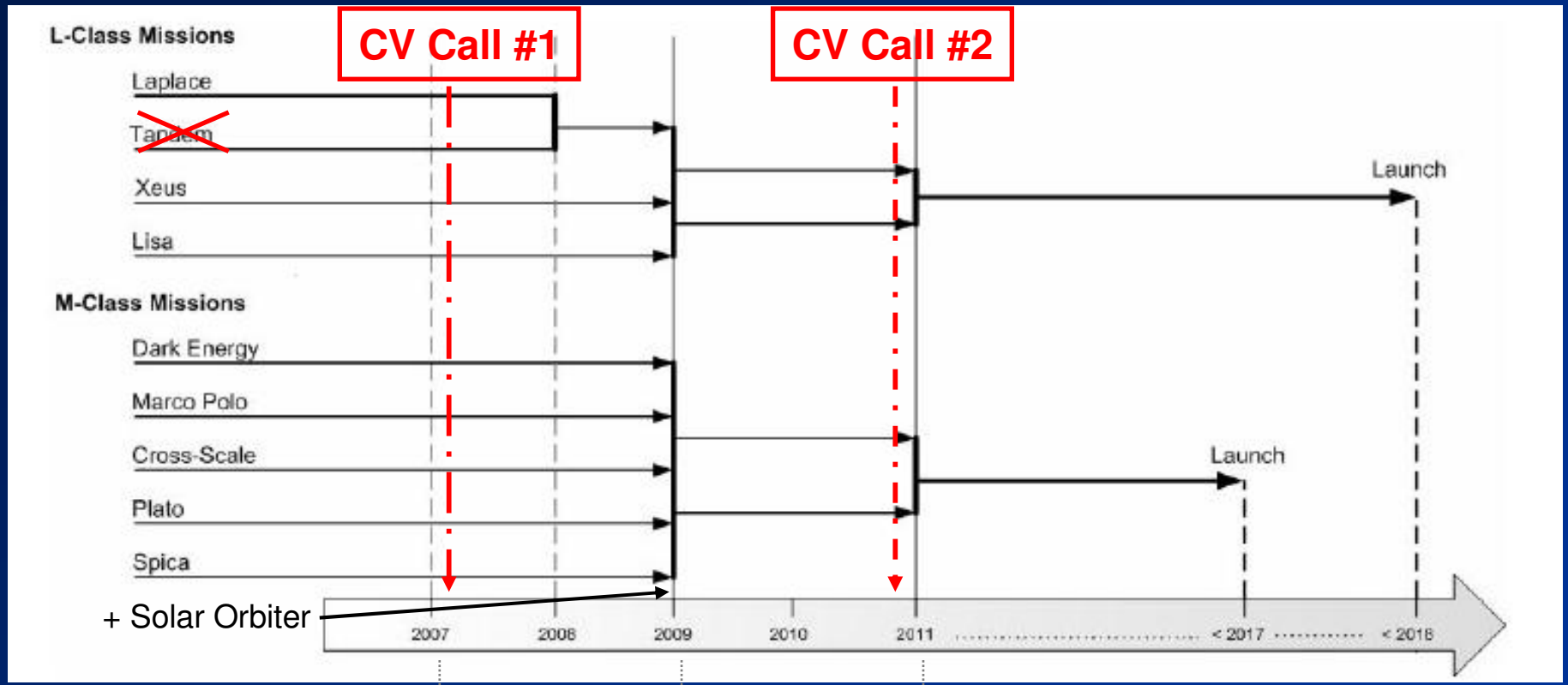
Cycle 1 selection outcome

- **Seven** Missions were selected for Assessment over 2008-2009:
  - **5 M** missions (< 300 M €) for launch in 2017:
    - *Euclid*
    - *Plato*
    - *Spica*
    - *Marco-Polo*
    - *Cross-Scale*

    + will compete with *Solar-Orbiter* (studied in H2000+ program)
  - **2 L** Missions (<650 M€) for launch in 2018:
    - *XEUS* → *IXO*
    - Outer-Planet mission *Laplace* or ~~*Tandem*~~ (Laplace pre-selected)

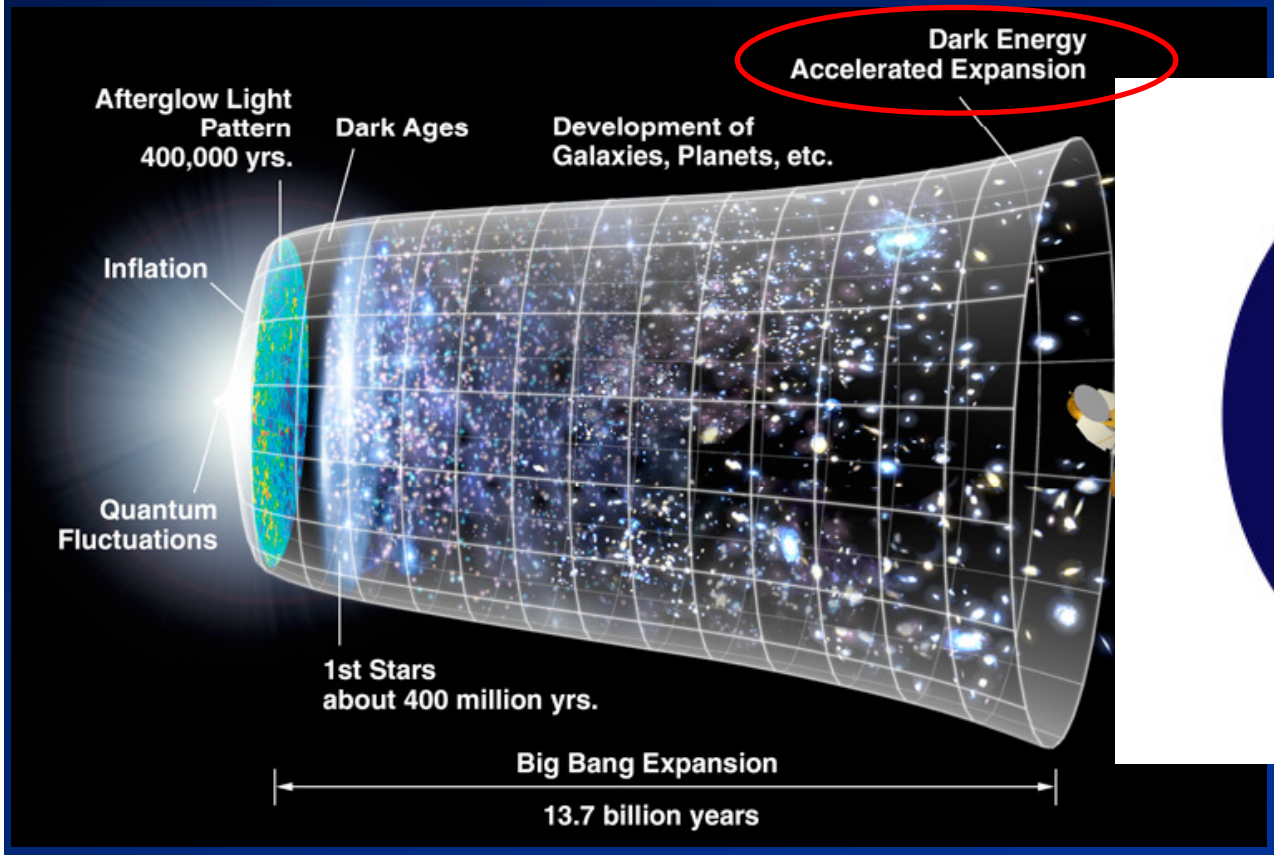
    + will compete with *LISA* (studied in H2000+ program)

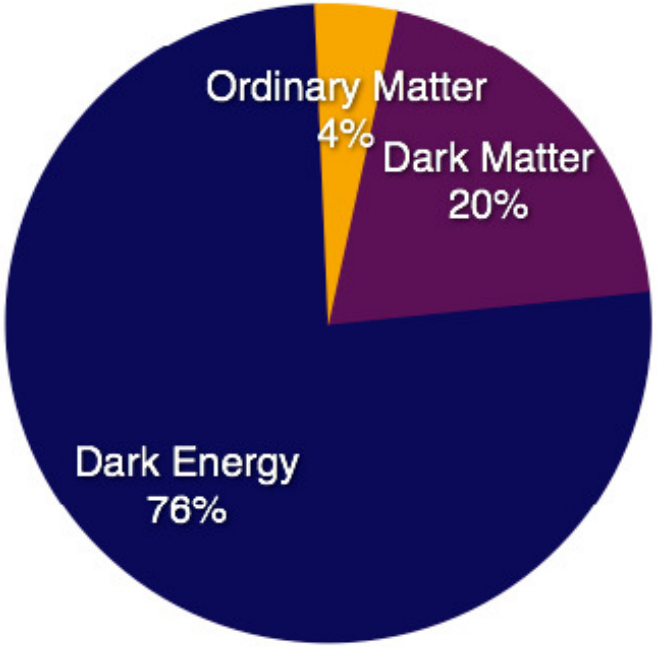
Mission selection process



EUCLID, a dark-energy surveyor

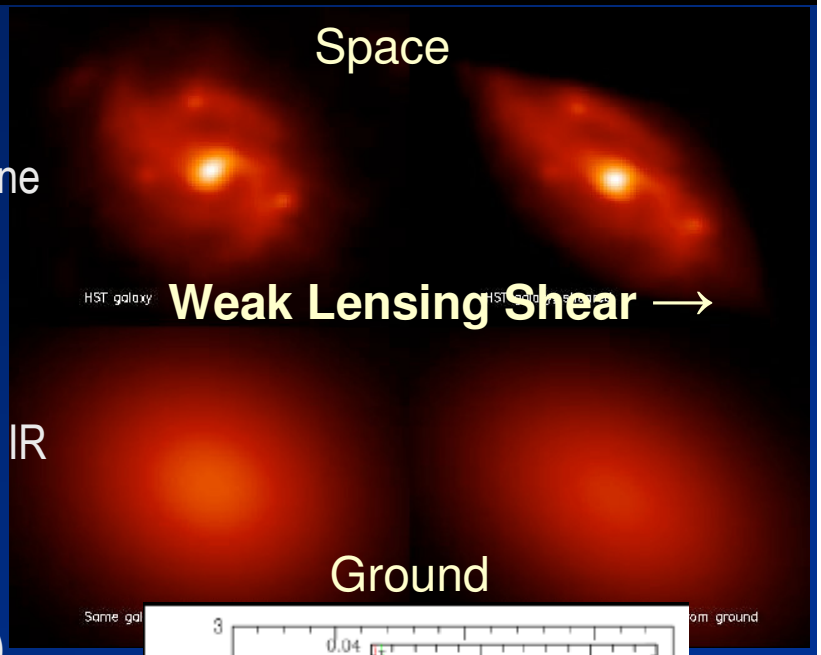
- To constrain Dark Energy equation of state parameter ***w*** to <1%
- Imaging & spectroscopic survey of entire extragalactic sky
- Uses 2 probes: *Weak Lensing* & *Baryonic Acoustic Oscillations*

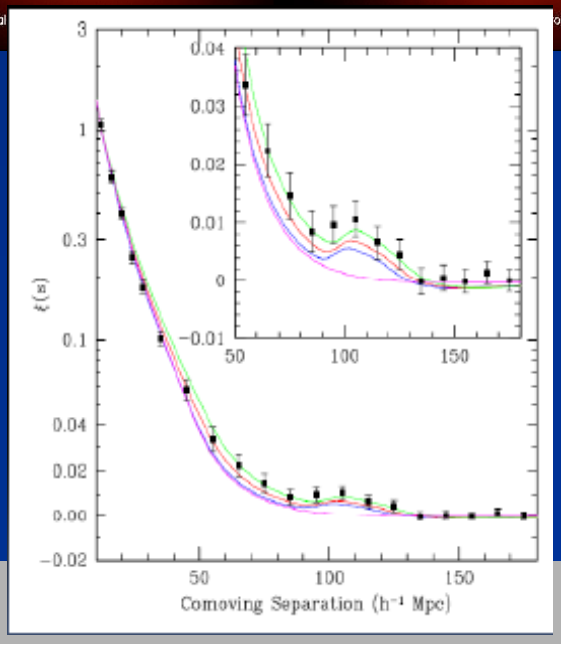




Euclid (2)

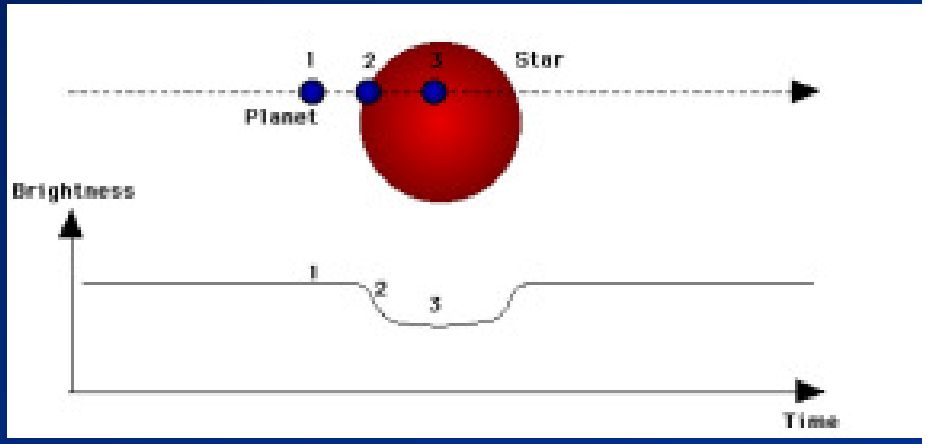
- **Weak gravitational Lensing**:
  - Matter in front of galaxies *distort* their shapes
  - This "shear" measures amount of matter along the line of sight (dark & normal) to galaxy
  - Shear ~1%, must be measured accurately
  - → Measure shape of 5×10^8 galaxies to 24.5 mag.
  - → Measure distance by photometric redshifts in 3 near IR bands to 24 mag.
- **Baryonic Acoustic Oscillations**:
  - Size & distribution of cosmic structures (ex. clusters) depends on expansion rate & gravity
  - → Measure spectroscopic distance to $\sigma_z < 0.001$ of 33% of all galaxies brighter than 22 mag. (~2×10^8 to z = 2)
- **EUCLID:**
  - 1.2 m telescope with 0.2" PSF; 5 years survey
  - Vis & NIR imager "DUNE"
  - near IR spectrograph "SPACE"

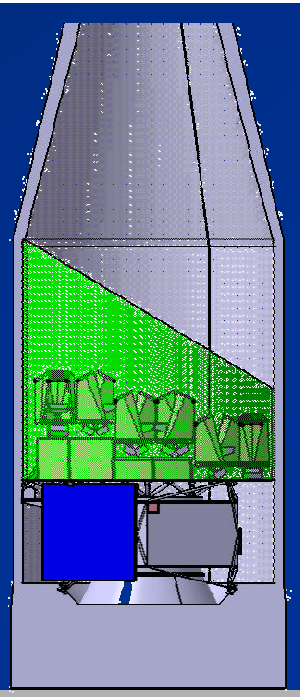




PLATO, the planet finder

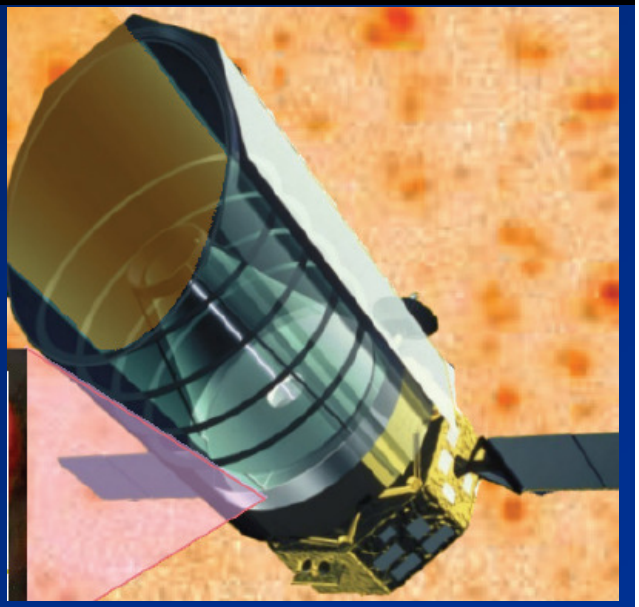
- Goal: find & characterise ***earth-size*** planets in **1-AU orbit** around 20,000 **Sun-like stars**
- Method: **occultation** technique i.e. measure star brightness to **27 p.p.m. accuracy**!
- Also characterise star by astroseismology → size & mass of star & planet
- Need to survey *large* sky area for *long time*
  - Can monitor many stars simultaneously
  - 12 to 54 co-aligned small telescopes
  - Observe 2 directions for 2.5 years each
- May find up to **200 earth analogues**, sufficiently close for follow-up with future spectroscopic mission (~Darwin)





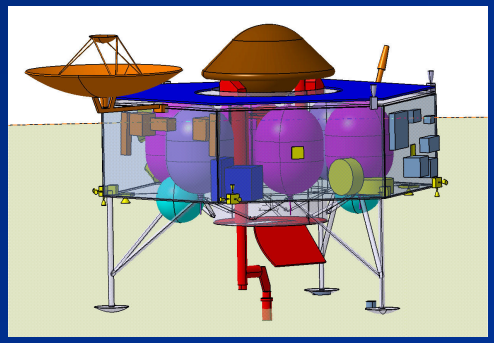
SPICA: the next generation Infrared observatory

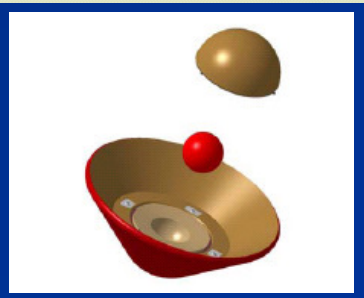
- Goal: study star & planet formation & the birth of galaxies
- Because of dust absorption, need to observe in infrared (IR)
- A joint Japan/Europe collaboration:
  - Japan provides spacecraft, launch & 2 instruments
  - Europe provides telescope & 1 instrument “SAFARI”
  - Satellite at Sun-Earth Lagrange point L2
  - Observatory open to Europe & Japan scientists
- Telescope:
  - 3.5 m diameter; heritage from Herschel
  - Actively cooled to 6 K → much more sensitive
  - Includes coronagraph for imaging exoplanets (“Jupiter”)
- SPICA also in assessment in Japan; selection schedule OK
- Mission of opportunity: cost to ESA ≤ 100 M€



Marco-Polo, the asteroid chaser

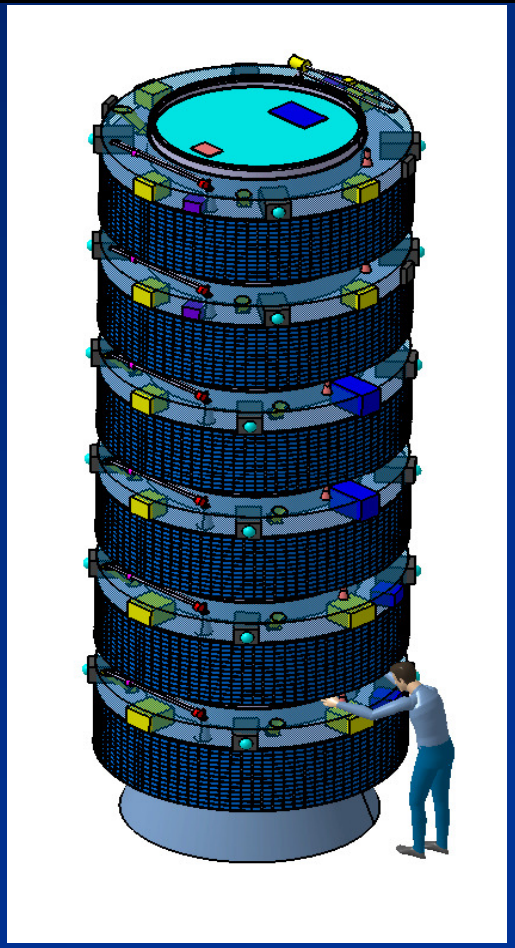
- Goal: land on a primitive asteroid, collect & ***return*** sample
- Will return 30 g of pristine material dating from the time of the formation of the solar system, 4.5 billion years ago
- Follow-up to ROSETTA mission now en route to comet 67P
- Possibly in collaboration with Japan
- Technology for capsule re-entry not mastered yet in Europe
- ~ 10 instruments nationally funded





Cross-scale: the earth magnetosphere in 3-D

- Flotilla of 7 spacecrafts to navigate in the earth magnetosphere and study its composition, electric and magnetic properties in 3 dimension and its interaction with the solar wind
- Follow-up of successful Cluster mission
- Possibly in collaboration with Canada (3 additional spacecrafts) and Japan
- 10 instruments on-board



Cross-Scale spacecrafts stacked launch configuration

Status of M-Missions

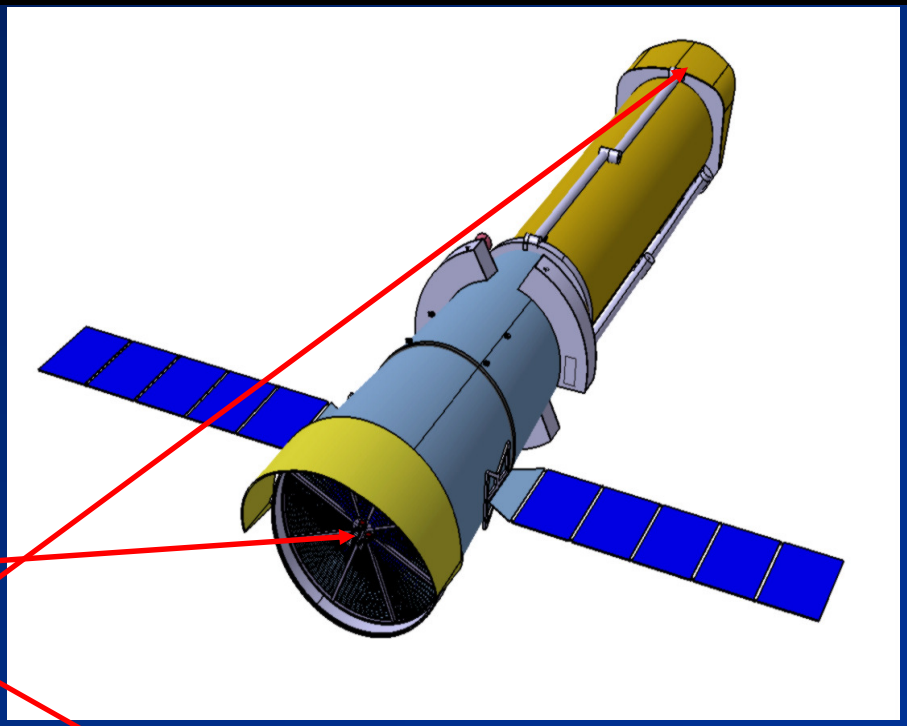
- Assessment study of 5+1 M-Missions almost complete.
  - No technical show-stopper; at least 2 could be ready for launch in 2017
  - Cost generally higher than 300 M€ (except for SPICA)
  - In January 2010, 3 of them will be selected for 2 years definition phase
  - End 2011, 1 or 2 of them will be selected for development & launch in 2017

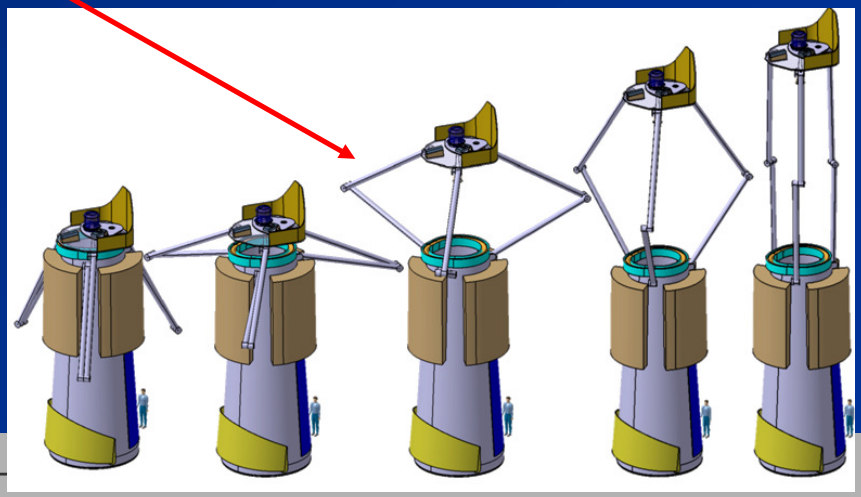
IXO, the International X-Ray Observatory

- **Goal:** study black-holes at the centre of galaxies and their evolution since they were formed; study the formation & evolution of large scale structures in the Universe
- Follow-up of XMM-Newton observatory
- Imaging X-rays requires long focal length:
  - 25 m deployable bench
  - Light-weight X-ray mirrors at one end
  - 5 X-ray instruments at other extremity
- Status from on-going assessment:
  - Expensive: cost > 650 M€

  → Collaboration with NASA & Japan
  - Light weight mirror technology need long development

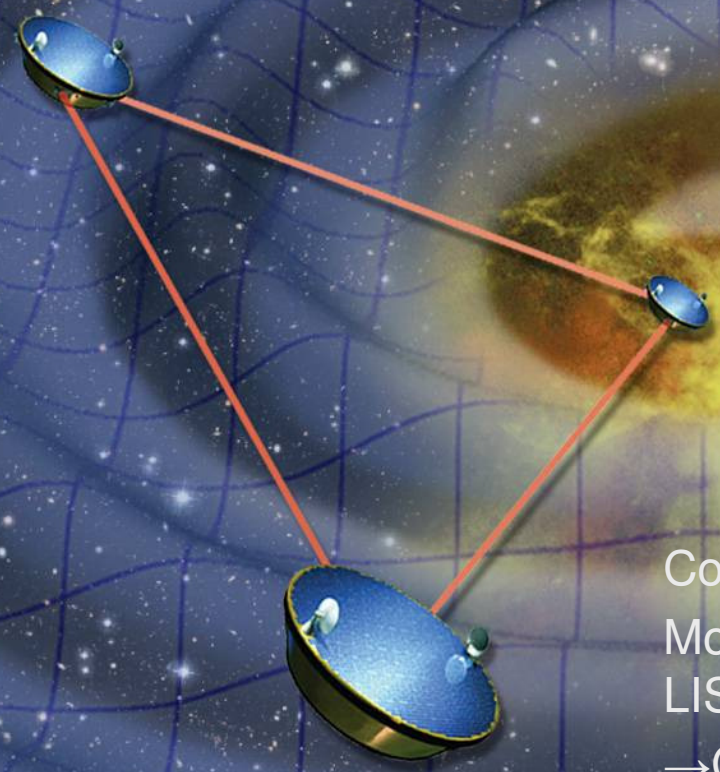
  → Cannot be ready for selection in 2010





LISA, the gravitational wave observatory

- Goal: study mergers of black-holes and neutron stars almost since the beginning of the Universe through the gravitational waves they emit
- Consists of 3 interacting spacecraft in an equilateral triangle with 5 million km arms orbiting the Sun
- As gravitational waves pass through, they distort space-time and therefore the shape of the triangle
- LISA measures this tiny distortion (10^{-12} m!) by interferometric measurement of the distance between S/C



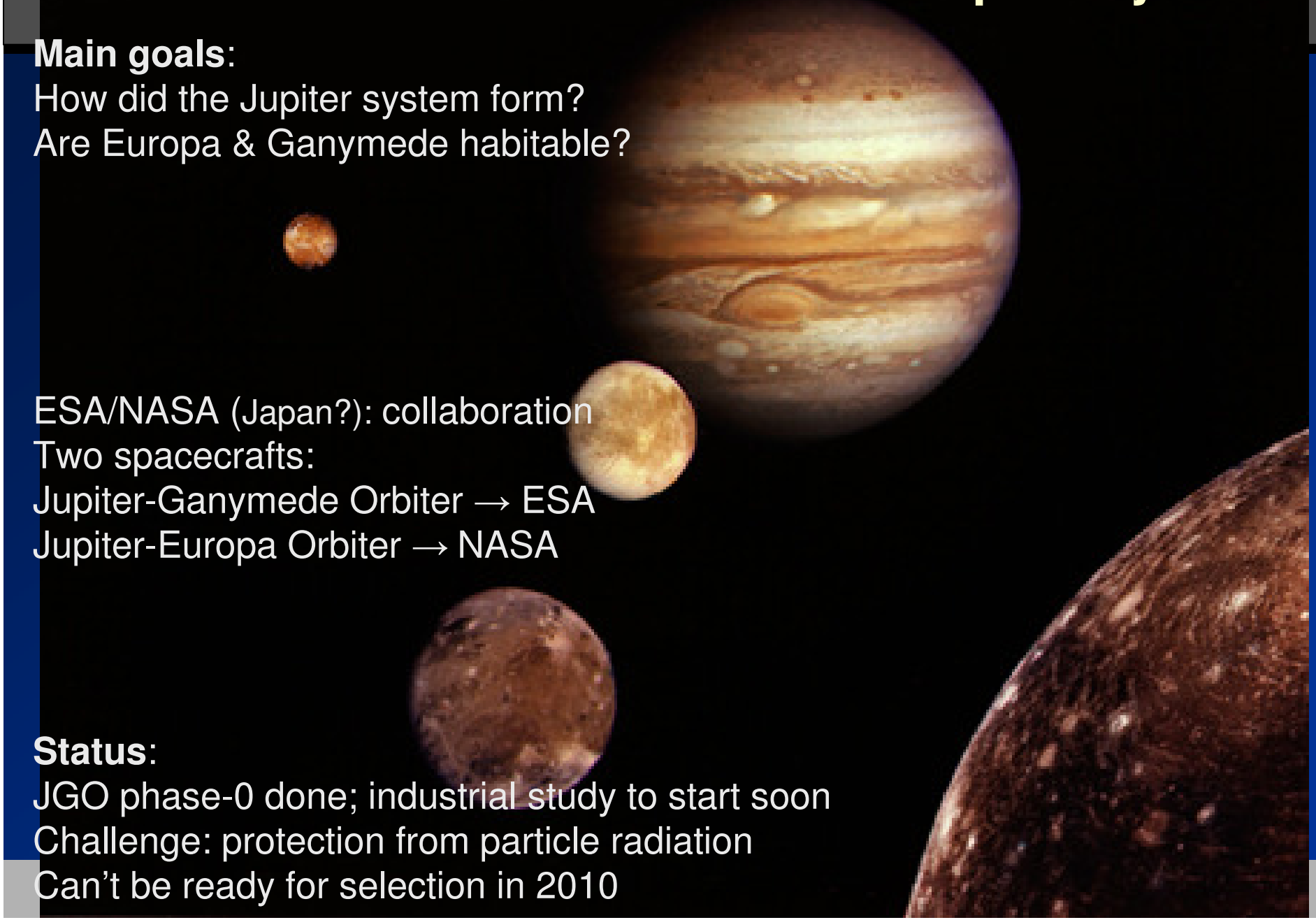
Cost > 650 M€ → Collaboration with NASA

Most technologies will be validated by LISA Pathfinder in 2011

→Can't be ready for selection in 2010

LAPLACE/EJSM: a mission to the Jupiter system

Main goals:
How did the Jupiter system form?
Are Europa & Ganymede habitable?



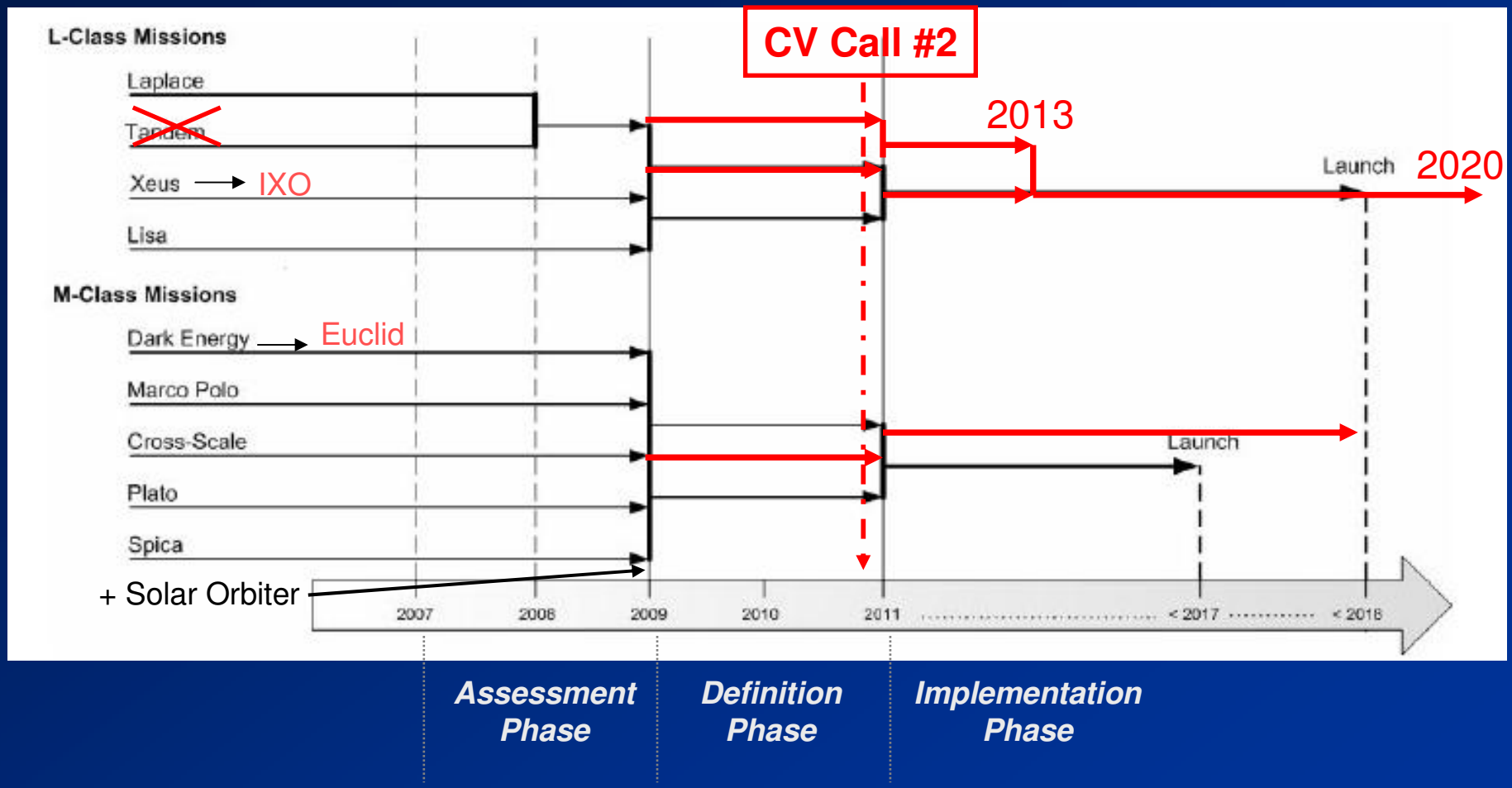
ESA/NASA (Japan?): collaboration
Two spacecrafts:
Jupiter-Ganymede Orbiter → ESA
Jupiter-Europa Orbiter → NASA

Status:
JGO phase-0 done; industrial study to start soon
Challenge: protection from particle radiation
Can't be ready for selection in 2010

Status of L-Missions

- Three L missions are being assessed (Phase-A)
  - IXO: the next generation X-Ray observatory
  - Laplace/EJSM: a mission to the Jupiter system
  - LISA : Gravitational Wave observatory
- 1-year industrial studies are about to start
- All 3 L missions are expensive and can only be done in collaboration
- All 3 L missions are studied in collaboration with NASA (& Japan for IXO)
- The ESA and NASA (Astro-2010 decadal) selection schedules are compatible
- All 3 L missions require strong multi-years technological development
- None of the 3 L missions can be ready for down-selection in 2010
- None can be developed and launched before 2020

Revised down-selection process



Thank you for your attention

M-Missions near term schedule

End of 1-year industrial studies	31-Jul-2009
ESA internal technical & programmatic review	Aug-Oct 2009
Phase-A study reports ("Yellow Book") available	15-Nov-2009
Study reports presentation to science community	8-Dec-2009
AWG, SSWG evaluation of study reports	Nov 2009-Jan 2010
AWG & SSWG selection recommended to SSAC	13-Jan-2010
SSAC recommendation of 2 M-Mission for Phase-B	14-Jan-2010
SPC approval of selected missions	18-Feb-2010