ESA's Cosmic Vision 2015-2025 Programme

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Outline

Cosmic Vision 2015 – 2025

- Recent and present missions
- Establishing the themes
- Implementation approach
- Payload development approach

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Ongoing and Recent Missions

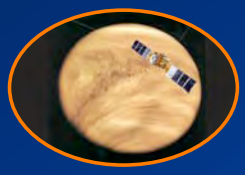
Hubble

Integral

Newton

Rosetta

Ulysses



Venus Express

Corot

Hinode

Akari

SOHO

Cluster

Smart 1

Cassini/Huygens

Mars Express

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Still to come….

Moon

Bepi Colombo

Mercury

Chandrayaan

Chang'E

ExoMars

Mars

GAIA

Deconstructing our galaxy

Herschel

The cold universe, origins of galaxies, stars, planets

JWST

The most distant universe the first light

μscope

LISA

Lisa Pathfinder

Gravitational Wave Observatory

Planck

The hiss of the Big Bang

Planck

- Image the temperature and polarisation anisotropies of CMB over the whole sky.
- Uncertainty on the temperature limited by “natural causes” (foreground fluctuations, cosmic variance).
- Temperature sensitivity (per pixel) of $\Delta T/T \sim 10^{-6}$
- Measure polarisation (Stokes I, Q, U) in CMB bands, with good cross-polar characteristics.
- 1.5 metre aperture telescope to provide ~5’ resolution for high-frequency channels.
- Extreme attention to systematic effects:
  - wide frequency coverage (25 - 950 GHz) with two instruments (HFI and LFI)
  - L2 orbit,
  - redundancy built in at many timescales, from one minute to half a year.

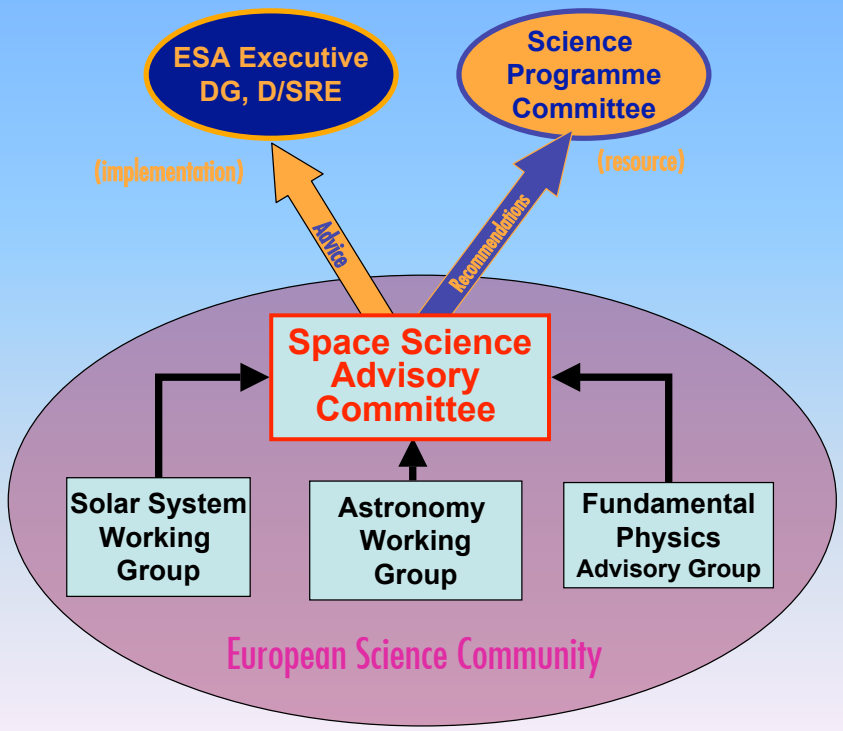
What comes next?

- New long-term plan for the Directorate:

Cosmic Vision 2015 - 2025

2004 - 2005	Establishing themes
2007	1st Call for Mission Proposals
2008 - 2009	Assessments (competitive)
2010 - 2011	Definition (competitive)
2011	Selections
~2011	2nd Call for Mission Proposals
2017 & 2018	Initial Launches

Science Community Chooses the Programme …

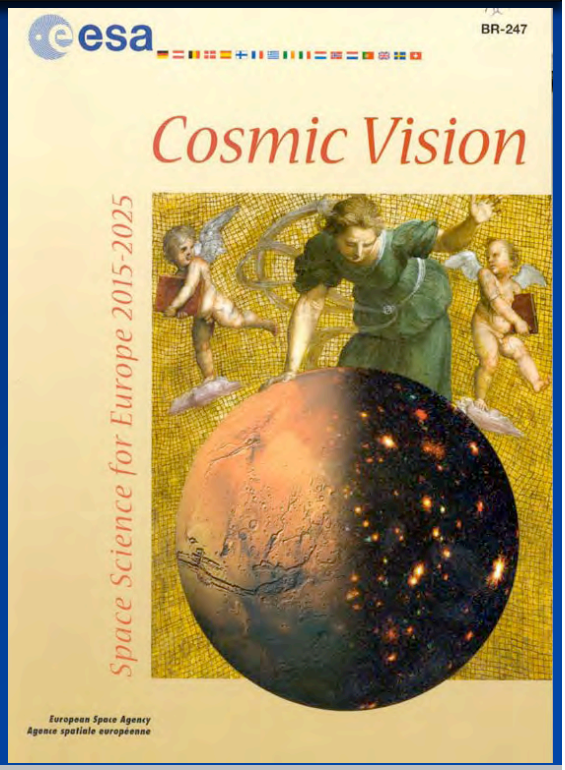


Establishing the Themes

Cosmic Vision 2015-2025: Themes

- Call for Science **Themes** in Spring 2004
- Responses (150) analysed by ESA's advisory structure in July 2004.
- Workshop with community in Paris in September 2004 (400 participants).
- Spring 2005: the Cosmic Vision Plan was presented to the community.
- Presentation to SPC in May 2005.
- "Glossy brochure" in October 2005.

Plan covers one decade, with **3 Calls** for Missions planned.



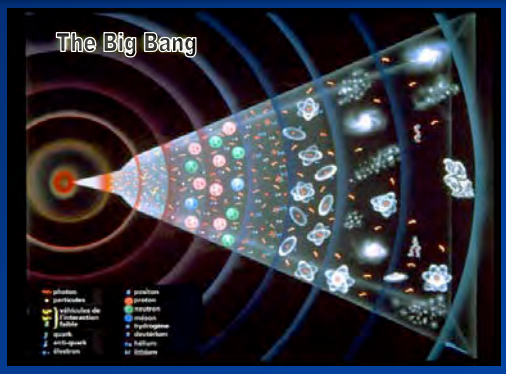
Four "Grand Themes" identified

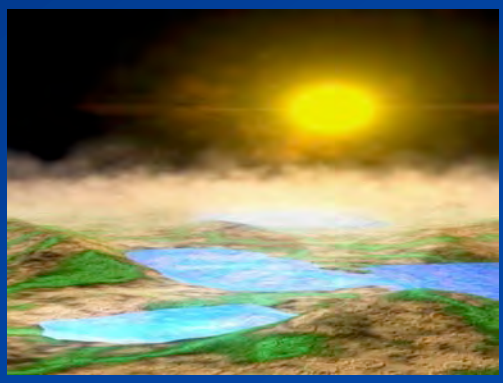
1. What are the conditions for life and planetary formation?
2. How does the Solar System work?
3. What are the fundamental laws of the Universe?
4. How did the Universe originate and what is it made of?

What does the programme mean for the 'person on the street'?

"Finding Earth and Humanity's place in the Universe"

- How did we get from the Big Bang to the 'here and now'?
- Are there worlds elsewhere?





Implementation Approach

Cosmic Vision: Programme Slices

- 2-3 programme slices of a 3~4 year period each are foreseen for missions to be launched in 2015 – 2025
  - implements major Cosmic Vision 2015 – 2025 objectives,
  - keeps flexibility of planning,
- Cosmic Vision plan concentrates on implementation of:
  - large missions ('L' missions, ~ 650 M€)
  - medium missions ('M', ~ 300 M€).
- Balance of scientific disciplines will depend on mission mix (size, number and sequence of missions) and inclusion of international cooperation.
- Mission frequency (in steady-state situation): 1 launch every 18 months.

Cosmic Vision: 1st Call for Missions

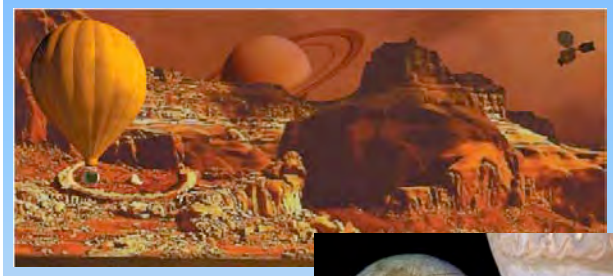
- First "Call for Missions" issued in Q1 2007
  - 2 launch opportunities, for 2017/2018
  - 950 M€ envelope
  - Foreseen as 1 Medium (2017) plus 1 Large (2018) mission
    - Other mixes of mission sizes possible
  - Payload funded separately by ESA member states
- 50 proposals received by June 2007 deadline
- Selection process by advisory structure on behalf of scientific community during summer 2007
  - Final recommendation from SSAC in October 2007

Cycle 1 Selection Outcome

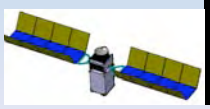
- Seven missions selected for assessment in 2008 – 2009
  - 2 L-class missions
    - Compete with LISA
    - Down-select to 2 at end 2009
    - Select 1 in 2011 for implementation for launch in 2018
  - 5 M-class missions
    - Down-select to 2 at end 2009
    - Select 1 in 2011 for implementation for launch in 2017
  - A number of highly-ranked science mission themes requiring technology development to enable readiness at the time of the next Call for Mision proposals (~ 2011).

L class missions

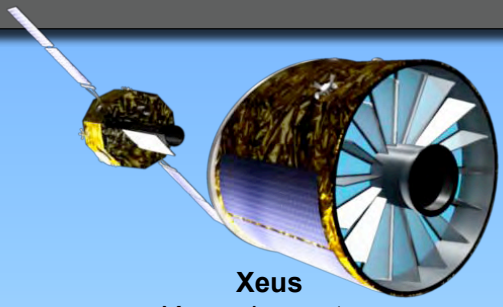
Outer Planet Mission,
ESA/NASA/JAXA collaboration



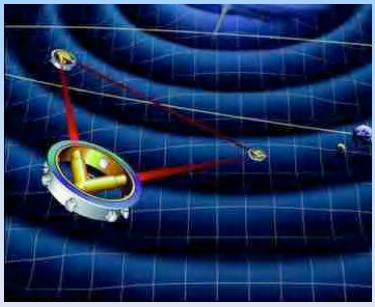
Tandem
mission to Saturn/Titan



Laplace
mission to the Jupiter system

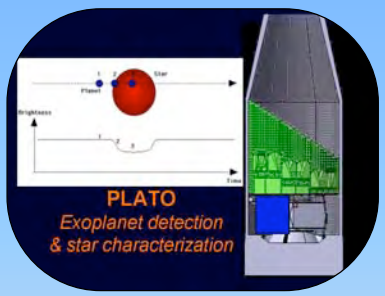


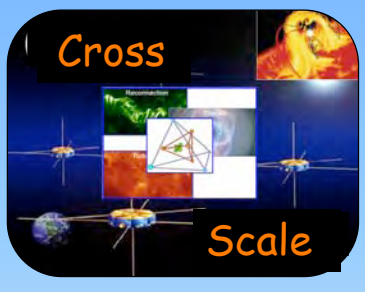
Xeus
X ray observatory
ESA/JAXA/… collaboration

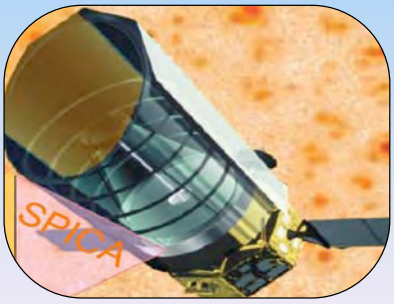


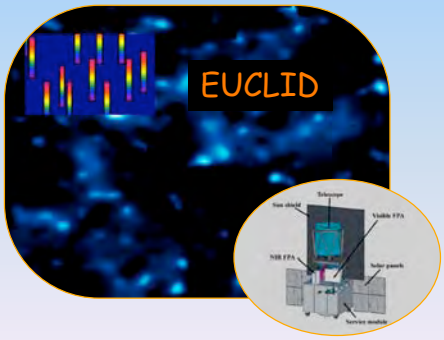
LISA
Gravitational waves measurement
ESA/NASA collaboration

M class missions









Euclid: Concept Convergence

- M mission addressing dark energy
  - Science concept derived in January-April 2008 from two CV proposals:
    - DUNE (lead by A. Refregier),
    - SPACE (lead by A. Cimatti).
  - Concept Advisory Team
    - Chaired by Malcolm Longair
  - Endorsed by ESA AWG.
- ESA Imposed boundaries on Euclid technical baseline:
  - to control size and budget of mission:
    - 1.2 m telescope diameter maximum
    - Limited number of NIR detectors

Euclid Concept

- Euclid will survey the entire extragalactic sky (20 000 deg^2) to measure simultaneously two principal Dark Energy probes:
  - Weak Lensing
    - Diffraction limited galaxy shape measurements in one broad visible band
    - Redshift determination by photo-z measurements in 3 Near-Infrared bands to H(AB)=24 mag for a 5σ point source detection
  - Baryonic Acoustic Oscillations
    - Spectroscopic redshifts for about 33% of all galaxies brighter than H(AB)=22 mag, with σ_z<0.001

Euclid's Science Objectives

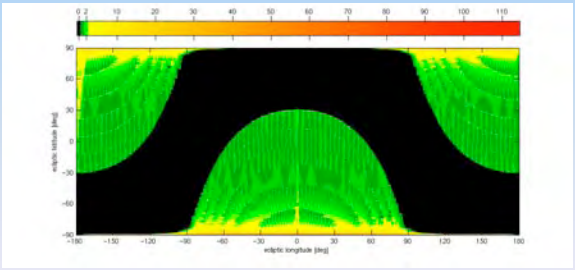
Issue	Euclid's Targets
What is Dark Energy	Measure the DE equation of state parameters w_n and w_a to a precision of 2% and 10%, respectively, using both expansion history and structure growth.
Beyond Einstein's Gravity	Distinguish General Relativity from the simplest modified-gravity theories, by measuring the growth factor exponent γ with a precision of 2%.
The nature of dark matter	Test the Cold Dark Matter paradigm for structure formation, and measure the sum of the neutrino masses to a precision better than 0.04eV when combined with Planck.
The seeds of cosmic structure	Improve by a factor of 20 the determination of the initial condition parameters compared to Planck alone.

Euclid Mission Profile

CDF study case

Launcher
SOYUZ ST 2-1b from Kourou

Sky coverage
Panoramic survey over the full extragalactic sky
20 000 sq. degrees
Two galactic polar caps, latitude $|b| > 30°$
Solar aspect angle adjusted for scan optimisation



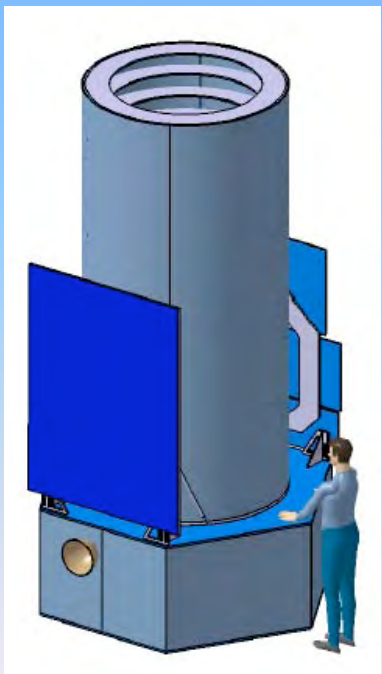
Observation mode
Continuous scanning vs. step&stare (trade-off)

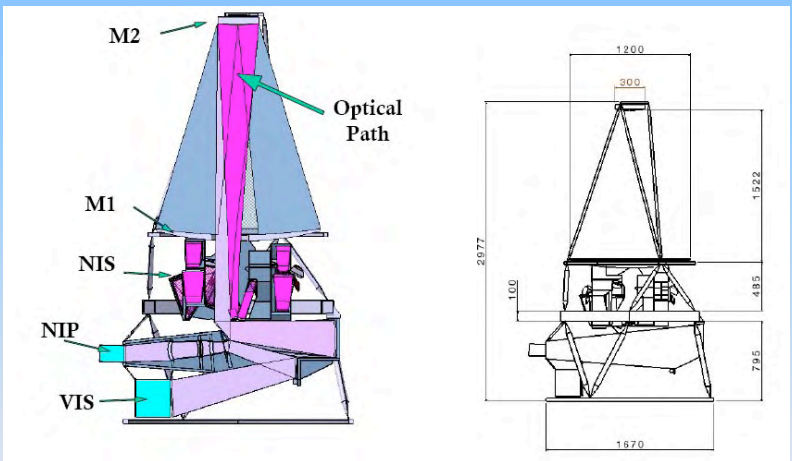
Orbit
Large amplitude Lissajous around SEL2
Free insertion, 30-day transfer time
DeltaV budget: 50 m/s
Orbit maintenance: 1 manoeuvre/month

Spacecraft
Body-mounted solar array
3-axis stabilised platform
Relative pointing error: 25 marcsec with FGS
Attitude control - proportional cold gas system
Hydrazine propulsion for orbit manoeuvres
Satellite mass (wet): 1540 kg

Communications
Housekeeping in X-band
Science telemetry in K-band
700 Gbits/day after compression
4 hours/day link with Cebreros 35-m antenna

Euclid PLM





Euclid Payload

CDF study case

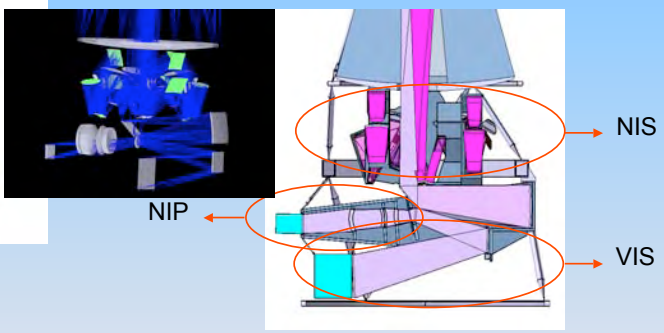
Telescope
1.2 meter Korsch TMA

Thermal
Passive cooling
170 K CCD
140 K NIR detectors

Power
One power conditioning unit per instrument
Total payload: ~200 W peak

Data-handling
Spectroscopy target selection
Full frame images lossless compression
NIR detectors noise reduction

3 instruments
Visible Imaging VIS: 0.21" PSF at 800 nm, 0.1"/pixel
NIR Photometry NIP: 0.33"/pixel, 3 bands (Y, J, H)
NIR Spectroscopy NIS: 0.9-1.7 μm, set of 3 cameras, multi-objects (micro-mirror array), R~400
Each of them with a field of view ~0.48 deg^2



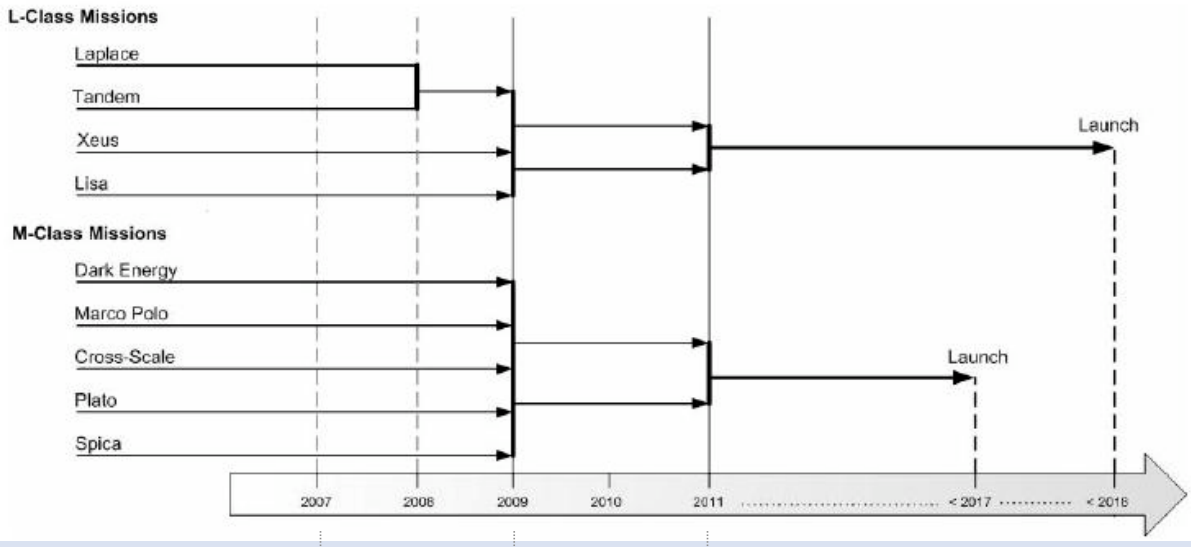
Observation mode
Step and stare case fully investigated
Continuous scanning requires de-scan mechanism for infrared channels

Science Programme Implementation

Three step process from the Mission candidate selection to the launch

- **Assessment Phase**
  Nominal duration is ~ 2 years. Mission studies, Phase 0/A level
  Enables mission down-selection for the Definition Phase: Mission concept, programmatic assessment, technology readiness evaluation
- **Definition Phase**
  Nominal duration is ~ 2 years. Mission studies, Phase A/B1 level
  Enables mission adoption for Implementation Phase: Mission consolidation (technical & programmatic), technology readiness evaluation & preparation
- **Implementation Phase**
  Typical duration is ~ 5-6 years,
  Industrial team build-up and spacecraft manufacturing, Phases B2/C/D

Mission down-selection process



Status

- ESA internal studies:
  - Complete for all the M-missions
  - Ongoing for the L-missions
- ITTs for industrial studies issued for the four M missions plus SPICA telescope study
  - Will start in July-September 2008
  - Completion by mid-September 2009, to enable down-selection.
- Xeus and Outer Planet mission industrial studies planned in 2009
  - Internal studies to be completed by September 2008
  - Down-selection of outer planet mission by end 2008
  - Schedule highly dependent on progress in definition of international collaborations.

Payload Development Approach

Payload provided by Member States

- Maintain tradition of delivery of instruments to ESA by Member States
  - Actual contributions depend on specific mission (e.g. Gaia v. BepiColombo)
  - National activities conducted **in parallel** to ESA system studies
- ESA is in charge of technology developments for spacecraft items which will be produced through ESA industrial contracts.
- Member States in charge of technology developments for payload items which will be provided by the Member States.
- Technology Development Plan:
  - Establised for the entire spacecraft, including science instruments,
  - Aiming at TRL ≥ 5 before implementation phase
  - Payload-related activities to be reviewed and endorsed by the Member States
    - Monitored by SPC.

Technology Readiness

- Strict need if for TRL ≥ 5 for the whole spacecraft including payload before entering implementation phase
  - TRL level 5 definition: breadboard or component validation in relevant environment
- Technology readiness wlll be evaluated for 2009/2011down-selection steps
  - In 2009, if TRL≠5, technical assessment for evaluating the probability to reach TRL 5 by 2011
  - In 2011, for the Mission Adoption: Development risk assessment - schedule, cost and technology readiness – before entering the Implementation phase.

Payload Development Timeline

- Follow recommendations from recent review (SPRT) of programme:
  - Complete payload phase A/B1 before entering implementation phase
  - Move payload selection (AO) to start of definition phase
  - Perform instrument assessment study before entering definition phase.

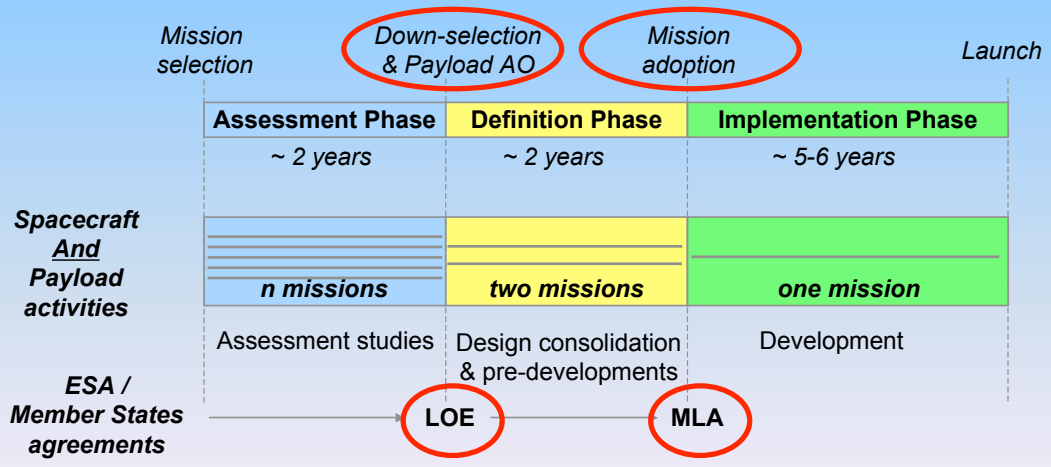


Illustration for the case of M missions

Status of Instrument Studies

- Call for "Declaration of Interest" for Instrument studies issued for all M missions:
  - SPICA/SAFARI instrument team in place,
  - Responses for all missions received by mid-July,
  - ESA evaluation will be made by end July 08,
  - Convergence with Member States expected by end Sept 08,
  - Instrument studies will be made in parallel with industrial studies.

- XEUS and Outer Planet Call for Instrument Studies will be phased with the corresponding industrial ITTs
  - Expected by end 2008,
  - Instrument studies will be made in parallel with industrial studies.

Summary

- Cosmic Vision 2015 - 2025
  - builds on the successes of the previous long-term plans,
  - is community-driven,
  - is based on a portfolio of missions of various sizes selected from successive calls allowing progressive implementation of the scientific priorities embedded in the Cosmic Vision themes for the 2015-2025 time frames.

- Missions chosen in 1st Call are in assessment phase with industrial studies about to start,
  - down-selection for:
    - definition phase foreseen for end 2009
    - and end 2011 for implementation.