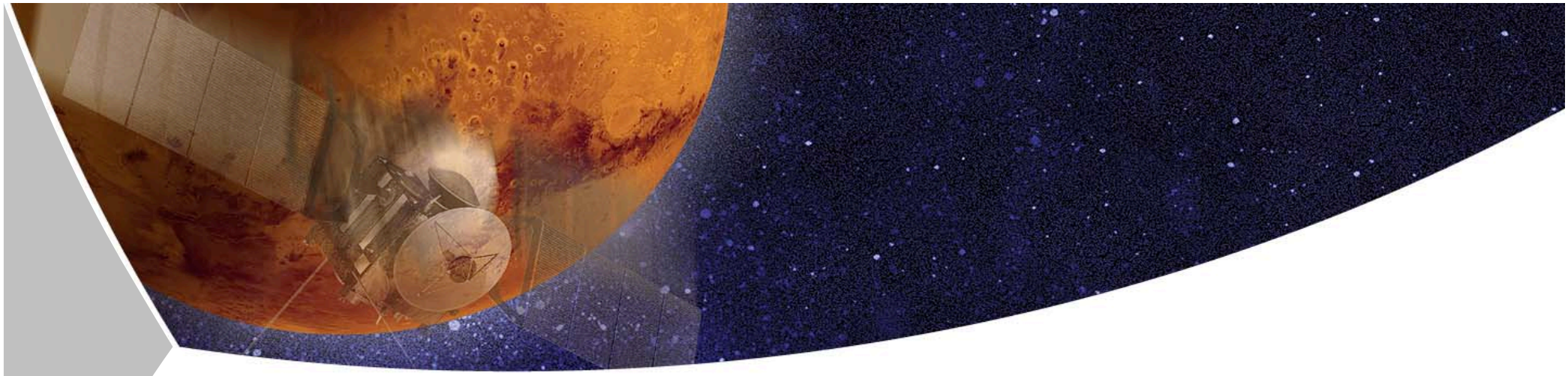


# Cosmic Vision
# Space Science for Europe 2015-2035

Athéna Coustenis

LESIA, Observatoire de Paris-Meudon

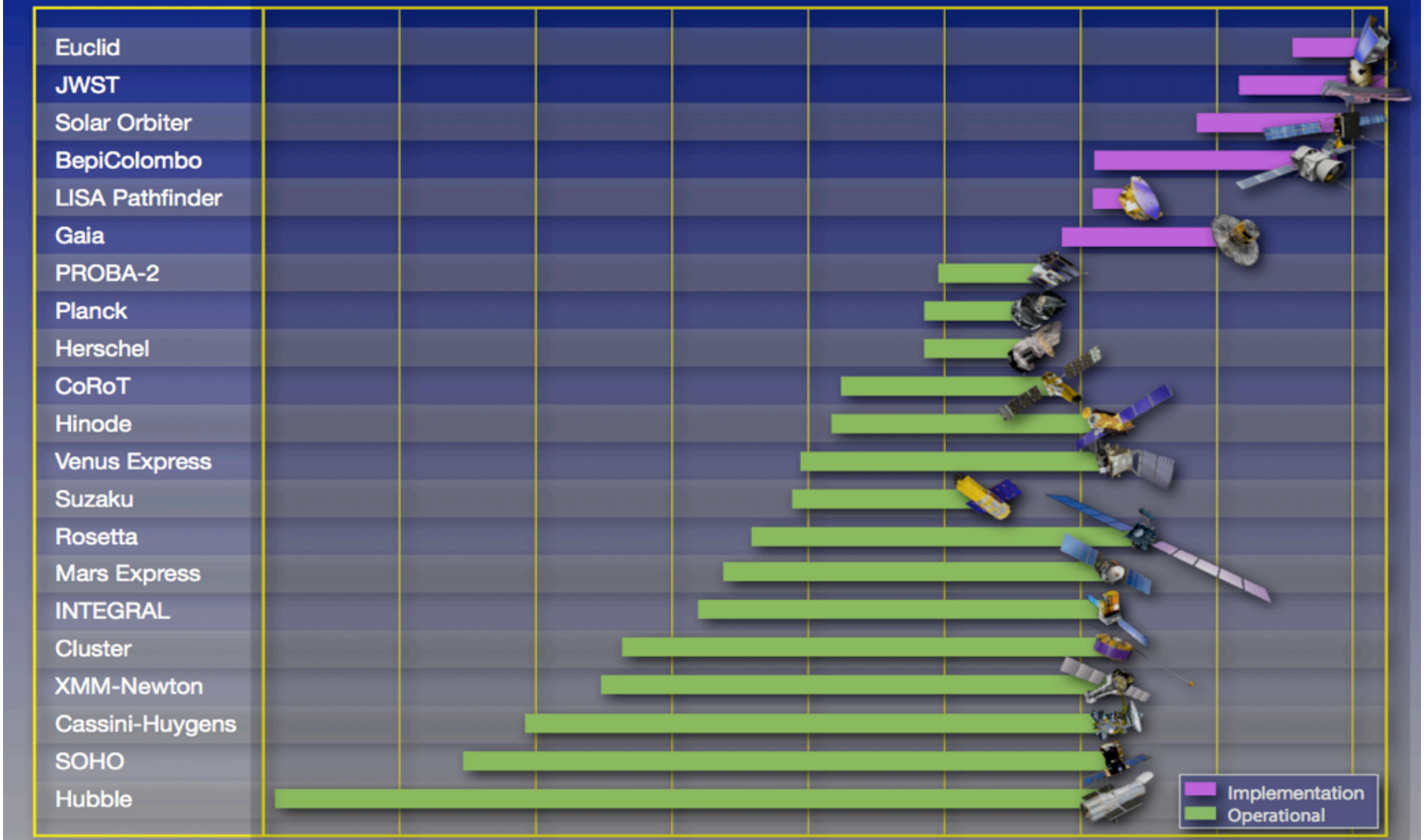
Chair du Solar System and Exploration Working Group de l'ESA

Membre du Space Sciences Advisory Committee

# Long-Term Plan of ESA's Space Science Programme

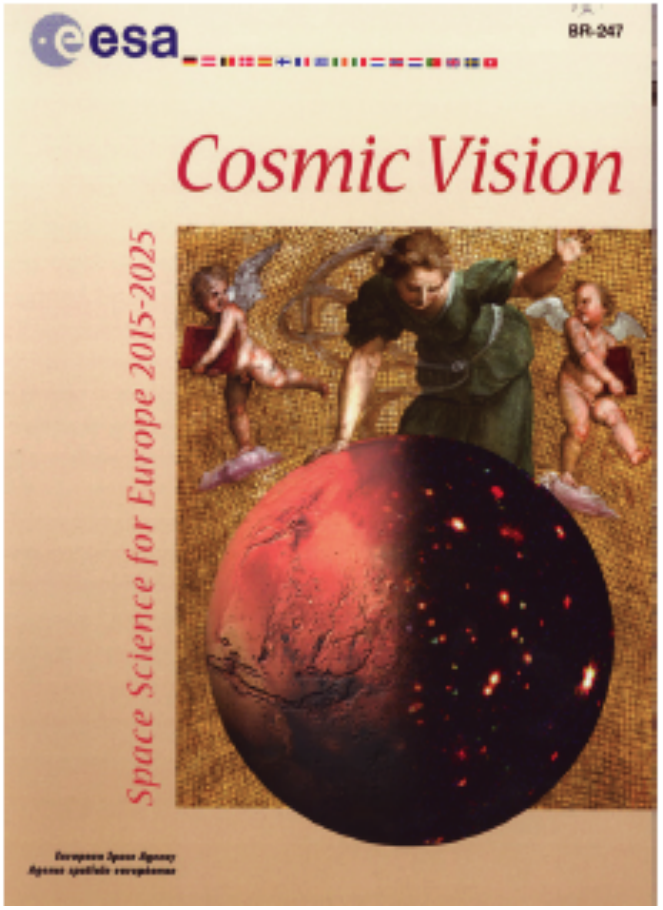
- Horizon 2000 (1984)
  - Cassini-Huygens, Herschel, Planck
- Horizon 2000 Plus (1994/5)
  - Gaia, BepiColombo, JWST, LISA, Solar Orbiter
- Cosmic Vision (2005)
  - What are the conditions for planet formation and the emergence of life?
  - How does the Solar System work?
  - What are the fundamental physical laws of the Universe?
  - How did the Universe originate and what is it made of?

# Current ESA space science missions



# COSMIC VISION

In 2005, a new programme was introduced to replace H2000+, for one more decade (until 2025) with the name Cosmic Vision (2015-2025).

# Basics of the Science Programme

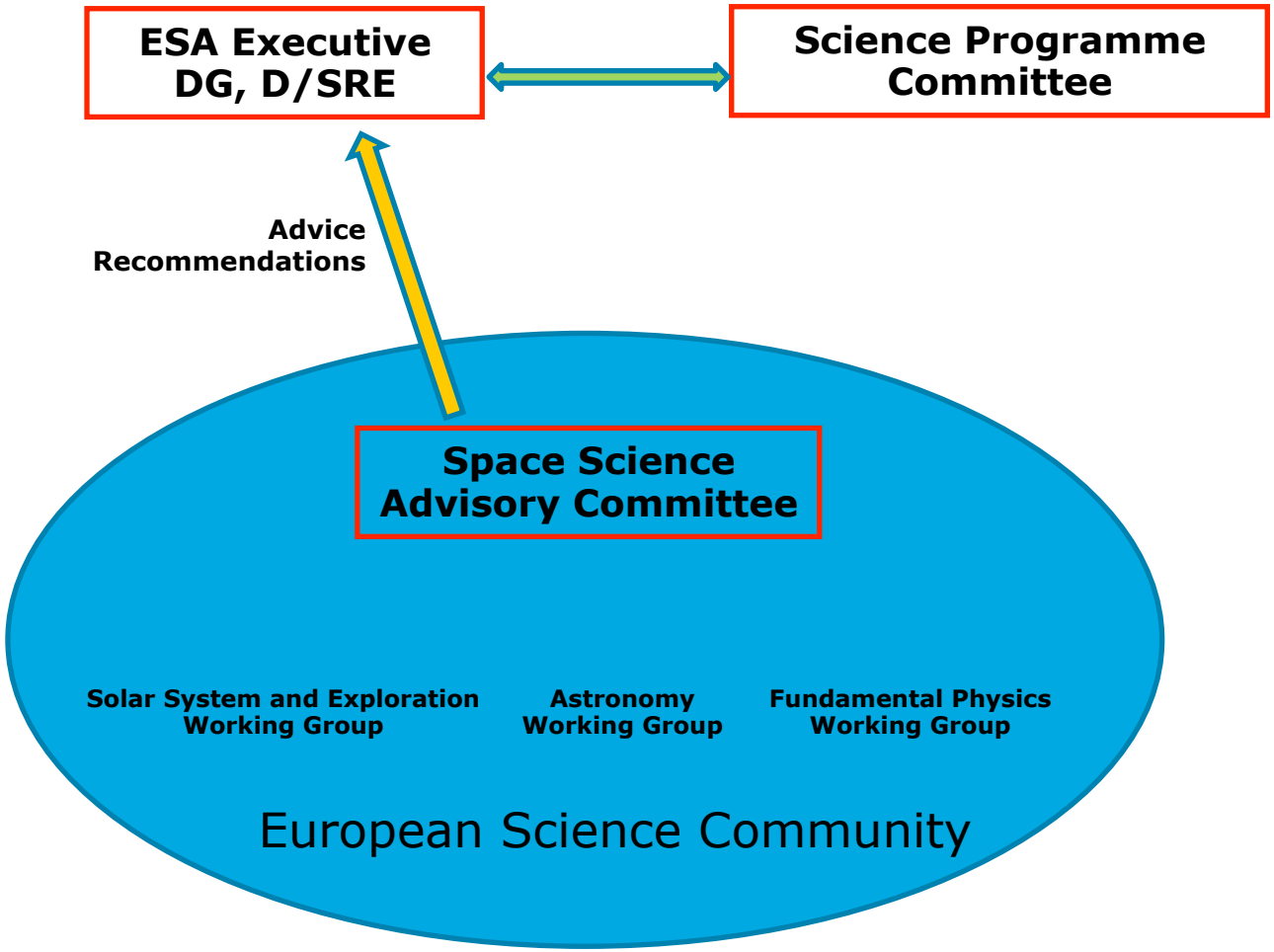
- **The Programme is Science-driven:**

  both long-term science planning and mission calls are bottom-up processes, relying on broad community input and peer review.

- **The Programme is Mandatory:**

  all member states contribute pro-rata to GDP providing budget stability, allowing long-term planning of its scientific goals and being the backbone of the Agency.

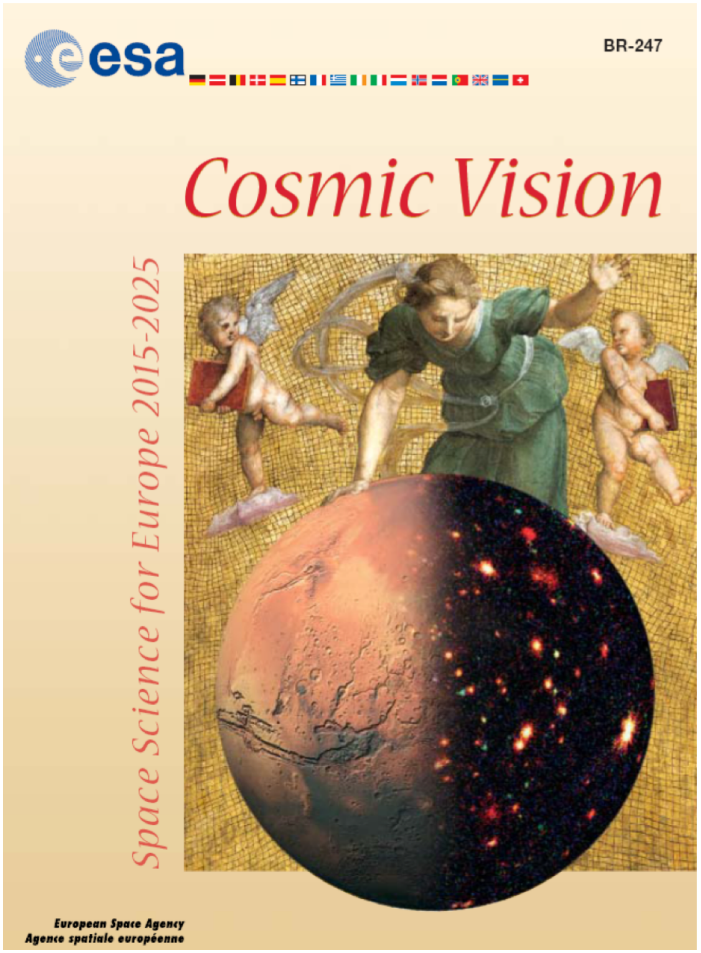
# COSMIC VISION
# A bottom-up approach




- First "Call for Missions" issued in 1st Q 2007.
- Both L and M mission proposals solicited.
- More than 50 proposals received.

# Cosmic Vision 2015-2025

2005, 15 octobre: Document « Cosmic Vision: Space Science for Europe 2015-2025 »




Themes:

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

M-class : missions moyennes avec budget < 450 Meuros sans défits technologiques importants

L-class : larges missions avec budget < 650 M€, avec partenaires internationaux et développement technologique

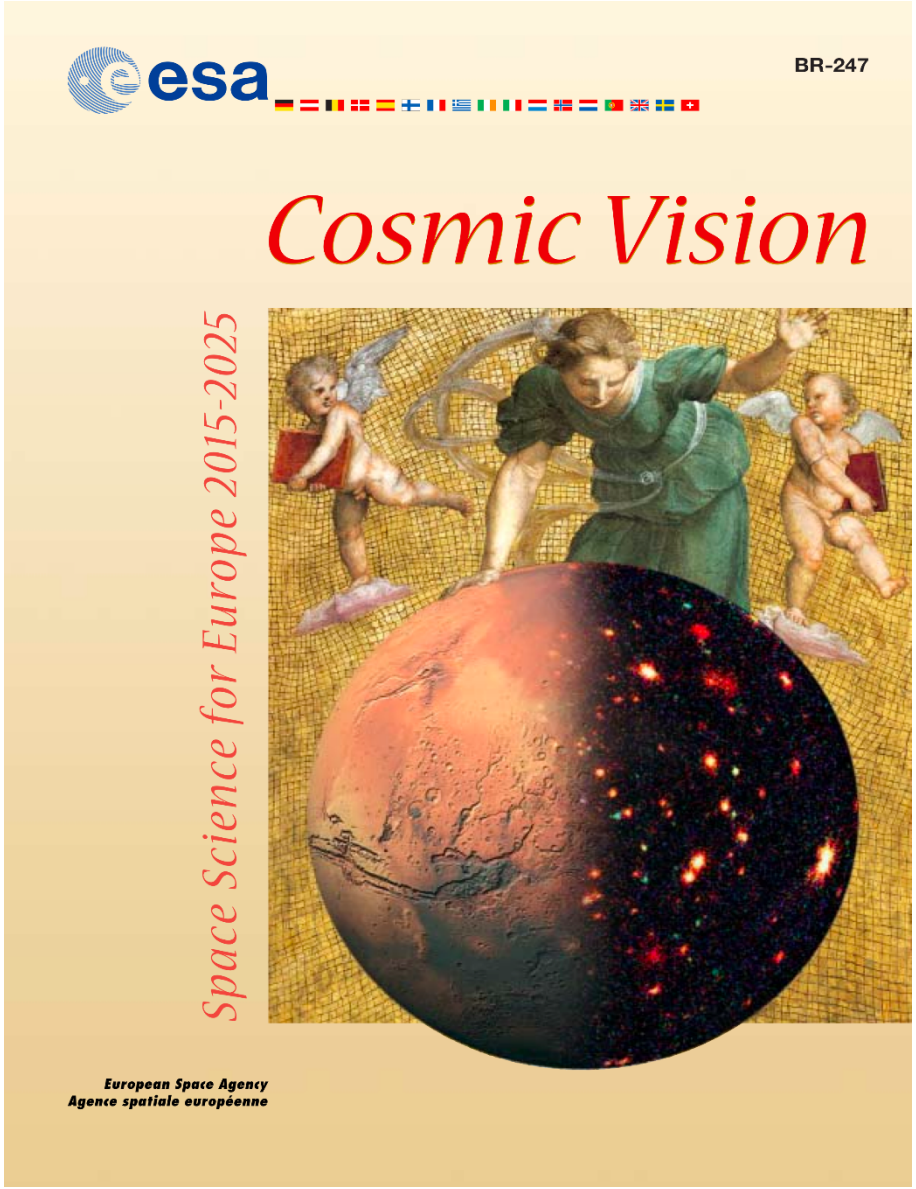
2007, mars= premier appel à mission M1, L1, M2

2010, juillet= appel à missions M3

2011, mai = appel pour les S1 missions

2013, mars= appel pour des thèmes L2/L3

# The call




The call for proposals for Cosmic Vision missions was issued in March 2007. This call was intended to find candidates for two medium-sized missions (M1, M2 class, launch around 2017) and one large mission (L1 class, launch around 2020).
Fifty mission concept proposals were received in response to the first call.
From these, five M-class and three L-class missions were selected by the SPC in October 2007 for assessment or feasibility studies.
In July 2010, another call was issued, for a medium-size (M3) mission opportunity for a launch in 2022.
Also about 50 proposals were received for M3 and 4 concepts were selected for further study.

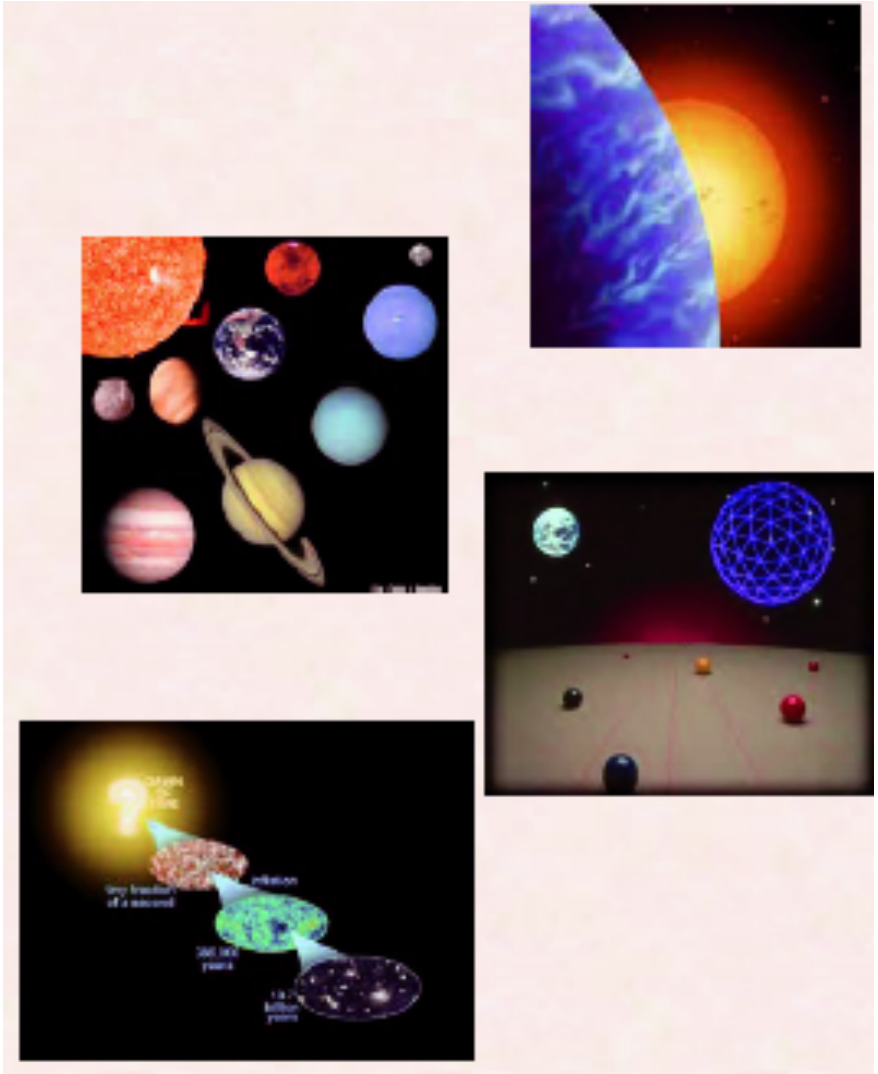
# The COSMIC VISION "Grand Themes"

1. What are the conditions for planetary formation and the emergence of life ?

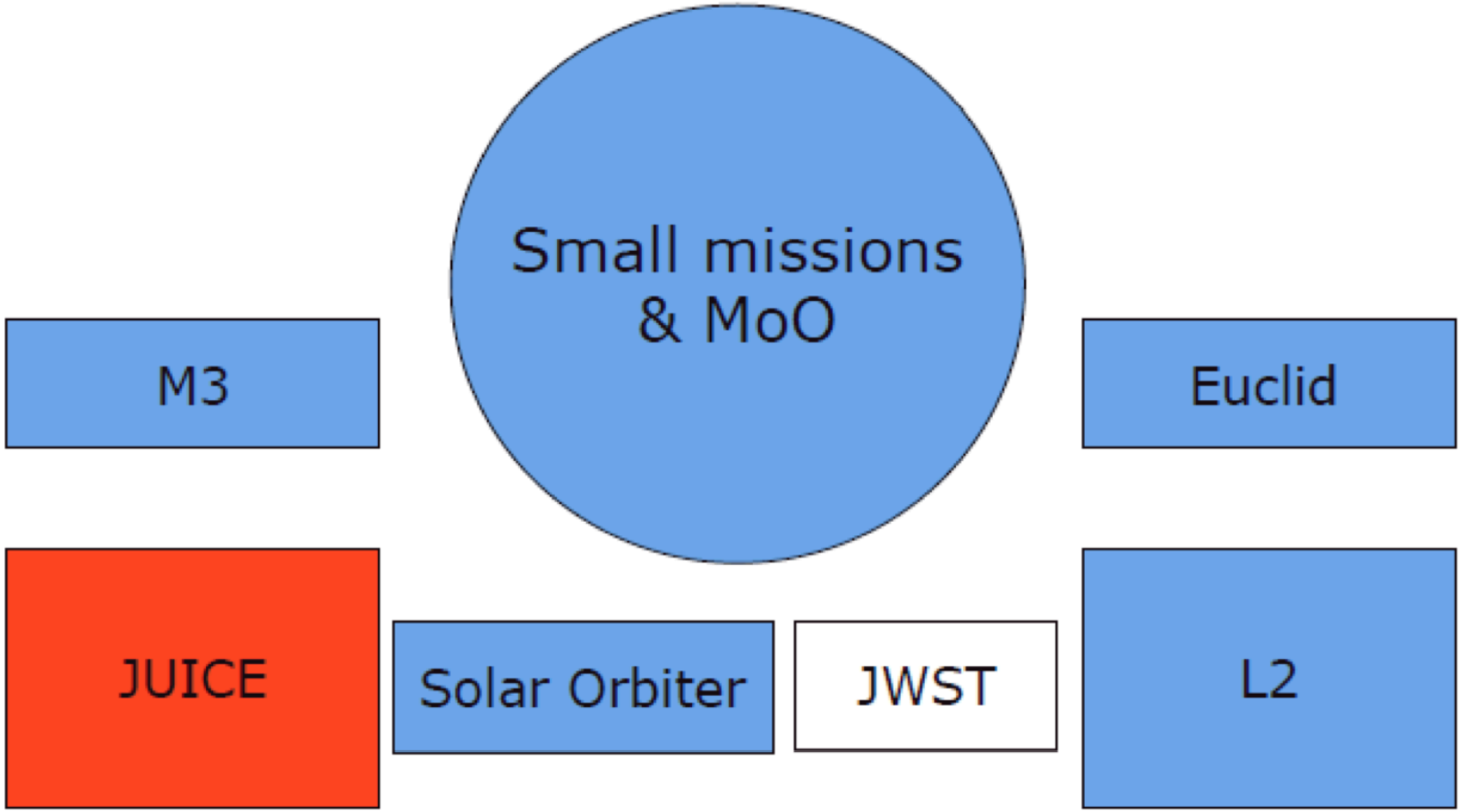
2. How does the Solar System work?

3. What are the physical fundamental laws of the Universe?

4. How did the Universe originate and what is it made of?



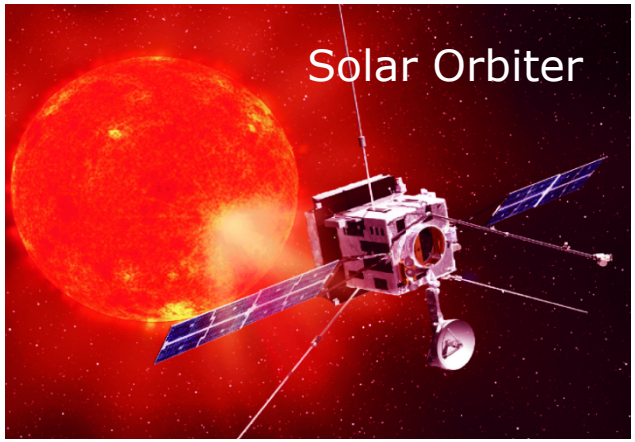
# CV First Slice (2015-2025)

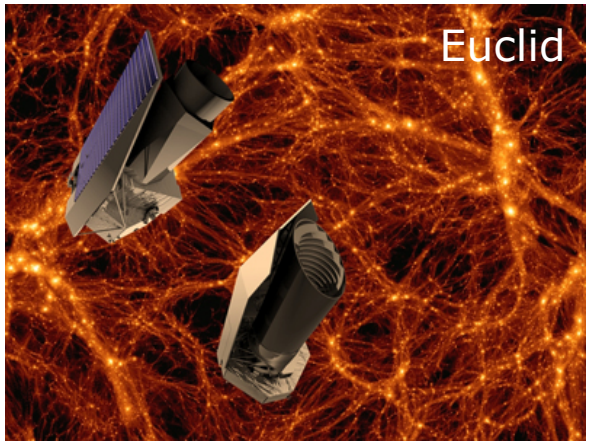


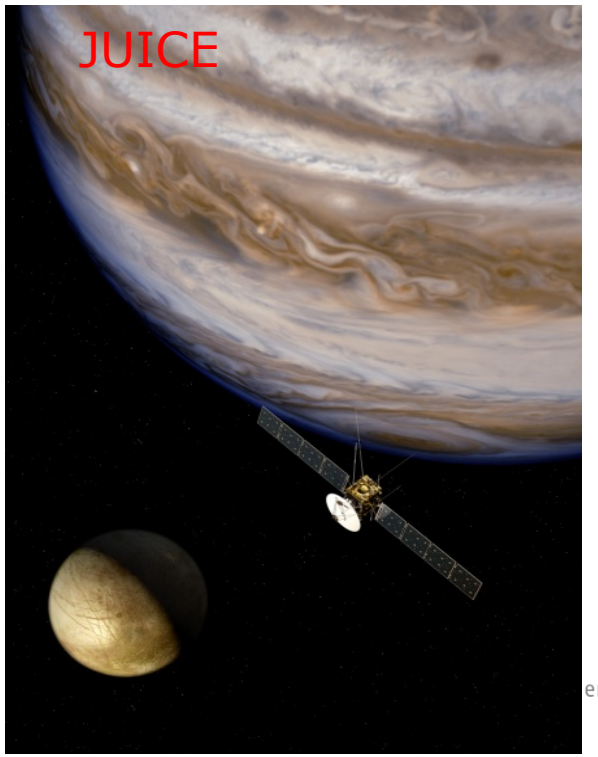
# COSMIC VISION (2015-2025)
# Step 1

- Proposal selection for assessment phase in October 2007
  - 3 M missions concepts: Euclid, PLATO, Solar Orbiter
  - 3 L mission concepts: X-ray astronomy, Jupiter system science, gravitational wave observatory
  - 1 MoO being considered: European participation to SPICA

- **Selection of Solar Orbiter as M1 and Euclid as M2 in 2011.**
- **Selection of Juice as L1 in 2012.**



# The finally selected M1/M2-class missions


Solar Orbiter (theme 2), a mission intended to produce images of the Sun at an unprecedented resolution and perform the closest-ever measurements of local, near-Sun phenomena. Solar Orbiter was carried over from Horizon 2000 Plus.


Euclid (theme 4) – to map the geometry of the dark Universe, measuring the distance-redshift relation and the growth of structure by using two complementary dark energy probing methods, baryonic acoustic oscillations and weak gravitational lensing.


+ possible contribution to SPICA
(SPace Infrared telescope for Cosmology and Astrophysics; theme 4) – a next-generation infrared space observatory to probe galaxy, star and planetary system formation, as well as the evolution of dust and gas in the interstellar medium of our own and distant galaxies by performing imaging and spectroscopic observations in the 5–210 micron waveband. Mission led by JAXA.

# The candidate L-class missions


**ATHENA** –It was the result of the reformulation, in 2011, of the IXO mission, a next-generation facility to address some of the most fundamental questions in astrophysics and cosmology by investigating black holes and matter under extreme conditions, the formation and evolution of galaxies, clusters and the large scale structure, and the lifecycles of matter and energy.

NOR


The New Gravitational wave Observatory (**NGO**) is a space mission designed to measure gravitational radiation over a broad band at low frequencies, from about 100 μHz to 1 Hz, a band where the Universe is richly populated by strong sources of gravitational waves. It was the result of the reformulation, in 2011, of the LISA mission.

# JUICE L1 ESA CV mission! (2 May 2012)

The JUpiter ICy moons Explorer mission, JUICE, will be the first Large-class mission in ESA's Cosmic Vision 2015–2025 programme.

Planned for launch in 2022 and arrival at Jupiter in 2030, it will spend at least three years making detailed observations of the biggest planet in the Solar System and three of its largest moons, Ganymede, Callisto and Europa.

These moons are thought to harbour vast water oceans beneath their icy surfaces and JUICE will map their surfaces, sound their interiors and assess their potential for hosting life in their oceans.

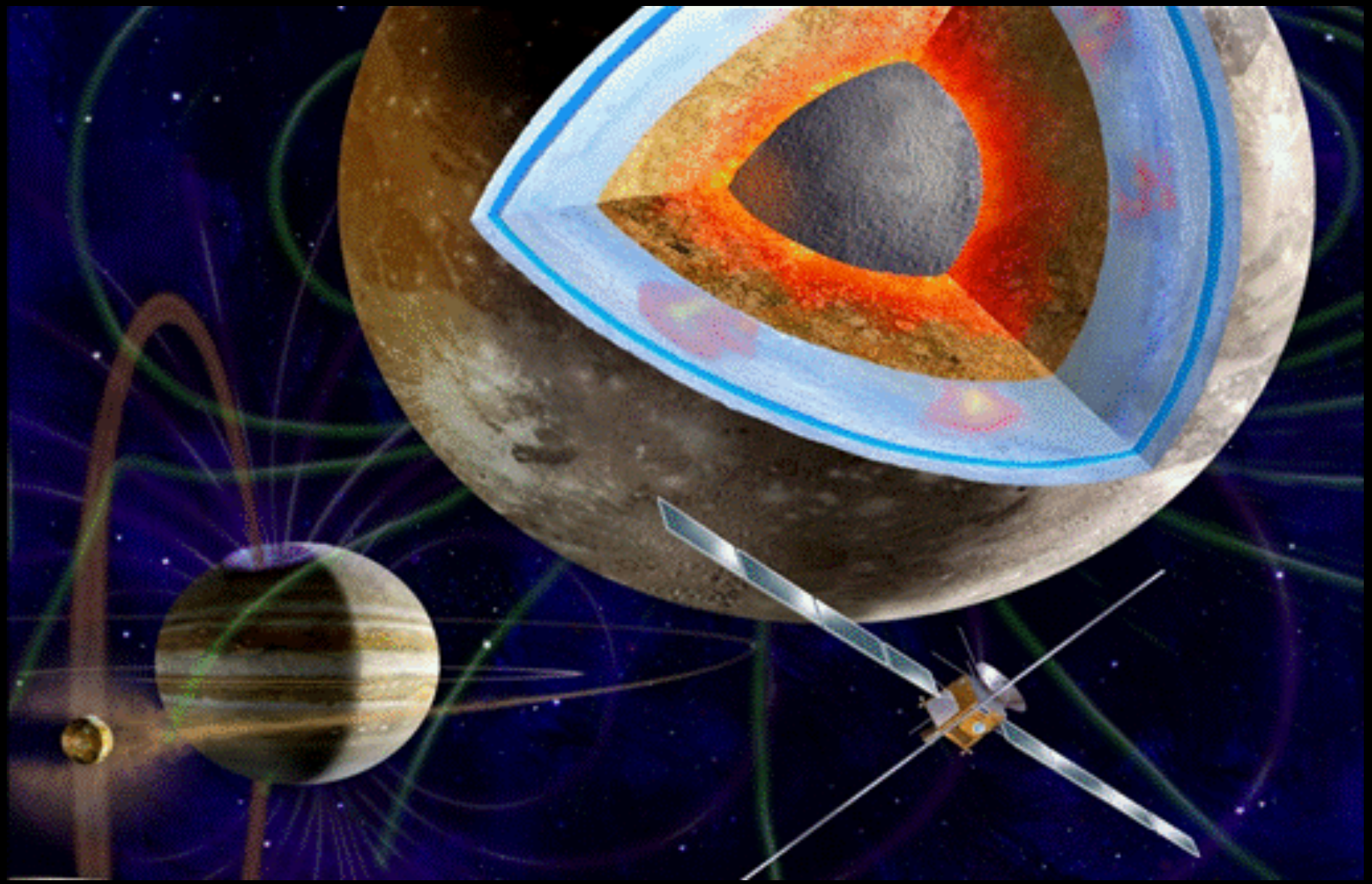
# JUICE L1 ESA CV mission! (2 May 2012)

JUICE sera la première grande classe mission de l'ESA Vision 2015-2025 du programme Cosmic.

Prévu pour un lancement en 2022 et l'arrivée à Jupiter en 2030, il passe au moins trois ans à faire des observations détaillées de la plus grande planète du système solaire et de trois de ses plus grandes lunes, Ganymède, Callisto et Europe.

Ces lunes sont considérées océans du port en eau abondantes sous leurs surfaces glacées et des jus seront cartographier leurs surfaces, sonner leurs intérieurs et évaluer leur potentiel pour accueillir la vie dans leurs océans.

# Jupiter Icy Moons Explorer : JUICE
# ESA's first L-class mission



# Exploration of the Jupiter system

JUICE

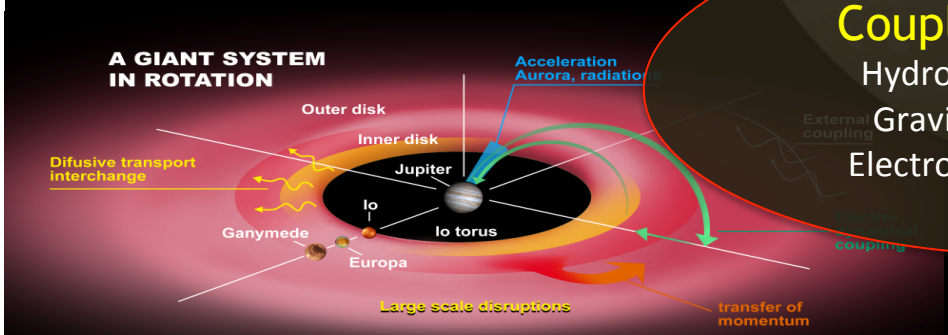
The biggest planet, the biggest magnetosphere, and a mini solar system

## Jupiter

- Archetype for giant planets
- Natural planetary-scale laboratory for fundamental fluid dynamics, chemistry, meteorology,...
- Window into the formational history of our planetary system

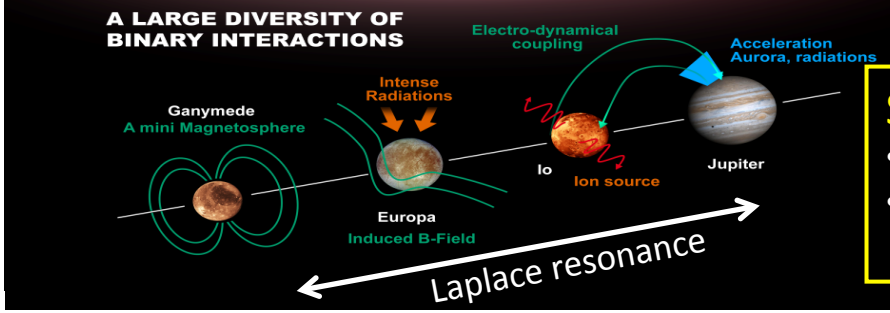
## Magnetosphere

- Largest object in our Solar System
- Biggest particle accelerator in the Solar System
- Unveil global dynamics of an astrophysical object




## Coupling processes

Hydrodynamic coupling
Gravitational coupling
Electromagnetic coupling




## Satellite system

- Tidal forces: Laplace resonance
- Electromagnetic interactions to magnetosphere and upper atmosphere of Jupiter

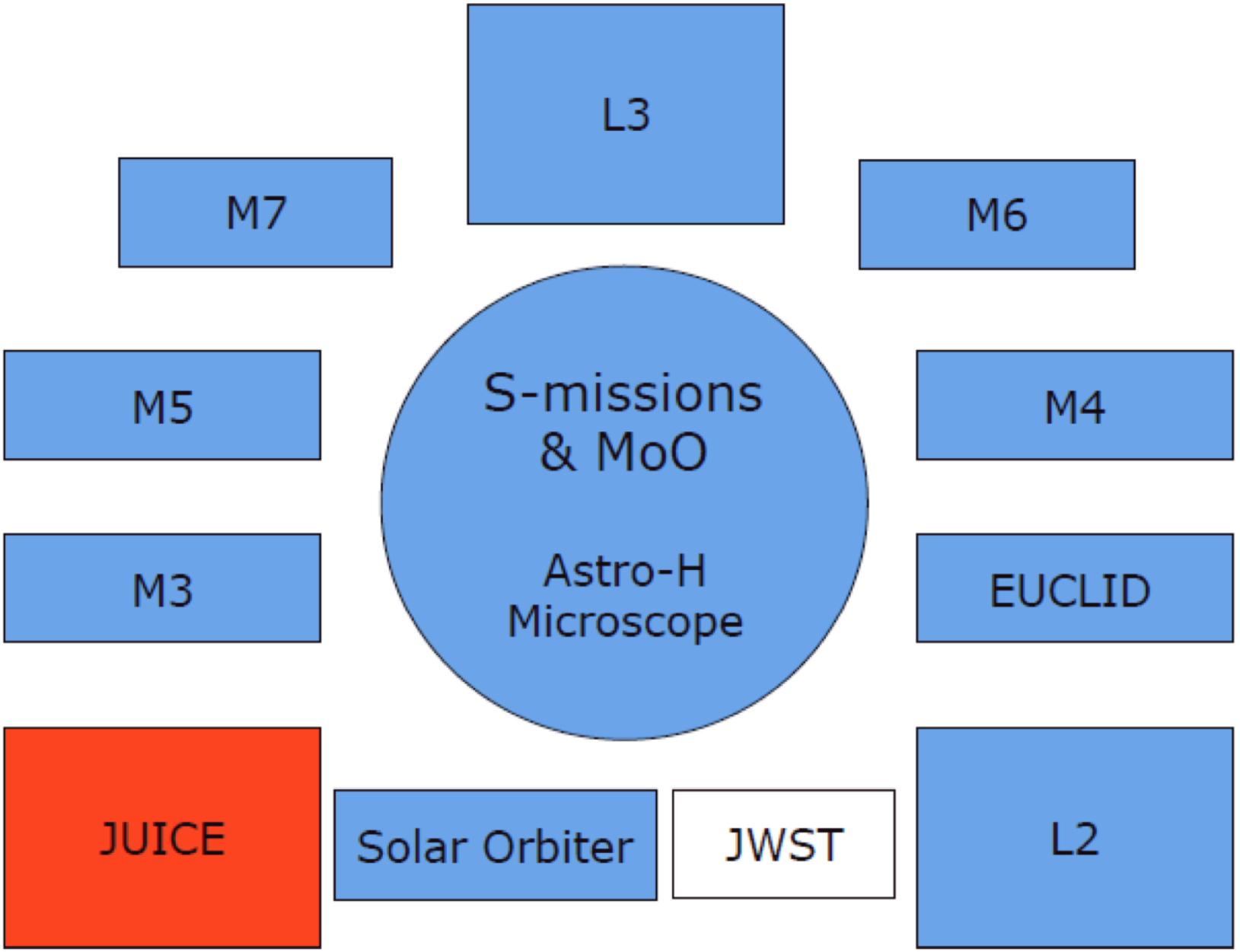
# JUICE instuments chosen ! (21 February 2013)

JUICE portera un total de 11 expériences scientifiques pour étudier la planète géante gazeuse et ses grandes lunes cachant sans doute des océans sous la surface, l'ESA a annoncé aujourd'hui.
On suppose que ces lunes ont des océans d'eau liquide sous leurs surfaces glacées et le complément instrumental de JUICE sera en mesure de cartographier leurs surfaces, sonder leurs intérieurs et évaluer leur potentiel pour accueillir la vie dans leurs océans.
Le SPC a approuvé le 21 Février 2013 une suite d'instruments qui comprend des caméras et spectromètres, un altimètre laser, un radar qui pénétrera la glace, un magnétomètre, de quoi étudier le plasma et les particules, et de la radio.
Les instruments seront développés par des équipes scientifiques de 16 pays européens, aux États-Unis et au Japon, grâce à des financements nationaux.

| | | |
|---|---|---|
| **Imaging** | | |
| JANUS (NAC and acting as WAC ) | 14 kg | IT, G |
| **Spectroscopy** | | |
| Visible Infrared Hyperspectral Imaging Spectrometer (MAJIS) | 22 kg | FR, IT |
| UV Imaging Spectrometer (UVS) | 6 kg | USA |
| Sub-mm Wave Instrument (SWI) | 10 kg | G |
| **In situ Fields and Particles** | | |
| Magnetometer (J-MAG) | 2.4-5 kg | UK |
| Radio and Plasma Wave Instr. (RPWI) | 12 kg | SUE |
| Particle and Plasma Instrument - Ion Neutral Mass Spectrometer (PEP) | 23/18/13 kg | SUE |
| **Sounders & Radio Science** | | |
| Laser Altimeter (GALA) | 12 kg | G |
| Sub-surface Radar (RIME) | 10 kg | IT |
| Radio Science Instrument (3GM = KaT+USO) | 4 kg | IT |

**Total mass: ~110 kg**

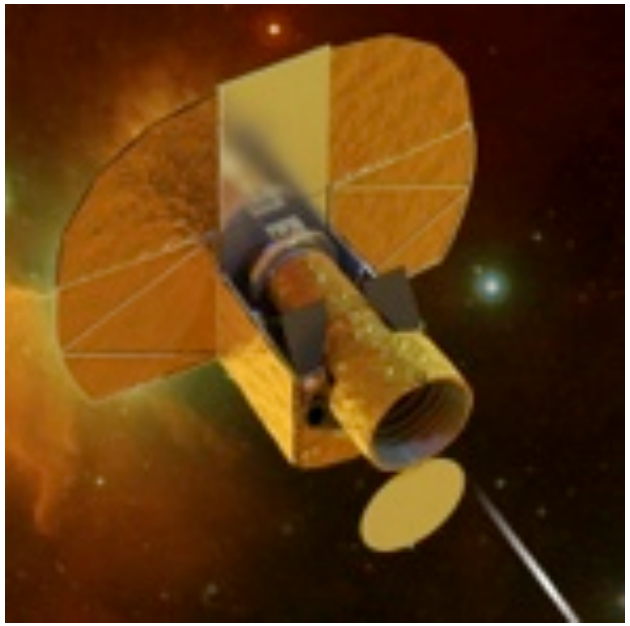
# COSMIC VISION (2015-2035)



# ESA S1 MISSION SELECTED ! (19 October 2012)

CHEOPS has been selected as the S1 mission, with targeted launch date in 2017.

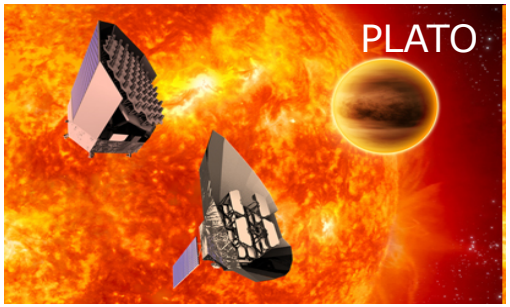
A technical screening was carried out by ESA on all proposals received in response to the call for S-class missions. On 20 September 2012, the proposals that passed the screening were evaluated by the Space Science Advisory Committee, which recommended CHEOPS as the S1 mission. The Science Programme Committee selected CHEOPS at their meeting on 19 October 2012.

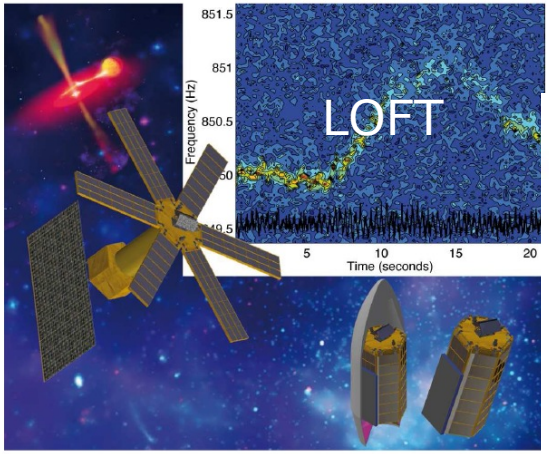


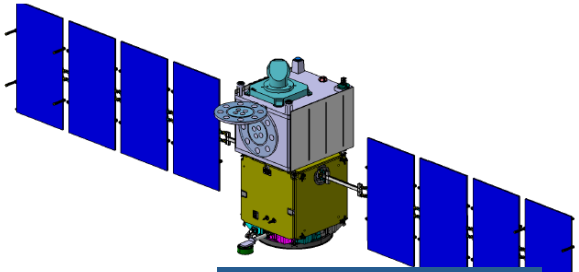
CHEOPS - *CH*aracterizing *E*x*OP*lanet *S*atellite - will be the first mission dedicated to searching for exoplanetary transits by performing ultrahigh precision photometry on bright stars already known to host planets. It will provide the unique capability of determining accurate radii for a subset of those planets, in the super-Earth to Neptune mass range, for which the mass has already been estimated using ground-based spectroscopic surveys. CHEOPS will also provide precision radii for new planets of Neptune-size and smaller that are discovered by the next generation of ground-based transit surveys.

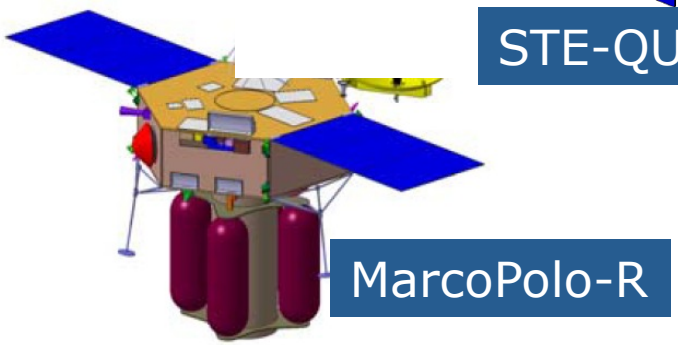
# COSMIC VISION (2015-2025)
# Step 2

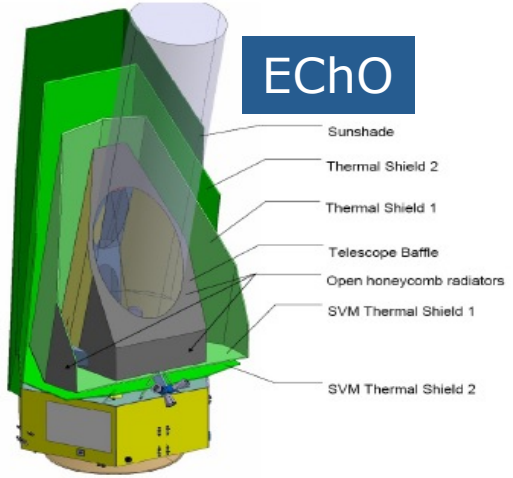
- Second “Call for Missions” issued in 2010
- Only M mission proposals solicited
- ECHO, MarcoPolo-R, LOFT, STE-QUEST selected for assessment with PLATO retained from previous round
- Selection planned for the beginning of 2014



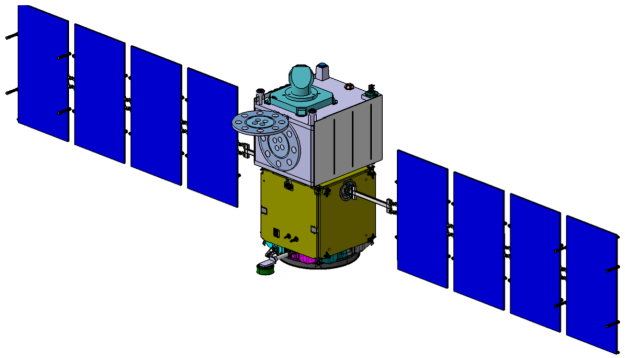



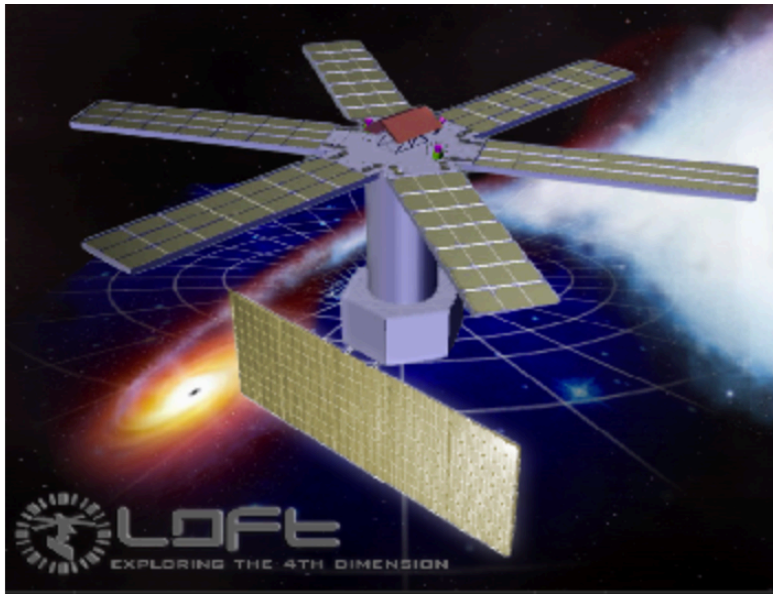



# ESA SELECTS 5 M-CLASS CANDIDATE MISSIONS TO FLY IN 2022+



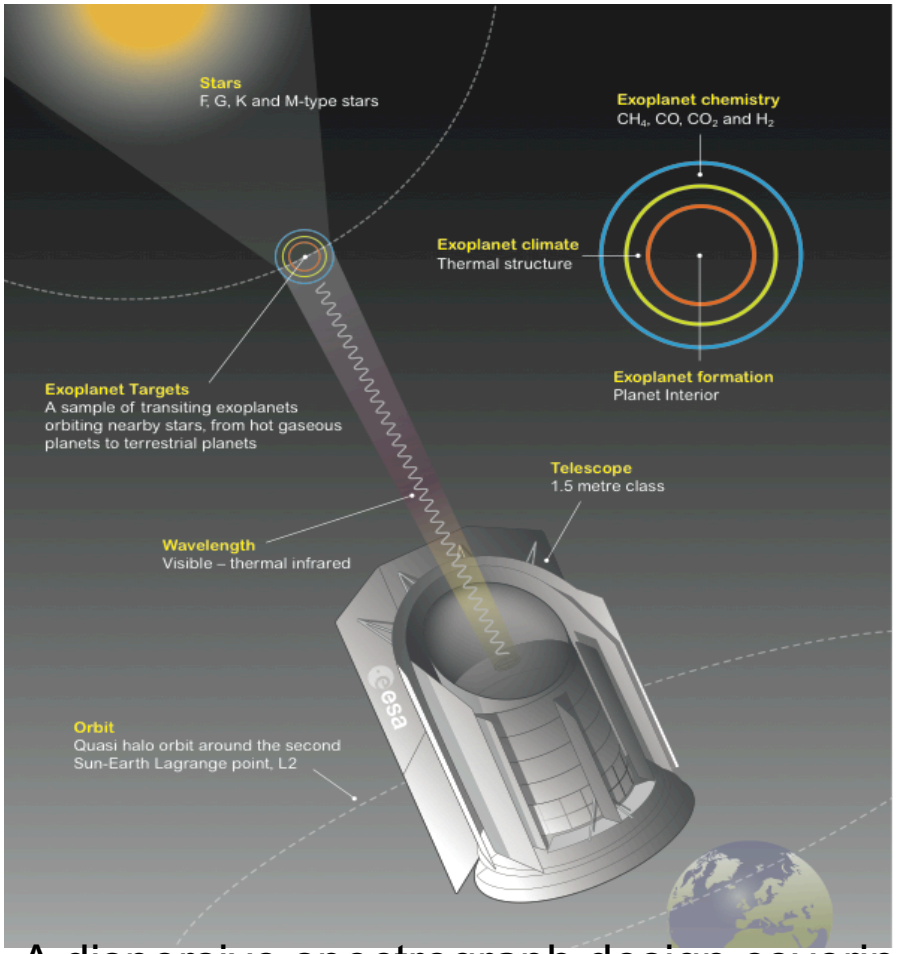
**STE-QUEST–The Space-Time Explorer and Quantum Test of the Equivalence Mission** is devoted to a precise measurement of the effect of gravity on time and matter using an atomic clock and an atom interferometer. It tests a fundamental assumption and one of the most fundamental predictions of Einstein's Theory of General Relativity with high precision and thereby searches for hints of quantum effects in gravity. The first primary goal of the mission will be to measure space-time curvature via the precise determination of gravitational time dilation.




The **Large Observatory for X-ray Timing** (LOFT) is devoted to the study of neutron stars, black holes and other compact objects by means of their very rapid X-ray variability. The main scientific objectives of LOFT are: the determination of the neutron star structure and its equation of state the study of the physics in strong gravitational fields, e.g. in the accretion disks around black holes the direct measurements of black hole mass and spin

# Les missions (exo)planétaires M3 en compétition


PLATO (PLAnetary Transits and Oscillations of stars; theme 1) – to open a new way in exoplanetary science, by providing a full statistical analysis of exoplanetary systems around stars that are bright and nearby enough to allow for simultaneous and/or later detailed studies of their host stars.




A dispersive spectrograph design covering continuously the 0.4-16 µm spectral range in 6 channels (1 VIS, 5 IR) which allows the spectral resolution to be adapted to the target brightness from several tens (λ≥ 11 µm) to several hundreds (λ≤ 11 µ m). Thus optimising for the scientific objectives over the observation spectral range. The instrument is mounted behind a 1.2/1.5 m class telescope passively cooled

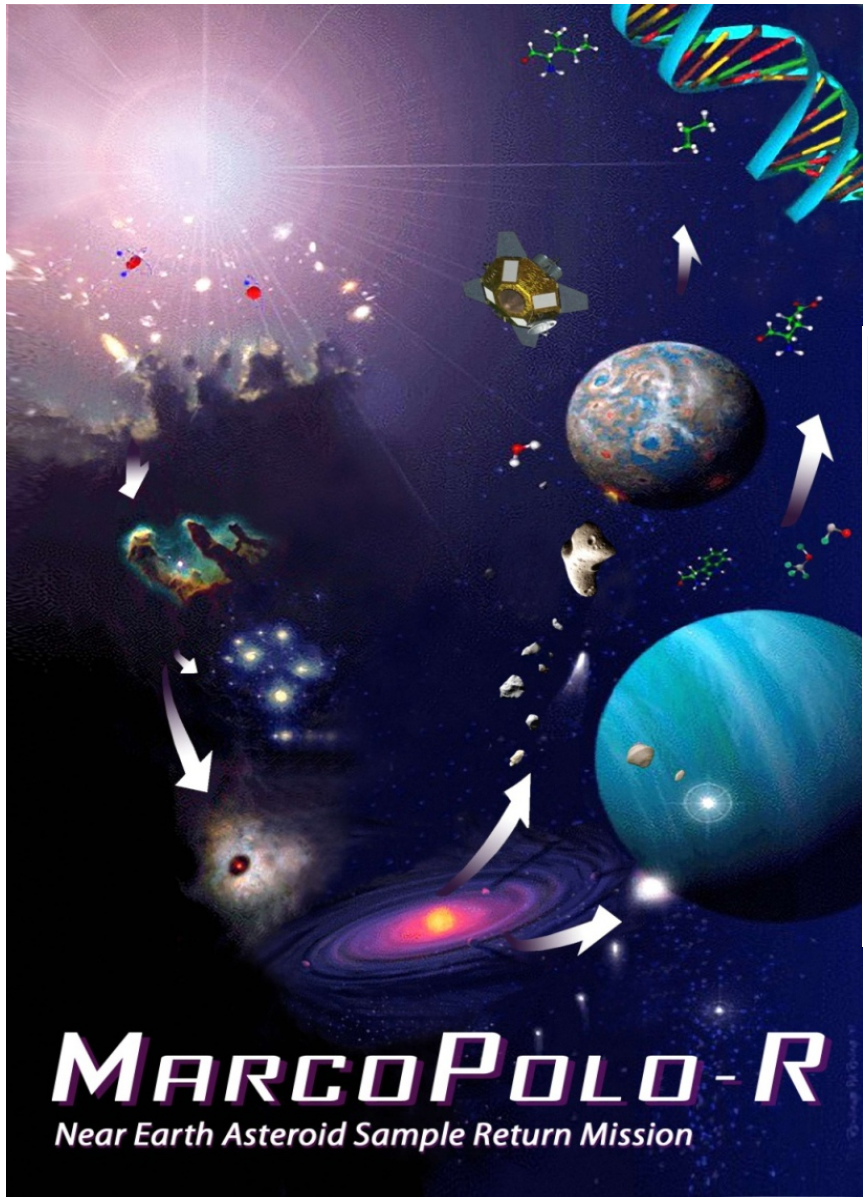
## Objectifs scientifiques ECHO

Pour un portfolio représentatif d'exoplanetes

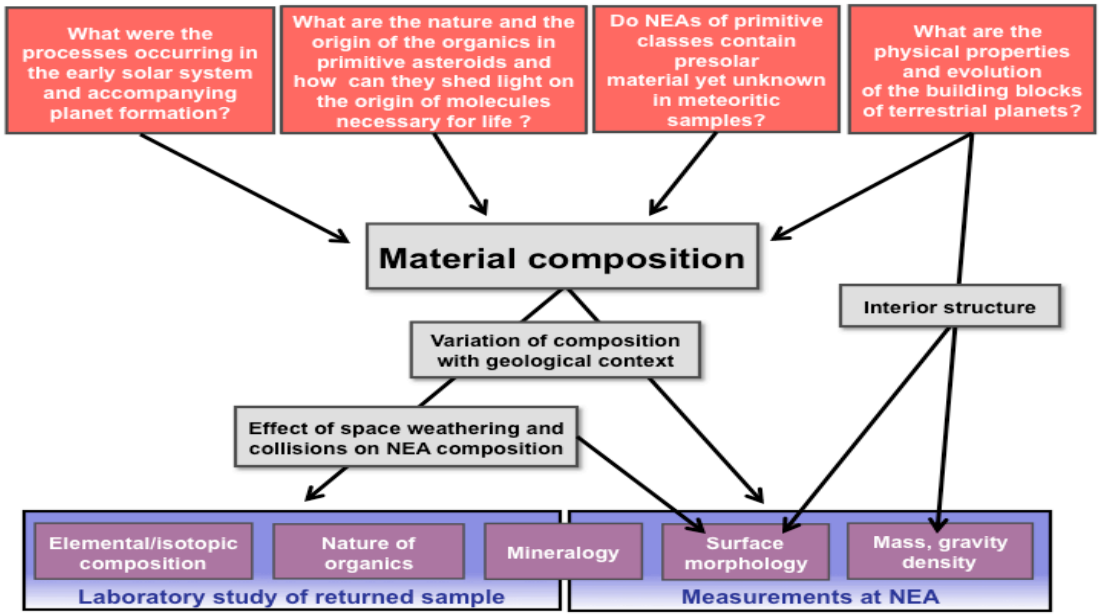
(Jupiters, Saturnes, Neptunes, Super Terres), chaudes à tempérées

- Etude composition, chimie, profils thermiques des atmosphères
- Influence de la dynamique
- Interaction étoile-planète
- Contraindre la structure interne
- Améliorer notre connaissance des mécanismes de formation et évolution.
- Météorologie des exoplanètes
- Biomarkers ?
- Planètes en transit (primaire et secondaire)
- Planètes ne transitant pas.
- Dimensionnement pour Super Terres habitables autour des naines M

# MarcoPolo-R mission



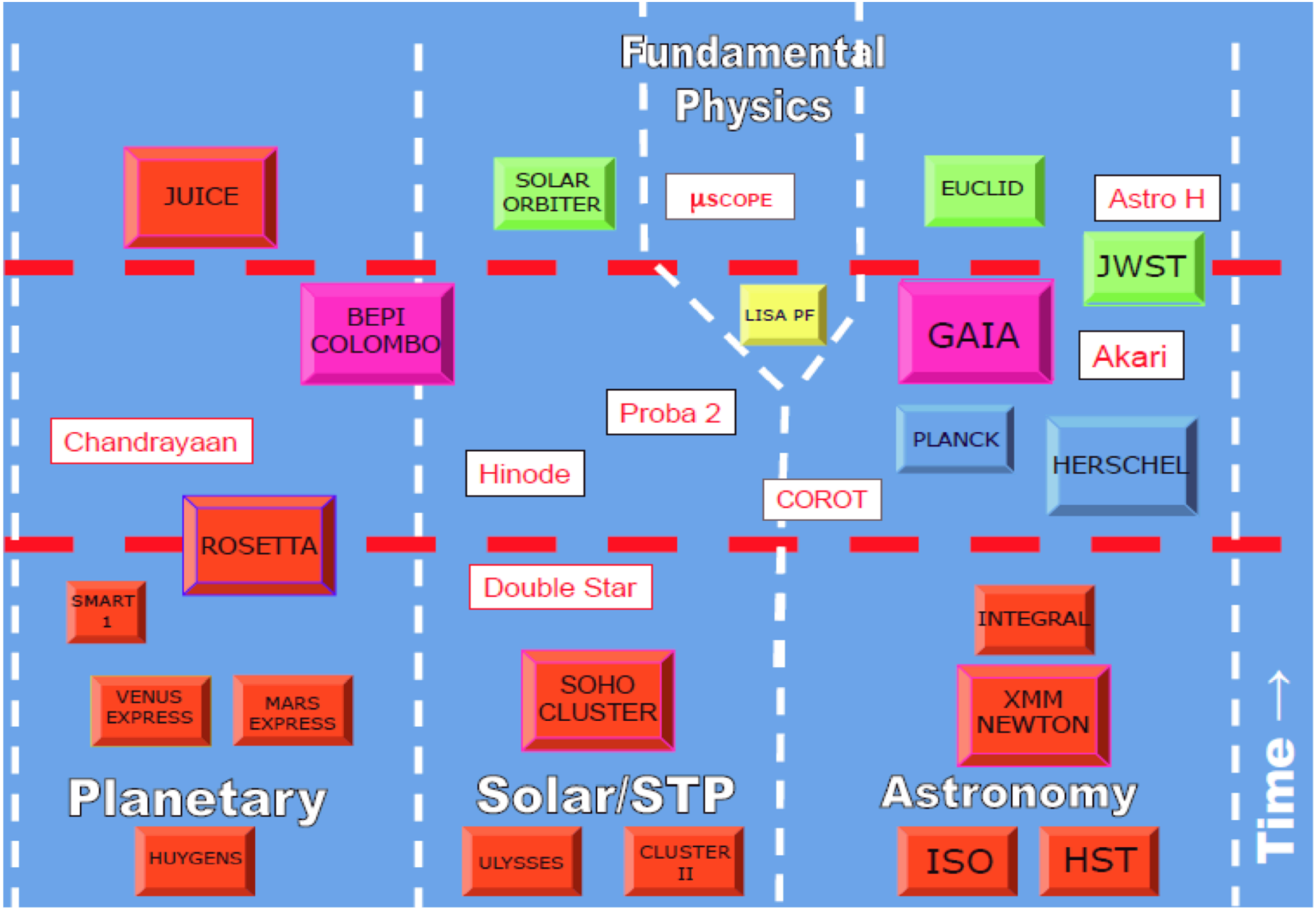





A. Barucci et al

l'Observatoire de Paris | LESIA

| Sun | Solar System | Astrophysics | Fundamental |
|---|---|---|---|
| **Operations** | | | |
| Proba-2 [2009] | Venus Express [2005] | Planck [2009] | |
| SOHO [1995] | Rosetta [2004] | Herschel [2009] | |
| | Mars Express [2003] | Integral [2002] | |
| | Double Star [2003] | XMM-Newton [1999] | |
| | Cluster [2000] | Hubble [1990] | |
| | Cassini-Huygens [1997] | | |
| **Implementation** | | | |
| Solar Orbiter [2017] | BepiColombo [2015] | Gaia [2013] | LISA Pathfinder [2015] |
| | | JWST [2018] | |
| | | Euclid [2020] | |
| **Completed** | | | |
| Ulysses [1990] | SMART-1 [2003] | ISO [1995] | |
| | Giotto [1985] | Hipparcos [1989] | |
| | | Exosat [1983] | |
| | | IUE [1978] | |
| | | Cos-B [1975] | |
| **Future Missions** | | | |
| Cosmic Vision 2015-2025: | | | |
| Mission of Opportunity: | | SPICA | |
| M3 candidate missions: | | EChO, LOFT, MarcoPolo-R, PLATO, STE-QUEST | |
| L1 mission: | | JUICE | |
| S1 mission: | | CHEOPS | |
| **Collaborative Missions** | | | |
| Akari, Chandrayaan-1, Chang'E 1, CoRoT, Hinode, Microscope, Phobos-Soil (Phobos-Grunt), Suzaku | | | |


Fundamental Physics
JUICE
SOLAR ORBITER
µSCOPE
EUCLID
Astro H
JWST
BEPI COLOMBO
LISA PF
GAIA
Akari
Proba 2
Chandrayaan
PLANCK
HERSCHEL
Hinode
COROT
ROSETTA
Double Star
SMART 1
INTEGRAL
SOHO CLUSTER
VENUS EXPRESS
MARS EXPRESS
XMM NEWTON
Time
Planetary
Solar/STP
Astronomy
HUYGENS
ULYSSES
CLUSTER II
ISO
HST

- **L missions:**
  - Missions with a high science ambition, serving a wide community.
  - Europe's flagships or pillars of the programme
  - Challenging technologies, long development times.
  - Predefined by the scientific community.
  - Launched according to programmatic and technology readiness.
  - European-led, with cooperation up to 20%.
  - Estimated cost of 2 LoR years

# Call for whiter papers to define the L2/L3 Science Themes (5 March 2013)

**The Director of Science and Robotic Exploration intends to define, in the course of 2013, the science themes and questions that will be addressed by the next two Large (L-class) missions in the Cosmic Vision 2015-2025 plan, "L2" and "L3", currently planned for a launch in 2028 and 2034, respectively. This process starts with a consultation of the broad scientific community, in the form of the current Call, soliciting White Papers to propose science themes and associated questions that the L2 and L3 missions should address.**

**The submission deadline for White Papers is 24 May 2013, 12:00 CEST (noon).**
Direct link to this Call page: http://sci.esa.int/Call-WP-L2L3

Large (L-class) missions are the pillars of ESA's Science Programme, representing the stability and long-term planning for the scientific community and the ESA Member States. The definition of the Programme's pillars should rely on an adequate long-term perspective to achieve the adequate technological and scientific preparation required by missions that set out to provide a significant, paradigm-changing advance in their respective fields.

The ESA Science Programme can implement three L-class missions every 20 years (two decades being the planning horizon covered by the Programme's successive long-term plans). Considering that the JUICE mission was recently selected for the L1 launch opportunity in 2022, the two other L-class missions (L2 and L3) can be launched in approximately 2028 and 2034.

## OBJECTIVES FOR 2013-2015:

- 2013: Launch of GAIA
  Instruments for JWST delivered
  Identification of L2 and L3,
  Selection of M3 and call for M4
- 2014: Launch of LISA Pathfinder
  Arrival of Rosetta to the comet Ch-G
  Competitive review of mission extensions
- 2015: Launch of Bepi Colombo
  Call for Small Mission 2
  Preparation of CM2015

# Missions CV: les prochaines étapes

## En attendant la sélection d'une mission M3 début 2014:

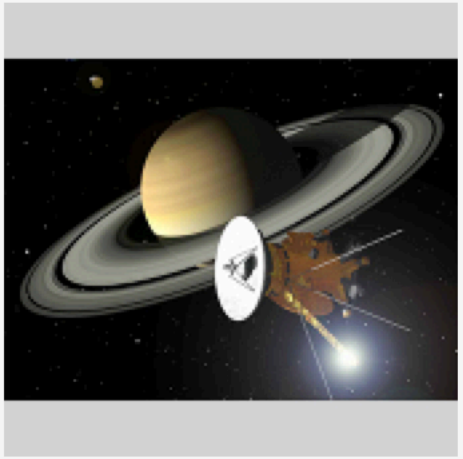
Sélection des instuments pour les missions candidates:

- (Exo)Planétaire: ECHO , MARCO POLO-R

  Et PLATO dont le consortium est déjà choisi
- Astronomie: STE-QUEST & LOFT

Il y a l'appel à thèmes (white papers) L2/L3

Ne pas oublier:



### Cassini-Huygens Participating Scientists Announcement of Opportunity 2013

08 March 2013 The scientific community is invited to submit proposals for Participating Scientists (PS) to the Cassini-Huygens mission. This Announcement of Opportunity is published jointly by ESA, NASA, and ASI. This year proposals are being taken via a two-step process. Step-1 proposals are required. The deadline for submission of Step-1 proposals is 26 March 2013. Full proposals are due 3 May 2013. Read more

Merci et répondez massivement aux appels!