The Solar System in the ESA scientific program

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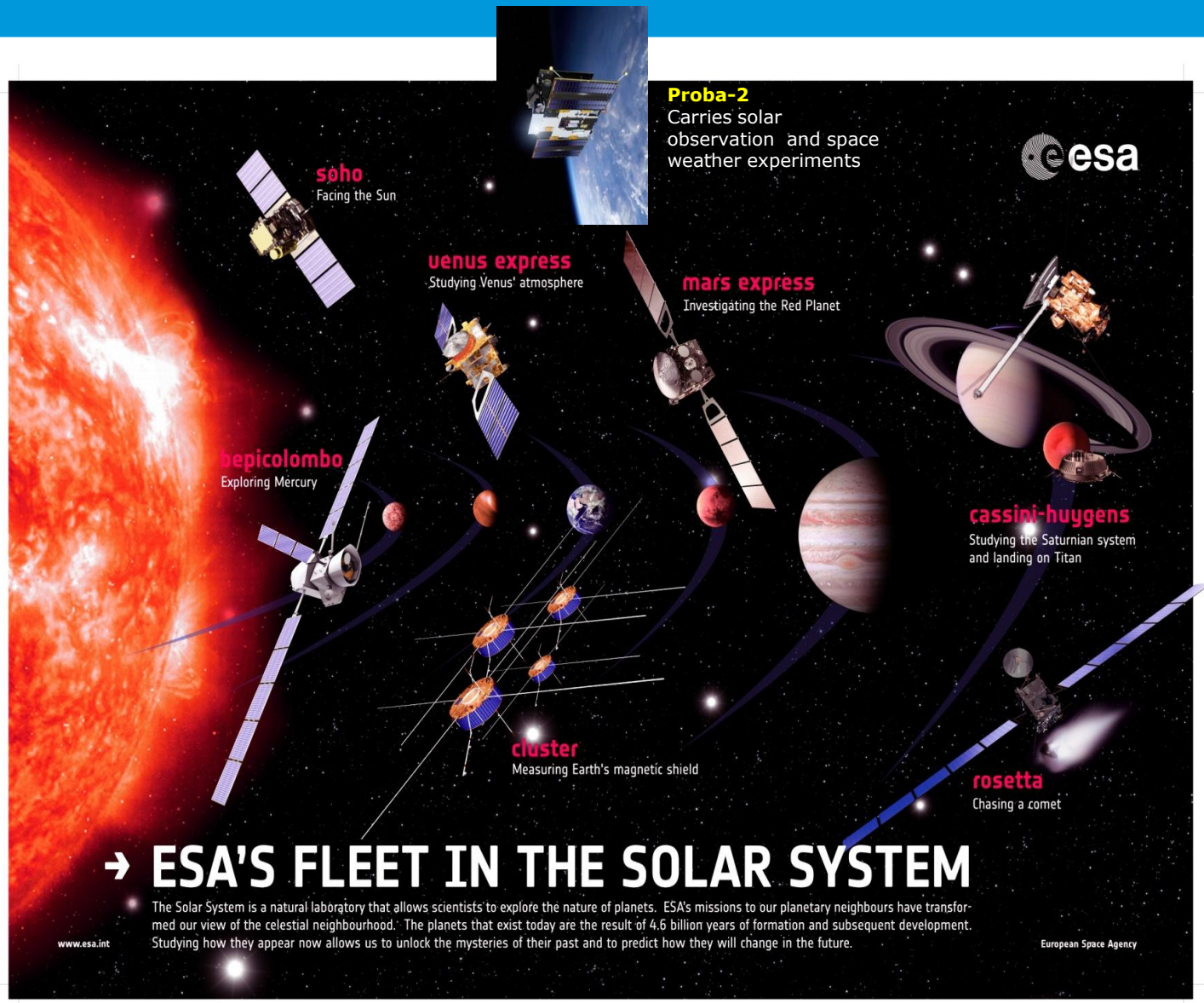
European Space Agency

The ESA fleet in the Solar System

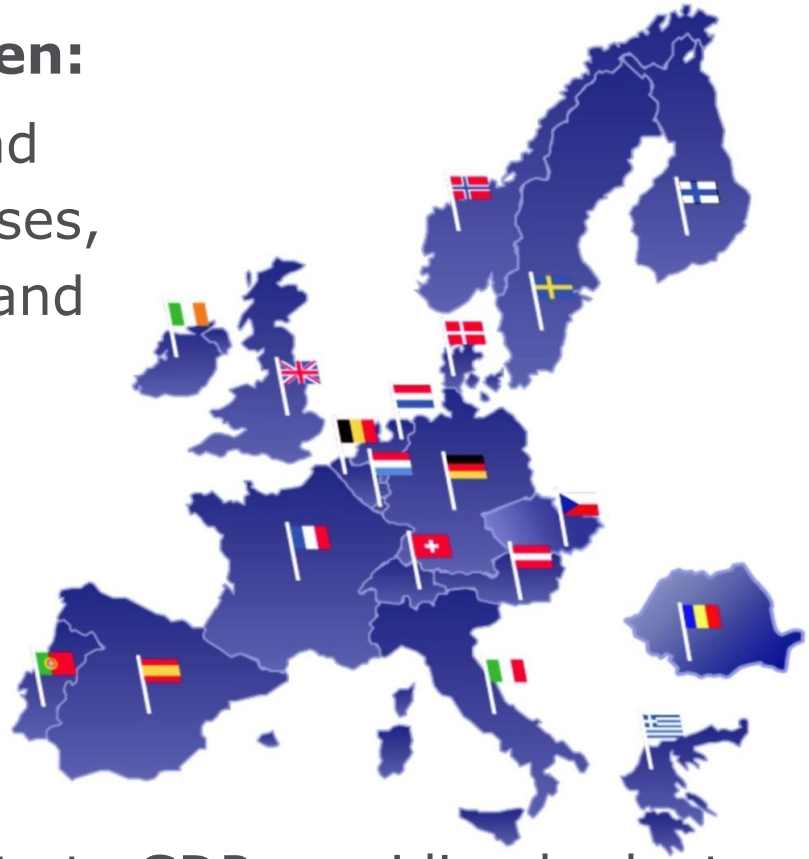
- The ESA Science Programme has consistently allowed European scientists to score key "firsts"
- Europe today has leadership in a number of fields in Space Science
- ESA aims at maintaining this leadership



Basics of the Science Programme

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

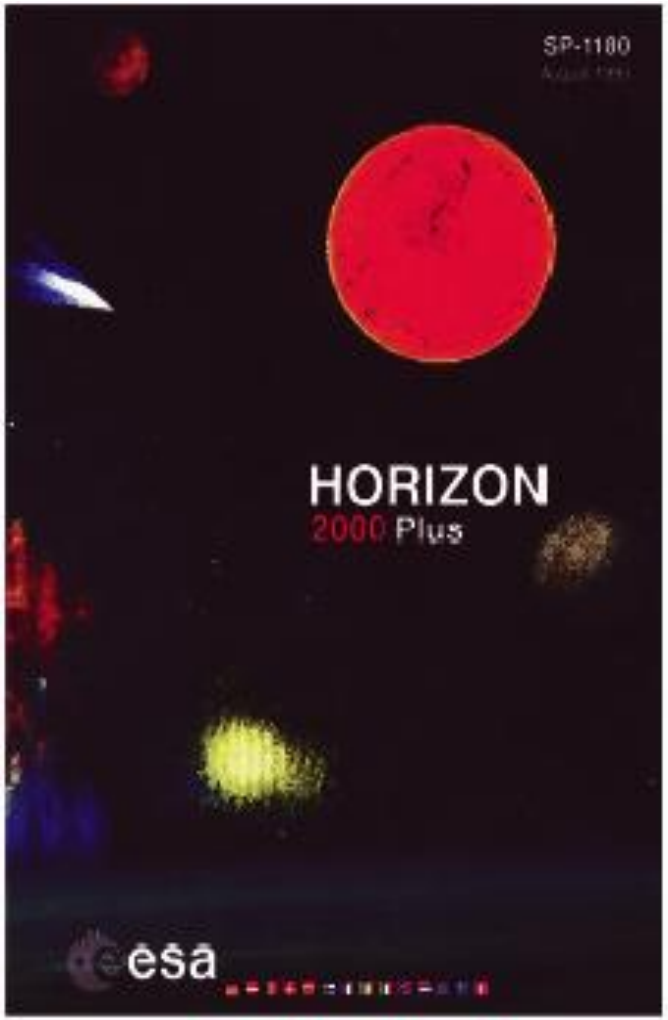
  both long-term science planning and mission calls are bottom-up processes, relying on broad community input and peer review.



- **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.

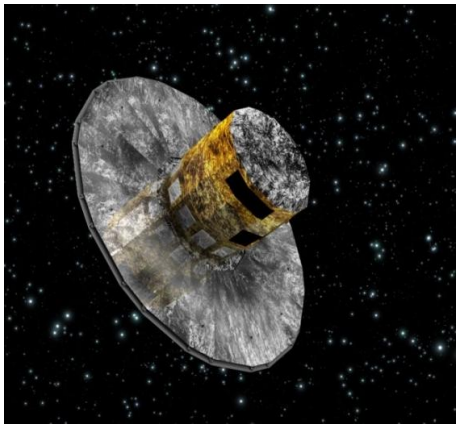
HORIZON 2000 (1986-2005)
HORIZON 2000+ (2006-2015)



In 1995, a roll-forward of the programme was established, with the name Horizon 2000+, for 10 additional years, i.e. with launches up to 2015.

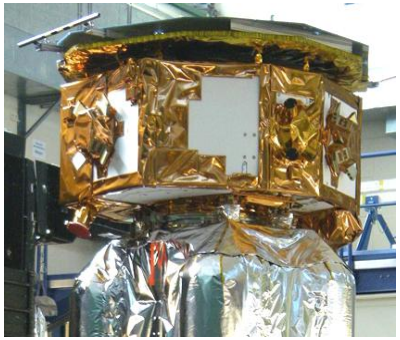
OBJECTIVES for 2013-2015

- 2013: Launch of GAIA



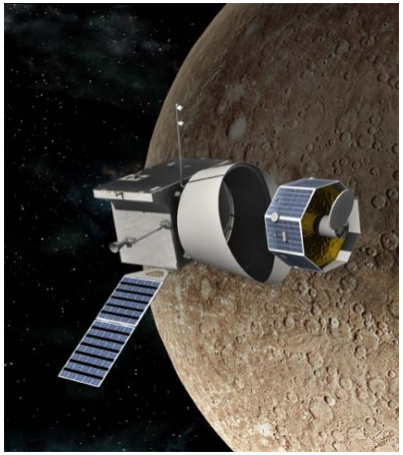
To create the largest and most precise three dimensional chart of our Galaxy by providing unprecedented positional and radial velocity measurements for about one billion stars in our Galaxy and throughout the Local Group

- 2014: Launch of LISA Pathfinder



LISA Pathfinder is to demonstrate the key technologies to be used in future missions for gravitational wave detection

- 2015: Launch of BepiColombo



Mars Express
Images and Geology

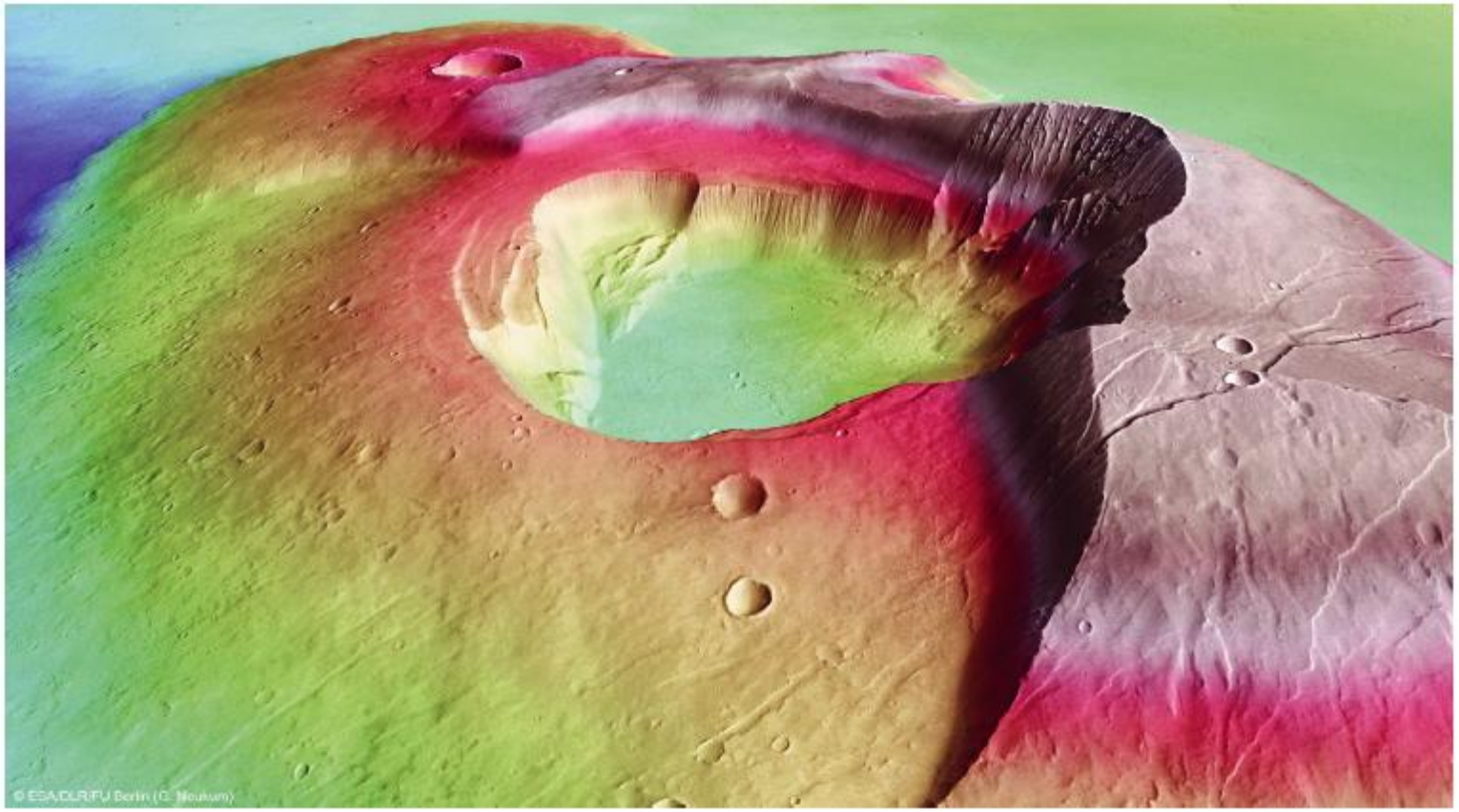
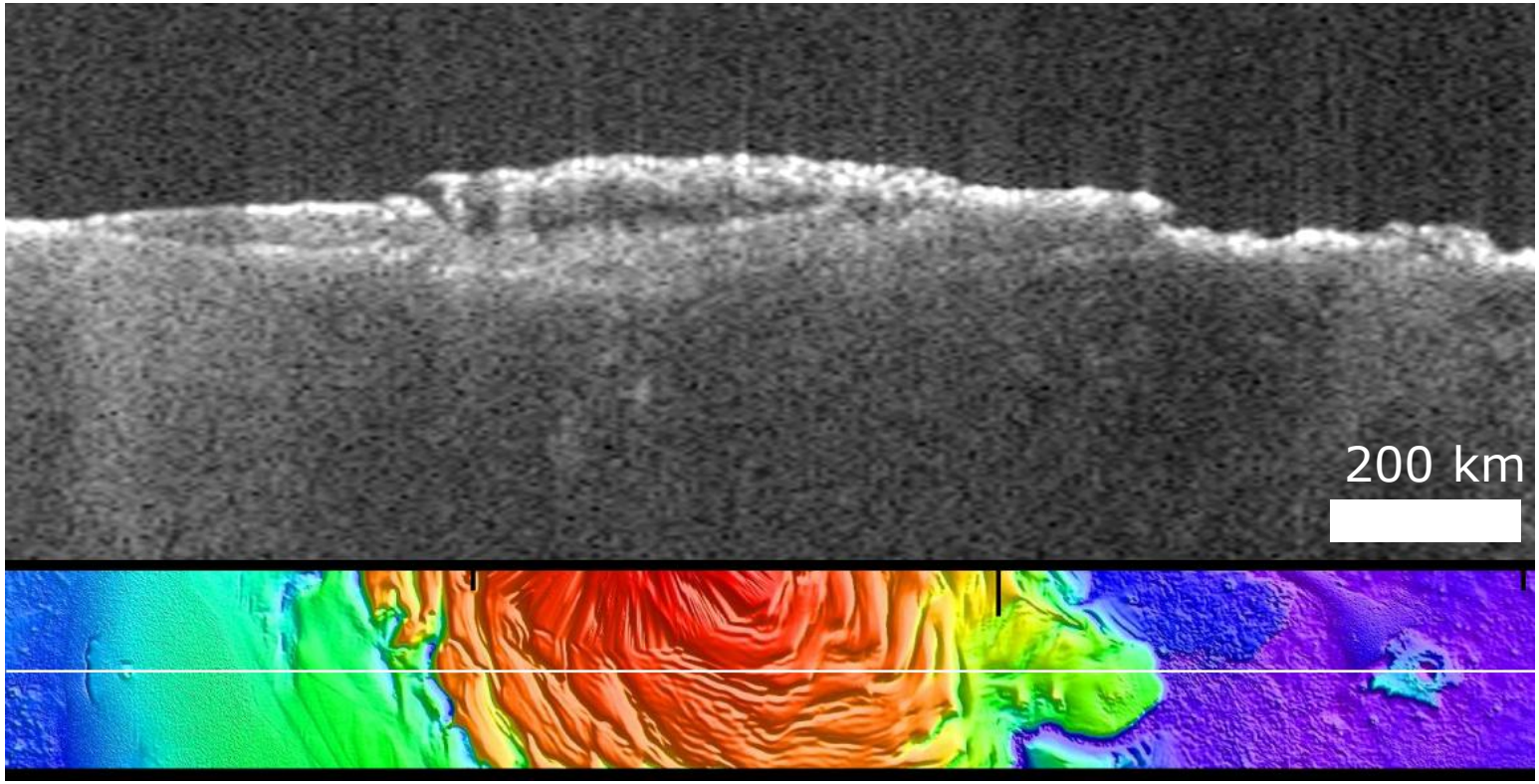


Figure 2.7.1. Image of the volcano Tharsis Tholis released by ESA in November 2011 on the occasion of the 10 000th orbit of Mars Express. The volcano is 8 km high with a base extending 155 × 125 km and a central caldera measuring 32 × 34 km. The image was created using a Digital Terrain Model (DTM). Elevation data from the DTM are colour coded: purple indicates the lowest-lying regions and beige the highest. The relief has been exaggerated by a factor of three. (©ESA/DLR/FU Berlin; G. Neukum)

ESA's Report to the 39th COSPAR Meeting ESA SP-1223 June 2012

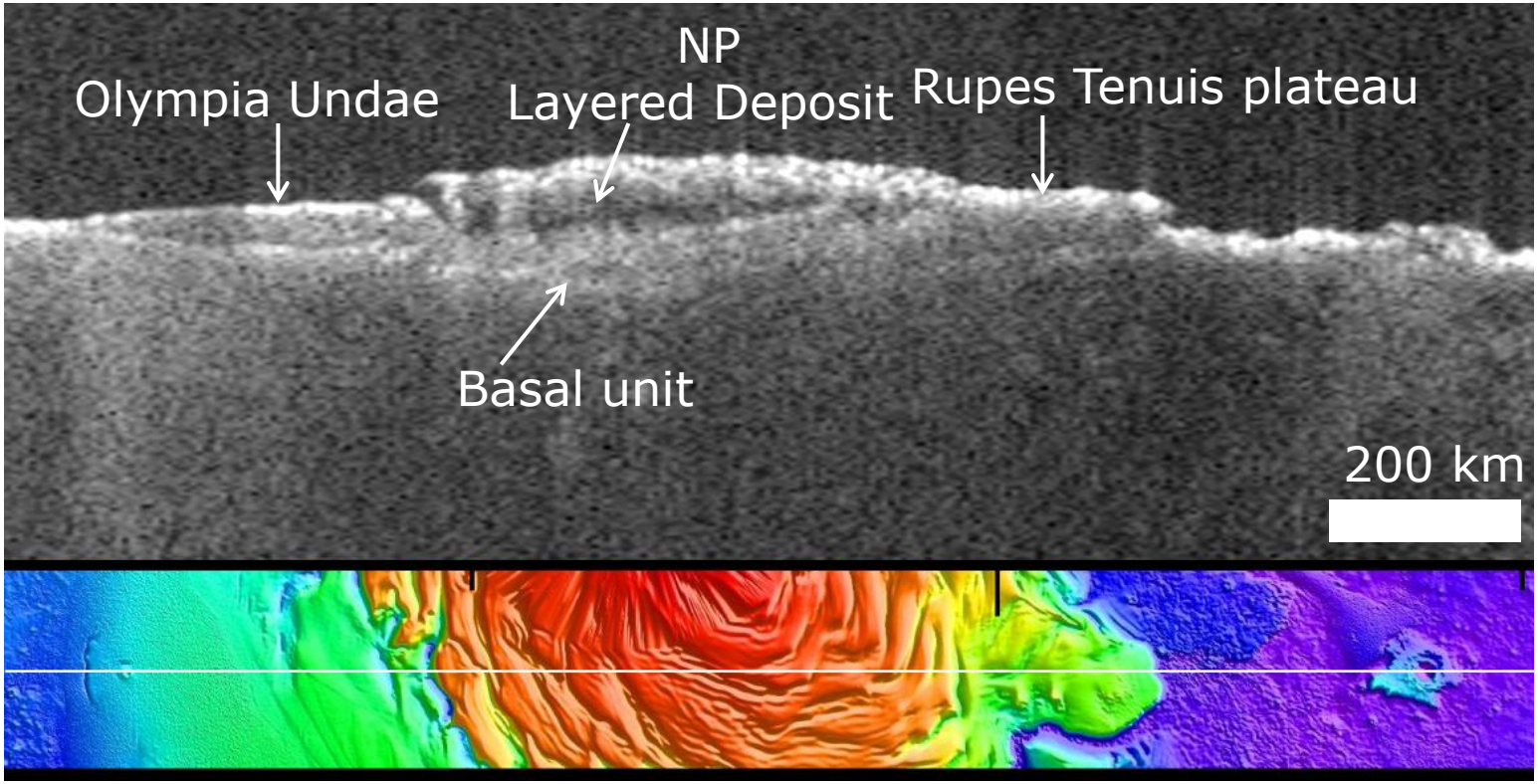
http://sci.esa.int/cospar_report

Mars Express
North Pole MARSIS investigation



- Base of basal unit is visible across entire polar plateau. Allows better constraints on thickness and volume.
- Preliminary estimate of real dielectric constant of basal unit at Rupes Tenuis is ~4. Implies lithic component up to ~50%.

Mars Express
North Pole MARSIS investigation



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Mars
Atmosphere and water cycle

Figure 2.7.2. The water cycle in the atmosphere of Mars. When the polar caps are illuminated by the Sun during spring and summer, their water content progressively sublimates and is released into the atmosphere. The molecules are transported by winds to higher altitudes where, in the presence of dust and aerosols, they condense to form clouds. If there are too few dust particles, condensation is impeded, leaving substantial amounts of water vapour, i.e. the atmosphere is supersaturated. Supersaturated water vapour may be transported by winds to the southern hemisphere or carried high into the upper atmosphere, where solar radiation splits it into hydrogen and oxygen atoms, which can then escape into space. (ESA/AOES Medialab)

- OMEGA has detected, for the first time, the nightside emission of molecular oxygen at 1.27 μm (Bertaux et al., 2012). This emission, formed by the recombination of two oxygen atoms, is a clear diagnostic of the atmospheric circulation from dayside to nightside, similar to what occurs on Venus.

- From measurements of α-particles (He^{2+} ions) with ASPERA, it has been concluded that α-particles in the solar wind contribute to the helium content observed in the martian atmosphere (Stenberg et al., 2011). Such studies of the helium balance in a planetary atmosphere are providing critical information on the formation of the Solar System.

- Observations made by the SPICAM instrument have provided evidence, for the first time, of the existence of water vapour in excess of saturation, by an amount far surpassing that encountered in Earth's atmosphere (Maltagliati et al., 2011). This finding contradicts the assumption that atmospheric water on Mars cannot exist in a supersaturated state, directly affecting the long-term representation of water transport, accumulation, escape and chemistry on a planetary scale (Fig. 2.7.2).

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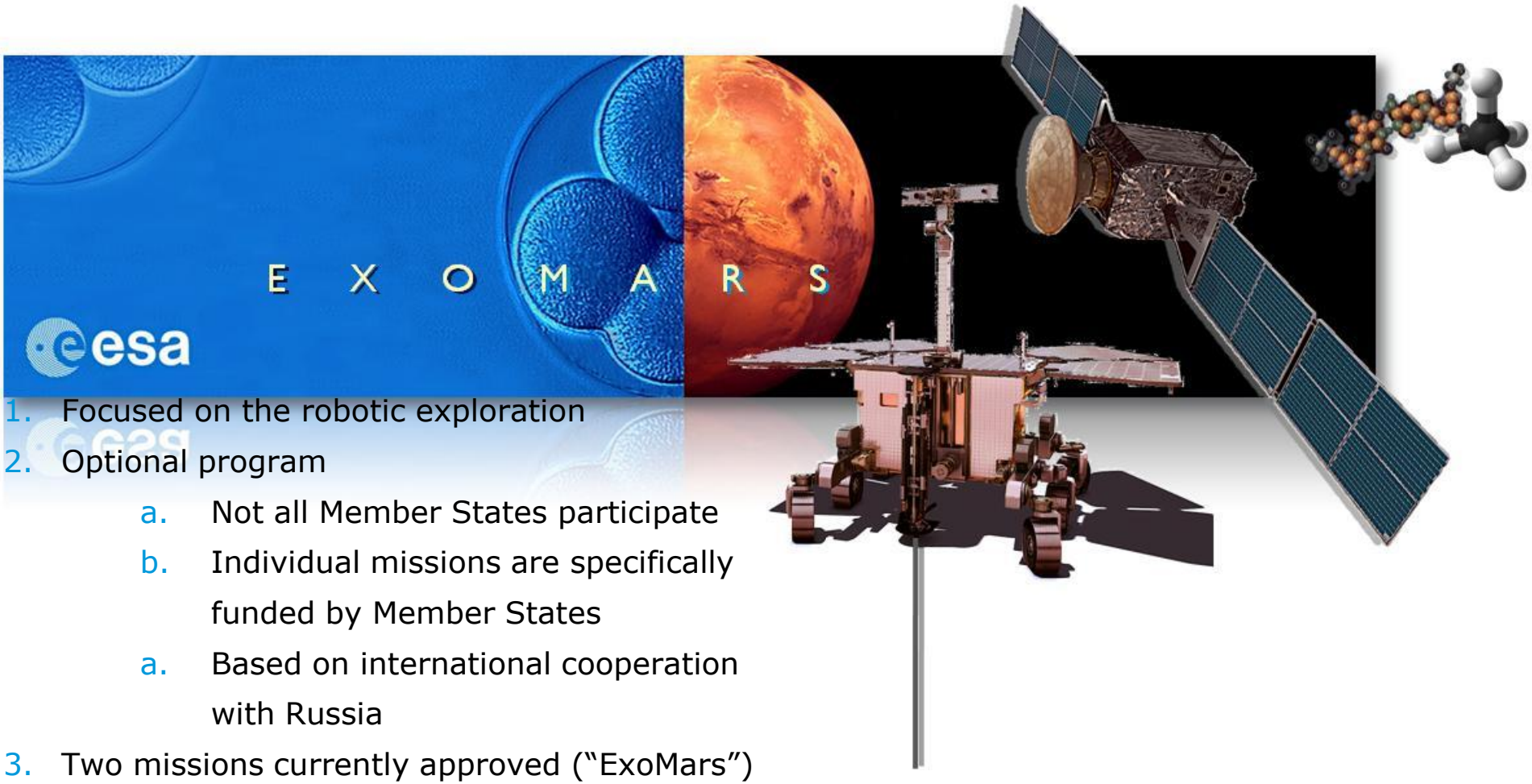
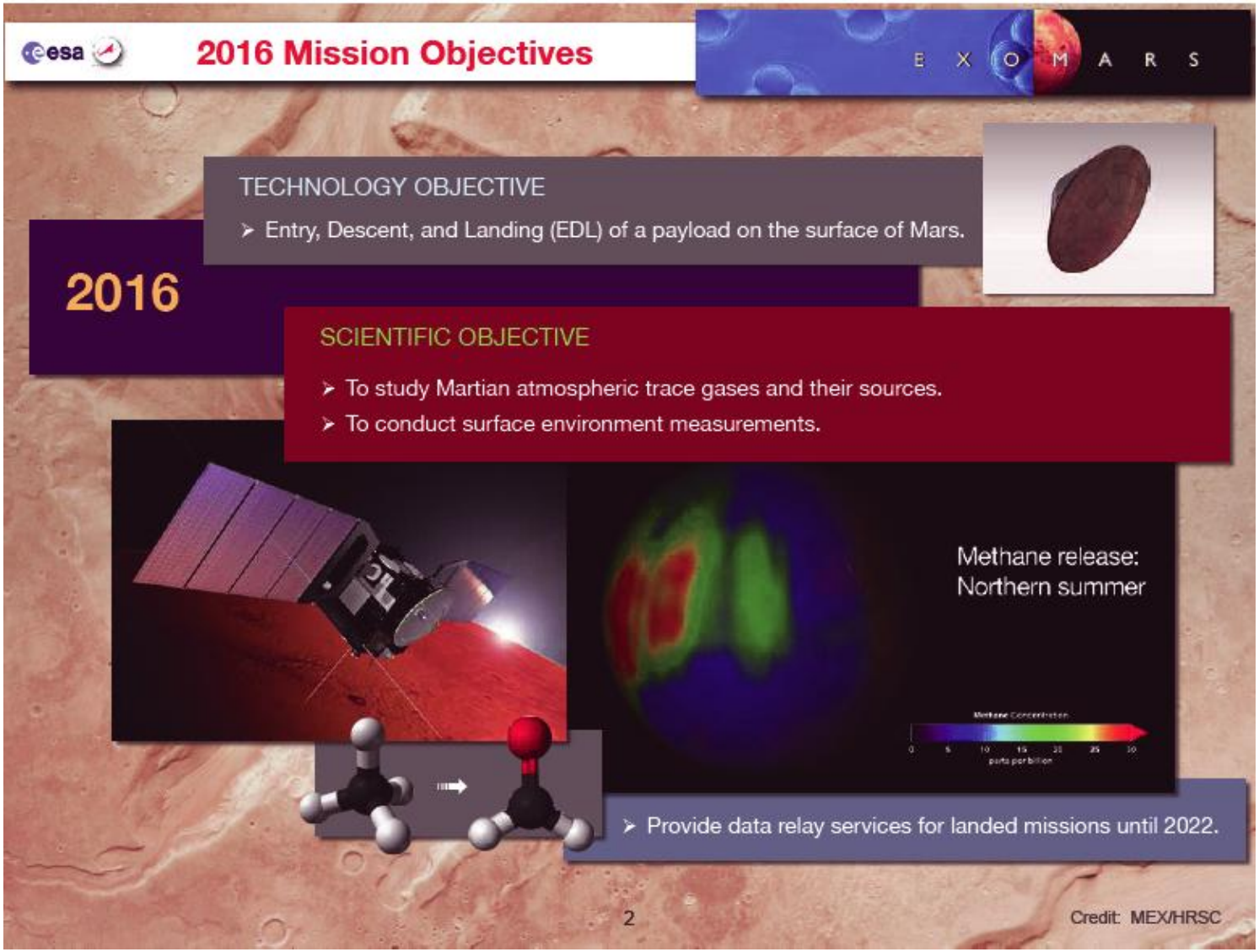
http://sci.esa.int/cospar_report

The (optional) European Robotic Exploration Program



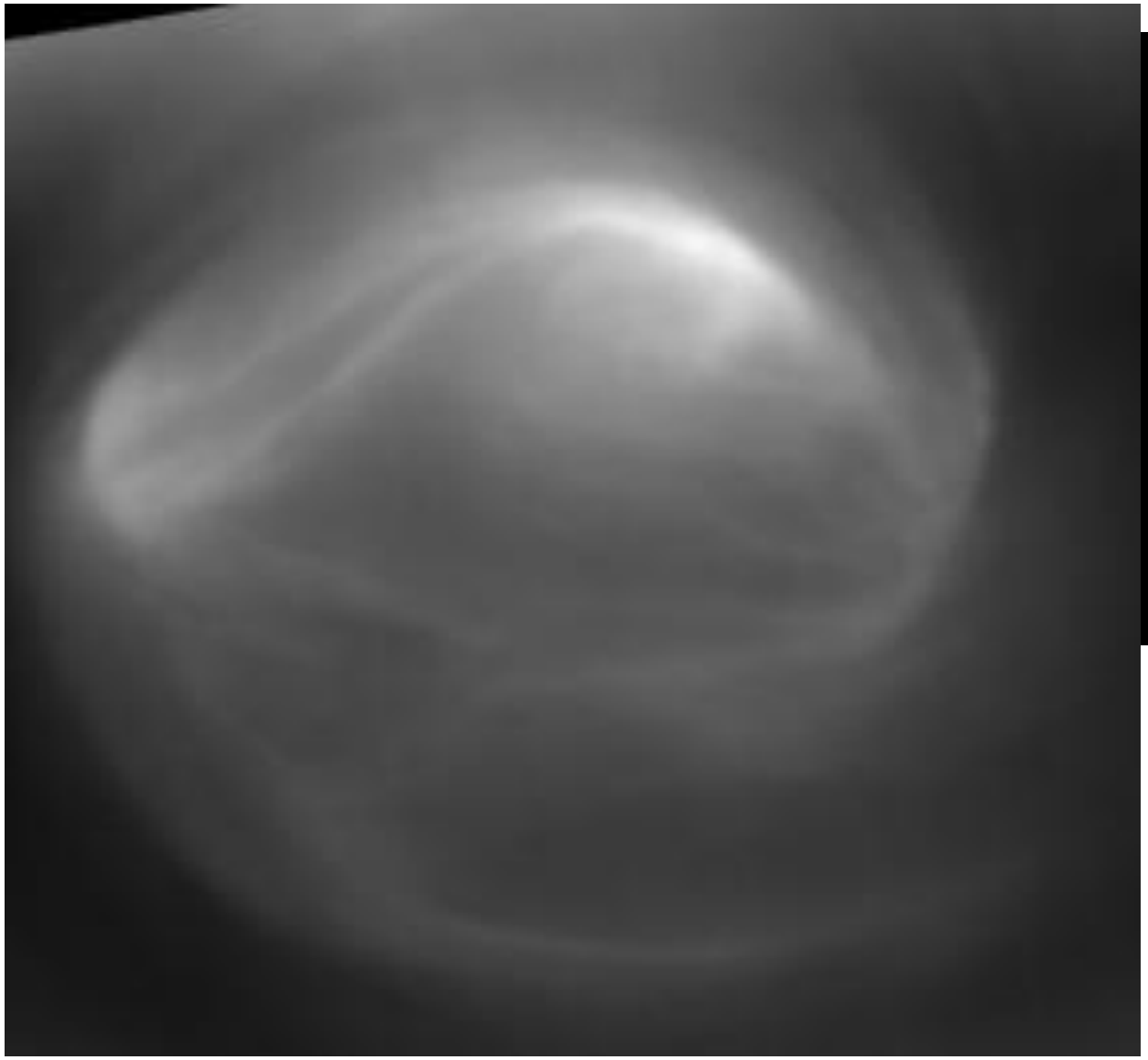
1. Focused on the robotic exploration
2. Optional program
    a. Not all Member States participate
    b. Individual missions are specifically funded by Member States
    a. Based on international cooperation with Russia
3. Two missions currently approved ("ExoMars")
    a. Trace gas orbiter (TGO) and Entry, Descent, and Landing Demonstrator Module (EDM) (2016)
    b. Exo-biology rover with Pasteur P/L (2018)
4. Long-term goal is Mars Sample Return

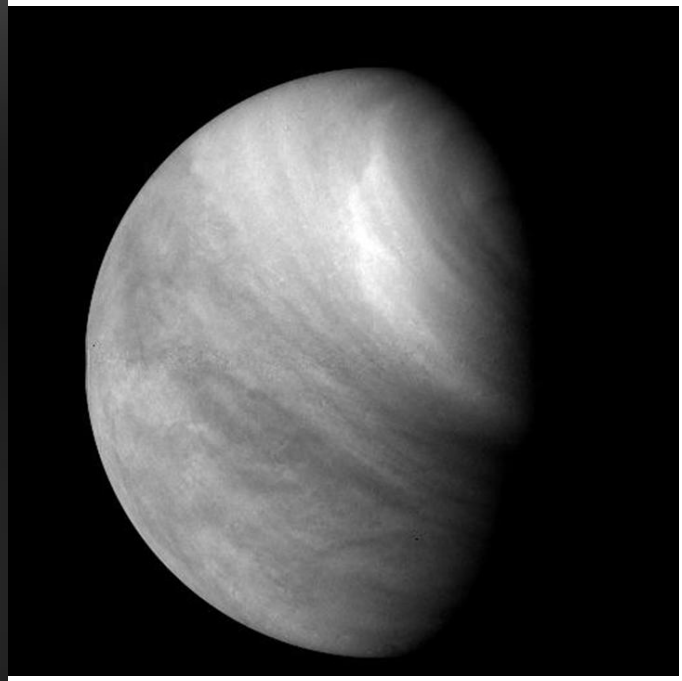
The scientific portfolio offered by the ExoMars missions



The scientific portfolio offered by the ExoMars missions

Venus Express
A complex atmosphere - Polar vortex dynamics

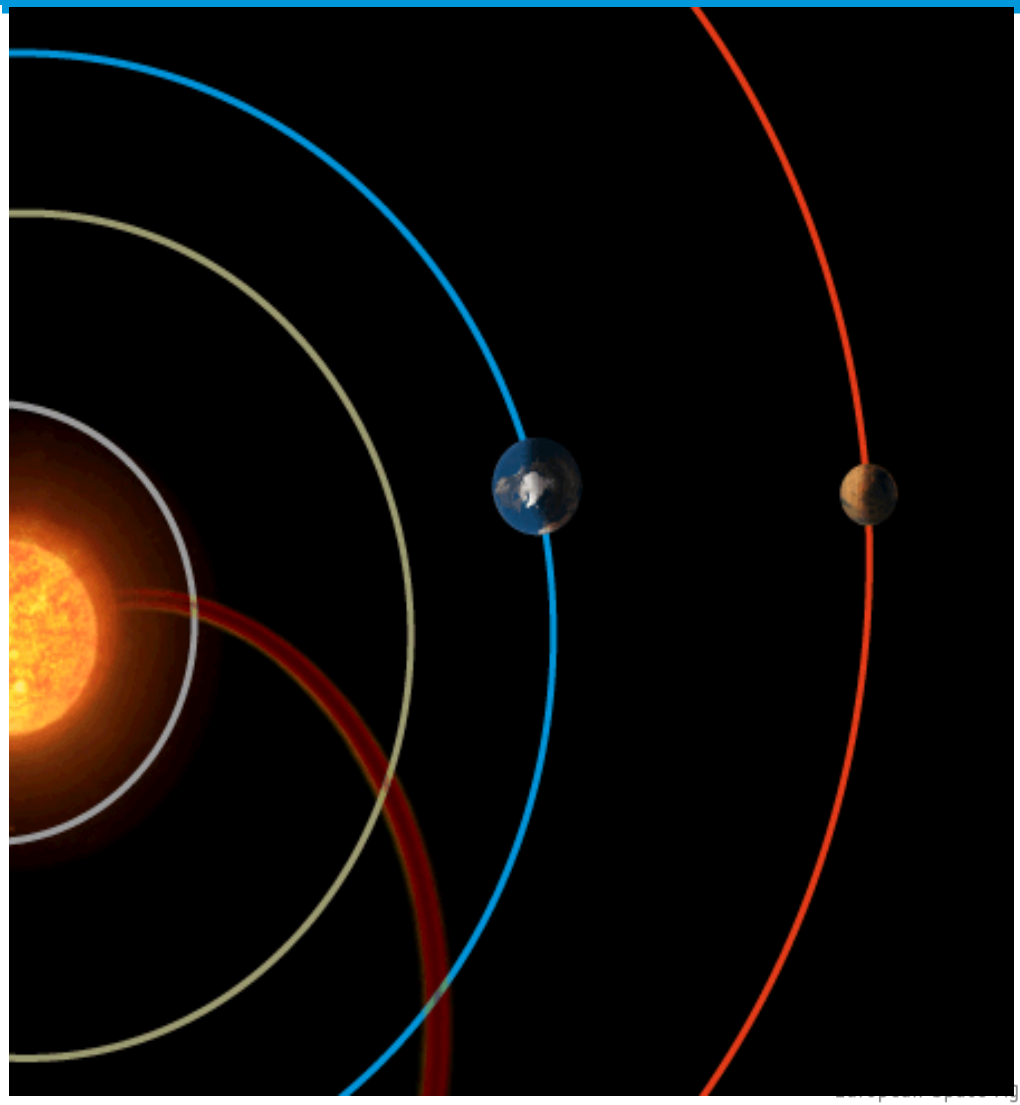




VIRTIS data @5μm,
sampling altitude ~65km

Cluster and MEX show importance of terrestrial magnetic field

- Mars O^+ loss rate 10 times higher than Earth found under equivalent solar wind dynamic pressure increase at both planets
  - Earth's magnetic field has a key role to keep our atmosphere in place
- Distance from Sun also found to play an important role
- Future studies to include Venus

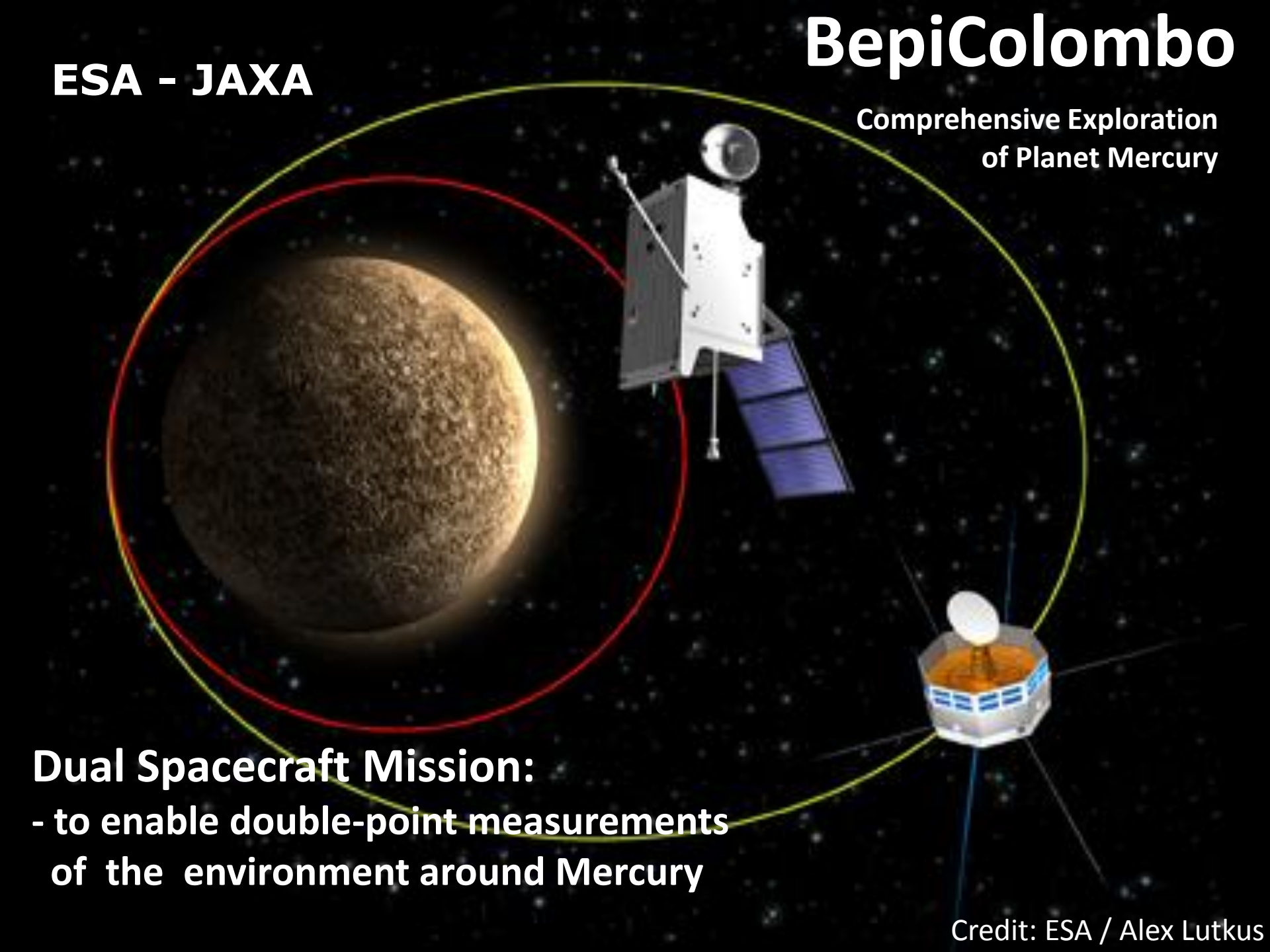


Wei et al., JGR, 2012

BepiColombo

ESA - JAXA

Comprehensive Exploration of Planet Mercury



Dual Spacecraft Mission:

- to enable double-point measurements of the environment around Mercury

Credit: ESA / Alex Lutkus

BepiColombo - Status

- **MPO & MMO & MTM & sunshield**
  - MMO “Thermal Vacuum”
    - ✓ **test successfully completed**
  - MMO plus sunshield “Thermal Vacuum”
    - ✓ **test successfully completed**
  - MPO “Thermal Vacuum”
    - ✓ **test successfully completed**
  - Vibration & Mechanical
    - ✓ **test successfully completed**
  - MTM “Thermal Vacuum”
    - ❑ **test to come**
  - Electrical Tests all payloads plus spacecraft (SFT)
    - ✓ **test successfully completed**

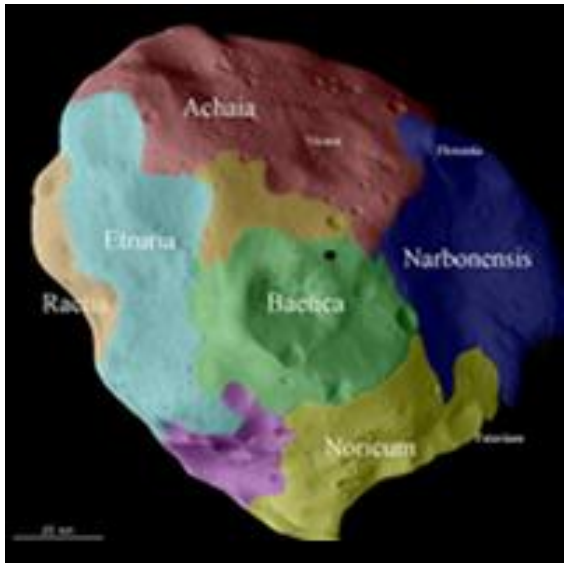
European Space Agency

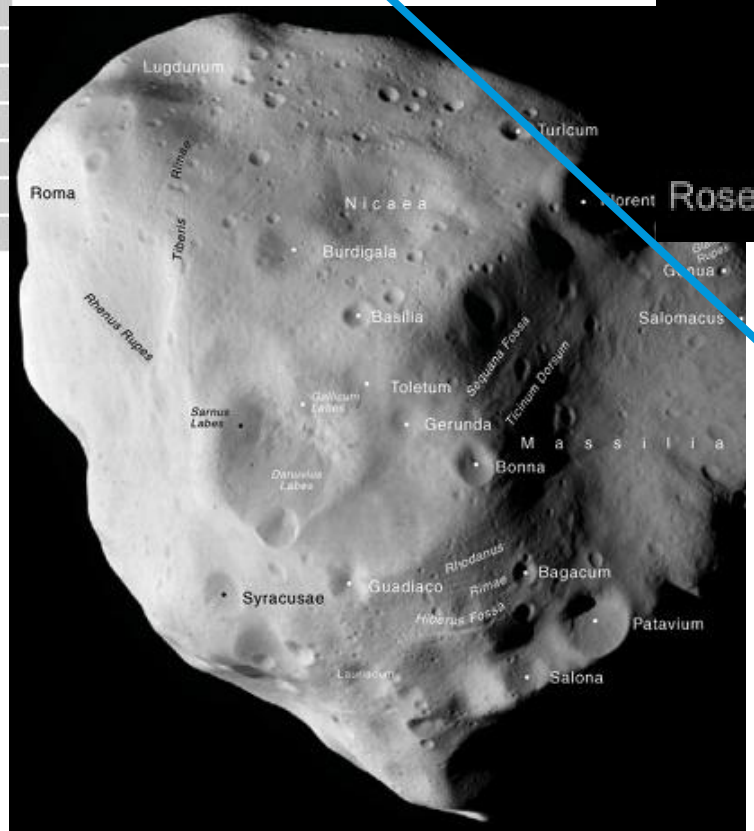
Small Bodies
Comets and Rosetta... and Asteroids

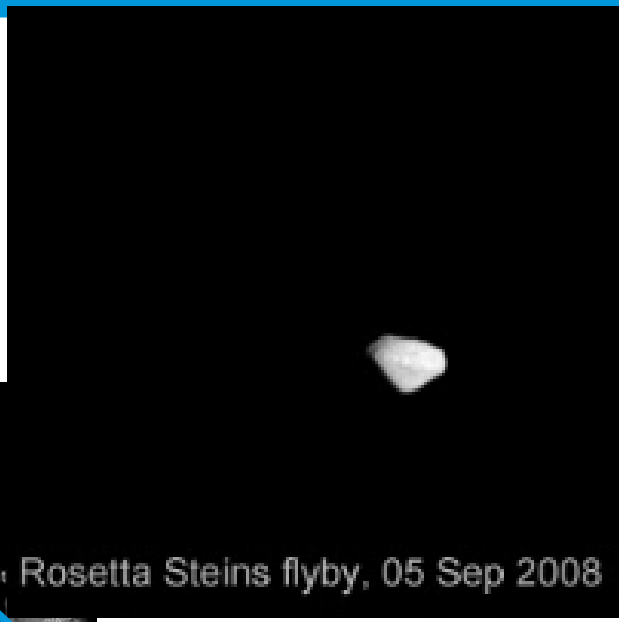
esa

Orbit

Event	Nominal date
Launch	March 2004
First Earth gravity assist	March 2005
Mars gravity assist	February 2007
Second Earth gravity assist	November 2007
Asteroid Steins flyby	5 September 2008
Third Earth gravity assist	November 2009
Asteroid Lutetia flyby	10 July 2010
Enter deep space hibernation	July 2011
Exit deep space hibernation	January 2014
Comet rendezvous manoeuvre	May 2014
Global mapping of comet	August 2014
Lander delivery	November 2014
Perihelion passage	August 2015
Mission End	December 2015





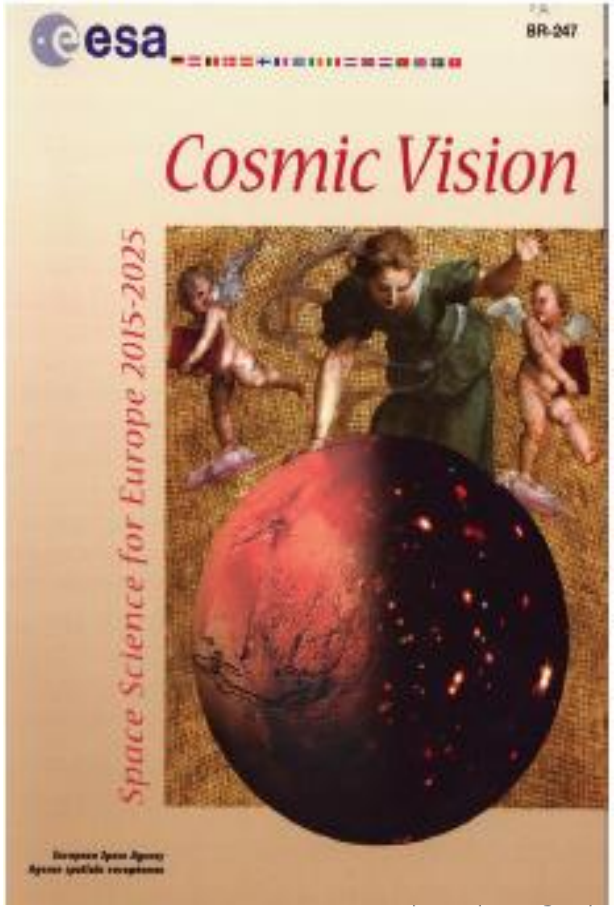


121 km

European Space Agency

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).



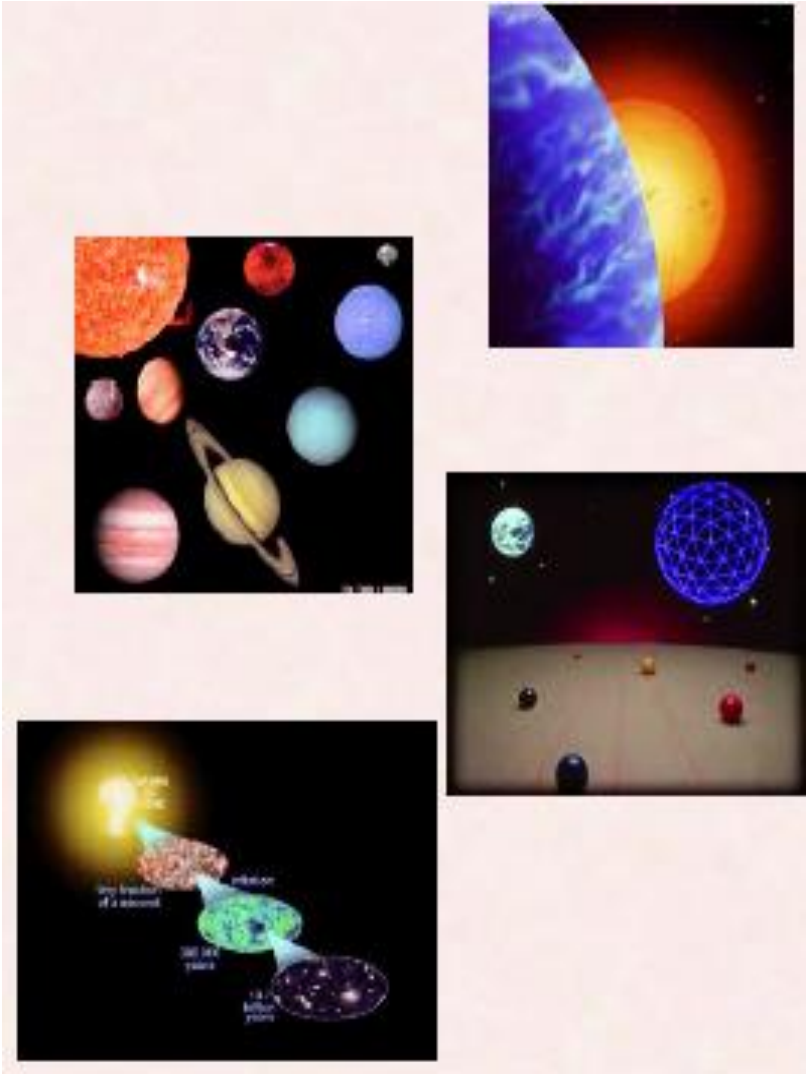
The COSMIC VISION "Grand Themes"

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

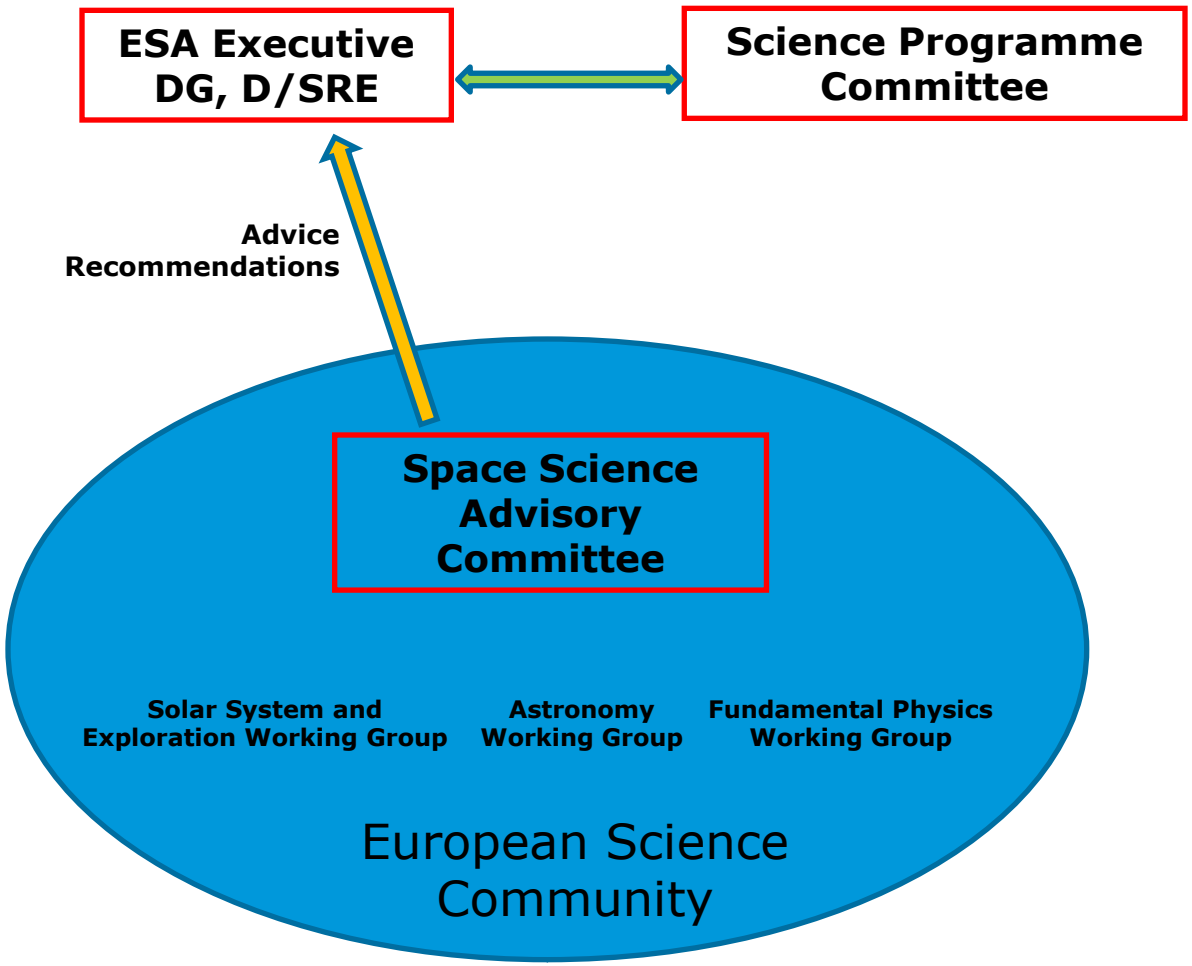
2. How does the Solar System work?

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

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



COSMIC VISION
A bottom-up approach

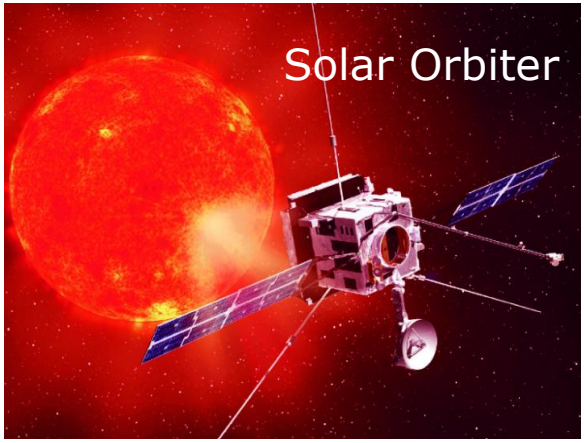


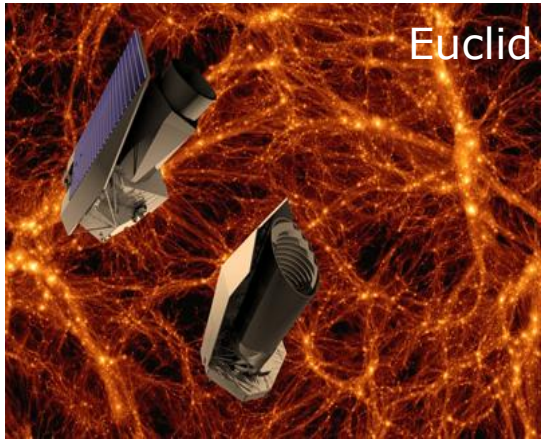
- First "Call for Missions" issued in 1st Q 2007.
- Both L and M mission proposals solicited.
- More than 50 proposals received.

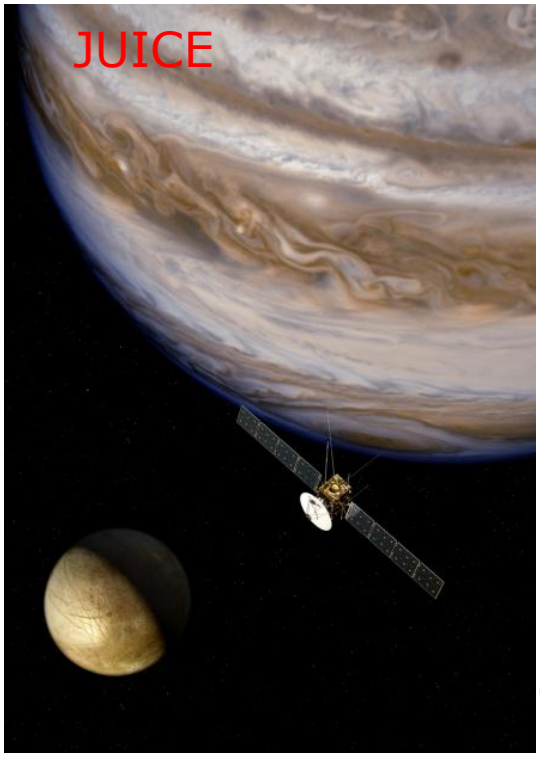
COSMIC VISION (2015-2025)
Step 1

- 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

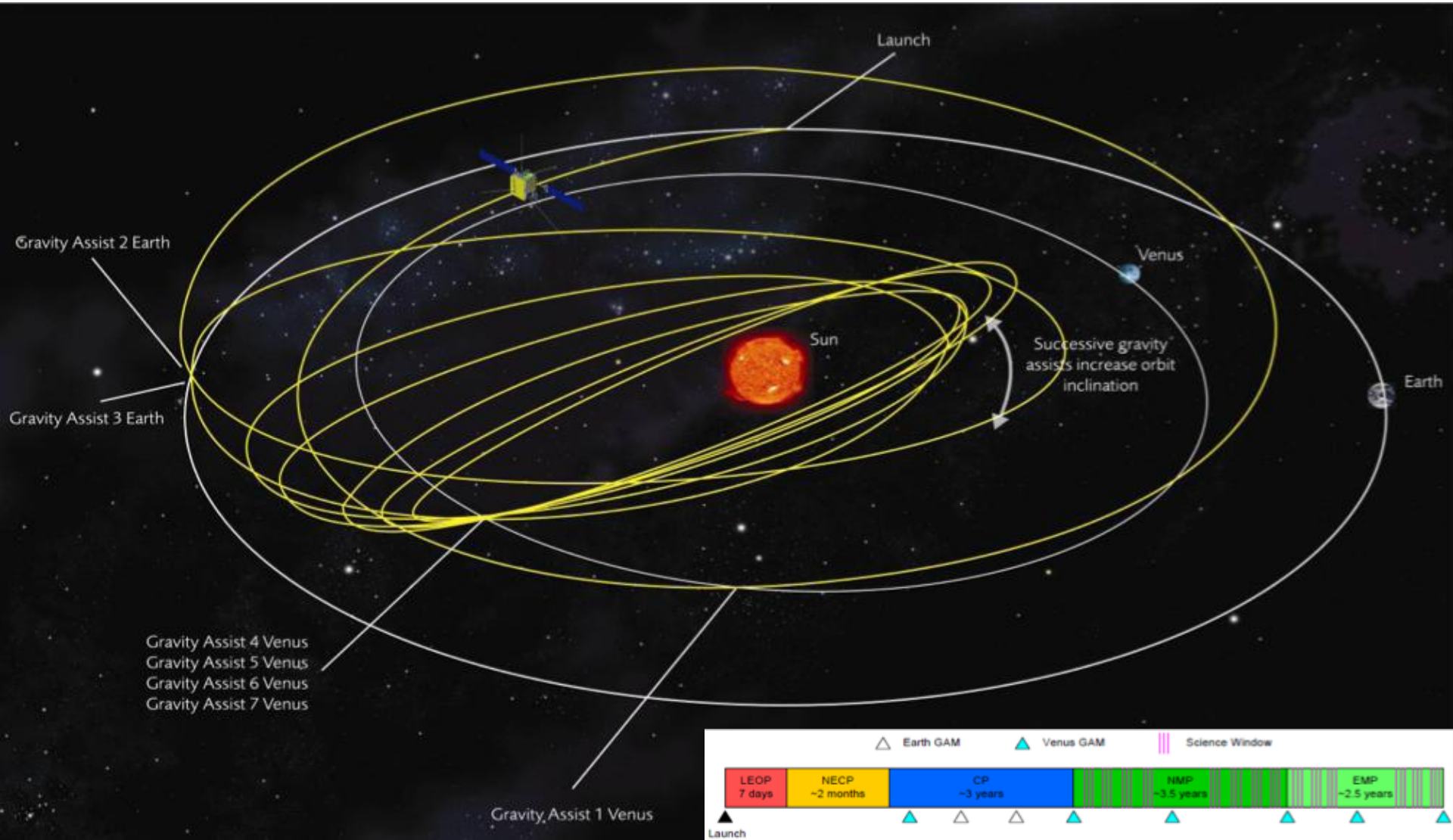
- Selection of Solar Orbiter as M1 and Euclid as M2 in 2011.
- Selection of Juice as L1 in 2012.



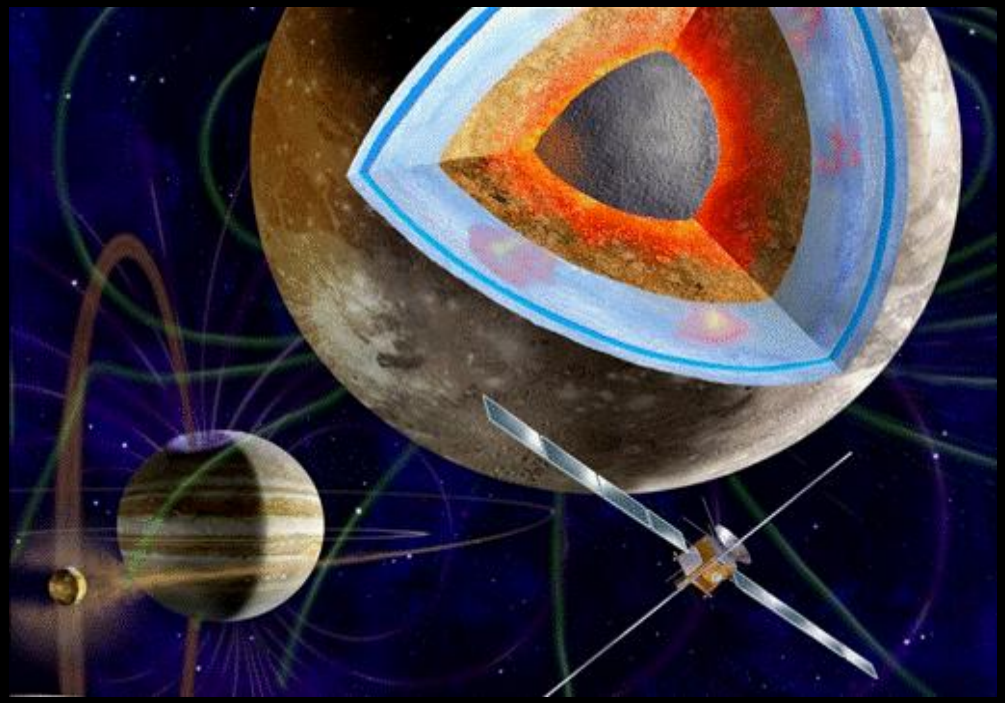




Solar Orbiter Mission Profile



JUICE Mission Scientific Objectives (a summary)



JUICE Science Themes

- ***Emergence of habitable worlds around gas giants***
- ***Jupiter system as an archetype for gas giants***

Cosmic Vision Themes

- *What are the conditions for planet formation and emergence of life?*
- *How does the Solar System work?*

JUICE concept

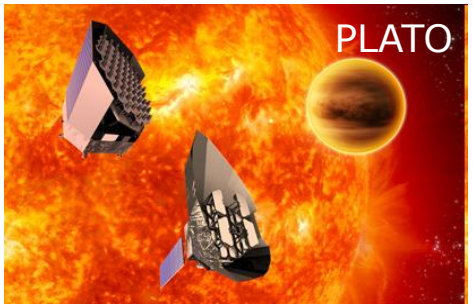
- *A single spacecraft mission to the Jovian system*
- *Investigations from orbit and flyby trajectories*
- *Synergistic and multi-disciplinary payload*
- *European–led mission*

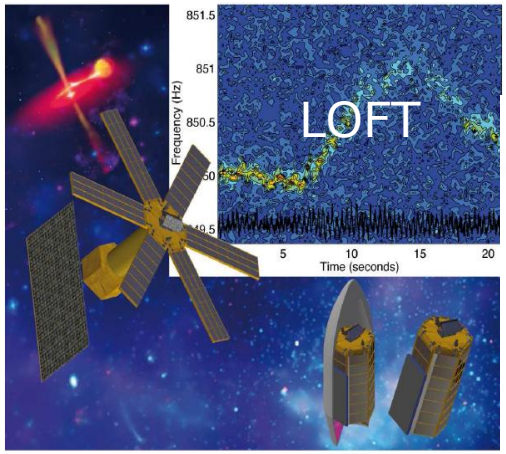
JUICE scientific payload selection plan

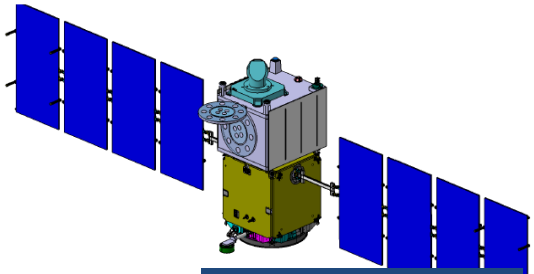
Date	Event
June 25, 2012	Release of AO for scientific instruments onboard the JUICE spacecraft
July 6, 2012	Deadline for submission of (**binding**) Letters of Intent
July 13, 2012	Briefing meeting
October 15, 2012	**Proposals due**
October - December, 2012	***Proposal evaluation***
January, 2013	SSEWG and SSAC recommendations
February, 2013	Preliminary technical KO of instrument Phase A
February, 2013	SPC selection
End 2013	Release of an updated set of ESA documents
Mid 2014	Update of Instrument Consortia documents
November 2014	Mission adoption and MLA signature

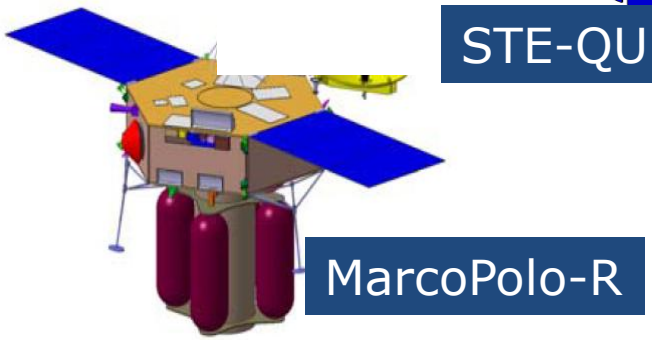
COSMIC VISION (2015-2025)
Step 2

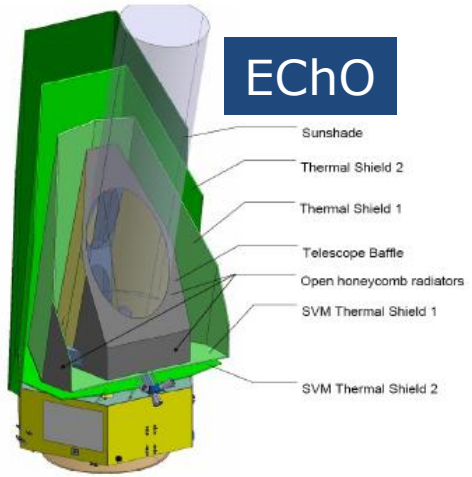
- Second "Call for Missions" issued in 2010
- Only M mission proposals solicited
- ECHO, MarcoPolo-R, LOFT, STE-QUEST selected for assessment with PLATO (possibly) retained from previous round
- Selection planned for 2013









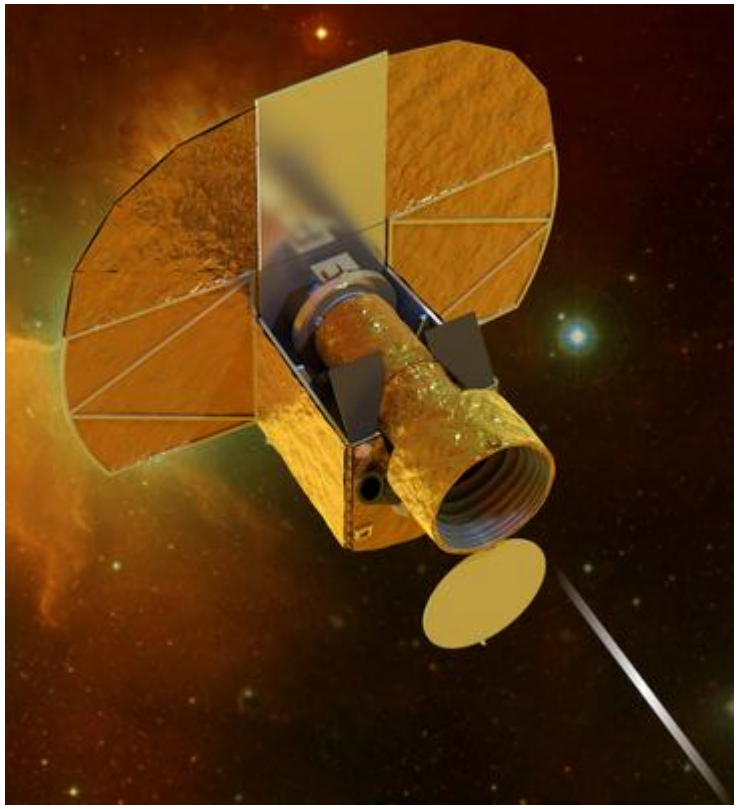


Announcement of Opportunity for the provision of scientific payload including SGS elements for the M3 mission candidates

Date	Event
September 24, 2012	Release of AO for scientific payload, including science ground segment elements, for the M3 mission candidates
October 5, 2012	Deadline for submission of (**mandatory**) Letters of Intent
October 10, 2012	Briefing meeting
November 30, 2012	**Proposals due**
December 14, 2012	Letters of Endorsement from Funding Agencies due
November 2012 - January 2013	Proposals evaluation
January-February 2013	Recommendations from ESA Advisory Structure
February 2013	Science Program Committee selection
February 2013	Preliminary technical KO of payload studies (in parallel with industrial studies extension phase)
September-October 2013	M3 candidate missions Preliminary Requirements Review (PRR)
End 2013	M3 mission selection process completed
May 2014	Kick-off definition phase (Phase B1) of the selected mission Request to Consortium(a) of the selected mission for an updated set of documents
July 2014	Updated set of documents by Consortium(a) due
June-July 2015	M3 selected mission System Requirements Review (SRR)
November 2015	Mission adoption and MLA signature
October 2016	Kick-off selected M3 mission implementation phase (B2/C/D)

COSMIC VISION – Small Missions

- Novel component within the ESA Science Programme
- Call to the scientific community for novel ideas and explore approaches complementary to the current (L-M) components of the ESA Science Programme
  - ***26 proposals submitted***
- The Call imposed strict limits on the cost of the missions that can be implemented under the advertised scheme
- Small-size missions with a development time not exceeding 4 years
- Proposals can address all areas of space science



Cheops mission selected on 19 October 2012

CM 2012 – Revisiting Cosmic Vision

- ESA Science Program budget is decided at ministerial-level conferences with a 5 yr horizon
- Next ministerial conference in November 2012
- Purchasing power in 2013-2017 to be decided

COSMIC VISION (2015-2035)

COOPERATION

- **International cooperation:**
  a. Maintain cooperation with traditional partners (NASA)
  b. Consolidate partnership with Japan
  c. Consolidate cooperation with Russia
  d. Open cooperation with China
  e. Avoid cooperation at 50/50 level

- **Partnership with National agencies:**
  a. 30-40% of the programme with national contributions (instruments, their operation and exploitation)
  b. Specific calls for small missions to trigger cooperation between Member States
  c. Missions of Opportunity (open to contribution to national projects)

Conclusions