The ESA Science Programme

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ESA – ESTEC

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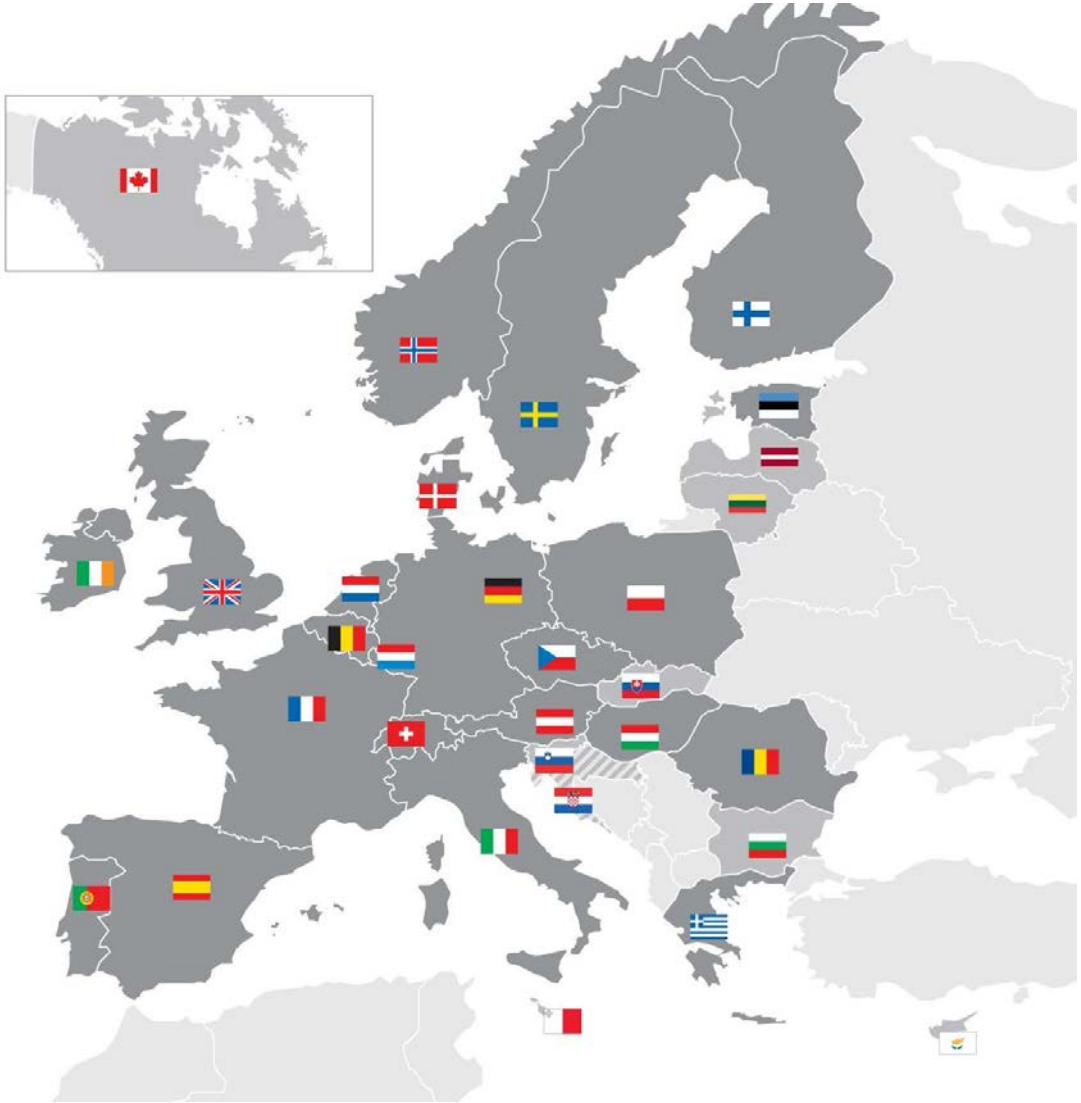
Plan of the talk

- ESA and the Science Programme
- Missions overview
- The future

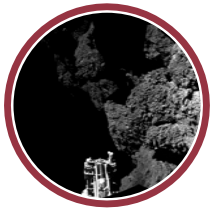
TOPIC I

1. ESA and the Science Programme

Member States



Activities



space science

human spaceflight

exploration

earth observation

launchers

navigation

operations

technology

telecommunications

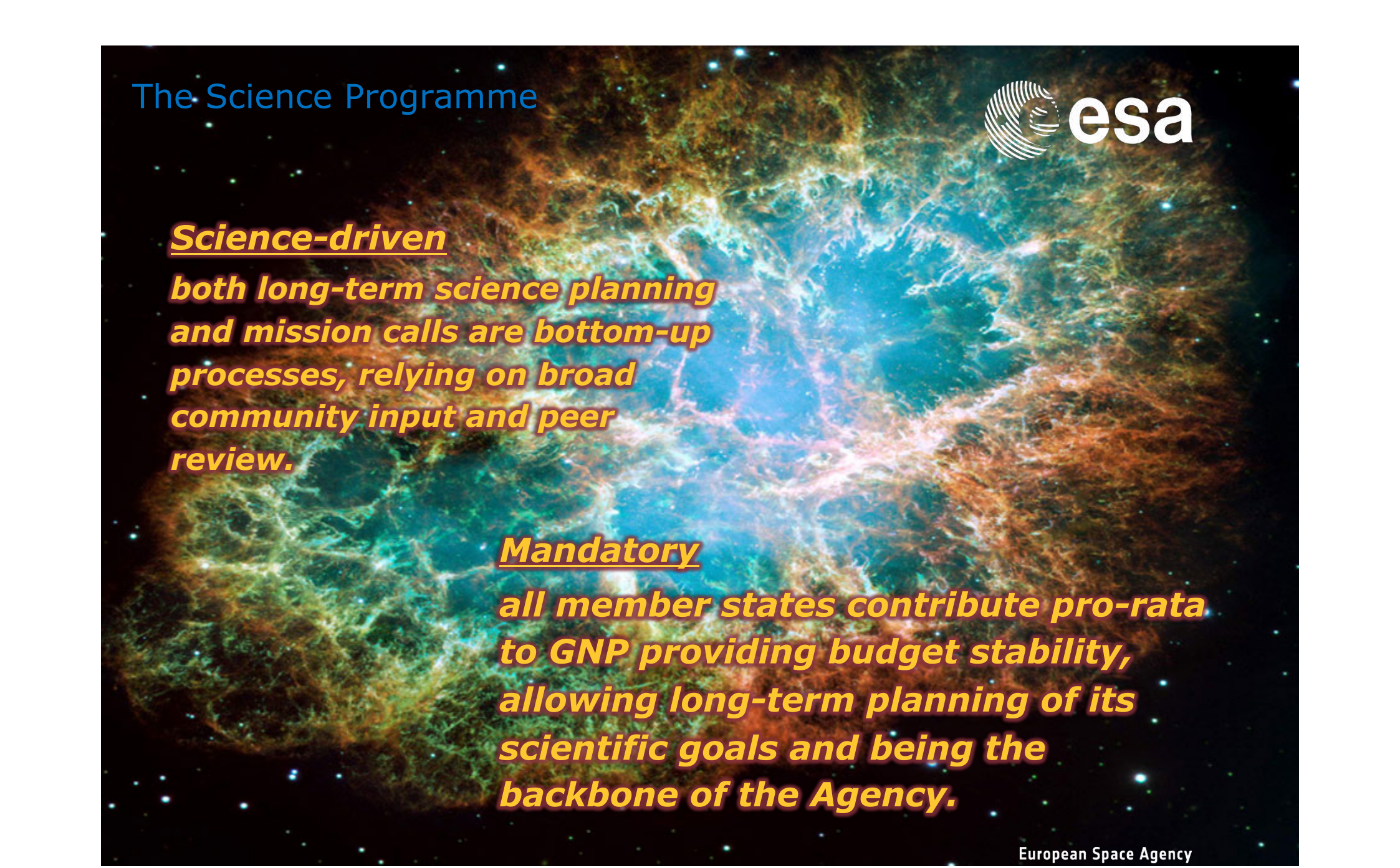
The Science Programme

Science-driven

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

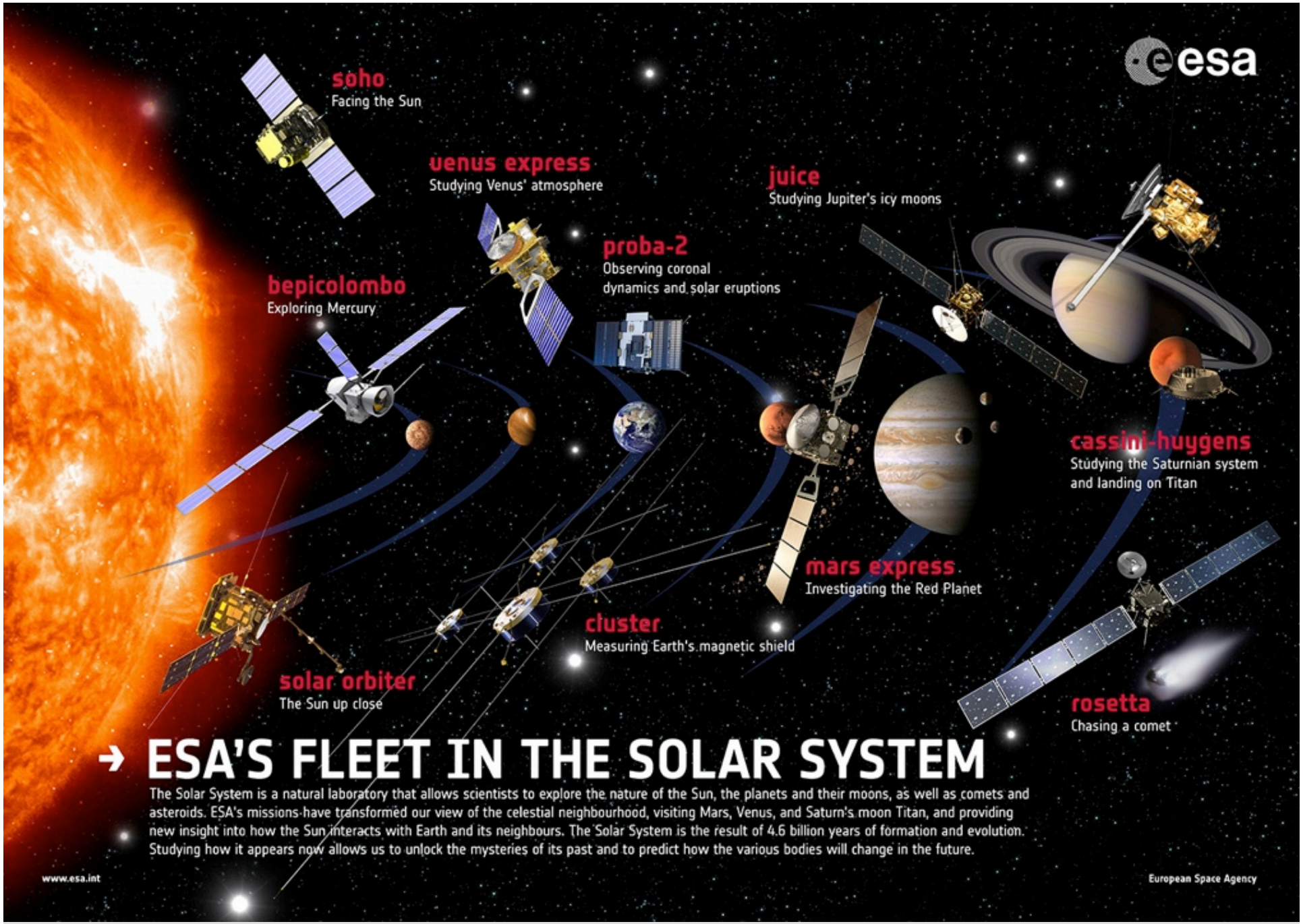
Mandatory

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



European Space Agency

2. Missions overview

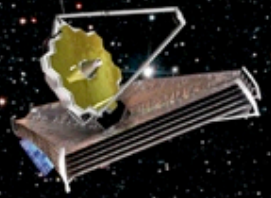

esa
soho
Facing the Sun
venus express
Studying Venus' atmosphere
juice
Studying Jupiter's icy moons
proba-2
Observing coronal
dynamics and solar eruptions
bepicolombo
Exploring Mercury
cassini-huygens
Studying the Saturnian system
and landing on Titan
mars express
Investigating the Red Planet
cluster
Measuring Earth's magnetic shield
solar orbiter
The Sun up close
rosetta
Chasing a comet
ESA'S FLEET IN THE SOLAR SYSTEM
The Solar System is a natural laboratory that allows scientists to explore the nature of the Sun, the planets and their moons, as well as comets and asteroids. ESA's missions have transformed our view of the celestial neighbourhood, visiting Mars, Venus, and Saturn's moon Titan, and providing new insight into how the Sun interacts with Earth and its neighbours. The Solar System is the result of 4.6 billion years of formation and evolution. Studying how it appears now allows us to unlock the mysteries of its past and to predict how the various bodies will change in the future.
www.esa.int
European Space Agency

→ ESA'S FLEET ACROSS THE SPECTRUM

esa

Thanks to cutting edge technology, astronomy is unveiling a new world around us. With ESA's fleet of spacecraft, we can explore the full spectrum of light and probe the fundamental physics that underlies our entire Universe. From cool and dusty star formation revealed only at infrared wavelengths, to hot and violent high-energy phenomena, ESA missions are charting our cosmos and even looking back to the dawn of time to discover more about our place in space.

jwst
Observing the first light



gaia
Surveying a billion stars

herschel
Unveiling the cool and dusty Universe

planck
Looking back at the dawn of time

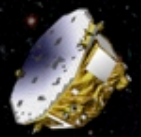
cheops
Sizing and first characterisation of exoplanets

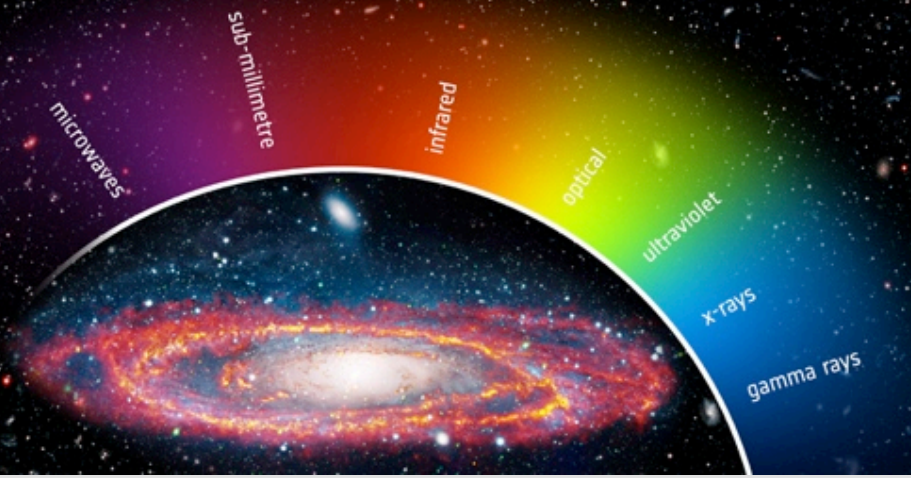
euclid
Exploring the dark Universe

hst
Expanding the frontiers of the visible Universe

xmm-newton
Seeing deeply into the hot and violent Universe

lisa pathfinder
Testing the technology for gravitational wave detection





integral
Seeking out the extremes of the Universe

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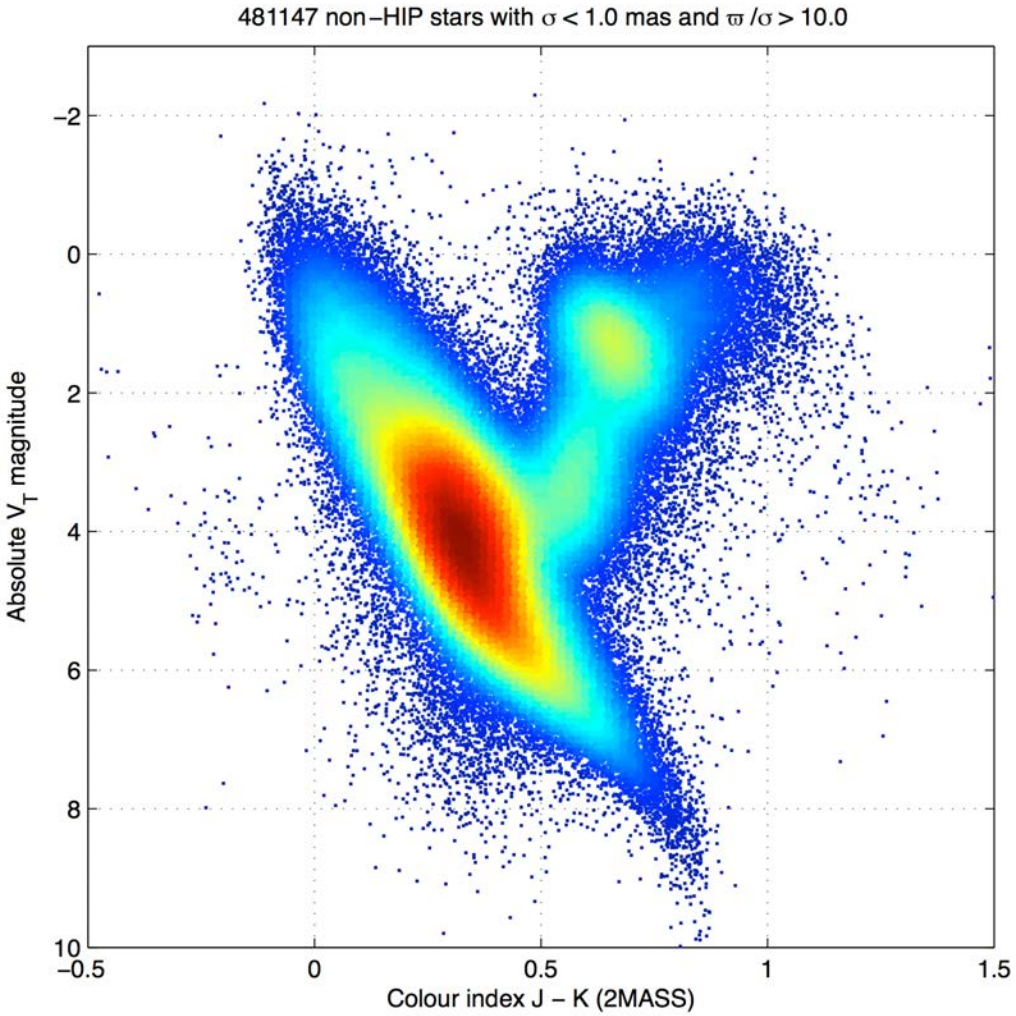
European Space Agency

GAIA Summary

GAIA Data release => 14 September 2016

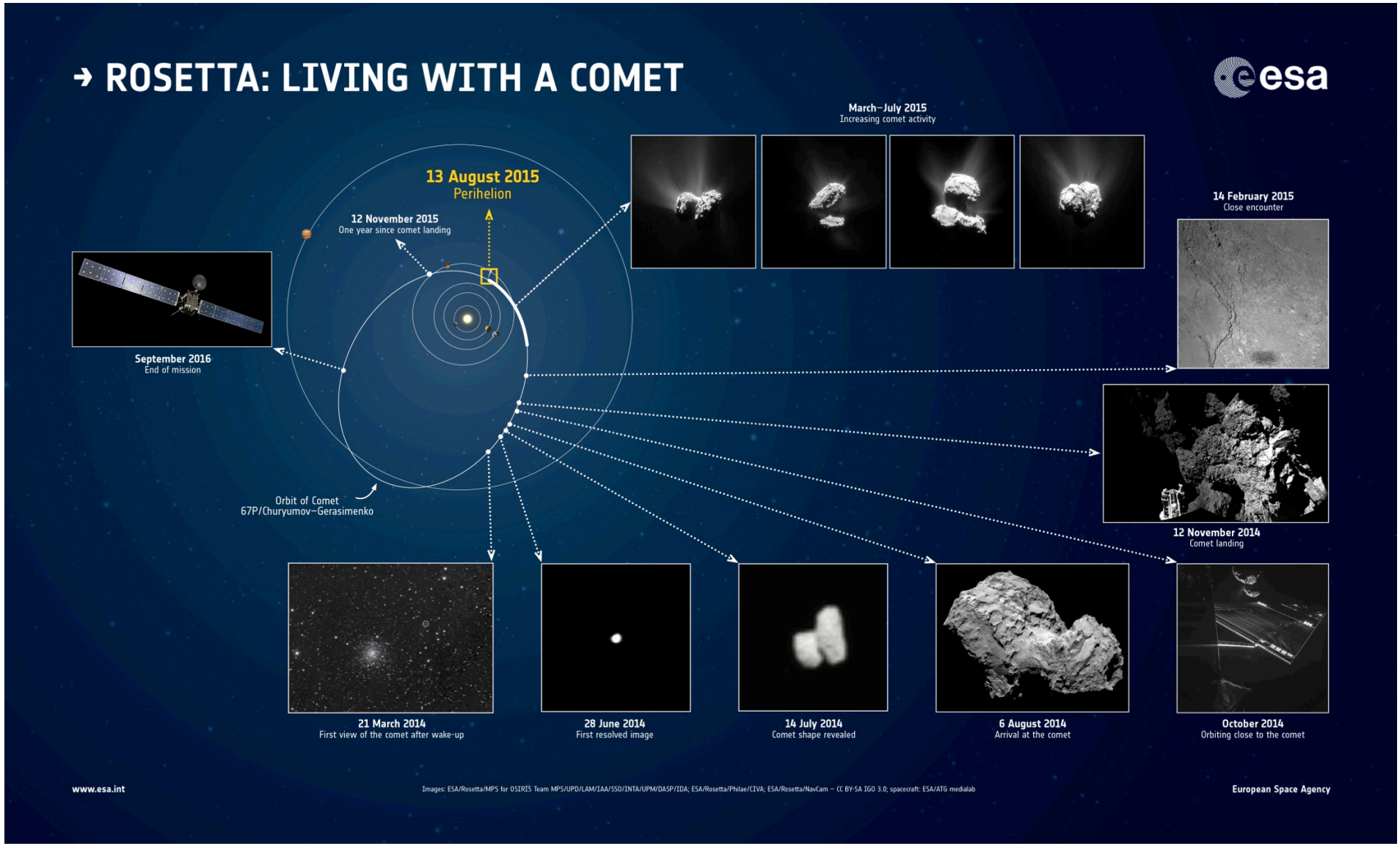


The Hertzsprung-Russell diagram based on the parallaxes from the Tycho Gaia Astrometric Solution. Only new parallaxes with error less than 1 milliarcsec and 10% are included.

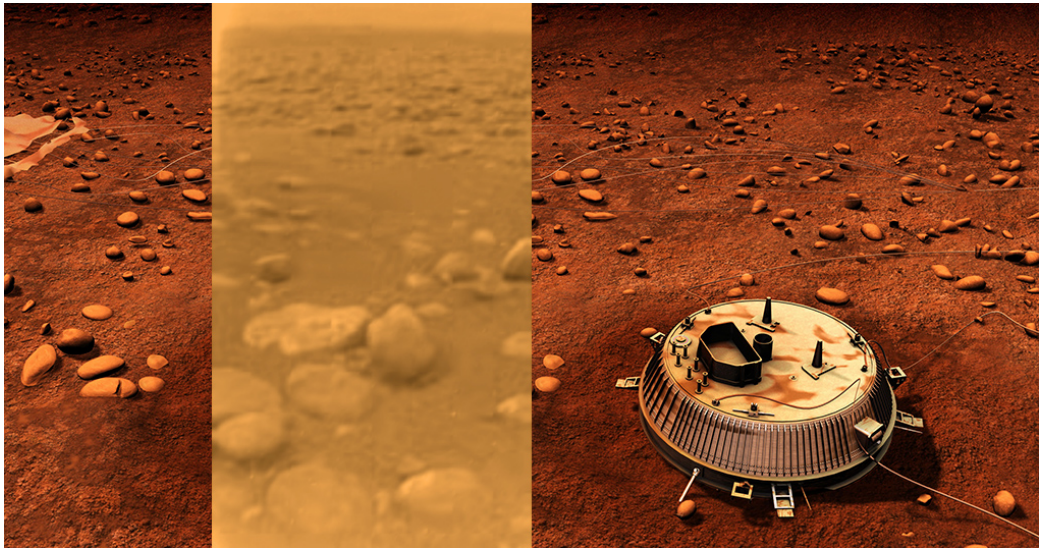
credits: ESA/Gaia/DPAC/IDT/FL/DPCE/AGIS

Lisa Pathfinder

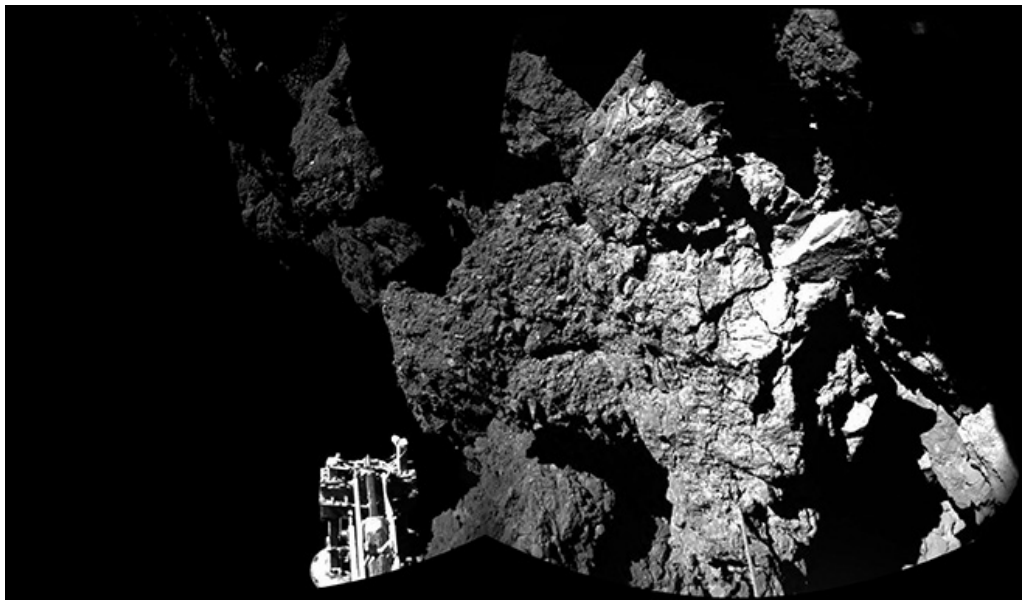
Rosetta

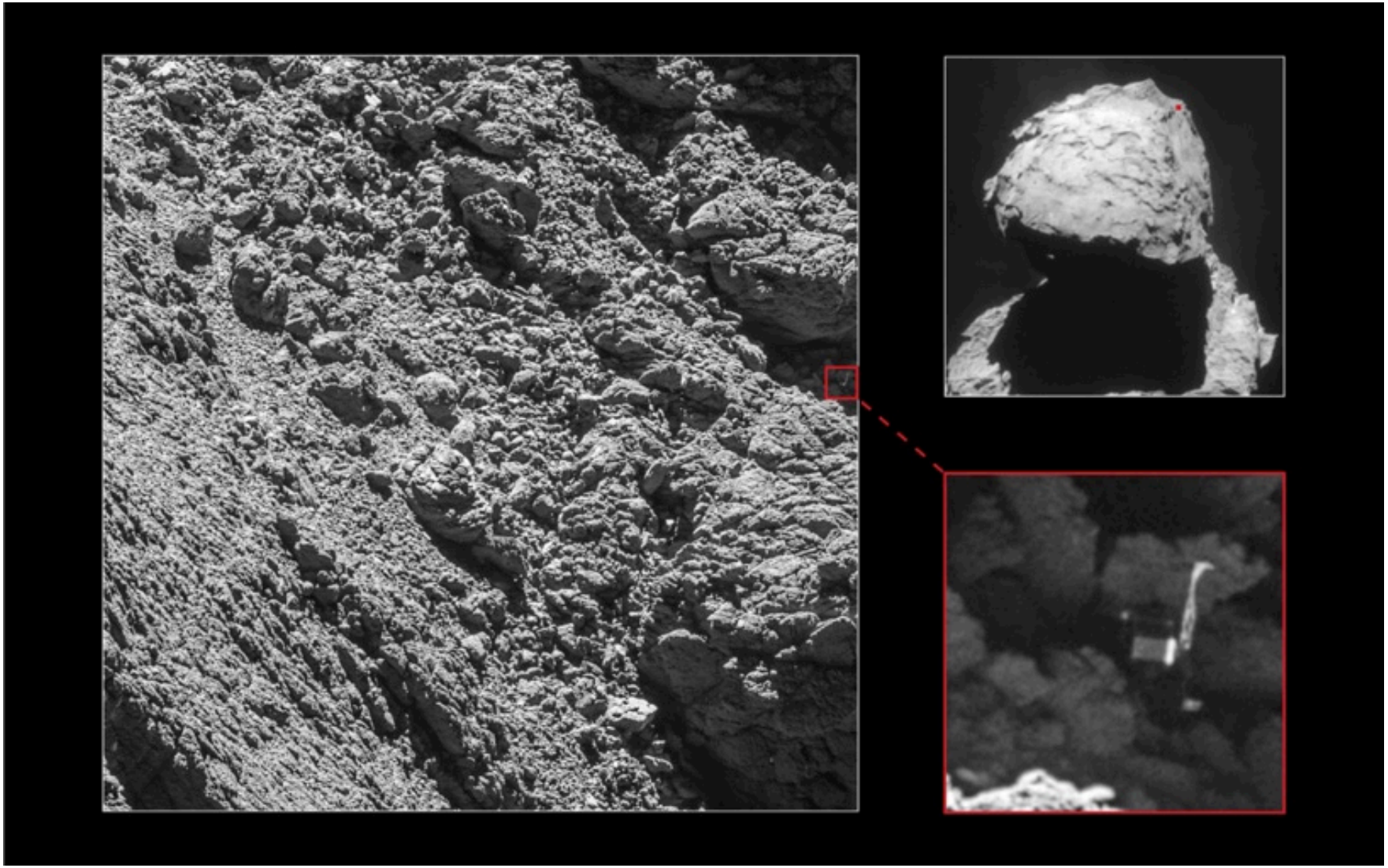

→ ROSETTA: LIVING WITH A COMET
esa
March–July 2015
Increasing comet activity
13 August 2015
Perihelion
12 November 2015
One year since comet landing
14 February 2015
Close encounter
September 2016
End of mission
Orbit of Comet
67P/Churyumov–Gerasimenko
12 November 2014
Comet landing
21 March 2014
First view of the comet after wake-up
28 June 2014
First resolved image
14 July 2014
Comet shape revealed
6 August 2014
Arrival at the comet
October 2014
Orbiting close to the comet
www.esa.int
Images: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA; ESA/Rosetta/Philae/CIVA; ESA/Rosetta/NavCam – CC BY-SA IGO 3.0; spacecraft: ESA/ATG medialab
European Space Agency

First landing on a world in the outer Solar System



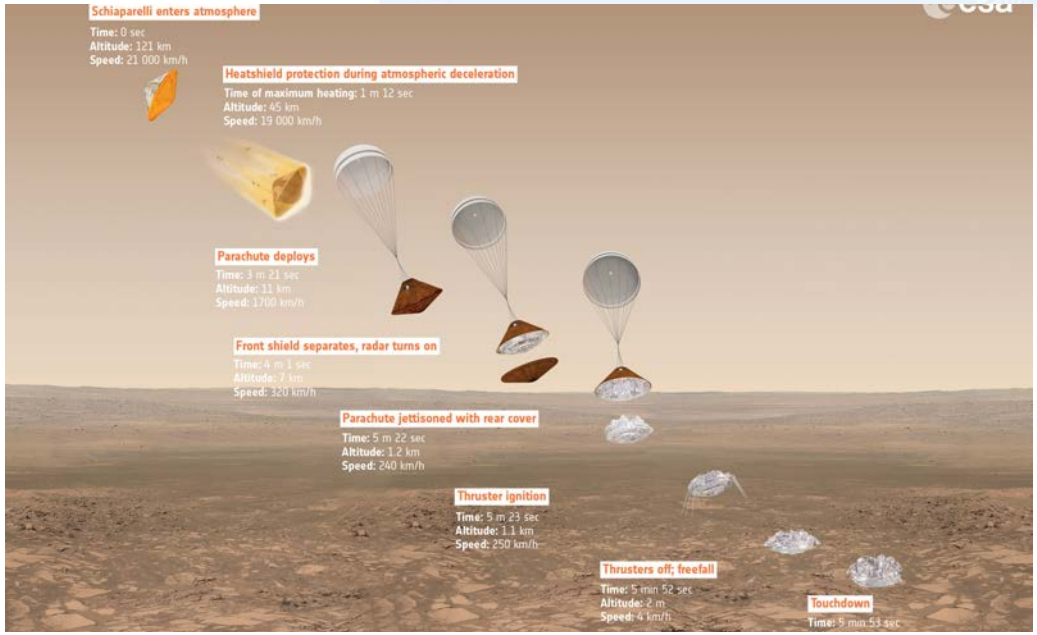
First rendezvous, orbit and soft-landing on a comet



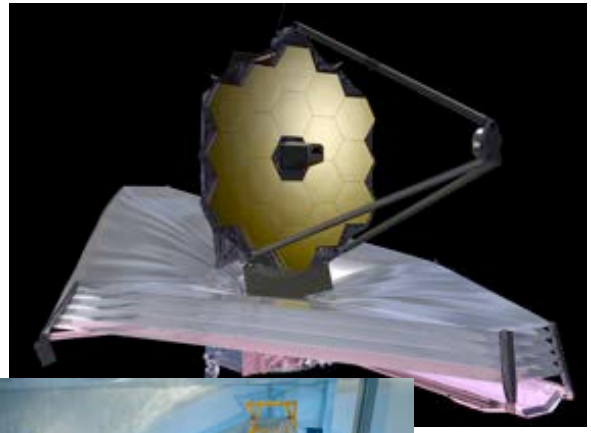


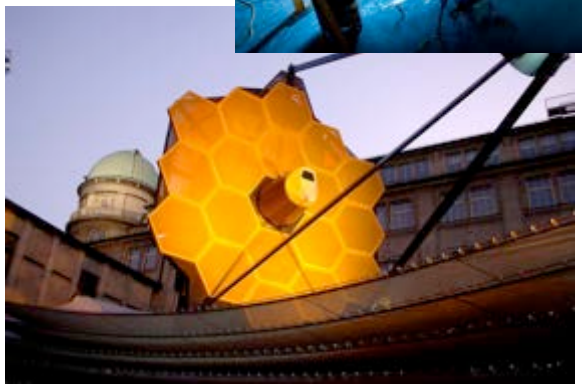
ExoMars and the European Robotic Exploration Program

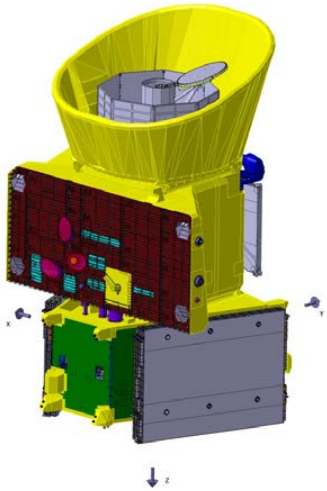
EDL Landing scheduled 19 October

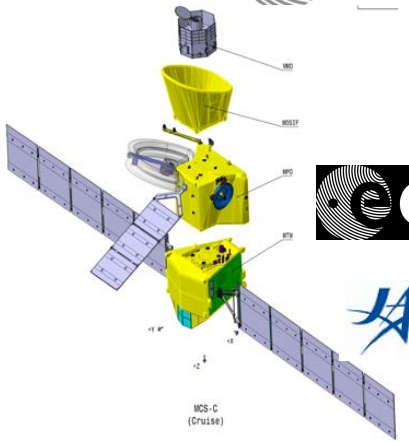


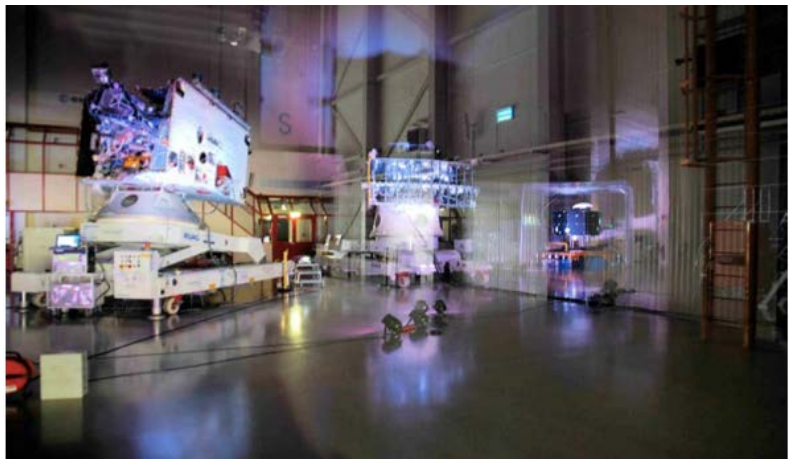
James Webb Space Telescope (JWST) and BepiColombo









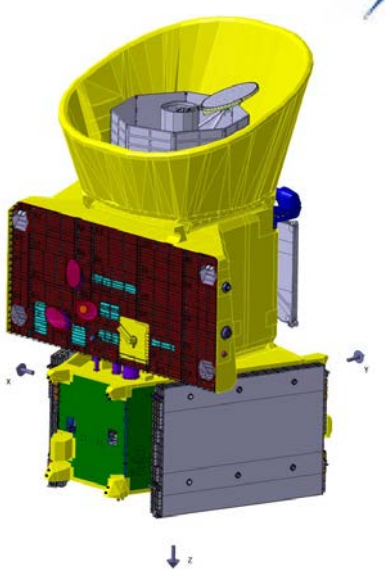


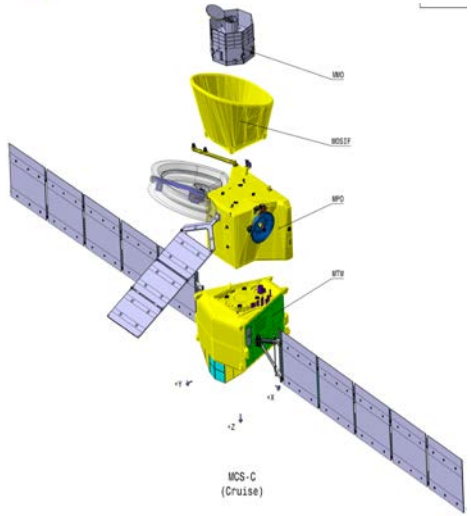
BepiColombo

bepicolombo

Science Objectives:

- Origin and evolution
- Interior, structure, geology, composition
- Exosphere composition and dynamic
- Magnetosphere structure and dynamics
- Origin of Mercury's magnetic field
- Test of Einstein's theory of general relativity



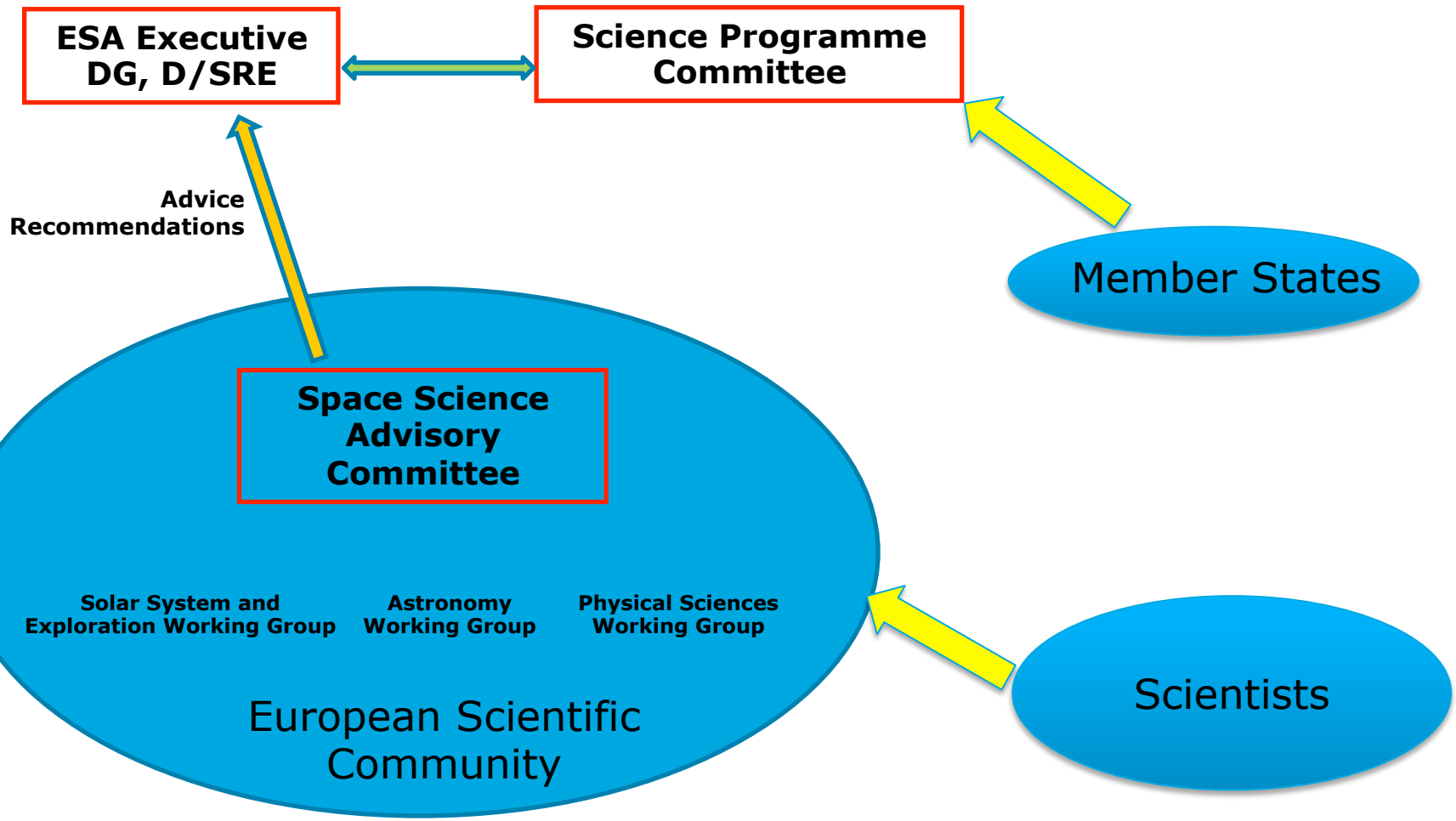


Dual spacecraft mission:

- MPO (Mercury Planetary Orbiter) from ESA focuses on surface and interior science
- MMO (Mercury Magnetospheric Orbiter) from JAXA focuses on Mercury's magnetic environment
- *BepiColombo will follow up on MESSENGER results*

3. The future of the Science Programme

A bottom-up approach

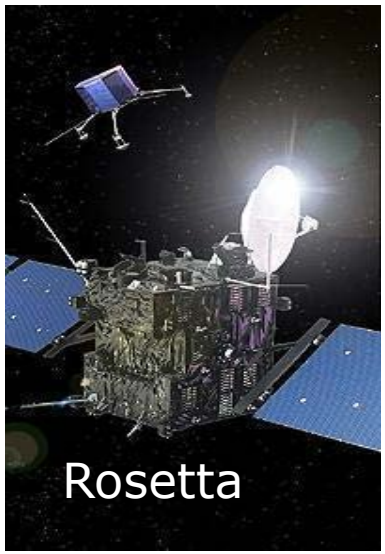


The elements

The building blocks of the programme include:

a. **L-missions**, large European led flagship missions with a cost to ESA of around 2 annual budgets, one every 7-8 years.

- High innovation content
- European flagships



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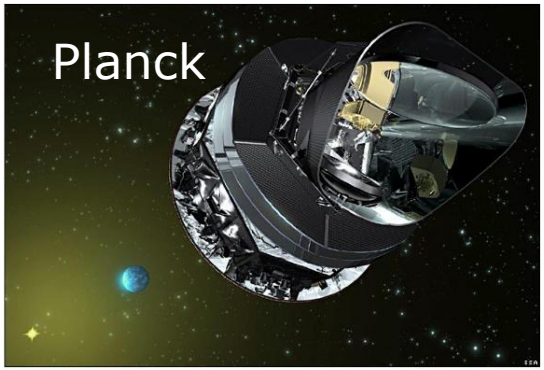
b. **M-missions**, provide the programme with flexibility. ESA led or implemented through international collaboration. Cost to ESA of around one annual budget, one every 3-4 years.

- Makes use of current cutting-edge technology
- Programme workhorse



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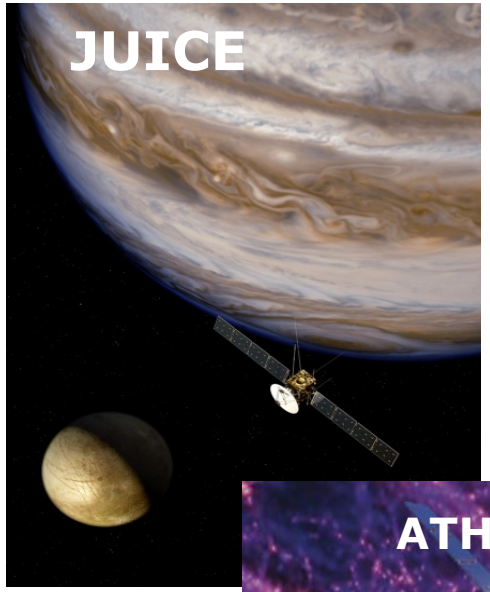
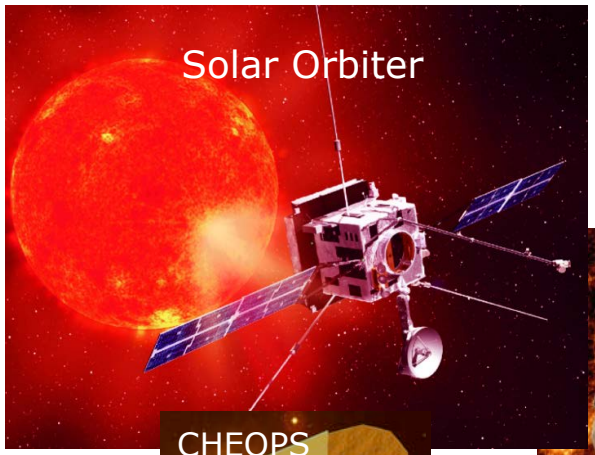
c. **S-missions**, new concept allowing national agencies to play a leading role in missions, 0.1 annual budgets, one every 4 years, potentially.

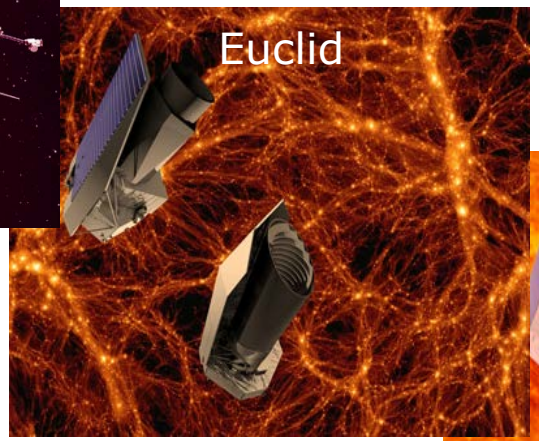
d. **O-missions**, which are "missions of opportunity", led by other agencies, small contributions.

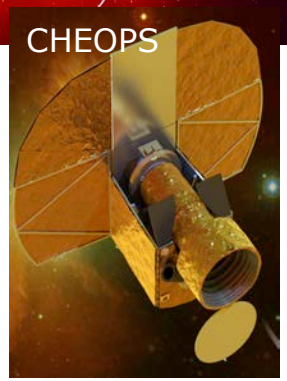
COSMIC VISION

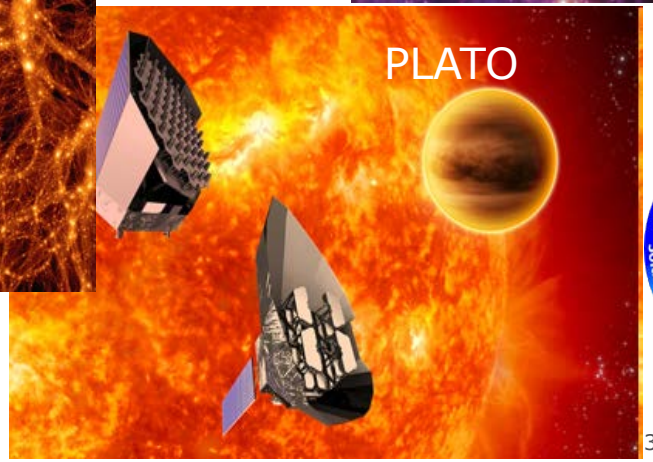
- **Selection of Solar Orbiter as M1 and Euclid as M2 in 2011**
- **Selection of JUICE as L1 in 2012**
- **Selection of CHEOPS as S1 in 2012**
- **Selection of L2 and L3 “themes” in 2013: “The hot and energetic Universe” and “The gravitational Universe”**
- **Selection of PLATO in early 2014 as M3**
- **Selection of ATHENA in June 2014 as L2**
- **Selection of SMILE in Nov. 2015 as ESA-CAS joint mission**

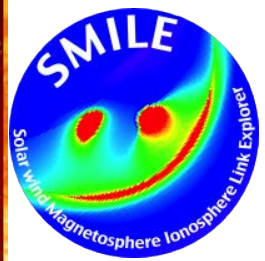






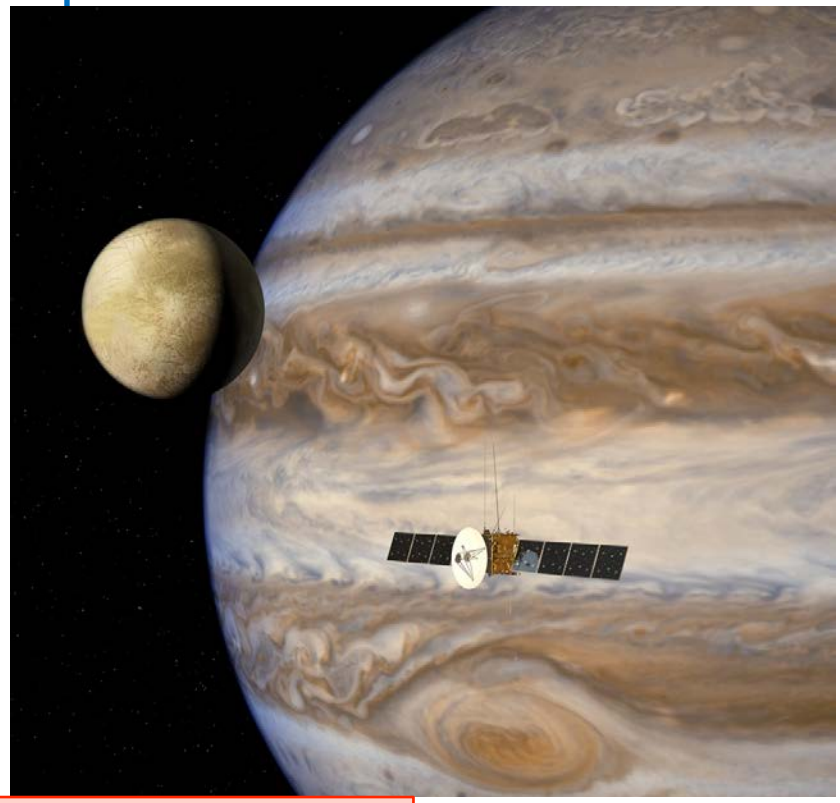


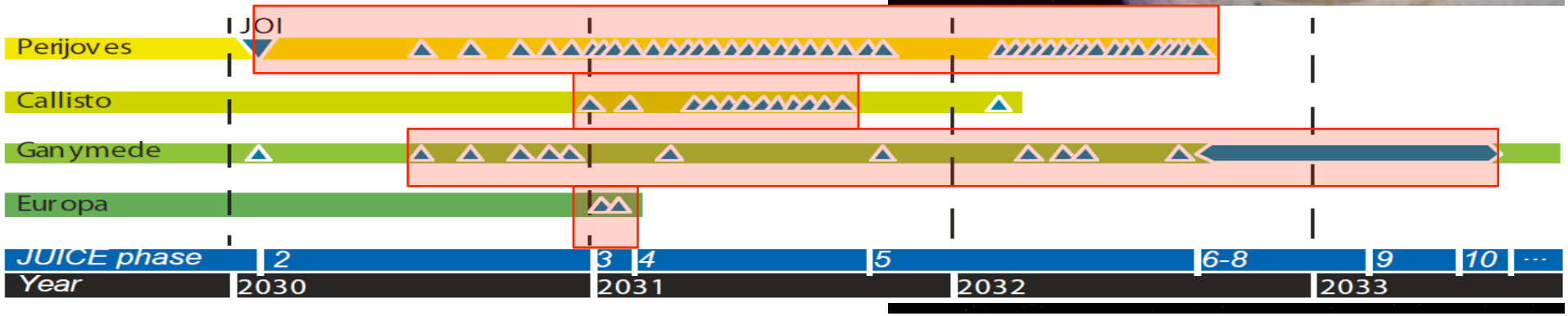




L1 - JUICE: JUpiter Icy moons Explorer

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

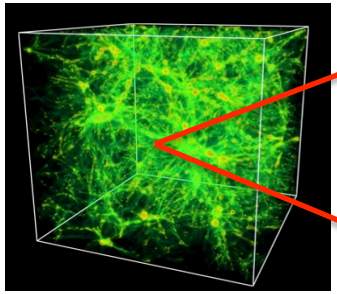




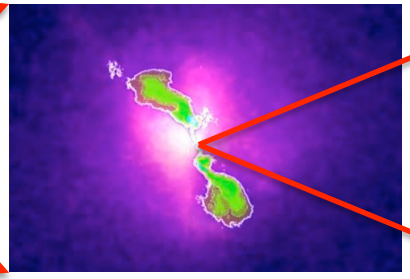
L2 – Athena

- Athena is ESA's large X-ray observatory, under study for a launch in 2028. Was selected by the SPC in June 2014.

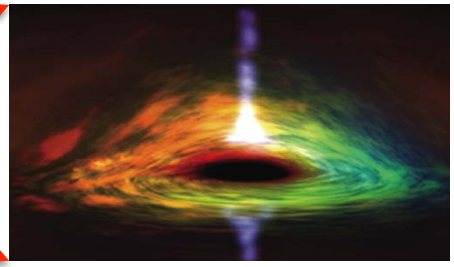
- It will fulfill the science objectives defined in the Senior Survey Committee's "Hot and Energetic Universe" science theme for the L2 launch opportunity.



Cosmic Web



Feedback Processes



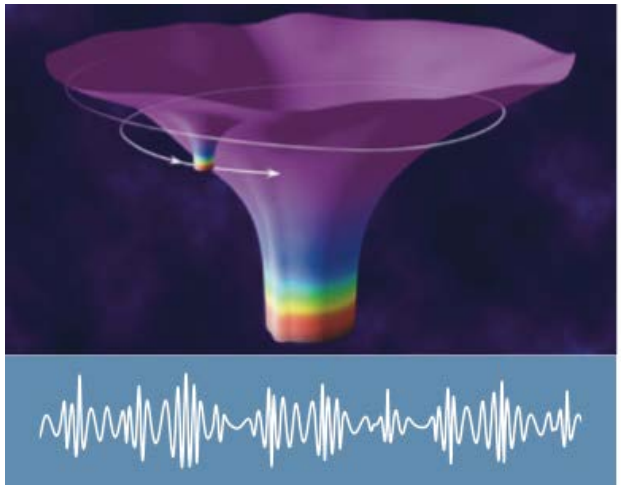
Black Hole Accretion

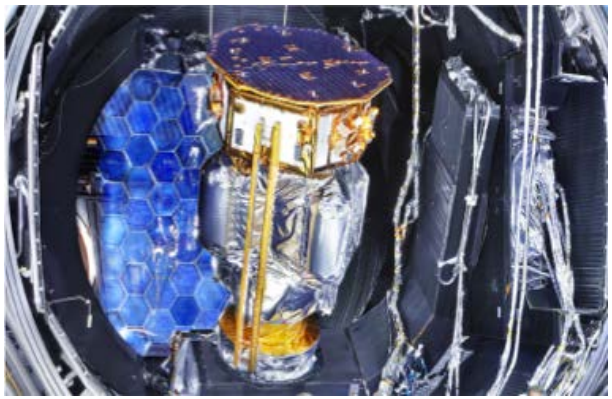
L3 Science Theme:
The Gravitational Universe

- ESA appointed an advisory team to evaluate and recommend on possible scientific and technical approaches for a launch in 2034.

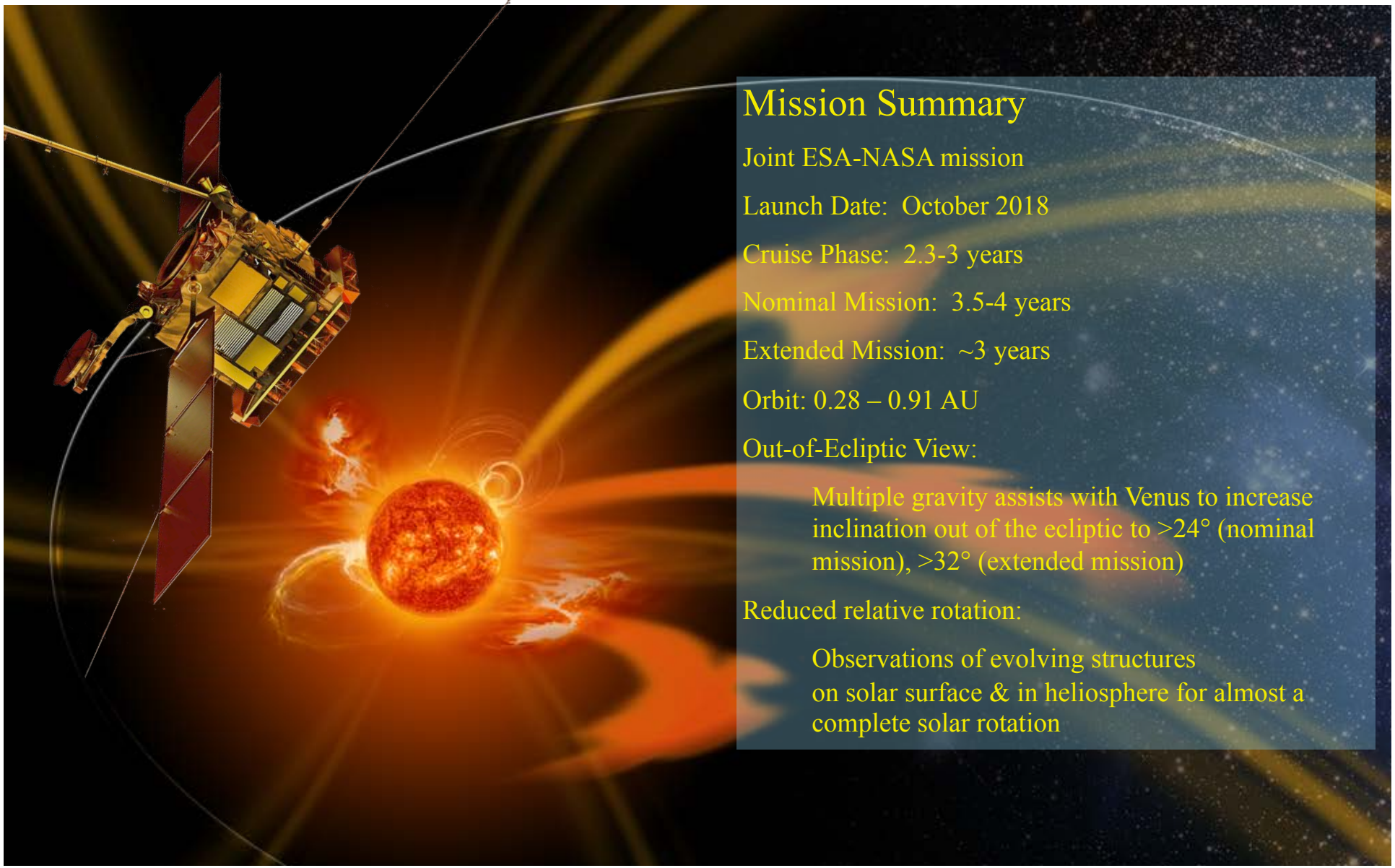
- Final report available:

  http://www.cosmos.esa.int/web/GOAT





Solar Orbiter – M1: Exploring the Sun-Heliosphere Connection



Mission Summary

Joint ESA-NASA mission

Launch Date: October 2018

Cruise Phase: 2.3-3 years

Nominal Mission: 3.5-4 years

Extended Mission: ~3 years

Orbit: 0.28 – 0.91 AU

Out-of-Ecliptic View:

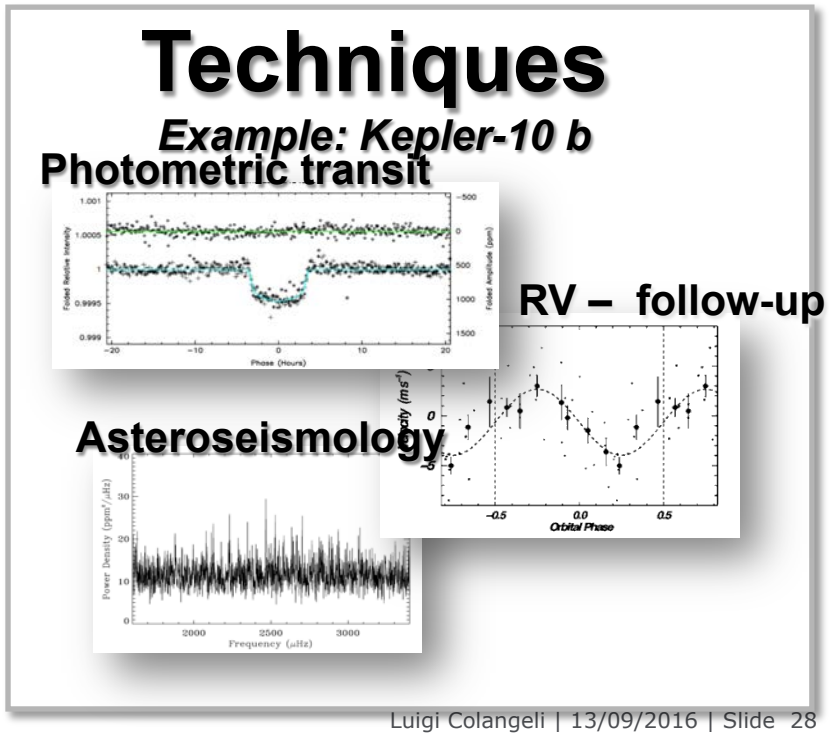
- Multiple gravity assists with Venus to increase inclination out of the ecliptic to >24° (nominal mission), >32° (extended mission)

Reduced relative rotation:

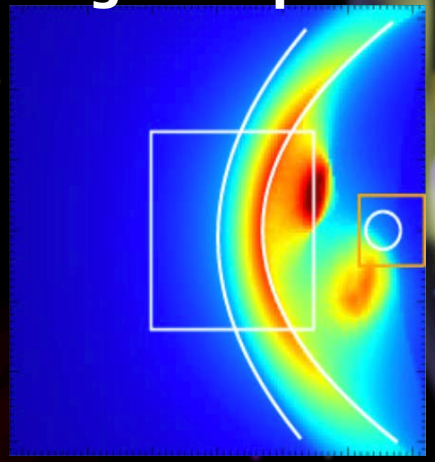
- Observations of evolving structures on solar surface & in heliosphere for almost a complete solar rotation

PLATO – M3

- Detect and characterise Earth-like planets (1-10 Earth masses, 1-2 Earth radii) in the habitable zone of bright solar like stars:
  - radii (down to 2% accuracy, photometric transit method)
  - masses (~10% accuracy, from radial velocity follow-up at ground-based telescopes)
  - mean densities
  - ages (~10% accuracy, astero-seismology analysis)
  - host stars knowledge
- Detect and characterise thousands of rocky, icy and giant planets, the architecture of their planetary system and their host star
- Advance stellar science



ESA – Chinese Academy of Sciences
Joint mission
SMILE
(Solar wind Magnetosphere Ionosphere Link Explorer)



Co-Pis: G. Branduardi-Raymont and C. Wang

Smile will investigate the interaction between Earth's protective shield – the magnetosphere – and the supersonic solar wind

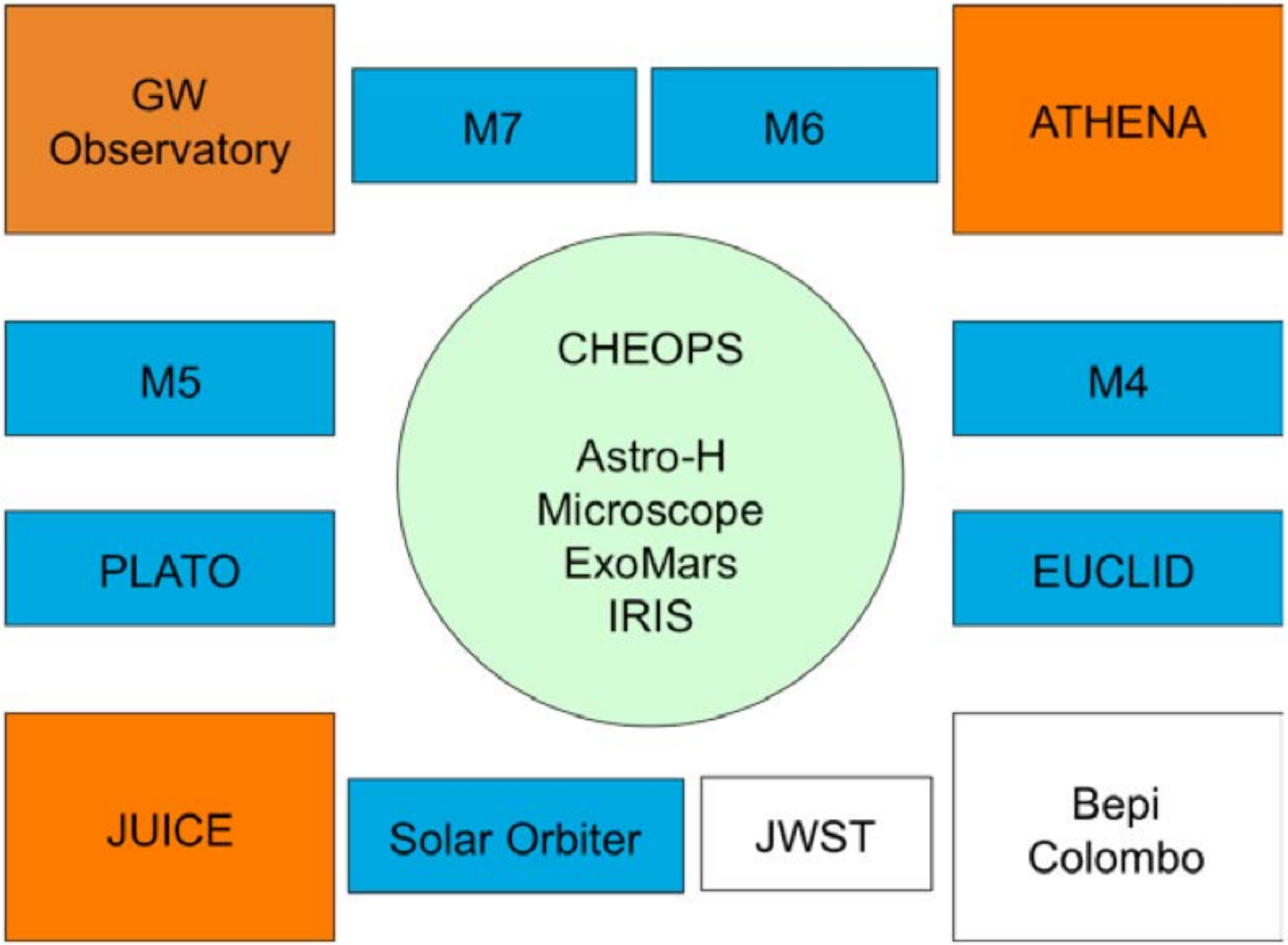
Goal: understanding the physical processes taking place during the continuous interaction between the solar wind and the magnetosphere

Aurora: NASA Polar

Medium missions: typical timeline

Call	T_0
Selection of candidates for study	T_0 + 1.2 yrs.
Phase 0 study completed	T_0 + 1.5 yrs.
Phase A completed / Mission selection	T_0 + 3 yrs.
Mission adoption (TRL 5-6 achieved)	T_0 + 5 yrs.
Development to launch	T_0 + 13 yrs.

Scientific Programme - Plan



Call for new science ideas

Scientific Programme – Level of Resources

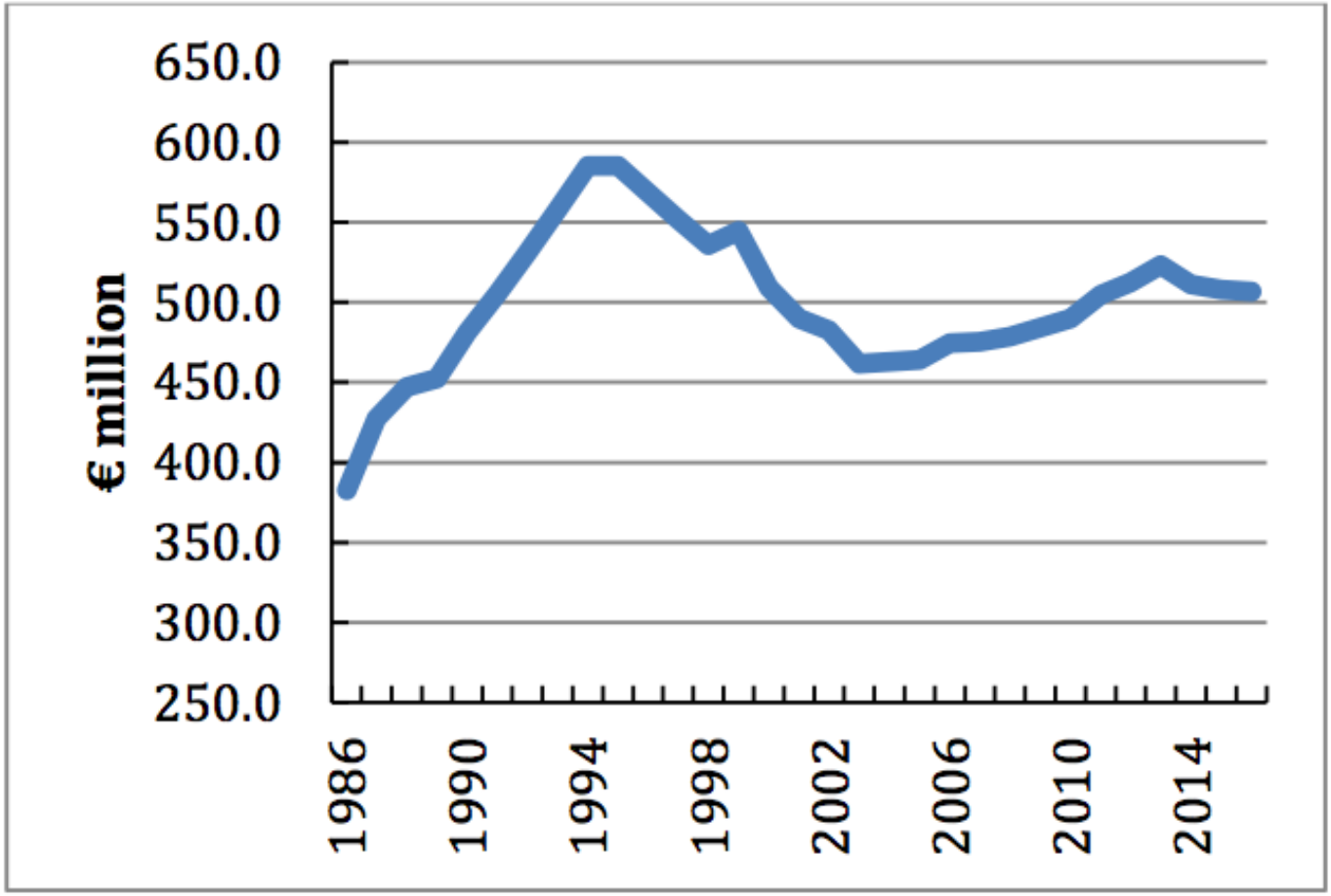


Figure 1: Evolution of the LoR of the Scientific Programme in 2016 e.c.

The future

- The annual budget over five years is decided by unanimity at ESA Council at Ministerial level.
- Last full Ministerial was in 2012 in Naples.
- The ESA Council at Ministerial level, in Luxembourg in 2014, did not include the Science Programme in the Agenda.
- Next Ministerial meeting dealing with the Science Programme is planned for December 2016.
- The next Council at Ministerial level is an important opportunity, the first to take place during the implementation time of Cosmic Vision.