The ESA Science Programme and Associated Technology Preparation

IX SEMINAR,
„ESA SCIENCE &TECHNOLOGY PROGRAMMES,
USER-EXPERIENCE (FINLAND)“
Tartu Observatory, 24.09.2014

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Head of Technology Preparation Section
Science and Robotic Exploration Directorate
ESA

ESA PROGRAMMES

All Member States participate (on a GNP basis) in activities related to space science and a common set of programmes (**Mandatory** programmes).

In addition, Member States choose their level of participation in **Optional** programmes.

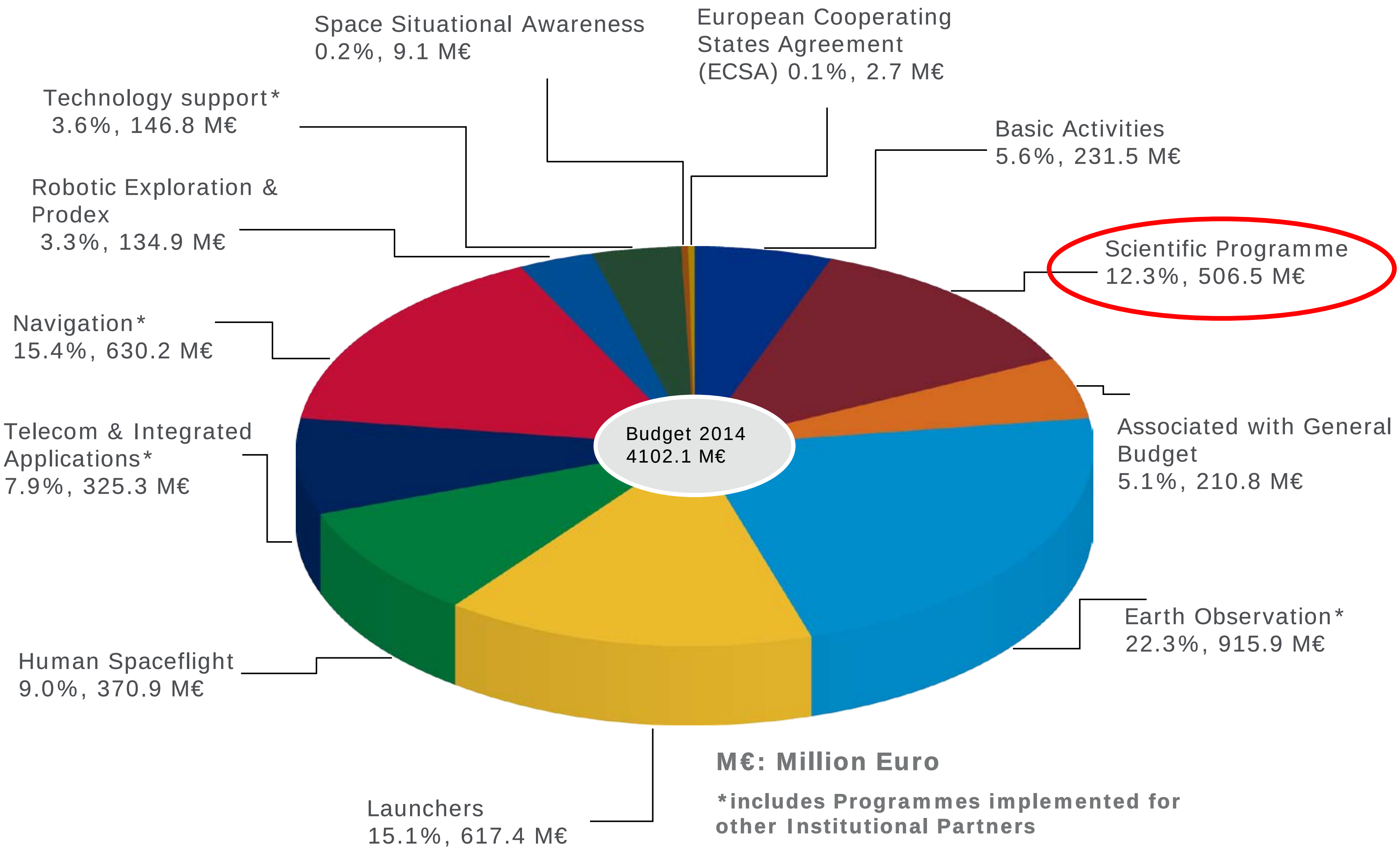
Mandatory

- General Budget: Future studies, technological research, education, common investments (facilities, laboratories, basic infrastructure)
- **Science: Solar System science, astronomy and fundamental physics**

Optional

- Human Spaceflight
- Telecommunications & Integrated Applications
- Earth Observation
- Launchers
- Navigation
- Robotic Exploration
- Space Situational Awareness

ESA 2014 BUDGET BY DOMAIN



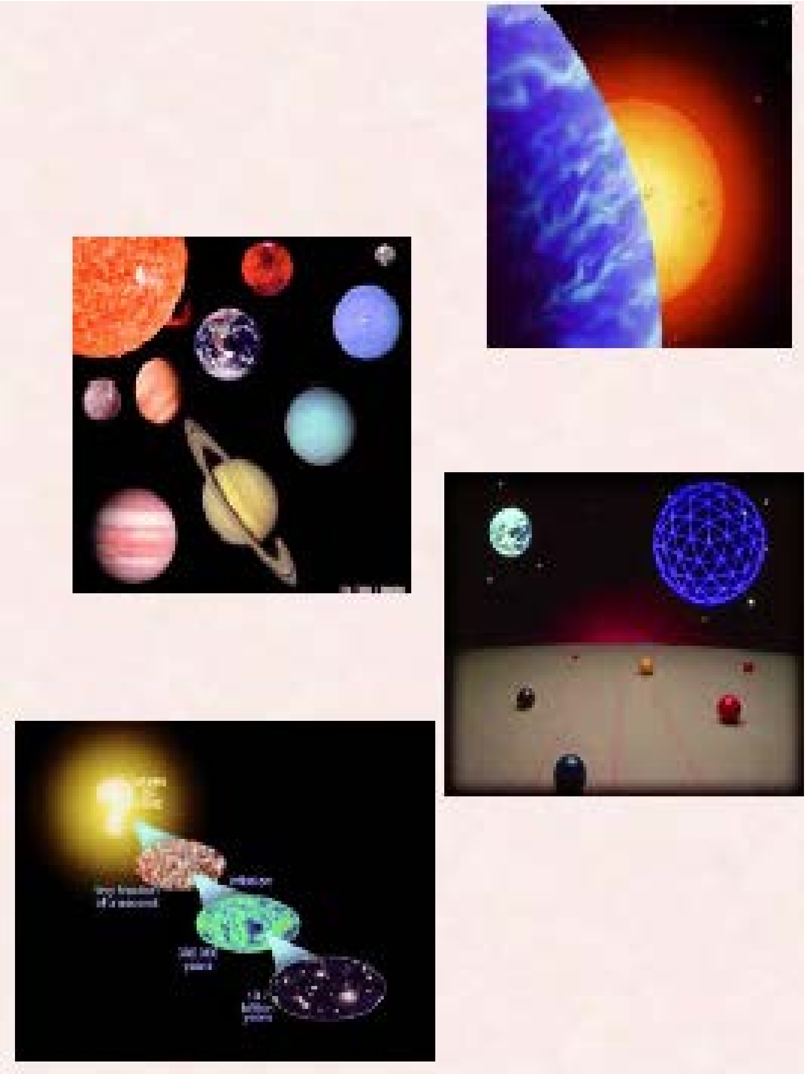
M€: Million Euro

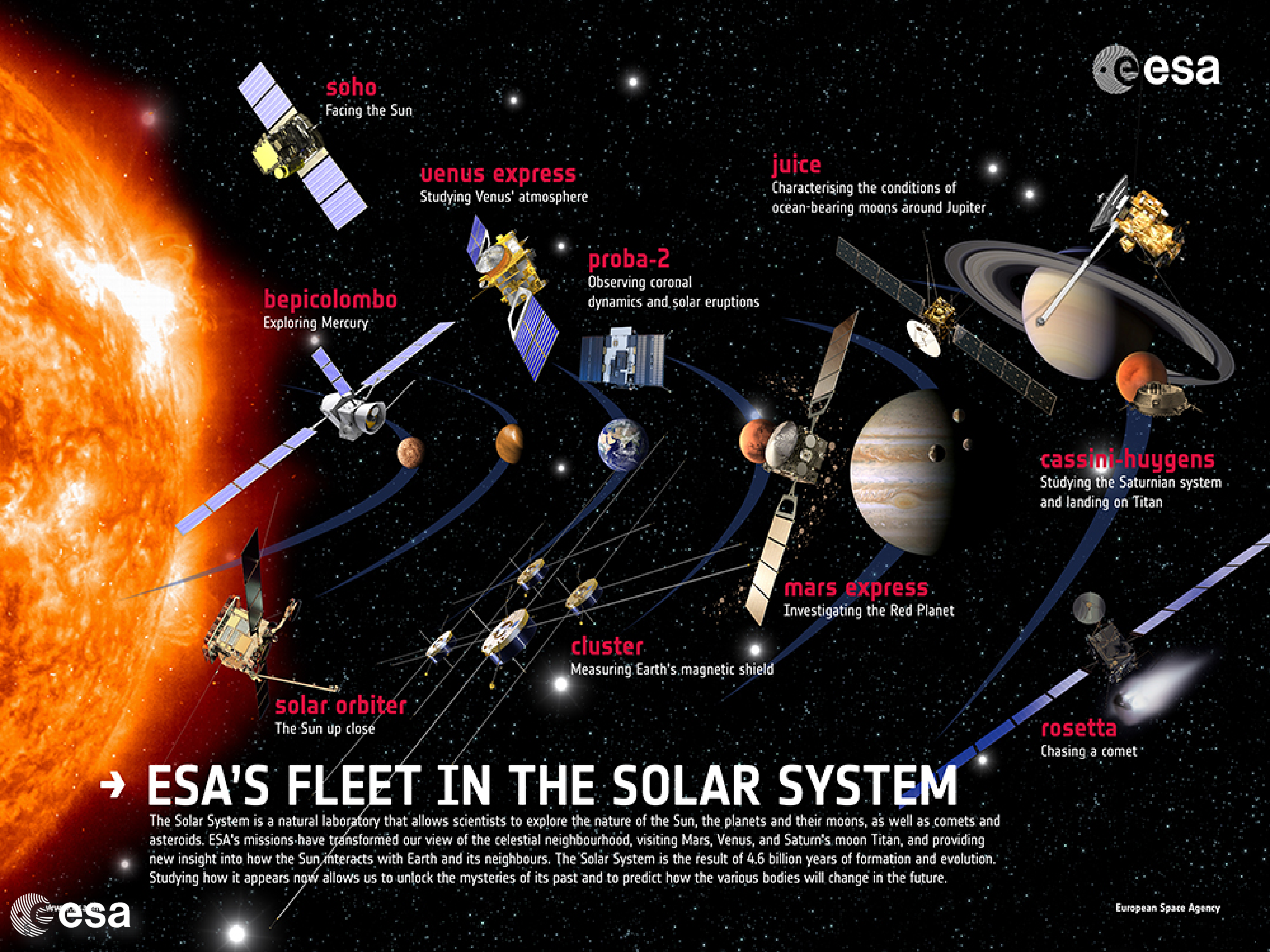
***includes Programmes implemented for other Institutional Partners**

COSMIC VISION "GRAND THEMES"

In 2005 the Cosmic Vision plan was announced covering the Science Programme in the 2015-2025 decade. Four questions were posed:

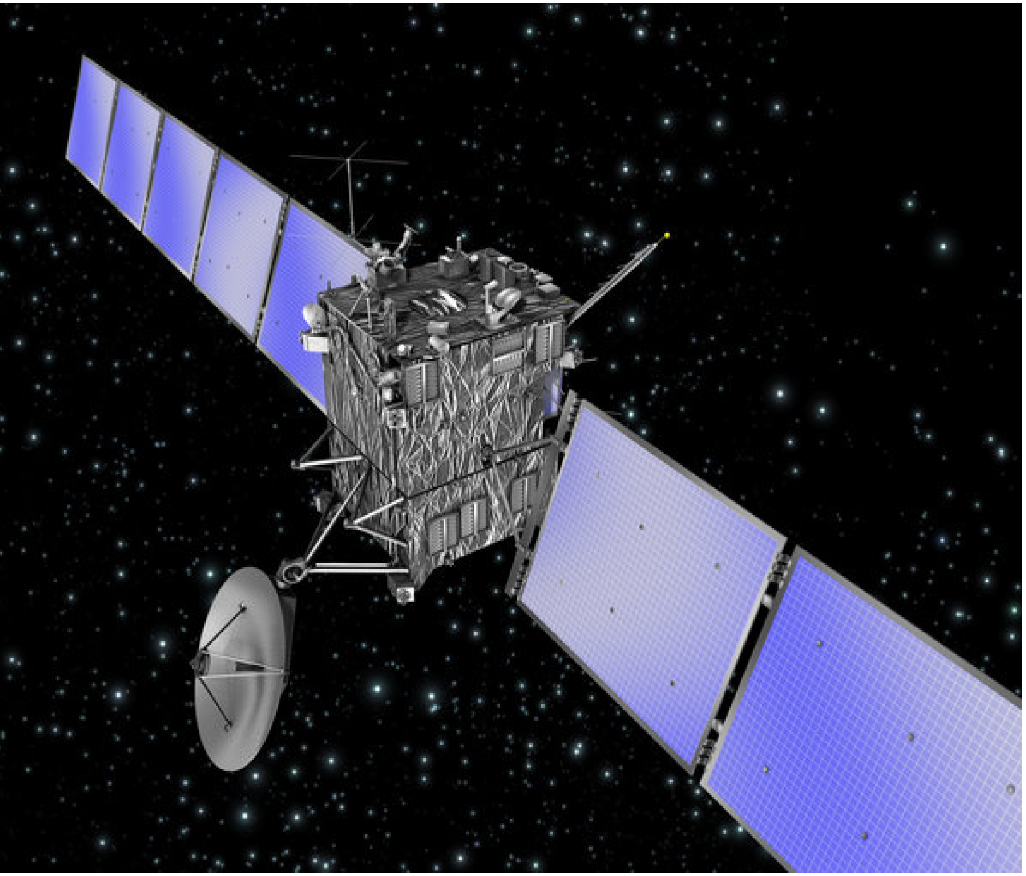
1. What are the conditions for planetary formation and the emergence of life ?
2. How does the Solar System work?
3. What are the physical fundamental laws of the Universe?
4. How did the Universe originate and what is it made of?




soho
Facing the Sun
venus express
Studying Venus' atmosphere
juice
Characterising the conditions of ocean-bearing moons around Jupiter
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.
European Space Agency

ROSETTA - RENDEZ-VOUS WITH A COMET

esa



First mission to **orbit a comet nucleus, and deploy a lander** (Philae) onto its surface

Studying the evolution of the comet's phenomena while it approaches the Sun

Bringing a full **lab to a comet for *in situ*** chemical analysis

Helping to understand if comets contributed to the **origin of life** and the formation of oceans on Earth

Studying two **asteroids** at close quarters during the journey

Helping to understand the **origin and evolution of the Solar System**

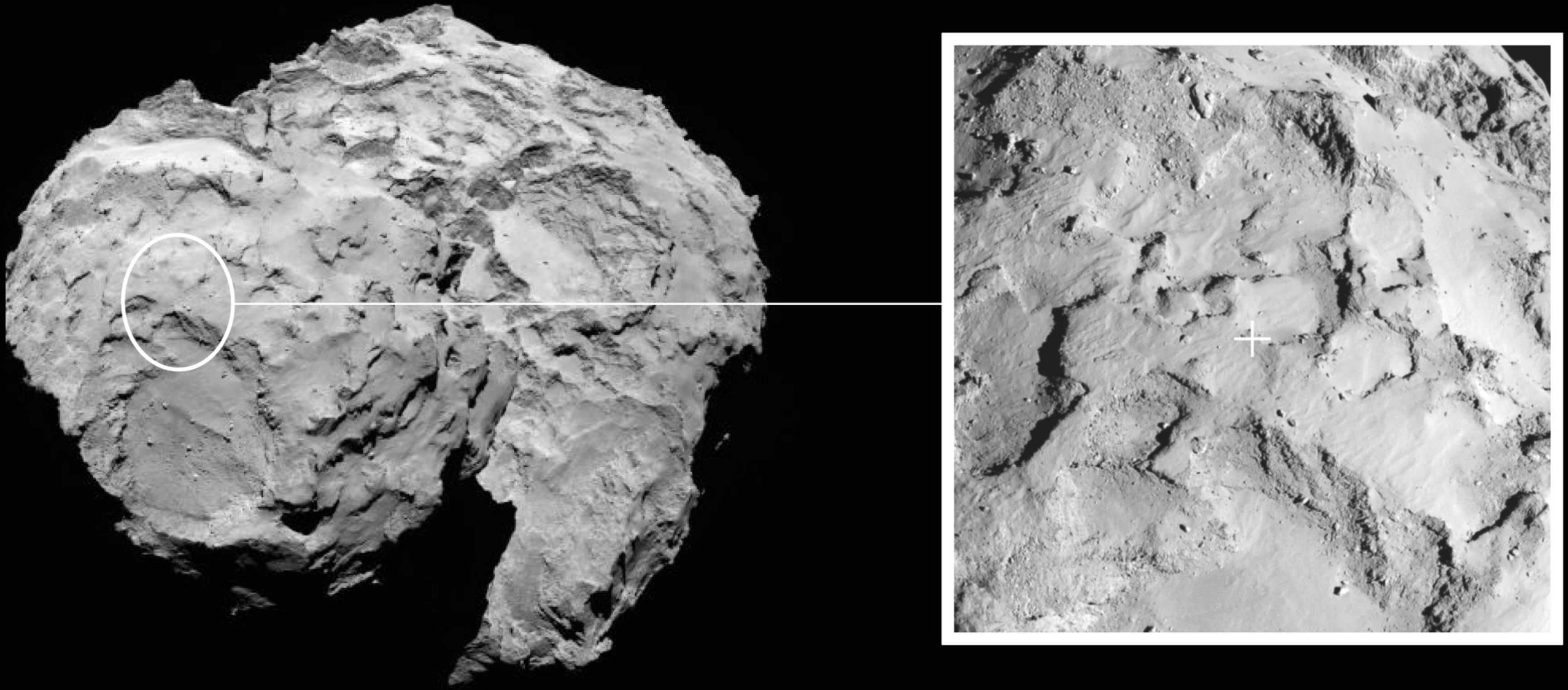
Launch: 2 Mar 2004, Ariane 5 ECA
Gravity assists: Three from the Earth and one from Mars
Asteroid Steins fly-by: 5 Sep 2008
Asteroid Lutetia fly-by:10 Jun 2010

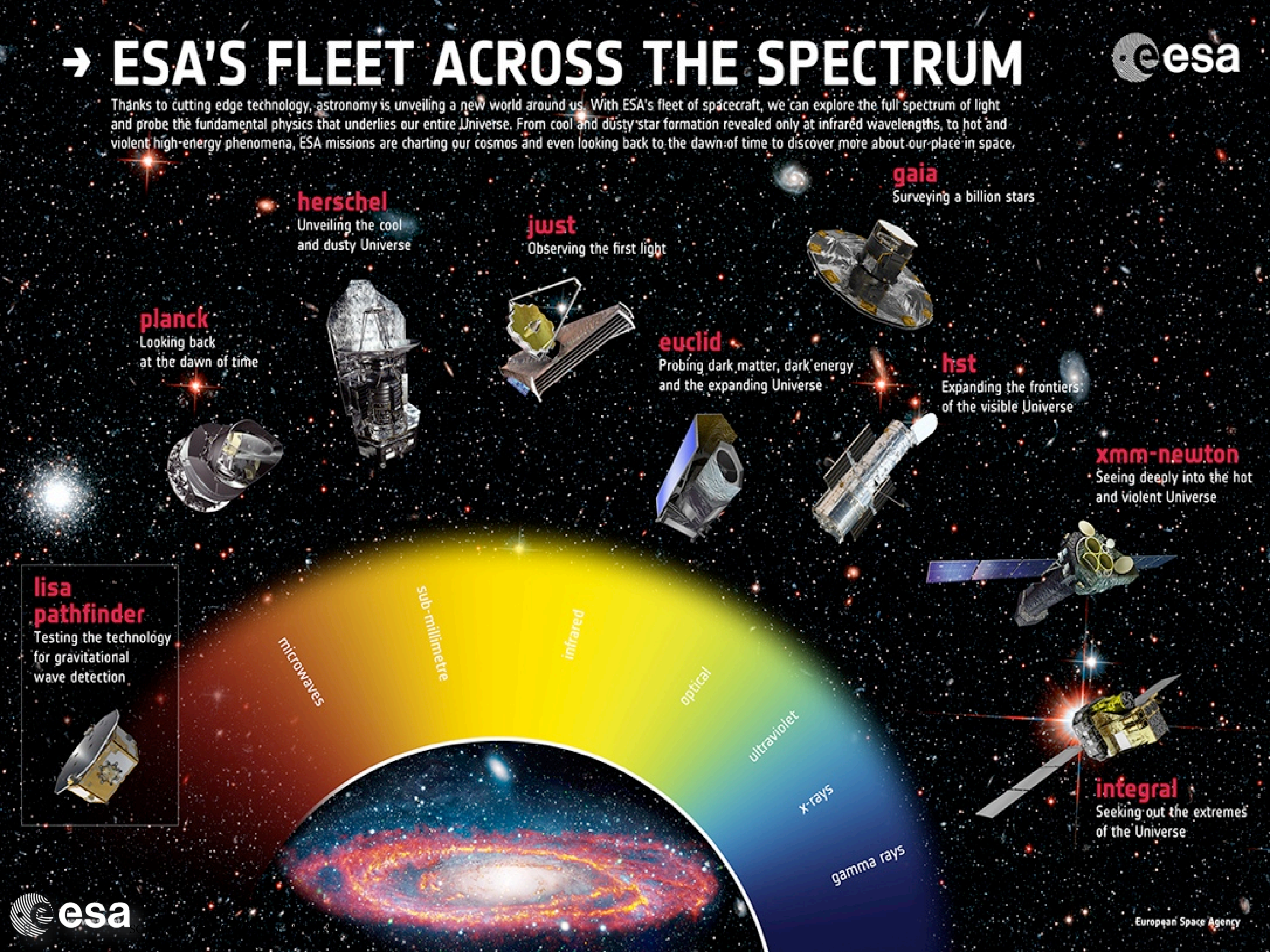
End Hibernation: 20 Jan 2014 10 UTC
Comet encounter: 22 May 2014
Lander delivery:10 Nov 2014

ROSETTA – SELFIE at COMET

ROSETTA – LANDING SITE

→ PHILAE'S LANDING SITE




→ 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.
herschel
Unveiling the cool and dusty Universe
jwst
Observing the first light
gaia
Surveying a billion stars
planck
Looking back at the dawn of time
euclid
Probing dark matter, dark energy and the expanding 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
microwaves
sub-millimetre
infrared
optical
ultraviolet
x-rays
gamma rays
integral
Seeking out the extremes of the Universe
esa
European Space Agency

Herschel Space Observatory

HERSCHEL

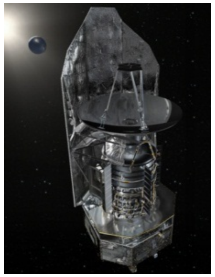
The **largest telescope** ever flown in space, to observe infrared wavelengths and details never seen before

A giant leap forward in the study of **star and galaxy formation and evolution**

Looking back to the unknown earliest stages of star formation, to reveal the **youngest stars in our galaxy**, and making the most detailed and complete study of the vast **reservoirs of gas** in our galaxy

Studying **planetary formation** around other stars

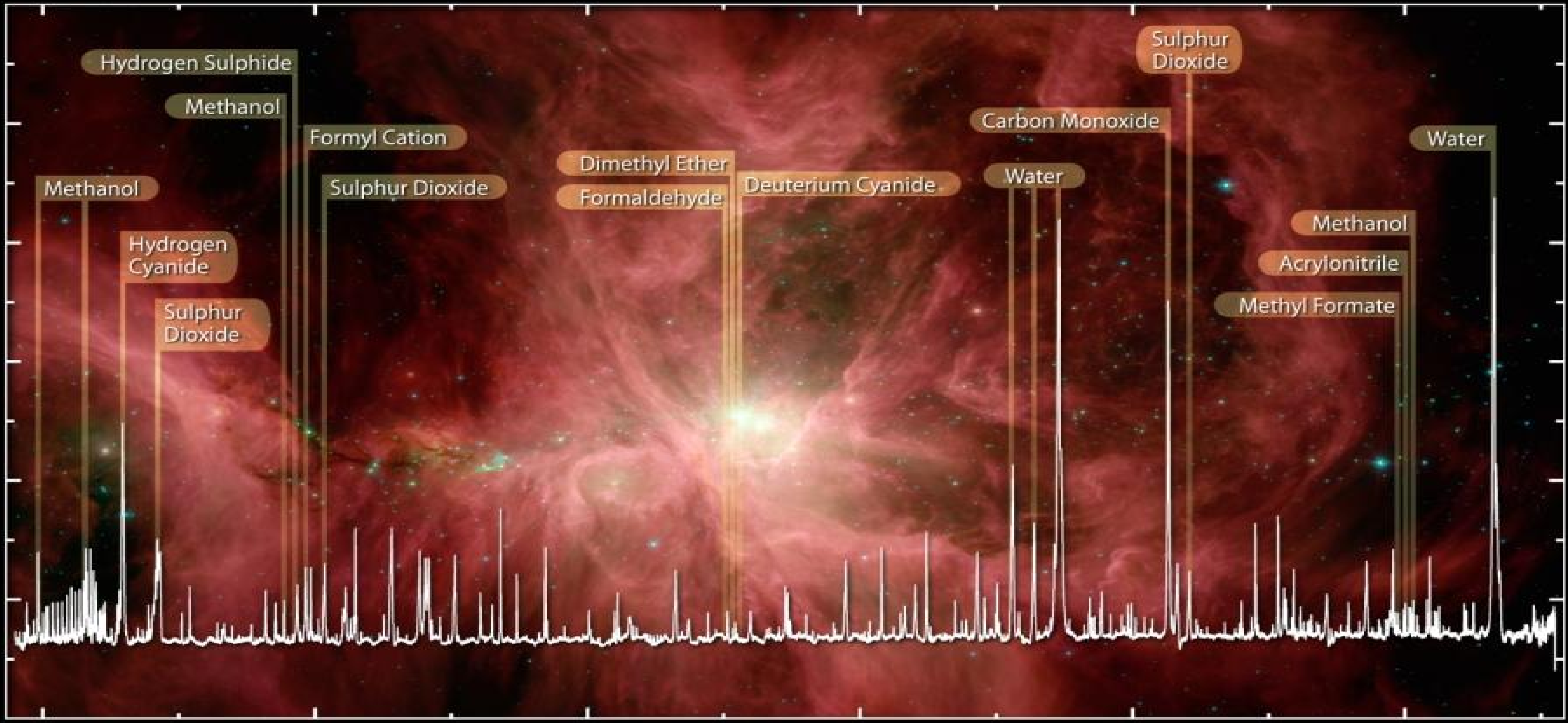
Unprecedented study of formation and **evolution of galaxies in the Universe,** back to 1000 million years ago



Launch: Spring 2009, Ariane 5 ECA
Orbit: around L2
Status: operations ended april 2013, archival phase and data exploitation until 2017

Rosette /ESA PACS-SPIRE/HOBYS

MOLECULES IN SPACE



HIFI Spectrum of Water and Organics in the Orion Nebula

Science missions selection and implementation

Missions are selected through open Calls ("bottom-up" approach)

2007: Call for M1/M2 and L1 mission

2010: Call for M3 mission

2012: Call for S1 mission

2013: Call for L2/L3 missions science themes (White Papers)

2014: Call for L2 mission

Three type of missions considered today: L, M and S missions

L-Missions: ~ 2 ESA Science Programme yearly budget, possibly with international partner(s), typically 6-7 years preparation, then 7-8 years development (Phase B2/C/D)

L1 = JUICE, L2 = Athena

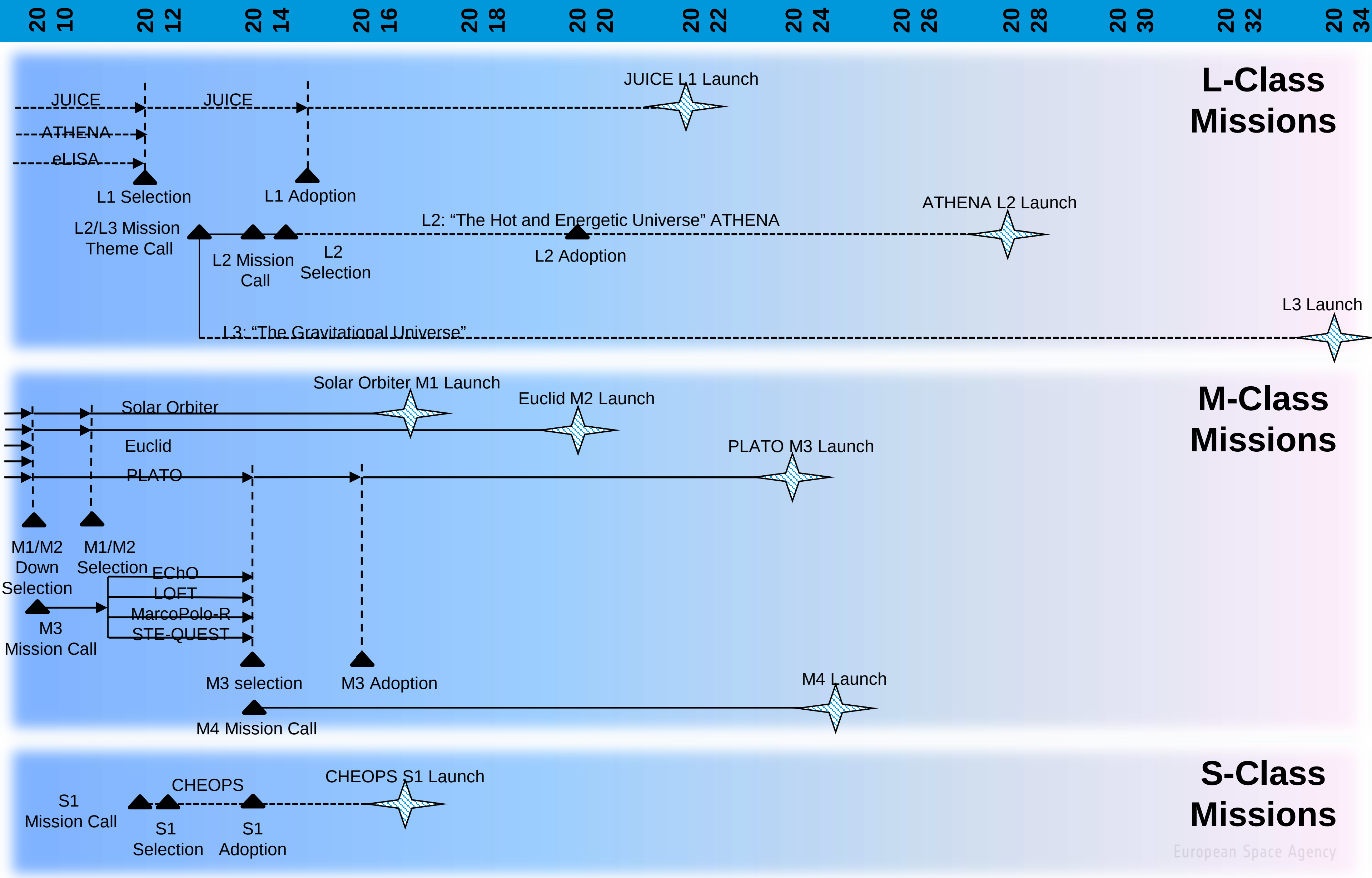
M-missions: ~ 1 ESA Science Programme yearly budget, ~ 4 year preparation (Phase 0, A, B1 studies and technology activities), then 6-7 years development (Phase B2/C/D)

M1 = Solar Orbiter, M2 = Euclid, M3 = PLATO

S-missions: Capped budget, use of available technology, fast cycle ~ 4-5 years.

S1 = CHEOPS

COSMIC VISION TIMELINE



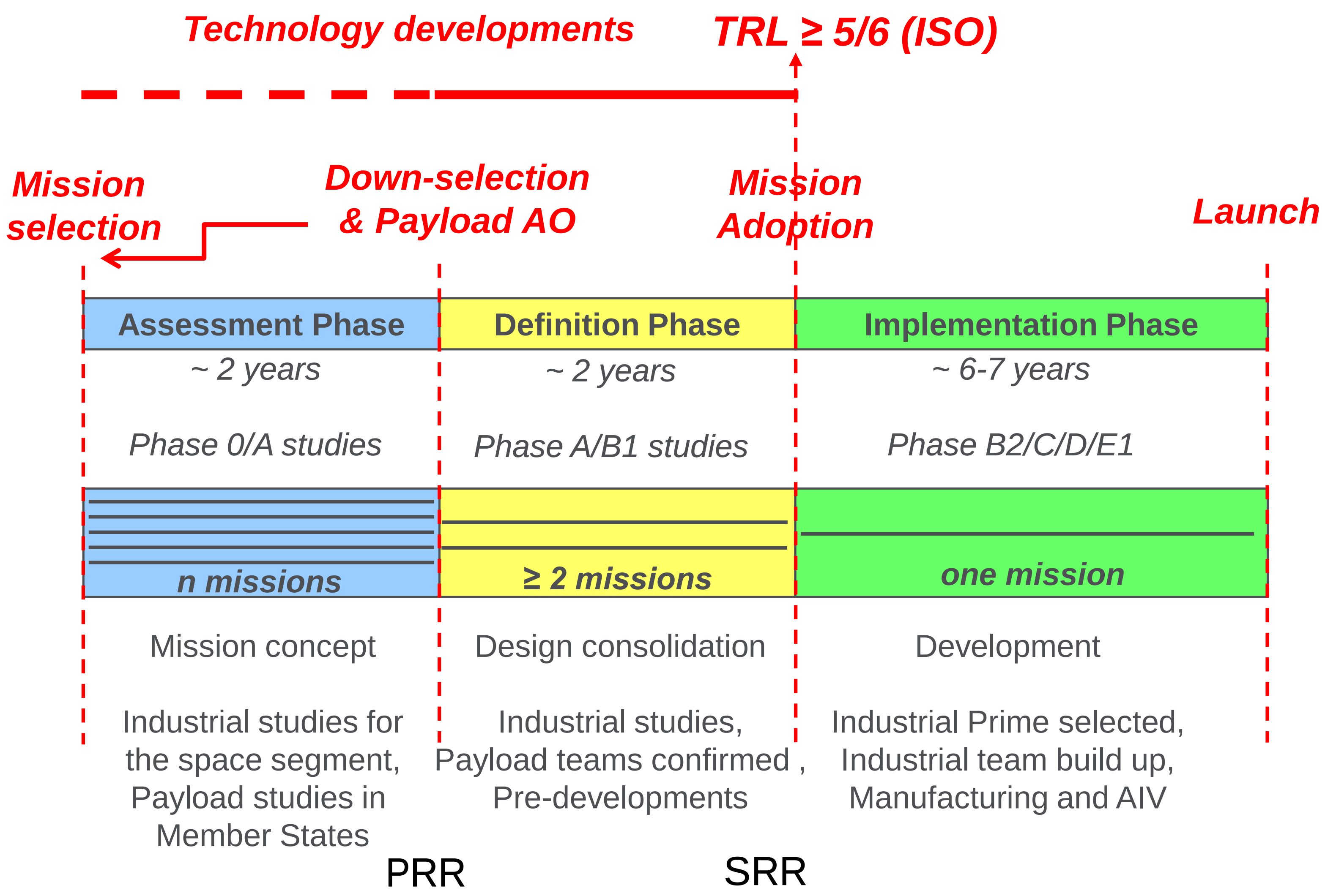
Mission under preparation or in early development

Over the next decade, three missions will be prepared/developed and remain accessible to potential Austrian involvement:

- **Euclid (M2):** Dark Energy Observatory,
  - Prime Contractor Thales Alenia Space (Italy)
  - Industrial procurement structure will be frozen by ~ 2015,
- **JUICE (L1):** Mission to the Jupiter system.
  - Phase A/B1 and technology preparation running,
  - Prime Contractor should be selected in 2015
  - Industrial procurement structure will be frozen by ~ 2017
- **PLATO**, PLAnetary Transits and Oscillations of stars,
  - Prime Contractor should be selected in 2016-2017
  - Industrial procurement structure would be frozen by ~ 2019, launch in 2024

It is essential to already position Member State industry on these missions for enabling a balanced industrial return in the Science Programme

Phases for M-missions

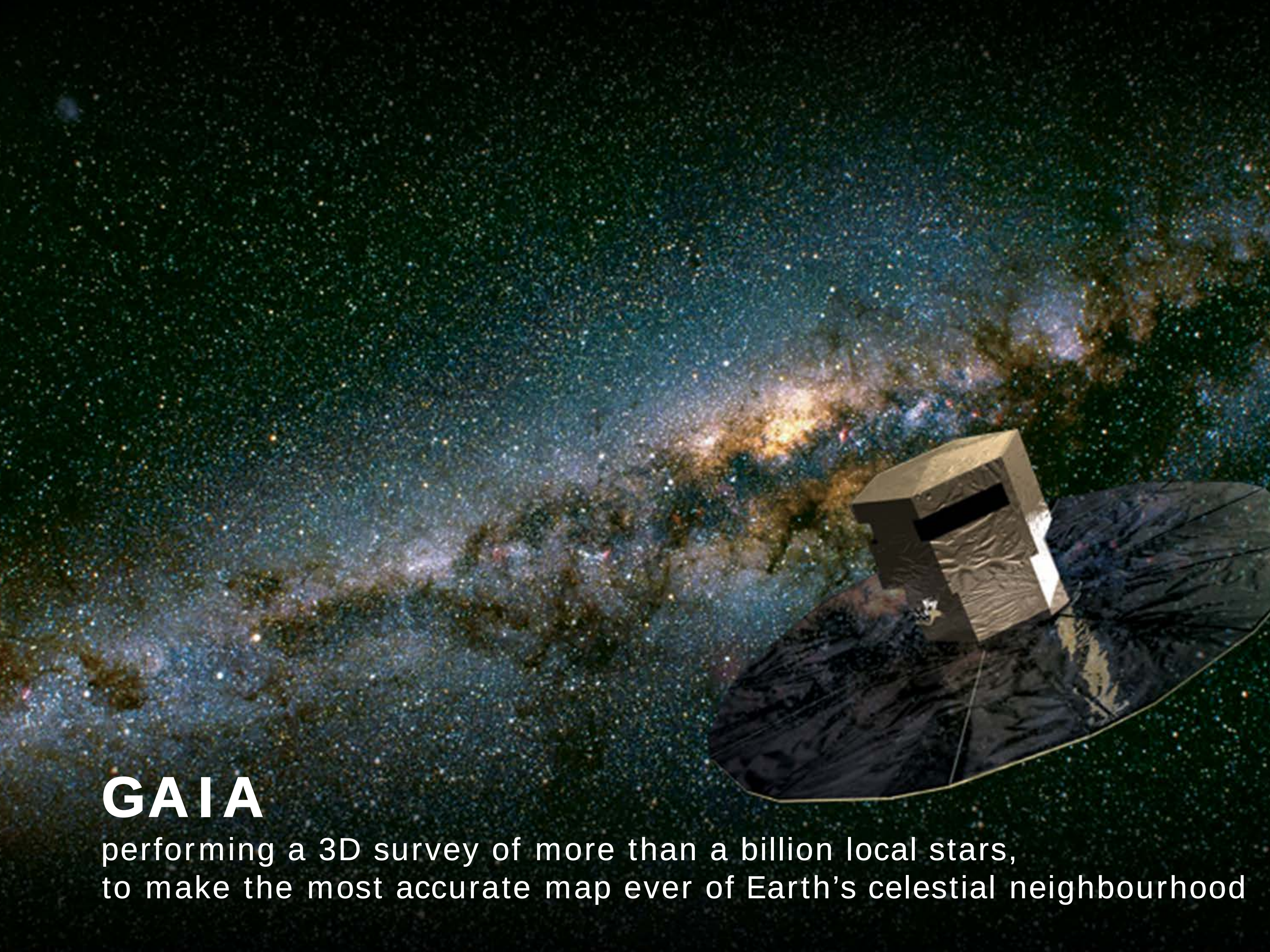


Technology development objectives

1. The general objective is to reach TRL 5/6 for the space segment before entering the implementation phase (spacecraft including payload)
2. Independent “gate reviews” are made for mission readiness evaluation and down-selection (technology maturity, design maturity, schedule, cost)

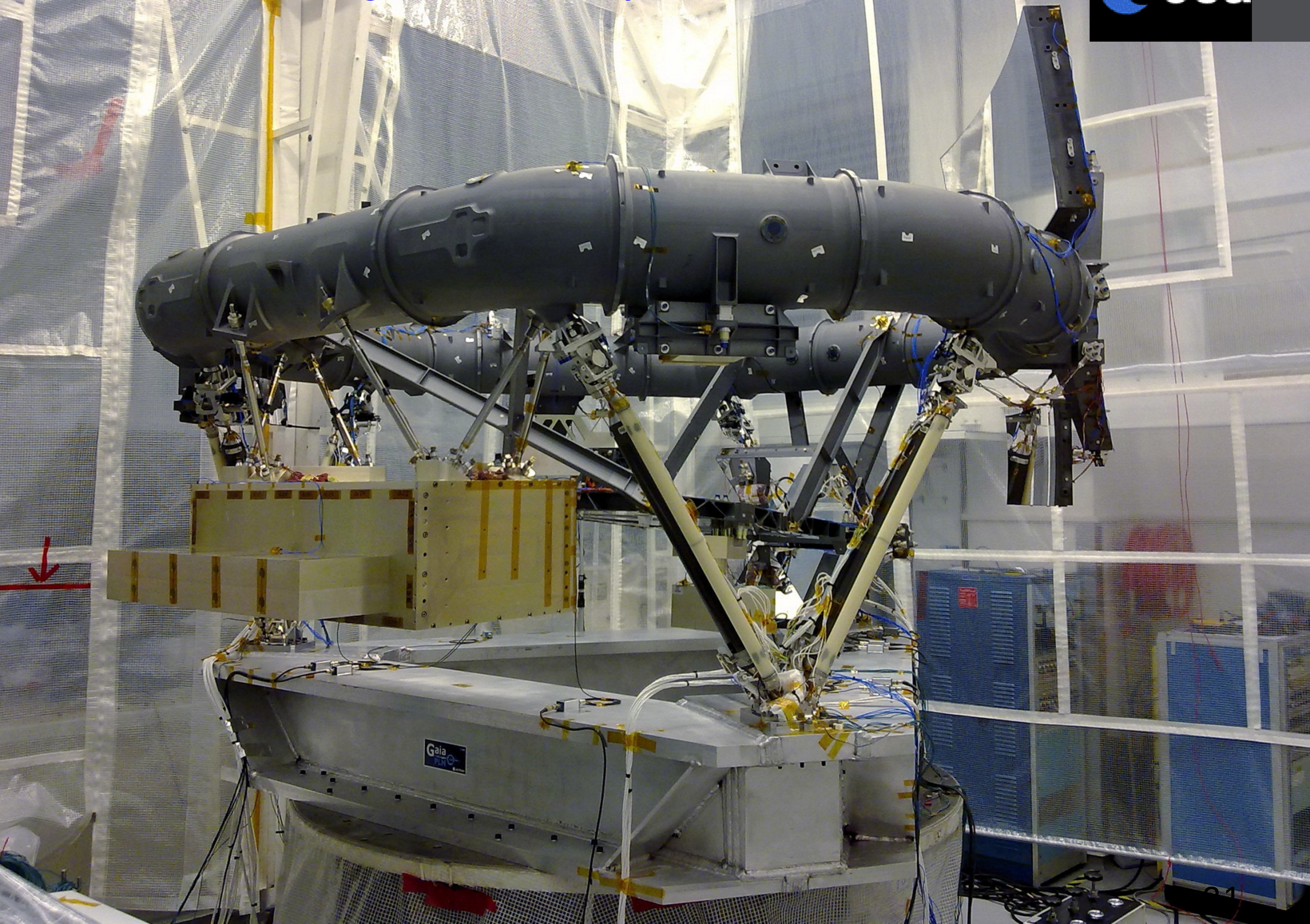
TRL	ISO definition	Associated model	Performance requirements	Representativity of environment & test	Comment and practical use
1	Basic principles observed and reported	Not applicable	In elaboration	No	Seldom considered in ESA developments
2	Technology concept and/or application formulated	Not applicable	In elaboration	No	Seldom considered in ESA developments
3	Analytical and experimental critical function and/or characteristic proof-of-concept	Mathematical models, supported e.g. by sample tests	Partly defined	No	Use in technology developments for monitoring progress
4	Component and/or breadboard functional verification in laboratory environment	Breadboard	Partly defined	No	Use in technology developments for monitoring progress
5	Component and/or breadboard critical function verification in a relevant environment	Scaled EM for the critical functions	Fully defined	Yes, for critical functions subject to scaling effect	Could be used as threshold for enabling the start of implementation phase (C/D), subject to risks related to scaling effects
6	Model demonstrating the critical functions of the element in a relevant environment	Full scale EM, representative for critical functions	Fully defined	Yes, for critical functions	Critical threshold for enabling the start of implementation phase (C/D) with mastered schedule
7	Model demonstrating the element performance for the operational environment	QM	Fully defined	Yes	QM validated, generally during the implementation phase C/D Note: project may allow EQM or PFM instead of QM
8	Actual system completed and “flight qualified” through test and demonstration	FM acceptance tested, integrated in the final system	Fully defined	Yes	Qualification of ground achieved, last step before launch of most of space developments
9	Actual system completed and accepted for flight (“flight qualified”)	FM, flight proven	Fully defined	Yes	Corresponds to mature technology

Herschel:
SiC technology

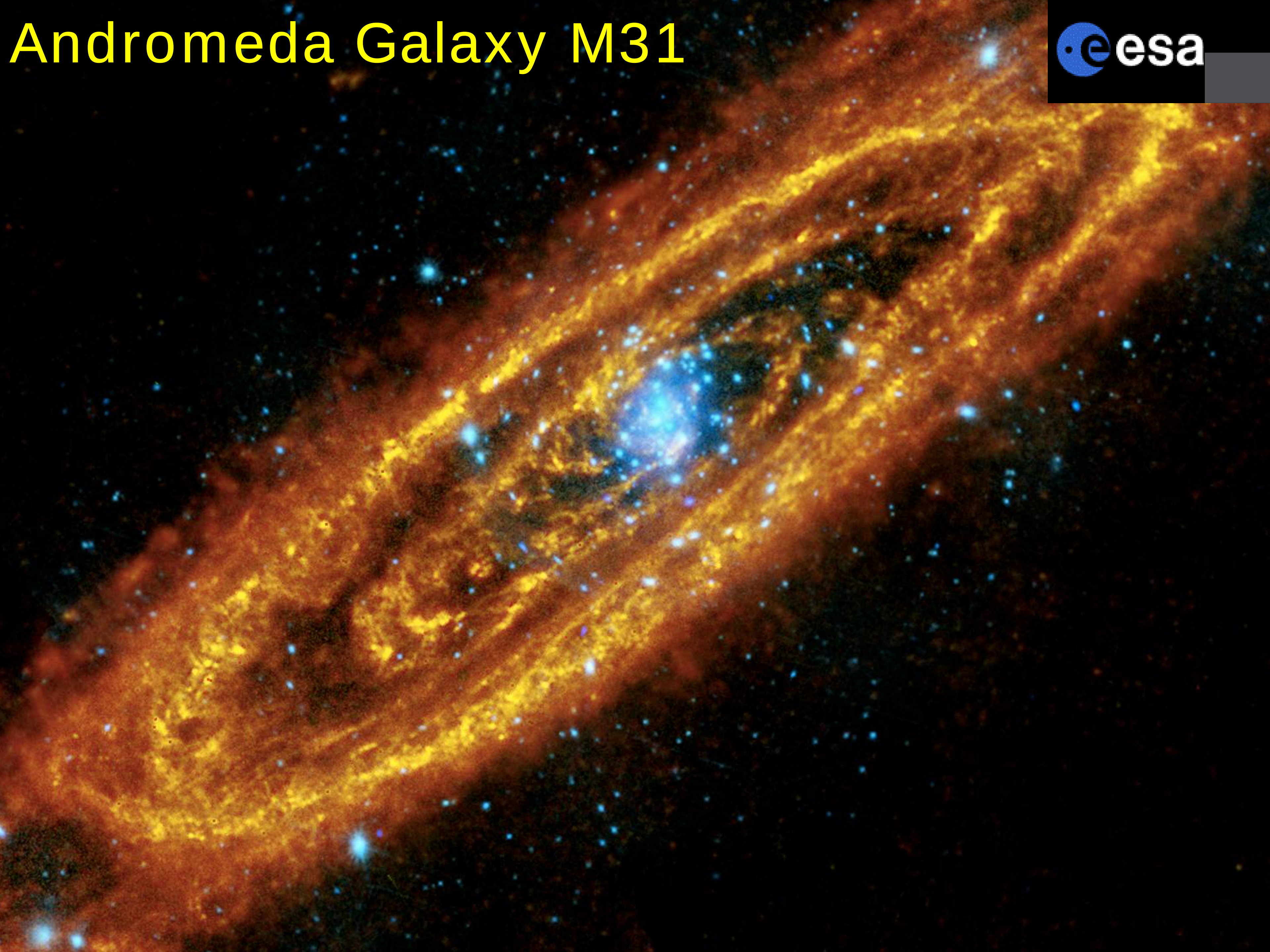

GAIA
performing a 3D survey of more than a billion local stars,
to make the most accurate map ever of Earth’s celestial neighbourhood

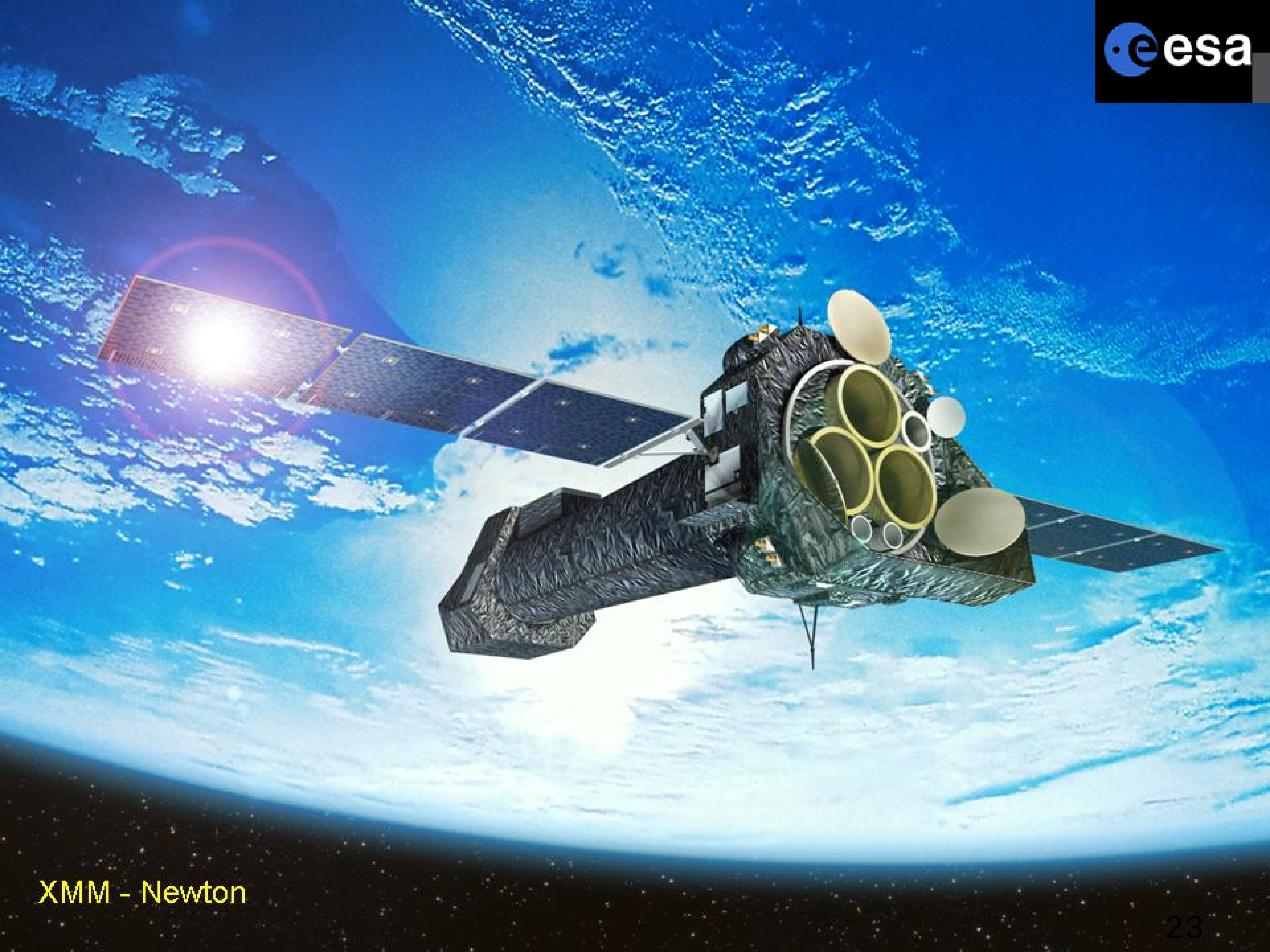
Gaia primary (M1) mirrors: SiC, 40 kg

Vibration testing of Gaia Payload Module



Andromeda Galaxy M31



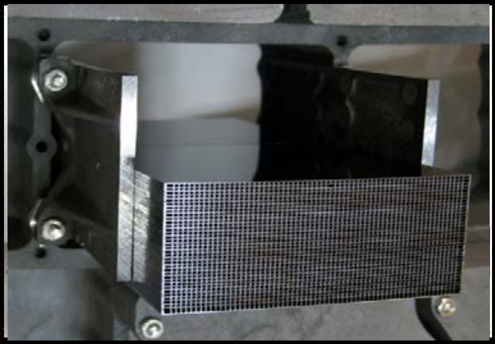

XMM - Newton

Key technology: Replicated Nickel Optics

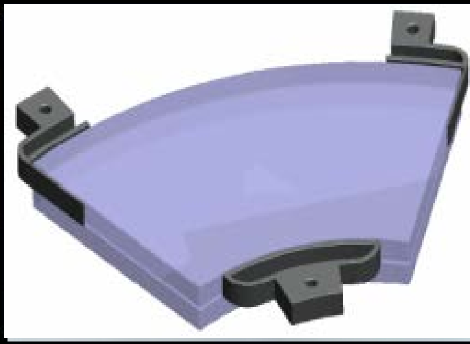
Athena: enabling technology X-ray Optics

CHANDRA
0.5”
18500 kg/m²
A_{eff} @ 1 keV

XMM-NEWTON
14”
2300 kg/m²
A_{eff} @ 1 keV



Si-HPO
5”
200 kg/m²
A_{eff} @ 1 keV



Glass-MPO
30”
25 kg/m²
A_{eff} @ 1 keV

ATHENA Optics technology

Technology Developments in SRE

1. Substantial effort is spent for reaching sufficient definition and technology maturity of Science and Robotic Exploration missions
    a. Science technology development budget: ~18-20 M€/year (TRP + CTP)
    b. MREP technology developments: ~ 8-9 M€/year (TRP + ETP)
    c. TRP: TRL up to 3 or 4, CTP: generally TRL up to 6

2. Technology developments are generally Mission-focused
    a. Work plans are regularly updated for reflecting the Programmes evolution

3. Some generic or long term developments are also implemented for enabling new missions
    a. Generic developments in science missions, for themes identified by the Science Advisory structure
    b. Enabling technologies for robotic exploration

Cosmic Vision 2015-2015 TDP

EUROPEAN SPACE AGENCY

INDUSTRIAL POLICY COMMITTEE

COSMIC VISION

TECHNOLOGY DEVELOPMENT PLAN

Programme of Work 2009-2014 and Related Procurement Plan

SUMMARY
This document presents the activities in the Basic Technology Research Programme (TRP) and in the Science Core Technology Programme (CTP) supporting the implementation of ESA's Cosmic Vision Plan. The Strategic Initiatives (StrIn) activities and national initiatives activities of relevance to the Science programme are provided for information.

This document is provided for information only and is subject to future updates.

April 2014

http://sci.esa.int/cosmicvision-tdp

Thank you