Future ESA Science Missions
And their Technological Preparation

Presentation at the
Nuclear Physics in Stellar Explosions Workshop

M. Bavdaz

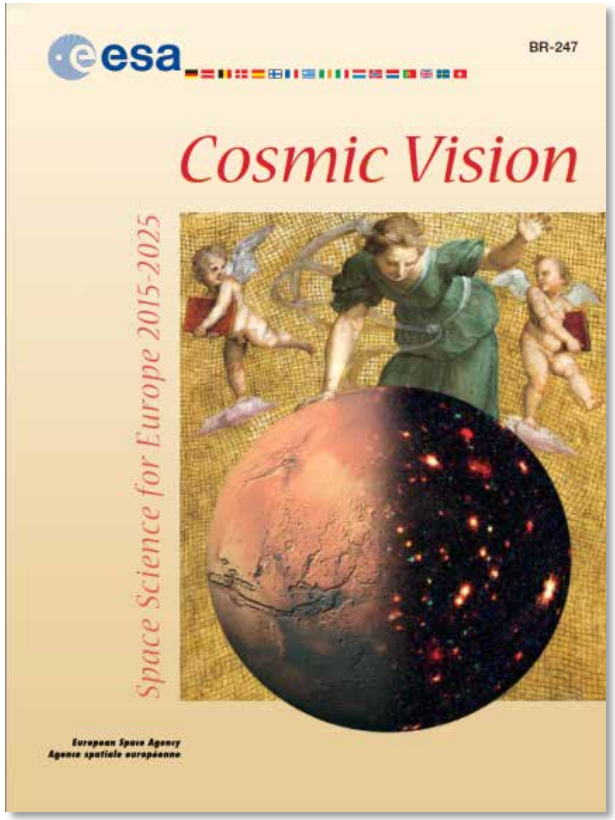
13/09/2018

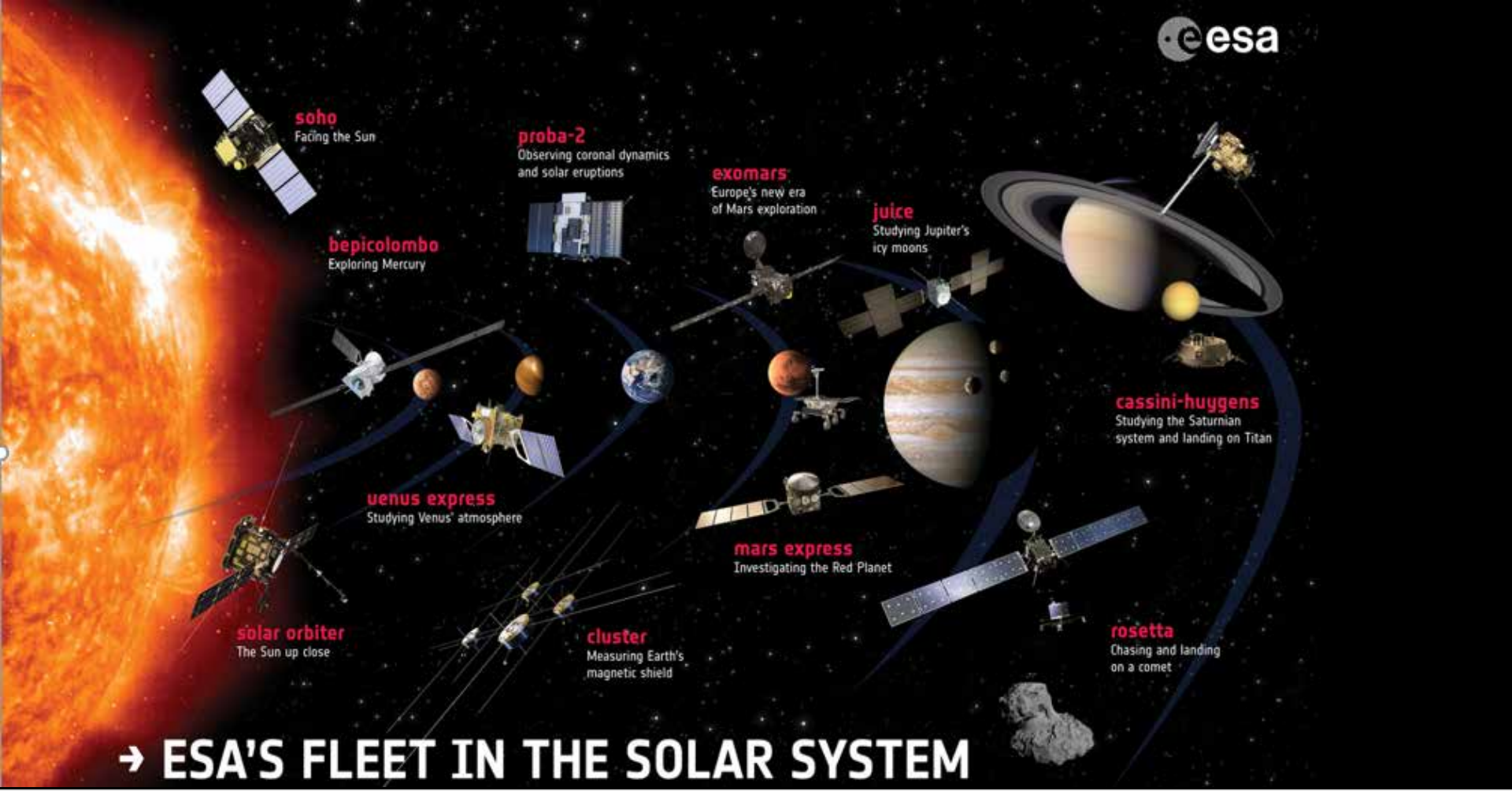
Science Programme

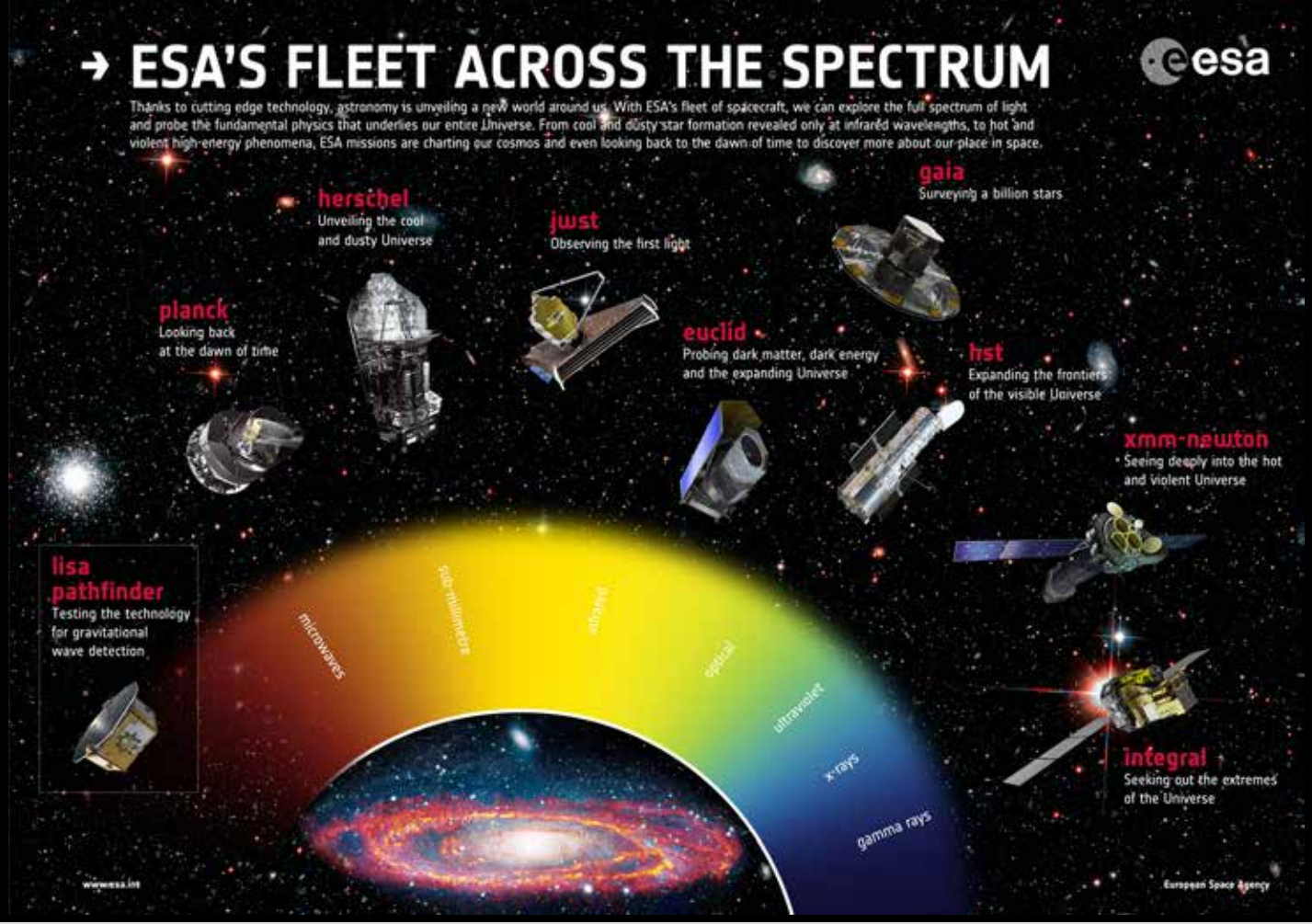
The Cosmic Vision plan was introduced in 2005.

It covers currently the ESA Science Programme till 2035 and is centred around the following four key questions:

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?




esa
soho
Facing the Sun
proba-2
Observing coronal dynamics
and solar eruptions
exomars
Europe's new era
of Mars exploration
juice
Studying Jupiter's
icy moons
bepicolombo
Exploring Mercury
cassini-huygens
Studying the Saturnian
system and landing on Titan
uenus express
Studying Venus' atmosphere
mars express
Investigating the Red Planet
solar orbiter
The Sun up close
cluster
Measuring Earth's
magnetic shield
rosetta
Chasing and landing
on a comet
→ ESA'S FLEET IN THE SOLAR SYSTEM


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
integral
Seeking out the extremes of the Universe
microwaves
sub-millimetre
infrared
optical
ultraviolet
x-rays
gamma rays
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Science Programme

The Science Programme has an yearly budget (YB) = ~510 M€ and is structured along the following building blocks:

- **L-missions**: large European led flagship missions; ESA cost of ~2 YB, launched every 7-8 years.
  L1: JUICE (2022), **L2**: ATHENA (2031) and **L3**: LISA (2034)
- **M-missions**: provide the programme with flexibility; ESA led or implemented through international collaboration. Cost to ESA of ~ 1 YB; launch one every 3-4 years
  M1:Solar Orbiter, **M2**:Euclid, **M3**:PLATO, **M4**:ARIEL, **M5:** Theseus, Spica and EnVision (Phase 0 in 2018)
- **S-missions**: small missions allowing national agencies to play a leading role in missions, ~ 0.1 YB
  S1: CHEOPS
- **O-missions**: missions of opportunity; led by other agencies (XARM, LiteBird, EP, WFIRST,..) or joint missions: ESA-CAS mission SMILE
- **F-Missions**: cost cap to ESA ~150 M€ (~0.3 YB); call issued 16 July 2018, (300-500kg S/C, ~ 6 years from selection to launch); see http://sci.esa.int/cosmic-vision/60498-call-for-a-fast-f-mission-opportunity-in-esas-science-programme/

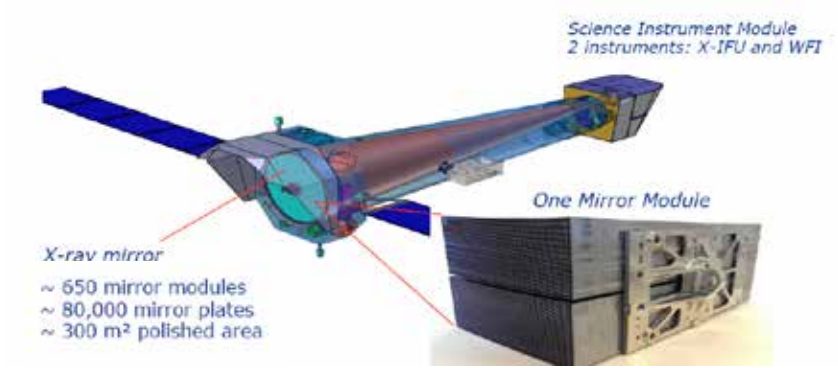
Science Missions in Implementation

BepiColombo (2018), JWST (2020)

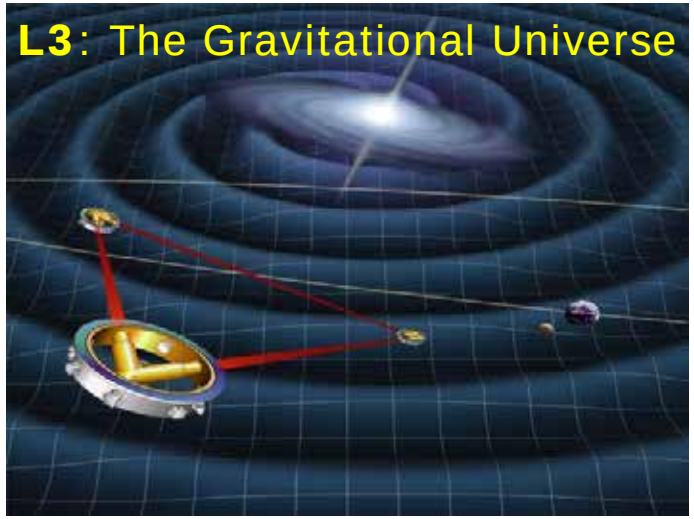
Future Science Missions

L2: The Hot and Energetic Universe

Mapping hot gas structures and determining their physical properties. Searching for supermassive black holes



L3: The Gravitational Universe



L2 ATHENA (2031)

- Selected in June 2014
- In Phase A ext. (MCR,SR1 done)
- iPRR end of 2018 (key point), MFR 2019
- Mission Adoption >2022
- Launch 2031 (earliest)

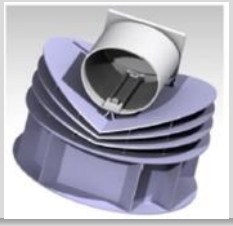
L3 Gravitational Universe (2034)

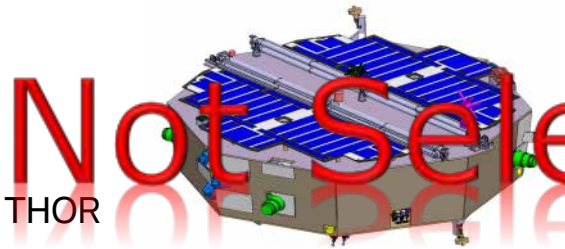
- Call for L3 mission end 2016
- LISA selected
- Phase 0 (CDF done Mission + P/L)
- Passed MDR, preparation of Phase A
- Launch 2034

Future Missions M4 candidates (2028)

M4: ARIEL measurement of exoplanets atmosphere by transit spectroscopy *(λ =1.25-8 μm)*

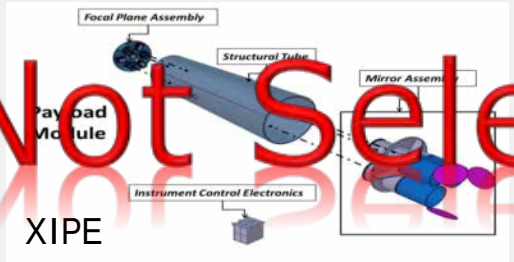
- *Ariane 6.2 launch, eclipse free SEL2*
- *0.6 m² mirror aperture*
- *Detectors at 35 K*
- *Pointing < 100 mas over 10h*





M4: THOR Turbulence Heating Observer

- *Highly Elliptical Earth orbit , Ariane 6.2 launch*
- *6x13 R_e (y1), 6x26 R_e (y2) and 6x45 R_e (y3) orbit*
- *10 instruments, EMC sensitive*
- *2 rpm spinner*



M4: XIPE X-ray polarisation in the range 2-8 keV

- *Low Earth orbit (550km), low incl., VEGA-C launch*
- *Gas Pixel Detector, Wolter-I x-ray mirror*
- *A_{eff} ~ 1100 cm² at 3 keV*

Future Missions M5 candidates (2032)

Candidate

M5: Theseus

Transient High Energy Sky and Early Universe Surveyor

Candidate

M5: Spica

SPace Infrared telescope for Cosmology and Astrophysics

Candidate

M5: EnVision

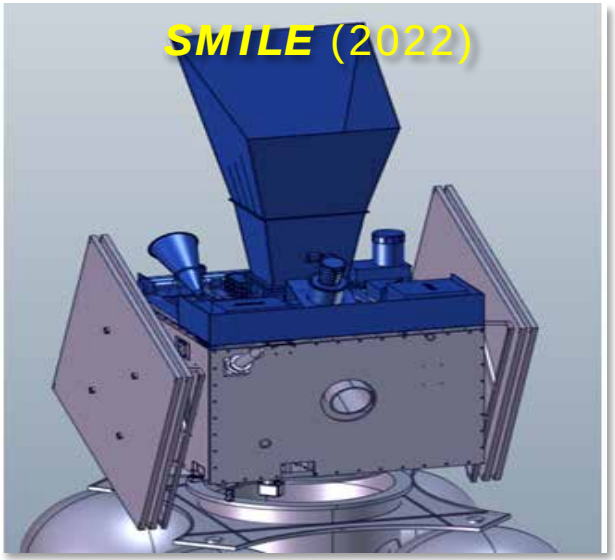
Orbital mission to Venus

Phase 0 Studies on-going and to be completed in 2018

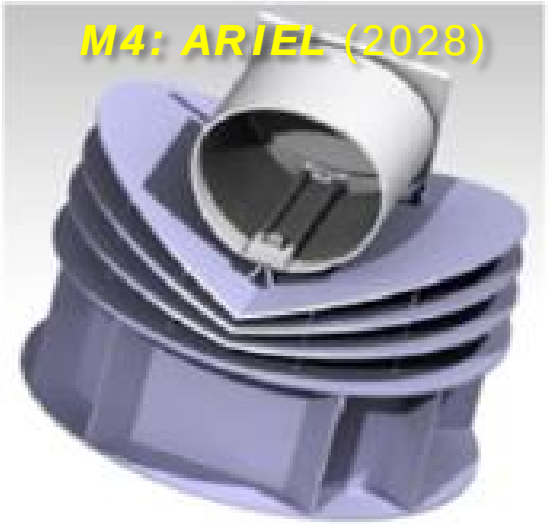
See for details:

http://sci.esa.int/cosmic-vision/60257-esa-selects-three-new-mission-concepts-for-study/

Future Science Missions



- ESA: PLM, CAS: SVM+PM
- Investigate the dynamic response of the Earth's magnetosphere to the solar wind impact, Phase A/B1
- Adoption: end 2018



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- *Ariane 6.2 launch, eclipse free SEL2*
- *0.6 m² mirror aperture*
- *Detectors at 35 K*
- *Pointing < 100 mas over 10h*

Missions of Opportunity

- XARM (X-ray Astronomy Recovery Mission, JAXA, launch 2021)

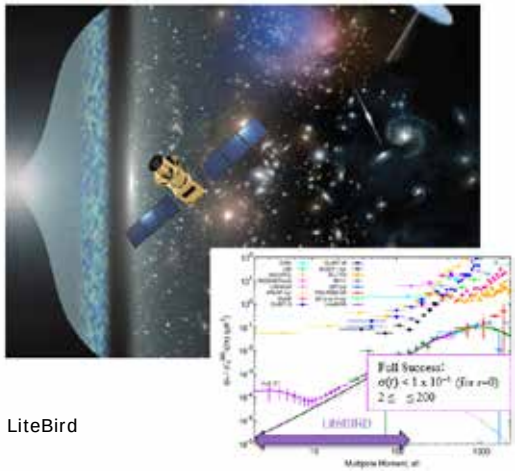
  approved by SPC June 2017; Currently in Phase B, prep. of procurement:

  Loop Heat Pipes, AOCS equipment (Star Tracker, MagnetoTorquers+ Magnetometer)

- LiteBird (MoO candidate) with JAXA, launch 2027, currently in CDF
  - CMB polarisation mission with 2 telescopes (LFT: 40-140GHz, HFT: 100-402GHz)
- WFIRST (NASA, 2025), Large Wide Field IR Observatory
- EinsteinProbe (CAS, 2023), Small X-ray all-sky monitoring mission

XARM


WFIRST


LiteBird

Future Missions preparation – main activities

1. **Calls (bottom up approach of selection)**
   - M5 mission candidates selected: Theseus, Spica and EnVision
   - Call for New Science Ideas: 3 themes selected: Quantum Physics, Small Planetary Platform, GAIA-NIR
   - Call for F-missions: call issued 16 July 2018

2. **System studies:** for defining the mission space segment:
   - Parallel industrial studies,
   - Iterations with the science community, ESOC (MOC), ESAC (SOC)
   - Convergence on requirements and interfaces

3. **Science and instrumentation related activities:**
   - Achieved by the science community, under Member States funding
   - Includes the Science Ground Segment
   - ESA funded Phase A P/L studies (new)

4. **Technology developments:** to reach TRL 5/6 prior to Mission Adoption
   - Mission driven technology work plans, in parallel to the studies
   - TRP/CTP joint work plan, with a yearly update (more if needed)

5. **Independent reviews:** to control the achievements and enable decisions
   - Assessment of the definition maturity, the technology readiness and cost/risks
   - Mission Selection/Formulation Review (MSR/MFR) end Phase A; Mission Adoption Review (MAR) end Phase B1

Technology Development Priorities

Mission	Payload Category	Member State Provision	ESA Payload Provision
Athena (L2 mission)	C	Focal plane instrumentation: Wide Field Imager X-ray Spectrometer (with JAXA and NASA contributions)	X-ray telescope (Silicon Pore Optics) Cryogenic cooling chain for X-ray spectrometer (with possible contributions from partners)
LISA (L3 Mission)	C	Optical bench, Gravitational Reference Sensor, Phasemeter	Telescope, Laser system (with possible contributions from NASA)
PLATO (M3 mission)	C	Payload Cameras	CCD detectors and payload optical bench
ARIEL (M4 mission)	B	Complete payload module including telescope and focal plane detectors	

New “Science Ideas” selected following call and scientific peer review process:

(1) further investigation of the feasibility of a mission to study quantum decoherence

(2) assessment of the potential for small planetary missions

(3) investigation of the concept for a GAIA-like mission in the NIR

Technology Development

- Substantial effort is spent for reaching sufficient technology maturity of Science missions before adoption:
  - Science Core Technology Programme: ~ 14 M€/year
  - TRP ~ 6 M€/year

- Technology developments are generally mission-driven (following calls & candidate selection)
  - Work plans are regularly updated for reflecting the programme evolution

- Some generic or long term developments are also implemented for enabling new missions
  - Generic developments in science missions, for themes identified by the Science Advisory structure (e.g. science infrared detectors)

- Currently ~100 running, 140 finished, 50 in preparation… total ~290 TDA's

- See also: http://sci.esa.int/sci-ft/47731-european-space-agency-science-programme-technology-development-plan-programme-of-work-for-2018-2019/#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ESA/IPC(2018)88
Att.: Annexes
Paris, 30 May 2018
(Original: English)

EUROPEAN SPACE AGENCY

INDUSTRIAL POLICY COMMITTEE

Science Programme
Technology Development Plan:
Programme of Work for 2018/2019 and Related Procurement Plan

SUMMARY

This document presents the activities in the Science Core Technology Programme (CTP) and in the Technology Development Element (TDE, replacing the TRP) of the Discovery, Preparation & Technology Development Basic Activities supporting the implementation of ESA's Science Programme. The national initiatives activities of relevance to the Science programme are provided for information.

REQUIRED ACTION

The IPC is invited to approve this CTP/TDE work plan for the year 2018/2019 and the connected procurement proposals.

VOTING RIGHTS AND MAJORITY REQUIRED

Simple majority of member States, present and voting.