The ESA Science Future Missions and their Preparation

Presentation at the Finnish Space Industry Days - 04/04/2018

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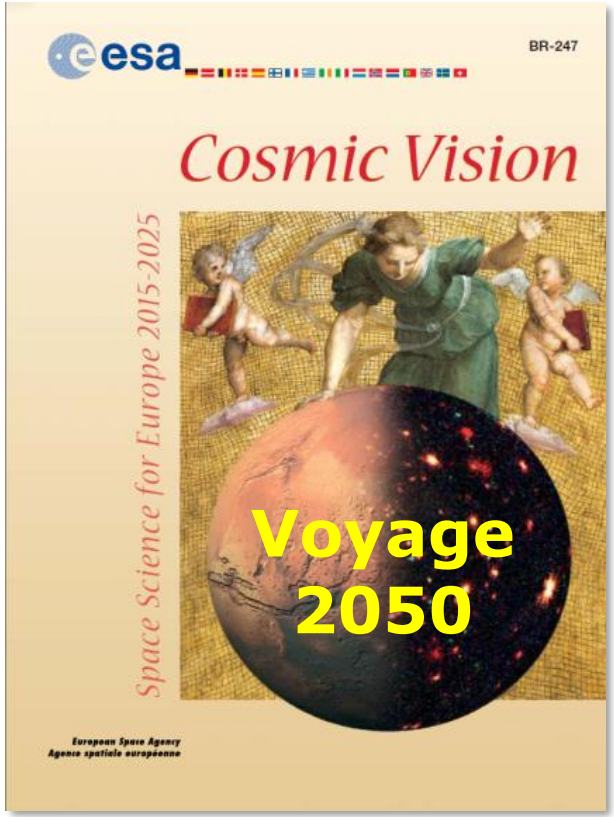
The ESA Science Programme

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:

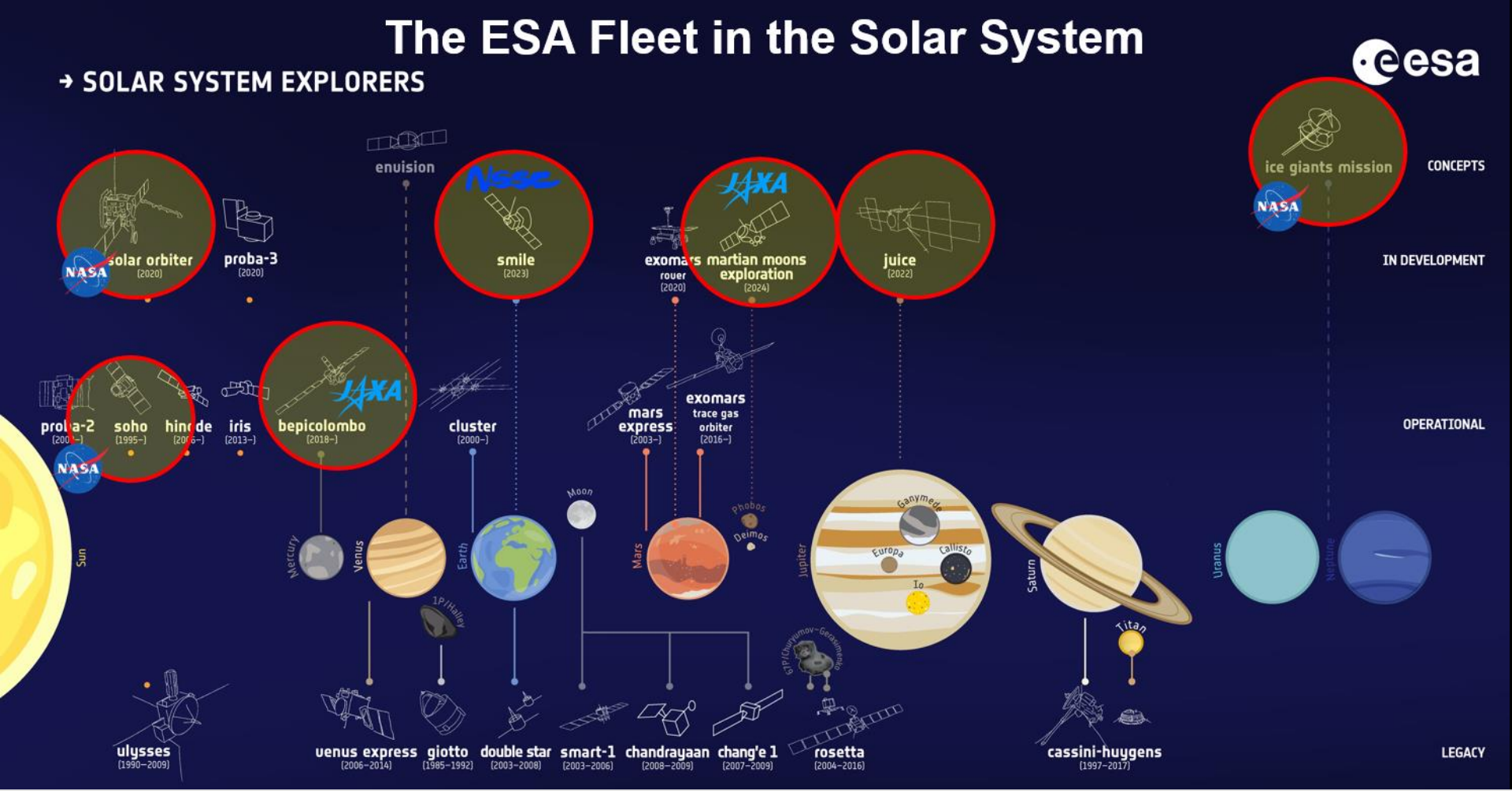
1. What are the conditions for planetary formation and the emergence of life?
2. How does the Solar System work?
3. What are the physical fundamental laws of the Universe?
4. How did the Universe originate and what is it made of?

Cosmic Vision 2035 will be followed by **Voyage 2050** !



The ESA Fleet in the Solar System

→ SOLAR SYSTEM EXPLORERS



The ESA Fleet for Astrophysics

→ COSMIC OBSERVERS

CONCEPTS

IN DEVELOPMENT

OPERATIONAL

LEGACY

spica

theseus

JAXA

NASA

webb (2021)

ariel (2028)

euclid (2022)

cheops (2019)

plato (2026)

xrism (2021)

einstein probe (2022)

athena (2031)

lisa (2034)

Bring Sound to Cosmic Movies

hubble (1990–)

gaia (2013–)

xmm-newton (1999–)

integral (2002–)

microwaves | sub-millimetre | infrared | optical | ultraviolet | x-rays | gamma rays | gravitational waves

planck (2009–2013)

herschel (2009–2013)

iso (1995–1998)

akari (2006–2011)

hipparcos (1989–1993)

corot (2006–2014)

iue (1978–1996)

exosat (1983–1986)

hitomi (2016)

suzaku (2005–2015)

cos-b (1975–1982)

lisa pathfinder (2015–2017)

microscope (2016–2018)

European Space Agency

“Bringing sound to the cosmic movies”

Space19

Athena
hot gas structures
supermassive black holes

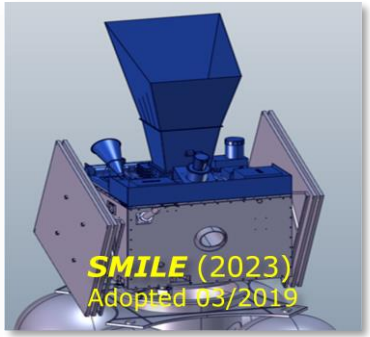
LISA
gravitational wave observation

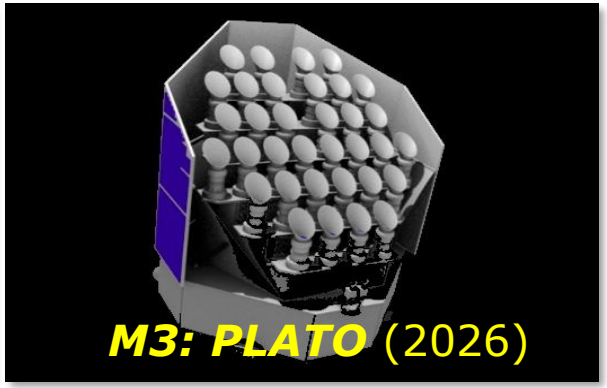
Science Programme

The mandatory Science Programme has an yearly budget (YB) of ~510 M€ and is structured along the following mission classes:

- **L**: 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**: 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:SolarOrbiter, **M2**:Euclid, **M3**:PLATO, **M4**:ARIEL, **M5**: EnVision, SPICA, Theseus (Phase A)
- **S**: small missions allowing national agencies to play a leading role in missions, ~ 0.1 YB
  S1: Cheops (2019)
- **O**: missions of opportunity; led by other agencies (XARM, EP, MMX, WFIRST,..) or joint missions:
  ESA-CAS mission SMILE
- **F:** cost cap to ESA ~150 M€ (~0.3 YB); Call issued (Jul 2018); start of Phase 0 Q2/2019

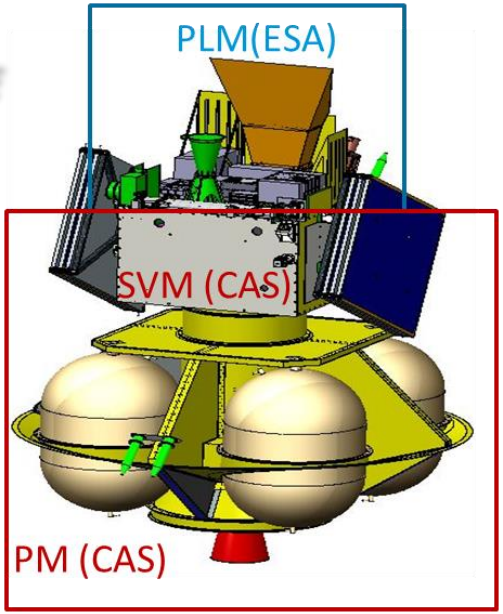
Science Missions in Implementation





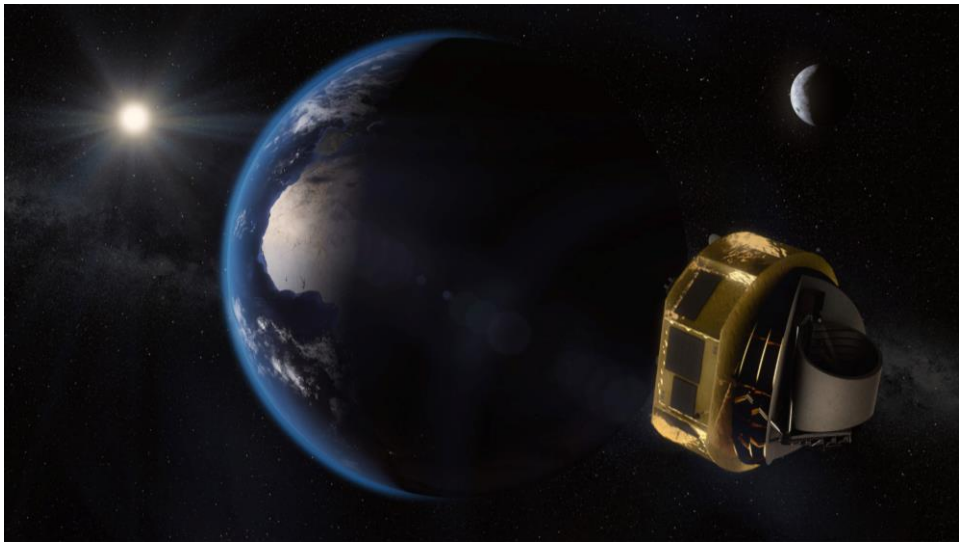
Future Science Missions

SMILE (2023)



- ESA: PLM, CAS: SVM+PM
- Investigate the dynamic response of the Earth's magnetosphere to the solar wind impact, Phase B1
- SPC adoption: Mar 2019

M4: ARIEL (2028)



M4: ARIEL measurement of exoplanets atmosphere by transit spectroscopy *(λ =0.5-7.8 μm)*

- *Ariane 6.2 launch, eclipse free SEL2*
- *0.6 m^2 mirror aperture, detectors at 35 K*
- *Pointing < 100 mas over 10h*
- *In Phase B1, Adoption Nov 2020*

THESEUS (M5 candidate)

Main science objectives:

- Observation of the high energy transient sky (GRB-census) over all cosmic history.

Mission profile:

- Direct VEGA-C launch to equatorial LEO (600 km, <5° inclination) - LV-capability to this orbit > 2,000 kg
- 3 yrs mission (2 years extension)
- Single (Malindi) Ground Station (~14 passes/day, ~10 min/pass)
- Uses burst-alert system (VHF GS on equator)
- Controlled re-entry EoL

Spacecraft:

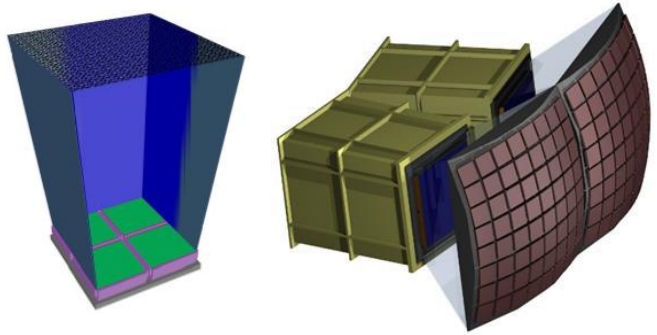
- One S/C 1600 kg wet mass
- 1 kW total power
- Body-mounted SA

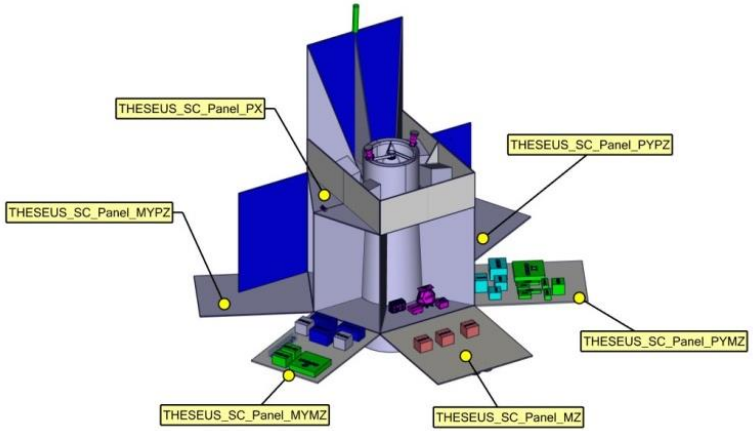
Payload:

- Soft-X-ray Imager (SXI) - used as a wide-field monitor for transients: 0.3 keV -6 keV, ~1 sr FoV
- X-Gamma Imaging Spectrometer (XGIS) - used to reliably identify GRBs from SXI-spotted transients: 2 keV – 20 MeV, ~2.4 sr FoV
- Infra-Red Telescope (IRT) - used for imaging, low-resolution and mid-resolution spectra of GRBs: 0.7µm – 1.8µm λ, 700mm M1/M2, All SiC or Zerodur, 10'x10' FoV

Implementation scheme & ESA contribution:

- **Role of ESA**: Mission architect, S/C, L/V, OGS/SGS, P/L - IRT: telescope, instrument & Mini Pulse Tube Cooler; SXI: CCDs/CMOS detectors
- **Role of Member States:** The rest of the P/L
- **Role International Partner(s):** None





EnVision (M5 candidate)

Main science objectives:

- Determine level and nature of geological activity/ sequence of events that generated Venus surface features
- Assess whether Venus once had oceans/was hospitable for life
- Understand geodynamics framework that controls the release of internal heat over Venus history

Mission profile:

- Launch on an Ariane 6.2 on 2029 or 2032
- 5 months cruise followed by insertion manoeuvre into a 50000km apoapsis orbit
- 6 months aerobraking to a final 259km altitude circular orbit
- 4 years science from 8 November 2030 to 5 November 2034

Spacecraft:

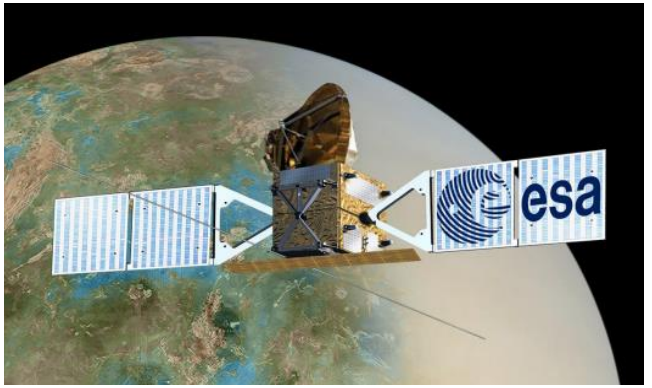
- 3-axis stabilized platform
- Dry mass (incl. 20% margin) : 949 kg; 1673 kg wet mass (including 20% system margin and launch adaptor)
- > 2400 W
- 1.2 Mbps at 1.7 AU to 40 Mbps at 0.3 AU telemetry rate

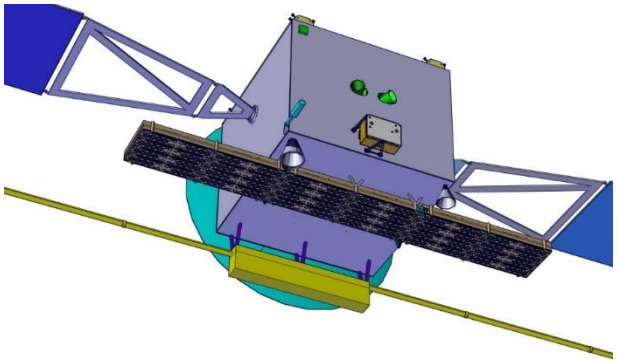
Payload (3 instruments):

- VenSAR synthetic aperture radar in S-band
- SRS subsurface radar sounder (9.4m deployable antenna)
- VM IR mapper and IR/UV spectrometer

Implementation scheme & ESA contribution:

- **Role of ESA**: mission architect provide launcher, spacecraft, G/S and operation, VenSAR and SRS antenna
- **Role of Member States:** provision of VenSAR and SRS backend electronics and VEM instrument.
- **Role International Partner(s):** no international partner





SPICA (M5 candidate)

Main science objectives:

- Reveal processes for galaxy and black hole formation and evolution
- Resolve far-infrared polarisation of galactic filaments
- Understand formation and evolution of planetary systems

Main required performance: Spectral sensitivity: $2*10^{-20}$ W/m^2 (~100 times better than Herschel; it drives the Mirror size and the Telescope temperature)

Mission profile:

- Launch by H3 (new LV by JAXA), claimed perfo : 3700 kg in L2 insertion orbit, fairing: 4.6 m diam
- L2 large Halo orbit , total Delta-V: 265 m/s (biased trajectories)
- 3 yrs lifetime (5 goal)
- Several pointing modes: Pointing observations, raster pointing observations and line scanner observations

Spacecraft:

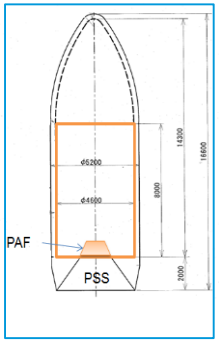
- Single SC, 3-axis stabilised, architecture a with Horizontal Telescope , PLM isolated from SVM by V-grooves
- Shielded Cryogenic PLM at <8 K, “Standard” SVM, K-band down (260 Gbit/day science data)
- Fixed array (up to 15 m^2 giving >2.3 kW)
- AOCS requires FAS (Focal plan Attitude Sensor) for 150 mas over 200 s RPE
- SC Mass : 3800 kg TBC

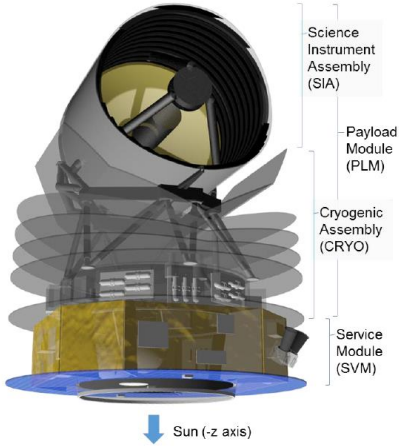
Payload:

- SiC Ritchey-Chretien on-axis Telescope with M1=2.5 m
- 2 Instruments: SAFARI (Far IR), SMI (MIR). Focal Plane @ 4.8 K. final ADR cooling to 50mK
- SAFARI: Fourier spectrometer (34-230 µm continuous in 4 bands): 3500 xTES bolometer detectors
- SMI: mid IR (12-36 um) Spectrometer/camera

Implementation scheme & ESA contribution:

- **Role of ESA**: Mission + SVM, Telescope, Focal Plane, MOC, Part of SOC
- **Role of Member States:** SAFARI instrument
- **Role International Partner(s):** JAXA: Launcher, Overall PLM, Mechanical cryo-Coolers, SMI instrument, Part of SOC





Future Missions preparation – main activities

1. **Calls (bottom up approach of selection)**
   - M5 call: → EnVision, SPICA, Theseus (Phase 0 competed, now in Phase A)
   - Call for F-mission: → issued Jul 2018, open → 6 proposals Phase 2 received, CDF Jun/Jul 2019

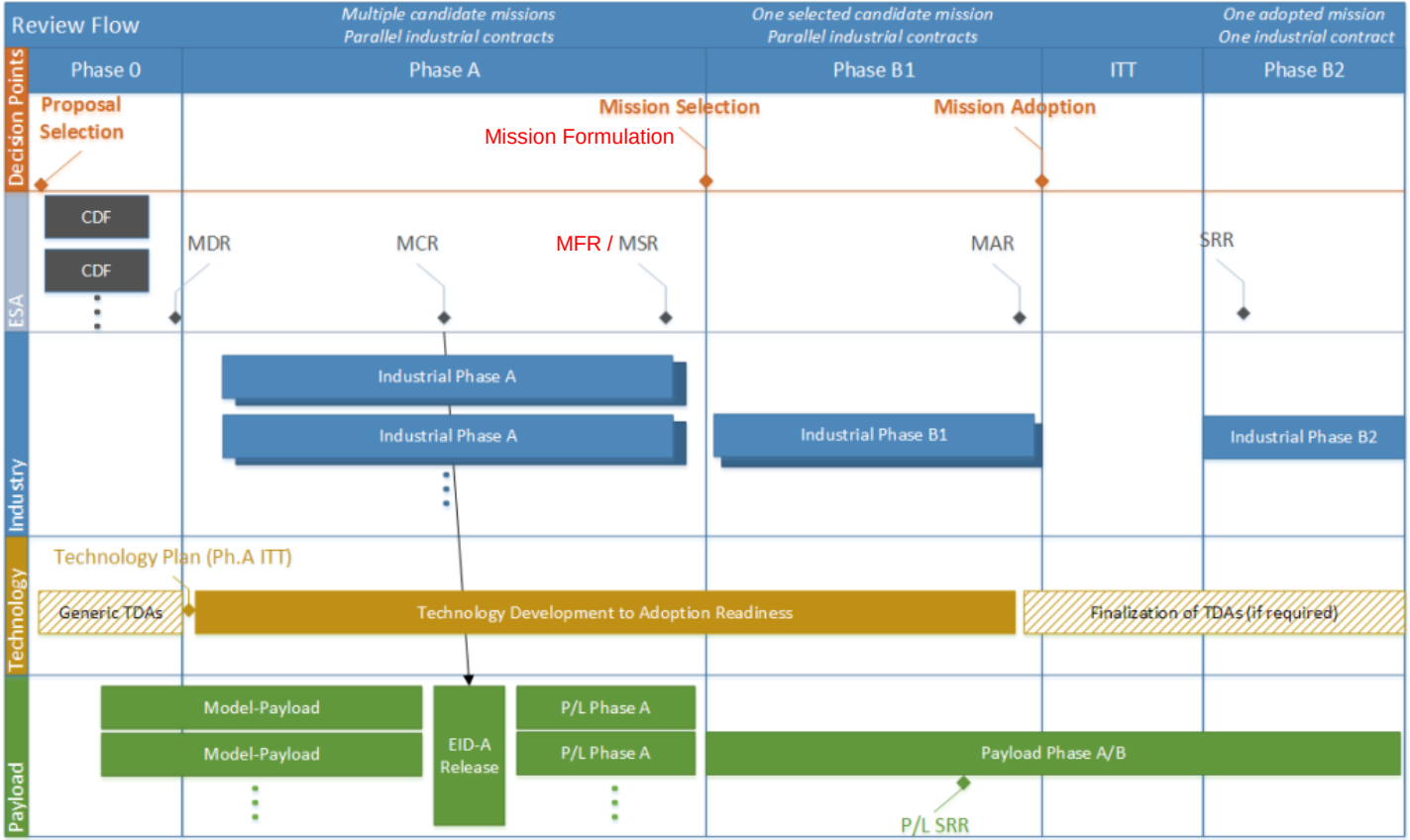
2. **System studies:** for defining the mission space segment:
   - Parallel industrial studies,
   - Iterations with the science community, ESOC (MOC), ESAC (SOC), Member States, P/L consortia, international partner
   - Convergence on requirements and interfaces

3. **Science and instrumentation related activities:**
   - Achieved by the science community, under Member States funding
   - Includes the Science Ground Segment
   - ESA support for Phase A P/L development activities

4. **Technology developments:** to reach TRL 5/6 prior to Mission Adoption
   - Mission driven technology work plans, in parallel to the studies
   - TDE/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) Phase A; Mission Adoption Review (MAR) Phase B1

The Process


Review Flow
Multiple candidate missions
Parallel industrial contracts
One selected candidate mission
Parallel industrial contracts
One adopted mission
One industrial contract
Decision Points
Phase 0
Phase A
Phase B1
ITT
Phase B2
Proposal Selection
Mission Selection
Mission Formulation
Mission Adoption
ESA
CDF
CDF
MDR
MCR
MFR / MSR
MAR
SRR
Industry
Industrial Phase A
Industrial Phase A
Industrial Phase B1
Industrial Phase B2
Technology
Technology Plan (Ph.A ITT)
Generic TDAs
Technology Development to Adoption Readiness
Finalization of TDAs (if required)
Payload
Model-Payload
Model-Payload
EID-A Release
P/L Phase A
P/L Phase A
Payload Phase A/B
P/L SRR

Technology Development

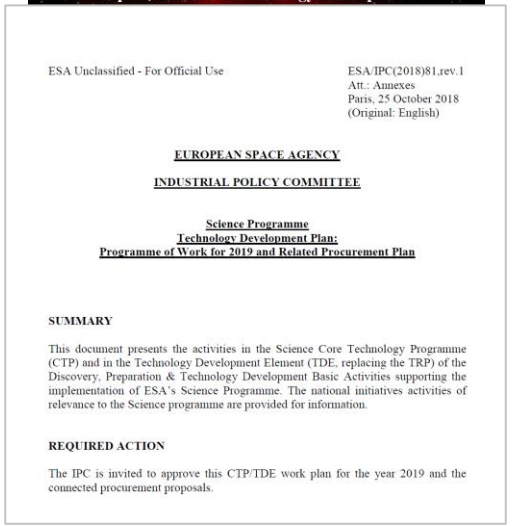
- Substantial effort is spent for reaching sufficient technology maturity of Science missions before adoption:
  - Science Core Technology Programme: ~ 14 M€/year
  - Technology Development Element: ~ 6 M€/year

- 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, ~150 completed, 70 in preparation… total ~320 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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Att.: Annexes
Paris, 25 October 2018
(Original: English)

EUROPEAN SPACE AGENCY

INDUSTRIAL POLICY COMMITTEE

Science Programme
Technology Development Plan:
Programme of Work for 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 2019 and the connected procurement proposals.

The ESA PRODEX Programme to fund scientific instruments

Outline Presentation – April 4th 2019

Marline Claessens
Deputy Head of the PRODEX Office (SCI-FE)
In: Future Missions Department (SCI-F)
In: ESA Directorate of Science (D/SCI)

PRODEX Programme

PRODEX: Scientific Experiment Development Programme

- Develop scientific experiments provided by the Participating States to ESA Programmes
- Can also be used to develop scientific experiments proposed for non-ESA Programmes

PRODEX is an ESA Optional Programme

- Participating States contribute to the programme as desired
- **Guaranteed georeturn** to each Participating State
- Currently the Programme counts 15 Participating States

PRODEX Participating States (Feb. 2019)


Switzerland (1986)


Austria (1991)


The Netherlands (2012)


Slovenia (2016)


Ireland (1987)


Denmark (1994)


Poland (2012)


Spain (2016)


Belgium (1988)


Czech Republic [2000-2004] (2008)


Romania (2012)


Hungary [1996-2003] (2017)


Norway (1989)


Greece (2008)


Portugal (2016)

PRODEX activities

Address all space science instrumentation fields

Hardware developments: full or part of a flight instrument H/W, ground support equipment

Software development: on-board, or for ground segment, incl. data analysis

Scientific activities: preparation, planning, execution or exploitation of a research activity

Cover a variety of domains and programmes

Experiments contributing to **any ESA Programme**: Science, Earth Observation, Microgravity (ISS), Robotic Exploration…

ESA Member States / PRODEX Participating States **National Programmes**

Bilateral projects between Participating State(s) and international Agency

Implementation aspects

PRODEX Office does not select the experiments

Experiments in ESA missions are defined by the relevant Programmes following their procedures

Science Programme: missions defined following a bottom-up process and peer reviews. Member States contributions to science instruments defined during the mission preparation phase (early phase).

Other ESA Programmes, National Programmes: specific rules or approaches.

Each PRODEX activity must be ***endorsed*** by the Participating State

Letter of Endorsement sent by the Delegation to the PRODEX Office

Activities in institutes (e.g. research institutes or universities):

Generally executed through "PRODEX Experiment Arrangements" (P.E.A.)

Activities in industry: Industrial ESA contracts

PRODEX project structure

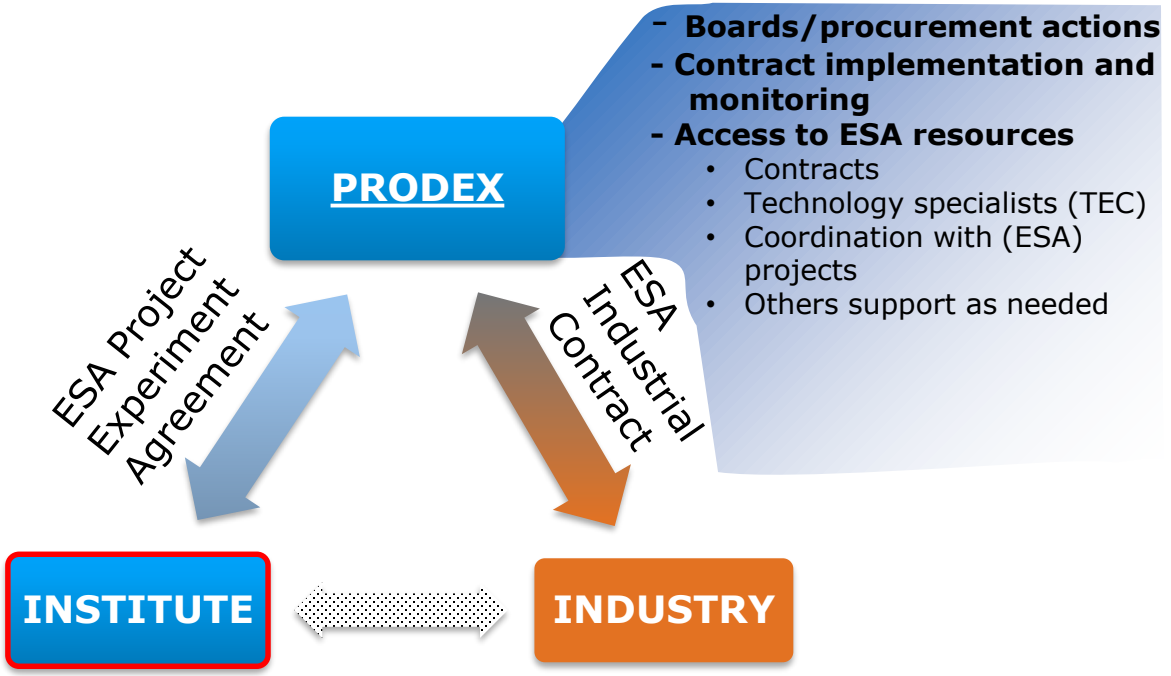
Structure of typical PRODEX project (development)

Institute / University & industry

=> Scientific activities

=> Instrumentation (ground segment) requirements

=> Industrial development (ESA contract)



PRODEX in figures: Running contracts in 2018

- Institute contracts 251
    - Out of which hardware developments 84
- ESA industrial contracts 30

PRODEX contacts

Future Missions Department (SCI-F) contact: frederic.safa@esa.int (Head of Department)

PRODEX Office (SCI-FE) contact: michel.lazerges@esa.int (Head of Office)

marline.claessens@esa.int (Deputy Head of Office)

veronique.dowson@esa.int (Project Controller)

PRODEX management address: prodex-management@esa.int

To be used for letters of endorsement, draft proposals submitted for review etc. Indeed addressing bilateral emails always possible.

Message received by people listed above + Department assistants Birgit Schroeder and Florence Teindas.