ESA programmes – opportunities for POLAND

IPL/TEC/EOP/SCI

24/05/2018

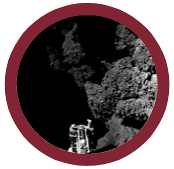
ESA - Activities

ESA is one of the few space agencies

in the world to combine responsibility

in nearly all areas of space activity.

* Space science is a Mandatory programme, all Member States contribute to it according to GNP. All other programmes are Optional, funded ‘a la carte’ by Participating States.



space science

human spaceflight

exploration

earth observation

space transportation

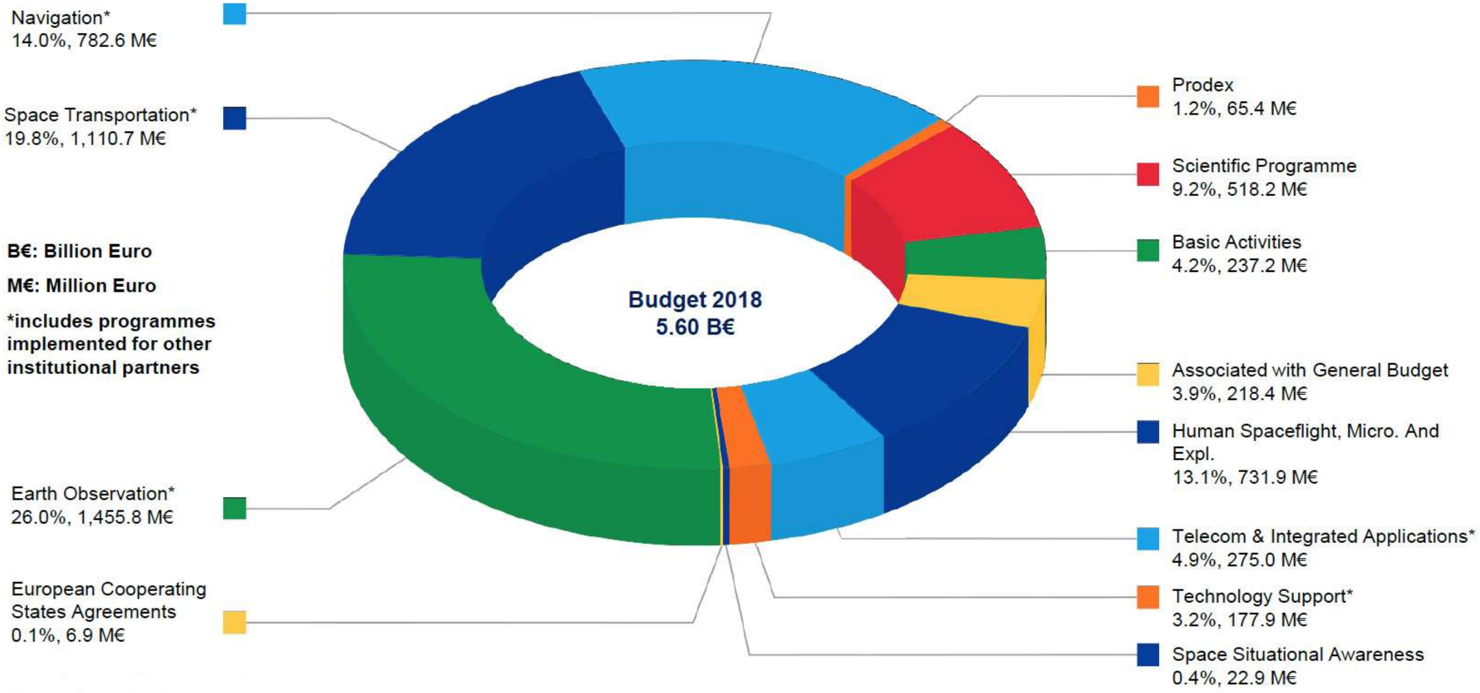
navigation

operations

technology

telecommunications

ESA budget for 2018: by domain



Summary of presentation

1. Poland as ESA NMS – the Industry Incentive Scheme
2. Opportunities in Technology
3. Opportunities in EO
4. Opportunities in Science

Poland as New Member State (NMS) The Industry Incentive Scheme

Stephane Combes (IPL-IPS)

New Member State Poland in ESA

- European Cooperating State (ECS) Agreement between the Government of the Republic of Poland and the European Space Agency signed in Warsaw on 27 April 2007 and entered into force on 28 April 2008, in force until accession agreement
- Accession agreement with ESA signed 31th July 2012
- Integration period of 6 years starting in 2012 until 31th December 2017 extended by two years until end 2019: The **Polish Industry Incentive Scheme (PLIIS)**

Status of Poland contribution to ESA

- PL yearly average contribution to ESA is ~**34 M€**
  (incl. ~23 M€ mandatory part: Incentive Scheme, Science)
- Recall of Polish contributions at the last ministerial council in 2016

Programme	**Element**	**Acronym**	**Period**	**Amount (Million €)**
Earth Observation Envelope Programme		EOEP 5	2017-2021	9.7
ARTES	Future Preparation	FP	2017-2019	0.25
ARTES	Next Generation Platform (NEOSAT)	NEOSAT	2013-2020	2.12
ARTES	Integrated Application Promotions	IAP	2017-2019	5
Navigation Innovation and Support Programme	Element 2 "Competitiveness"	NAVISP	2017-2021	1.5
Future Launchers Preparatory Programme	NEO Core	FLPP	2017-2019	3.75
European Exploration Envelope Programme	SciSpacE	E3P	2017-2019	0.76
European Exploration Envelope Programme	ExPeRT, Luna-Resource Lander, Commercial Partnerships	E3P	2017-2019	3.04
Space Situational Awareness Programme		SSA	2017-2020	6
General Support Technology Programme	Element 1 "Develop"	GSTP	2017-2019	7.57
Prodex				5
Total				**44.69**

- Since then, additional contributions made to Prodex, SSA, GSTP

PLIIS evolution for 2018-2019

- Since 2012, **133 PLIIS Activities** kicked off for 32M€ and 20 additional in the pipeline
- In 2017, the ESA-PL Task Force initiated a Working Group to suggest changes to PLIIS for the last 2 years of operation;
- Changes targeted to a two prong approach – **Top Down Activities with an ESA SoW** in parallel to a **more restricted Open Call**
- Working Group used questionnaires to Polish industry and ESA technical officers of Polish activities as basis of recommendations together with face to face meetings, Polish optional programs and their GEO return.

On 01/02/2018, ESA-PL TF approved:

- Topics and the associated budget per topic for the Top Down Activities
- Amendments to cover letter to restrict the Open Call

PLIIS evolution for 2018-2019
Roadmap areas for Top Down Activities

Area	PLIIS budget	Description
Professional PM/QA/PA Support	0.5 M€	Frame contract to support call off order on request. PA/QA and Project management commonly cited as needing improvement by ESA TOs.
Downstream user lead	0.6 M€	Pre-operational services to deliver needed products to the potential (governmental) customers.
Propulsion	2 M€	Targeted higher TRL activities in areas considered to be near term candidates for ESA or commercial missions or for the development of propulsions system elements to replace non-EU supply.
Telecommunication and microwaves	1.25 M€	Targeted higher TRL activities to be able to become successful in ESA telecom or remote sensing activities or commercial missions.
SSA	0.5 M€	Activities shall enable Poland to participate in the SSA programmes.
Operations infrastructure	0.6 M€	Many successful activities already took place. Additional ones will be defined to further enable the entry of Polish entities into ESOC frame contracts.
Qualification of recurring space hardware	2 M€	Targeted high TRL activities to support the development of supply chains for system and subsystem integrators.
TOTAL	**7.25 M€**	

PLIIS evolution for 2018-2019
Top Down Activities – high level process

01/02/2018 | June 2018 | July 2018 | < end 2019

Task Force Decision on Topics and Financial Envelope

→ Production of Roadmaps (per topic)
By ESA and the Polish Delegation

→ Approval by ESA-Poland Task Force

→ Open Call ITT on EMITS
Roadmaps workplan in Annex

→ Normal ESA ITT process

PLIIS evolution for 2018-2019
Open call restrictions

The following additional **exclusions** will be introduced:

1. *Mechanisms*
2. *Software including Operational software and Downstream applications*
3. *Activities supporting the participation to SSA*
4. *Activities supporting the participation to Prodex*
5. *Overlap with and duplication of the roadmaps shall also be excluded*

Type a) Hardware activities will be limited to **600 k€**.

Overall marking above Good (**60**) will be required.

Technology Programmes

Matthew Bollock (TEC-TI)

Technology Programmes

Mandatory Programmes

- Science Core Technology Programme (CTP),
- **Technology Development element of DPTD (Basic Technology Research Programme, TRP)**

Optional Programmes

- **General Support Technology Programme (GSTP)**
- Earth Observation Envelope Programme (EOEP) and InCubed
- Advanced Research in Telecommunication Systems (ARTES)
- European GNSS Evolution Programme (EGEP) and Navigation innovation and Support Programme (NAVISP)
- Future Launchers Preparatory Programme (FLPP)
- Robotic Exploration (ETP), European Exploration Envelope Programme (E3P) with Science in Space Environment (SciSpacE) and Exploration Preparation, Research and Technology (ExPeRT)

Technology Programmes
DP**TD** Technology Development element (TRP)

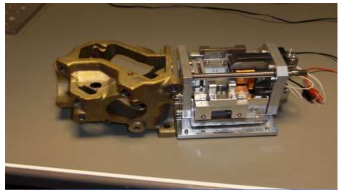
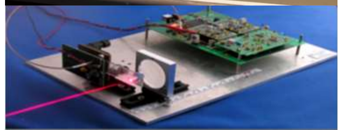
- Part of ESA's Mandatory Basic Activities
- All technology disciplines & applications
- Based on two year workplans, with yearly updates
- About 40-50 M€ in industrial contracts per year
- About 150 contracts per year
- One of the main contributors to scientific & engineering excellence
- One of the main sources of new ideas

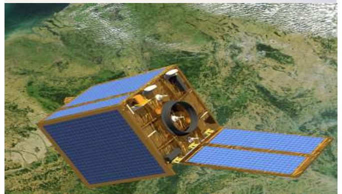
2016-2017 TRP work plan is being implemented, invitations to tender for each activity are published throughout the year (see emits.esa.int)

2019-2020 work plan is under definition

The TRP is the backbone of ESA's innovation effort covering up to proof-of-concept TRL 3

Technology Programmes
GSTP - Overview



- Part of ESA’s Optional Programmes. Covering all technology disciplines and applications except Telecommunications (covered by ARTES)
- All ESA Member States are participating. ESA Member States contribute yearly approximately 150 M€ to the GSTP.
- Work Plans, with yearly updates, and multiyear activities are published.
- GSTP projects require a written letter from the Delegation for a specific activity.
- The average yearly Polish contribution is about **2.5 M€** until end of 2019 in the “**Develop**” component of the programme.
- From accession to ESA until today, Poland has already contributed with 20,9 M€ in GSTP, this budget has been fully expended awarding industrial contracts in Poland.

The GSTP ensures the right technology with the right maturity are available at the right time

Technology Programmes
GSTP – Elements structure

ELEMENT 1

Develop

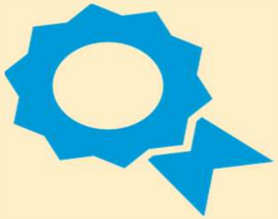
Development of technologies and products from low TRL to qualification Platform, Payload, Ground Segment and Engineering tools

75% of the activities

ELEMENT 2

Make

Market driven, industry initiated co-funded activities to mature technologies that lead to products

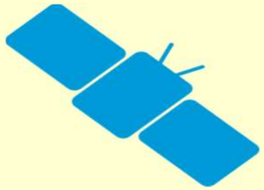


15% of the activities

ELEMENT 3

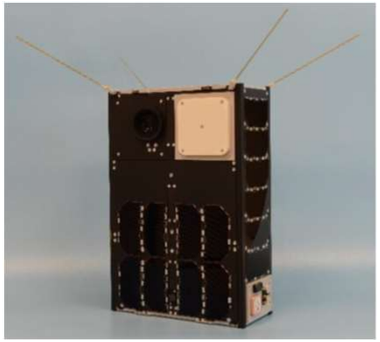
Fly (Small Missions)

Envelope which hosts components such as Proba 3, cubesats, ISS payloads, techno flight opportunities



10% of the activities

Technology Programmes
GSTP Element 3 – Fly



Recently launched missions and ongoing developments

- Proba 3
- GOMX-3 and GOMX-4B In-orbit Demonstrations
- OPS-SAT, Picasso, Simba, QARMAN, RadCube
- Mission for IOD of small Hall Effect Thruster

Upcoming missions

- PRETTY (GNSS reflectometer, radiation monitor) Phase B
- Norwegian nano/microsat IOD Phase A
- GOMX-5 Phase A/B1
- Rendezvous Autonomous Cubesats Experiments Mission Phase A/B
- Proba-V follow-on Phase A

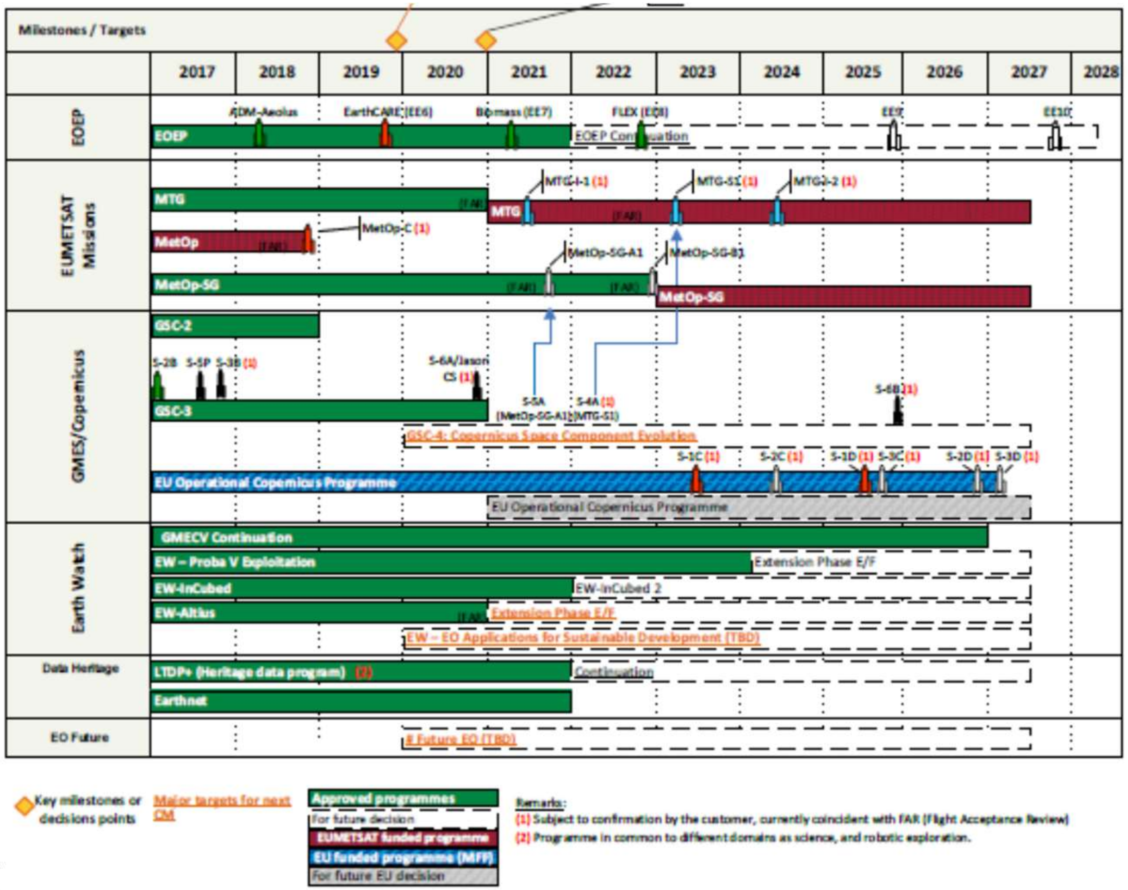
Earth Observation Programmes

Arnaud Lecuyot (EOP-8MP)

Activities of the Earth Observation Directorate

- Yearly budget ~1.5 B€ shared between Member States and Partners (EUM, EU)
- A key programme is **Earth Observation Envelope Programme** (EOEP-5) with a budget of ~1.2 B€ in the 2017-2025 period, to which Poland contributes ~3 M€/yr
    - "EE" Earth Explorer missions and preparation for Copernicus missions
    - Block #1 Future Missions: **EE10 phase 0/A, Future Missions**
    - Block #2 Mission development: EE8 FLEX, EE9, Preparation Copernicus
    - Block #3 Management/exploitation
    - Block #4 use of Data (#4, EO Science for Society)
- Also EarthWatch programme (Poland not present), including:
    - CCI/GMEVC (Data reprocessing, monitoring of ECV)
    - Incubed (co-funded / PPP commercial-focused developments)
    - Altius (small mission separate from EOEP)
- Partners programmes:
    - Copernicus (1st Gen) S1-2-3 C+D (A&B operational), S4, S5, S6 A+B
    - MeteoSat 3rd Generation (I+S), **Metop 2nd Generation (A+B)**
    - Preparation of Copernicus Expansion: 6x Phase A/B1 for new Sentinels
    - Preparation of Copernicus Extension: Next Generation Sentinels

EO Missions timeline



Opportunities for Poland in EOP up to 2021

- EE7, EE8, S1 to S6, MTG, MetOp-SG are largely fully contracted
- EE9 in phase A, expected full-consortium approach (Poland not present currently)
- Sentinels Expansion Phase A/B1 already awarded – Ph. B/C/D at CMIN19
- **EE10 possibilities** as part of phase A/B1 prime
- Potential **small satellites programme** "FutureEO" – To be decided at CMIN19
- Continuing opportunities in **EOEP Block #4 Data Exploitation**

Overview of future science missions

Space Sector Forum 2018

Warsaw, 24/05/2018

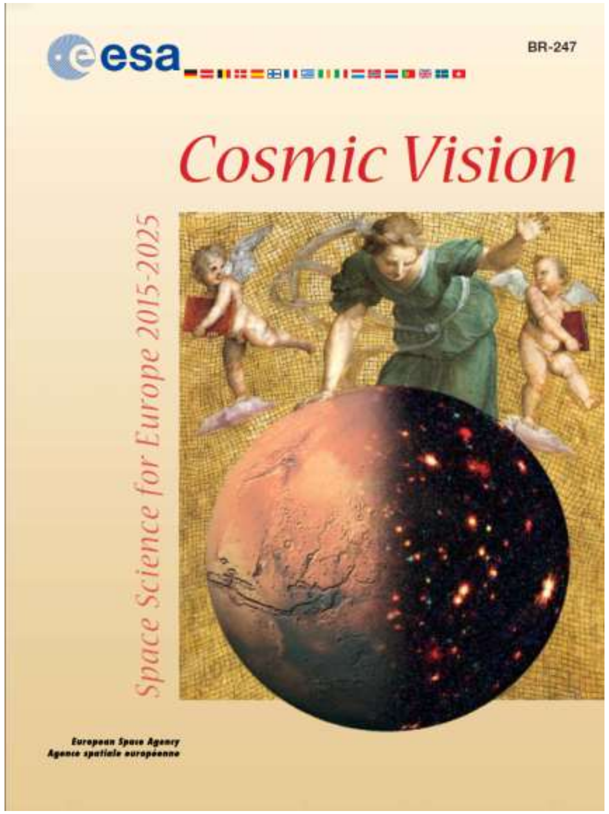
Ivo Ferreira

ESA – ESTEC, Science Directorate, Future Missions Department

Science Programme

The Cosmic Vision plan was introduced in 2005. Currently it covers the ESA Science Programme till 2035 and is centred around the following four key questions:

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



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**:3 candidate missions selected for further study (Phase A in 2018-2019)
- **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); possible call Q3/Q4 2018, details TBC
  (300-500kg S/C, ~ 6 years from selection to launch)

Science Program

BepiColombo, JWST

L1 JUICE 2022	L2 ATHENA 2031 (TBC)	L3 LISA 2034

M1 SolarOrbiter 2020	M2 Euclid 2020	M3 PLATO 2026	M4 ARIEL 2028	M5 Sel+Phs.0 2018 2029	M6 cancelled	M7 -> M6 call TBD

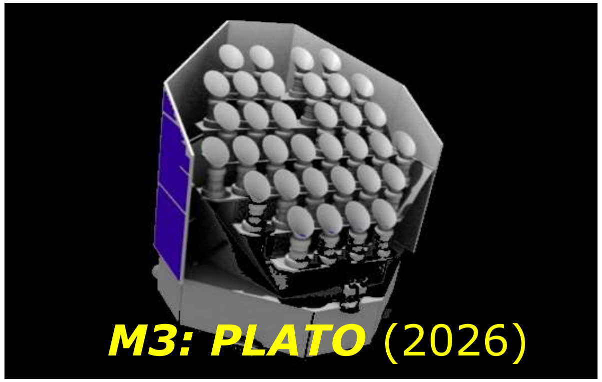
S1
Cheops
2018 → F-
missions
?

MO SMILE 2022	MO XARM 2022	MO WFIRST 2025/26	MO LiteBird 2027	MO Einstein Probe

Sun	Solar System	Astrophysics	Fundamental Physics
Implementation			
[2020] Solar Orbiter	[2022] JUICE [2018] BepiColombo	[2026] PLATO [2020] Euclid [2020] JWST [2018] CHEOPS	
Operations / Post-Operations			
[2009] PROBA2 [1995] SOHO	[2016] ExoMars TGO & Schiaparelli [2005] Venus Express [2004] Rosetta [2003] Mars Express [2003] Double Star [2000] Cluster [1997] Cassini-Huygens	[2013] Gaia [2009] Planck [2009] Herschel [2002] INTEGRAL [1999] XMM-Newton [1990] Hubble	[2015] LISA Pathfinder

Science Missions in Implementation

BepiColombo (2018), JWST (2020)



Future Missions preparation – main activities

1. **Calls (bottom up approach of selection)**
    - M5 call under evaluation: 3 candidates selection occurred in April 2018
    - Call for New Science Ideas: 3 themes selected: Quantum Physics, Small Planetary Platform, GAIA-NIR
    - Call for F-missions: Q3/4 2018 (TBC)

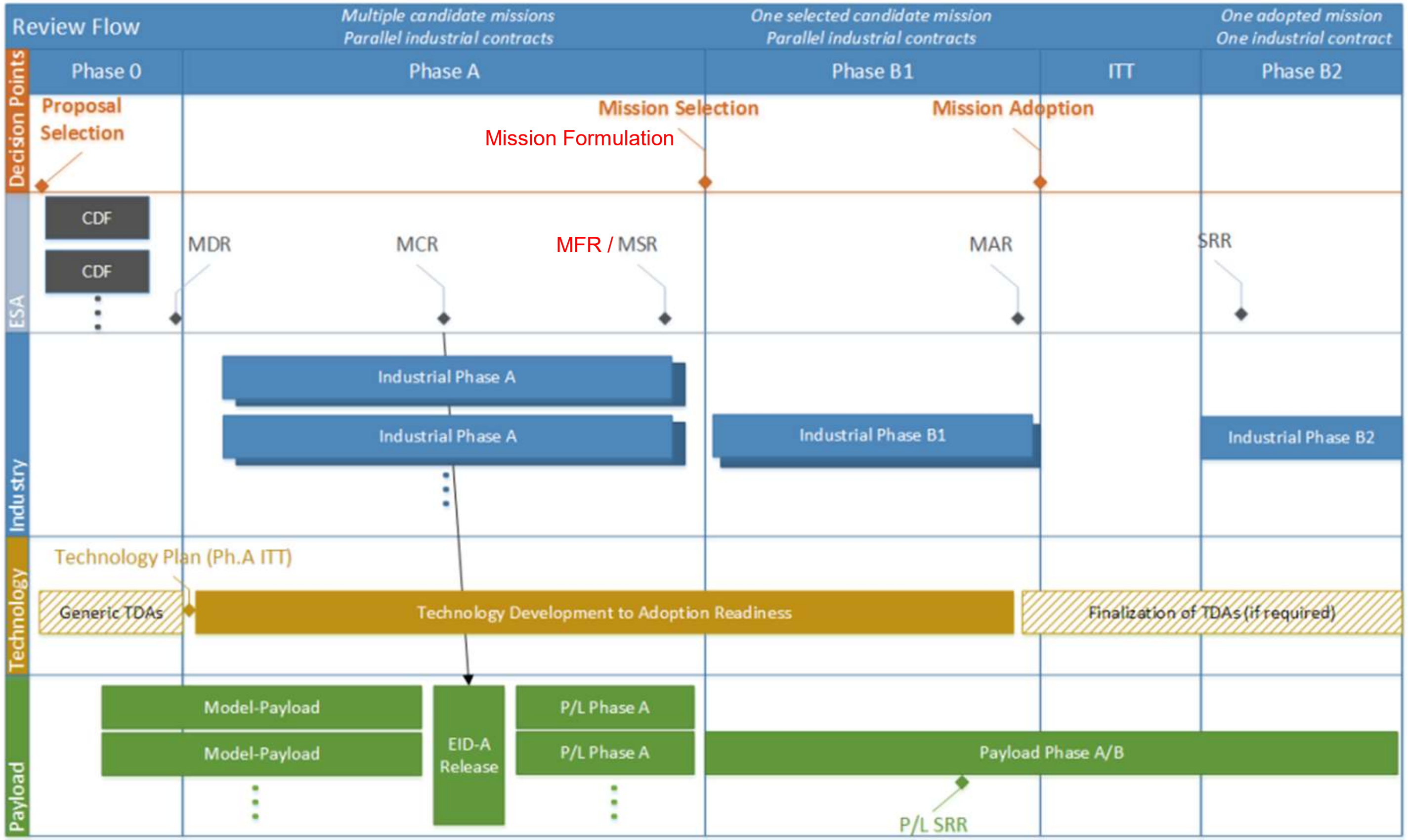
2. **System studies:** for defining the mission space segment:
    - Parallel industrial studies,
    - Iterations with the science community, ESOC (MOC), ESAC (SOC)
    - Convergence on requirements and interfaces

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)

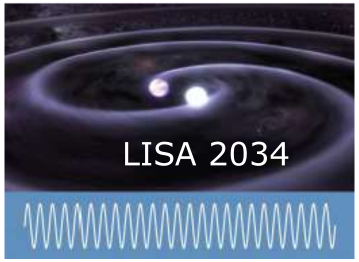
5. **Independent reviews:** to control the achievements and enable decisions
    - Assessment of the definition maturity, the technology readiness and cost/risks
    - Mission Selection/Formulation Review (MSR/MFR) end Phase A; Mission Adoption Review (MAR) end Phase B1

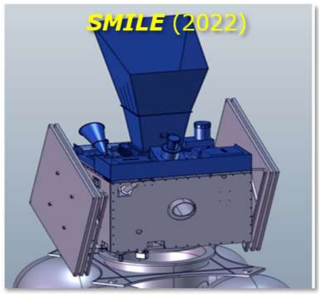
The Process

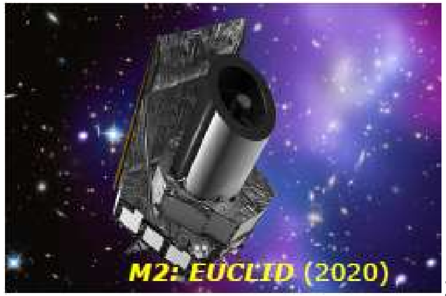

Review Flow
Multiple candidate missions
Parallel industrial contracts
One selected candidate mission
Parallel industrial contracts
One adopted mission
One industrial contract
Phase 0
Phase A
Phase B1
ITT
Phase B2
Decision Points
Proposal Selection
Mission Selection
Mission Formulation
Mission Adoption
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

Mission Calls

- M1/M2/L1 (2007) → Solar Orbiter (M1), Euclid (M2), Juice (L1)
- M3 (2010) → PLATO
- S1 (2012) → Cheops
- L2/L3 WP (2013) → The hot and energetic Universe & The gravitational Universe
- L2 (2014) → ATHENA
- M4 (2015) → ARIEL
- S2 (2015) → SMILE (ESA, CAS)
- M5 (2016) → under evaluation → Phase 0 in 2018
- L3 (2017) → LISA
- Future calls F1 (2018, TBC), ~~M6~~, M7 (?)







Call for New Science Ideas

- Open call to scan for new ideas which not necessarily have to fit TRL, schedule, budget constraints as for M, L, S & O missions

- Call issued in 2016 ⇨ received proposals ⇨ evaluation done ⇨ <u>Three topics selected</u>:
  1) GAIA-NIR: GAIA in the Near-IR
  2) Small Planetary Platform (SPPF): multi-point/multi-target observation with small sats
  3) Quantum Physics (QPPF): De-Coherence in Space

- Progress
  ⇨ Workshops done for QPPF & SPPF (June 2017, Sep 2017)
  ⇨ CDF done for GAIA-NIR (completed) and SSPF (work ongoing)
  ⇨ CDF for QPPF in preparation (KO 15-May 2018)

Technology Development

- Substantial effort is spent for reaching sufficient technology maturity of Science missions before adoption:
  - Science Core Technology Programme: ~ 14 M€/year
  - TRP ~ 7 M€/year (last years)
- 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: ~105 running, 110 completed, 63 in preparation = total ~280 TDA’s
- Some of the technology development highlights are presented today


Att.: Annexes
Paris, 24 October 2016
(English Only)

EUROPEAN SPACE AGENCY

INDUSTRIAL POLICY COMMITTEE

Science Programme
Technology Development Plan
Programme of Work for 2017 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 Science Programme. The national initiatives activities of relevance to the Science programme are provided for information.

REQUIRED ACTION

IPC is invited to approve this CTP/TRP work plan for the year 2017 and the connected procurement proposals and take note of activities envisaged for 2018, included for information.

VOTING RIGHTS AND MAJORITY REQUIRED

Simple majority of member States, present and voting.

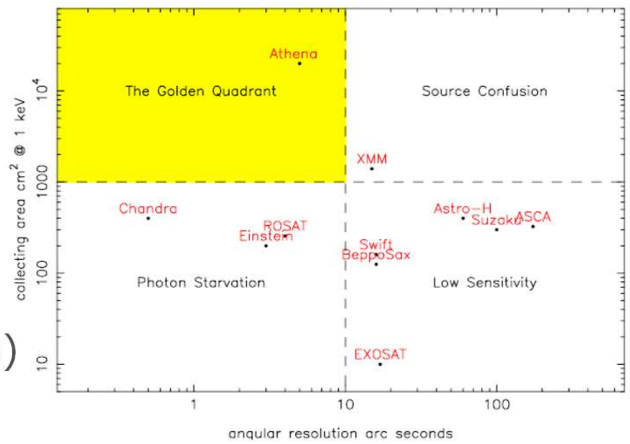
L2: ATHENA

Objectives, Requirements and Status

Objective: Spatially resolved X-ray spectroscopy and wide field spectral imaging of Hot Structures and Black Holes (0.1-15 keV)

Main Requirements:

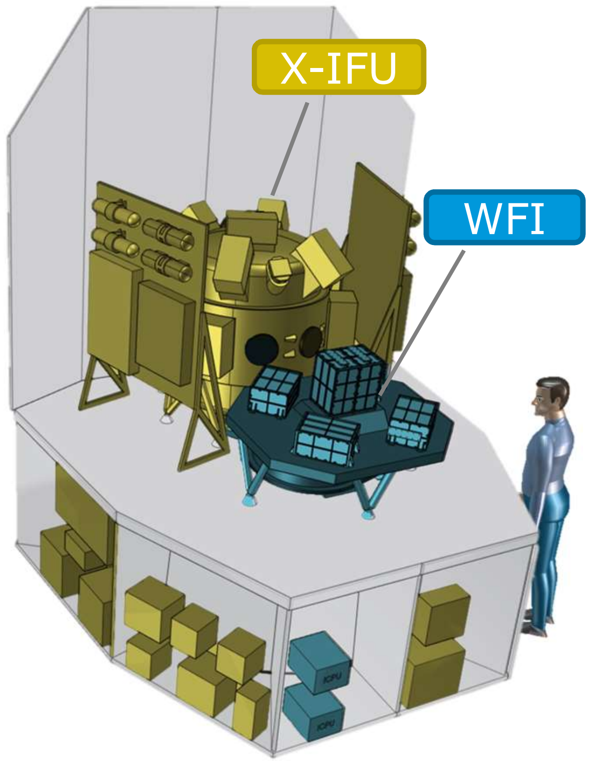
- 5 arcsec angular resolution (HEW) imaging
- Mirror effective area on-axis: 1.4 m^2 @ 1 keV
- 2.5 eV spectral resolution @ 6 keV
- Target of Opportunity reaction time <4 h (for 67% cases)



Status:

- Phase A extension till summer 2019 (Mission Formulation Review)
- Mission Adoption Nov 2021
- Launch in 2031

ATHENA Payload

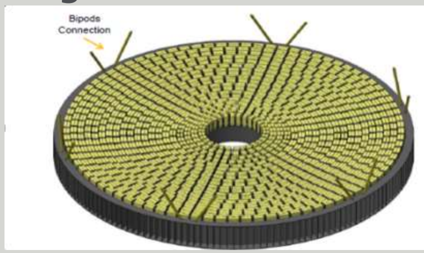


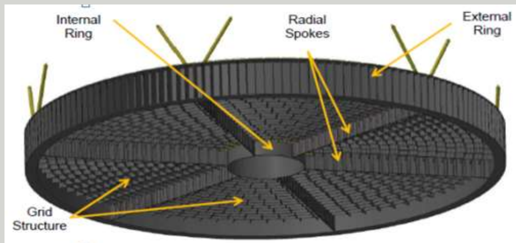
Two instruments:

- **Wide Field Imager (WFI)**: APS (DEPFET sensor) camera with 40′ FoV (~270 kg mass)
- **X-ray Integral Field Unit (X-IFU)**: cryo-cooler TES detector-based spectroscopy (~770 kg mass)

Mirror Assembly Module: based on SPO technology

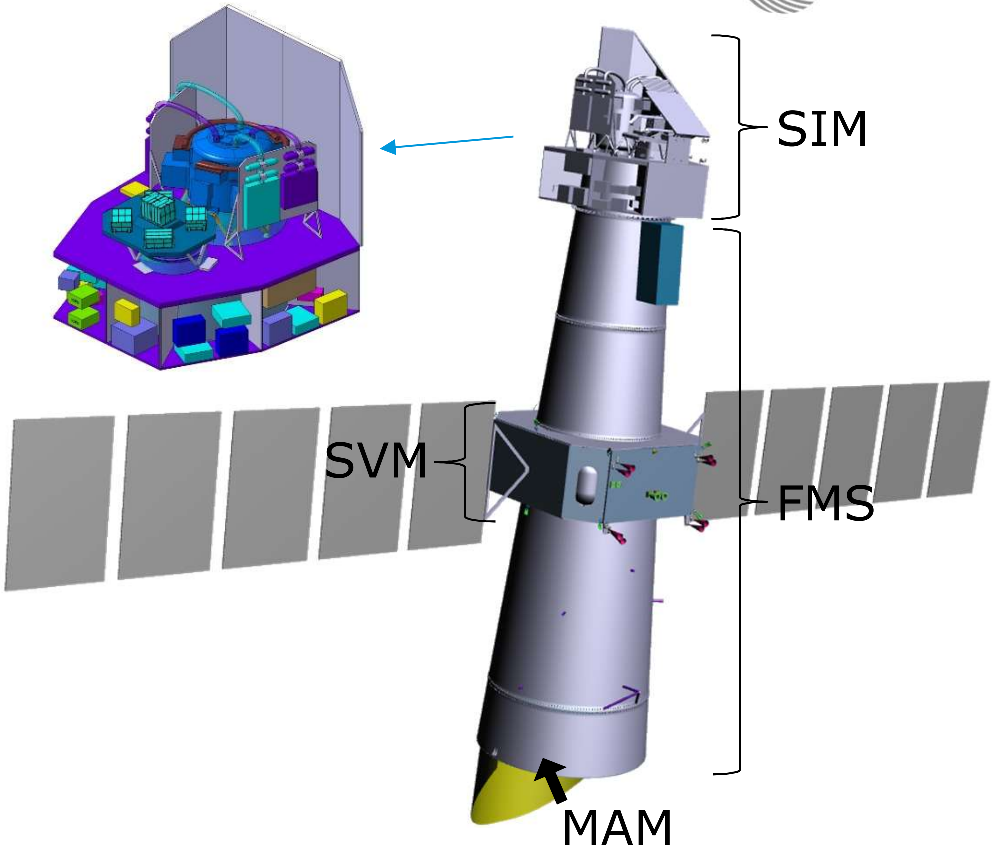
- 12 m focal length
- 2.4 m diam
- 750 kg





ATHENA – Spacecraft

- Launch Mass: <7.000 kg
- Mirror and Focal Plane separated by Carbon Fibre fixed metering structure
- Large LV I/F (3936 mm) to fit the Mirror
- SVM positioned along the tube
- Mirror Assembly tilted by mechanism (hexapod) to switch between the two instruments
- Need of metrology system to measure Telescope Line-of-Sight misalignment (lateral offset between mirror and detector)



L3: LISA

Objectives, Requirements and Status

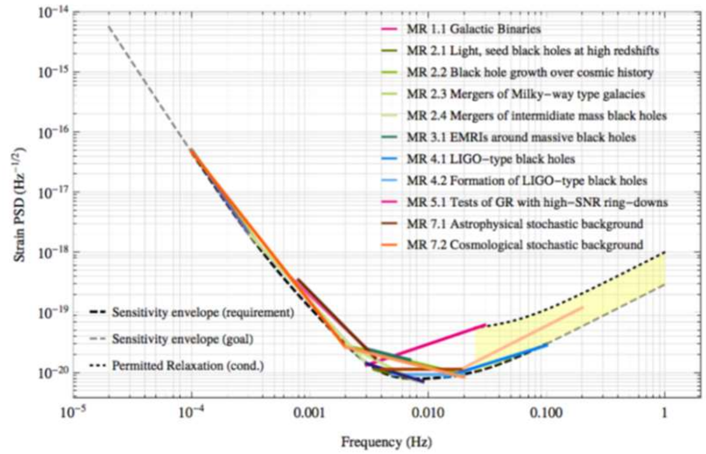
Objective:

- Measurement of Gravitational Waves based on laser interferometry to study formation and evolution of a variety of astrophysical sources (compact binary stars, massive black holes, etc.)

Main Requirements:

- Test masses displacement noise ~10pm/sqrt(Hz)
- Test masses acceleration noise ~3fm/s^2/sqrt(Hz)

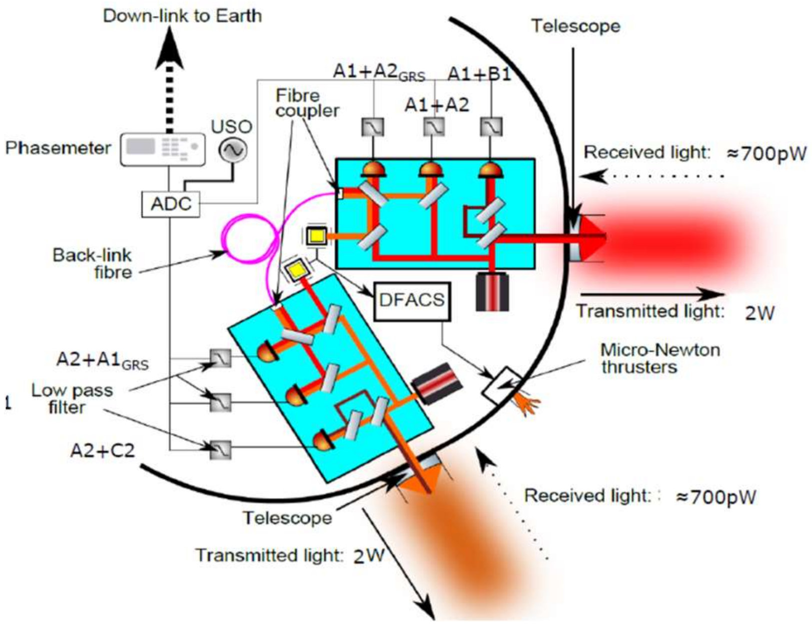
@ 0.1 mHz to 100 mHz

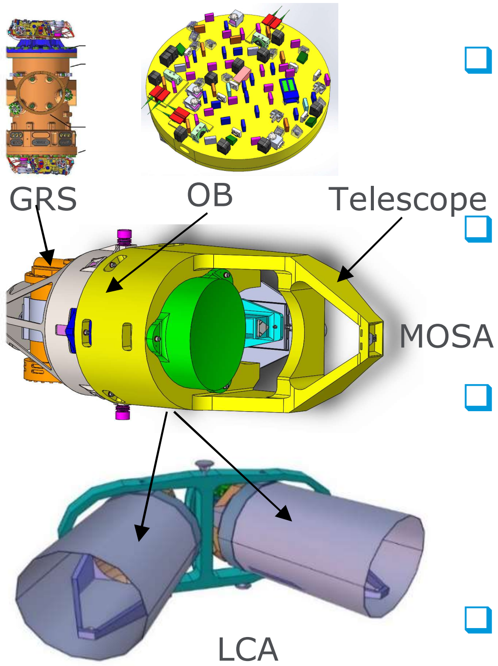


Status:

- Phase A due to start May 2018
- MCR: March 2019
- Mission Formulation Review: end 2019
- Adoption by 2024/Launch by 2034

LISA – Payload



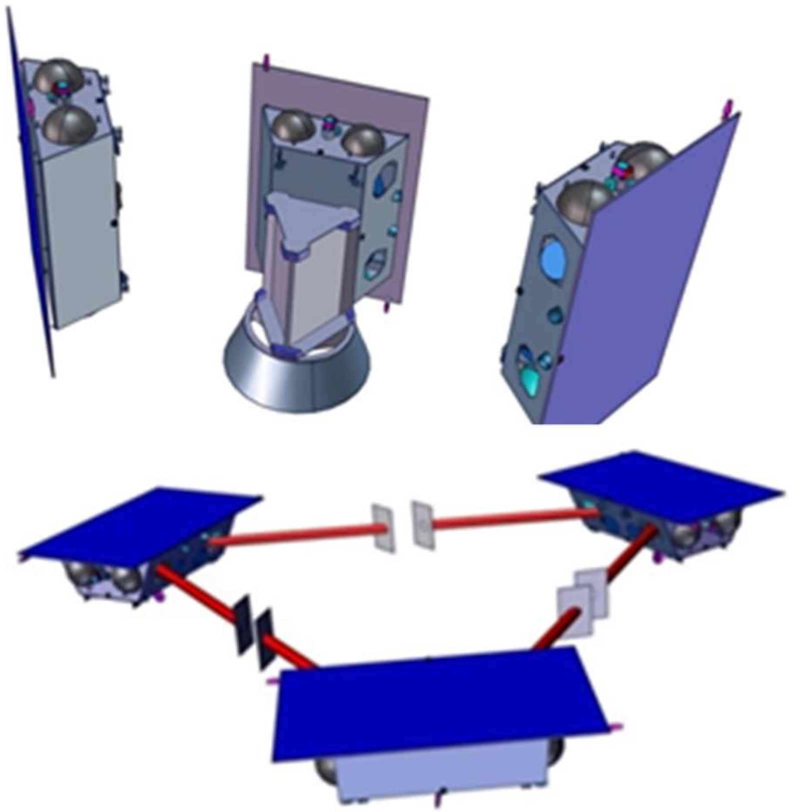


- Interferometry is made against a fiducial test mass in the GRS (LPF heritage).
- All optical interferometry functions are housed on the OB
- Due to the arm length and beam divergence, a telescope ensures sufficient power is received
- Phasemeter processes the raw signals measured on the OB photo detectors and produce the science signal

MOSA: Movable Optical Sub-Assembly

LCA: LISA Core Assembly: Two MOSAs articulated each other

LISA – Spacecraft



Spacecraft Design (CDF Status):

- 3 identical spacecraft launched together via dispenser (requires “flat” configuration)
- Electric Propulsion for transfer to operational orbit
- Cold gas micropropulsion for drag-free control(LPF heritage) – 240 kg Xe
- SC mass: 1950 kg
- Stack mass: 6850 kg
- Fixed SA sized for 2.4 kW transfer
- Baseline TT&C X-band @ 100 kbps (antenna under trade: movable dish vs phased array)

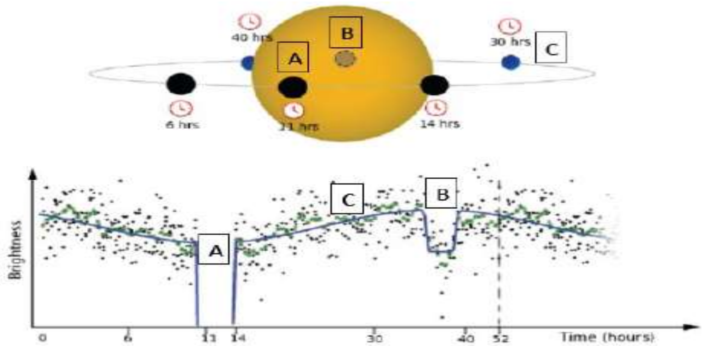
M4: ARIEL

ARIEL Objectives, Requirements and Status

Objective: measurement of exoplanets' atmosphere by transit spectroscopy *(λ=1.2-7.8 µm)*

Main requirements:

- Mirror aperture A_{eff} = 0.6 m^2
- Detectors cryogenic cooling (@35 K)
- Noise and photometric stability leading to pointing stability <100 mas over 10 h (requires Fine Guidance Sensor)



Status:

- Phase B1 started in Apr 2018
- Mission Adoption in November 2020
- Launch: 2028

ARIEL Payload

Telescope:

- Off-axis Cassegrain telescope, 1.1m x 0.7m elliptical M1; diffraction limited at 3µm. Mirrors, optical bench and telescope all manufactured from Al 6061 for isothermal design

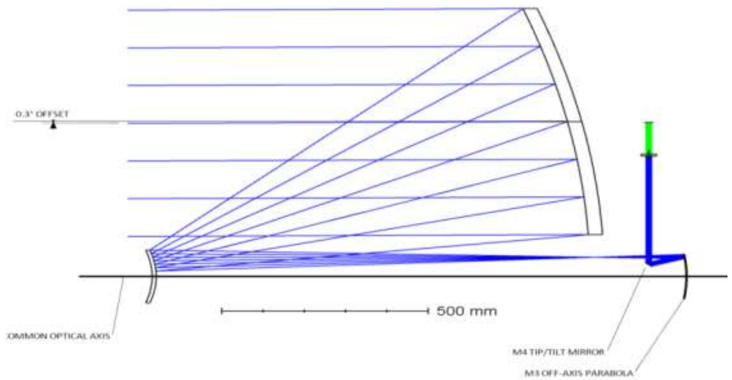
VNIR instrument:

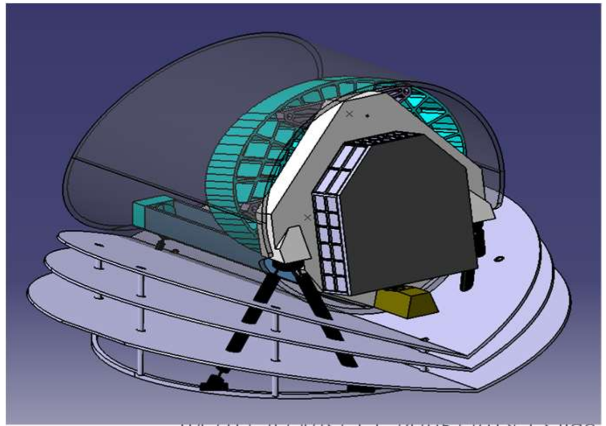
- 3 photometric channels (0.5-1.2 µm) for FGS and monitoring of stellar activity.
- Low resolution spectrometer (R=10) between 1.25-1.9 µm.
- HgCdTe detector(s) from Teledyne e2V, or European equivalent.

AIRS instrument:

- IR spectrometer covering 1.95-7.8 µm over two channels with R=100/30 (below/above 4 µm).
- 1 channel with HgCdTe standard detector from Teledyne e2V
- 1 channel with HgCdTe NEOcam detector from Teledyne e2V.

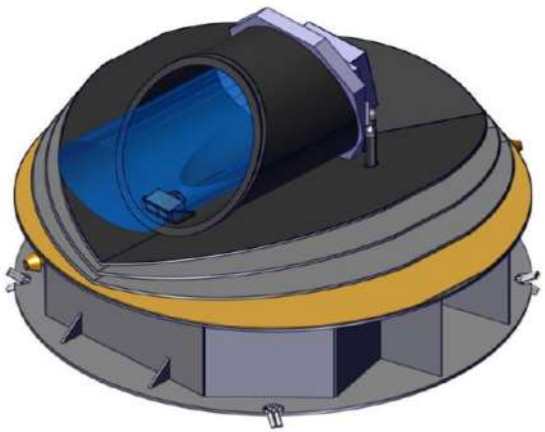
- AIRS detectors @ 35 K.

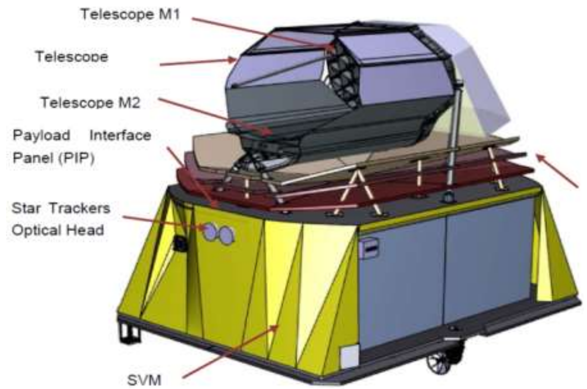




ARIEL Spacecraft

- Design driven by thermal: Warm SVM, cryogenic PLM cooled passively to ~55K with the thermal shield assembly (incl. V-grooves).
- Active cooler (Neon JT) included to ensure AIRS detector operating temperature of ≤40K
- AOCS based on RWs on dampers and angular rate controlled within a narrow band to avoid excitation of harmonics (low micro-vibrations).
- ~1400 kg mass at launch
- Fixed SA: ~1000 W
- Baseline TT&C X-band @ 2.5 Mbps





SMILE

SMILE Mission Summary

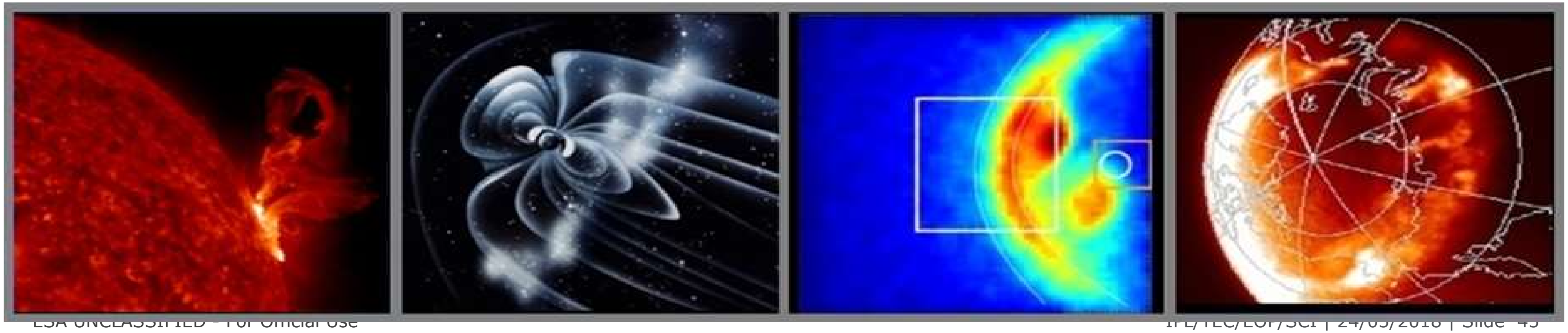
Objective: **Investigate the dynamic response of the Earth's magnetosphere to the solar wind impact**

Orbit: Highly Elliptical Earth Orbit: 5.000 x 121.000 km, inc.=70 deg

Launch: Vega-C or dual launch Ariane 6.2 (~ 2.000kg launch mass)

Spacecraft: Service Module (220 kg dry), Payload Module (120 kg), Propulsion Module (315 kg dry), 480W, 3-axis stabilized

Payload: 4 Instruments for X-ray and UV observations, magnetic field

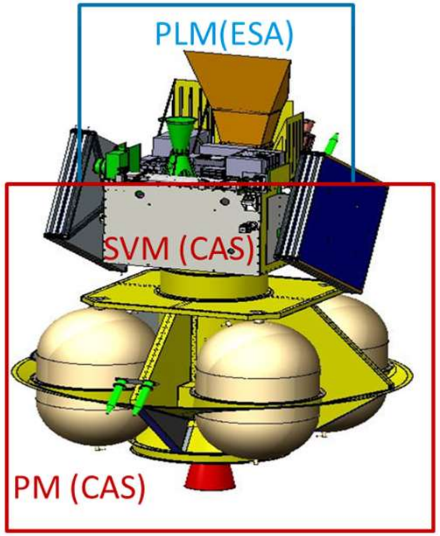


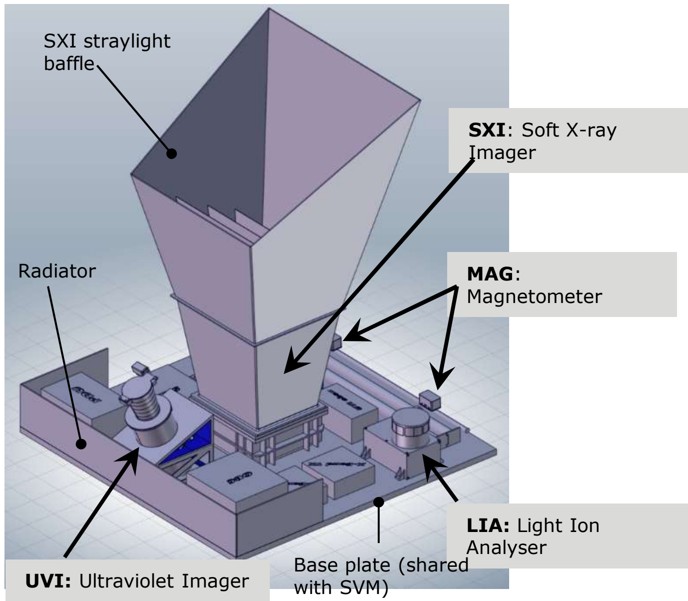
Payload and Spacecraft overview

- **Two imaging instruments**:
  - Soft X-ray Imager (SXI)
  - Ultraviolet Imager (UVI)

  Imaging the solar wind - magnetosphere interaction zones & northern aurora.
- **In-situ measurement package**:
  - Light Ion Analyser (LIA)
  - Magnetometer (MAG)

  Measure the solar wind properties simultaneously with imagers.

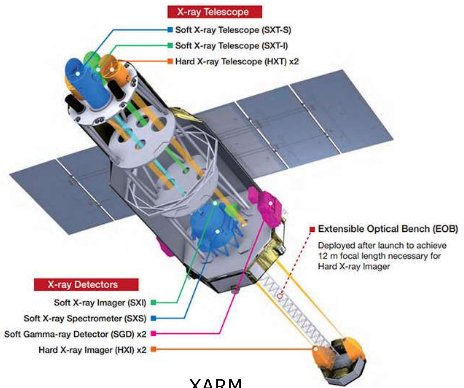




Missions of opportunity

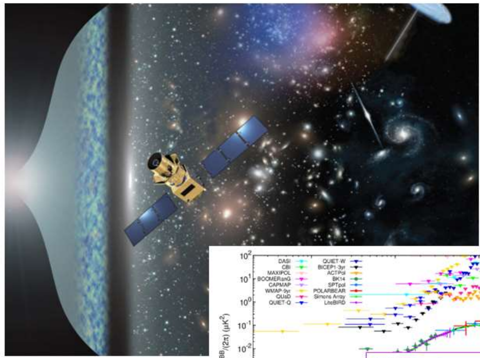
Missions of Opportunity

- 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

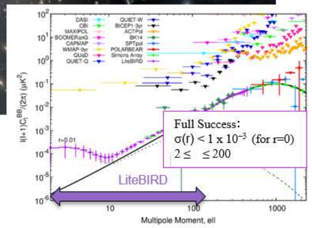


XARM

WFIRST

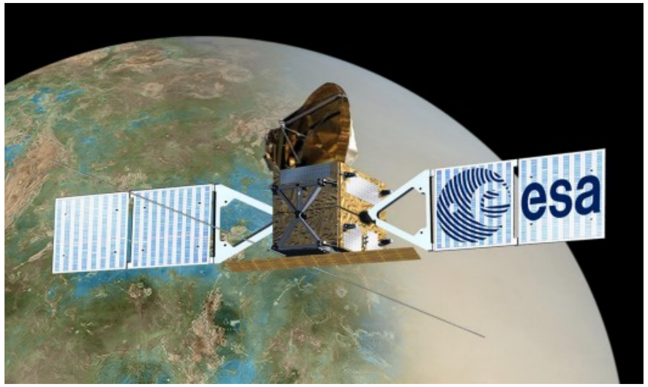


LiteBird



M5 candidates

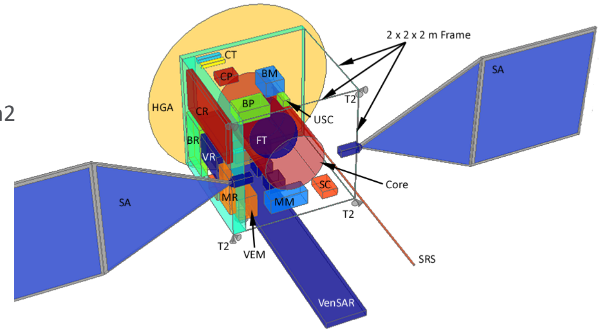
EnVision



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 24 October 2029
- 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

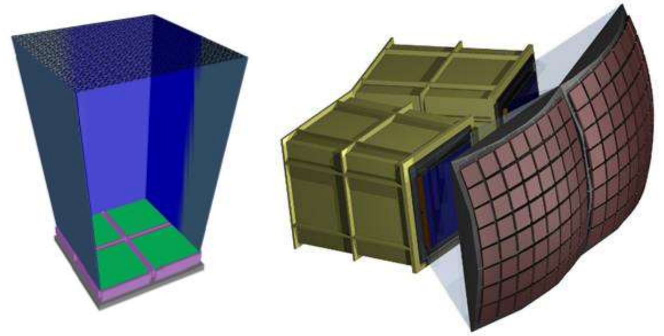
Spacecraft (no. of S/C mass, power):
- 3-axis stabilized platform
- Dry mass (incl. 20% margin) : 949 kg; 1673 kg wet mass (including 20% system margin and launch adaptor)
- > 2400 W
- 3m X/Ka HGA antenna, 65 W RF power ,
- 1.2 Mbps at 1.7 AU to 40 Mbps at 0.3 AU telemetry rate



Payload (212kg, 2076W peak, 3 instruments):
- VenSAR synthetic aperture radar in S-band (176kg, 1933 W peak and 112 W average, 66 to 513 Gbps data rate ,5.5 x 0.6 m2 antenna)
- SRS subsurface radar sounder (22kg, 60W, 3.7Mbps data rate, 9.4m deployable antenna)
- VM IR mapper and IR/UV spectrometer (14kg, 23W, CCD + intensifier in UV, IR Hg-Cd-Te PV detectors + accousto-optics tunable filter + Stirling cooler)

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

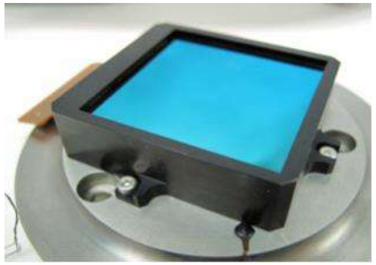
THESEUS



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

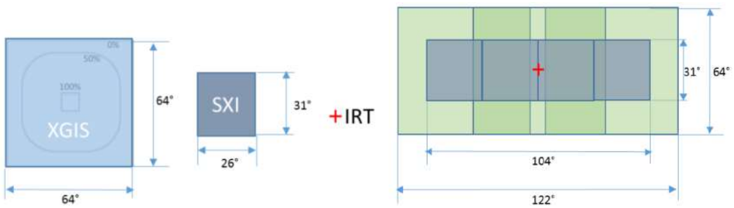
Mission profile:
- Direct VEGA-C launch to equatorial LEO (600 km, <5° inclination) - LV-capability to this orbit > 2,000 kg
- 3 yrs mission (no operational availability requirements or extension discussed)
- Single (Malindi) Ground Station (~14 passes/day, ~10 min/pass)
- Uses burst-alert system (VHF GS on equator)
- Controlled re-entry EoL.

Spacecraft (no. of S/C mass, power):
- One S/C 1165 kg wet mass (1065 kg dry)
- 850 W total power
- Body-mounted SA, no mechanisms



Payload (mass, power, no. of instruments):
- Soft-X-ray Imager (SXI) - used as a wide-field monitor for transients: 0.3 keV -6 keV, ~1 sr FoV, 1-2' location accuracy, 300mm FL, 4 Detector Units each comprising 320x320mm aperture with 64 Micro-Channel Plate slumped optic plates in 8x8 configuration (MXT/MIX-C heritage) serving 2x2 Plato-like large format CCDs (160x140mm), Thermo-Electric Cooled.
- X-Gamma Imaging Spectrometer (XGIS) - used to reliably identify GRBs from SXI-spotted transients: 2 keV – 20 MeV, ~2.4 sr FoV, Source location accuracy ~5', 3 Detector Units each comprising stainless steel coded-mask optics (~500x500 mm) and Tungsten baffle, serving 2x2, 32x32 pixel detectors (passive cooled), pixel size 5x5mm (scintillators 5x5x30mm, with SDD PDs either end, VEGA-derived ASIC designs).
- Infra-Red Telescope (IRT) - used for imaging, low-resolution and mid-resolution spectra of GRBs: 0.7µm – 1.8µm λ, 700mm/230mm M1/M2, All SiC, 10'x10' FoV using Teledyne Hawaii-2RG 2048x2048 pixels (18µm) for 0.3''/pixel Plate-scale.

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
- **Role of Member States:** The rest of the P/L.
- **Role International Partner(s):** Brazil contribution of Alcantara GS mentioned but optional and not critical.



SPICA

Main science objectives:

- Mid and FAR IR (12-230 um)observatory to:
  - 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 (no. of S/C mass, power):

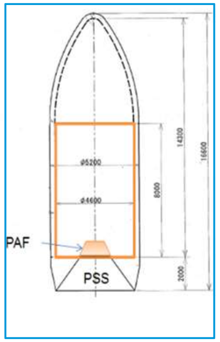
- Single SC, 3-axis stabilised, architecture a with Horizontal Telescope , PLM isolated from SVM by V-grooves
- Shielded Cryogenic PLM at <8 K, "Standard" SVM, K-band down (260 Gbit/day science data) TT&C baselined with S-band uplink (unlike CDF, may need to be replaced by X-band as S-band not available at ESA DSN)
- 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

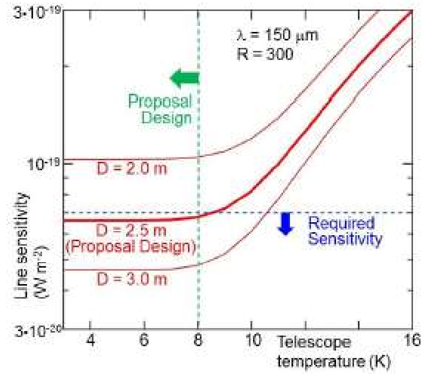
Payload (mass, power, no. of instruments):

- 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 (SRON) @ 50 mK, with sensitivity: NEP= $2*10^{-19}$ W/Hz$^{-0.5}$ Low resolution mode R~300, High resolution through Martin-Puplett Interferometer: R up to 11000. Polarimeter with half wav plate
- SMI: mid IR (12-36 um) Spectrometer/camera: SMI/LR-CAM (R~100), SMI/MR-HR (R~28000 @12-18 um): Detectors: Si: As (HR) and Si:Sb
- Total Instrument mass: 185 kg (vs. 120 in CDF), incl. electronics: 279 kg (vs 179 kg in CDF): significant increase

Implementation scheme & ESA contribution:

- **Role of ESA**: Mission + SVM, Telescope, Focal Plane+FAS, 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

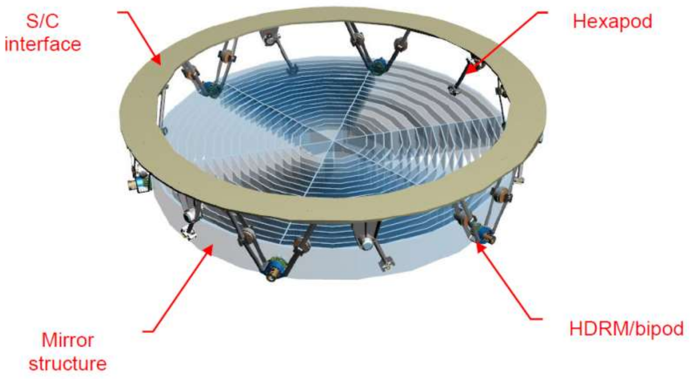


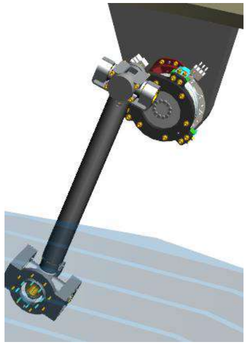


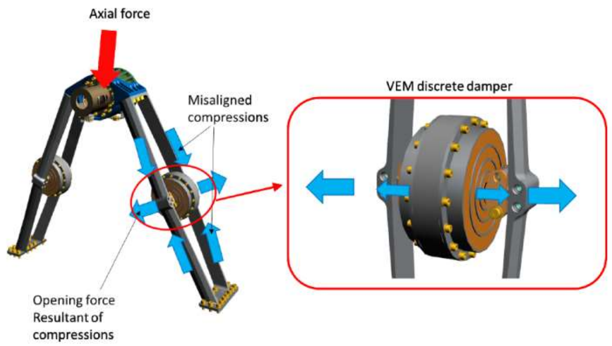
Examples of Polish led technology development activities to support future science missions

ISM: Instrument switching Mechanism (ATHENA)

- Activity with SENER PL. Targeting TRL 5 demonstrator.
- Design, Manufacturing and environmental/functional tests.
- Hexapod mechanism based on rotary actuator
- Hold Down and Release Mechanism assembly using visco elastic material dampers to provide load and shock damping
- Mechanism design with good expected performances in terms of lateral resolution and stability
- TDA started in 2016. PDR held. Manufacturing on-going.

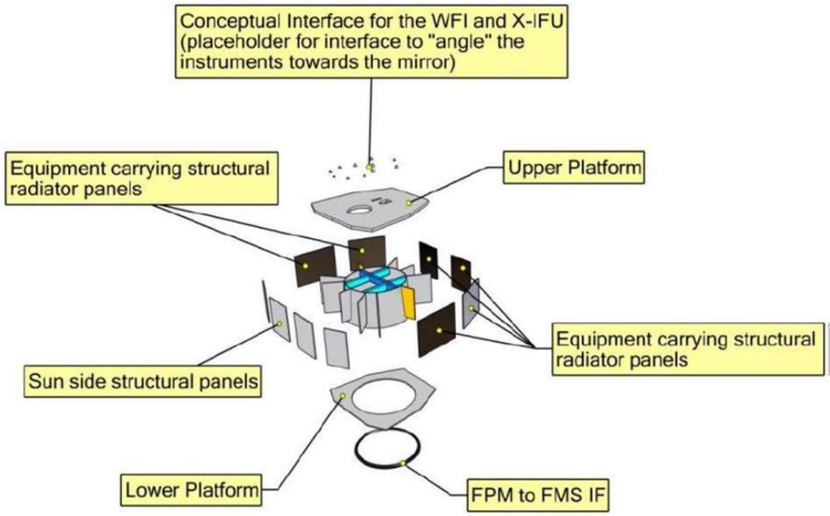






SIB: Science Instruments Bench (ATHENA)

- Activity with a consortium led by TAS PL (SCNTPL also part). Targeting TRL 5 demonstrator but also looking into process qualification.
- Design, Manufacturing and environmental/functional tests.
- Primary structure of the ATHENA SIM.
- Conic metallic structure with a number of sandwich panels (both CFRP and Al skins)
- TDA K/O soon.
- Vibration and functional tests foreseen.



Questions ?

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