



Science at UK Space Agency

Chris Lee
Chief Scientist

Nov 2018



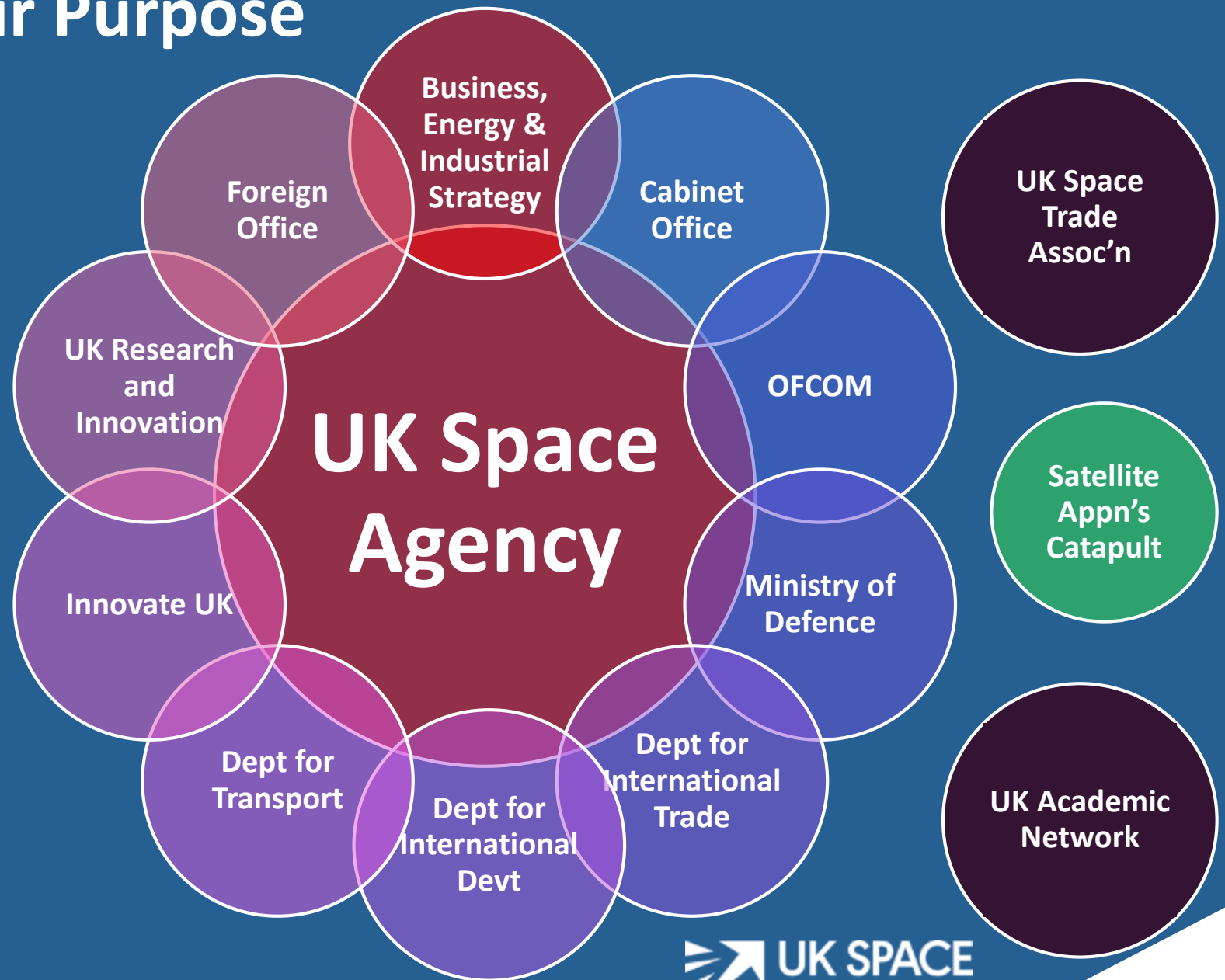
Space is a key part of UK

- Active in space for 50+ years
- £13.7 billion to the UK economy
- Employs 38,500+ people
- High skills
- 6.5% of global space economy
- A critical national infrastructure
- Supports £250bn of UK GDP
- **At the heart of science, discovery and technical innovation**

UK Space Agency- Our Purpose

Responsible for all strategic decisions on the UK civil space programme and a clear, single voice for UK space ambitions...

... with the maximum economic, scientific and policy benefit for the UK



UK Space Agency – Our Roles

Leadership & Strategy

170 staff
£430M p.a.

Science & Technology

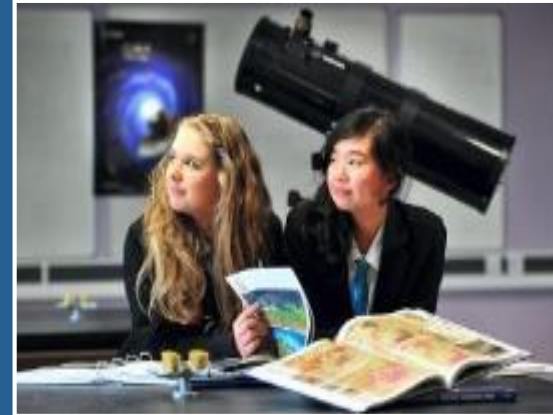
Policy & Regulation



Innovation & Investment



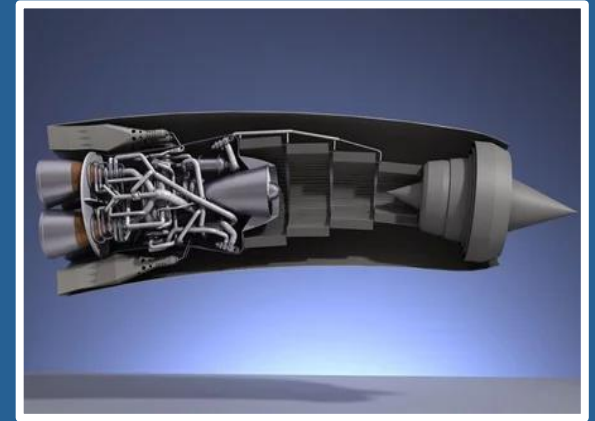
Education & Training



Business Growth



Programmes



Partnership



UK Space Policy – 4 Linked Themes

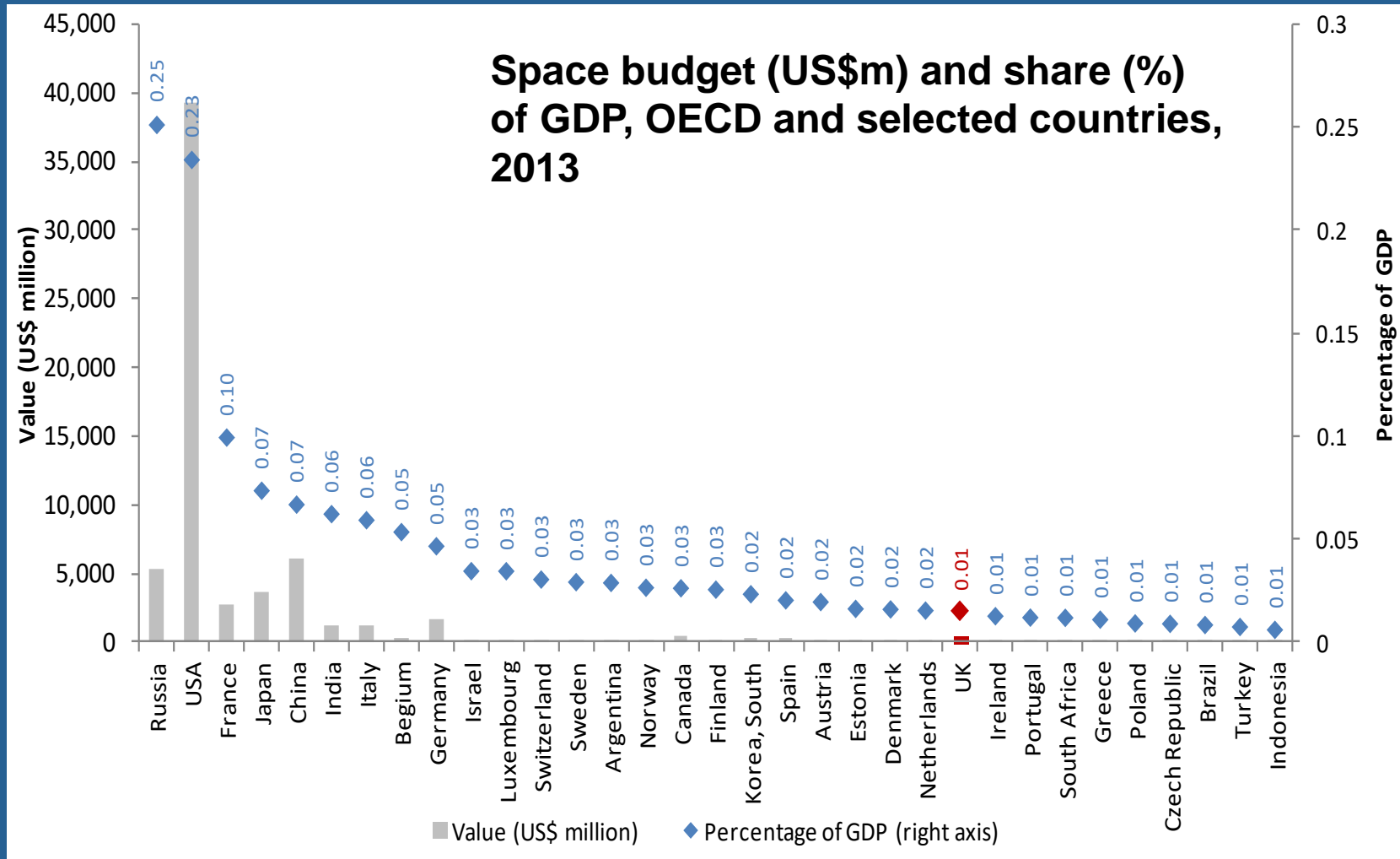
Space is of
strategic
value

We need to
protect the
space
operating
environment

We need to
sustain and
grow our
space
capability

Space is an
international
endeavour

International Comparison - snapshot



- UK not in top 10 space funders (#11); 23rd in % of GDP
- BUT UK Industry captures 7% of global space market
- MESSAGE: It's about **FOCUS...**

Source: OECD, The Space Economy at a Glance, 2014. Ranked by % GDP

UK “Science & Space”

- Carry out world class frontier science
- Exploit mandatory GDP funding through ESA
- Deliver strategic benefits — forcing-house for new technology and skills – drives innovation
- Showcase UK capabilities (academia and industry) on world stage
- Develop and nurture international partnerships
- Public understanding of science and inspiration



UK Space Agency – Our Domains and “Science”

Astrophysics



Solar System



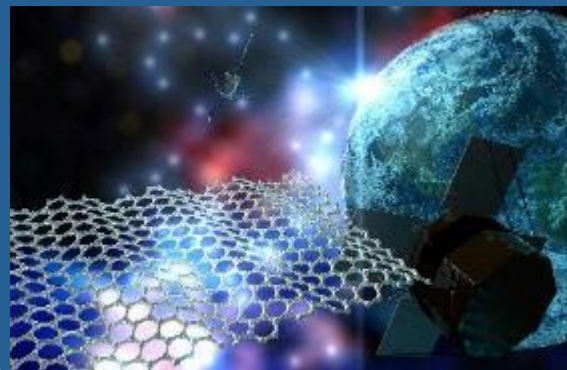
Space Situational Awareness



Spaceflight



Microgravity/Life Sciences



EO Science



Sustainable Devt



“Science” at UKSA - Approx 40% of our budget

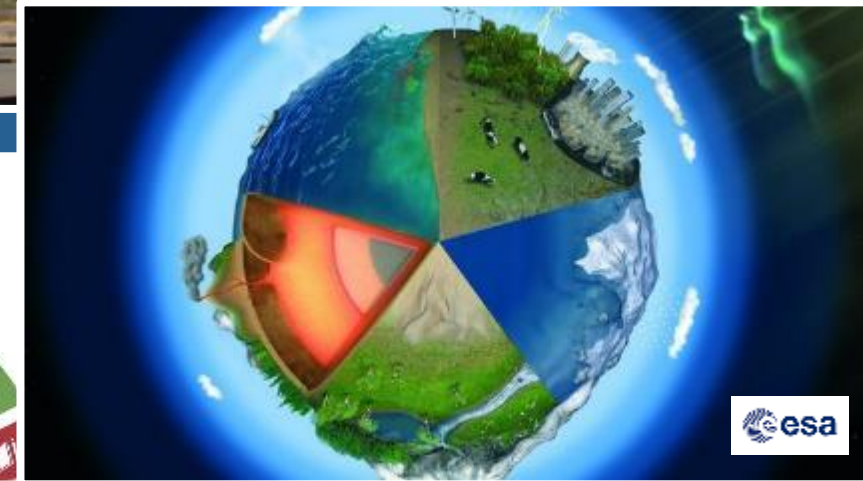
£40M p.a. National

- science instruments
- data exploitation
- sustainable devt

£150M p.a. ESA

- technology
- satellite & ops
- science instruments
- applied research

(Few) bilateral missions



Science focus in practice at UK Space Agency

- **Space Science**

- Space Instruments funded through **national** UKSA programme
- Satellite and key technology funded via **ESA** subscription
- Key TRL 1-3 and Exploitation of data funded by **STFC**

- **Exploration** (incl Life Science and Microgravity)

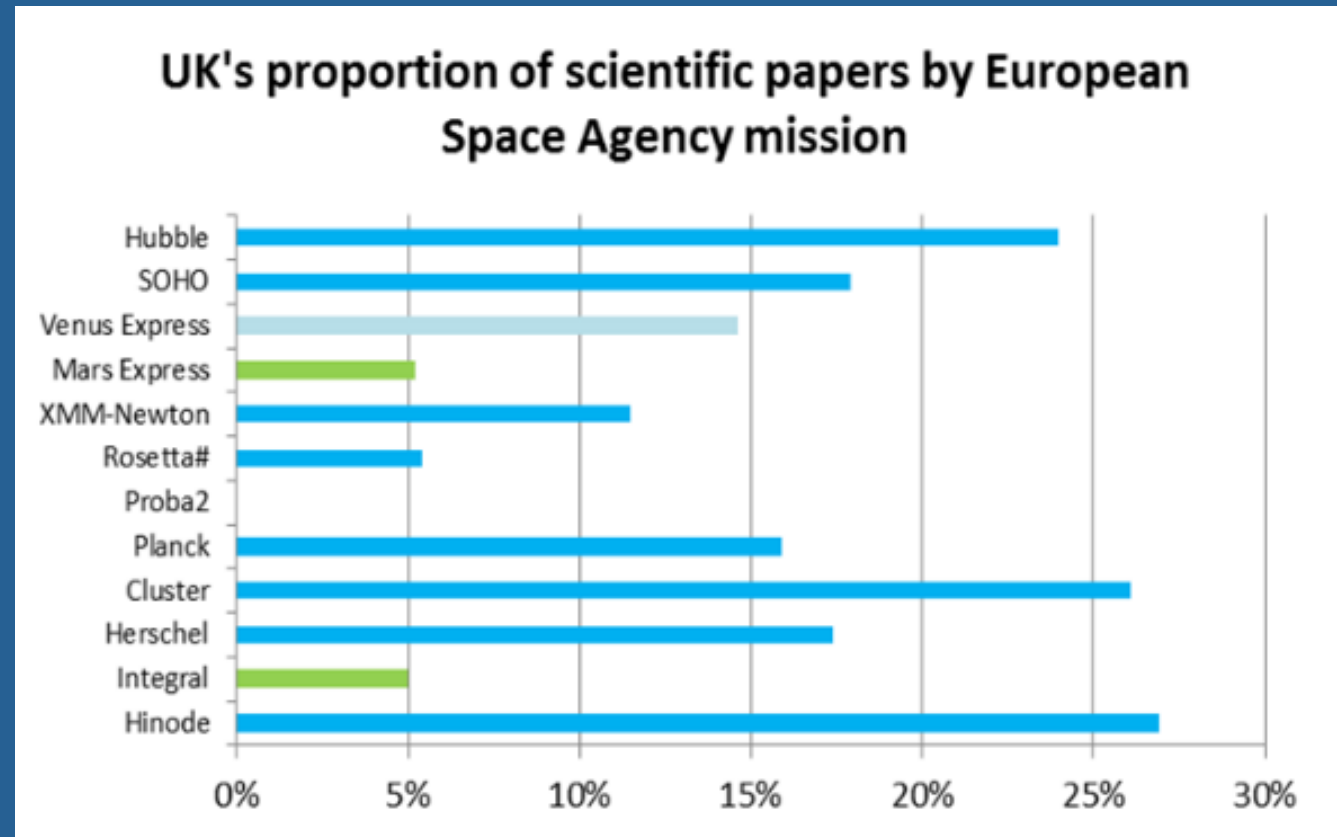
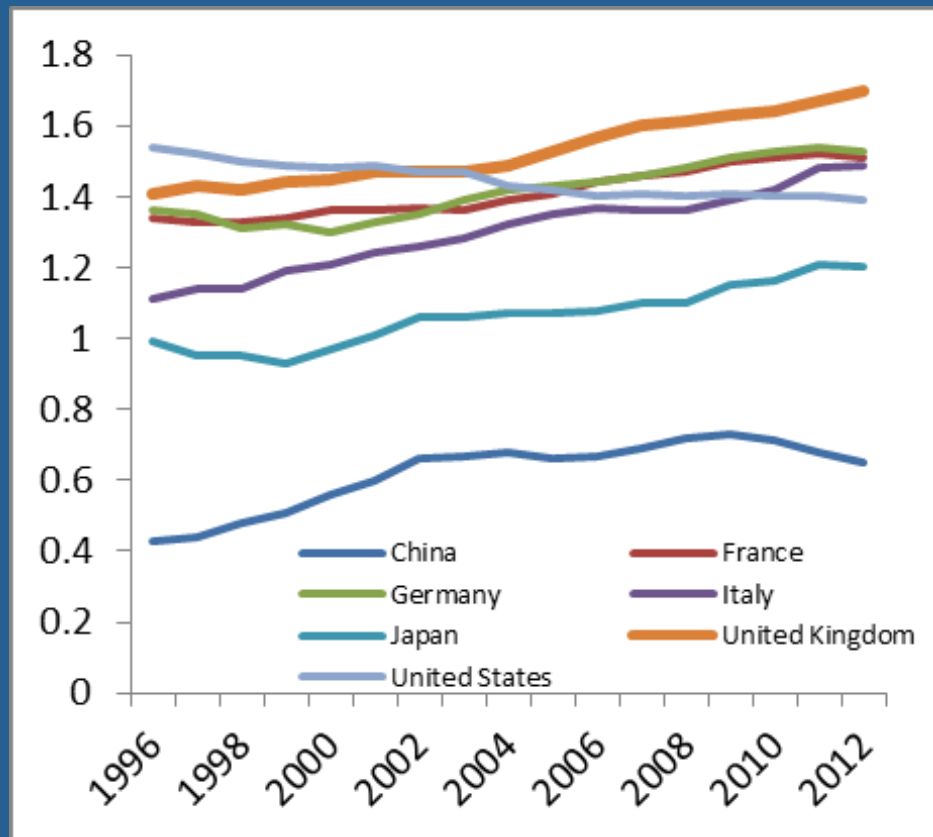
- Instruments, satellite, access to ISS and technology largely funded via **ESA** subscription
- Exploitation of data funded by UKSA through both **national** and **ESA** programmes

- **Earth Science**

- Instruments, data, satellite and technology largely funded via **ESA** subscription

Key Partner in Space-related Science

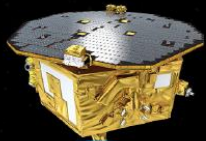
- Citation Index compares performance between countries vs global average
- UK is **strong in space-related science** (left chart) especially where we have leading roles in the science (blue line on right chart)



Science Programmes

- Space Science
- Earth Science
- Exploration
- Sustainable Devt

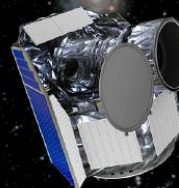
ESA Astrophysics Missions



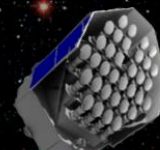
**lisa
pathfinder**
Testing the technology
for gravitational
wave detection



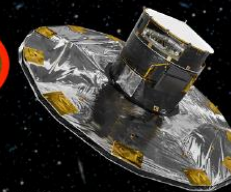
jwst
Observing the first light



cheops
Characterising exoplanets



plato
Exoplanets & stars



gaia
Surveying a billion stars

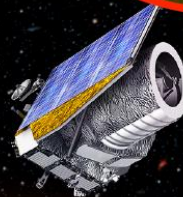


herschel
Unveiling the cool
and dusty Universe

euclid
Exploring the dark Universe



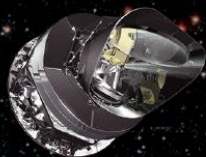
xmm-newton
Seeing deeply into the hot
and violent Universe



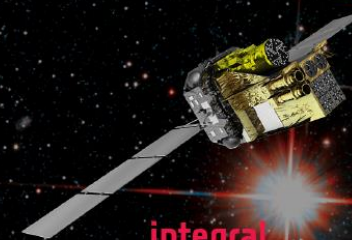
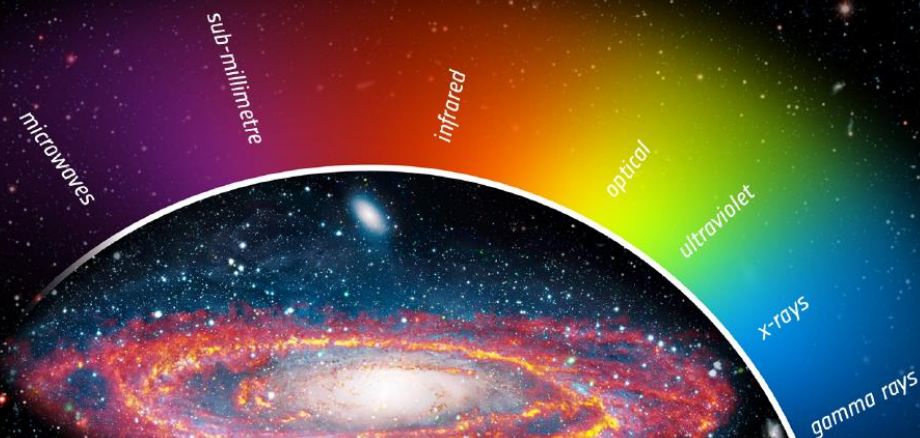
hst
Expanding the frontiers
of the visible Universe



Xarm /xrism
Formation of the
elements



planck
Looking back
at the dawn of time



integral
Seeking out the extremes
of the Universe

ESA Solar System Missions

Ice Giants?



soho
Facing the Sun

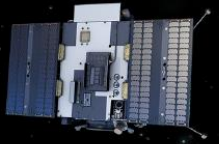


proba-3
Solar Coronagraph

proba-2
Observing coronal dynamics and solar eruptions



bepicolombo
Exploring Mercury



exomars
Europe's new era of Mars exploration



juice
Studying Jupiter's icy moons



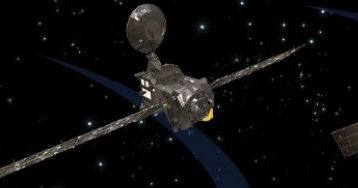
cassini-huygens
Studying the Saturnian system and landing on Titan



venus express
Studying Venus' atmosphere



smile
Solar Wind
Magnetosphere
Ionosphere



mars express
Investigating the Red Planet



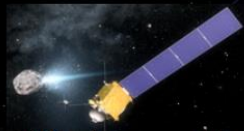
rosetta
Chasing and landing on a comet



solar orbiter
The Sun up close



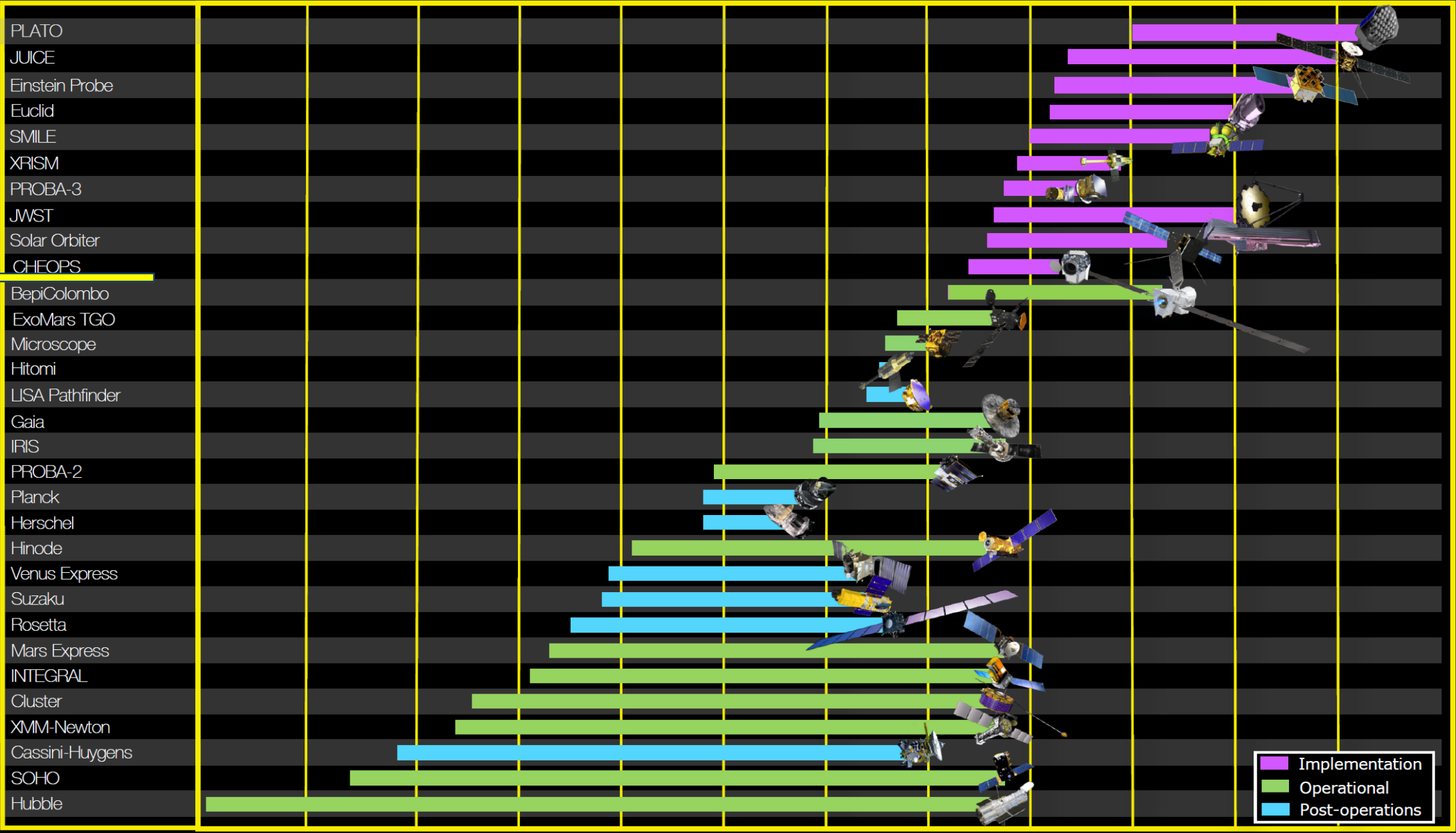
cluster
Measuring Earth's magnetic shield



Small Bodies?

ESA Space Science Missions

New

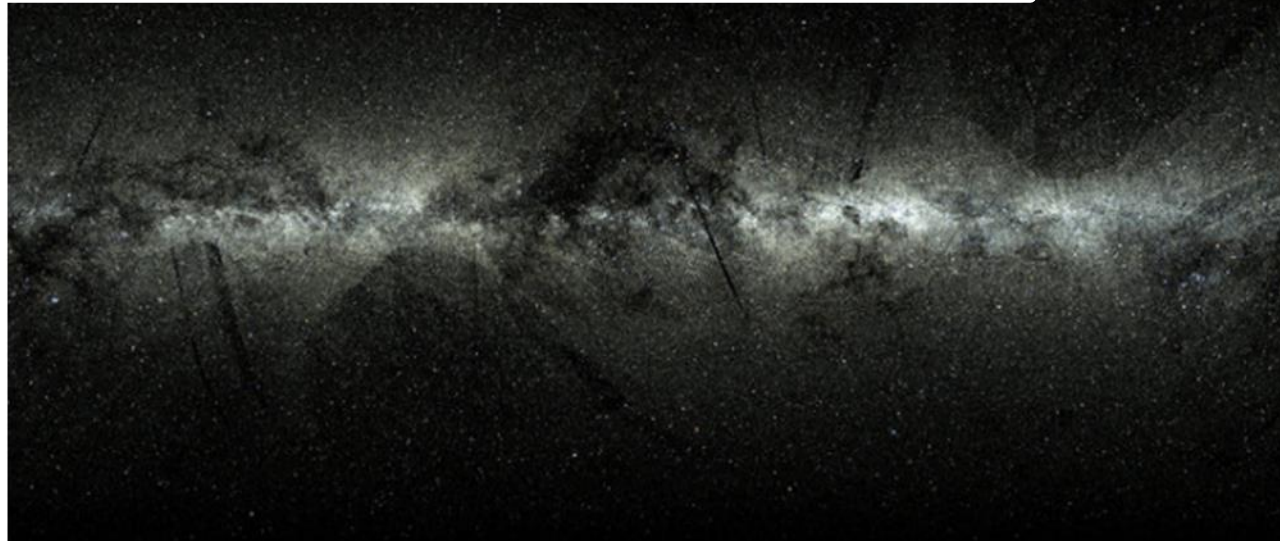
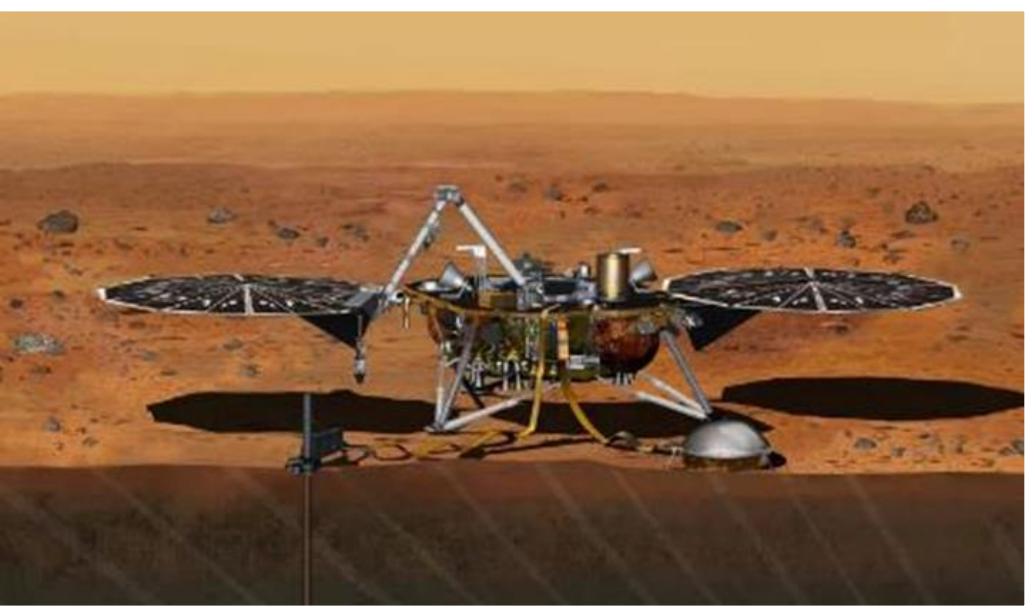


Long tail of ops

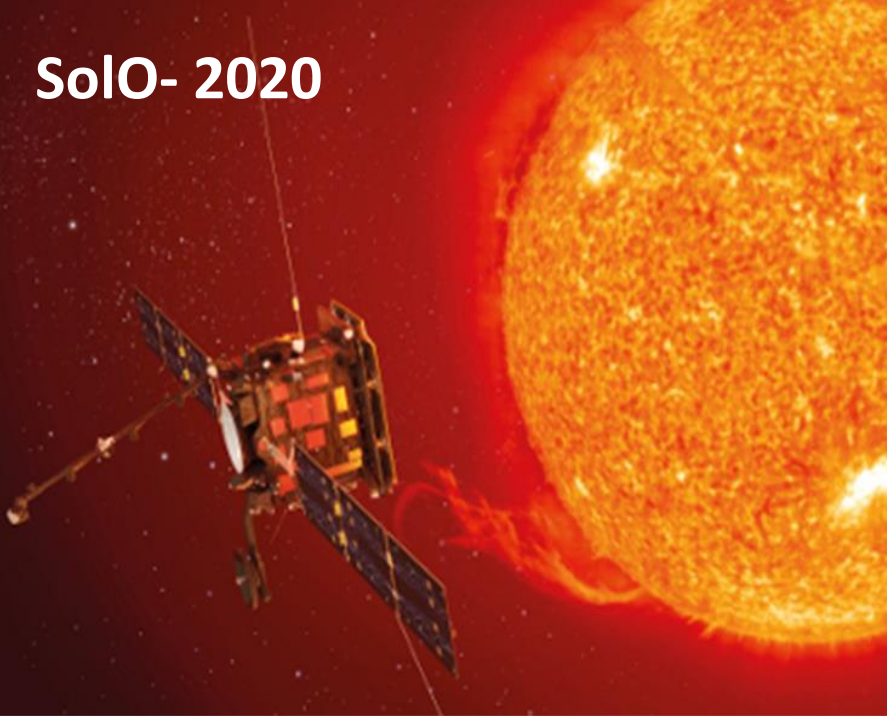


Implementation
Operational
Post-operations

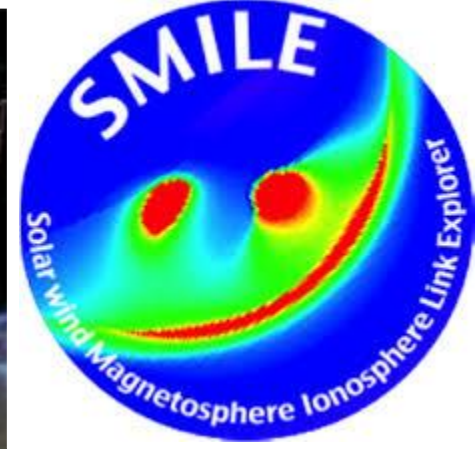
2018



Solo- 2020

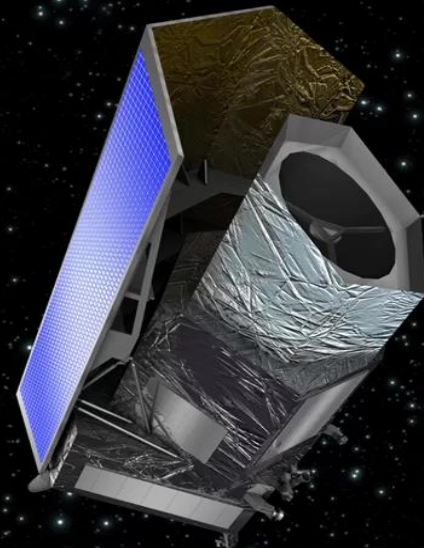
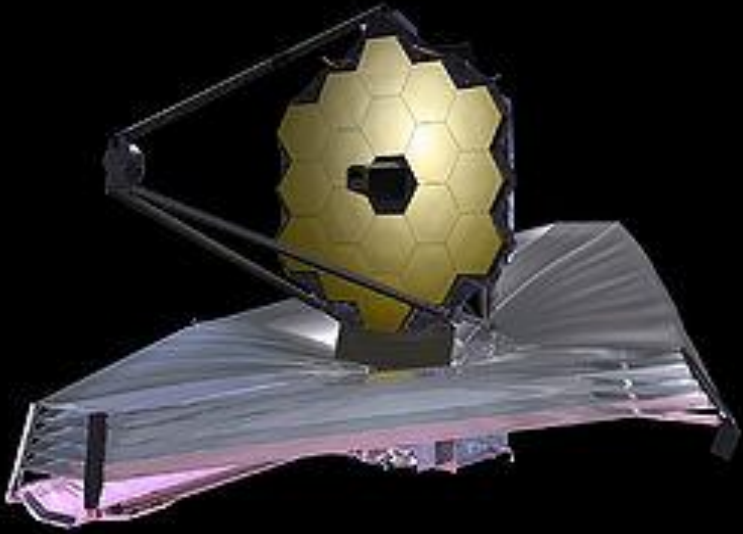


JUICE- 2022



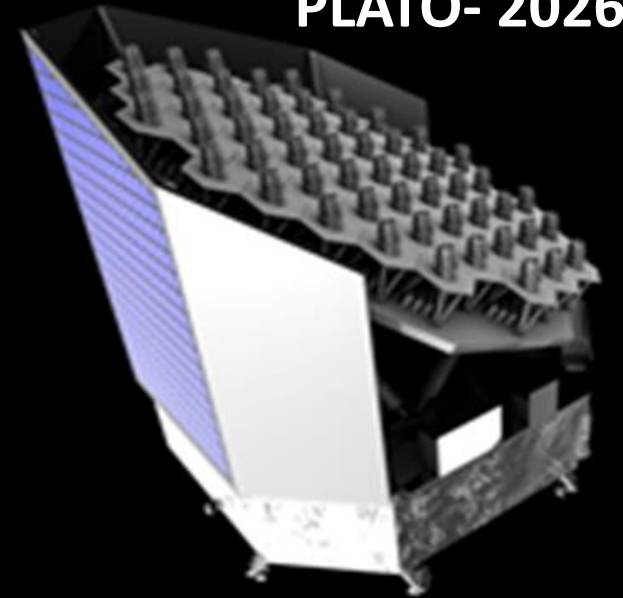
SMILE- 2023

JWST-2021



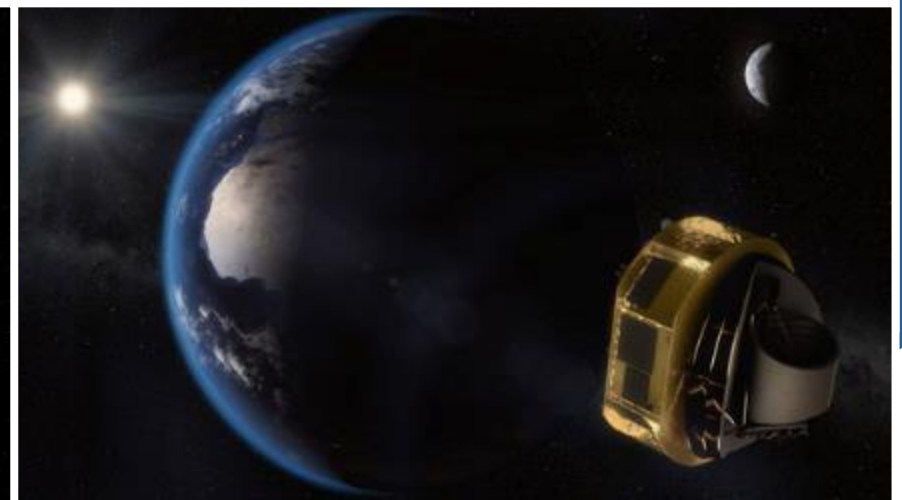
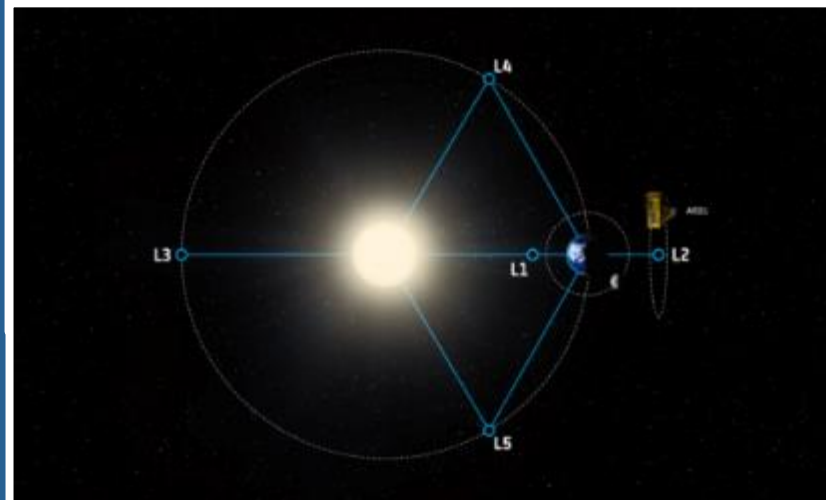
Euclid- 2022

PLATO- 2026



Ariel

- ESA selected “M4” mission; 450M€
- Launch in 2028
- Chemical fingerprints of exoplanet atmospheres
- UK-led science (UCL)
- RAL key engineering payload partner



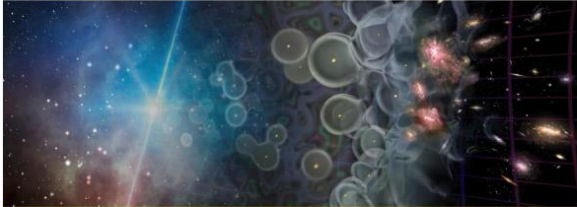
ESA M5 Candidates – all teams include key UK capabilities



SPICA
Unveiling the obscured Universe

JAXA

Dr. P. R. Roelfsema
On behalf of the international SPICA consortium


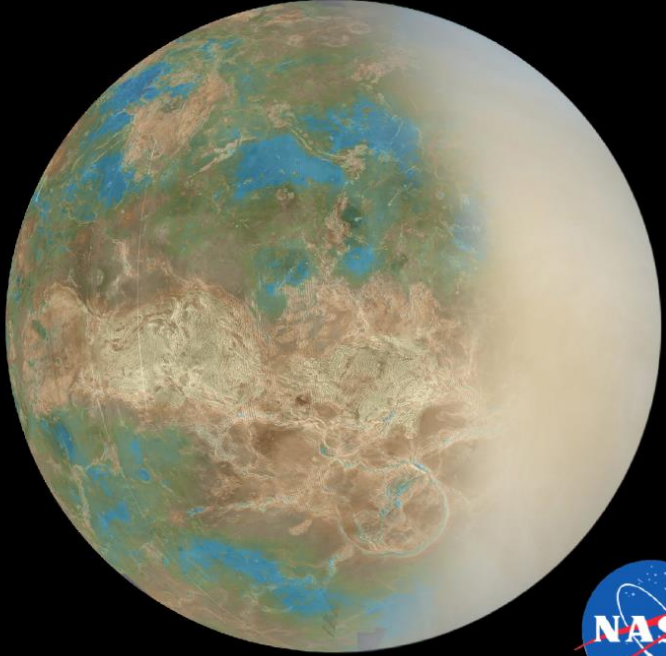


theseus

Transient high energy sky and early universe surveyor

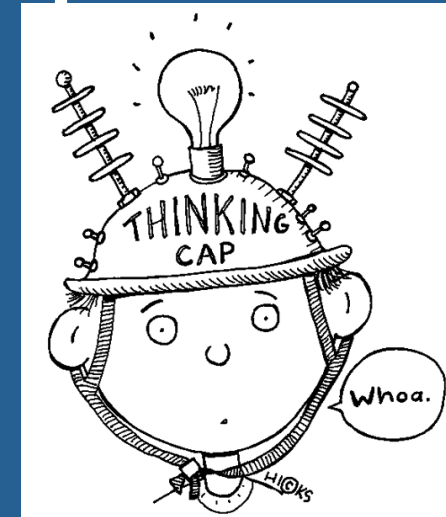
Lead Proposer: Lorenzo Amati (INAF-IASF Bologna, Italy)

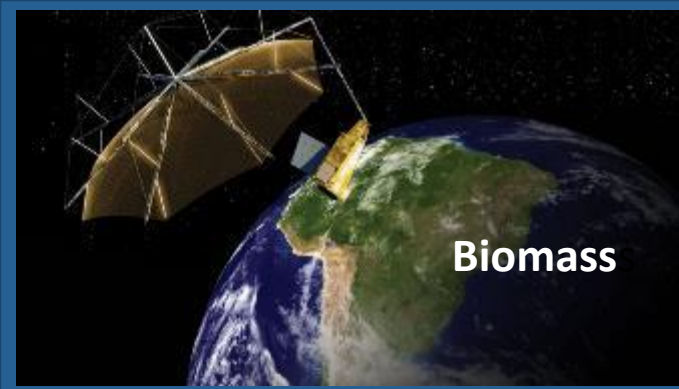
EnVision
Understanding why our most Earth-like neighbour is so different



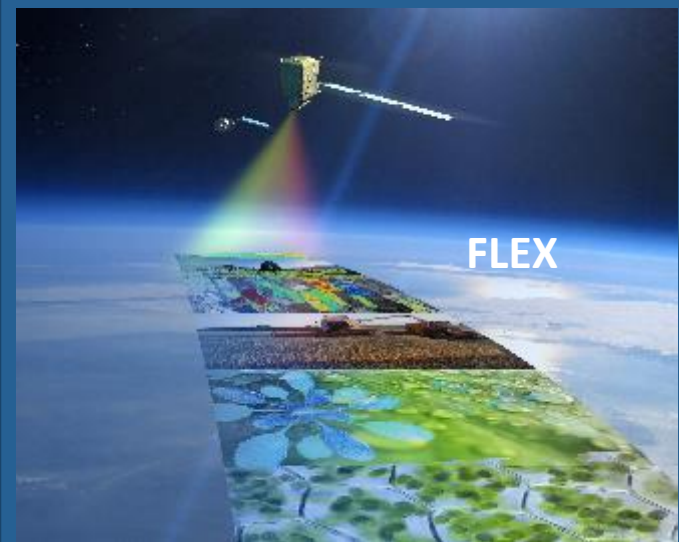
ESA Missions of Opportunity

Corot	Exoplanets	France
Microscope	Fundamental physics	France
Hinode	Solar physics	Japan
Proba-2	Plasma physics	TEC/Belgium
Hitomi	X-ray astronomy	Japan
ExoMars	Planetary science	HRE/Russia
IRIS	Solar physics	NASA
Proba-3	Solar physics	TEC/Belgium
XRISM	X-ray astronomy	Japan
Einstein Probe	X-ray astronomy	China
MMX	Planetary science	Japan
eXTP	X-ray Astronomy	China
LiteBIRD	Cosmic Microwave	Japan
WFIRST	NIR Astronomy	NASA
Taiji	Gravitational Waves	China
HERA	Asteroid deflection	OPS/Safety
L5	Space Weather	OPS/Safety
Lunar Gateway	Planetary science	HRE





Biomass



FLEX

ESA Earth Explorers
– Science-driven missions



adm aeolus

cryosat 2

earthcare

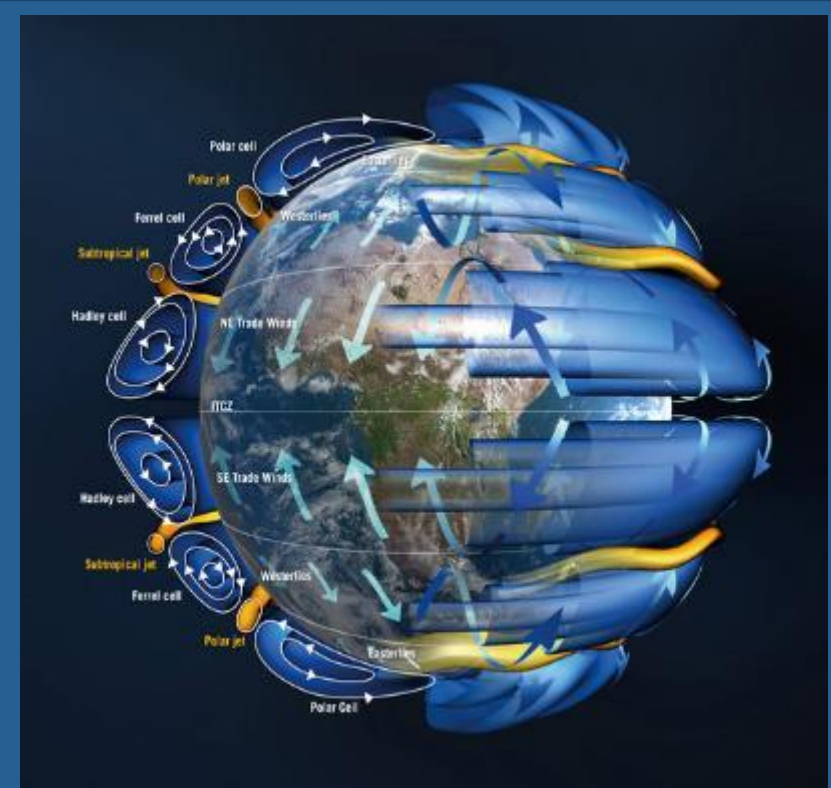
swarm

gocce

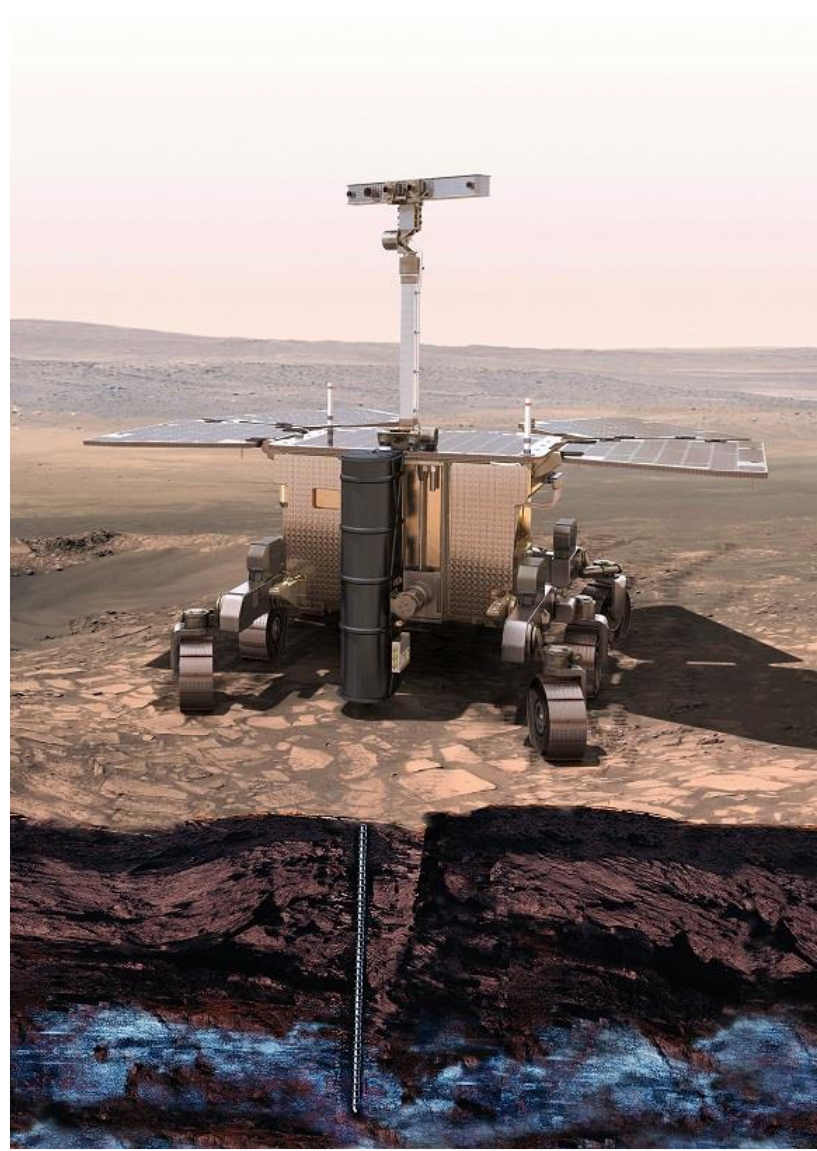
smos

ESA Earth Explorer: AEOLUS

- **Science** challenge: To acquire profiles of the wind on a global scale and advance our understanding of tropical dynamics and processes relevant to climate variability.
- **Technology** challenge: To operate a doppler wind lidar (laser) from space at an operational cadence (100 wind profile measurements an hour)
- Launch: August 2018 (3 yr mission)
- Prime contractor: Airbus UK
- UK connections: UK Met Office; European Centre for Medium-Range Weather Forecasts in Reading, UK, UK Climate community



Exploration: LEO-ISS, Moon, Mars, Asteroids...



LEO-ISS: Life Science and Microgravity

"The UK will be a recognised and valued participant in human spaceflight and space environments research...

...augment the UK economy and provide measurable societal benefits in sectors such as healthcare, communications and education"

- **Astrobiology and astrochemistry**
- **Life and biomedical sciences**
- **Fundamental physics**
- **Materials research**
- **Access to space**



UK Examples: ISS

ElectroMagnetic Levitator (Uni of Greenwich; Leeds etc)

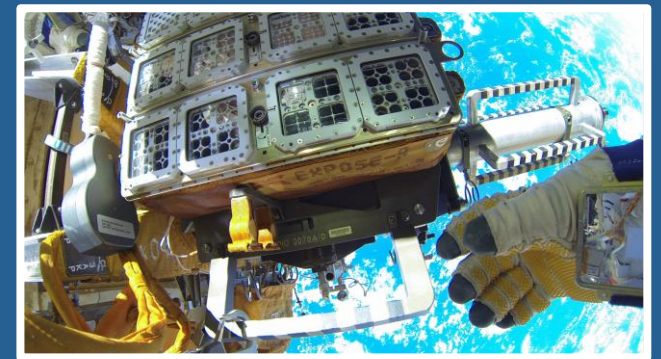
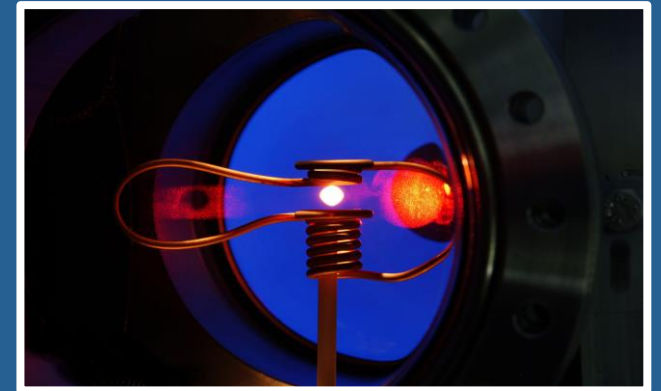
- Measurements of very high temp heating/cooling of metals – no container needed to hold the metal; new alloys for turbines etc

EXPOSE (Univ of Edinburgh)

- BIOMEX - BIOlogy and Mars Experiment facility mounted outside the ISS dedicated to astrobiology

Worms in Space (Uni of Exeter, Nott, Lancaster) – Dec 2018

- Nematode muscle loss in space, which in turn could lead to developing effective therapies and new treatments for muscular dystrophies.

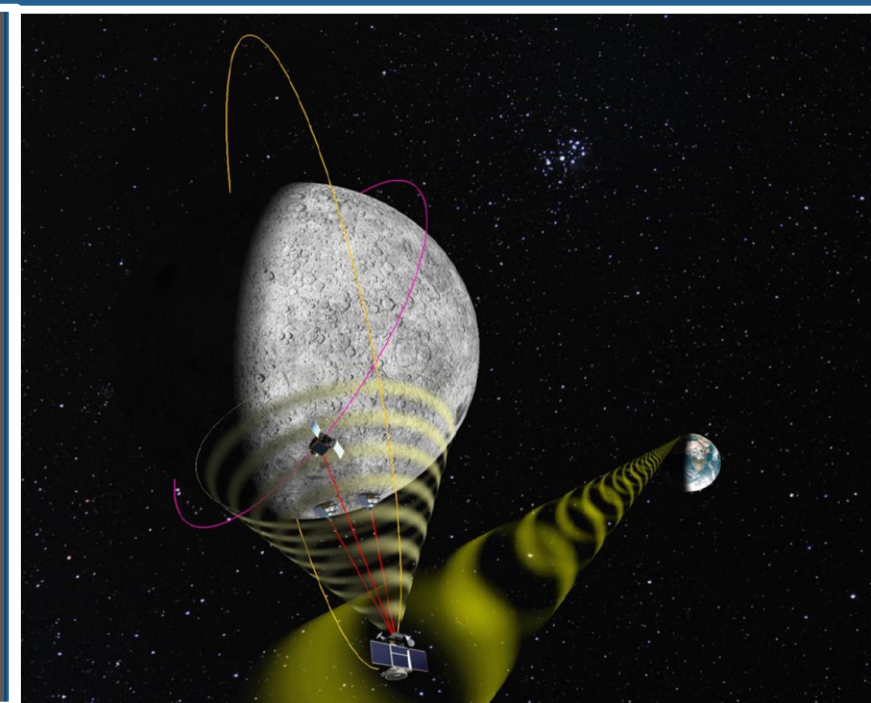


The Moon- New Funding Models?

- Quality of Lunar Science case vs other pressures (ground, astronomy, planets..)
 - Science in orbit
 - Return of lunar samples
 - Novel science from the surface

Lunar Pathfinder (SSTL/GES)

- 1kg payload mass allocation (x60)
- Data relay & navigation allocation
- Launch and transfer to lunar orbit
- Internet-based secure interface for dedicated mission control and data access
- Mission support and partner coordination



Mars: Trace Gas Orbiter

- Investigate the Martian atmosphere
 - where does the methane come from?

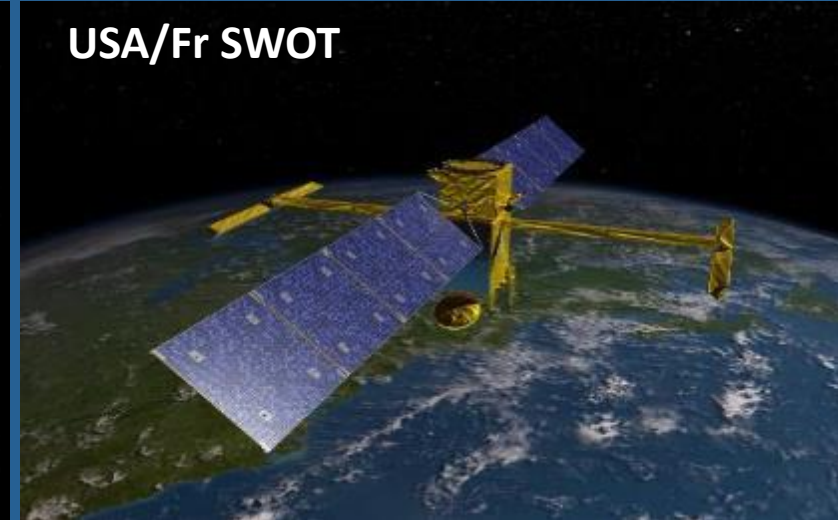
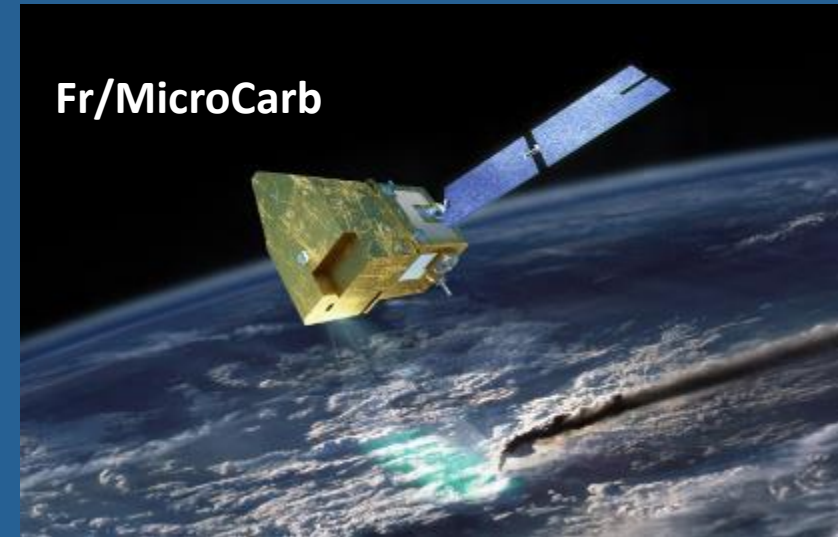
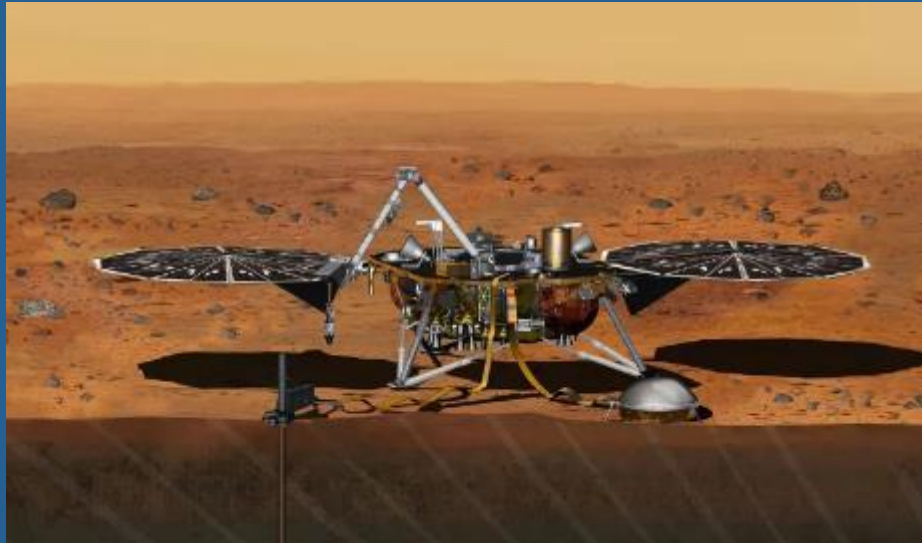
- Aerobraking started in March 2017
- Final 400-km orbit April 2018
- Primary role science data until arrival rover 2021
- Primary role change to data relay

Mars: ExoMars Rover

- Launch 2020
- Arrival 2021 Oxia Planum

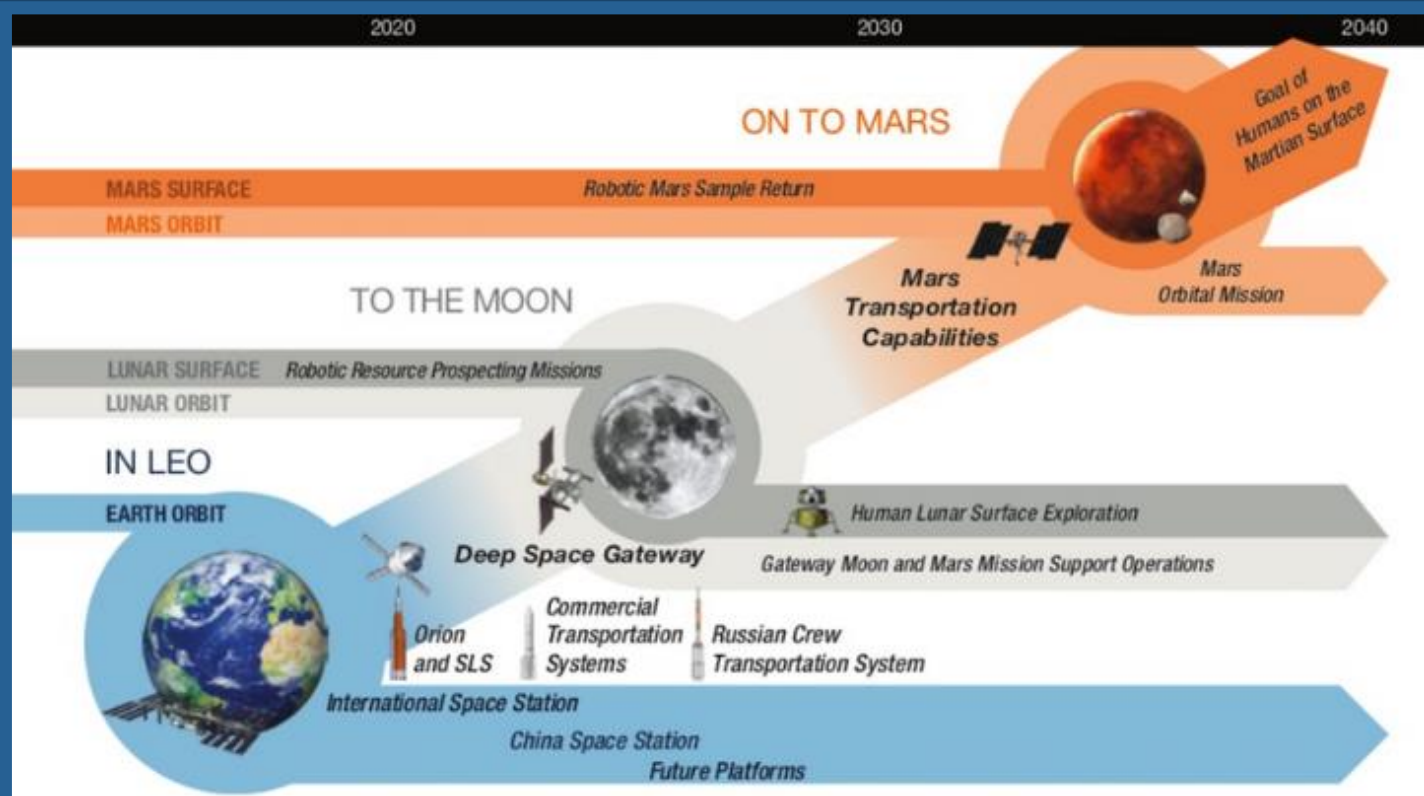
- Understand present and past environment
- When and where conditions for life
- Search for past and present life
- Technology land, traverse, drill

UK Space and Earth Science “Mission Bilaterals”



The Global Exploration Roadmap

January 2018



Australia



Canada



China



European Space Agency



France



India



Italy



Japan



Republic of Korea



ROSCOSMOS

Russia



Ukraine

وكالة الإمارات للفضاء
UAE SPACE AGENCY

United Arab Emirates



UK SPACE AGENCY

United Kingdom

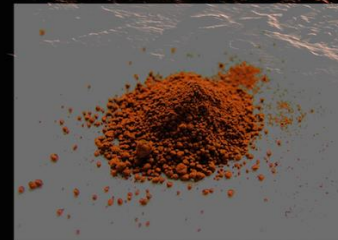
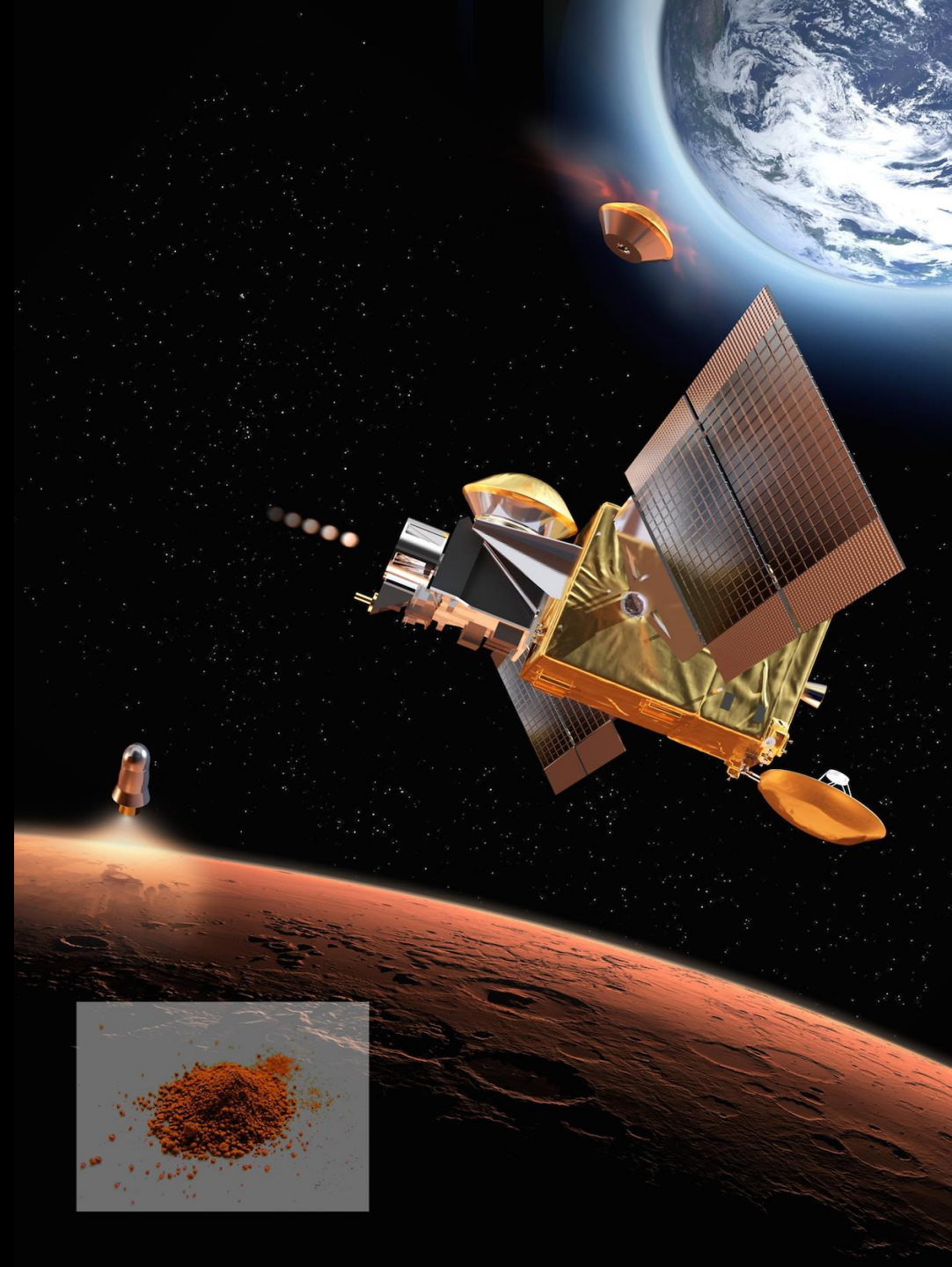
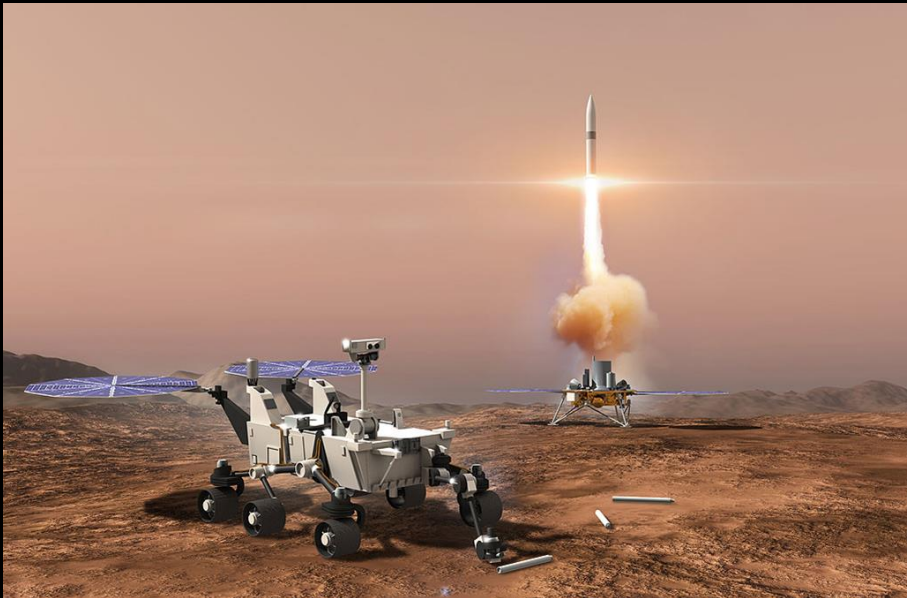


United States

THE GLOBAL EXPLORATION ROADMAP

Mars Sample Return - Key UK Focus

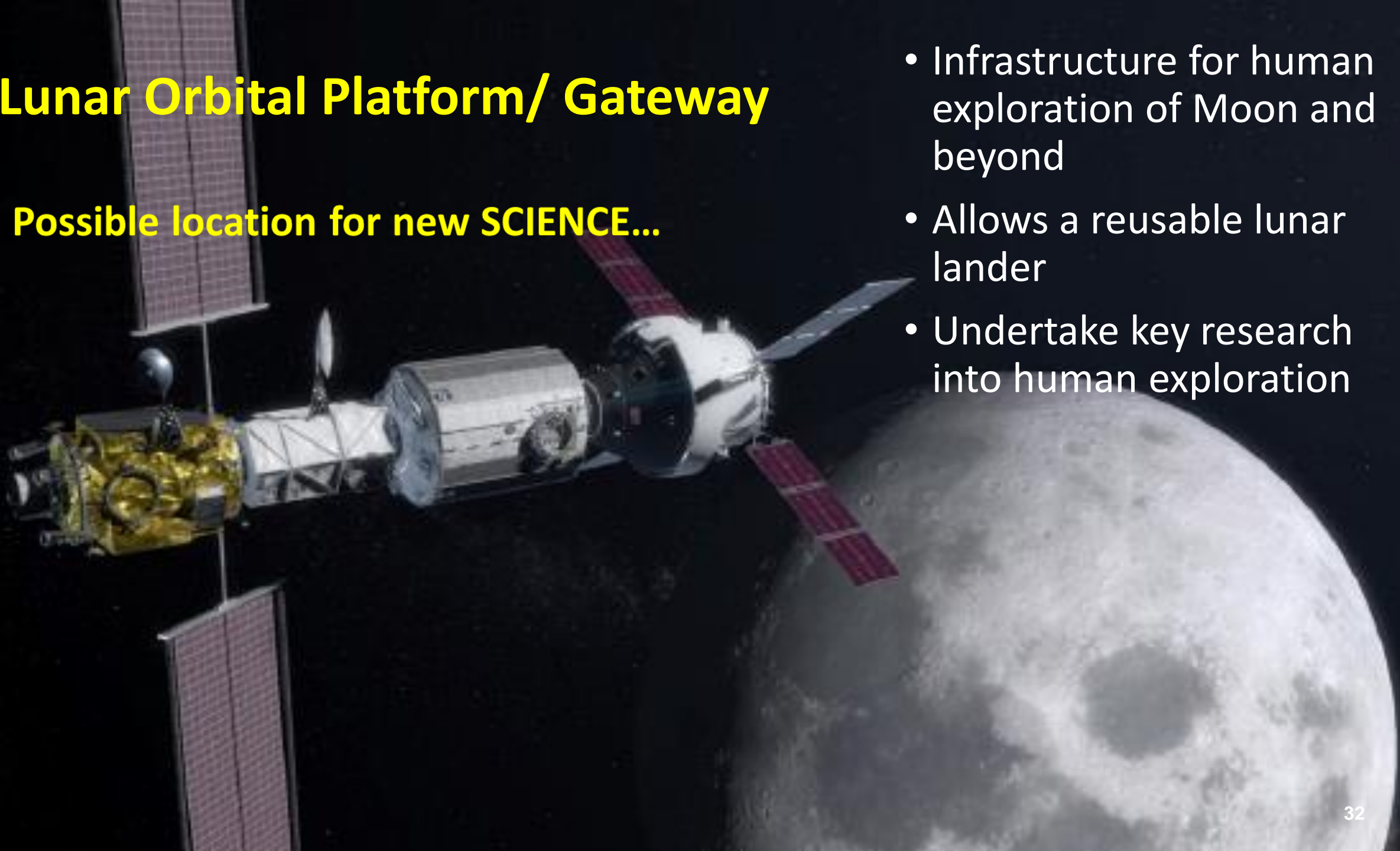
- 2020 Cache Rover NASA
- 2026 Rendezvous Return Vehicle – ESA
- 2026 or 28 Mars Ascent Vehicle -NASA and fetch rover- ESA (UK)
- Return end 2029 or 2031



Lunar Orbital Platform/ Gateway

- Possible location for new SCIENCE...

- Infrastructure for human exploration of Moon and beyond
- Allows a reusable lunar lander
- Undertake key research into human exploration



Challenges facing ESA/UK Science Programme

- **A “Golden Age” for European Space Science but...**
- ESA missions - ambitious science, technology risk and complex structures.
 - Are they still compatible with academic life-cycles?
- “Flat cash” over many years = declining purchase power.
- National instruments often over-budget and now a mission schedule driver
- Academic and Industry resource and skills imbalances?

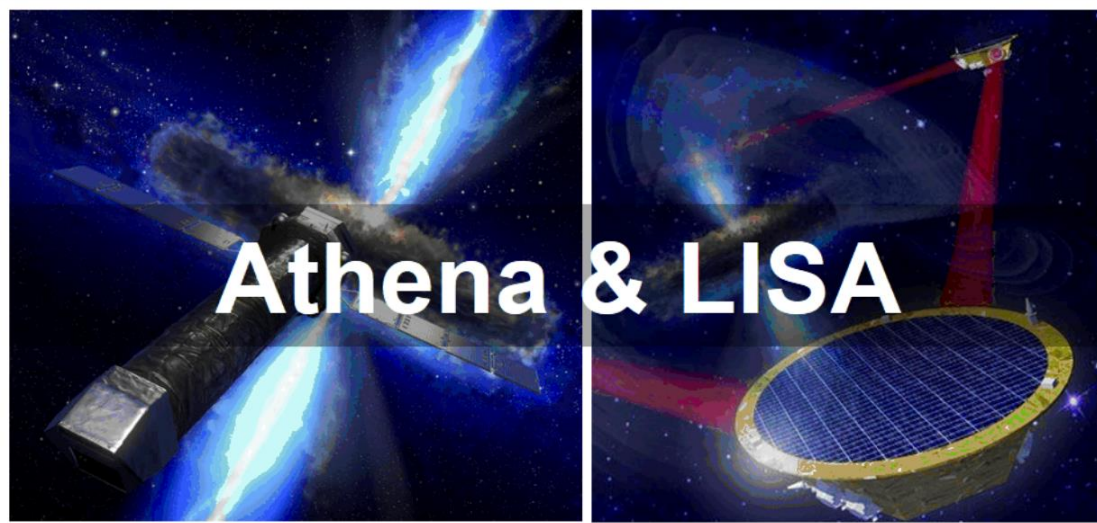
Mission	Initial €	Final €	Launch delay (months)
LisaPF	160M (2004)	427M	75
BepiC	665M (2006)	1,356M	50
SolarO	499M (2009)	668M	37
Euclid	595M (2009)	800M	22?

ESA Interim Ministerial – Oct 2018

“The most important decisions facing Member States at Space19+ will be: ... to **restore ESA’s science programme as the world leader in the physics of the Universe** by reversing the long-standing decline in buying power of the Level of Resources ...”

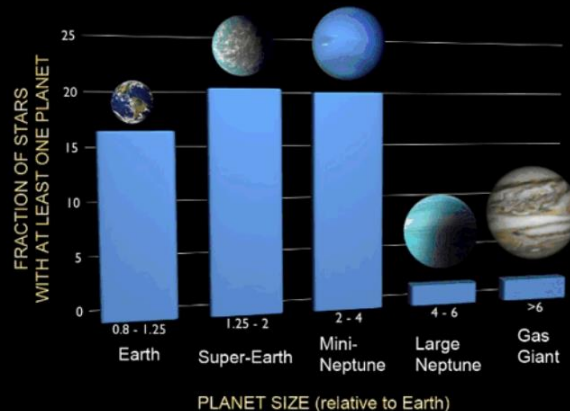


Possible proposal from ESA Directorate of Science



F-missions in sync with M-missions (joint launch) → new line of opportunities with special emphasis on novel implementations

Unique celestial opportunity to explore Ice Giants



Payload system provision → alleviate/facilitate/support Member State provision

Preparation of Cosmic Vision in the 2050 time frame

“Bringing sound to the cosmic movies”



Athena
hot gas structures
supermassive black holes

LISA
gravitational wave observation



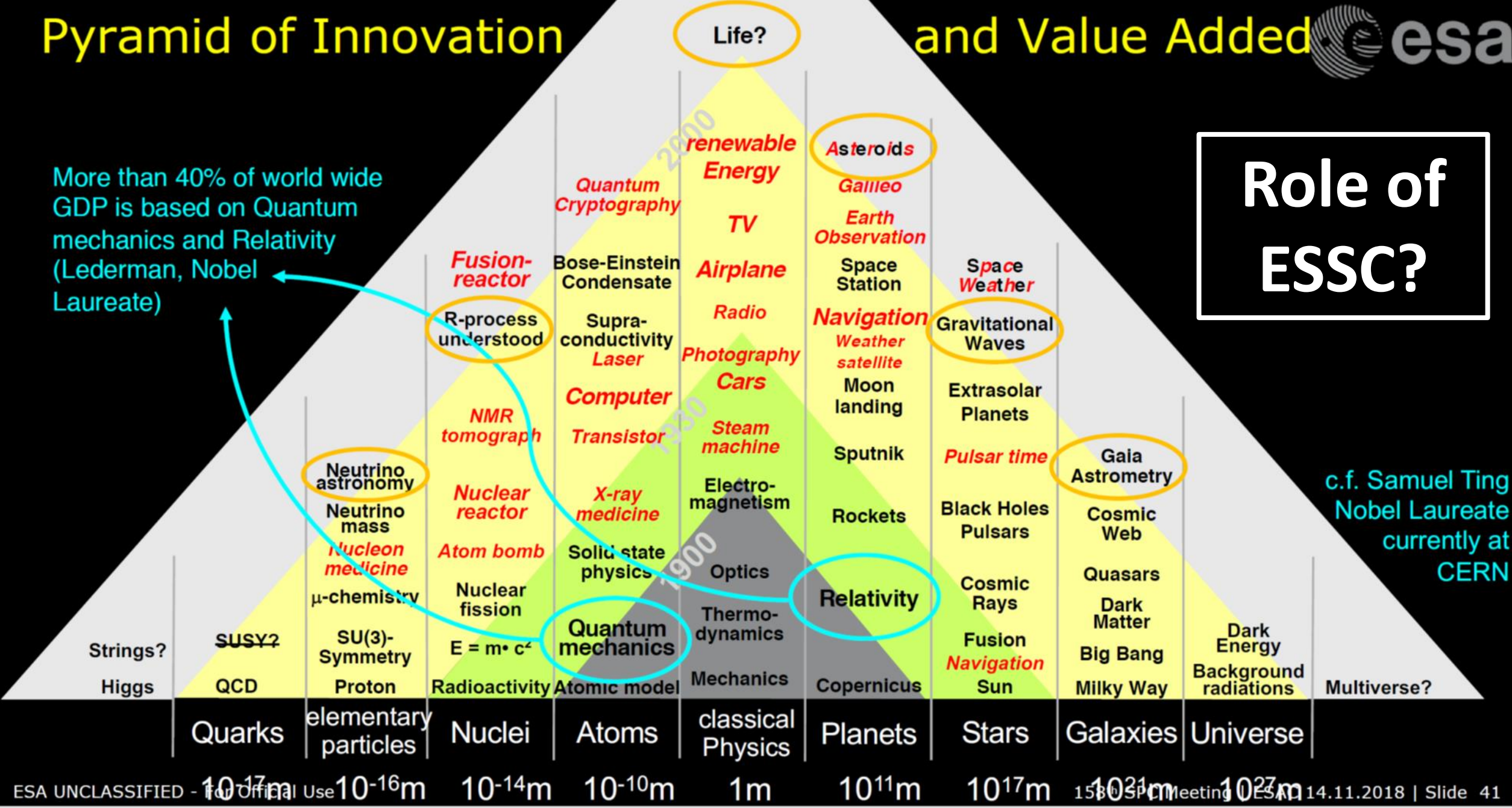
Pyramid of Innovation

and Value Added



**Role of
ESSC?**

More than 40% of world wide GDP is based on Quantum mechanics and Relativity (Lederman, Nobel Laureate)



c.f. Samuel Ting Nobel Laureate currently at CERN



Sustainable Devt: **Science** and Innovation

Mexico

Chile

Brazil

South Africa

Nigeria

Kenya

Tanzania

UAE

Kazakhstan

Singapore/Indonesia

Malaysia/Vietnam

China

Australia

[Colombia, Philippines, Taiwan, India]



30+ countries

Space Science as a force in Sustainable Devt and skills agenda...



5 Key Sciences of NARIT



Optical Astronomy



Radio Astronomy



Solar Physics and
Space Weather

High Energy Astrophysics
and Cosmology



Astronomical
Instrumentation

