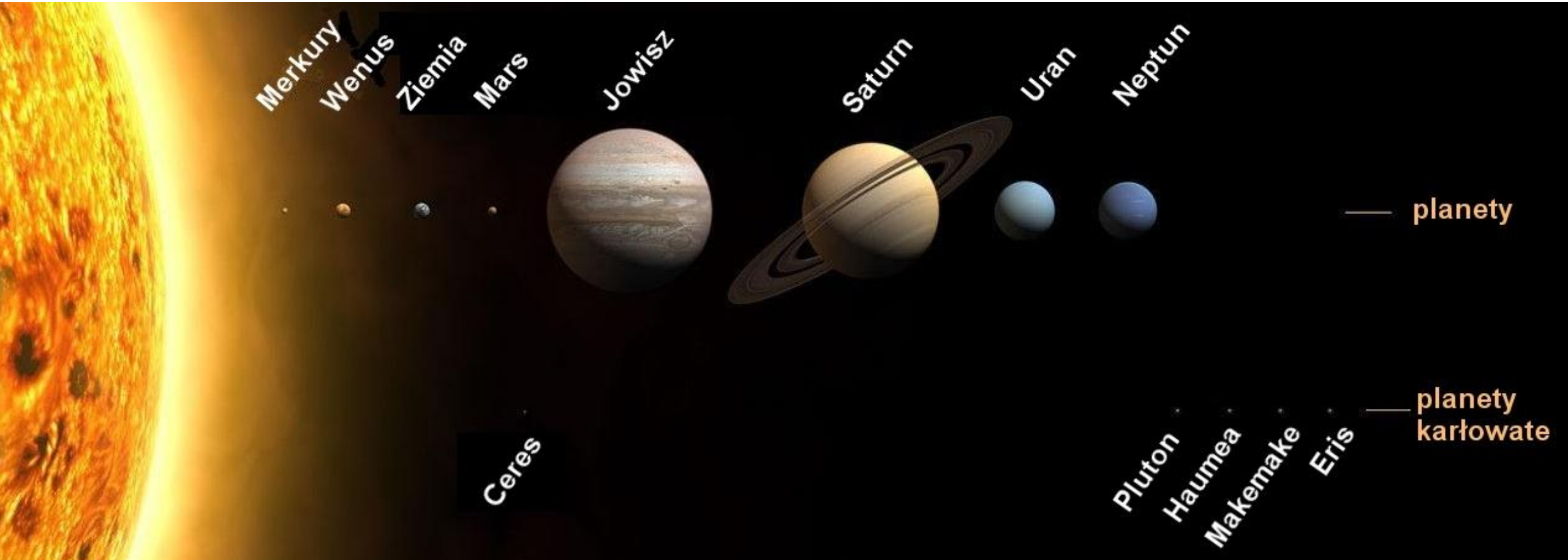
Polska Agencja Kosmiczna

Space exploration & use

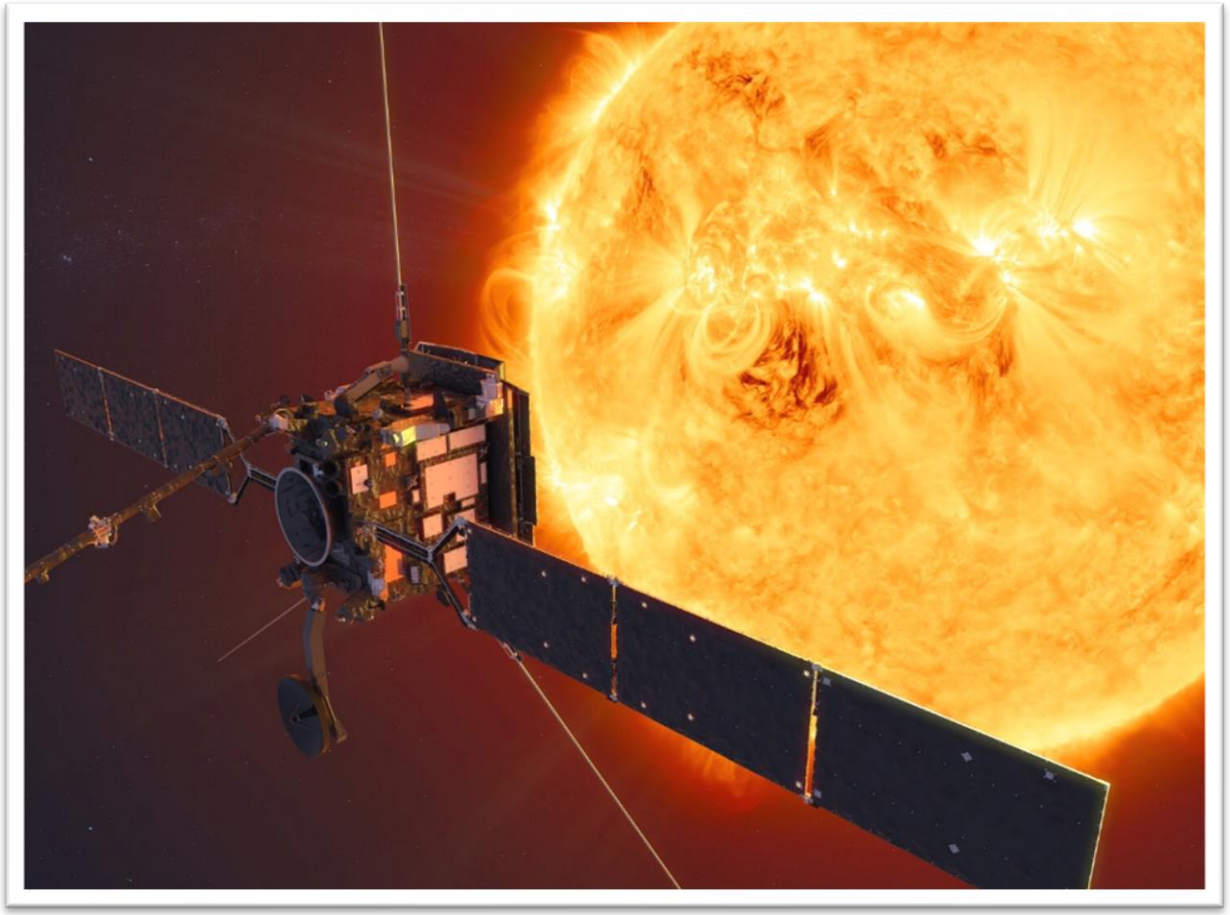
Prof. Grzegorz Wrochna
President of Polish Space Agency
www.polsa.gov.pl

Warsaw, April, 28th, 2021

Space exploration



The Sun



source: ESA

Solar Orbiter, ESA launched 2020 (February).

- What drives the Sun's 11-year cycle of rising and subsiding magnetic activity?
- What heats up the upper layer of its atmosphere, the corona, to millions of degrees Celsius?
- What drives the generation of the solar wind?
- What accelerates the solar wind to speeds of hundreds of kilometers per second?
- And how does it all affect our planet?

In CBK PAN an experiment STIX was developed and later on integrated to the probe.
STIX provides imaging spectroscopy of solar thermal and non-thermal X-ray emission from ~4 to 150 keV.

In 2018 NASA launched Parker Solar Probe.

Some of Polish scientists are involved in research of heliosphere (for e.g. Romana Ratkiewicz-Landowska).

Mercury

source: ESA

source: Wikipedia

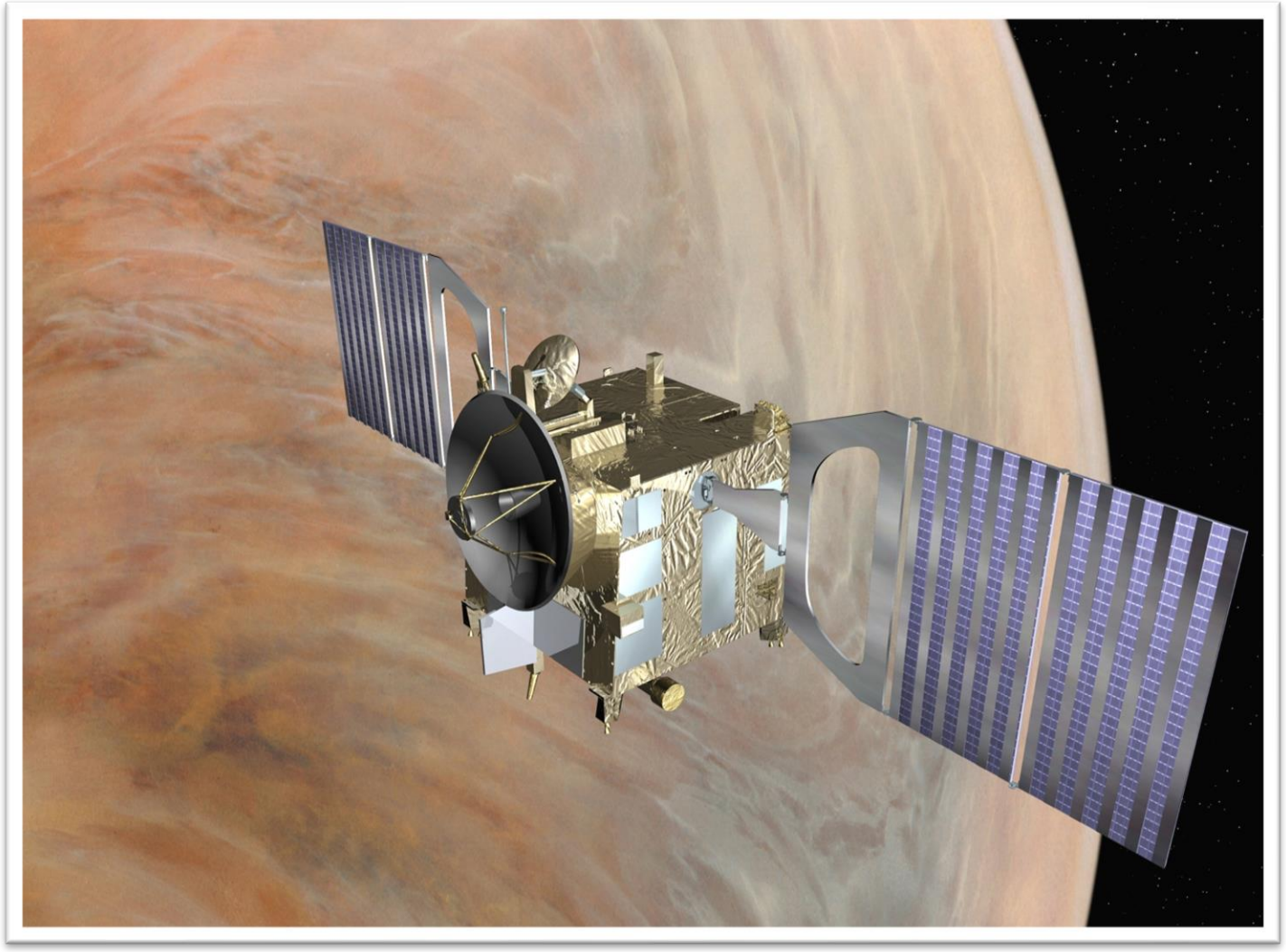
BepiColombo, ESA-JAXA

- Launched in 2018 (October)
- What is the history of solar system formation?
- CBK PAN developed Mercury Radiometer and Thermal Infrared Spectrometer – MERTIS.

NASA missions:

- Mariner 10 (1973)
- MESSENGER (2004)

Venus



source: ESA

Venus Express, ESA

- Launched 2005
- Supports research on Venus dynamics and chemistry, evolution of the planet as well as interplanetary environment.
- The Planetary Fourier Spectrometer a key instrument in the study of middle & lower atmosphere was developed by CBK PAN.

Other actors involved in missions: Soviets, JAXA. Working on the mission: India Space Research Organization, ROSKOSMOS.

MARS

[Mars Express, ESA 2003]

The CBK PAN provided two parts of the Planetary Fourier Spectrometer: a power supply and scanner to navigate the observation's angle.

[Curiosity, NASA, 2011]

Tunable Laser Spectrometers, VIGO System S.A. detectors detected methane,

[ExoMars, ESA-Roskosmos, 2016]

Tunable Laser Spectrometers, Vigo System S.A.

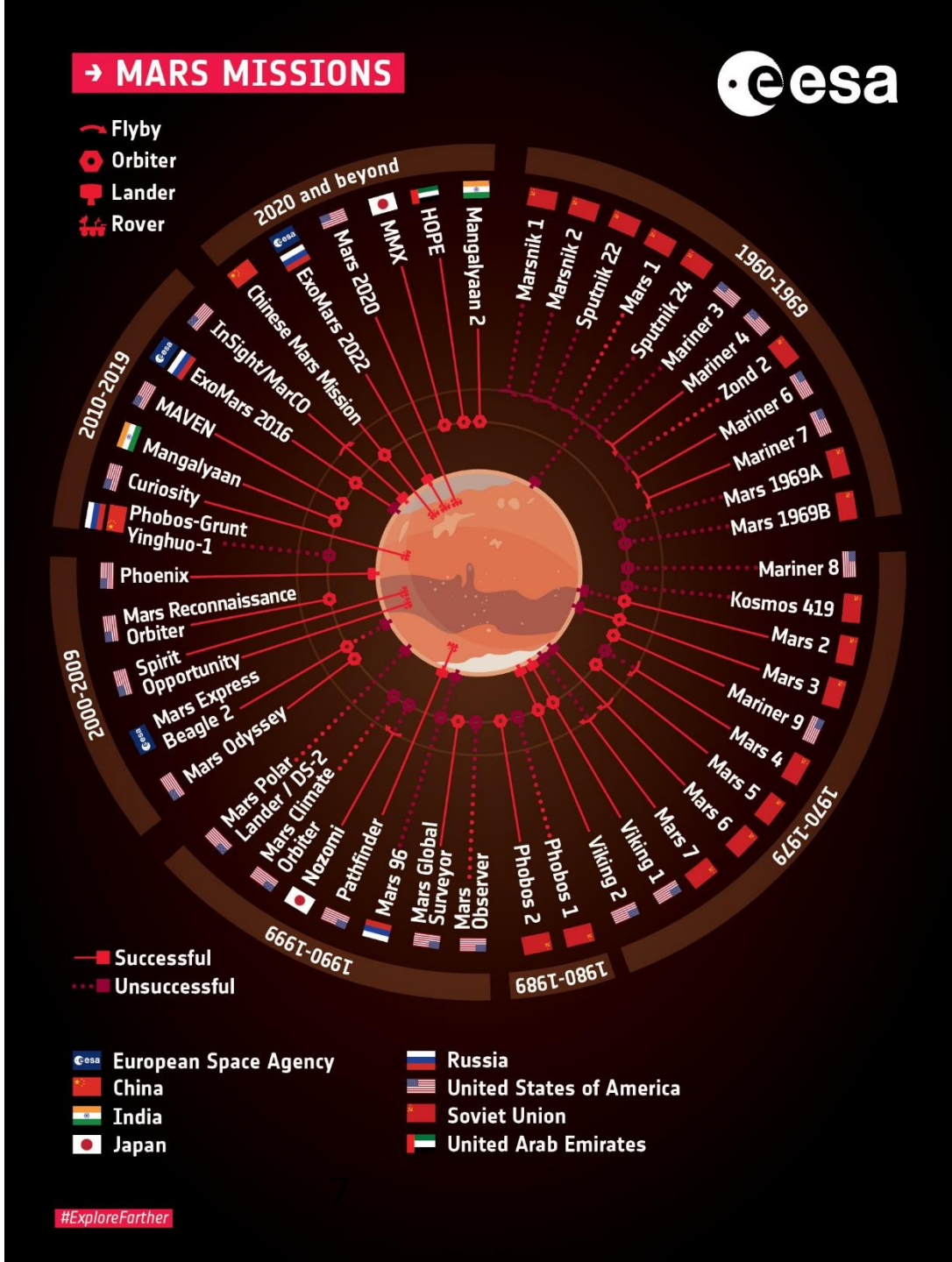
Trace Gas Orbiter: Colour and Stereo Surface Imagining System (CaSSiS) supported by power supply unit.

[Insight, NASA, 2018]

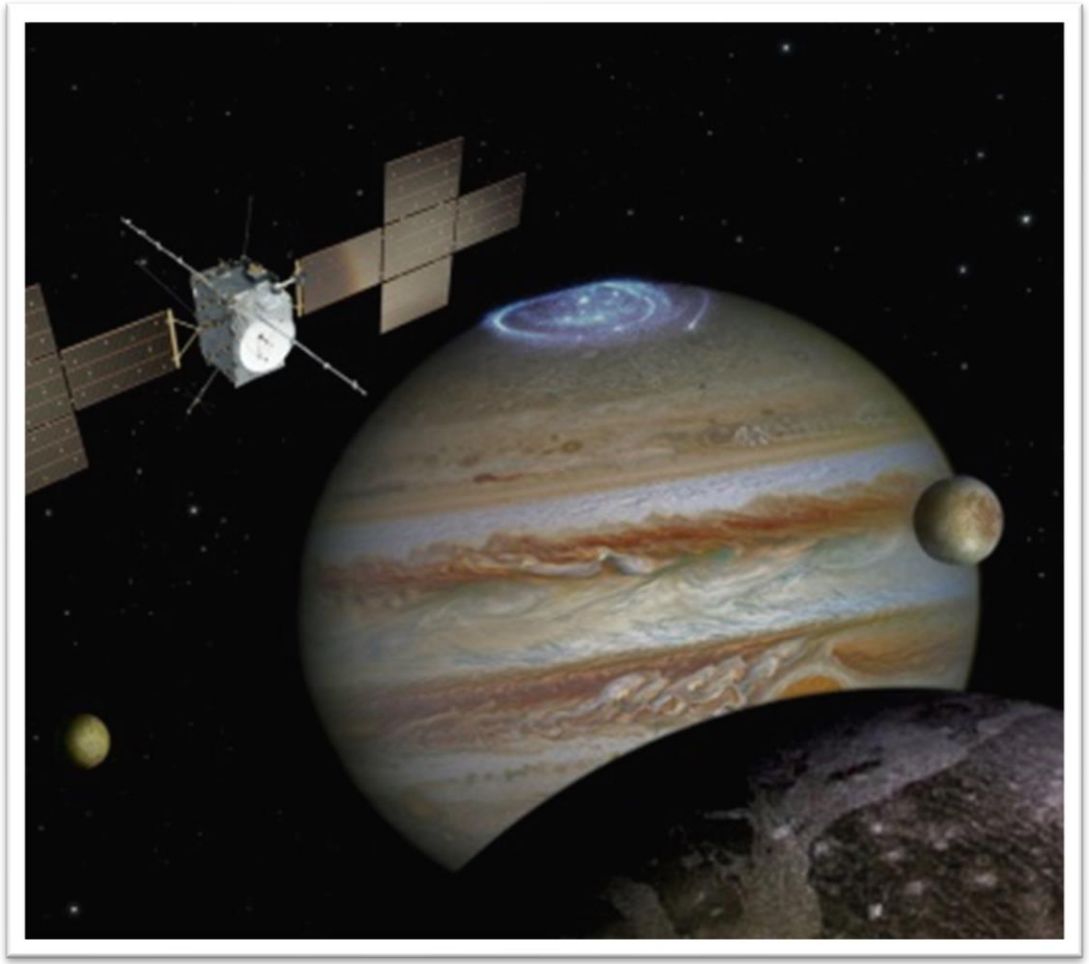
HP3 mole by Astronika spin-off of CBK PAN penetrating the Surface.

[ExoMars, ESA-Roskosmos, 2022]

Umbilical Release Mechanism developed by SENER.



JUPITER



source: ESA

JUpiter ICy moons Explorer, JUICE, ESA

Launch: 2022

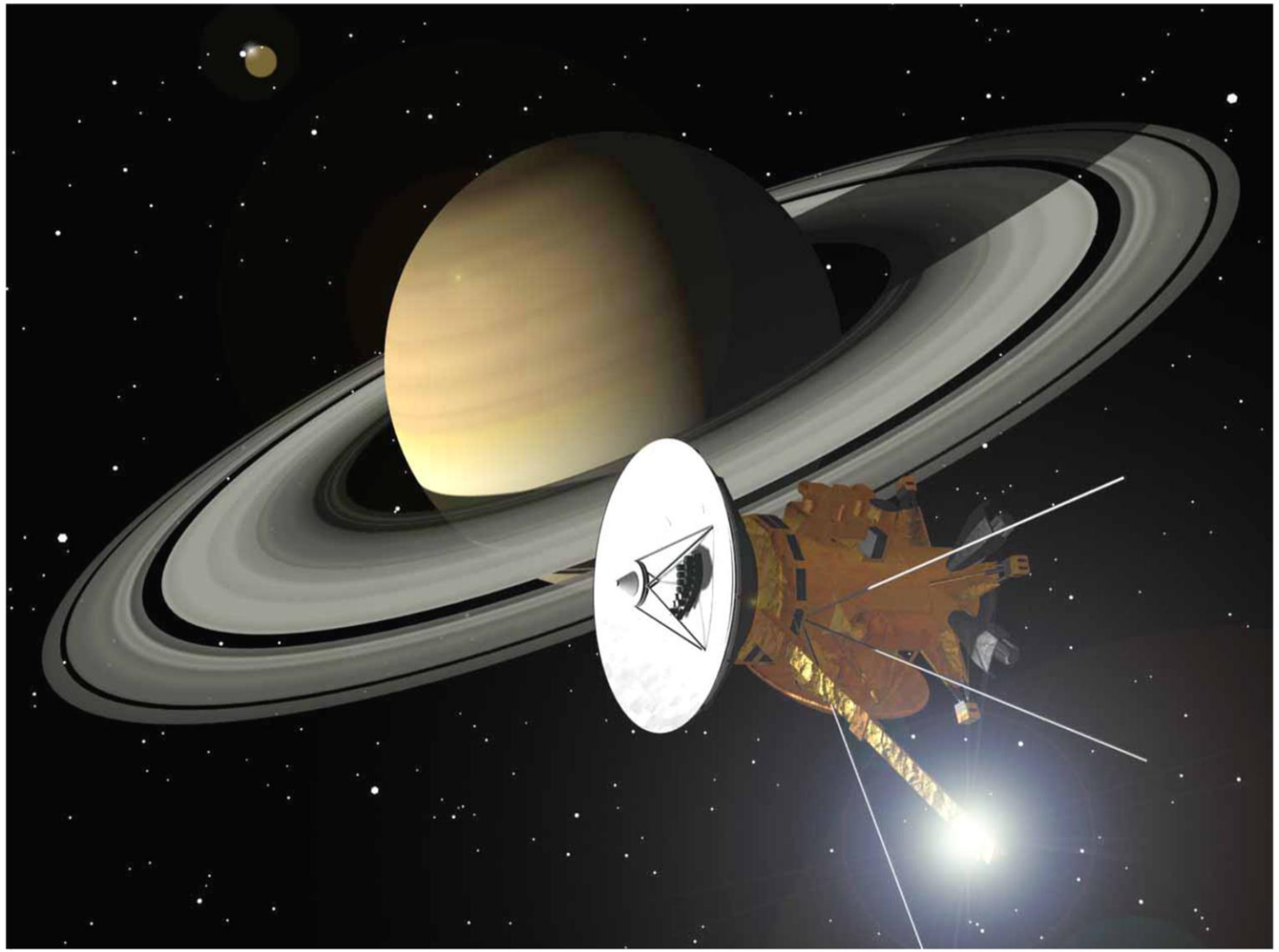
Observations of the giant gaseous planet Jupiter and three of its largest moons, Ganymede, Callisto and Europa.

Involvement of CBK PAN, Astronika, Astri Polska, Creaotech Instruments, Airbus Poland.

Other missions:

- Flyby
  - Pioneer 10 & Pioneer 11, NASA, 1973-74
  - Voyager program, NASA, 1979
  - Ulysses, ESA-NASA, 1990
  - Cassini-Huygens, ESA-NASA, 1997
  - New Horizons, NASA, 2006
- Dedicated orbiter:
  - Galileo, NASA, 1989
  - Juno, NASA, 2011.

SATURN

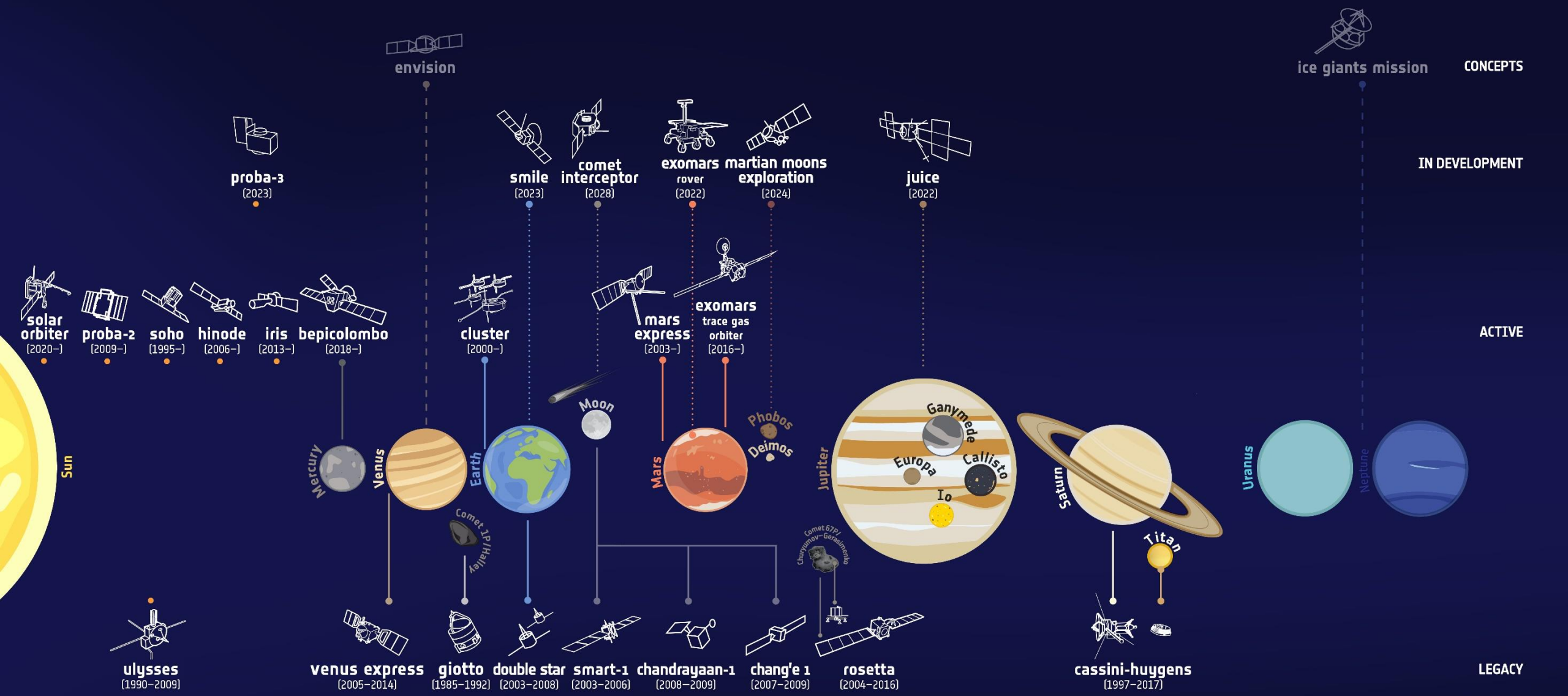


source: ESA

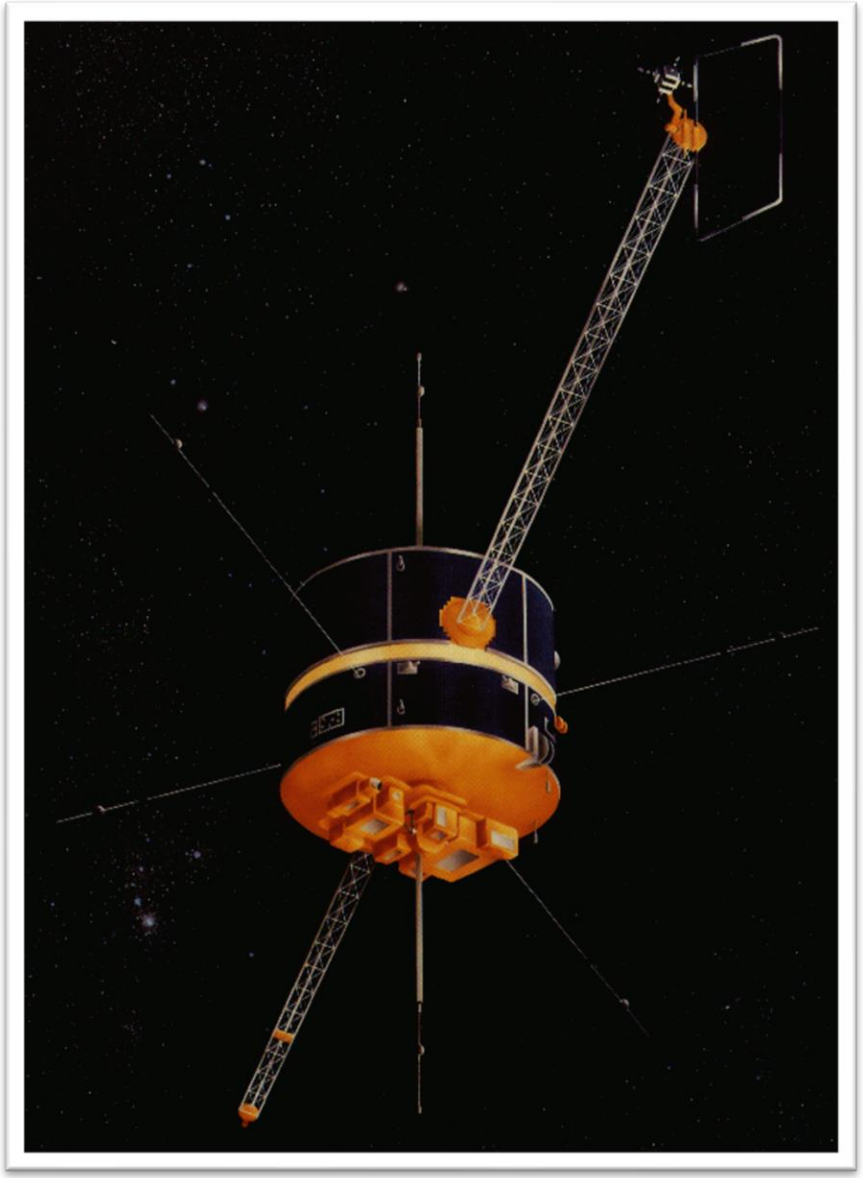
Cassini-Huygens, ESA-NASA

- Launched 1997 (October)
- Huygends module landed on Titan in 2005. Cassini grand finale entered Saturn atmosphere 2017.
- CBK PAN provided thermal prosperities sensor.

SOLAR SYSTEM EXPLORERS



Exploring space



POLAR experiment, European-Chinese project

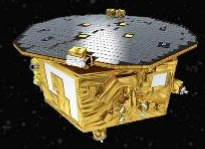
Launched in 2016;

Detection of Gamma-Ray Bursts;

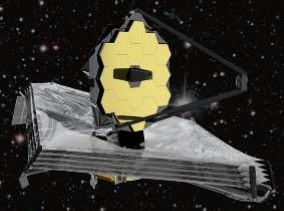
Involvement of National Centre for Nuclear Research (NCBJ).

→ ESA'S FLEET ACROSS THE SPECTRUM

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 underly 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.



lisa pathfinder
Testing the technology for gravitational wave detection

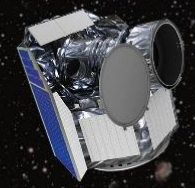


herschel
Unveiling the cool and dusty Universe

jwst
Observing the first light

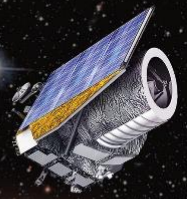
gaia
Surveying a billion stars

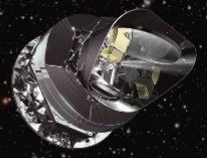
cheops
Characterising exoplanets



xmm-newton
Seeing deeply into the hot and violent Universe

euclid
Exploring the dark Universe

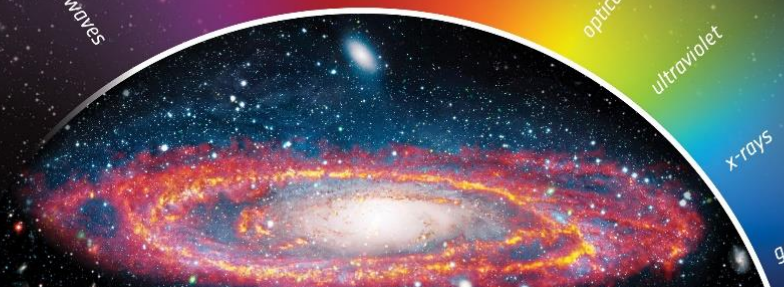




planck
Looking back at the dawn of time

hst
Expanding the frontiers of the visible Universe

integral
Seeking out the extremes of the Universe

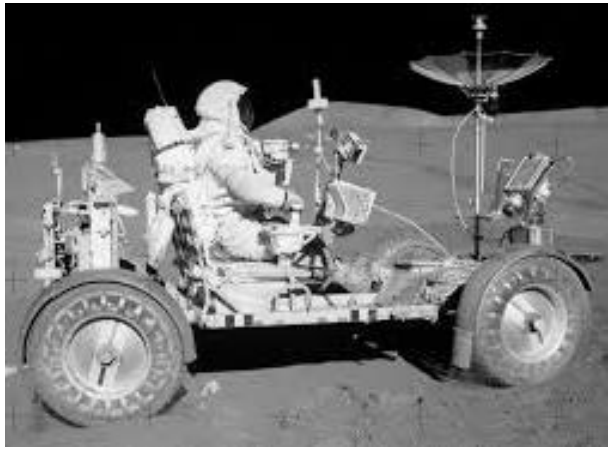


The Moon - Poles engaged in Apollo programme

source: ESA/NASA

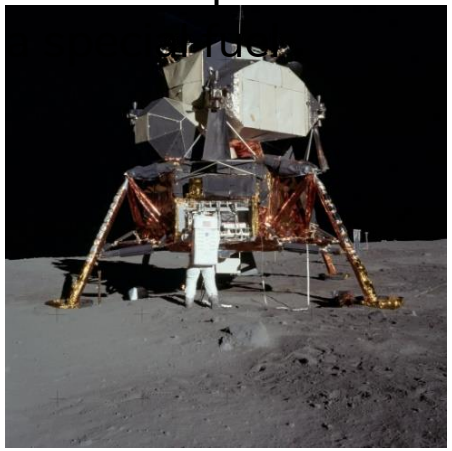
Mieczysław Bekker
(1905–1989)

Chief designer of the manned lunar rover vehicle (LRV)



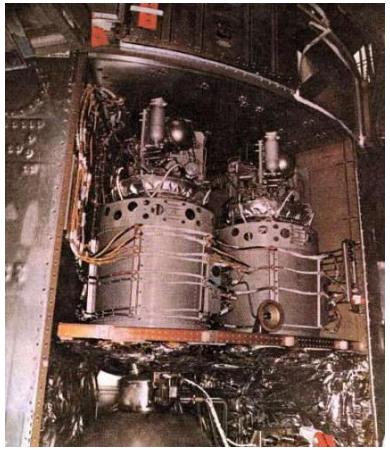
Werner Ryszard Kirchner
(1918–2008)

He worked on the engine of the Eagle lunar lander, for which he developed



Eugeniusz Lachocki
(1921–2010)

He was responsible for developing power supplies for Apollo spacecraft



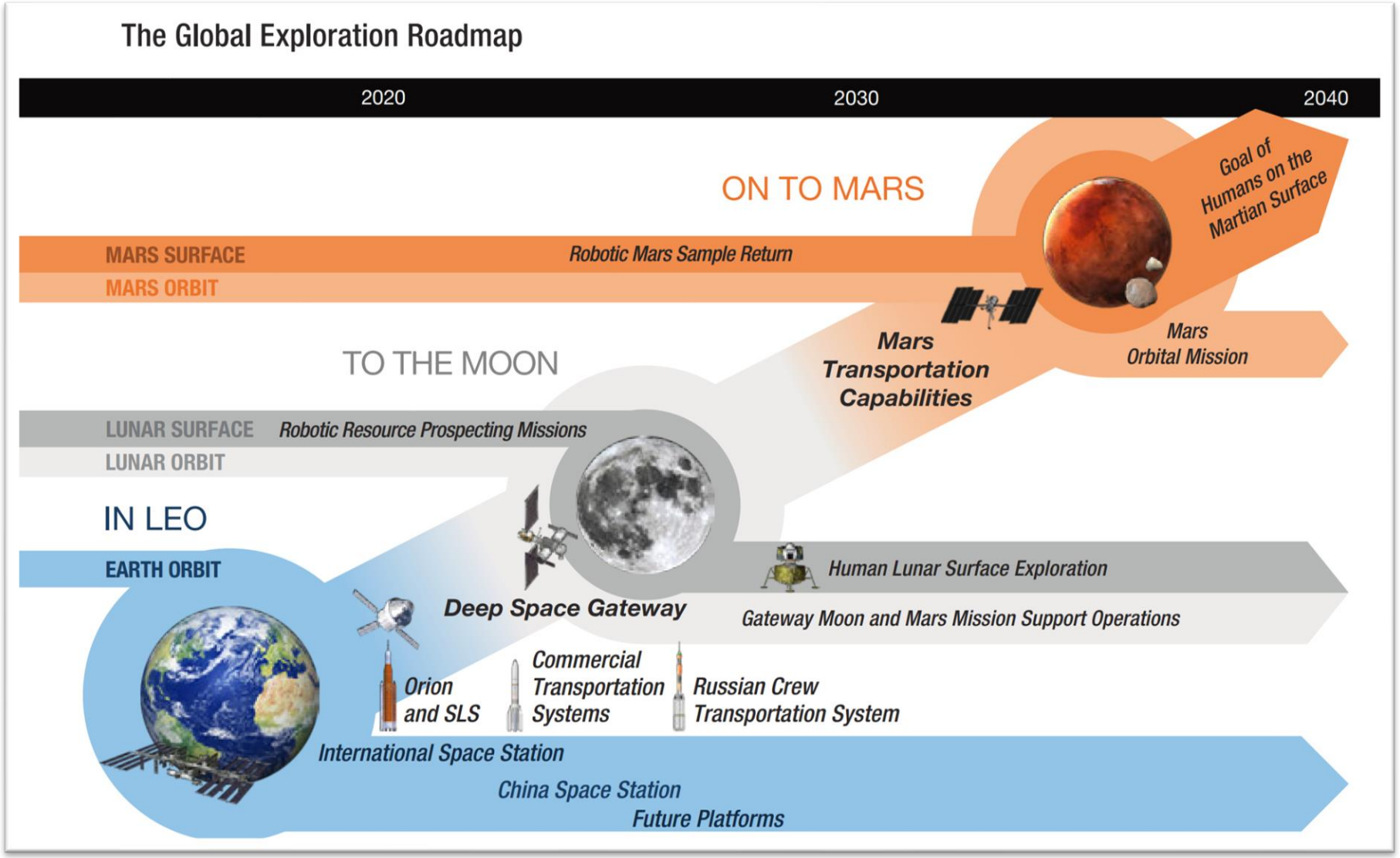
MISSION	AGENCY/LAUNCH DATE	DESCRIPTION/OBJECTIVES
Queqiao	CNSA 2018	Communication relay satellite.
Chang'e-4	CNSA 2018	Far side scientific lander and rover.
Chandrayaan-2	ISRO 2019	Polar scientific orbiter, lander, and rover.
Chang'e-5	CNSA 2020	Near side sample return.
Luna 25	Roscosmos 2021	Lunar volatile prospecting. Soft landing technology demonstration.
Chandrayaan-3	ISRO 2021	Lunar polar lander and rover.
Artemis I	NASA/ESA 2021	Uncrewed Orion/ESM flight with science and technology payloads. Deployment of cubesats in lunar orbit.
SLIM	JAXA 2021/22	Pinpoint landing technology demonstration.
KPLO	KARI 2022	Polar scientific and technology demonstration orbiter.
Chang'e-6	CNSA 2022-2024	Polar volatiles sample return.
VIPER	NASA 2023	Lunar polar rover. Polar science and volatiles.
LUPEX	JAXA/ISRO 2023/24	Polar lander and rover. Polar science and understanding the distribution and characterization of volatiles.
Luna 26	Roscosmos 2024	Polar scientific orbiter. Polar volatiles mapping.
Luna 27	Roscosmos with ESA 2025	Polar science, volatile prospecting and acquisition. Drill technology demonstration.
EL3 (TBC)	ESA 2027/2028	Science and/or logistic capabilities.
Luna 28	Roscosmos 2027	Cryogenic polar volatiles sample return.
ISRU demo	ESA 2027	In-situ end-to-end extraction of oxygen from lunar regolith.
Chang'e-7	2023-2030	Prototype of International Lunar Research Station (ILRS).
Chang'e-8	2023-2030	Prototype of International Lunar Research Station (ILRS).
Mid Lander	JAXA Late 2020's	Transport logistics and/or science.
Korea lunar lander	KARI 2030	Technology demonstration.

Lunar rock – **samples return**:

- Apollo program enabled collection of almost 381 kg samples;
- Luna program through robotic spacecraft collected 0.5kg of material;
- Chang'e-5 collected around 1,731 g of samples.

Source: ISECG, The Global Exploration Roadmap, Supplement 2020
Lunar Surface Exploration Scenario Update

What's next?



Source: ISECG, The Global Exploration Roadmap 2018

Getting prepared for exploration by ESA&NASA

Earth and its orbit:

- Sounding rockets, parabolic flights, testing, 0g experiments, analogues missions (also in Poland)
- International Space Station and astronaut training — ongoing, with ESA astronauts visiting every year,

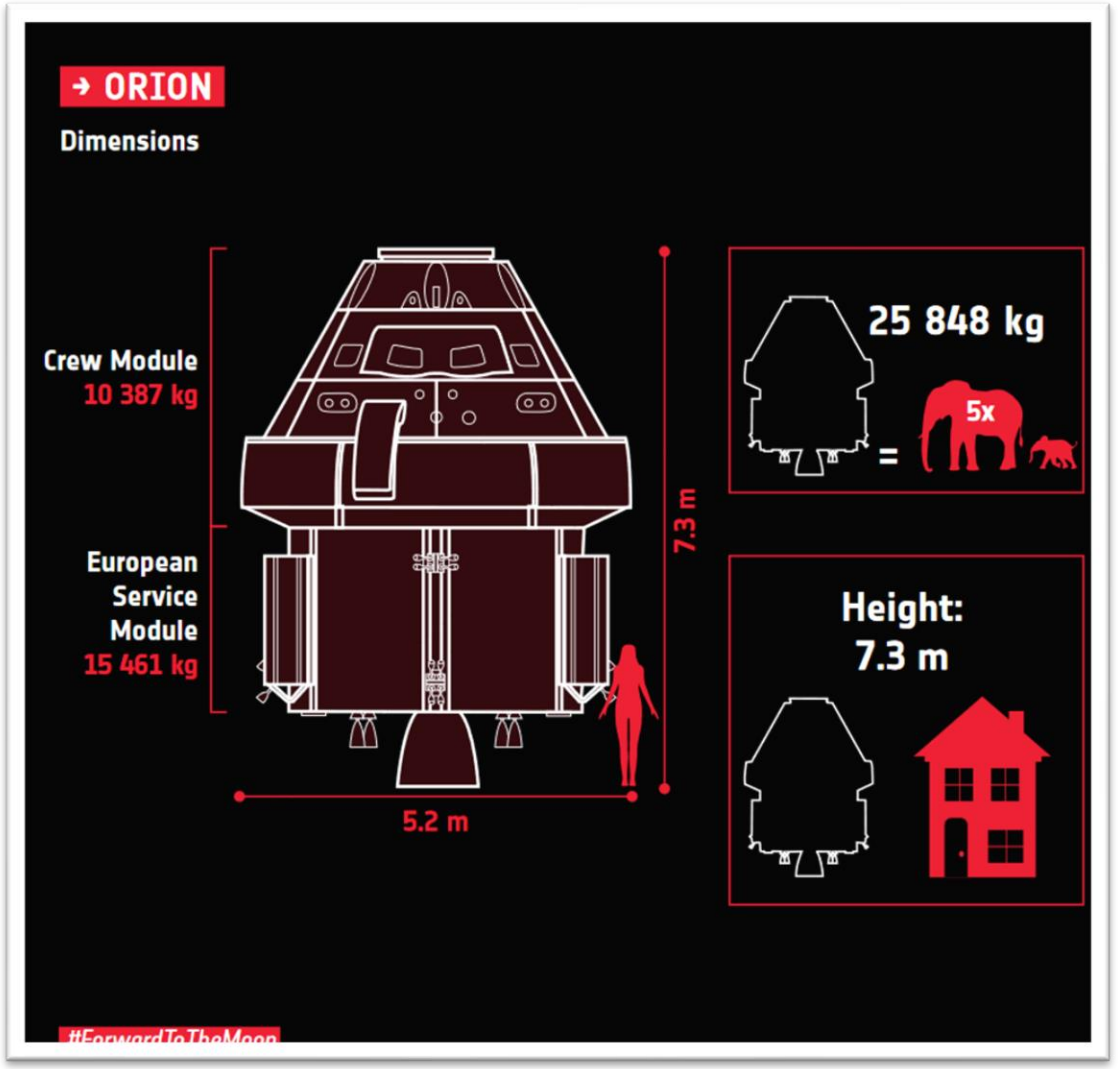
Moon:

- Orion with European Service Module — 2021
- Orion landing on the Moon — by 2024
- Gateway first European experiment — 2022 with first module
- Gateway first ESA astronaut — mid 2020s
- Luna — mid-2020s
- European Large Logistics lander — by 2028
- First three European astronauts on the Gateway — second half of 2020s
- First European astronaut on the Moon — before 2030

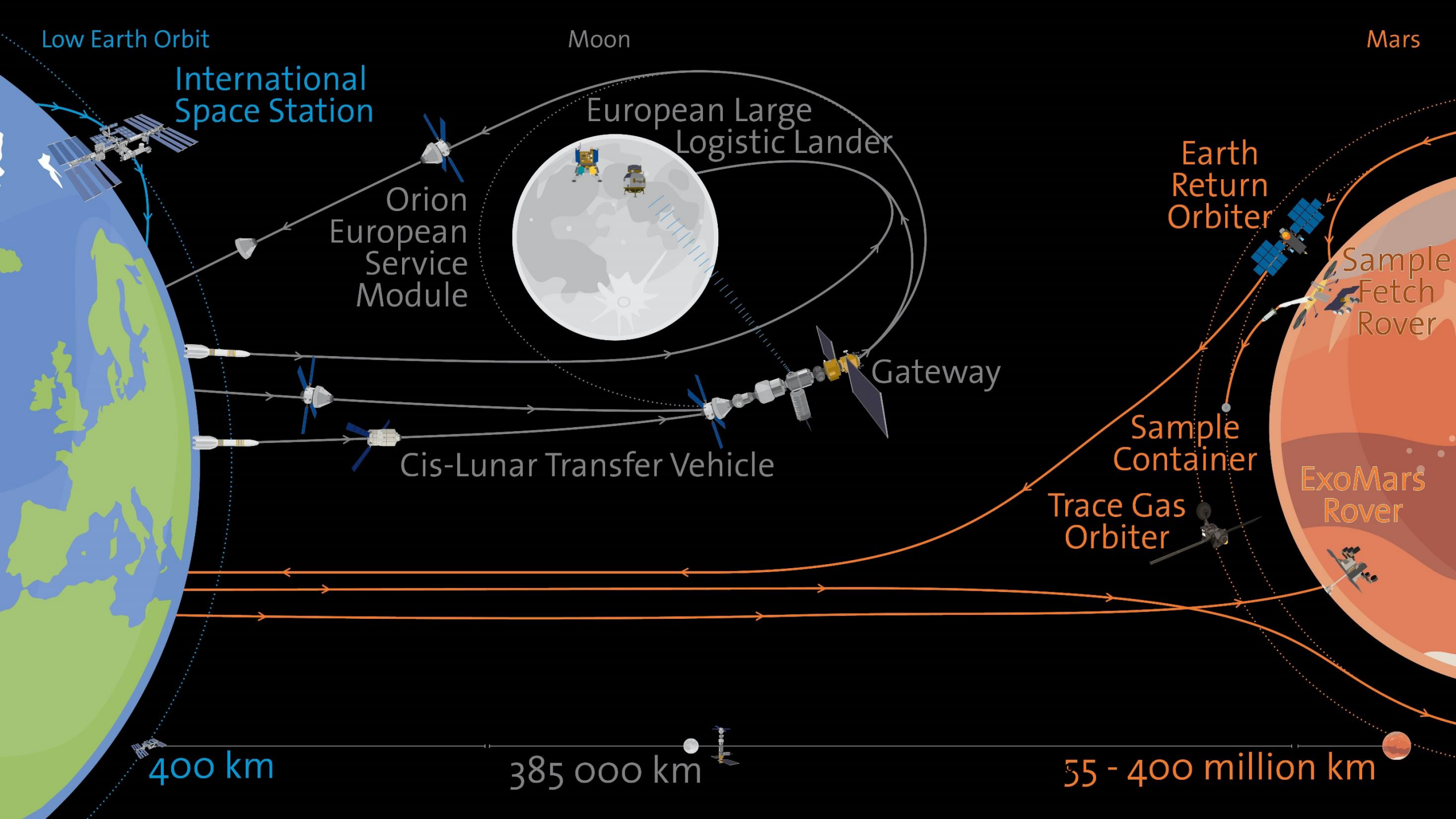
Way forward

Mars:

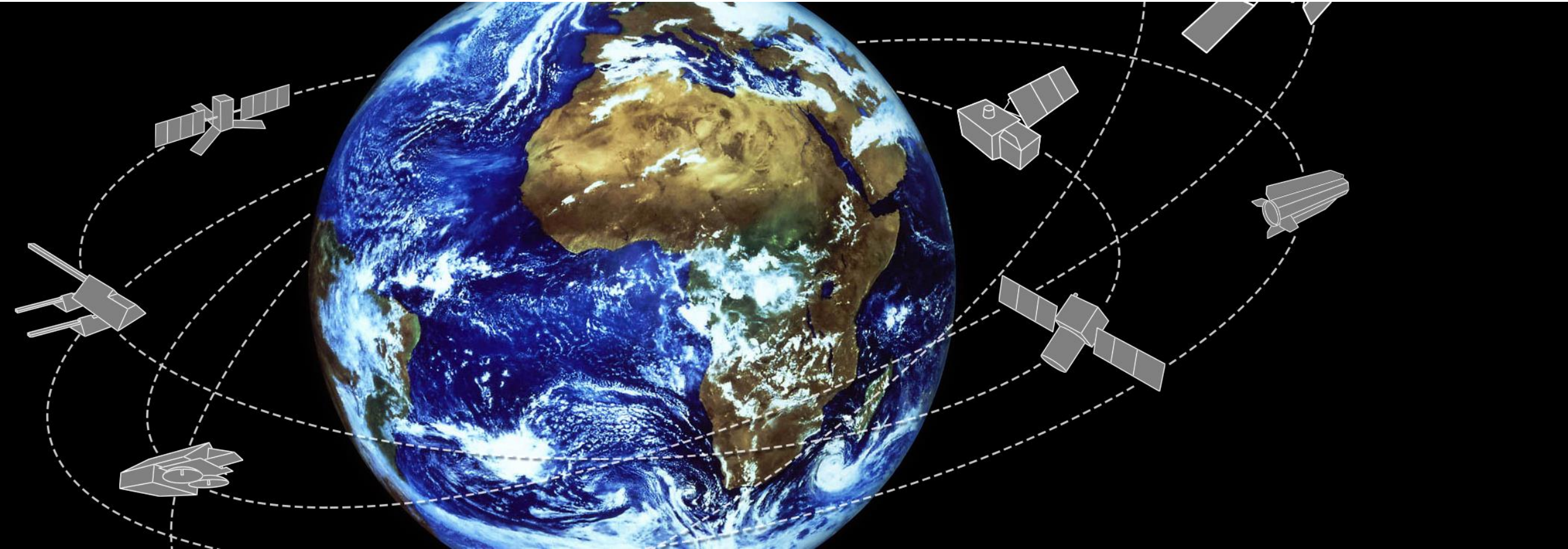
- ExoMars trace gas orbiter + Rosalin Franklin rover
- Mars Sample Return:
  - First element, NASA Perserverance, rover — currently en route to Mars
  - ESA's Earth Return Orbiter, Sample Fetch Rover and Transfer Arm — by 2026
  - Landing of first martian samples on Earth — 2031



Source: ESA–K. Oldenburg


Low Earth Orbit
Moon
Mars
International Space Station
European Large Logistic Lander
Orion European Service Module
Earth Return Orbiter
Sample Fetch Rover
Gateway
Cis-Lunar Transfer Vehicle
Sample Container
ExoMars Rover
Trace Gas Orbiter
400 km
385 000 km
55 - 400 million km

Benefits of space exploration



Technology transfer

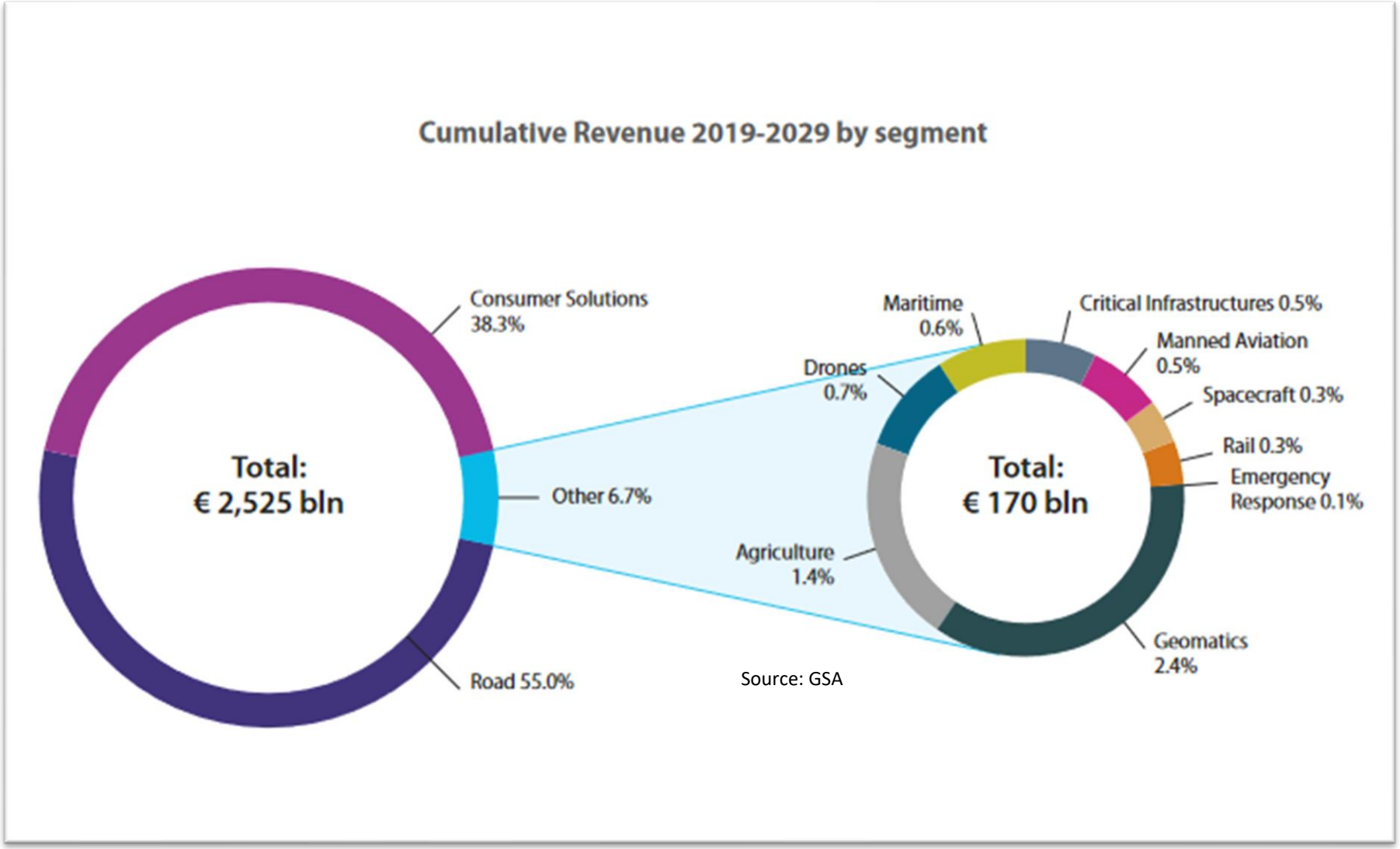
- Technology & ssoftware used for space application is used in medicine for e.g. in Alzheimer disease research, cancer detection;
- Sensor developed for space missions are used in other industries for e.g. in transportations;
- Hand vacuum cleaner, WD-40 and many other innovations we have thanks to investment in space exploration.

source: PSPA

Use of satellites

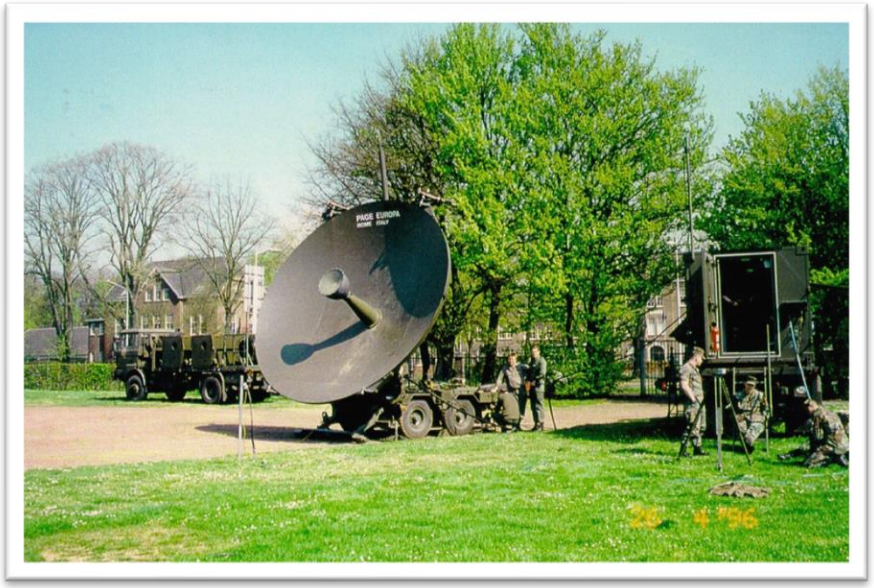
source: ESA

Positioning & navigation



- Transportation, rail & automotive (autonomous cars);
- Aviation & drones;
- Maritime;
- Emergency response;
- Agriculture;
- Geomatics;
- Critical infrastructure;
- Other (for e.g. banking).

Communication



Source: NATO

- Crisis management;
- Border surveillance;
- Maritime surveillance & control;
- Humanitarian aid;
- Civil protection;
- Defense & diplomacy;
- Management of infrastructure;

Source: EURISY

Imagery – Earth observation

Destruction caused by earthquake

Source: Copernicus.eu

Fire in Greenland

Source: ESA

- Crisis management:
  Land deformation,
  Earthquake destruction;
  Fires, floats, etc.
- Biomass condition / forestry;
- Agriculture;
- Preserving culture heritage;
- Climate change understanding,
- Maritime;
- Infrastructure monitoring;
- Humanitarian aid;
- Urban planning.

Space Situational Awareness (SSA)

= space safety

- Space Surveillance and Tracking (SST)
  - Need for constant monitoring, collision avoidance, on-orbit servicing, deorbitation, regulations.
- Near Earth Objects (NEO) – asteroids etc.
- Space Weather – solar radiation bursts

EU SST monitors potential collision between space objects SL-8 R/B and OPS 6182

T-57H

National Operations Centres (NOCs) detect the event. First estimates point to a **probability of 1.5% and miss distance of 40 m.**

T-51H

EU SST Taskforce is activated. Led by SatCen, it coordinates monitoring and communication of major SST events.

T-51H to T-2h

Sensor network tasked and predictions refined by **FR & ES OCs**. Fragmentations simulated by **IT OC**. Last estimates: **21 m miss distance, 20% probability.** EU SST informs on social media.

T0

Time of Close Approach: 17:18 UTC

T+2H

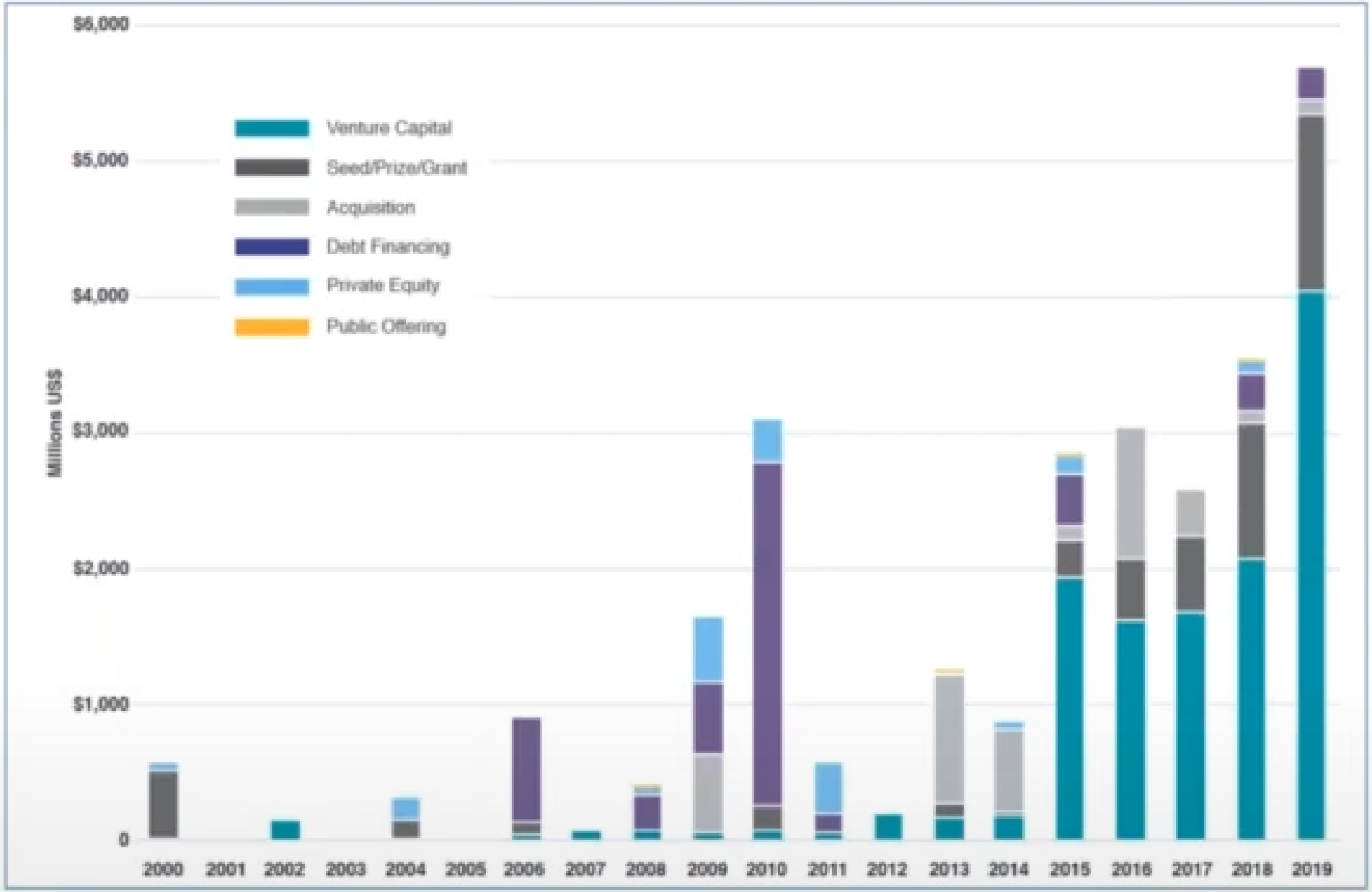
Six radars confirm there was **no collision**. **17 contributing sensors shared data.**

New Space

Private investment in space sector 2000-2019

According to the Bryce Start-Up Space Report 2020,

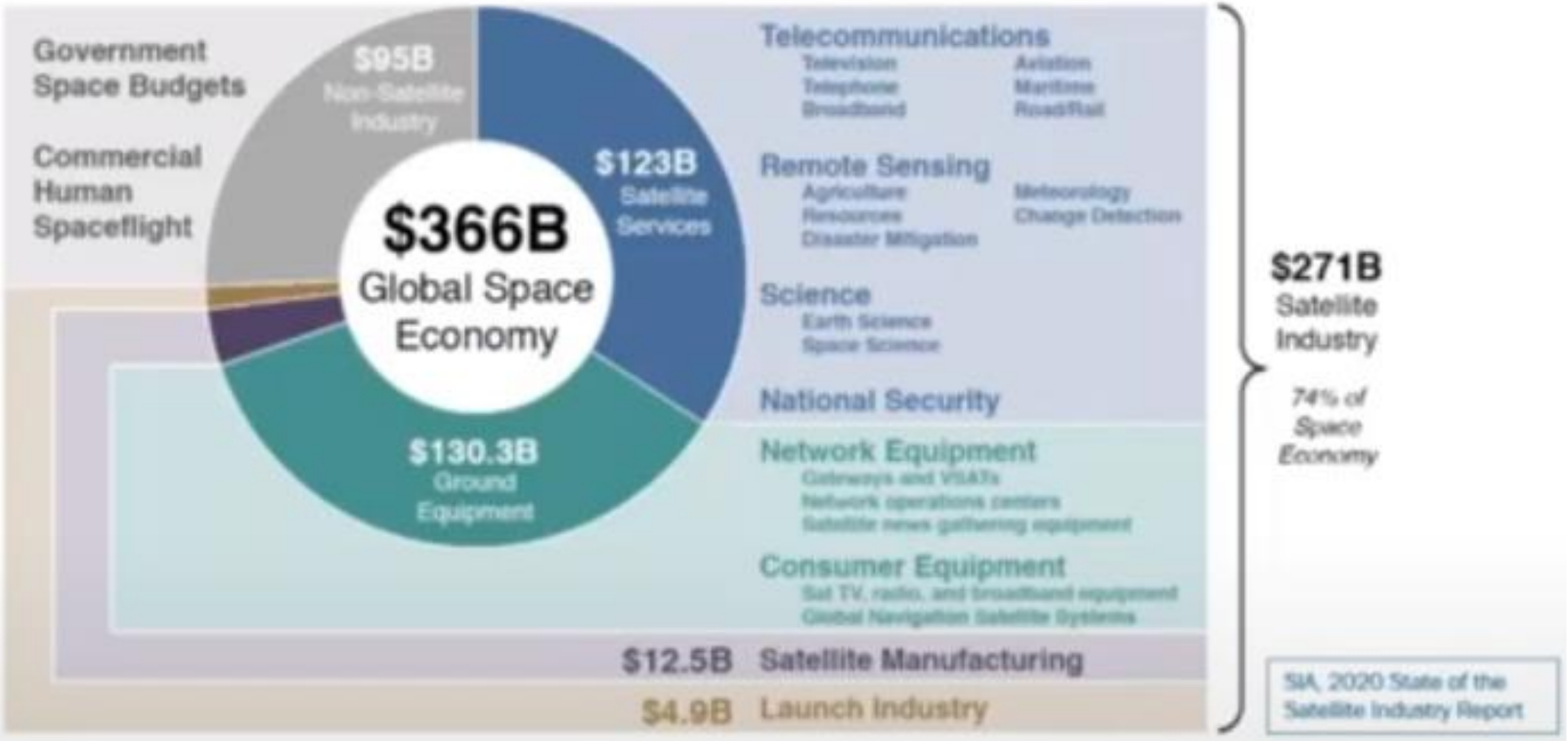
- Cumulative investment since 2000 totals $27.8 billion;
- More than 60% of investment in start-up space ventures since 2000 has occurred in the last five years;
- Nearly $18 billion (more than 80%) of investment since 2015 has been seed and venture capital.



public 25%, private 75%

The Satellite Industry in Context

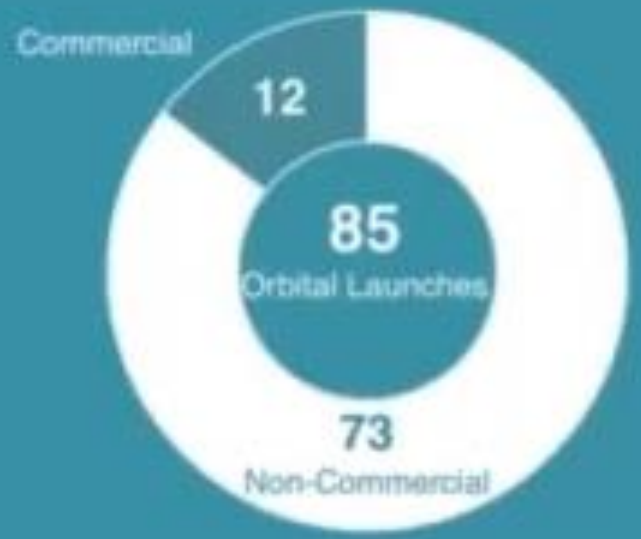
(2019 revenues worldwide, in billions of U.S. dollars)



2020 Year in Review (through October 31)

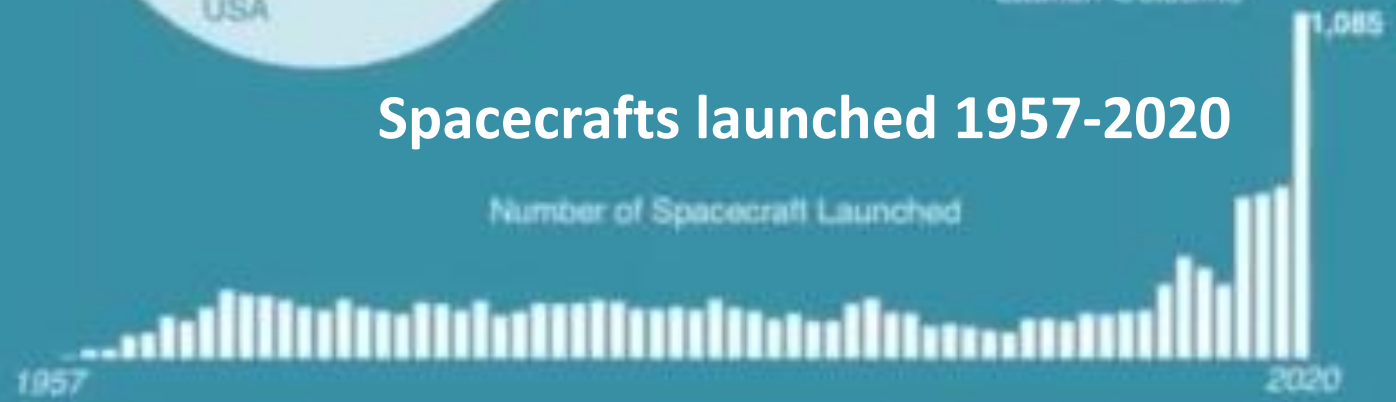
BRYCE space and technology

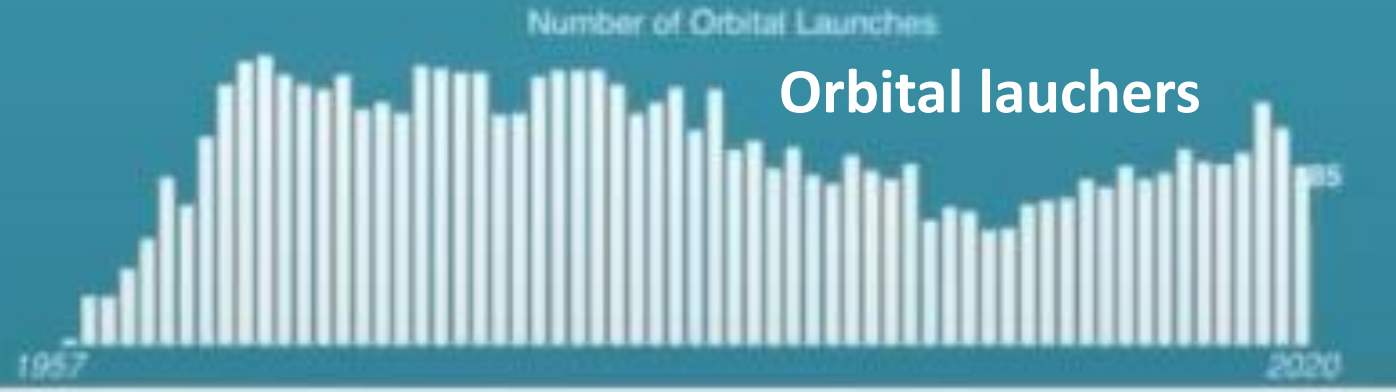
Orbital lauchers in 2020



Spacecrafts launched in 2020

Spacecrafts launched 1957-2020





* Partial successes counted as failures

Big4: 68%, small US: 16%, small EU: 16%

According to market reports, large investments focus on a few companies

- In 2019 close to 70% of the worldwide investment in private space companies was concentrated the "Big 4" – SpaceX, Blue Origin, OneWeb, and Virgin Galactic.
- Between 2014-2018, SpaceX, Blue Origin, and OneWeb were the recipients of 47% of the start-up space investments.
- These companies weigh substantially on global investment estimations.
- However, it is questionable whether they are still to be considered as "start-ups" given the size of their business.

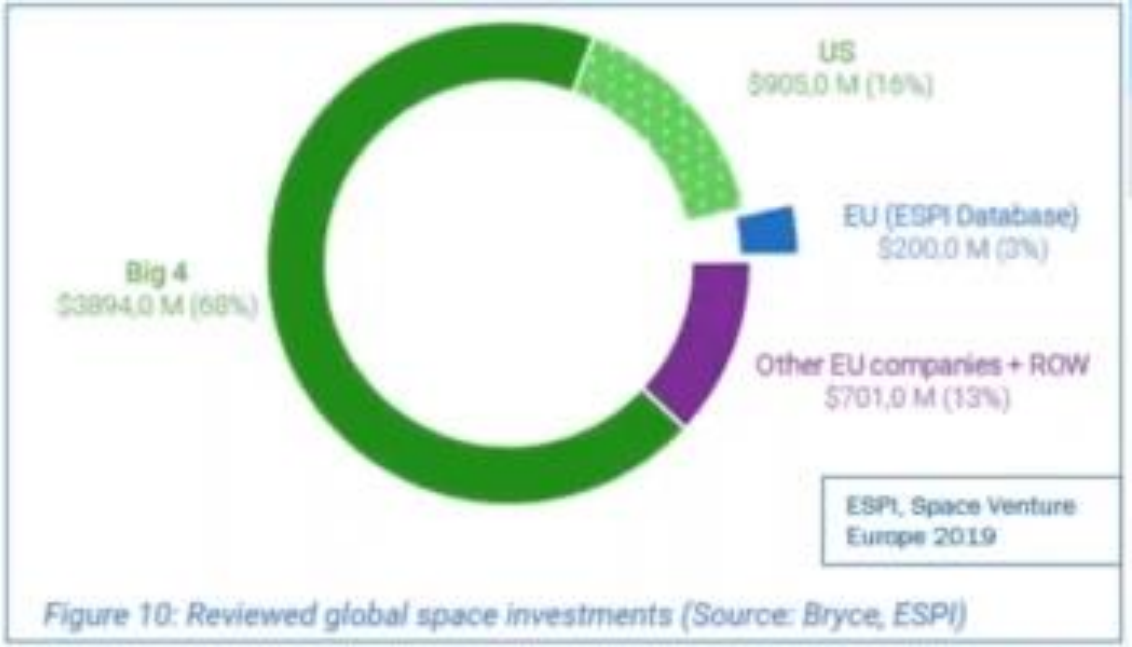
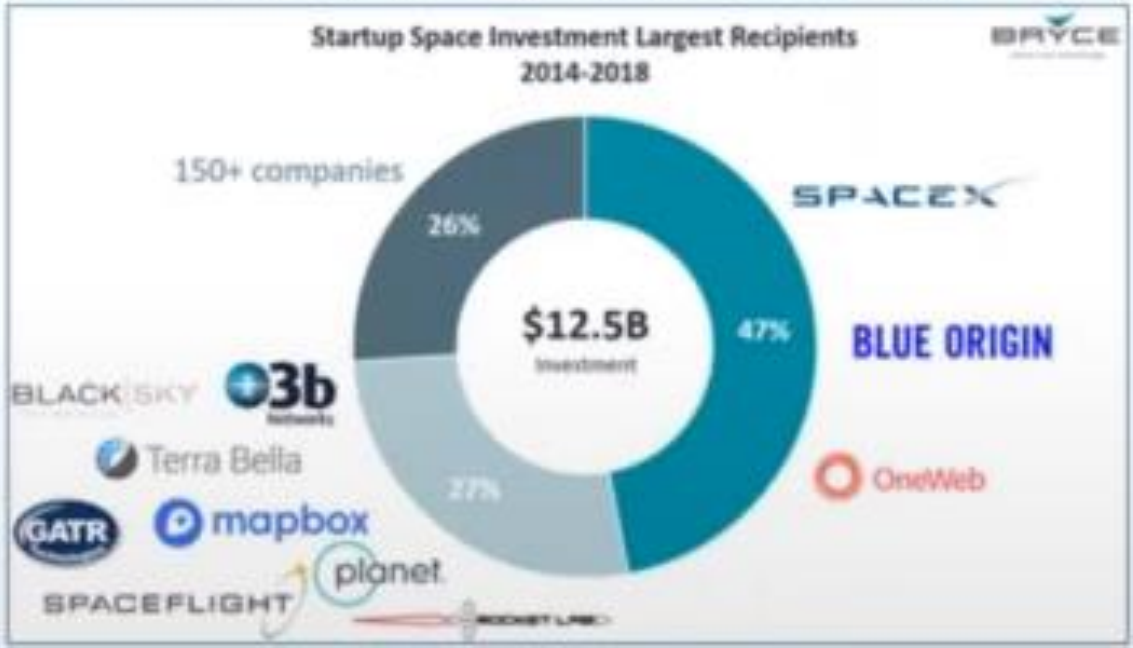
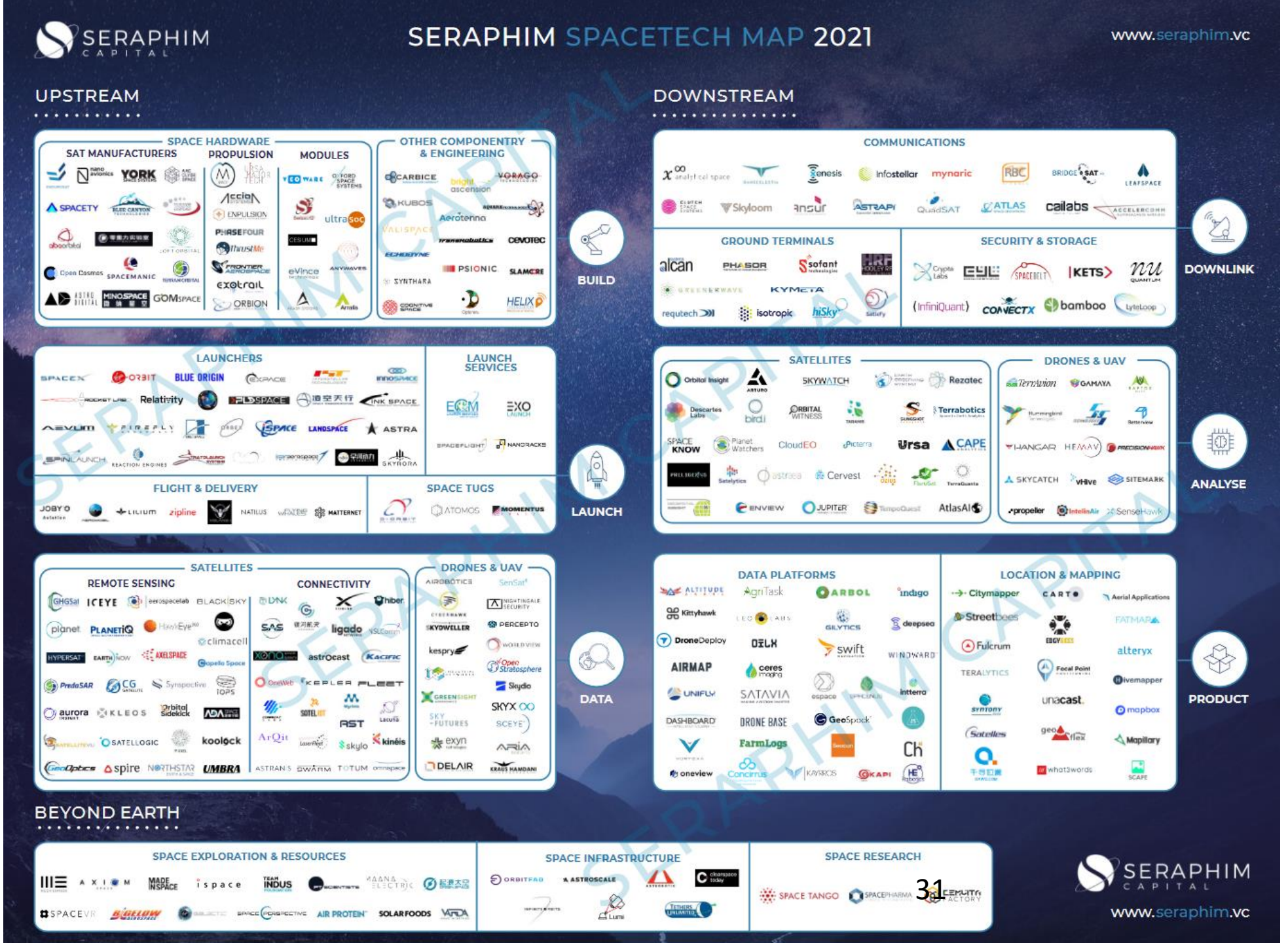


Figure 10: Reviewed global space investments (Source: Bryce, ESPI)




SERAPHIM CAPITAL
SERAPHIM SPACETECH MAP 2021
www.seraphim.vc
UPSTREAM
DOWNSTREAM
SPACE HARDWARE
SAT MANUFACTURERS
PROPULSION
MODULES
OTHER COMPONENTRY & ENGINEERING
COMMUNICATIONS
GROUND TERMINALS
SECURITY & STORAGE
BUILD
DOWNLINK
LAUNCHERS
LAUNCH SERVICES
FLIGHT & DELIVERY
SPACE TUGS
SATELLITES
DRONES & UAV
LAUNCH
ANALYSE
SATELLITES
REMOTE SENSING
CONNECTIVITY
DRONES & UAV
DATA PLATFORMS
LOCATION & MAPPING
DATA
PRODUCT
BEYOND EARTH
SPACE EXPLORATION & RESOURCES
SPACE INFRASTRUCTURE
SPACE RESEARCH
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What is new space?

Previously	Now
Militarization & higher goals (cold war)	Commercial wave, democratization of space
Limited access to knowledge & research	Not that strict limitations (still some international regimes, also law regimes); Technology transfer; New applications
Large national agencies, government, small number of actors	New actors, startups, spin-offs, spin-ins from other sectors
Risk taken by governments	Risk shares through public-private partnerships and private investors
High cost	Lower cost, increased production rate and speed
Acceptance of costs	Challenging costs through miniaturization, reusability, new production technology, prototyping with 3D printing

Key trends dribing the New Space sectorial dynamic by ESPI, 2017

- Entrants from different sectors for e.g. IT, but also new needs of research on space anthropology, astrobiology, human behaviour in space, etc.
- Innovative industrial approaches – bottom up approach & cooperation.
- Disruptive solutions – hunt for cheaper approaches, faster one, more integrated.
- Private investment not limited to the biggest players.
- New industry verticals – transfer of technology and commercialization.
- Innovative public procurement and support schemes – cost and risk sharing approaches.
- New actors, new space nations

New Space – innovative approach - example

The United States has announced a new lunar exploration programme Artemis, that soon will enable human missions to the Moon and in a manner that is sustainable long-term and tests the systems and operations necessary to prepare for future human Mars missions.

The Commercial Lunar Payload Services (CLPS) project was developed by NASA to procure delivery of payloads to the lunar surface from commercial providers. NASA has currently awarded contracts for four surface deliveries to both polar and non-polar lunar locations.

NASA is utilising the CLPS capability for one of these deliveries to land the Volatiles Investigating Polar Exploration Rover (VIPER) on the South Pole to investigate the location and concentration of water ice in the region and takes samples to inform future science and human missions to the South Pole.

NASA also recently awarded the first Gateway Logistics Services (GLS) contract to SpaceX to deliver cargo, experiments and other supplies to the outpost.

NASA's currently awarded contracts for surface deliveries to both polar and non-polar lunar locations beginning in 2021

YEAR	CLPS PROVIDER	MANIFEST	LOCATION
2021	Astrobotic	Science/ Technology	Lacus Mortis
2021	Intuitive Machines	Science/ Technology	Oceanus Procellarum
2022	Masten	Science/ Technology	Polar Region
2023	Astrobotic	VIPER rover	Polar Region

Space Sector in Poland

- More than 380 entities registered in ESA-Star tendering system
- Around 100 entities actively involved in space business
- Well developed and experienced scientific community
- Industrial sector based mainly on SMEs and start-ups

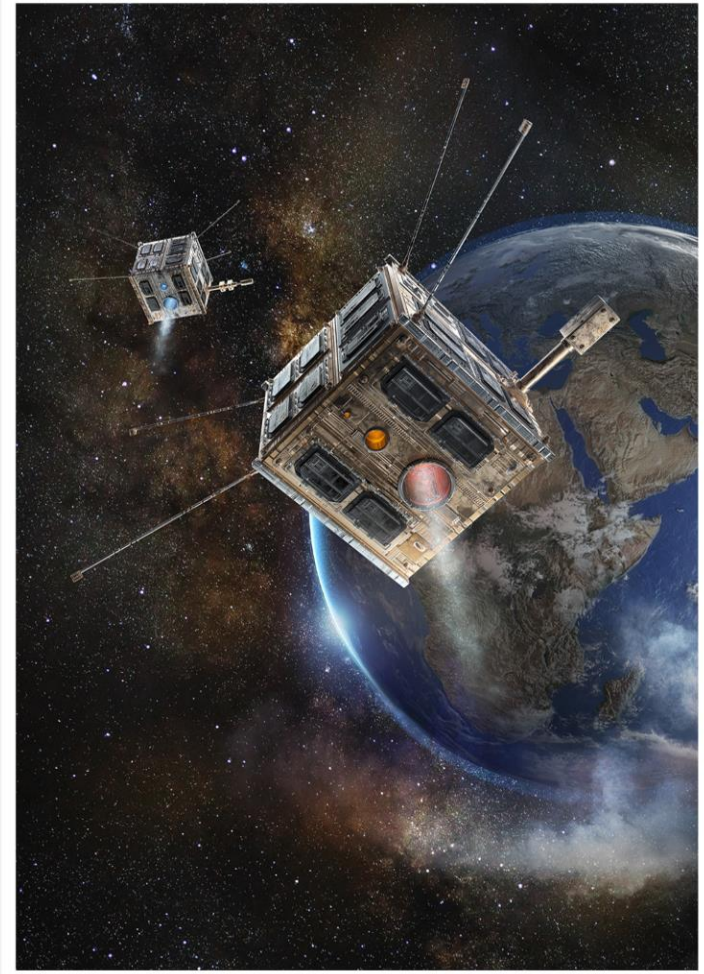
Flying heritage

- Spectometers
- Electronic subsystems
- Mechanisms (also: Multi Purpose Sensors for Surface and Subsurface Scienc)
- On-board software
- MGSE & EGSE
- PW-Sat1 & PW-Sat2
- KrakSat
- Światowid
- Brite-PL (Lem & Heweliusz)

Work in progress

- Intuition-1
- PW-Sat3
- EagleEye
- TST-1 & TST-2

+ missions with ESA, other agencies



Polish Space Strategy

- The Polish space sector will be able to compete effectively on European market and its market turnover will be at least 3% of total turnover of this market.
- Polish public administration will make use of satellite data for faster and more effective realisation of given goals, and national companies will be able to meet their internal demand.
- The Polish economy and public institutions will be granted access to satellite infrastructure in order to satisfy their needs.

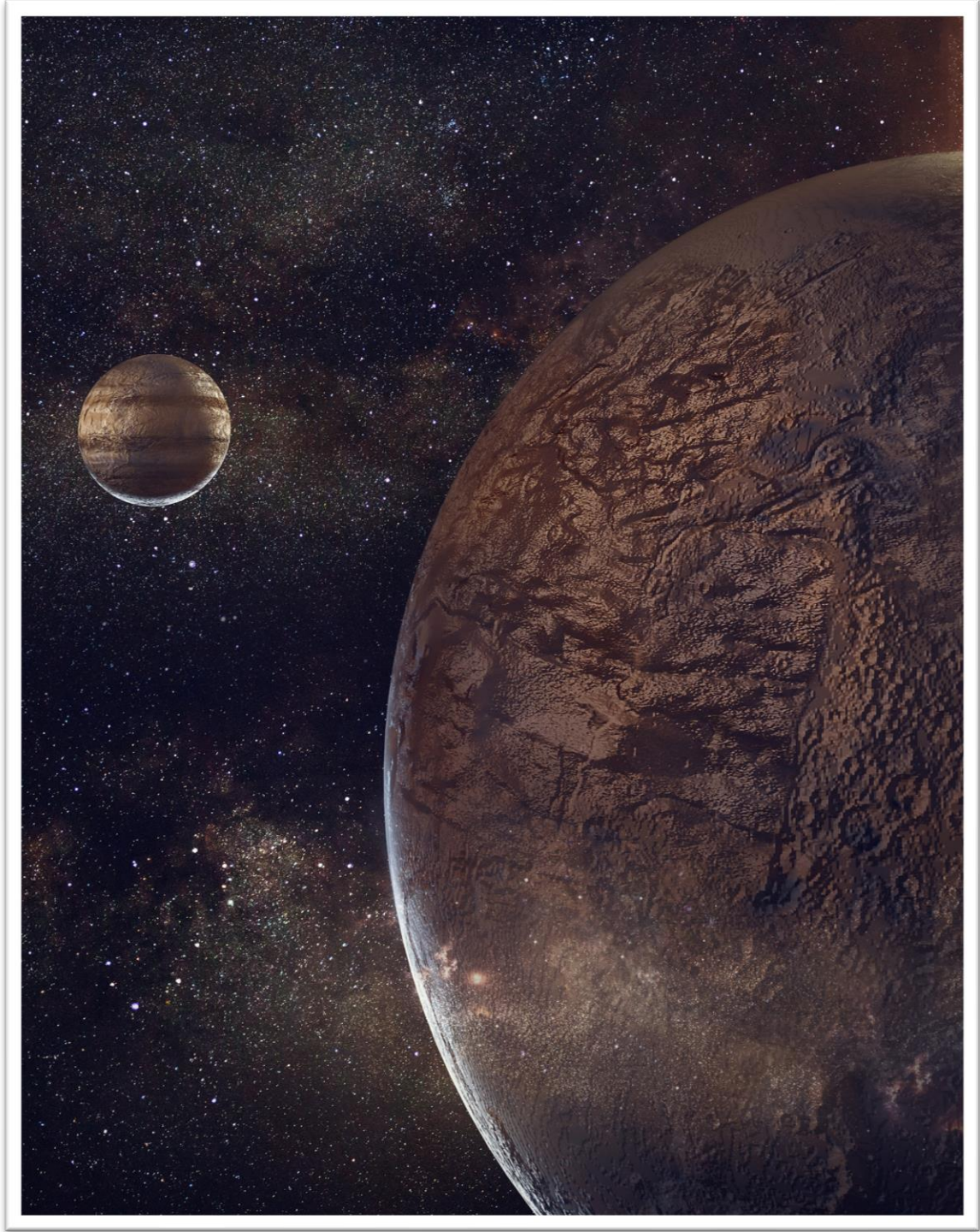
- Growth of competitiveness of the Polish space sector;
- Development of satellite applications – contribution to digital economy;
- Development of national security and defensive capabilities using space technologies and satellite techniques;
- Creating favourable conditions for the development of the Polish space sector;
- Training qualified personnel to meet the sector's needs.

Polish Space Agency

POLSA activities

International cooperation;

- Supporting Polish space sector through International outreach, experts support, law enforcement;
- Earth observation activities – trainings, services;
- Research & Development – support scientific institutions and companies;
- Education – inspiring into STEM, supporting students, training SMEs;
- Defence – supporting MoD and technology development.



Participation to ESA

On the recently completed ESA Ministerial Council Poland has subscribed to following programmes:

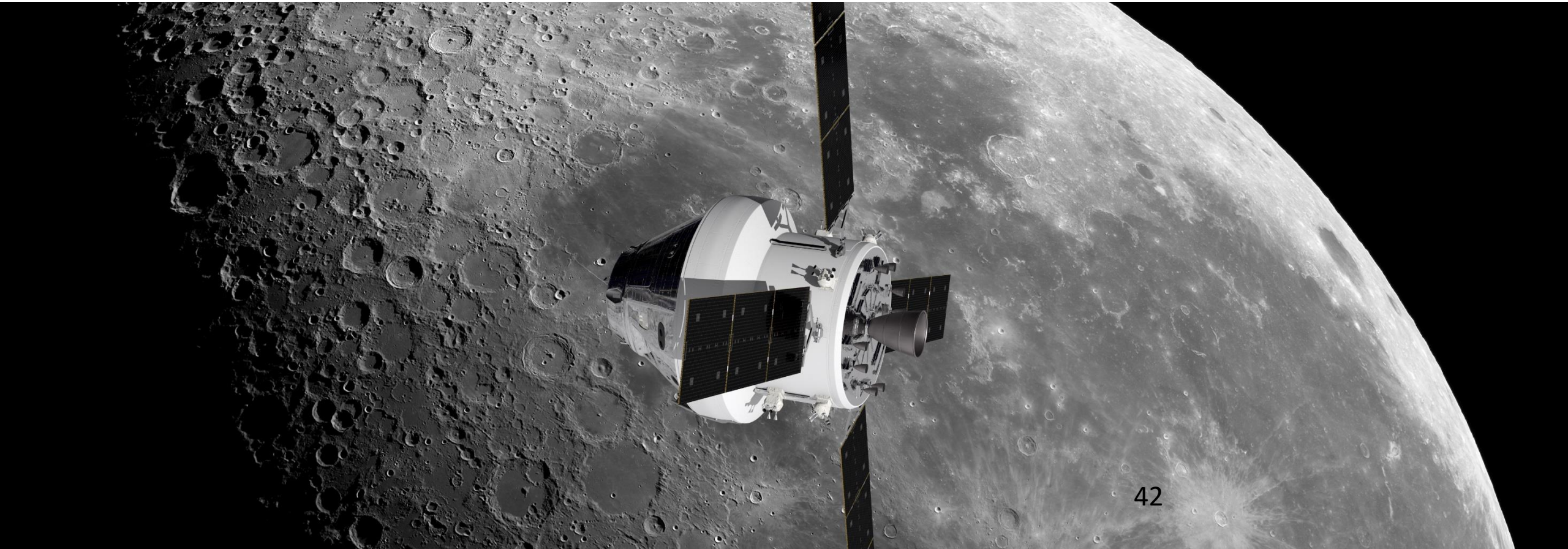
- Mandatory programme – science
- Space Safety Programme (S2P)
- Earth Observation (EO)
- Programme for Advanced Research in Telecommunication Systems (ARTES 4.0)
- European Exploration Envelope Programme (E3P)
- Scientific Experiment Development Programme (PRODEX)
- General Support Technology Programme (GSTP)
- Navigation Innovation and Support Programme (NAVISP)

- Two ESA Labs: Gdansk Technology University (maritime) & Kozminski University (socioeconomic impact of space)
- High need of science involvement in research/mandatory program
- ESA industry policy uses georeturn
- ESA Business Incubation Center under development

EU projects

- Sat4envi - Operating system for gathering, sharing and promotion of digital satellite information about the environment
- PERASPERA - *The Plan European Roadmap and Activities for Space Exploitation of Robotics and Autonomy* – *"PER ASPERA* (ad ASTRA)"
- EUSST - Space Surveillance and Tracking cooperation
- Future Space – for teachers and high school students
- ENTRUSTED - European Networking for satellite Telecommunication Roadmap for the governmental Users requiring Secure, inTeroperable, InnovativE and standardiseD services
- SUN – the Space hUbs Network – satellite data usage acceleration and startups support
- Cosmic Hub – Spacetech in everyday life series, workshops, discussions and mentoring

What next?



Following the fast development of space technologies,
I risk the thesis:

Mankind will create colonies on other planets

- e.g. Mars,
- by the year 3000,
- >1000 people,
- living lifes and growing children (not research base, not mining)