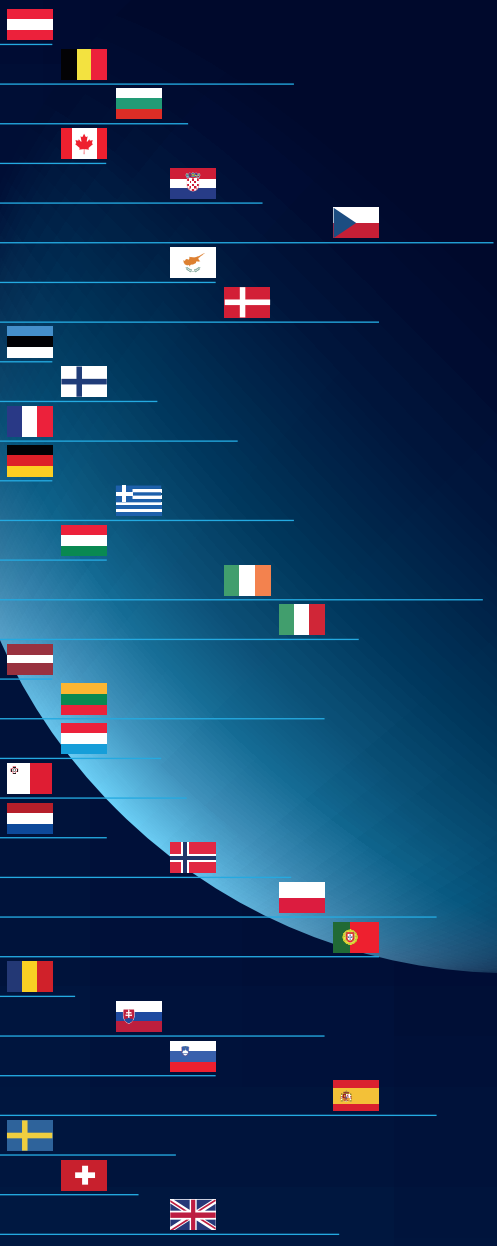
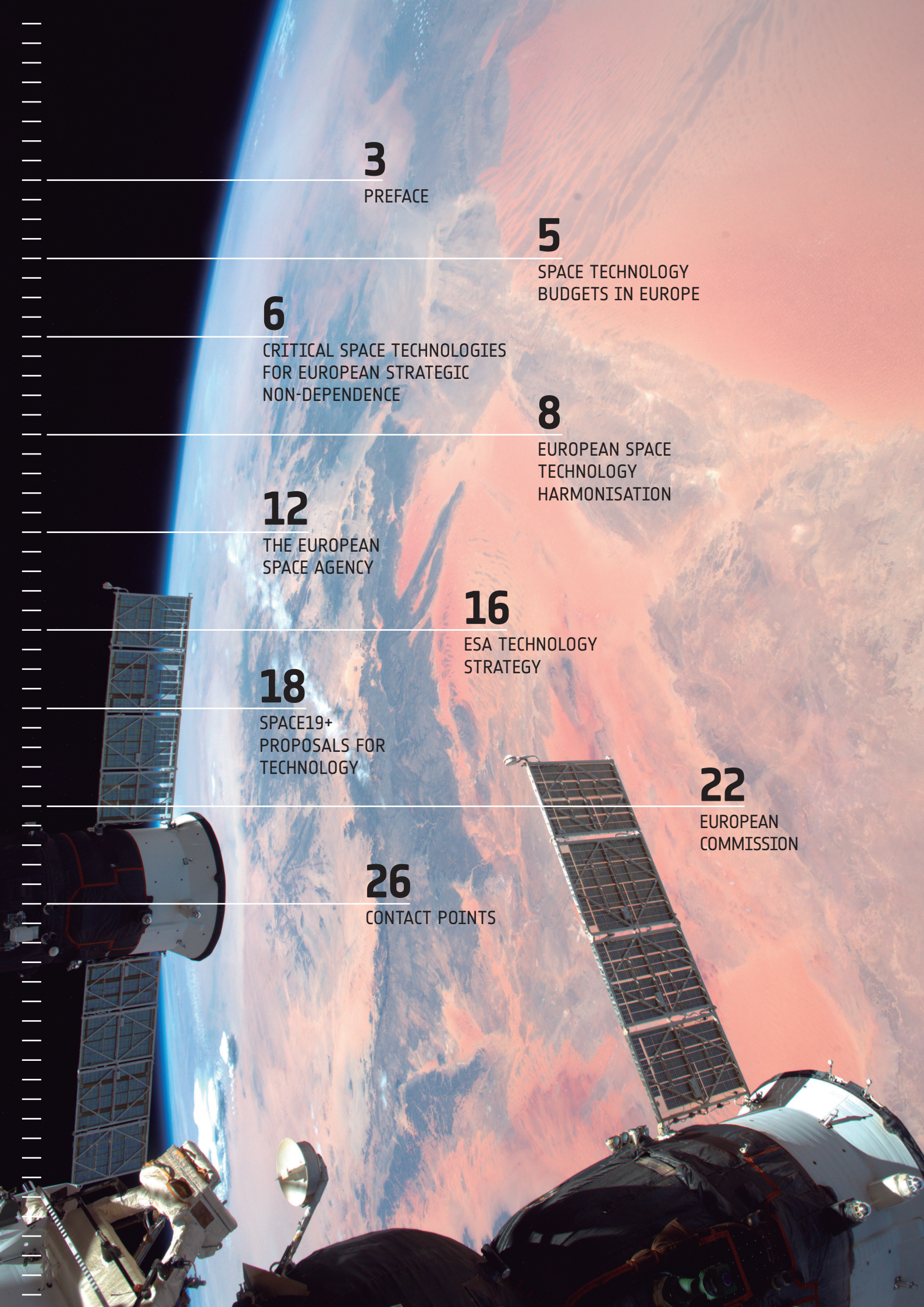
→ EUROPEAN SPACE TECHNOLOGY MASTER PLAN

Space19+ edition





PREFACE

The development of space technologies is key to enable ambitious space missions, as well as to sustain the competitiveness of our European industry. By its nature, space technology requires “out of the box” thinking, thereby stimulating and sustaining innovation also back on Earth. Most of all, it is back on Earth that the growth in space activities translates into growth of new jobs.

Coordination and cooperation on technology in Europe remain of particular importance. In the recent years, the cooperation between ESA and the EU has intensified in the field of space technology and research with the aim of continuously improving efficiency of public investments in R&D. Part of this evolution concerns the role of space technology harmonisation, which remains an important instrument of coordination at European level, involving an increasing number of stakeholders.

Space19+ will be the decision point for the 22 ESA Member States to decide on ESA’s vision for the future of Europe in space, and an opportunity to direct Europe’s ‘next generation’ ambitions in space. Technology will be the engine of this vision and the ESTMP constitutes a good atlas of what is being envisaged.

We are pleased to present this special Space19+ brochure edition of the ESTMP and would like to thank all contributors for their continuous support, which makes this publication possible.

Franco Ongaro
Director of Technology, Engineering and Quality
European Space Agency

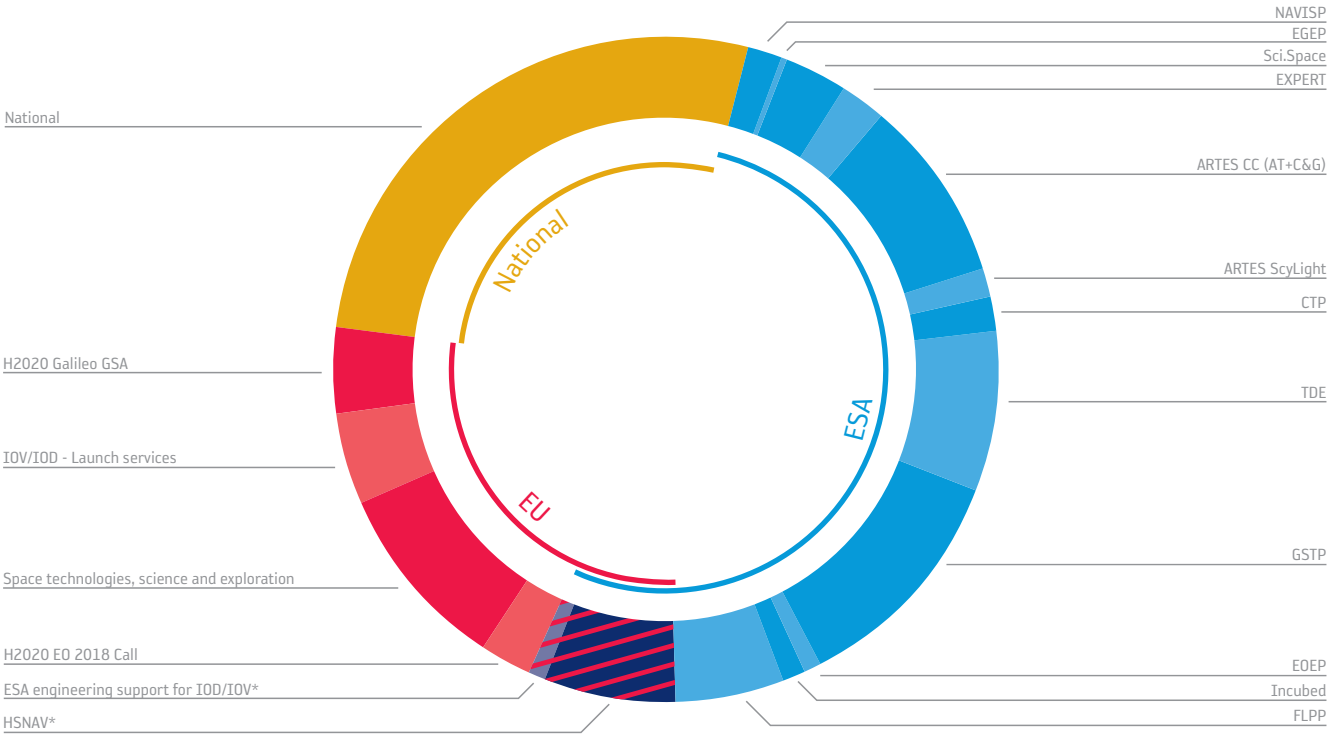
Pierre Delsaux
Deputy Director General DG GROW
Space Policy, Copernicus, Defence, Satellite Navigation Programmes
European Commission

SPACE TECHNOLOGY BUDGETS IN EUROPE

In 2018, budgets specifically focused on R&D activities for space technologies funded through National, ESA and EU programmes amounted to approximately €860 million.

ESA's space technology R&D budget amounted to around €400 million in 2018. These internal estimations take into account the overall Technology R&D activities: primarily those that are aimed at increasing the TRL level of technology inside dedicated technology programmes. Typical examples of technology programmes taken fully into account are the ESA Technology Development Element (TDE) - part of the Discovery, Preparation and Technology Development (DPTD) activities, the General Support Technology Programme (GSTP), the Science Core Technology Programme (CTP) and ARTES Advanced Technologies (ARTES AT). For other ESA programmes an estimation of the amount of the budget spent on core space technology is made.

Space Technology R&D via ESA, EU and nationally in ESA Member, Cooperating and Associate States: estimated civil institutional budget of 860 M€ for 2018.



*Programme implemented by ESA through a delegation agreement

In the context of this document Space Technology R&D is defined as the part of Technology R&D work up to TRL 6 (model demonstrating the critical functions of the element in a relevant environment) focused on space activities.

CRITICAL SPACE TECHNOLOGIES FOR EUROPEAN STRATEGIC NON-DEPENDENCE

Europe depends on space systems for many applications of high economic and strategic value, including the safety and security of its citizens. Space is part of daily life and Europe has the objective to be non-dependent when conceiving, developing, deploying and exploiting such space systems.

Non-dependence is one of the objectives of the Space Strategy for Europe as security of supply and industry's ability to export its products are impacted by high dependence on non-European critical components and technologies. In the context of European space research programmes, priority will be given to actions addressing the vulnerability of European supply chains by supporting the development of critical space components, systems and technologies associated with the technological non-dependence. There is a need to support long-term R&D needs to space.

A coordinated and coherent European institutional approach has been established, targeting the development of critical space technologies and products for European Strategic Non-Dependence. The ESA Technology Harmonisation Advisory Group (THAG) was expanded to include the Commission and EDA and their National Delegates, for Non-Dependence issues.

The process follows three main steps. The first stage involved all European stakeholders (the Commission, ESA, EDA, Research, SMEs, Industry, ..),

HISTORY OF THE JTF ON NON-DEPENDENCE

9 September 2008
1st joint Commission-ESA-EDA workshop on Strategic Non-Dependence.

2008
Resulting from the workshop, the Commission-ESA-EDA Joint Task Force (JTF) was established to address Critical Space Technologies for European Strategic Non-Dependence.

July 2009
1st European Non-Dependence process, based on the developed common methodology, not only producing a European Non-Dependence List of Actions but also establishing a structured way for identifying a common European position on the priorities and scope of individual activities to be proposed for funding.

2011
The second cycle in this Non-Dependence process took place in 2011, with a Mapping and a Roadmap Meeting that served as platforms for discussion and update of the priority critical items, resulting in an updated List of Urgent Actions.

2014
Preparation of the JTF List of Actions for implementation in 2015-2017 to address the critical needs of the coming years.

2016
Preparation of the JTF List of Actions for implementation in 2018-2020 to address the critical needs of the coming years.

2019
Preparation of the JTF List of Actions for implementation in 2021-2023 to address the critical needs of the coming years.

to build a complete mapping of critical technologies for European Strategic Non-Dependence. It is followed by the planning of the way ahead in the form of a European Non-Dependence List, including recommendations for their implementation as appropriate. As a final step, the European Non-Dependence List will be implemented in National and European Programmes.

The implementation of the actions identified by the European Non-Dependence list is up to now approached individually by the three organisations and their Member States using their available instruments for implementation until more dedicated programmatic instruments will be established. The List of Actions for 2018/2020 has been used as a basis for the Critical Space Technologies topic in the Horizon 2020 Space 2018/2020 Work Programme. The items identified in the list are also considered in several ESA programmes e.g. TDE, GSTP or ECI, and in EDA R&T activities. In addition, the List is also used as a reference for coordination of the relevant activities in this field and its implementation is monitored on a yearly basis.

The Commission, EDA and ESA perform a yearly monitoring of the implementation progress of the overall list by updating the Background Document.

In 2019, the three institutions started the 5th excercice of the Non-Dependence process, aimed at establishing a list of urgent actions for implementation in 2021-2023.

↑ 2019 European Non-Dependence Process.

"As an outcome of the 2019 cycle of the European Non-Dependence process, a compact list of high priority Actions for Critical Space Technologies for European Strategic Non-Dependence for implementation in 2021-2023 will be finalised in December 2019"

TECHNOLOGY NON-DEPENDENCE

Technology "non-dependence" means having free, unrestricted access to any technology required to implement Europe's space missions.

It is not just an export restriction problem, non-export- restricted products can come with limitations that create undesirable dependence issues.

Non-dependence does not mean producing everything in house (i.e. in Europe).

The supply chain sustainability of alternative European sources is also deemed key to ensure "non-dependence".

EUROPEAN SPACE TECHNOLOGY HARMONISATION

The purpose of the European Space Technology Harmonisation is to achieve better and more coordinated Space Technology Research and Development activities among all European actors.

The European Space Technology Harmonisation has been developed to achieve better-coordinated research and development (R&D) activities among all actors of European space sector and to establish a strong technology base as a key to the worldwide competitiveness of European Industry and to the success of future space missions.

The Technology R&D Harmonisation provides to all European actors the framework and the key instruments to coordinate Space Technology at European level. This is achieved essentially by identifying the needs and existing capabilities within Europe (documented in Technology Harmonisation Dossiers) and by agreeing on European Space Technology Roadmaps, through a process of concertation, coordination, and agreement between all participants. These joint Roadmaps aim at optimising public funding and guiding developments to ensure the right technology is at the right maturity at the right time.

Harmonisation is a voluntary process, based on transparency and exchange of information. The continuous support from all participants, is key to the success of this European initiative.

For nearly two decades of operation, and several major reviews recommending its strengthening, the Technology Harmonisation is now an established well proven European process.

The European Commission and ESA have been further strengthening the coordination in the context of the European Space Harmonisation process, with the aim to continue using it as an instrument of coordination at European level.

european space technology harmonisation

MAIN OBJECTIVES

Objective 1

"Fill strategic gaps" and "Minimise unnecessary duplications"

Objective 2

Consolidate European Strategic capabilities

Objective 3

Achieve a coordinated and committed European Space Technology Policy and Planning

Objective 4

Contribute to continuity and coherence between Technology and Industrial Policies

2018
European Space Technology Harmonisation Workshop - ESA/ESTEC

2018
ESTMP jointly published with the European Commission

2017
ESTMP jointly published with the European Commission

2016
1st ESTMP with foreword from DGs of both ESA and DG GROW, Jan Wörner and Lowri Evans

2015
Public release of the ESTMP 12th Edition during an ESA press conference at Le Bourget of former DG, Jean-Jacques Dordain, in presence of ESA DG, Johann-Dietrich Wörner

2014
1st European Space Technology Harmonisation Conference - ESA/ESTEC

2013
100th Harmonisation Roadmap agreed and released

2010/2011
Major review of the Harmonisation to further refine the process

2009
European Commission-ESA-EDA Non dependence process defined based on Harmonisation

2007
Mention in European Space Policy

2006
Creation of the IPC-THAG

2005
ESA's IPC Council approved the Agency's Executive "Proposal for the adaptation of the Technology Harmonisation process"

2004
Recommendations by FINPOL-CWG to strengthen the process

2003
ESTMP presented at Le Bourget

2002
ESTMP first issued

2001
1st Harmonisation Roadmap agreed and released: AOCS

2000
Harmonisation started with pilot case; is fully operational since 2002

Participants of the Harmonisation

The community involved in the Harmonisation has progressively increased and now includes ESA Member States, the European Cooperating States (ECS), the European Commission (COM), the European Defence Agency (EDA), Eurospace, SME4Space, industry and research organisations.

Through the Harmonisation Team of the Technology Coordination and Planning Office of D/TEC, ESA supervises and coordinates all the Harmonisation phases. ESA Technical Experts are designated to provide the technical knowledge and prepare the documentation, the Technology Harmonisation Dossiers (THD) and the Roadmaps. The internal coordination is achieved on technical, strategic and programmatic sides: the active participation of the Competence Domain Leads (CDL) ensures quality, coherence, relevance and consistency of the technical content, while the involvement of the TECNET Chairs Forum and Programmes Managers provides Programme Directorates' view.

ESA Technology Harmonisation Advisory Group (THAG)

The Technology Harmonisation Advisory Group (THAG) is an ESA delegate body, established in 2006 to advise the ESA Industrial Policy Committee (IPC) on Technology Harmonisation matters.

In particular, THAG advises the IPC and makes recommendations on the following matters:

- Selection of topics for Technology Harmonisation
- Mapping of European capabilities with respect to the needs of the institutional and commercial markets
- Technology roadmaps and conclusions
- Implementation within ESA programmes of agreed roadmaps and conclusions, and identification of national and European level funding
- Harmonisation measures to be applied in institutional programmes and by industry.

Harmonisation cycles

The Harmonisation Process is divided in two cycles, each covering half of the subjects selected for a given year.

Inside each cycle, there are two main steps, the Mapping phase and the Roadmap phase.

For each Technology addressed, the Harmonisation Process results in two main documents: the Technology Harmonisation Dossier and the Roadmap presentation.

Mapping

The first part of the Harmonisation Process is the mapping. The goal is to arrive to a consensus on the landscape and situation (worldwide but focusing on the key issues for Europe) of the technology under Harmonisation.

Roadmap

The next step in the Harmonisation Process is the preparation of the roadmaps, taking into account the data provided during the Mapping Meeting. The roadmap covers all on-going, approved and proposed new European activities, from ESA, the European Commission and National Institutions, as well as Industry ones, when data is available.

Harmonisation: an inclusive process.

european
space technology
harmonisation

~20 YEARS
OF HARMONISATION

3500
ACTIVE ROADMAP ACTIVITIES

54
ACTIVE ROADMAPS

~10 TOPICS
UPDATES / YEAR

62%
OF ACTIVITIES IMPLEMENTED

LIST OF ACTIVE HARMONISATION TOPICS

- De-orbiting Technologies
- Frequency and Time Generation and Distribution - Space & Ground
- Photonics
- Position Sensors (for Mechanisms)
- RF & Optical Metrology
- Chemical Propulsion - Components
- Coatings
- Deployable Booms & Inflatable Structures
- Life Support Technologies (Bioreactors and Membrane-based Processes)
- System Modelling and Simulation Tools

- Array Antennas
- Additive Manufacturing
- Big Data from Space
- Two-Phase Heat Transport Equipment
- Electric Propulsion Technologies
- Optical Detectors, IR Range
- Optical Communication for Space
- Lidar Critical Subsystems
- Microwave Passive Hardware
- Automation and Robotics

- Avionics Embedded Systems
- Data Systems and On Board Computers
- On-Board Payload Data Processing
- Microelectronics - ASIC & FPGA
- Reflector Antennas
- Technologies for Passive Millimetre & Submillimetre Wave Instruments
- RF Metamaterials and Metasurfaces
- Electric Propulsion Pointing Mechanisms (EPPMs)

- Power RF Measurements and Modelling
- Optical Detectors, Visible Range
- Solar Generators and Solar Cells
- Ground Station Technology
- Electrical Motors and Rotary Actuators
- Technologies for Hold Down and Release Mechanisms and Deployment Mechanisms (HDRM&DM)
- Radiation Environments & Effects
- AOCS Sensors and Actuators II

- Electrochemical Energy Storage
- Critical Active RF Technologies
- Solar Array Drive Mechanisms
- Functional Verification and Mission Operations Systems
- System Data Repository
- Composite Materials
- Micro and Nano Technologies: RF MEMS, MOEMS AND MEMS PRESSURE SENSORS
- On-Board Software

- Technologies for Optical Passive Instruments (Stable & Lightweight Structures)
- Technologies for Optical Passive Instruments (Mirrors)
- AOCS Sensors and Actuators I
- Pyrotechnic Devices
- On-Board Radio Navigation Receivers
- Cryogenics and Focal Plane Cooling
- Power Management and Distribution

- TT&C Transponders and Payload Data Transmitters
- Fluid Mechanic and Aerothermodynamics Tools

- Chemical Propulsion - Micro Propulsion and Related Technologies

THE EUROPEAN SPACE AGENCY

From the beginnings of the 'space age', Europe has been actively involved in spaceflight. Today, it launches satellites for Earth observation, navigation, telecommunications and astronomy, sends probes to the far reaches of the Solar System, and cooperates in the human exploration of space.

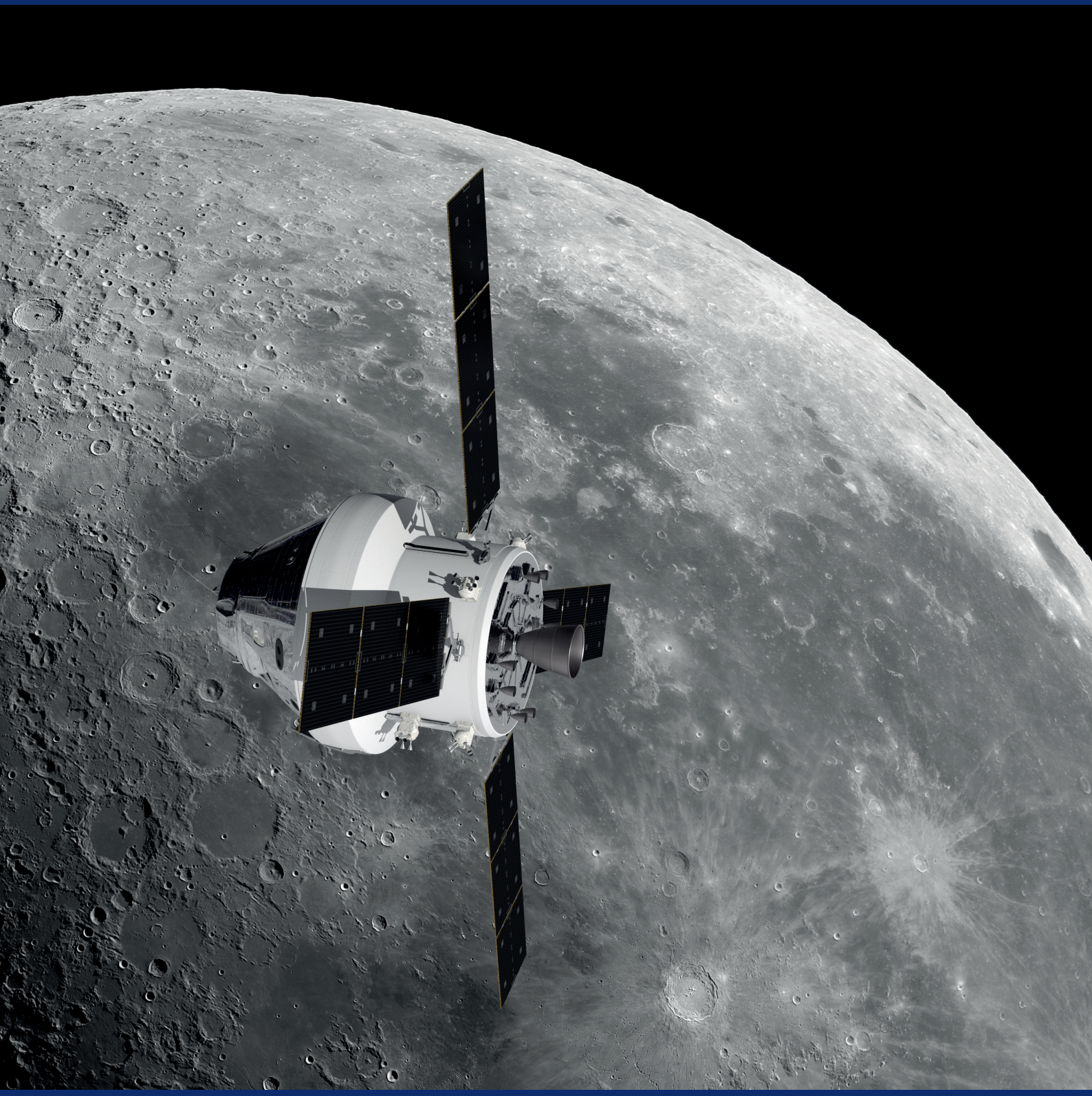
Space is a key asset to Europe, providing essential information needed by decision-makers to respond to global challenges. Space provides indispensable technologies and services, while increasing our understanding of our planet and the Universe. Since 1975, the European Space Agency (ESA) has been shaping the development of this space capability and ensuring that investment in space continues to deliver benefits to the citizens of Europe and the world.

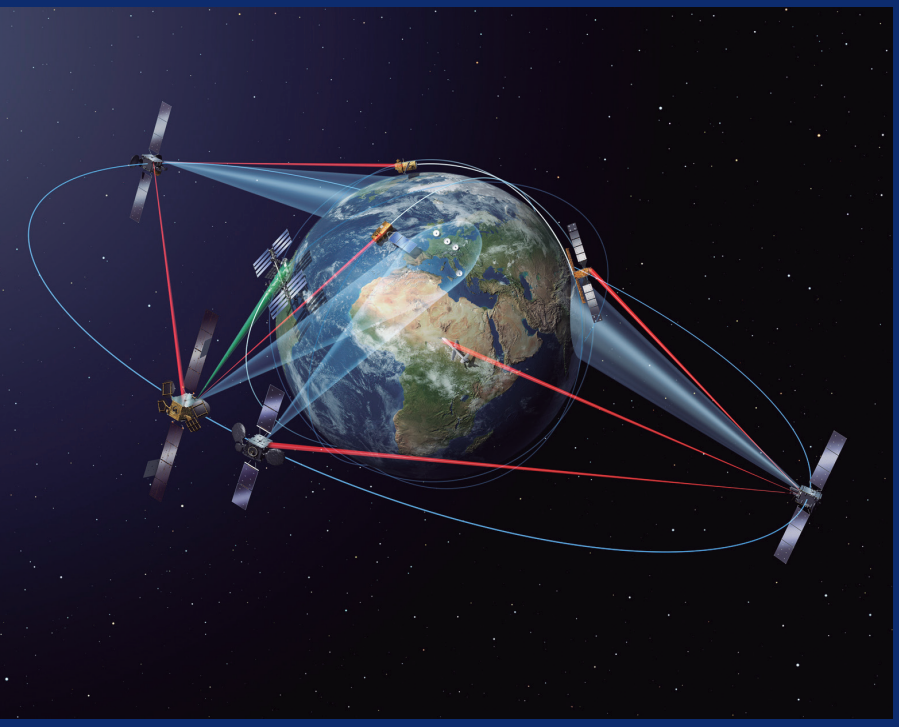
By pooling the resources of 22 Member States, ESA undertakes programmes and activities far beyond the scope of any single European country. ESA programmes are designed to find out more about Earth, its immediate space environment, our Solar System and the Universe, as well as to develop satellite-based technologies and services, and to promote European industries. ESA also works closely with space organisations outside Europe.

ESA activities are financed via its Member States, with Canada as a Cooperating State and Slovenia as an Associate Member State. Specific programmes are also financed by third parties, such as EUMETSAT or the European Commission.

As a flying laboratory, ESA's OPS-SAT will test and validate new techniques in mission control and on-board systems. It will be operated by ESA's European Space Operations Centre as a test and validation resource for over 100 European industrial partners from 17 countries (copyright: ESA).

Artist's impression of Orion and European Service Module orbiting the Moon (copyright: NASA/ESA/ATG Medialab).





EDRS relaying Copernicus Sentinel Earth Observation data via laser links (copyright: ESA).

Artist's view of Vega-C (copyright: ESA).

Governance of ESA is through its Council with its Committees on Industrial Policy, Science, Administration and Finance, and Industrial Relations. Further to these Committees, ad-hoc Programme or Participants' Boards steer ESA's activities in different optional programmes, such as the Joint Communication Board, or the Programme Boards for Earth Observation, Space Transportation, Human Spaceflight, Microgravity and Exploration, Navigation and Space Situational Awareness.

ESA missions rely heavily on timely development of technologies advanced through ESA technology programmes to the maturity level required to support the missions themselves. European space industry relies on ESA technology programmes to boost the competitiveness of European industry.

A key achievement in 2019 was the completion of the first Orion spacecraft, which will carry humans further into space than ever before. ESA is partnering with NASA on Orion, to contribute the European Service Module. This 4-m long module provides electricity, water, oxygen and nitrogen as well as keeping the spacecraft at the right temperature and on course. The combined spacecraft is undergoing rigorous environmental testing in the US.

The second satellite in the European Data Relay System (EDRS), EDRS-C, was launched in August 2019. Equipped with laser-based optical communications, the two satellites together form a 'SpaceDataHighway' for rapid, high-bandwidth data delivery from Europe's Earth Observation fleet.

ESA astronaut Luca Parmitano had his second tour of duty aboard the International Space Station during the six-month Beyond mission, becoming the third ESA astronaut to command the Station and the first Italian to do so.

In Europe's Spaceport in French Guiana, preparations were made for the first launch of Vega-C, a more powerful version of Europe's small satellite launcher whose first stage will also be utilised as a strap-on booster by the coming Ariane 6, itself taking shape for integrated testing.

The end of the year 2019 will see the launch of the Cheops mission, which will measure the sizes of known exoplanets by detecting tiny fluctuations in the light of their parent stars, along with the smaller OpsSat, a software laboratory in space to test out radically new control systems and techniques.

November 2019 sees **ESA's Space19+ Ministerial Council** in Seville, Spain, where ESA presents a complete portfolio of next-decade space activities based on four programmatic pillars: **Science & Exploration**, including advanced X-ray and gravitational wave observatories as well as a leading European role in exploring the Moon; **Safety & Security**, a world-first which builds upon ESA's existing Space Situational Awareness programme to safeguard Earth and space assets from hazards such as orbital debris, space weather and near-Earth asteroids; **Applications**, to turn Europe's telecom, navigation and Earth-observing satellites into the basis of world-beating businesses and services; and **Enabling & Support**, focused on renewing the underlying technologies and capabilities underpinning Europe's space sector, as well as its new generation of launchers.

ESA BUDGET FOR 2019
5.72 B€

PROGRAMMES IMPLEMENTED FOR OTHER INSTITUTIONAL PARTNERS

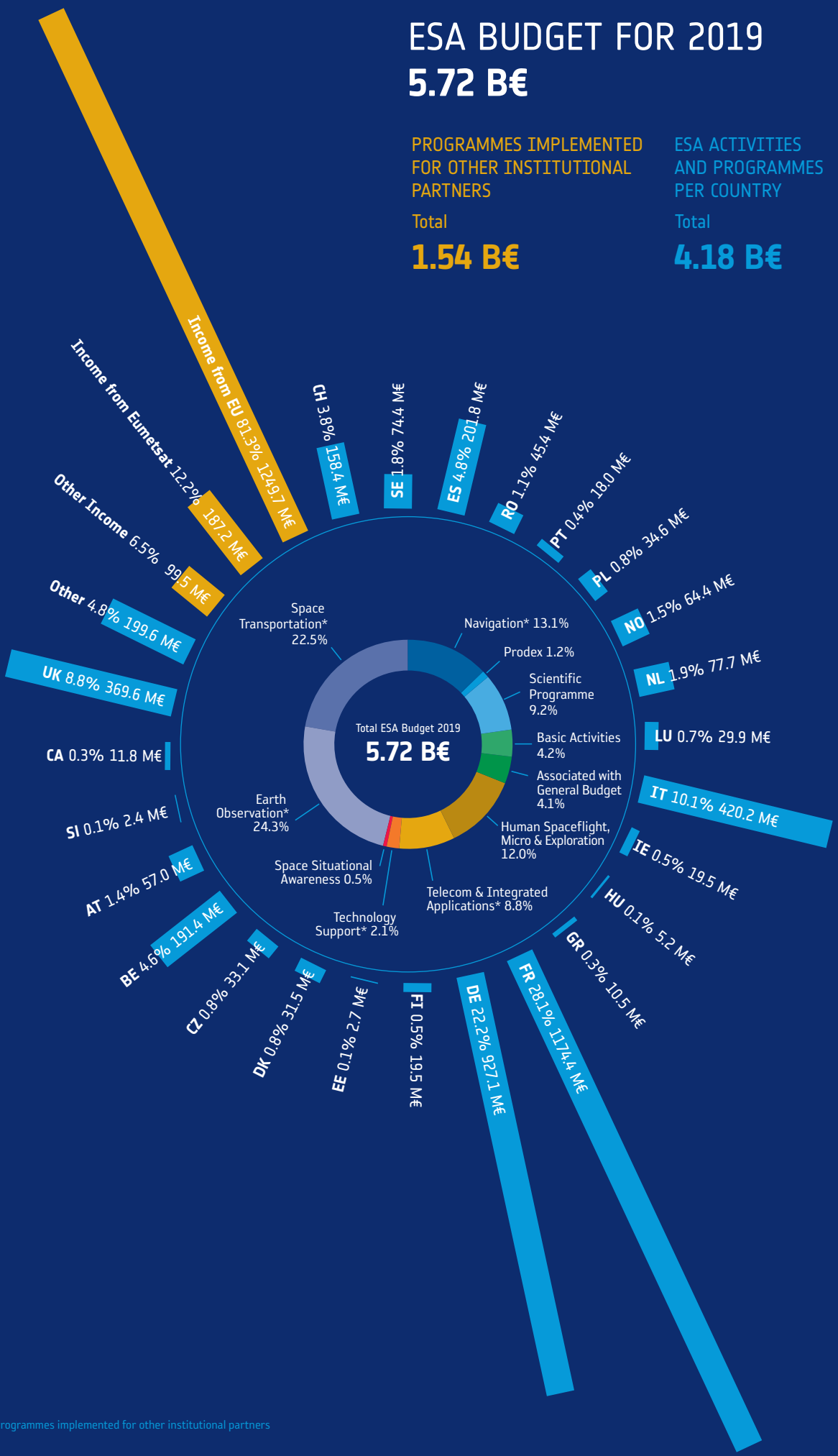
Total

1.54 B€

ESA ACTIVITIES AND PROGRAMMES PER COUNTRY

Total

4.18 B€



*includes programmes implemented for other institutional partners

ESA TECHNOLOGY STRATEGY

Technology is at the heart of all European space activities and enables Europe to achieve its ambitions in space. ESA's new Technology Strategy sets out ambitious targets which are essential to keep Europe at the forefront of a fast changing space sector.

The technology strategy guides the planning, development and implementation of all technology development activities prepared, conducted and coordinated by ESA.

The strategy reflects the technical expertise of ESA, grouped into ten competence domains, and the insight for future needs for space missions. This analysis of user needs and technology innovation has resulted into priority **technology themes**, the development of four concrete technology development **targets** to be implemented via a **technology portfolio** strategy.

The space sector is in the midst of rapid, fundamental change. This change is triggered by a mature, increasingly diverse and vibrant industrial base and sustained high market growth driven by downstream services along with the emergence of new commercial opportunities and the full-scale integration of space into modern economies. The result is a profound shift in the underlying requirements and drivers of space system design from performance (for one-off missions and prototypes) to cost and schedule.

In parallel, the digital revolution is transforming industries and markets. To best serve the interest and needs of its stakeholders and shareholders – while continuing to undertake cutting-edge technology activities for science-driven missions – ESA needs to invest now and focus its technology development and engineering efforts to seize these opportunities.

By spinning-in, investing in and embracing **digital engineering** throughout all the design, development and exploitation phases, ESA will drive the technological base of the European space sector to draw full benefit from this technology: for the reduction of cost; to reach shorter, more agile development cycles; and to enable innovative technology to be adopted into space systems much faster.

The implementation of this strategy requires substantial investment in skills and tools for technology R&D at ESA. It extends beyond the engineering community with impacts on procurement and processes.

The analysis of user needs and new capabilities from technology innovation has led to recurrent technology needs grouped into **priority technology themes** specific to space activities:

- **Advanced manufacturing**, identifies new materials and processes, and spins in disruptive materials and manufacturing processes from non-space industrial sectors.
- **Digital Design-to-Produce**, develop, spin-in and demonstrate core technologies, which enable a digital engineering process flow from design to operations and data exploitation.
- **Cleanspace / Sustainability**, focusses on technology which allows leaving the space environment in a better stage to future generation.
- **Cybersecurity**, addresses the vulnerability of the space system due to the increasing integration of space systems to larger ground systems.

ESA's **technology portfolio** ensures cohesion and effectiveness between the different technology development programmes. It is balanced between *enabling* critical technology developments, and sufficiently investing in technology that can substantially *enhance* mission performance or introduce *game-changing* capabilities.

ESA Technology Developments Targets

30%

improvement in spacecraft development time by 2023

ESA will develop key technologies to allow ESA to reduce by 30% the time from Phase B2 to launch.

Specifically, ESA will:

- Develop technologies to fully digitalise the work early concept development, through manufacturing to integration and testing.
- Develop technologies needed to achieve increased flexibility, scalability and adaptability based on modular space system designs and standardization.
- Develop necessary processes to facilitate a fast introduction of new terrestrial technological progress into spacecraft.

3D visualisation system at ESA's Concurrent Design Facility.

10x

one order of magnitude improvement in cost efficiency with each new generation.

ESA will develop key technologies to allow Europe to achieve one order of magnitude cost efficiency improvements with every space system generation. Specifically, ESA will develop technology that will:

- allow end-to-end cost efficiency improvement by one order of magnitude to the user when considering space as a service.
- reduce the cost per useful bit transmitted by telecom satellite systems by one order of magnitude before 2023.
- allow the positioning, navigation and timing services of navigation systems to provide 100% service availability, reliability, extend accuracy by one order of magnitude for mass market and make the system resilient to spoofing attacks by 2025.
- improve remote sensing mission performance in terms of resolution (4x), accuracy (4x), revisit time (10x), tasking and product delivery time and distribution (10x) overall by at least one order of magnitude cost ratio by 2023.
- allow transformational science and increasing the science performance to cost ratio by one order of magnitude.

30%

faster development and adoption of innovative technology

We develop processes, methods and technologies to allow Europe to take faster the full benefit from the early introduction of new technologies into space systems enabling new applications.

Specifically, ESA will:

- Double the number of new space system technologies demonstrated al TRL [8/9] per year by 2021 and quadruple this number by 2024.
- Reduce the time from TRL 4/5 to TRL 7/8 by 50% for technologies selected for in-orbit demonstration.
- Double the use of COTS in ESA spacecraft by 2021 via a dedicated COTS strategy.

Martian meteorite on Earth calibrates camera bound for Mars.

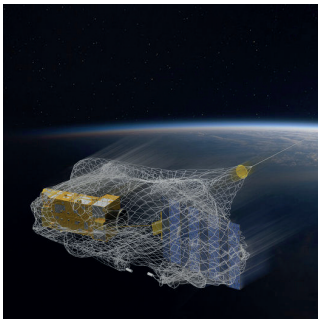
2030

target for inverting Europe's contribution to space debris

We develop the technologies that allow us to leave the space environment to the next generation in a better state.

Specifically, ESA will:

- Ensure that all ESA missions will be environmentally neutral by 2020, thus not producing debris larger than 1mm in orbit.
- Develop the technologies necessary for the successful active removal of space debris by 2024.
- Develop the technology that allows all ESA missions to be risk neutral by 2030.



ESA's e.Deorbit mission is developing robotic arms and nets to capture Envisat.

PARTICIPANTS:

22 ESA MEMBER STATES

Space19+

PROPOSALS FOR TECHNOLOGY

The Ministerial Council 27-28 November 2019

ESA's Ministerial Councils bring together its Member States and observers every two to three years to decide on new proposals and funding for the following years. The previous Ministerial Council was held in December 2016. The next one, called 'Space19+', will be held 27-28 November 2019. European ministers in charge of space activities will gather in Sevilla, Spain, to decide on ESA's vision for the future of Europe in space.

Space19+ will be an opportunity to direct Europe's 'next generation' ambitions in space, and address the challenges facing not only the European space sector but also European society as a whole. This proposal includes the Director General's plan for space programmes to be carried out by the Agency beyond 2019, and covers all aspects of space activities: science and exploration, applications, access to space, operations, research and development. It also puts ESA in a world-leading position in the emerging field of space safety and security.

From CM16 to Space19+: the 5th dimension of Space 4.0

Space is a strong actor for many parts of our life. At the ESA Council at Ministerial Level 2016 the idea of Space 4.0 was introduced as an overall concept for future developments. Space 4.0 was explained having several aspects which can be summarised by the keywords: **inform, innovate, interact, inspire.**

All space activities serve specific interests and needs, which means that space also has a fifth dimension: **infrastructure.**

Space has the enormous power of delivering concrete information, innovation and benefits while at the same time offering geopolitical support to bridge Earthly crises. Such an overarching function can best be described by the term "infrastructure", without being moved in the corner of a commodity. Space is used as an infrastructure for different activities from Earth Observation, Navigation, Telecommunication to Science and Exploration and the technologies developed for space are at the same time innovation drivers for the non-space sector.

Space: Infrastructure for Daily Life and more

Space provides the infrastructure for personal mobility, communication for work or when on vacation, weather forecasting, precision farming to maximise crop harvesting and crop rotation, banking transactions, management of precious resources such as potable water, monitoring of forest fires, archaeological investigations, scientific knowledge and the dream of expanding the reach of humanity. These and many more activities rely today on space data and the infrastructure to generate this data and enable its use.

Space has become an integral, though largely invisible, part of day-to-day activities. The perception however is not there yet. The majority of the wider public still sees space, beyond space science and exploration activities, as the remit of

nations fighting for sovereignty and competing for prestige through a race for space.

The 2016 ESA-EU Joint Statement setting out the "Shared vision and goals for the future of Europe in space", provides the goals and objectives for space activities in Europe for the years to come:

- Foster a globally competitive European space sector
- Maximise the integration of space into European society and economy
- Ensure European autonomy in accessing and using space in a safe and secure environment

Signed in October 2016 the ESA-EU Joint Statement goals (in line with the United Nations Sustainable Development Goals (SDGs)) are still relevant today and ESA is putting forward programmatic elements to fulfil these goals fully aware of the responsibility to develop a space sector that can serve to address regional and global challenges.

Space19+ Programmatic Pillars

Four main programmatic pillars can be used to present space activities and those of the Agency, including related downstream uses:

- Space Science and Exploration
- Safety and Security
- Applications
- Enabling and Support

These four pillars describe the overall perimeter of ESA's activities implemented through multiple programmatic frameworks. Each of these programmatic frameworks has its own legal setup – mandatory, optional, public private partnership, third party – and uses implementation instruments tailored to the specificities and goals of each activity performed.

ENABLING & SUPPORT: BASIC ACTIVITIES & TECHNOLOGY

"For us, the key challenge is to make sure that we are able to sustain the competitiveness of our industry, to sustain the innovation of our sector and to make sure there are opportunities for the young ones in the future."

Franco Ongaro
ESA Director TEC

Part of the fourth programmatic pillar "Enabling & Support", the **Basic Activities** serve as the enabler of all other activities carried out by ESA and enabler of future European space activities in general. The Basic Activities (DPTD, Harmonisation) prepare and enable all ESA missions, those of the mandatory Scientific Programme, as well as those of the optional programmes and programmes being implemented by ESA on behalf of third parties, in particular the European Union.

'Early-stage research and development enabled through Basic Activities stimulates industry to develop brighter ideas'

These range from developing laboratories, ground stations and mission control facilities to Europe-wide early-stage technology development efforts, actions to support innovation and standardisation and IT infrastructure.

They also include means of developing, preserving and disseminating knowledge for European capacity building and sustainable growth.

Investing in Basic Activities means creating the ability for Europe to develop and fly the next generation of sophisticated missions that will enable scientists to discover new knowledge about the farthest reaches of the universe or the environment right here on our home planet.

It means fostering innovation and boosting the competitiveness of European industry in the global market, and it means ensuring the Agency's common infrastructure and expertise continue to enable the most complex and demanding tests and analysis to be available to all companies, large and small, profiting from world-class laboratories and competences.

Early-stage research and development enabled through Basic Activities stimulates industry to develop brighter ideas, to conceive smarter missions in space and improve life on Earth. World-leading commercial initiatives rely on European products developed with the technology fostered by ESA.

A rising tide lifts all boats; a significant boost to ESA's Basic Activities (with increased resources in particular for the DPTD) is the most effective means of benefiting all Agency missions and programmes, bringing the future nearer to fruition.

Technology

The continued funding for Basic Activities is complemented by the continuation of the General Support Technology Programme (GSTP): for Space19+, an enhanced level of investment is foreseen to renew these world-class R&D resources. The latest developments in digital engineering and advanced manufacturing techniques will be harnessed to sharpen the European competitiveness.

As indicated in the Technology Strategy (page 16), the way ESA innovates will also be innovated, by achieving a 30% faster development and adoption of new technologies, doubling the number of innovations ready for flight by 2021, and quadrupling this number by 2024. A 30% improvement in spacecraft development time is also targeted by 2023, including through the introduction of digital engineering technologies.

Technologies will be developed to provide an order of magnitude improvement in cost efficiency with each new generation of space systems. The resilience of space systems to hacking and spoofing will be strengthened with enhanced cyber-security technology, hastening their introduction into the terrestrial economy. Physical space will also be made securer, by reversing the trend of Europe's contribution to space debris by 2030.

EUROPEAN COMMISSION

Space research in the EU Framework Programme for Research and Innovation Horizon 2020

Maximising benefits of space for society and EU economy

SPACE-EO

- EO market uptake
- Copernicus mission and services evolution

SPACE-ENGSS

- EGNSS market uptake
- EGNSS infrastructure, mission and services evolution

SPACE-BIZ

- Support to space hubs
- Space outreach and education
- EIC Horizon Prize on "Low cost Space Launch"
- InnovFin Space Equity Pilot (ISEP)
- SME-instrument
- FTI-Fast Track to Innovation

Globally competitive and innovative space sector

SPACE-TEC

- Technologies for European non-depend. and competitiveness
- Strategic research clusters
- Generic space technologies
- EO and SatCom technologies
- In-Orbit validation/demonstration

SPACE-SCI

- Scientific instrumentation and technologies for exploration
- Scientific data exploitation

Access to space & Secure and safe space environment

SPACE-TEC

- Access to space

SPACE-SEC

- Space weather
- Exploring concepts for space traffic management
- Space Surveillance and Tracking (SST)
- Near Earth Objects (NEOs)

↑ H2020 funding supports three main policy lines.

Maximising benefit of space for society and EU economy

Under Earth observation, the 2018 Work Programme was calling for actions to prepare Copernicus evolution such as mission exploitation concepts for monitoring of Polar Regions, agriculture monitoring in support of the CAP and forest monitoring or prepare the next generation of marine service ocean models.

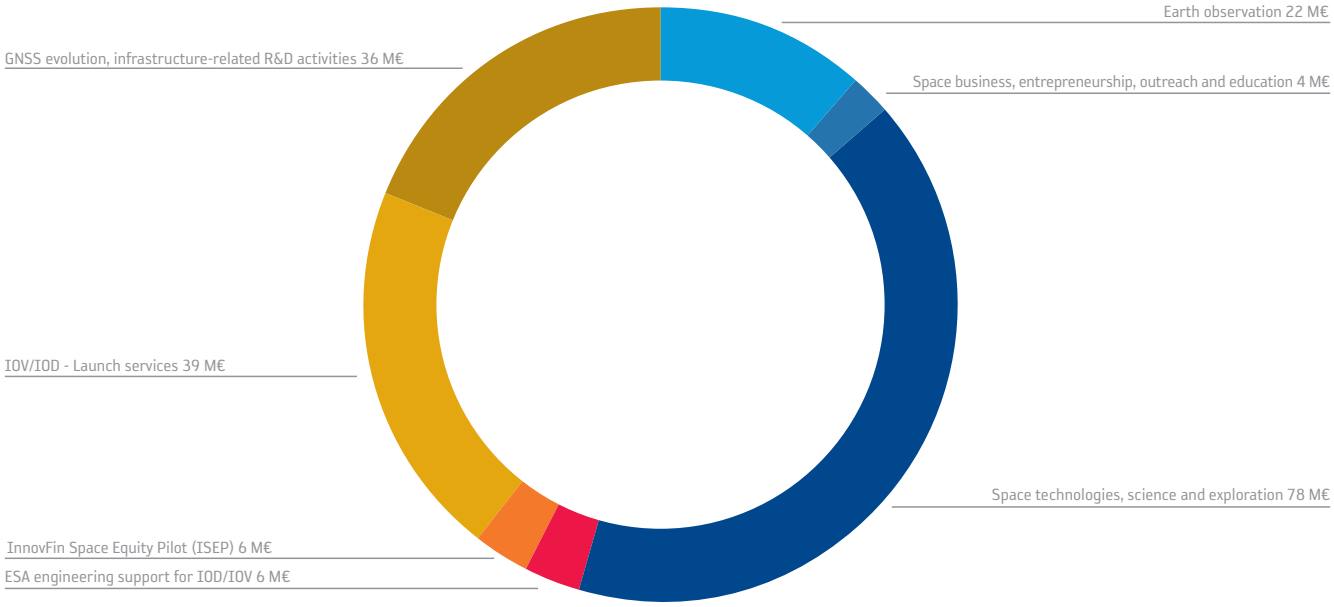
Under Space business, entrepreneurship, outreach and education, the call was dealing with the support for Copernicus Relays and the Copernicus Academy, which are voluntary participative networks related to Earth observation and Copernicus. Also, support was proposed for outreach and education for initiative capable of attracting the interest of a significant number of students towards space and space-related themes.

Under EGNSS, Eur 36 million were delegated to ESA for implementation on GNSS evolution, infrastructure-related R&D activities. Other calls relevant to EGNSS evolution and infrastructure are planned in 2019 and 2020. Also, the above activities will be complemented in 2019 and 2020 by R&D on Galileo and EGNOS mission and services.

It is also worth to be noticed that H2020 space is contributing with €6 million to the European Investment Fund for the InnovFin Space Equity Pilot financial instrument. The goal is to improve access to risk finance for innovative enterprises in the space sector. ISEP will invest in venture capital and other risk-capital funds focused on innovative SMEs and small midcaps that aim to commercialise new products and services linked to space data and space technologies.

Globally competitive and innovative space sector

A significant budget was dedicated to Space technologies, science and exploration (€78 million). The EU continues to provide support to the development of technologies for European non-dependence and competitiveness, which are identified by the Commission-ESA-EDA Joint Task Force (JTF). Support was also made available



for the maturation of generic technologies in the field of very high power systems, innovative thermal control for high temperature missions, spacecraft bus stability and line-of-sight, advanced materials, structures and production techniques and ground systems with massive processing.

A topic on Earth observation technologies was opened, focusing on improving timeliness and reactivity of observations, their resolution and swath, the performance of sensors and the underlying technologies, while addressing the new challenges associated to larger data collection in remote sensing missions, including at ground segment level (e.g. massive data processing, machine learning, knowledge-based systems).

It also included some technologies and building blocks such as deployable antennas and/or (electrically) steerable antennas and mechanisms/structures, high mechanical/thermal stability aperture solutions, high efficiency power components, data processing and networks, or data links. This can provide synergies with SATCOM application domains.

Regarding satellite communication technologies, the topic was calling for secure and robust satellite communications, bandwidth efficient transmission techniques, high speed processing and flexible and reprogrammable telecommunication payloads. Technological development for optical communications, including photonics, for very high throughput system, flexible broadband passive and active antenna techniques, inter-satellite links, data relay solutions and on-board switching, advanced RF equipment and ground systems technologies was also open.

The development of instrumentation and technologies enabling space science and exploration missions was also supported in 2018. The focus was the development of new and innovative approaches, such as the use of Cubesats and other small space platforms, including planetary entry probe. The use of Commercial off-the-shelf (COTS) components was encouraged as long as it leads or contributes to the implementation of space science and exploration with significant scientific outputs.

Access to space & secure and safe space environment.

Regarding access to space, the emphasis was put on potential launch system reusability technologies and their applicability for European needs, launch system advanced manufacturing and modernisation of infrastructures.

One of the main objectives of the 2016 Space Strategy for Europe is to foster a globally competitive and innovative European space sector in particular by improving support to technological maturity for sub-systems, equipment and technologies, including In-Orbit Demonstration/In-Orbit Validation (IOD/IOV) activities, to reduce time to market. In this endeavour, the Commission has set up a dedicated selection process to gather feasible experiments that could go through a multi stage analysis to be considered for IOD/IOV actions. The Horizon 2020 Space Work Programme 2018-2020 includes actions for the implementation actions on IOD/IOV mission design, integration and

↑

In 2018, a total indicative budget of almost 200 M€ was made available through H2020 for R&I and related activities.

implementation, as well as launch services with an overall budget of €83 million for the period 2018-2020. These actions are implemented by ESA through EU-ESA contribution agreement signed in April 2019.

Preparing Horizon Europe

In June 2018, the European Commission tabled a proposal for the next framework programme for research and innovation Horizon Europe which will cover the period 2021-2027 with an overall budget of Eur €100 billion (COM(2018) 435 and 436). Discussions with the European Parliament and the Council have progressed well.

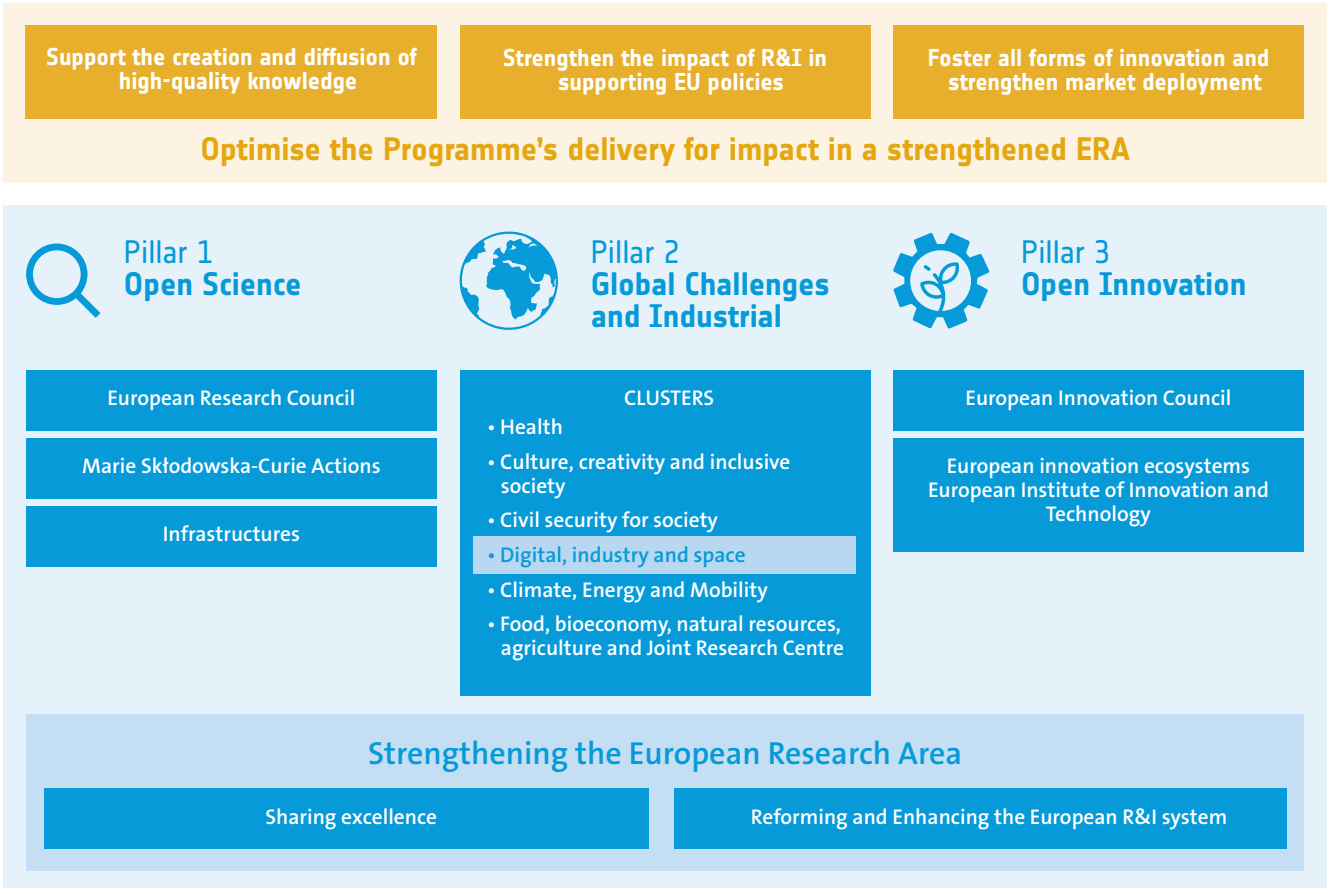
The programme is structured in three pillars: open science, global challenges and Industrial and Open Innovation, see figure below. Space is naturally under the second pillar in a joint Cluster 'Digital, industry and space' with a proposed envelope of €15 billion.

The budget figures are pending the negotiations on the Multiannual Financial Framework which are ongoing in parallel.

For space, Horizon Europe is expected to fund R&I for the new 'Space Programme of the Union' (COM(2018)447) which regroups in a single programme 4 components EGNSS, Copernicus, SSA and GOVSATCOM and 3 horizontal activities to support access to space, start-ups and security. In addition, Horizon Europe will continue to provide support to foster the competitiveness of the EU space sector and to reinforce the EU capacity to access and use space.

The identification of R&I needs in the different components are ongoing. The preparation work for the first Work Programme on Horizon Europe is expected to start end of 2019 / beginning of 2020 so that it can be published in 2020 and the first grants signed in the course of 2021.

Space under Horizon Europe: Cluster 4 Digital, industry and Space with a proposed budget of €15 billion.

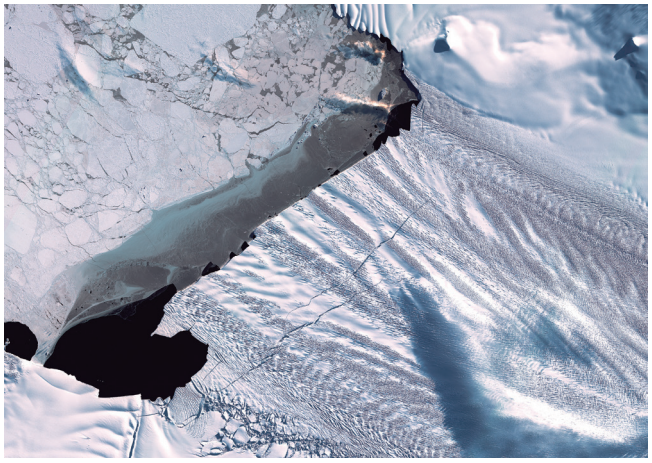


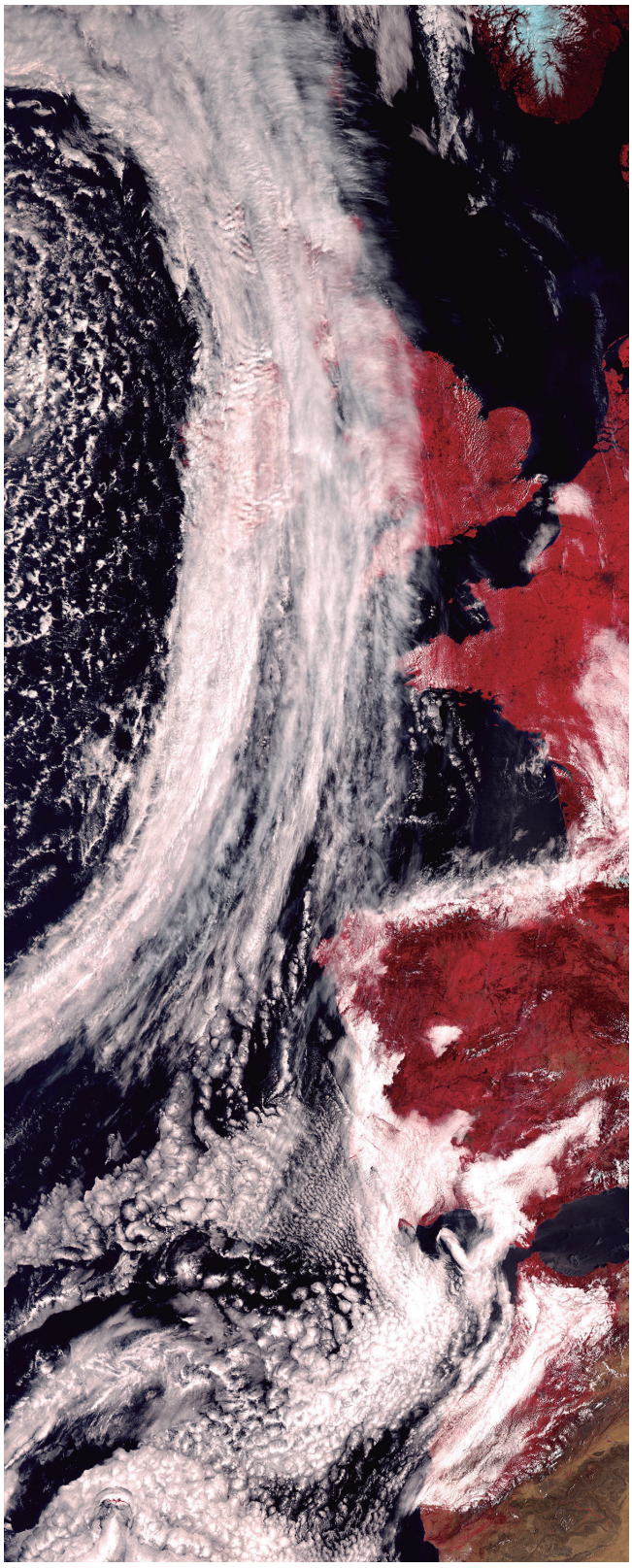
Meeting of waters

The Copernicus Sentinel-2 mission takes us over the "meeting of waters" in Brazil where the Rio Negro and the Solimões River meet to form the Amazon River. (copyright: contains modified Copernicus Sentinel data (2018), processed by ESA).

Dorian hurricane brings destruction

Hurricane Dorian as it pummels the Bahamas on 2 September 2019. This mighty storm has been parked over the northwest Bahamas for more than 24 hours unleashing a siege of devastation. As the US authorities responded to the devastation, Europe's Copernicus Emergency Mapping Service had been activated to provide flood maps based on satellite data. (copyright: contains modified Copernicus Sentinel data (2019), processed by ESA).





Cracked Pine Island Glacier

The Copernicus Sentinel-1 and Sentinel-2 satellites have revealed new cracks, or rifts, in the Pine Island Glacier one of the primary ice arteries in the West Antarctic Ice Sheet. The two large rifts were first spotted in early 2019 and have each rapidly grown to approximately 20 km in length in September 2019. (copyright: ESA).

Western Europe

Captured on 9 May 2018 by Sentinel-3B radiometer's optical channels, this image shows a low pressure system over the UK and Ireland, France, the Bay of Biscay, Spain and part of north Africa. Vegetation appears in red. (copyright: contains modified Copernicus Sentinel data (2018), processed by EUMETSAT).

CONTACT POINTS

European Space Agency
ESA/ESTEC
Keplerlaan 1 - P.O. Box 299
2200 AG Noordwijk
The Netherlands

For more information, contact:
Technology Coordination & Planning Office (TEC-H)
harmo@esa.int

European Commission
Wetstraat 200
1049 Brussel
Belgium

Space19

blogs.esa.int/space19plus

The next full edition of the ESTMP is planned to be released in 2020.

The 35-m antenna is part of ESA's New Norcia ground station, located 140 kilometres north of Perth. The impressive structure is one of three such stations in the Agency's ESTRACK network, designed for communicating with spacecraft exploring the far reaches of the Solar System (copyright: ESA / D. O'Donnell)