

Brochure
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2024

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EU-FUNDED SPACE R&I

BE PART OF THE
**COMPETITIVE EU
SPACE INDUSTRY**

AND DEVELOP
CUTTING EDGE
**SPACE
TECHNOLOGY**



Horizon Europe,
a programme of the
European Union

EU-funded Space Research & Innovation

supporting EU competitiveness
in the space domain for
cutting-edge space technology,
products and services

Today EU citizens enjoy watching satellite TV, increasingly accurate global navigation services for all transport modes and users (e.g. mobile phones and car navigation systems), extended Earth monitoring for land, marine, atmosphere and climate change, global meteorological observation and accurate cartographies of a wide number of variables.

Space also makes important contributions to security crisis management and emergency services. These are key assets for the EU policies on climate, environment, transport, agriculture and secure society (e.g. Maritime Strategy, the Arctic Strategy, the Digital Agenda, the Common Security and Defence Policy, the Sustainable Development Strategy, the SDGs). Finally, the space sector is a source of economic growth, jobs and exports.

In order to stay ahead in a dynamically changing domain marked by growing competition and major technology advances, the EU space sector requires continued, smart and coordinated investments in cutting-edge technologies, innovation, applications and skills. **The Horizon Europe programme is a major leverage to boost space innovation across the EU with close to €1.6 billion earmarked over the programming period 2021-2027.**

Funded R&I projects foster competitiveness and technological non-dependency of the EU space sector while consolidating EU flagship programmes and developing new downstream applications and evolution schemes for the existing services of the European Union Space Programme. EU-funded space R&I projects also emphasise European access to space as well as future technologies such as quantum technologies, space weather and space science.

Europe is already a major player in space. If we want to be stronger and more self-confident on the global landscape, we must also be stronger in space. [...] Developing our space sector will help us reinforce our strategic autonomy – goal number one of our generation, in my view.

Charles Michel,
President of the
European Council

13th European Space Conference,
12-13 January 2021

Learn more about EU-funded space R&I & how to be part of it!

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NEW SPACE AND EUROPEAN ENTREPRENEURSHIP IN SPACE ELEVATING EUROPE'S SPACE **ENTREPRENEURS TO NEW HEIGHTS**



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The emergence of New Space that gradually develops new commercial fields

Traditionally, the space industry catered mainly to governmental customers. However, in the past decade, a significant shift took place at a global level towards **greater involvement of the private sector**, both as client and supplier. New Space refers to the emergence of a privately owned, commercially motivated space industry. This impacts many layers of the space sector: innovative technologies, entrepreneurial activities, new models for R&D, commercialisation and financing new frontiers and explorations, as well as new industrial processes. It also spurs cross-fertilisation and synergies with other industries, such as automotive and digital.

The European New Space ecosystem, unfolding commercial opportunities in space

The **European New Space ecosystem is steadily growing**, even though New Space is still dominated by the US. It is gradually developing new commercial fields beyond the traditional space sector, with many European companies popping up in different segments. For instance, the development of new launch systems ("Micro-launchers" rockets) by European SMEs such as ISAR Aerospace, RFA and PLD Space aims at providing cheaper and more flexible access to space, while in-orbit services (e.g. D-Orbit) create complete new space activities.

Another important segment in the European New Space ecosystem is the satellites. Today, many companies such as Iceye, Kinéis and KLEO are deploying constellations of hundreds of small satellites (<=500 kg mass) to provide customers with advanced Earth Observation, IoT and communication services. The growth and importance of this ecosystem is recognised by the European Commission, which has **increased its funding and support for start-ups and SMEs**.

Teaming up across Europe

The Commission has put together all relevant public players to create the best conditions for New Space companies to scale up in Europe, with the support of:

- The **European Investment Fund** for the implementation of the CASSINI investment facility;
- The **European Investment Bank** for debt operations;
- The **European Space Agency** and the **EU Agency for the Space Programme**, including for matchmaking activities;
- The **European Innovation Council**, that provides a tangible financial support to New Space companies, complementing the CASSINI initiative.



Boosting entrepreneurship

€1+ billion investment to support the European space ecosystem



Boost space

Produce fundamental measures that are required to sustain the five strategic capabilities, ensuring growth of the economy competitiveness, foster competitiveness and accelerate the pace of innovations, support EU non-dependency on critical technologies and strengthen international cooperation



Supporting EU objectives

By promoting a globally innovative European New Space domain



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NEW SPACE AND EUROPEAN ENTREPRENEURSHIP IN SPACE

Elevating Europe's space entrepreneurs to new heights

Introducing CASSINI

CASSINI boosts the commercialisation of Europe's space industry, with the aim of increasing revenue growth among startup companies and easing access to investment capital.

CASSINI Investment Facility provides €1+ billion capital to venture capital funds focusing on space investment. The Commission and EIF regularly offer capacity building workshops to create an ecosystem of space investors.

CASSINI Business Accelerator provides expert coaching and mentoring about marketing, sales, and business growth. 40 startup companies per year get admitted.

CASSINI Matchmaking provides a Europe-wide networking arena for space companies, investors, and corporations. Up to 12 events per year across Europe. 200+ companies have participated in 2022-23.

CASSINI has partnered with Dealroom to track the amount of investment capital raised by European space companies. Visit [Dealroom.co](https://www.dealroom.co) and use the CASSINI label: CASSINI Business Accelerator | [Dealroom.co](https://www.dealroom.co)

CASSINI Hackathons and **CASSINI Challenges** offer exciting competitions to spur early-stage innovation and assist new entrepreneurs taking the first steps towards building a viable company.

The **In-Orbit Demonstration and Validation service** enables new technologies to be tested in orbit by providing aggregation on spacecraft, if needed, and launch services and operations.

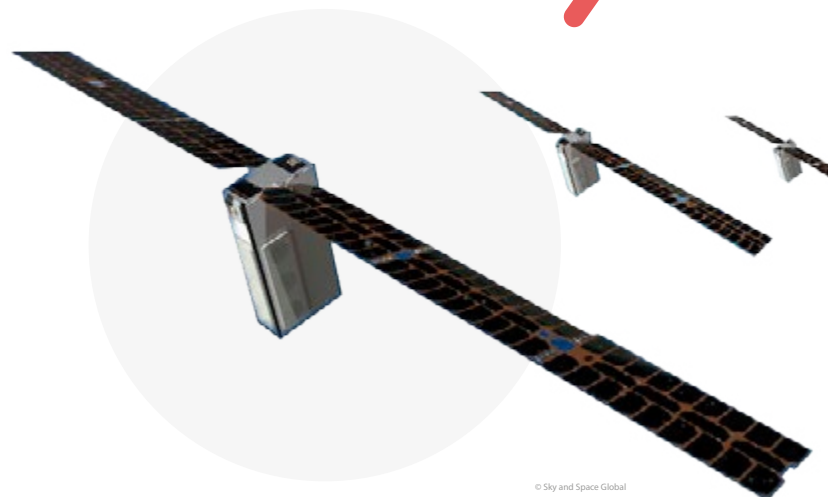
To stay informed about all **CASSINI** news/events/activities: www.cassini.eu

Introducing the EIC activities with Europe's flagship innovation programme, the European Innovation Council (EIC)

Introduced by the European Commission to support the commercialisation of high-risk, high potential, high-impact technologies in the European Union, the European Innovation Council (EIC) was launched in March 2021 under the Horizon Europe programme. Intended to identify, develop and scale up breakthrough technologies and game-changing innovations, the EIC provides several funding opportunities.

Introducing the EIC activities

- The **EIC Pathfinder & Transition programmes** support research teams exploring bold ideas at low TRLs for radically new and emerging breakthrough technologies, with grants of up to €4 million.
- Providing grant funding and equity investments for individual start-ups and small companies with TRLs above 5 to develop and scale up innovations is the objective of the **EIC Accelerator**.







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IN-ORBIT DEMONSTRATION AND VALIDATION (IOD/IOV)

**NEW TECHNOLOGICAL
DEVELOPMENTS
AND INNOVATIONS
TESTED IN ORBIT**



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An EU R&I initiative to gain flight heritage

Testing in real conditions is the true training ground to validate concepts, innovative technologies and performances and accelerate their entry into the market. However, in-orbit testing is a costly and complex endeavour resulting in the **infamous “valley of death”** for many innovative companies. Therefore, regular and affordable flight opportunities to validate space technologies are necessary to ensure international competitiveness and innovation of EU space technologies. This is **why the European Commission introduced the IOD/IOV initiative** under Horizon, the Union framework programme for Research and Innovation, to provide recurrent, accessible and sustainable IOD/IOV service in the EU. This will accelerate innovation and facilitate the commercialisation of EU space technologies, enhancing the global competitiveness of the EU space industry.

Skills and innovative technologies

for a competitive EU Space

The In-Orbit Demonstration and Validation service enables **new technologies to be tested in orbit** by providing aggregation on satellite, if needed, launch services and operations. Experiments from all space domains are welcome, from Earth Observation, telecommunications and satellite navigation to Space Traffic Management, space science and others. The IOD/IOV initiative enables SMEs, research centres and large companies to bring innovations to the market in a reduced timeframe. It also provides students and European engineers with invaluable hands-on experience in real-world space programmes.

The IOD/IOV European initiative has several **expected benefits:**

Global competitiveness of the European space sector: IOD/IOV allows innovations to be effectively tested in orbit, while reducing the time it would otherwise take to bring them to market. In doing so, the IOD/IOV initiative contributes to space entrepreneurship alongside the CASSINI initiative.

Development of new commercial entrants: IOD/IOV fosters the development of the New Space phenomenon in Europe, by progressively relying on solutions from new entrants active in satellite manufacturing and launch services in the EU.

EU non-dependence: IOD/IOV supports EU non-dependence by providing a cost-effective service based on EU solutions both for the spacecraft and for the launch services.

A European Higher Education system: IOD/IOV enables the development of skills and talents by providing European young engineers with hands-on experience in real-world space programmes.



IN-ORBIT DEMONSTRATION AND VALIDATION (IOD/IOV)

New technological developments and innovations tested in orbit

From experiment selection to space:

The first results of the initiative

The first call for expression of interest for IOD/IOV experiments under Horizon 2020 attracted **50+ proposals** from various European SMEs, large companies, universities and research organisations. Successful applications relate to technology innovation for EO, PNT, SatCom and space science. In September 2020, the first selected IOD/IOV experiment, UPMSat-2, was successfully launched onboard the Vega SSMS. The first ever IOD/IOV dedicated mission, Syndeo, then launched in October 2023.

In spring 2022, a new call published, kicking off the next phase of IOD/IOV services under Horizon Europe. This time again, **50+ applications** were received from the space community in various domains, including EO, PNT, STM, Telecom, etc. Since March 2023, two parallel calls are open until 2026 to gather experiments that could be considered for “IOD/IOV Experiments needing aggregation” and “Ready to Fly IOD/IOV satellites.”

European Flight Ticket Initiative

On 23 January 2023, at the margins of the European Space Conference, European Commission and ESA officials announced the creation of a **pool of European launch service providers** that will participate in the European Flight Ticket Initiative. The initiative's objectives are to:

- Stimulate new European launcher systems and solutions through open competition for the procurement of launch services;
- Provide regular opportunities for **affordable and responsive** launch services for European “ready to fly” IOD/IOV satellites;
- Purvey regular, affordable and responsive launch opportunities for other EU IOD/IOV missions and possibly EU institutional missions.

The flight ticket initiative for IOD/IOV missions will use exclusively **European manufactured launchers** co-funded through the EU Horizon Europe programme and the ESA Boost! programme. Each launch service provider will receive a “frame” contract as part of the initiative. This will stimulate demand for European launch services by allowing selected companies to compete for missions in the EU's IOD/IOV programme.

The current pool of European launch service providers includes: Isar Aerospace (DE), Orbital Express (UK), PLD Space (ES), Rocket Factory Augsburg (DE), and Arianespace (FR).

Introducing the first IOD/IOV mission: Syndeo

Syndeo is aggregating seven IOD/IOV experiments in two satellites. Syndeo 1 will test a miniature star tracker for attitude determination, a high-accuracy attitude determination and control system, a CubeSat star tracker, and a novel radiation sensor. Syndeo 2 will test a SpacePix Radiation Monitor, a magnetic measurement system for LISA, and a plasma jet pack electric thruster.



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ACCESS TO SPACE

**ENABLING THE INDUSTRIAL
COMPETITIVENESS
AND RESILIENCE**

WITH NEW SERVICES,
SOLUTIONS AND CONCEPTS



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About Access to Space

and why it is crucial for European competitiveness in space

There is no EU space policy without an independent access to space. **Access to space is strategic for Europe:** it allows the deployment of space infrastructures such as Galileo, Copernicus and EGNOS, and in the future, IRIS², that are essential for our society as they boost the economy and enhance security. In a globally ultra-competitive environment, Europe needs to support a resilient, cost-efficient, responsive and flexible access to space.

Shifting to sustainable, green, reusable technologies

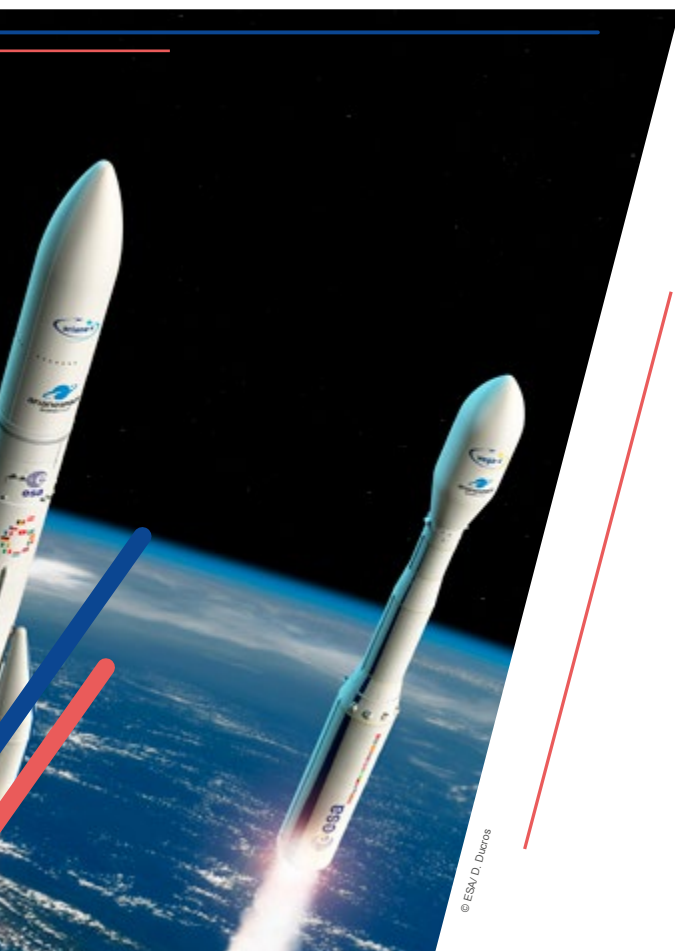
to support Access to Space

Launching spacecraft is a very resource-intensive and expensive endeavour. European launch systems and industrial processes need to be further optimised to establish a **globally competitive, yet economically and ecologically sustainable European space sector**. In this context, the Horizon Europe programme has four R&I priorities:

- Innovation for launcher competitiveness – targeting initial operational capability by 2030;
- Disruptive concepts for access to space – starting at low technological readiness levels;
- Fostering and enabling new commercial space transportation solutions;
- Modern, flexible and efficient European test, production and launch facilities, means and tools.

Among others, these lines of R&I activities include projects aimed at developing greener propulsion systems and reusable launch vehicles. Moreover, the projects are also looking into disruptive concepts and technologies that reduce the cost as well as the environmental impact of launch services.

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Access to space

Using innovative launcher concepts and enabling new commercial space transportation solutions



Boosting innovative R&I

26 projects focusing on Access to Space selected for funding of €166 million under Horizon 2020 and Horizon Europe



Supporting EU objectives

By fostering EU non-dependence and reinforcing Europe's autonomy in accessing space

ACCESS TO SPACE

Enabling the industrial competitiveness with new services, solutions and concepts

Ensuring competitiveness

for an innovative and autonomous European Space Transportation Sector

Europe faces several challenges to an autonomous European access to space. The global launch service market is getting more and more competitive with an increasing number of competitors (USA, Japan, China, India, etc.) and attractive prices on the commercial market.

What should Europe do?

1. **Rapidly improve launch competitiveness**, in terms of cost and increased flexibility. The aim is to contribute to reduce the cost of launch services by 50% in the next decade.
2. **Stimulate the development of new space transportation solutions**, including through the emergence of new launch systems, to complement the current EU launchers family and increase the resilience, responsiveness and flexibility of launch services.

The Horizon Europe R&I Programme is a major leverage in support of the EU industry developing access to space solutions. While enhancing the competitiveness and agility of existing launchers, it also contributes to the technological maturation of new launch systems. In early 2022, the European Commission awarded a €10 million EIC Horizon Prize to reward the most innovative, cost-effective and commercially viable solution for launching light satellites into Low-Earth Orbit, which promotes European technology non-dependence.

Introducing EU-funded space R&I projects

Examples of Horizon Europe

SALTO enhances European maturity for reusable vehicles by developing technologies and building blocks up to a low altitude flight system test, supporting the EU supply of key materials and technologies for launches.

SAFEST aims to develop an Autonomous Flight Termination System (AFTS) to implement on micro/small launchers. The system will enable customisation for different launchers and sites.

Eu-BEST develops a catalogue of generic ground segment services dedicated to the test of launchers engines and stages, with a concept of interoperable, modular and mobile test systems. This approach will avoid the high cost of custom-made facilities.





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SPACE CRITICAL TECHNOLOGIES FOR EU NON-DEPENDENCE

**SUPPORTING THE
DEVELOPMENT**

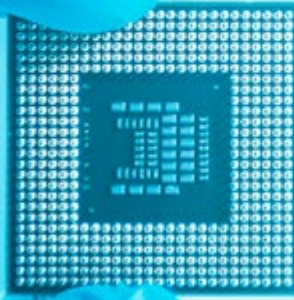
OF CRITICAL SPACE COMPONENTS,
SYSTEMS AND TECHNOLOGIES



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About space technology non-dependency and why it is so crucial for the European space industry

Space is a strategic sector for the economy as well as for EU's security and defence. It increasingly represents an invaluable asset in many sensitive and high-stakes matters. Europe needs to master certain space technologies to be non-dependent from other parts of the world. This is why the European Commission is focussing part of the space research programme on the **development of critical space technologies**, with the objective to allocate €20 million on a yearly basis.

Towards the future:

What are the next steps to achieve non-dependency?

Europe will further **prioritise the critical technologies** needed to achieve non-EU dependency and secure their supply chains. These technologies are focused on space Electrical, Electronic and Electro-mechanical (EEE) components, such as Radio Frequency (RF) and Power components, GaN based components, passive components, photonics components, SoCs (system on chip), microelectronics based on advanced technology nodes, very high-speed serial interfaces, and also include e.g. solar cells for space applications, advanced assemblies, PCB (Printed Circuit Board), large deployable structures and antennas and space-qualified carbon fibre material sources for launchers and satellite subsystems.

With the support of the Horizon funding programme, many critical space technology projects have increased technological readiness levels (TRL), allowing products to reach the space market. With Horizon Europe, over 2021-2027, the European Commission will **enhance its support to the development of critical space technologies** for European non-dependence.

The European Commission closely cooperates in this field with the European Space Agency and the European Defence Agency through a Joint Task Force.



Boosting innovative R&I

Funds in the order of €55 million have been provided under Horizon Europe for targeted and strategic actions supporting the EU space sector



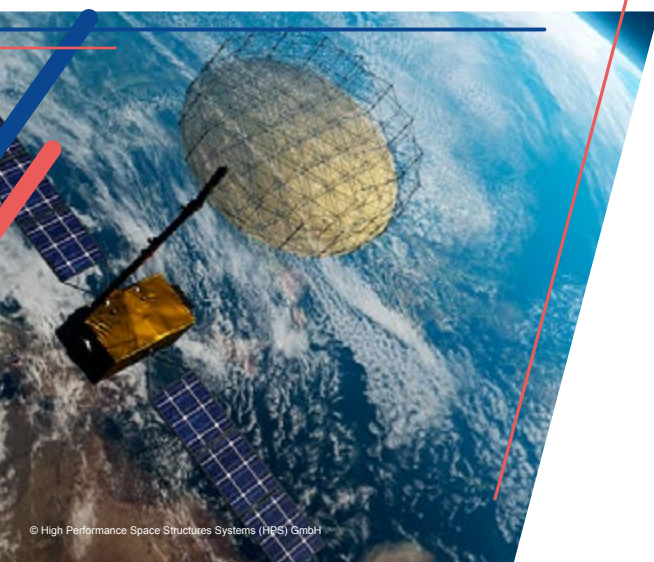
Boost space

Produce fundamental measures that are required to sustain the five strategic capabilities, ensuring growth of the economy competitiveness, foster competitiveness and accelerate the pace of innovations, support EU non-dependency on critical technologies and strengthen international cooperation



Supporting EU objectives

By ensuring a globally competitive and non-dependant European space sector



SPACE CRITICAL TECHNOLOGIES FOR EU NON-DEPENDENCE

Supporting the development of critical space components, systems and technologies

Current efforts and achievements

toward an autonomous European space industry

Space-grade electronic devices and other space systems are often subject to restrictive trade rules, such as the US International Traffic in Arms Regulations (ITAR). To be non-dependent, the EU should develop its **own domestic production of critical technologies**. Significant areas of R&D, evaluation/qualification and EU investments in the last years include:

- Funding the design, manufacturing, validation space qualification of the first EU radiation-hardened families of FPGAs (field programmable gate arrays). The first EU space qualified FPGAs have now been inserted in EU space missions like Galileo, Copernicus. New developments are on-going for paving the way toward the next EU FPGA based on 7nm.
- Establishing of the first EU high energy (up to GeV/n) heavy ion accelerator serving the space sector. The European Commission is building two facilities which will be crucial for high-density, advanced EEE components.
- Establishing a European supply chain for offering normally-off GaN (Gallium Nitride) devices for space applications including power conversion covering both low voltages (<50V) and high voltages of up to 650V.
- Creating advanced high dissipative packages with high thermal dissipation based on diamond and high dissipation with large pin count have been developed and evaluated for space.
- Developing of the first EU-developed radiation-hardened by design high density non-volatile memory magnetic RAM (MRAM) based on a European FDSOI process and 3D stacking.

These efforts will boost European competitiveness and non-dependency especially in space electronics, as well as improve resilience of space-related supply chains and technological performance.

Introducing current space R&I projects

Horizon Europe projects

Project SGAN-Next aims at maturing the EU based 100nm GaN on SiC MMIC foundry process for high frequency operations (up to Q-Band) and perform a formal space qualification.

Project STEP is providing a full European supply chain focused on the design and manufacturing of competitive and affordable large format T2SL eSWIR FPAs, which can drastically boost the observational capabilities of space IR payloads.





The background of the entire page is a photograph of Earth from space, showing a blue sky and white clouds. In the upper left, there are two large, rectangular solar panel arrays with a grid-like pattern, extending from a spacecraft. In the lower left, there is a smaller satellite with a gold-colored body and a solar panel. On the right side, there are several thick, diagonal lines in shades of red and light blue. At the bottom left, there are more thick, diagonal lines in shades of red and light blue.

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IN-SPACE OPERATIONS AND SERVICES

INTRODUCING THE FUTURE
SPACE ECOSYSTEM
AND OUR STRATEGIC
CAPACITY TO
ACT IN SPACE



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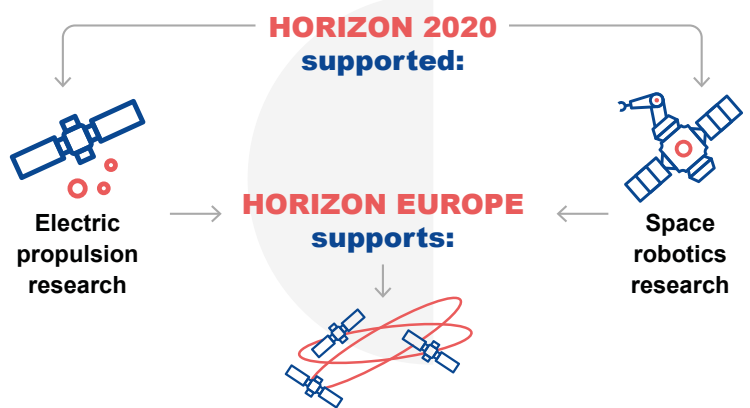


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In-Space Operations and Services (ISOS) will enhance the **adaptivity, resilience and sustainability of space assets**. It includes satellite servicing, assembly, manufacturing, recycling and logistics in space. The European Commission recognises the **strategic importance of ISOS**, in particular with regards to resilience and protection of the infrastructure in space and to commercialisation.

Towards a strategic flagship

In the current geopolitical context, it is essential to reduce technological dependencies in critical sectors. **Act in Space** is a key future strategic capacity for the EU as a space power. The EU is aligning objectives and acting towards a **new strategic flagship** for service provision to the European infrastructure in space that will also foster a new in-space economy. A pioneering pilot mission including technology and service demonstration is already under development. It will be the seed point for this future flagship. As global competition intensifies, it is necessary to maintain Europe's capabilities on par with competitors.



ISOS pilot detailed design and further R&I

ISOS aims at creating a new in-space economy and at fostering the protection of space assets, safeguarding the EU's freedom to act in space.



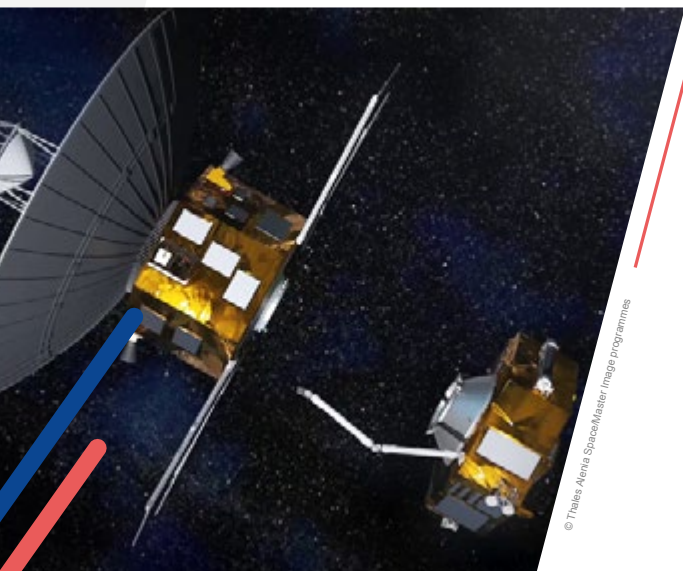
Act in Space

This strategic capacity will bring the EU to the forefront of emerging service applications, including inspection, rendez-vous and docking, grasping, repair, reconfiguration, assembly and disassembly, manufacturing, resource extraction, reuse/recycling, removal and transport of objects in space, for satellites, platforms and larger structures.



ISOS pilot mission

The EU ISOS mission shall demonstrate future applications and operational services.



IN-SPACE OPERATIONS AND SERVICES

Introducing the future space ecosystem and our strategic capacity to **ACT IN SPACE**

Game-changing innovations and enabling technologies

The paradigm shift towards adaptive space systems builds on **automation and robotics, AI, electric propulsion and modular and reconfigurable spacecraft concepts**. Together with other enabling technologies such as electric propulsion, they will change how space assets are designed, produced, tested, transported, and operated. Different means realised with AppStore-like approaches, will benefit the future space ecosystem and foster a **circular economy**.

Synergies between civil and defence sector

Autonomous, robotic, real-time and onboard decision-making ISOS technologies illustrate their potential use for both **commercial and governmental purposes**. ISOS, leveraging in-space servicing, assembly, manufacturing, and transport technologies, will foster the reliability, safety, security, sustainability, and flexibility of space missions.

Promoting rules and standardisation for an ISOS market

Appropriate regulation and standardisation are crucial for the growth of global ISOS. The European Commission works towards a comprehensive **regulatory framework** that provides the foundation for a new ecosystem, stimulating market growth and **fostering cooperation** between market players. Standardisation ensures interoperability of developed products and services.

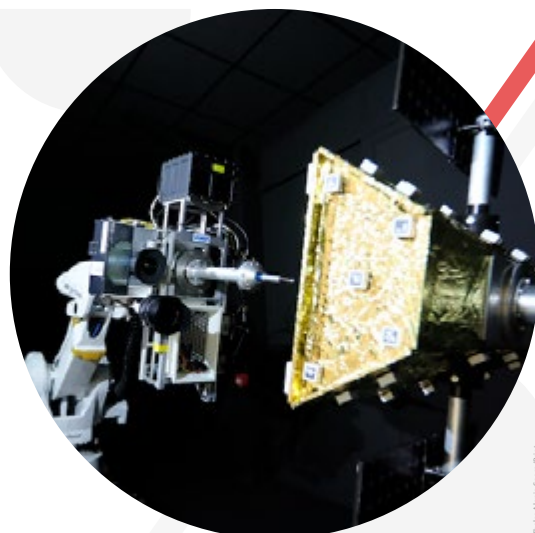
Introducing EU-funded space R&I projects

EROSS IOD seeks to enable the repair of satellites in orbit through autonomous robots, covering tasks like rendezvous, refueling, and component replacement to extend satellite lifespans.

STARFAB is developing an automated orbital warehouse unit that will enable the handling of goods in space, supporting sustainable on-orbit servicing, assembly and manufacturing (OSAM) business models.

EU-RISE is analysing the market for in-space services to develop and refine European capabilities in space robotics, thereby establishing a significant OSAM capacity in Europe.

SPACE USB aims to develop a flexible, universal interface akin to USB for on-orbit servicing and assembly, focusing on compactness, docking symmetry, and interoperability with existing space connectors.







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EGNSS AND COPERNICUS APPLICATIONS

CREATING VALUE-ADDED
APPLICATIONS THROUGH
**INNOVATIVE
SPACE R&I**



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Strengthening European space assets and services with the European Space Programme

The EU Space Programme provides Europe with cutting-edge space-based services in Earth Observation (EO), Navigation and in the future Secure Communication. The programme consists of different components, including:

- The **European Global Navigation Satellite System (EGNSS)**, which allows users with compatible devices to determine their position, velocity and time through satellite signals. It is made up of two elements, **Galileo**, a state-of-the-art global satellite navigation system and **EGNOS**, a satellite-based augmentation system used to improve the performance of global navigation systems, with essential applications mainly in aviation.
- **Copernicus**, the European Union's Earth Observation and Monitoring programme, which relies on its own set of satellites and a variety of technologies and measurement systems.

Providing benefits through applications of EGNSS and Copernicus

Copernicus services acquire and analyse Copernicus satellite and in situ data and transform it into value-added and user-friendly information used in different domains, including **atmosphere monitoring, marine environment monitoring, land monitoring, climate change monitoring, security and emergency management**. Navigation systems also provide many benefits, such as guiding us to our desired destination, supporting the stock exchanges to apply timestamps to the trades they execute, aiding farmers to work their fields efficiently, serving the energy operators as an accurate time source to monitor the flow of their networks or speed up rescue operations.

Thanks to further R&I activities, **EGNSS and Copernicus services and data will lead to innovations** in many areas of applications, such as:

- **Agriculture:** Navigation and EO technologies can help optimise fertiliser, fuel, pesticide and water use. EU research funds are being used to develop applications based on EGNSS and Copernicus, which ensure food security and traceability across significant parts of the supply chain, valorising what is "made in Europe".
- **Security & Emergency:** Timely and accurate geospatial data can provide crucial information in case of floods, fires, or earthquakes, optimising the emergency response while also assisting in disaster mitigation, preparedness and recovery with the development of tools and applications that exploit synergies among EGNSS and Copernicus data.
- **Digital innovations:** EGNSS and Copernicus can be used in applications supporting smart cities, urban planning, smart waste management etc.
- **Climate change:** EGNSS and Copernicus-based solutions can support the supply of clean, affordable and secure renewable energy. EU-funded research projects focus on improving data assimilation methods to help Europe study and further help mitigate, manage and adapt to climate change.
- **Health:** By effectively forecasting UV radiation or air pollution levels, Copernicus applications help decrease risks to health. In the same way, EGNSS can enable the use of autonomous robots in support of humans. EU research funds are being used to improve such applications.



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EGNSS AND COPERNICUS APPLICATIONS

Creating value-added applications through innovative space R&I

Why funding EGNSS and Copernicus applications is needed

to solve our global challenges

Copernicus's core services should evolve and improve to **continue responding to today's evolving challenges**, from continuing the push to climate change mitigation and adaptation to food security and protection of natural resources. Copernicus also needs to continue contributing to the ambitions outlined in the European Green Deal and other EU policies. Similarly, the Galileo applications portfolio should meet evolving user needs and market trends, for instance, with emerging technologies like 5G, Artificial Intelligence and autonomous vehicles. Research will ensure both EGNSS and Copernicus take full advantage of digital opportunities including artificial intelligence and cloud computing.

Introducing current space R&I projects

Examples of Horizon 2020 projects

Project JULIA fosters the uptake of EU Space services and data in the long lead public transport market at the global scale, ultimately unlocking significant, measurable, and durable impacts. It will do so by advancing existing, mature public transport-oriented, user-centric applications.

Project CoCO2 built a prototype systems for a European Monitoring and Verification Support capacity for anthropogenic CO2 emissions by bringing together expertise, existing capacities and innovative ideas from European and international players.

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Boosting innovative R&I

€115.2 million in 2021-2023 through Horizon Europe for the development of innovative space downstream applications



Use of space on Earth

Provide space-based secure communication, navigation and Earth observation services for the benefits of the whole society. Additionally, manufacture, operate, and evolve the EU space infrastructure



Supporting EU objectives

Leveraging Copernicus and EGNSS data to support the European Green Deal and other important EU priorities







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EVOLUTION OF EGNSS INFRASTRUCTURE

ENSURING INDEPENDENT
AND STATE-OF-THE-ART
**SERVICES FOR EUROPEAN
CITIZENS AND BUSINESSES**



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European Global Navigation Satellite System (EGNSS)

and why it's important for our everyday lives

Today, the use of a Global Navigation Satellite System (GNSS) is deeply ingrained in our everyday lives and can be found in our phones, cars, planes, ships and many other applications. Navigation systems guide us to our desired locations, aid farmers in efficiently working their fields, and even speed up rescue operations. Europe has its own GNSS systems, **the European GNSS**, encompassing **Galileo**, a state-of-the-art global satellite navigation system, and **EGNOS**, a regional satellite-based augmentation system used to improve the performance of global navigation systems. Galileo is of strategic importance to Europe, providing robust and accurate positioning services to European citizens, industries and governments without having to rely on the US GPS, the Chinese Beidou, or the Russian GLONASS systems. It is also enabling the European Union to develop and maintain its know-how and its industrial capacity in such a high-value sector. Since Galileo went live in 2016, its fleet has grown to a total of 28 satellites in medium Earth orbit, delivering a rich portfolio of services, ranging from freely accessible timing and positioning services to authenticated signals or encrypted government geo-positioning, as well as search and rescue services, short messaging capabilities and broadcast of emergency warnings.

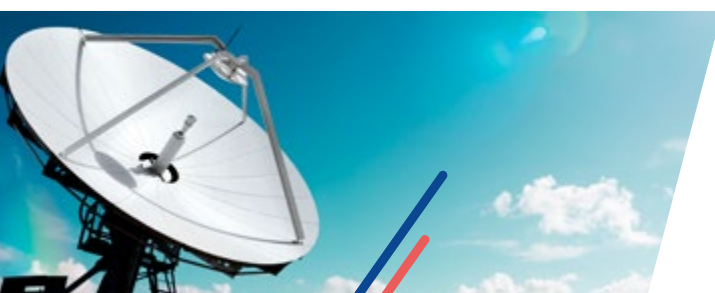
Global trends in satellite navigation

and how Galileo addresses them

Both Galileo and EGNOS services create extensive socio-economic benefits through a wide range of applications, spanning numerous market segments and generating value for both the public and private sectors. These competitive environments drive the need to anticipate ever-changing market demands and adapt the EU space infrastructure to meet them.

To this end, the Galileo infrastructure will evolve with the arrival of the **second generation of Galileo (G2G) satellites**. With a gradual introduction of cutting-edge new generation satellites in the current Galileo fleet, several important innovations will be made available to Galileo users:

- **Diversification of navigation services:** G2G will complement the already excellent Galileo portfolio with additional innovative services such as timing service, space service, and provision of integrity.
- **Strengthen robustness of the satellite navigation services:** G2G will bring solutions including frequency diversity, increased power levels, signal encryption and various levels of authentication features.
- **Increased accuracy in time and position:** Building upon the standard set by the first generation of Galileo satellites, G2G will rely on new a generation of atomic clocks, an innovative on-board time generation approach, and in-orbit validation of experimental models.
- **Use of state-of-the-art satellite technology:** G2G spacecraft will be flexible and react swiftly to evolving user needs with their modern and powerful platforms. Technologies such as intersatellite links and electric propulsion will improve the capacity to control and operate the constellation, while simultaneously lowering operating costs.



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EVOLUTION OF EGNSS INFRASTRUCTURE

Ensuring independent and state-of-the-art services for European citizens and businesses

The foundation of an efficient and robust system – now and in the future

In 2016, the European Commission published a 'Space Strategy for Europe', confirming its commitment to the stability of the EU Space Programme and to strengthening the systems' competitive advantages. In a changing environment and fast-evolving market, **this strategy laid down the principle of continuity of service with greater efficiency and robustness.**

To that end, the strategy recommended preparing the new generations of these systems on a user-driven basis and considering the technological progress. It also recommended addressing the vulnerability of the European supply chain by supporting the development of critical space components, systems and technologies associated with technological non-dependence.

In this context and together with the Member States, the European Space Agency (ESA), the Agency for the EU Space Programme (EUSPA) and the Joint Research Centre (JRC), the European Commission delivered in 2019 the **long-term plan for EGNSS Upstream R&D activity**. This framework identifies the strategic needs and recommendations for upstream R&D in Horizon Europe (2021-2027) to support the further development and evolution of the Galileo and EGNOS infrastructure and sets priorities for the accompanying upstream R&D activities.

Horizon Europe is supporting the evolution of Galileo

Horizon Europe is also supporting specific innovations, such as combining satellite signals with other solutions like 5G and 6G, allowing even more robust and continuous services or the diversification of Galileo's orbits and the integration between navigation and communication." with "Horizon Europe is also supporting specific innovations in the domain, studying ways to make the services more robust, or assessing the diversification of Galileo's orbits, or ensuring the integration between navigation and communication technologies like 5G and 6G.



Funding Galileo's future

Attaining the necessary technology level for modernising its space infrastructure and for delivering innovative services



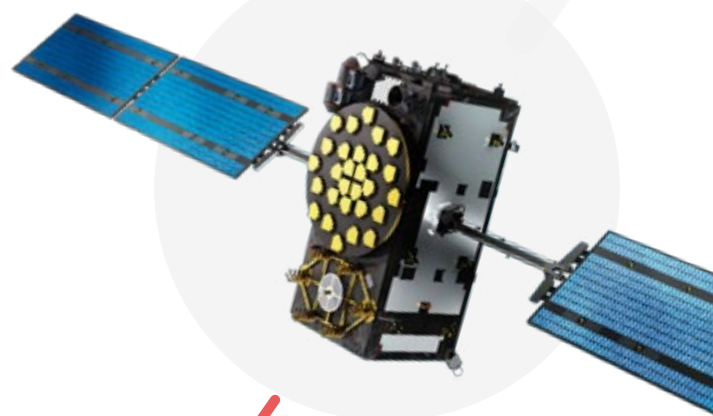
Use of space on Earth

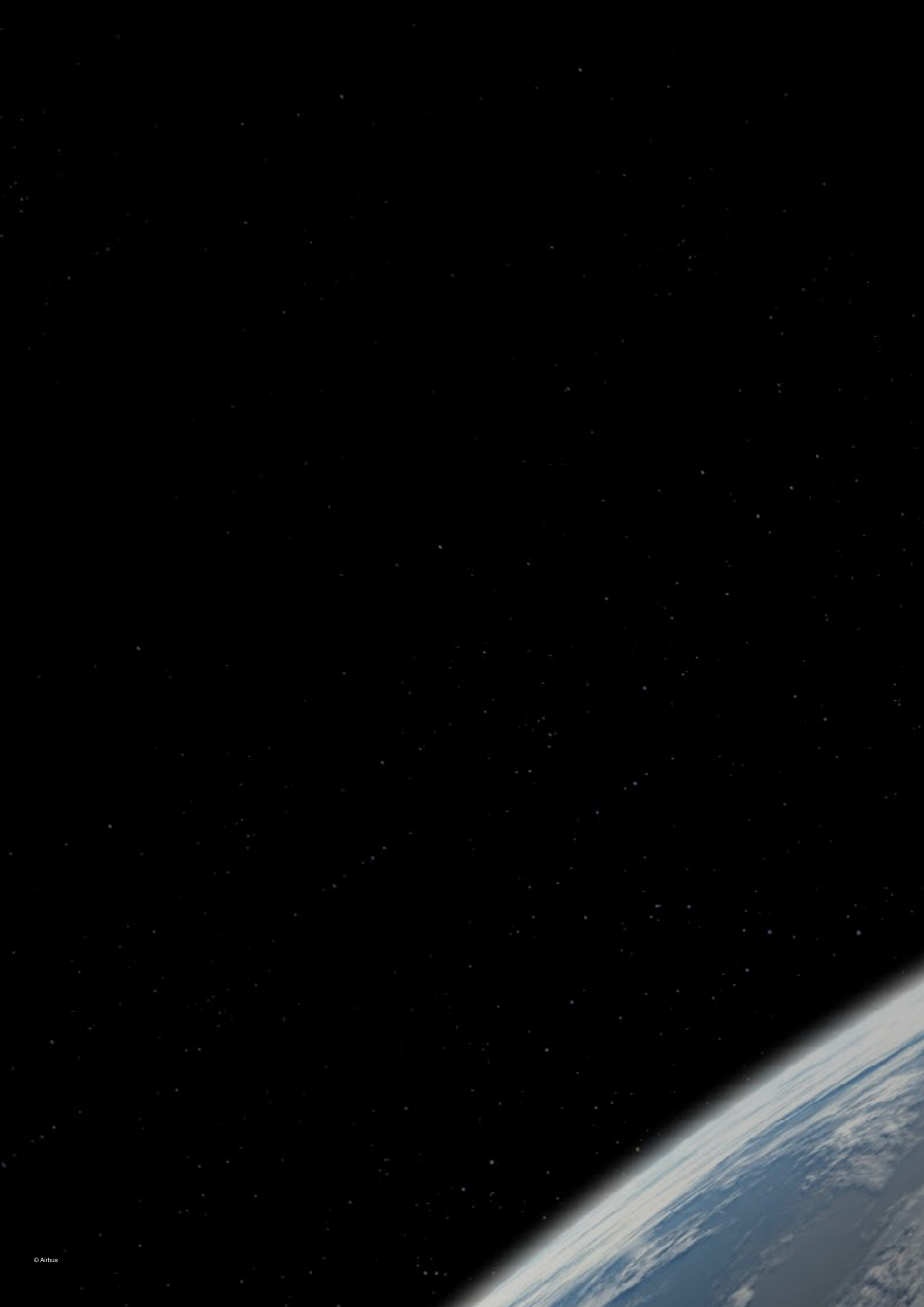
Provide space-based secure communication, navigation and Earth observation services for the benefits of the whole society. Additionally, manufacture, operate, and evolve the EU space infrastructure



Supporting EU socio-economic benefits

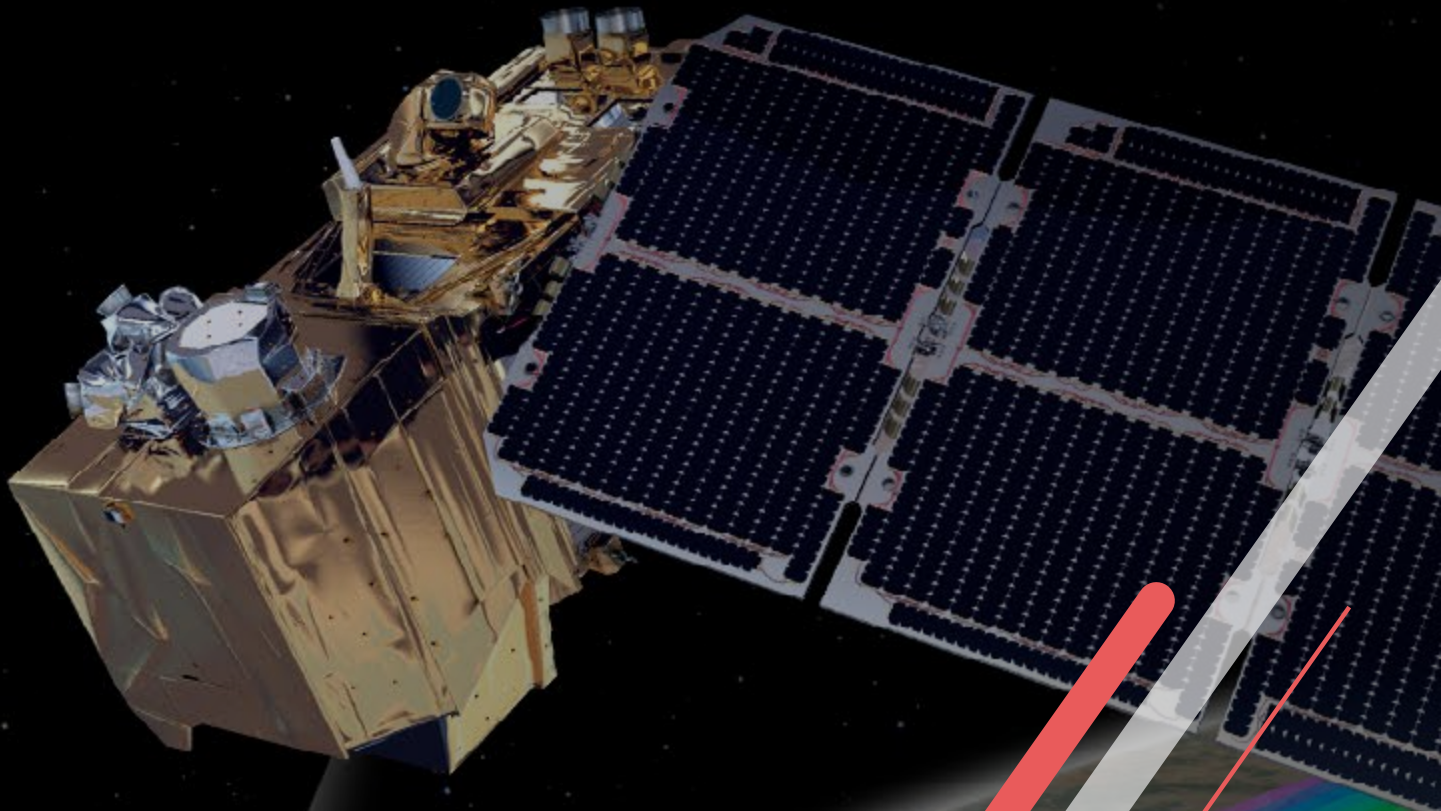
Addressing the emerging needs of user communities and reinforcing the competitiveness of the EU space industry







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a programme of the
European Union



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COPERNICUS: EARTH OBSERVATION SERVING SOCIETY

**EXTENDED CAPABILITIES
FOR THE BENEFIT OF
EUROPE'S CITIZENS**



Horizon Europe,
a programme of the
European Union



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Copernicus' Earth observations for a healthy planet

The Earth system and the human-made environment are constantly changing, instigated by both natural phenomena and the consequences of human activity. Through Earth Observation (EO) satellites, the status of and changes in these systems and environments can be monitored and assessed. Modelling, data assimilation and re-analysis provide seamless datasets on the different Earth subsystems about the past decades, the present and the future. These Earth observations and modelled data are invaluable in **understanding the planet's health and predicting future trends**. Furthermore, the gathered datasets, combined with research and development of targeted methods, provide us with unique means to mitigate climate change and moving to a fully sustainable future.

Copernicus serves as an independent and powerful European EO solution aimed at developing European information services to benefit all European citizens. It provides global data with its own fleet of Earth observation satellites (**Sentinels**) and offers geographic information services for environmental monitoring and civil security. These services are tailored to the needs of European users and primarily cover the areas of environment, climate change, sustainable development, humanitarian aid and security-related issues.

Copernicus evolves together with the Earth Observation market

Earth Observation is the second largest commercial market for the EU space industry. Market demand is expected to grow quickly in the next ten years. This is the case for **advanced, very high-resolution satellite imagery** and **affordable, high-resolution, high-revisit products** (typically smaller satellites in constellations). Horizon Europe supports efforts needed to mature application-oriented EO technologies to underpin competitiveness and contribute to the integration of space into society and the economy. The focus of EU-funded activities in EO technologies is on the timeliness and reactivity of observations, their resolution and swath (the area imaged by the sensor on the Earth's surface"), the performance of sensors, onboard data handling capabilities and underlying technologies, among others.



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Boosting innovative R&I

€63 million of Horizon Europe funds will contribute to EO technology research between 2021-2027



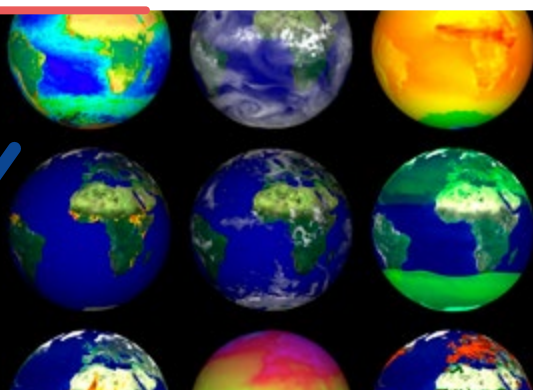
Use of space on Earth

Provide space-based secure communication, navigation and Earth observation services for the benefits of the whole society. Additionally, manufacture, operate and evolve the EU space infrastructure



Supporting EU objectives

Enabling climate change decision making and supporting EU policy and Green Deal objectives



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COPERNICUS: EARTH OBSERVATION SERVING SOCIETY

Extended capabilities for the benefit of Europe's citizens

Focused R&I supports the technological development

of Copernicus and the related services

Looking to the future, **six Sentinel Expansion missions** are being studied, with the support of Horizon Europe, to address EU policy needs and evolving Copernicus user needs and to expand the current capabilities of the Copernicus space component:

Copernicus Hyperspectral Imaging

Mission for the Environment: A unique visible-to-shortwave infrared spectrometer to support sustainable agriculture, biodiversity management, and soil property characterisation.

Copernicus Imaging Microwave Radiometer:

A wide-swath conically-scanning multi-frequency microwave radiometer to observe sea-surface temperature, sea-ice concentration and sea-surface salinity.

Copernicus Anthropogenic Carbon Dioxide

Monitoring: A near-infrared and shortwave-infrared spectrometer to measure atmospheric carbon dioxide produced by human activity.

Copernicus Polar Ice and Snow Topography

Altimeter: A dual-frequency radar altimeter and microwave radiometer to measure and monitor the sea-ice thickness and overlying snow depth.

Copernicus Land Surface Temperature

Monitoring: A high spatial-temporal resolution thermal infrared sensor to provide observations of land-surface temperature.

Copernicus L-band Synthetic Aperture

Radar: A L-band SAR providing additional information, such as on vegetation, dry snow or ice, that cannot be gathered by the Copernicus Sentinel-1 C-band radar mission.

Dedicated research projects are also foreseen to evolve and expand the capacity of the Copernicus services.

Introducing current space R&I projects

Horizon Europe projects

SCARBON will contribute to greenhouse gases emission monitoring by providing a constellation of small monitoring satellites flying an innovative miniaturised instrument (NanoCarb) to measure CO₂ and methane.

NECTON provides information about biodiversity conservation and fisheries management, by means of new modelling products for the green ocean: fishes, pollution and benthic habitats.

CERISE aims to enhance the quality of the reanalysis and seasonal forecast portfolio by focusing on land-atmosphere coupling with improved climate reanalysis and seasonal prediction systems.





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QUANTUM TECHNOLOGIES FOR SPACE

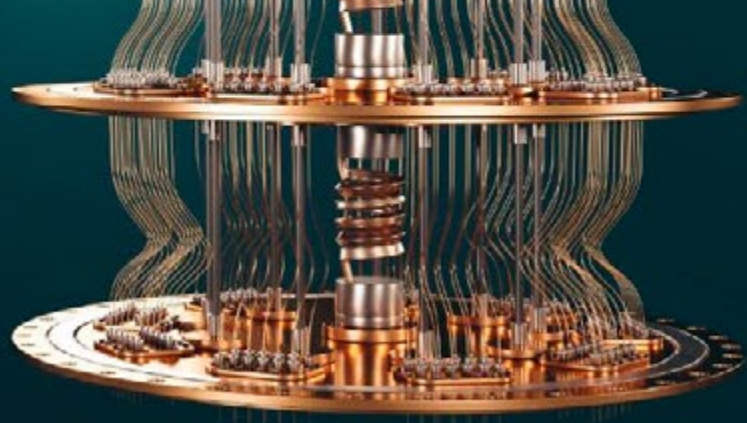
DEVELOPING NEW
TECHNOLOGIES AND
SERVICES
**FOR A CUTTING-EDGE
EU SPACE PROGRAMME**



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European Union



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a programme of the
European Union



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The quantum revolution

and its relevance for space

As the 19th century drew to a close, paradigm-changing scientific experiments on the physical properties of materials and radiation put into questions the certainties of classical mechanics. In 1927, the world's most notable physicists met to discuss the newly formulated quantum theory at the famous Solvay Conference. Quantum theory is the basis of modern physics that **explains the nature and behaviour of matter and energy on the atomic and subatomic levels.**

Quantum physics has fascinating properties, which reveal a world very different from ordinary human perception. For example, the behaviour of a particle can be described as a wave. In fact, the quantum state of a particle can even be described by the superposition of multiple waves. Their peaks and troughs can overlap or cancel out, depending on the forces and accelerations the atom is subject to. This "atom interferometry" can be used to make **highly sensitive gravity detectors, accelerometers and gyroscopes.**

Since the first quantum revolution in the early twentieth century, a whole range of applications in the field of scientific research, but also in our daily life, has emerged. Such **applications include laser, electronics, satellite-based positioning and medical imagery.** The second quantum revolution is now underway. The EU Space Programme and the EU satellite-based services must seize this opportunity and make the best and most strategic use of quantum technologies to improve the daily life and security of EU citizens.

The objectives for space quantum are to:

- Support the **EU space policy** and the **EU Space Programme**
- Reinforce **EU non-dependence** for the development of EuroQCI (the European Quantum Communication Infrastructure)
- Leverage **In Orbit Demonstration/In Orbit Validation (IOD/IOV) missions** dedicated to testing quantum technology in space
- Build a **dynamic and innovative industrial ecosystem** in Europe



Europe should invest massively in quantum technologies. This is a matter of technological sovereignty. Quantum could have important applications in the space domain like in encryption or in the mapping from space of the underground landscape.

*Commissioner T. Breton,
22 January 2020*

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Evolving European space

Leveraging the fascinating properties of quantum physics, which reveal a world very different from ordinary human perception



Creating scientific capabilities

Boosting European know-how and skills in critical key areas such as cybersecurity and quantum technologies



Achieving technology leadership

Ensuring European non-dependency in an enabling technology of the future

QUANTUM TECHNOLOGIES FOR SPACE

Developing new technologies and services for a cutting-edge EU Space Programme

Applications of the quantum revolution:

Quantum Space Gravimetry

The use of quantum technologies for enhanced space-based climate data and environmental processes modelling can be a game-changer to **monitor the Earth's resources, assess and predict adverse climate change and future disasters**. The satellite gravity missions provide unique observations which are not made available by other Earth Observation missions. The study of global mass transport phenomena via gravity field monitoring from satellite gravimetry offers essential insights and crucial information to understand and monitor, for example, underground water reservoirs.

This is why the European Commission is preparing for a future **EU Earth observation mission using quantum gravimetry, as part of the evolution of Copernicus**. The Commission is first setting the ground for a pathfinder mission with the support of Horizon Europe, starting with the development of the EU technologies and components for a space quantum gravimeter or gradiometer. In the Horizon Europe-funded project CARIOQA the engineering model of the **atomic accelerometer** for a subsequent space mission will be developed.

Quantum Key Distribution

In addition, the European Commission is developing a Quantum Communication Infrastructure (EuroQCI) with a terrestrial segment and a space segment. **This Quantum initiative "EuroQCI"** intends to mature the new technologies and perform the qualification for space and ground.

The **terrestrial segment of EuroQCI will rely on fibre communications networks** linking strategic sites at national and cross-border levels and the **space segment of EuroQCI will be based on satellites** to overcome the limitations of ground-based segments. It will connect national quantum communication networks across the EU, including its overseas territories. It will also **improve Europe's cybersecurity, digital sovereignty and industrial competitiveness**.

In this context, the European Commission will test the viability of quantum communication technologies in orbit and demonstrate the feasibility of operating the Quantum Key Distribution service with the **Eagle-1 mission**. The launch of Eagle-1 is scheduled for late 2025 / early 2026. This mission is co-funded by Horizon Europe under the **IOD/IOV component** and is a precursor of the **EuroQCI initiative**, which will later be integrated into the EU's Infrastructure for Resilience, Interconnectivity, and Security by Satellite (IRIS²)





An astronaut in a white spacesuit is seen from the back, standing on a dark, rocky surface. The background is a vast, star-filled space with a bright nebula in the upper right. The astronaut's suit has a circular logo on the back.

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BE PART OF EU-FUNDED SPACE R&I

HORIZON EUROPE FUNDING
SUPPORTS SPACE R&I FROM
FUNDAMENTAL SCIENCE
TO CLOSE-TO-MARKET
INNOVATIVE TECHNOLOGIES



Horizon Europe,
a programme of the
European Union



Horizon Europe,
a programme of the
European Union

Horizon Europe (HE) is the EU's main **funding programme for research and innovation, including in the space domain**. It addresses climate change, achieving the UN Sustainable Development Goals and boosting EU competitiveness and growth. The programme also strengthens the impact of research and innovation in developing, supporting and implementing EU policies and solving global challenges.

Pillar 1: Excellence Science


Marie Skłodowska-Curie Actions (MSCA)

The MSCA targets **doctoral education and postdoctoral training** and supports researchers from all over the world, at all stages of their careers, with a focus on their training, skills and career development. Thematic areas covered include **all domains of research and innovation, including space**. It funds:

- Living & mobility allowance
- Research, training and networking activities
- Management and indirect costs

Open to all MSC Actions research organisations receiving funding to support researchers via Doctoral Networks, Postdoctoral Fellowships, Staff Exchanges and COFUND.

 **Total HE budget** 6,6€ B  **Action budget** 0,05-2€ M


 For further information, [click here](#).

European Research Council (ERC)

The ERC **supports frontier scientific research in Europe**. ERC offers scientists a personal grant for their fundamental research projects. The ERC's frontier research grants operate on a 'bottom-up' basis without predetermined priorities, allowing applicants to choose freely among **all domains, including space**.

Open to researchers from early career stages to established researchers of any nationality, depending on the grant type.

 **Total HE budget** 16€ B  **Grant budget** 1-10€ M


 For further information, [click here](#).

Research infrastructures (RI)

The RI funding programme aims to endow Europe with **world-class sustainable research infrastructures** open and accessible to the best researchers from Europe and beyond. It also encourages using existing research infrastructures, including those financed from funds under the EU's cohesion policy.

Open to the EU Member States and Associated Countries.

 **Total HE budget** 2.4€ B  **Project budget** 0,8-15€ M

 For further information, [click here](#).

Pillar 2: Growth & Industrial Competitiveness

Digital, Industrial and Space


R&I funded within **digital, industrial and space policies & Sustainable Development Goals**

Space areas covered include:

- Space systems
- Space and ground infrastructure
- Evolution of services
- Innovative space applications
- Space entrepreneurship
- Targeted and strategic research and innovation non-dependence

Open to entities from all EU Member States (list available [here](#)). Non-governmental organisations can participate with their own funding. Strategic interest for the EU.

 **Total HE budget** 1,6€ B

 **Project budget** 1-20€ M

CASSINI entrepreneurship

European Commission **covering the whole of the Space Programme**

Open to students, researchers from the EU Member States and Associated Countries for an association

 For further information, [click here](#).

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BE PART OF EU-FUNDED SPACE R&I

Horizon Europe funding supports space R&I from fundamental science to close-to-market innovative technologies

contributes to fighting
encourages cooperation
global problems.

Global challenges and European competitiveness

Industry and Space

Pillar 2 aims to **boost key technologies and solutions underpinning EU Sustainable Development Goals** (SDGs).

included include:

and Access to Space

and infrastructures for Galileo/EGNOS

services and novel applications for Copernicus, Galileo and EGNOS

capabilities including SSA, GOVSATCOM, Quantum

ecosystems (incl. New Space and start-ups) and skills

strategic actions supporting the EU space sector, including technological

space sciences and In-Orbit-Demonstration and Validation

from EU Member States and Horizon Europe Associated Countries (updated

organisations, private companies, public authorities,

organisations and others. Entities from low and middle income countries

with EU funding while entities from other third countries may participate with

Exceptions to the eligibility to participate apply to thematic areas of

for Europe.



Further information can be found in the work programmes.

Apply via the **Funding and Tender opportunity portal**.

Note that some activities are implemented either through

HaDEA, EUSPA or ESA.

Entrepreneurship initiative

Commission's CASSINI initiative **supports the European New Space ecosystem**

the entrepreneurship cycle. The initiative is open to all areas of the EU

and covers both upstream and downstream space.

graduates, researchers, start-ups in their very early stages and SMEs from

states, Associated Countries or countries which are in ongoing negotiations

agreement and where the agreement applies before the award.

information, **click here**.

Pillar 3: Innovative Europe

European Innovation Council (EIC)

The EIC has a budget of €10.1 billion to **support game-changing innovations, including in the space domain**, throughout the lifecycle, from early-stage research to proof of concept, technology transfer, and the financing and scale-up of start-ups and SMEs. Thematic areas covered include:

- The proof of principle and validation of the scientific basis of breakthrough technology (TRL 1-4)
- Validation and demonstration of the technology in application relevant environment (TRL 4 to 5/6) and development of market readiness

Open to research organisations, universities, SMEs, industry, Single start-ups, individuals.



Total HE budget

10€ B



Grant budget

0,5-15€ M



For further information, **click here**.



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SPACE SITUATIONAL AWARENESS:

MAKING SPACE
ACTIVITIES SAFER AND
MORE SUSTAINABLE



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European Union



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a programme of the
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SSA – Europe’s eyes on Space

Space Situational Awareness (SSA) is a component of the **EU Space Programme** and encompasses capacities that **monitor the space environment**. It aims to **better understand, define, and recognise potential threats** coming from outer space that could harm space infrastructure and humans.

The EU’s SSA programme consists of **three subcomponents**:

- Space Surveillance and Tracking (SST)
- Space Weather Events (SWE)
- Near Earth Objects (NEO)

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SST – Ensuring space safety and sustainability

Space Surveillance and Tracking (SST) enables the observation of satellites and space debris to **avoid collisions**, survey **uncontrolled re-entries** of space objects into the Earth’s atmosphere, and **assess fragmentations** of objects in space.



Innovative sensor network

Currently¹ 15 Member States are gathered in the EU SST Partnership networking their national assets of more than 40 sensors to collect data on space objects. These radars, telescopes and lasers are distributed in different locations around the planet.



Keeping assets safe

The EU SST Front Desk at EUSPA together with the EU SST Partnership provide **SST services to more than 500² satellites and deliver collected data to over 200² organisations worldwide**.



Safeguarding space operations

EU SST constitutes the operational backbone of the EU approach to Space Traffic Management (STM). The EU STM approach³ encompasses the means and the rules to access, conduct activities in, and return from outer space safely, sustainably, and securely, aiming at sustainable space activities.



Performant European industry

The Union’s SST capabilities also rely on a cutting-edge and competitive SST industry. To that end, the EU Industry and Start-ups Forum (EISF)⁴ on STM allows industry stakeholders, the EU SST Partnership, EUSPA and the European Commission to jointly define activities and R&D priorities supported by EU budget through public tender processes.

SWE – Monitoring space weather

Space Weather Events (SWE) can, amongst other ways, manifest themselves as solar flares and coronal mass ejections, impacting the environment in space and Earth. To improve our capabilities in SWE **now-and forecasting, the EU invests in research which may help reduce their impact**.

¹ As of June 2024, number of MS can evolve over time

² As of June 2024

³ <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52022JC0004>

⁴ https://defence-industry-space.ec.europa.eu/eu-space/space-traffic-management_en

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SPACE SITUATIONAL AWARENESS:

Making Space Activities Safer and more Sustainable

NEO – Observing space rocks

Near-Earth Objects (NEO) are space rocks (comets, asteroids, and meteors) that orbit near Earth or enter the Earth's atmosphere. **Better understanding what they are made of helps to reduce the risks they may pose.** The EU has mapped Member State capabilities to **detect, monitor, and respond to NEOs**, and organises a yearly conference to facilitate NEO cooperation.

Introducing EU-funded space R&I projects

SST

SST Sensors and Processing aims at strengthening capabilities of radiofrequency (e.g., radars) and optical (e.g., telescopes) ground-based sensors to adapt to new technologies and improve coverage area.

Space-based SST (mission, system, and sensors network) addresses the study of several technical solutions including non-dedicated sensors or hosted payloads for the development of a future European capability of SBSS.

SST&STM system architecture and evolutions supports the improvement of the European SST system to reach higher performance and better autonomy while developing higher levels of cooperation with other SST systems.

SST Networking, Security & Data sharing supports coordination, interoperability, and resilience of EU SST assets to achieve higher efficiency and uninterrupted data provision; this requires enhancements of the EU SST Front Desk support and implementation of threat analysis e.g., on cybersecurity.

SWE

ARCAFF Solar flares and coronal mass ejections are some of the most powerful explosive Sun events. Better understanding these events will help to improve forecasting abilities to reduce their impact on the environment.

T-FORS aims at gaining capabilities to protect the performance of space assets through forecasting travelling ionospheric disturbances which is a phenomenon that disturbs e.g., communication between space- and ground-based infrastructure.

NEO

NEOROCKS focuses on developing observational capacities to identify and characterise new NEOs and simulate their behaviour.

NEO-MAPP helps to better understand the dynamical and physical properties of astronomical objects and their reaction to external forces. This will help to better protect space infrastructures in case of an impact with an NEO.





Be part of the EU-funded space R&I

Horizon Europe is the EU's key funding programme for research and innovation, with a budget of €95 billion over 2021-2027, of which close to €1.6 billion is dedicated to space research. That space part is managed by the Health and Digital Executive Agency (HaDEA), the EU Agency for the Space Programme (EUSPA), the European Space Agency (ESA) and the European Commission itself. Together with a broad range of European stakeholders, the European Commission defined the strategically important areas in its **Strategic Research and Innovation Agenda (SRIA) for Space R&I**.

It serves as a guidance for the Horizon Europe programming for everything related to competitiveness and access to space. The other elements guiding the programming are the evolution of the infrastructure, the services and the applications of the EU Space Programme components (Galileo, EGNOS, Copernicus), the development of key innovative capabilities such as Space Situational Awareness and Quantum technology-based applications, the preparation of the Secure Connectivity initiative (IRIS²) including GOVSATCOM, the achievement of technological non-dependence, the development of space entrepreneurship and the conduct of IOD/IOV experiments.

An upcoming Strategy for EU Space R&I will bring all these elements together. Find more information on the **website of the European Commission** and those of **HaDEA**, **EUSPA** and **ESA**. Most calls are also published on the **EC Funding and Tenders participant portal**.

