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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

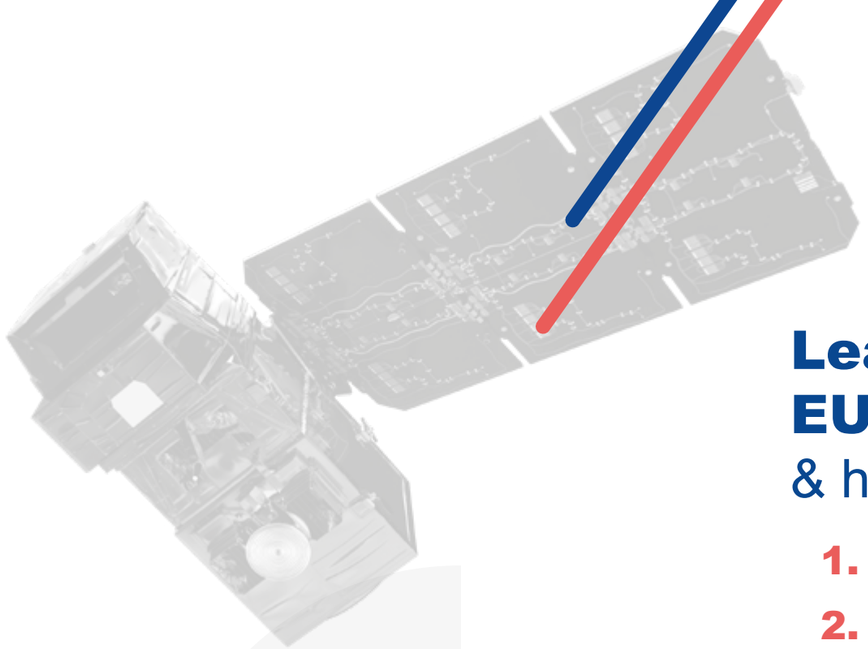
supporting EU competitiveness in the space domain for cutting-edge space technology, products and services

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 SGDGs). 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!

1. Access to space
2. Evolution of EGNSS infrastructure
3. Copernicus & EO
4. EGNSS & Copernicus downstream applications
5. Future Space Ecosystem
6. Technological non-dependency
7. Quantum technologies for space
8. In-Orbit Demonstration / Validation
9. Entrepreneurship & New Space
10. Horizon Europe & Financing

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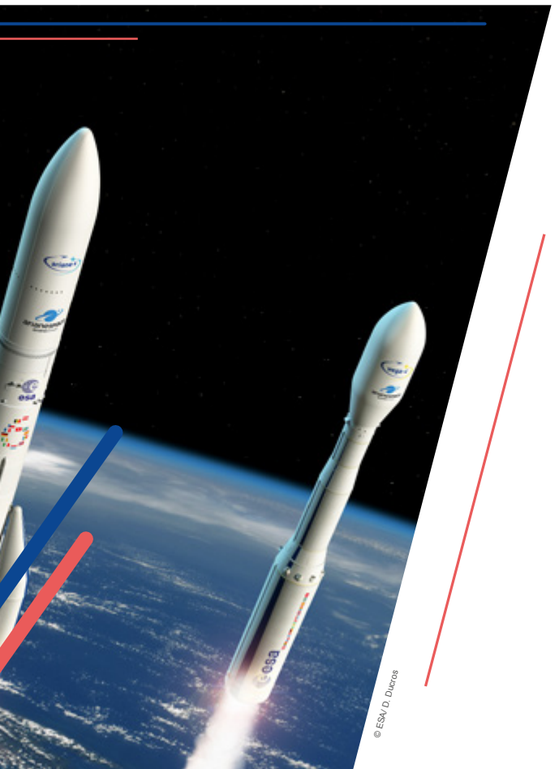
ACCESS TO SPACE

Enabling the industrial competitiveness with new services, solutions and concepts

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, Secure Connectivity, that are essential for our society as they boost economy and enhance security. In a globally ultra-competitive environment, Europe needs to support a cost-efficient, responsive and flexible access to space.



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Shifting to sustainable, green, reusable technologies

to support Access to Space

Launching spacecraft is a very resource-intensive and expensive endeavour. Existing 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.

Boosting innovative R&I

16 projects focusing on Access to Space selected for funding of €56.7 million under Horizon 2020

Accessing space

Using innovative launcher concepts and enabling new commercial space transportation solutions

Supporting EU objectives

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

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. European actors have yet to seize the emerging opportunities in space transportation, induced by the evolution of the commercial satellite market (e.g. small satellites, larger constellations).

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 responsiveness and flexibility of launch services.

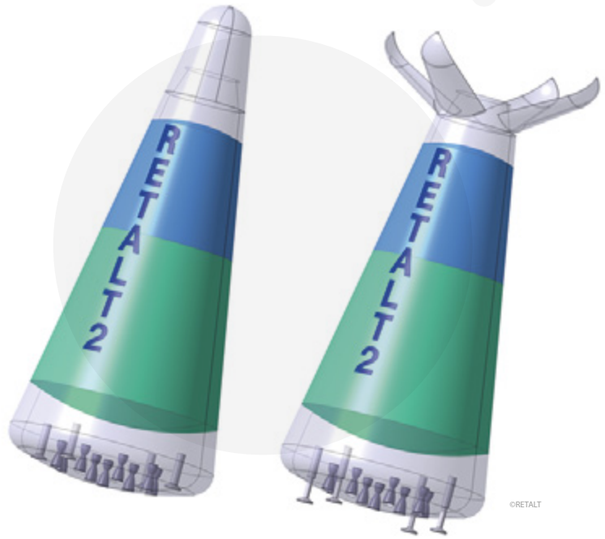
The Horizon Europe R&I Programme is a major leverage in support of the EU industry developing access to space solutions. While enhancing the competitiveness and agility of existing launchers, it also contributes to the technological maturation of new launch systems. In early 2022, the European Commission 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 current space R&I projects

Examples of Horizon 2020 projects

SAMMBA (Standard And Modular Microlauncher Based services) develops affordable, safe and flexible launch base services to meet Europe's growing demand for dedicated, reliable and frequent small satellite launches.

RETALT (Retro Propulsion Assisted Landing Technologies) investigates launch system reusability technology for operational and future launch vehicles to make reusability state-of-the-art in Europe.



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EVOLUTION OF EGNSS INFRASTRUCTURE

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

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 adresses 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 strengthen the already excellent Galileo portfolio with innovative services such as timing service, emergency warning, 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.

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 supporting the evolution of Galileo, both in space and on the ground, to leverage emerging trends, address evolving user needs and act on the other considerations outlined above. 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.

Funding Galileo's future

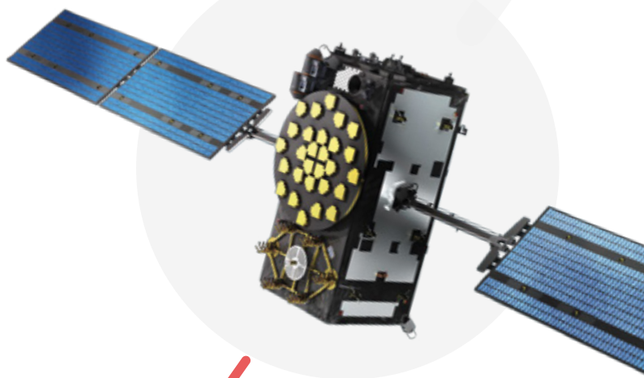
Attaining the necessary technology level for modernising its space infrastructure and for delivering innovative services

Achieving non-dependence

Fulfilling EU non-dependence in the supply of critical components of the EGNSS 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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COPERNICUS: EARTH OBSERVATION SERVING SOCIETY

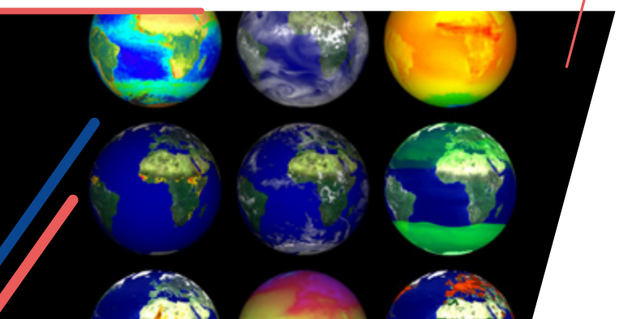
Extended capabilities for the benefit of Europe's citizens

Copernicus' Earth observations

for a healthy planet

The Earth's physical, chemical and biological systems 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 protection, 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 surface), the performance of sensors, onboard data handling capabilities and underlying technologies, among others.

Boosting innovative R&I

€50.7 million of H2020 funds contributed to EO technology research between 2014-2020

Europe's eyes on Earth

Monitoring our planet and its environment for the ultimate benefit of European citizens

Supporting EU objectives

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

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.

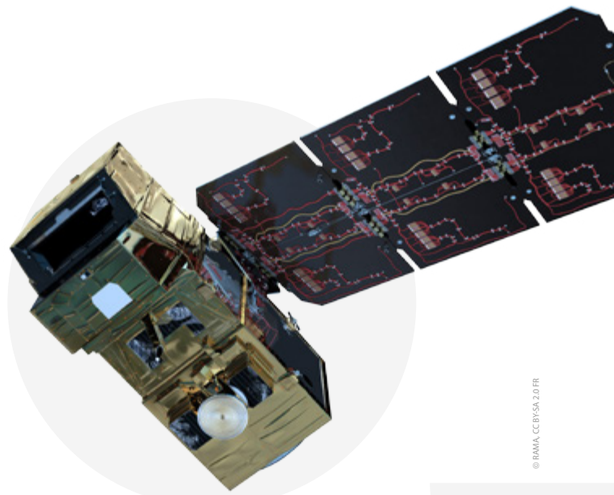
Introducing current space R&I projects

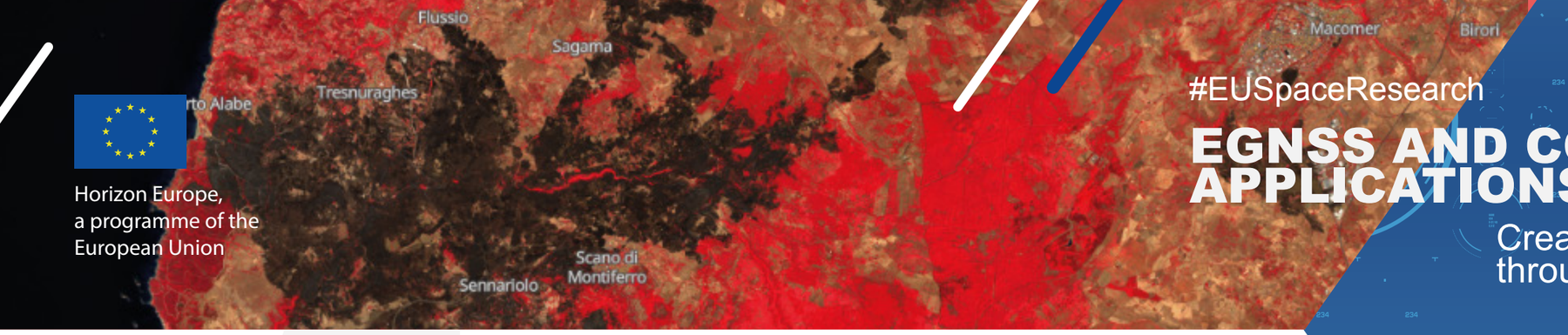
Examples of Horizon 2020 projects

Project HI-SIDE (High-Speed Integrated Satellite Data Systems) aims to develop and demonstrate satellite data-chain technologies to advance onboard data handling and support high-speed data transfer for future applications.

Project LEMON (Lidar Emitter and Multispecies greenhouse gases Observation instrument) aims to develop a Lidar emitter for space applications to monitor greenhouse gases and water vapour.

Project REDDCopernicus assessed a future Copernicus Earth Observation service component to support sustainable forest monitoring.





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EGNSS AND COPERNICUS APPLICATIONS

Creating value-added applications through innovative space R&I

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 EGNSS and Copernicus-based applications, which ensure food security and traceability across the entire 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 mitigate climate change.
- **Health:** By effectively forecasting UV radiation or air pollution levels, Copernicus applications help mitigate damage 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.

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 on 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 important 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.

Introducing current space R&I projects

Examples of Horizon 2020 projects

Project SARA developed a drone to be used for Search and Rescue (SAR) and Surveillance purposes, for instance to retrieve people lost at sea. SARA makes usage of Galileo GNSS receivers allowing high accuracy for guidance, navigation and control of drones as well as for target identification and localisation.

Project ARIADNA (Awareness Raising and capacity building Increasing ADoption of EGNSS in urbaN mobility Applications and services) supported the adoption of EGNSS for Public Transport and urban mobility by raising awareness on GALILEO / EGNOS benefits.

Boosting innovative R&I

€32.6 million in 2021 through Horizon Europe for the development of innovative space downstream applications

Accessible space data for all

Encouraging and facilitating the use of Copernicus and EGNSS data in a wide range of useful applications

Supporting EU objectives

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

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THE EU FUTURE SPACE ECOSYSTEM

Enable industrialisation and new services in space with intelligent solutions and concepts

In-space services:
A paradigm shift

In the future, in-space services (such as on-orbit satellite servicing, assembly, manufacturing, recycling, debris removal and logistic services) will enhance the **resilience and sustainability of space assets**.

New technologies and capabilities will increase the freedom of action, service life, system reliability, safety, economy as well as performance and function of systems. We will move from “static space” towards **“flexible, cost-efficient and sustainable space”**. Relevant space EU-funded R&I actions aim at accelerating the commercial opportunities and enhance European competitiveness.

Toward a flexible, highly automated, sustainable and economically viable EU future space ecosystem

At the core of the paradigm shift toward intelligent space systems are lying robotic technologies, new industrial processes, modular and maintainable spacecraft designs, architectures and approaches, digitalisation and artificial intelligence. Together with other **enabling technologies** such as electric propulsion systems, they will change how space assets are designed, produced, tested, transported and operated. Different means like Design-to-Manufacture, Design-to-Service, Design-to-Recycle, Design-to-Customise or Design-to-Value, realised with the construction kit and the “AppStore”/ Open-Architecture principles, will benefit the EU future space ecosystem and foster a circular economy. In-space services will reduce costs and time-to-market. They will also make multi-mission a possibility, enable reusability, protect the space ecosystem and incisively mitigate space debris. The European Commission recognises the **strategic importance of in-space services**.

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Boosting innovative R&I

35 projects focusing on Space Robotics and Electric Propulsion selected for funding over 2014-2021 for €115.5 million

Towards operationality:
What are the next steps to achieve in-space services?

Already under Horizon 2020, the Commission launched two Strategic Research Clusters: **PERASPERA in Space Robotics Technologies** and **EPIC in Electric Propulsion**. With PERASPERA, the Union funds the development of capabilities and technological building blocks that will enable applications and services in orbit and system concepts. With EPIC, the Union funds electric propulsion, a key technology to sustainably and efficiently manoeuvre in orbit. With the support of these two Strategic Research Clusters, the European Commission has paved the way for the EU Future Space Ecosystem.

The **EU Future Space Ecosystem will continue developing and taking shape through dedicated actions** in the Horizon Europe work programmes over 2021-2027. Calls will target topics such as On-Orbit Servicing/Assembly/ Manufacturing (OSAM) and other in-space services (e.g. logistics, warehousing and disassembly/reuse/recycling), new system concepts, functional building blocks, tools required for design, and new approaches for production and testing.

Reshaping space

Using standardisation and automation for space

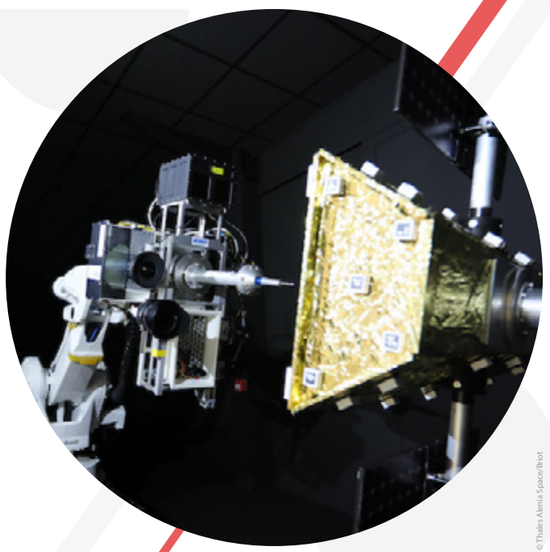
Supporting EU objectives

By ensuring a globally competitive and innovative European space sector

Introducing current space R&I projects
Examples of Horizon R&I projects

Project EROSS+ (European Robotic Orbital Support Services)’s objective is to demonstrate the European solutions for the servicers and the serviced LEO/GEO satellites, enabling a large range of efficient and safe orbital support services. Focus of application: On-Orbit Servicing.

Project PERIOD (PERASPERA In-Orbit Demonstration) prepares the paradigm shift to change the way space systems are designed, built and operated, moving from mission-specific solutions to a modular spacecraft environment. Focus of application: On-Orbit Assembly.



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EUROPEAN SPACE NON-DEPENDENCY

Supporting the development of critical space components, systems and technologies

About space technology non-dependencyy

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.

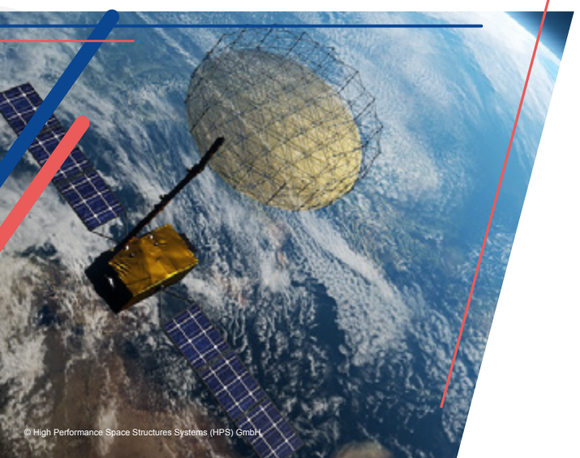
Towards the future:

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 though a Joint Task Force.



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Boosting innovative R&I

Funds in the order of €105 million have been provided under H2020 for critical space technologies for European non-dependence

Shaping solutions

By strategically funding European space technologies

Supporting EU objectives

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

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, Europe should develop its **own domestic production of critical technologies**. Significant areas of R&D, evaluation/ qualification and EU investments in the last years include:

- The development of the first radiation hard **FPGA (Field Programmable Gate Array)** supply chain in the EU that will be able to cover different families of FPGAs. The European Commission funded projects covering the design, manufacturing, validation and space qualification. These components will be used in multiple space missions, including Galileo.
- The first EU-developed and manufactured space driven, radiation-hardened **System on Chips (SoC)** based on 28nnm architecture.
- **GaN (Gallium nitride) technology**
  The European Commission funded several projects aimed at maturing and evaluating the GaN microwave foundry production process. This domain has also recently supported projects targeting the development of EU based GaN technology for power applications, covering both low voltages (<50V) and high voltages of up to 650V.
- **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.

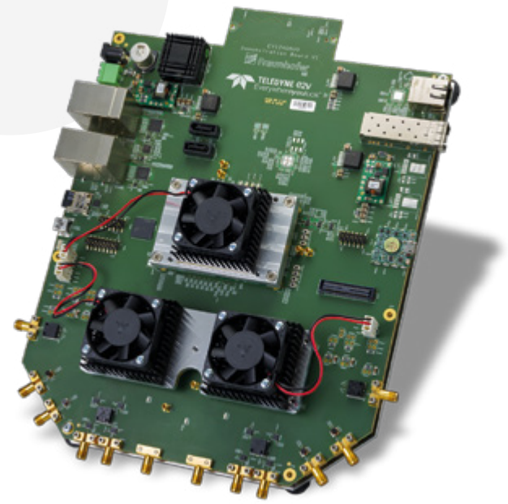
These efforts will boost European competitiveness and non-dependency especially in space electronics, as well as improve resilience of space-related supply chains and technological performance.

Introducing current space R&I projects

Examples of Horizon 2020 projects

Project INTERSTELLAR (Multichannel High-speed analogue-to-digital ADC and digital-to-analogue data converters DAC) builds the next generation of high-speed data converters to strengthen European excellence and competi- tiveness in space applications and beyond.

Project HEATPACK aims to develop the next generation of low thermal resistance packages for space applications, in particular thanks to the implementation of state-of-the-art diamond based composite materials and disruptive new heat sinking solutions.



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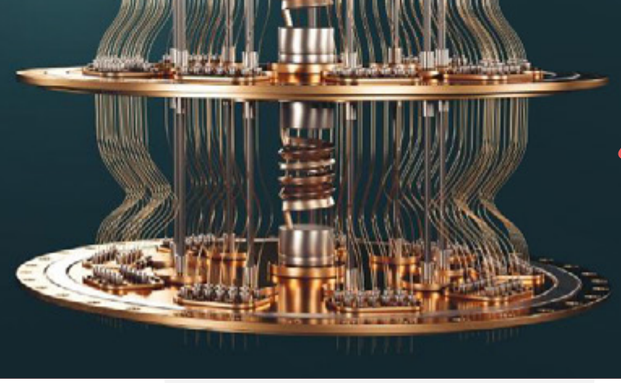

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QUANTUM TECHNOLOGIES FOR SPACE

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

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 **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*

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

Applications of the quantum revolution:

Quantum Space Gravimetry

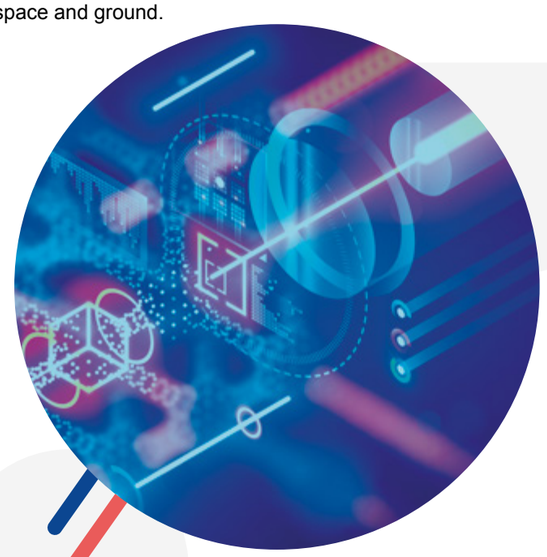
The use of quantum technologies for enhanced space-based climate data and environmental processes modelling can be a game-changer to **monitor the Earth's resources, assess and predict adverse climate change and future disasters**. The satellite gravity missions provide unique observations which are 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.

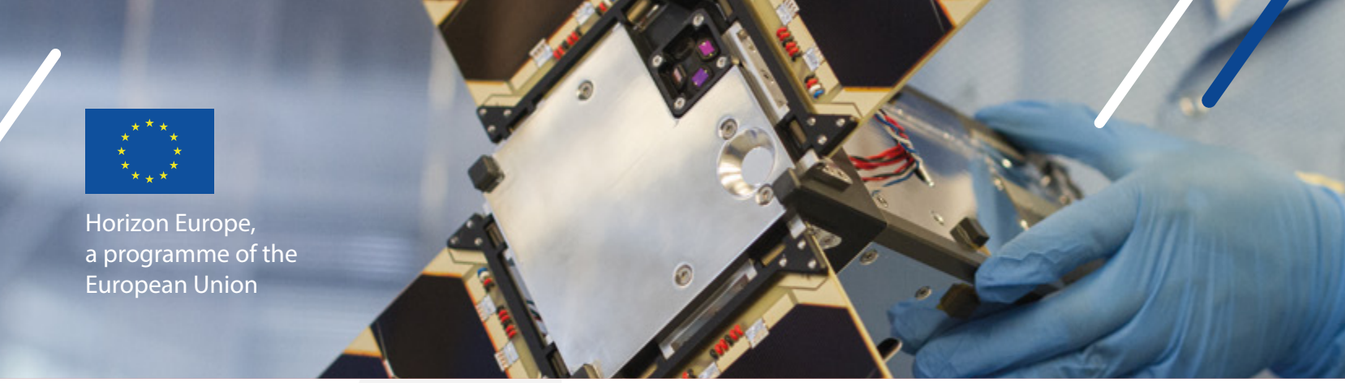
Quantum Key Distribution

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

EuroQCI will include a **terrestrial segment which will rely on fibre communications networks** linking strategic sites at national and cross-border levels and a **space segment 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 the operationalisation of the Quantum Key Distribution service with the Eagle-1 mission by the end of 2024. That mission is co-funded by Horizon Europe and is a precursor of the EuroQCI initiative, which will be at a later stage integrated into the EU's Secure Connectivity programme.



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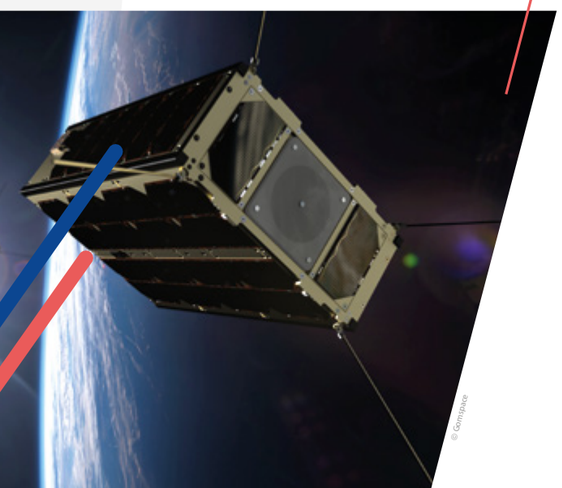
IN-ORBIT DEMONSTRATION AND VALIDATION (IOD/IOV)

New technological developments and innovations tested in orbit

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.



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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 spacecraft, if needed, and 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 thus enables SMEs, researchers and large companies to bring new technologies to the market in a reduced timeframe. It also provides students and European engineers with invaluable hands-on experience in real-world space programmes.

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Boosting innovative R&I

100+ applications received under the already published calls

Shaping solutions

Evidencing the capability of European space research and industry

Supporting EU objectives

- Maintaining Europe's place as a global space leader
- Ensuring EU non-dependence
- Providing hands-on opportunities for the European Higher Education system
- Supporting new entrants in satellites and launchers

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

The global competitiveness of the European space sector: IOD/IOV allows technologies 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.

Enable the development of new commercial entrants: IOD/IOV supports the development of the New Space phenomenon in Europe, by progressively relying on technology from SMEs and start-ups active in satellite manufacturing and micro launchers 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 aims to provide a generation of European engineers with hands-on experience in real-world space programmes.

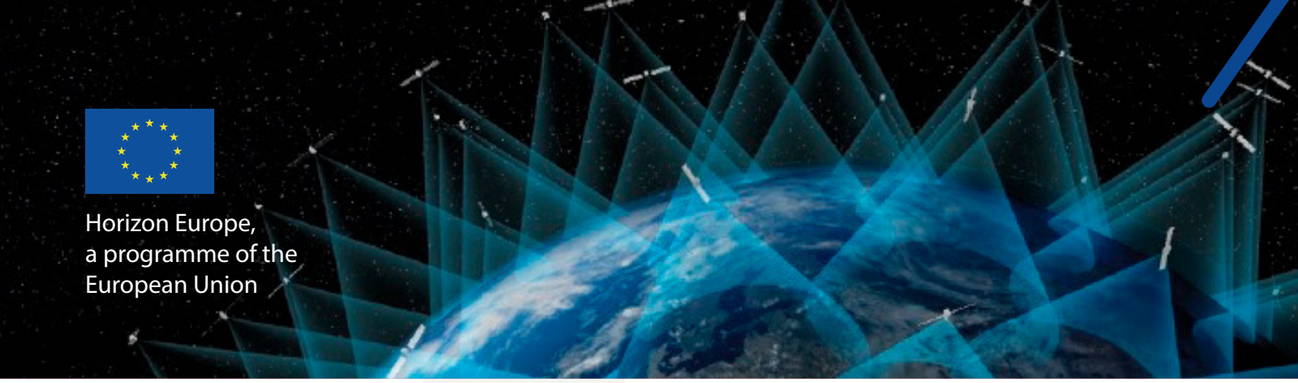
From experiment selection to space:
The first results of the initiative

The first call for expressing interest in IOD/ IOV experiments was kicked-off in April 2018 under Horizon 2020. It attracted **50+ proposals** from various European entities, from SMEs to 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 remaining experiments will be launched in the upcoming years.

In spring 2022, a new call for expression of interest was 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 Earth Observation, Positioning, Navigation and Timing, Space Traffic Management, Telecommunications, etc.

Introducing the first IOD/IOV project: UPMSat-2

As the first beneficiary of the IOD/IOV initiative, the Universidad Politécnica de Madrid (UPM) designed and built a 50-kg microsatellite **(UPMSat-2)** that carried six new payloads developed by industry, space agencies and research centres into orbit in 2020. The experiments included new technology for positioning satellite antennas, thermal microswitches, simplified solar sensors and radiation monitors that can observe how space radiation affects onboard computer memory. Improving knowledge in all these domains is helping scientists and engineers design and build more efficient, robust satellites and may also provide solutions to problems that we face here on Earth.



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NEW SPACE AND EUROPEAN ENTREPRENEURSHIP IN SPACE

Elevating Europe's space entrepreneurs to new heights

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

Reshaping space

Empowering new ideas for space

Supporting EU objectives

By promoting a globally innovative European New Space domain

Introducing the CASSINI Actions

To encourage and support the European New Space ecosystem, the European Commission has launched the CASSINI Space Entrepreneurship Initiative. Its objective is to cover the whole entrepreneurship cycle through a broad range of actions:

Cassini Facility deploys a €1 billion investment for Venture Capital funds interested in investing in EU-based companies in the space sector.

CASSINI Matchmaking supports start-ups, scale-ups and SMEs by connecting them with potential investors and/or corporate partners to expand their financing opportunities, secure new customers and access new markets.

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.

CASSINI Business Accelerator seeds grant of €75k and six months of business acceleration for space-based start ups finalising their Minimum Viable Product.

CASSINI Prizes trigger entrepreneurs to develop close-to-market digital applications based on EU space data, including satellite images, positioning services and other sources.

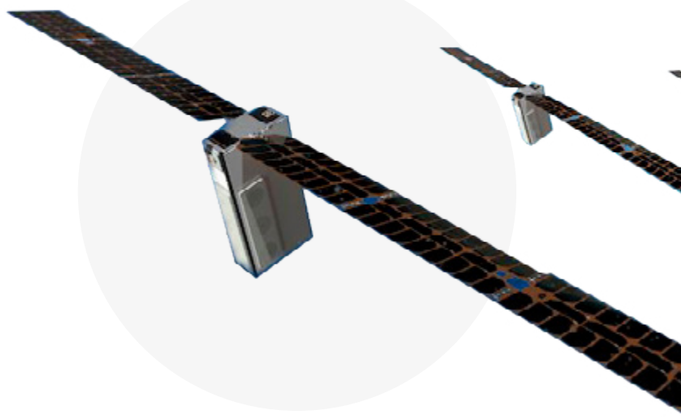
EU-wide **CASSINI Hackathons**: an opportunity to stimulate entrepreneurship and to develop ideas for digital applications building on space data, for students, graduates, researchers and teams/start-ups in the early stage of their journey.

Introducing the EIC activites

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.

- 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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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 (HE) is the EU's main **funding program for research and innovation, including in the space domain**. It contributes to fighting climate change, achieving the UN Sustainable Development Goals and boosting EU competitiveness and growth. The program encourages cooperation and strengthens the impact of research and innovation in developing, supporting and implementing EU policies and solving global problems.

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: Global challenges and European Industrial Competitiveness

Digital, Industry and Space

R&I funded within Pillar 2 aims to **boost key technologies and solutions underpinning EU policies & Sustainable Development Goals** (SDGs).

Space areas covered include:

- Space systems and Access to Space
- Space and ground infrastructures for Galileo/EGNOS
- Evolution of services and novel applications for Copernicus, Galileo and EGNOS
- Innovative space capabilities including SSA, GOVSATCOM, Quantum
- Space entrepreneurship ecosystems (incl. New Space and start-ups) and skills
- Targeted and strategic actions supporting the EU space sector, including technological non-dependence, space sciences and In-Orbit-Demonstration and Validation

Open to entities from EU Member States and Horizon Europe Associated Countries (updated list available **here**), such as research organisations, private companies, public authorities, non-governmental organisations and others. Entities from low and middle income countries can participate with EU funding while entities from other third countries may participate with their own funding. Exceptions to the eligibility to participate apply to thematic areas of strategic interest for Europe.

Total HE budget
1,6€ B

Project budget
1-20€ M

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**.

CASSINI entrepreneurship initiative

European Commission's CASSINI initiative **supports the European New Space ecosystem covering the whole entrepreneurship cycle.** The initiative is open to all areas of the EU Space Programme and covers both upstream and downstream space.

Open to students, graduates, researchers, start-ups in their very early stages and SMEs from the EU Member States, Associated Countries or countries which are in ongoing negotiations for an association agreement and where the agreement applies before the award.

For further 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.**

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 €95billion 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**.