

space economy

CREATING VALUE

FOR EUROPE

→ SPACE AS AN ENGINE OF SUSTAINABLE GROWTH AND AUTONOMY

In the context of critical environmental, social and economic challenges, like climate change or the energy crisis, all compounding the damage from the Covid-19 pandemic, space has an ever more important role to play. While geopolitical tensions are accelerating the global economic slowdown, leading to high risks of weak growth and increased inflation, space activities and capabilities hold the potential to fuel Europe's industrial competitiveness, innovation and non-dependence, and support a sustainable and more responsible economic growth.

As space becomes ever more integrated into the daily lives of citizens, the impact of space activities on the European economy and society is growing stronger and reaching further, providing crucial solutions and support for monitoring, early warning, or emergency responses in case of catastrophic events.

As urged by the Organisation for Economic Co-operation and Development (OECD), the continuous public investment in innovation, science and technology is essential in times of crisis, to support a sustainable economy and society and to prevent the loss of R&D capabilities and critical skills which safeguard and strengthen sovereignty.

CONTENTS

Science and Exploration	2
Safety and Security	4
Applications	6
Enabling and Support	9
Ambitious space for Europe's society and economy	11

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→ SCIENCE AND EXPLORATION

Expanding our fundamental understanding of the Universe



Scientific and technological benefits

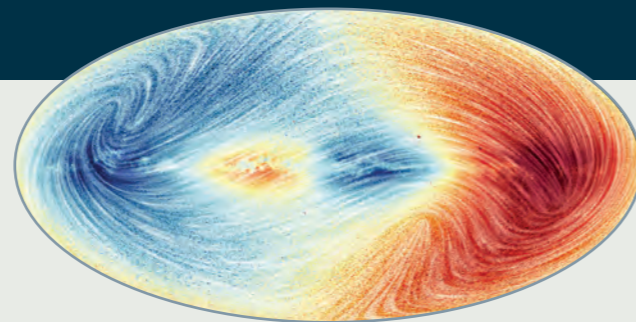
Creating knowledge

In 2021, ESA-led **science missions** generated more than 3,450 publications. When considering a longer time period, suitable to a large-scale science mission such as Gaia, the ambitious European mission to chart a three-dimensional map of our Galaxy, and launched in 2013, the number of publications exceeds 6,600 as of June 2022.

In exploration, as of September 2021, Europe's participation to the **International Space Station (ISS)**, as well as all other ESA low gravity platforms, had contributed to more than 6,400 publications since 1972. Almost 2,000 European researchers were involved in conducting ISS experiments.

Empowering Europe's technological edge

Space science and exploration are also major drivers of innovation, leading to the development of unique technological capabilities that increase European competitiveness and support European non-dependence. The **Science Core Technology Programme (CTP)** enables the development of cutting-edge technologies that not only allow the successful implementation of science missions, but also open access to new domains and market segments through space and terrestrial applications, such as precision mapping (from the development of high accuracy star tracker), quantum technologies (thanks to cooling technologies) or the medical sector (from x-ray optics technologies)¹.



Strategic benefits

Expanding global cooperation

Science and exploration stimulate interaction among scientists, across Europe and with international partners. As of fall 2021, the ISS had been visited by 243 individuals from 19 countries working together in international crews. **Terrae Novae** Period 2 involved more than 20 states, with 408 companies and 95 research organisations contracted.



Ensuring scientific leadership and non-dependence

The **Science programme** develops and operates a portfolio of missions, which ensures that the European scientific community maintains its position at the highest levels of discovery and innovation. Science and exploration develop industry-leading skills and capabilities, strengthening European supply chains and their position on the domestic and export markets. They also support the development of critical world-leading hardware and software solutions within the European industry, reducing dependence on outside suppliers. The **Science CTP programme**, through the development of the high-accuracy 3-axis accelerometer AQUILA, increased European non-dependence on an export-restricted critical technology¹.

¹ Know.space for ESA, Socio-economic benefits from ESA Science CTP, 2022



Societal benefits

Generating extremely high public visibility and inspirational value

The ability of **science and exploration** activities to inspire the public is one of their highest societal impacts. The 2021-2022 **astronaut selection** has seen more than 22,000 applications received from across Europe. Science and exploration missions trigger public interest and significantly more media attention than other satellite activities. More than 10 million people followed the event of the Philae landing on the comet in November 2014 as part of the **Rosetta** mission, after more than ten years travelling through space.



Contributing to global societal challenges such as sustainability and the circular economy

Science and exploration also provide new means to address global challenges and sustainable development. The knowledge, products, services, or applications derived from exploration activities provide solutions in areas such as climate, responsible consumption, architecture and resource

management, health care and medical technologies, and carbon footprint, contributing to global challenges, such as the UN Sustainable Development Goals, and the pressing European policy priorities.

Advanced Life Support Systems technologies developed for human spaceflight lead to highly valuable spin-offs for terrestrial applications, including carbon recycling for smart farming and waste or water treatment for isolated and developing communities².



Economic benefits

Supporting economic growth and employment in Europe

Some of the largest **science missions*** launched since 1984 together generate more than €7 billion of contribution to the European economy across the period 1984-2036³, and an employment multiplier of 2.1, from a total investment of Member States through ESA of just under €4.5 billion⁴.

The third period of **Terrae Novae** exploration programme, which includes missions and technology developments to LEO, the Moon and Mars, is expected to generate more than €2.8 billion of contribution to Europe's Gross Domestic Product, more than €800 million of government revenues (taxes) and about 3,850 jobs supported per year, across the period 2023-2030².

* XMM-Newton, Rosetta, SOHO, JUICE, ARIEL, SMILE and contribution to Hubble Space Telescope (HST) and James Webb Space Telescope (JWST)

² Euroconsult for ESA, Terrae Novae socio-economic impact and benefits assessment, 2022

³ Measured in terms of Gross Value-Added (GVA), the activities' contribution to GDP and economic growth

⁴ PwC for ESA, Socio-economic impact assessment of ESA's Science Programme, 2019

→ SPACE SAFETY

Protecting our planet, humanity and assets in space



Societal benefits

The **Space Safety Programme (S2P)** contributes to the protection of our planet, humanity and assets in space and on Earth from hazards originating in space. The early discovery of an asteroid on collision course with Earth will enable the successful application of mitigation measures, saving lives and avoiding potentially dramatic damage to infrastructure and property, estimated at €3.8 billion for a 50m object, €42 billion for a 140m object and €3.2 trillion for a 1km object (all in 2016 values)⁵.



Economic and strategic benefits

Avoiding damages to critical terrestrial services

One single extreme space weather event was estimated to cause potential socio-economic damages of up to €15 billion (in 2016 values)⁵. The Space Safety programme provides services to extensive terrestrial market segments such as resource exploitation, aviation, or power grids operations, avoiding costs from potential delayed flights, disruption of exploration activities due to magnetometer distortion or damages on life and property due to power grid blackouts.



Technological benefits

Enabling innovation and technology gap shortening

Space Safety overcomes technological challenges and further expands the portfolio of unique European capabilities⁶.

- **Aurora**, the mission for monitoring Auroral oval on both hemispheres, will further improve space weather services, with a 5 to 6 times higher reliability than a typical small satellite.
- A European **space weather 'smallsat' fleet** can improve cost efficiency by a factor of 3, and data latency by a factor of 8.
- **Laser tracking** would reduce collision avoidance manoeuvres and impacts by 90% for European satellites.

Opening market opportunities and competitive advantages for Europe

Space Safety activities open significant market opportunities for the European space industry, supporting its competitiveness through the development of strategic advantages.

The development of more robust platforms for space weather monitoring is expected to enable €1.5 billion of market opportunities in Europe for the nanosatellite and small satellite platforms (over a period 2028-2035)⁶.

⁵ PwC for ESA, An ex-ante cost benefit analysis of the ESA Space Situational Awareness (SSA) programme, 2016 | ⁶ PwC for ESA, Socio-economic impact assessment of ESA's ground systems engineering and operations activities and Space Safety programme, 2022

→ APPLICATIONS

Accelerating the use of space for both industry and society



Economic benefits

Supporting Europe's leading position in the commercial space application market

The European downstream market, through the selling of capacity, data and value-added services in **satellite navigation (satnav), satellite communication (satcom) and Earth observation (EO)** is worth €60 billion in 2021, accounting for almost one-fourth of the global downstream application market⁷.

The European downstream **navigation** industry has a dominant market share in critical market segments, such as the road and automotive segment (with a 53% market share in components and receivers in 2019) and the maritime segment (47% of market share in 2019)⁸.

The **satcom** market continues to account for almost half of Europe's commercial downstream revenues⁷. Each €1 million of Member States' investment in the **Advanced Research in Telecommunications Systems (ARTES)** programme has generated €3.4 million in revenues for the European space industry (to date) and is projected to increase by 2025 to a 9.8-times multiplier⁹.

The **EO** market in Europe has been sustaining a consistent growth, with a 7% growth rate over the past five years, a percentage point above the global growth rate⁷.

Creating economic value and employment for Europe

FutureEO provides the vital first links in the end-to-end value chain that delivers the socio-economic benefits of the overall European Earth Observation activities. Over the period 2018-2021, investment in FutureEO-1 Segment-1 and EOEP-5 generated more than €1.8 billion of contribution to the European economy³. Over the period 2023-2030, investment in FutureEO could generate up to €3.2 billion of value-added in Europe¹⁰.

At least 17,700 jobs have been created and maintained in Europe as a direct result of Member States' investment in satcom market through **ARTES**⁹ (across 2018-2021).

⁷ Euroconsult, The Space Economy Report, 2022

⁸ EUSPA, EO and GNSS Market Report, Issue 1, 2022

⁹ Euroconsult for ESA, TIA socio-economic analysis, 2022

¹⁰ PwC for ESA, ESA FutureEO Impact Assessment, 2022



Societal benefits

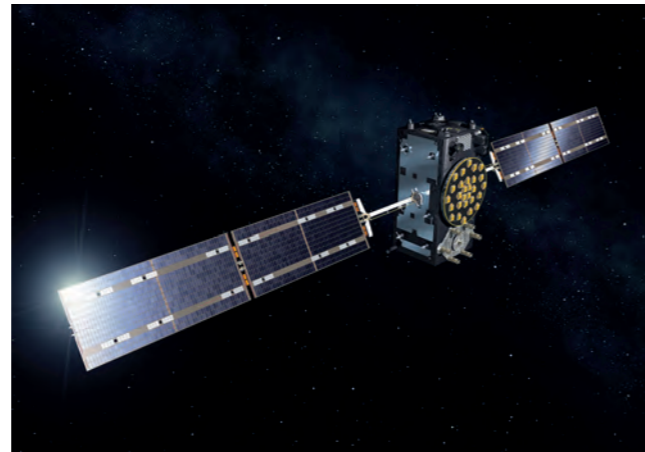
Providing reliable information to benefit European citizens and meet future challenges

As the number one world provider of space data and information, **Copernicus** is a tool leveraged by European public authorities to make informed decisions and enforce environmental policies. As an example, Sentinel-1 radar and Sentinel-2 optical satellite data were used to map flooded areas in Latvia following extremely heavy rainfall in 2017 which led to a state of emergency for the agriculture sector. With Sentinels used to check the damaged fields, the rural support service administration was able to finish compensation payments to farmers less than two months after the first raindrop¹¹.

The innovations financed under FutureEO feed operational and government programmes related to water management. **Earth Explorer missions** as Cryosat, SMOS or the future Harmony mission will support improved policy making due to e.g., better mapping of the water use. A better hydrological modelling can also lead to improving risk assessments, supporting the path towards a more climate resilient economy and better environmental regulation and protection.

Aeolus, the fifth Earth Explorer mission, provides data that help filling significant existing gaps in the global observation system, including the poles, oceans, and upper troposphere which lacked wind profile measurements. Through both the reduction of uncertainty for decision makers in Europe, and significant contribution to weather forecasts, the total benefits

of Aeolus data and information to European stakeholders and society are estimated at up to €3.5 billion over its lifetime. Aeolus-2 could generate up to €7.1 billion over the expected designed lifetime¹².



Galileo and EGNOS create significant societal value to Europe as the performance of the European satnav constellations continues to improve at the user level, making **Galileo** the most accurate satnav system worldwide and serving 3 billion users. Galileo's metre-level accuracy for countless products and services is leveraged to create applications that improve the lives of European citizens. While improving the accuracy and reliability of the positioning information, **EGNOS** also provides a crucial integrity message which benefits critical domains such as aviation and road but also maritime and inland waterways navigation.



¹¹ Nereus, Sentinel for flood and yield loss mapping, Copernicus User Stories, 2017 | ¹² London Economics for ESA, The Value of Earth Observation Information to European Decision-Makers: Case Studies from ESA Aeolus-1 and Aeolus-2 missions, 2022

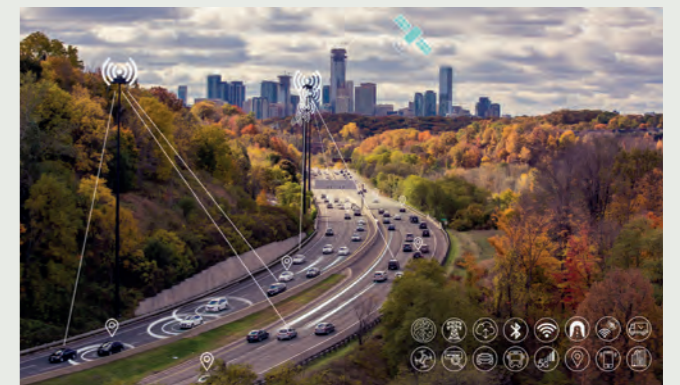


Strategic benefits

Enabling a strong and competitive European space industry

The **Telecommunication and Integrated Applications (TIA)** directorate is actively engaged in commercialisation of space as part of its DNA. Through many partnership projects with industry and other joint developments of technologies, products, and applications with significant private co-funding, Member States' investment in **ARTES** programmes has led to at least €1 billion of private investment (based on collected data for 2018-2021)⁹.

Galileo is enabling Europe and its citizens to benefit from independence and sovereignty for the provision of navigation, positioning and timing information services. The **NAVISP** programme supports the European industry in succeeding in the highly competitive and rapidly evolving global market for Positioning, Navigation and Timing (PNT, accounting for 10% of the European economy). With largely diversified activities, the programme has supported industry in generating €120 million of new commercial and institutional businesses proposing innovative PNT solutions in a wide spectrum of economic sectors, such as energy, autonomous transportation, robotics.



Scientific benefits

Ensuring European leadership in Earth System Science

Through the development of new instruments, algorithms and platforms, **FutureEO** provides free and unrestricted access to new data products for the scientific community, fully supporting Open Science and encouraging users to form communities around the data to collaborate and share best practices. The programme impacts an ever-growing international science community through the organisation of workshops attended by several thousands of scientists. From 2017 to early 2022:

- More than 400 scientific papers were published focusing on FutureEO Earth Explorers
- 17,000 scientists attended more than 40 ESA workshops
- More than 4,400 participants attended the 2022 Living Planet Symposium in Bonn

As of the end of 2021, more than 7,000 papers have been published related to the **Copernicus Sentinels**.



→ ENABLING AND SUPPORT

Ensuring an independent European access to critical capabilities and technologies



Economic benefits

Supporting economic growth and employment

The development and continued exploitation of **space transportation** services are essential capabilities for Europe to leverage space exploration, space science, and space applications for the wider benefits of society and the general public. Space transportation activities generate large positive impacts on the European economy and European space industry competitiveness, contributing 3 to 4 times Member States' investment through ESA to the European Gross Domestic Product (GDP) and ensuring European non-dependence in space through the development of key technologies, investments in assets and advancements in know-how and industrial processes¹³.

Over the period 2019-2021, investment in **space operations** (through the Operations Directorate) generated €682 million of contribution to the European economy, with each €1 of value-added generated by the European space industry

thanks to the activities leading to €3.1 into the European economy. Activities increased European employment with 3,600 jobs supported per year. Over the 2000-2021 timeframe, the total value-added from a €3.3 billion investment in OPS cumulates to €4.8 billion and an estimated 26,200 jobs supported annually in the Member States' economies⁶.

Enabling new space start-ups to generate growth and attract talent and capital

Between 2004 and 2021, 782 companies completed the ESA **business incubation programme**, while a further 320 were undergoing it. Based on the ESA BIC Network Survey 2021, with a response rate of around 50%, more than €165 million of revenue were generated in 2021, with start-ups earning on average around €300,000 from direct sales. Companies also raised over €434 million of financing and created and sustained altogether more than 3,700 jobs.



Strategic benefits

Ensuring independent access to critical systems and capabilities

Developing autonomous and independent European **Human Space Transportation** capabilities would enhance Europe's space exploration options, ensure that for procuring astronaut flight seats tax payer's money is invested in Europe rather than spent abroad, and generate additional space transportation service revenues worth several billion of euros by capturing a share of the commercial human space transportation market over the period 2028-2040¹⁴.

As Europe's centre of excellence for satellite operations, the **Operations Directorate** is home to the engineering teams that control spacecraft in orbit and build the systems on the ground that support missions in space. The activities pursued over the past 50 years provide European organisations with independent access to ground segment systems, capabilities and know-how, answering the needs and requirements of scientific, Earth observation and service-oriented space missions.

Allowing the European industry to address the most promising technology markets

The **Technology** directorate (TEC) drives the identification of future technology areas which will enable new missions and are highly strategic in ensuring European non-dependence. Technology roadmaps also allow the European space industry to have critical technologies and products with the necessary maturity, performance and competitiveness levels to meet the future market demand. Space robotics is fundamental for space exploration and utilisation and plays a role in every step of expansion of human activities from Earth to space. Having the Automation and Robotics domain addressed by the 2022 European Space Technology Harmonisation will support the European space industry to address a market potential valued at close to €6 billion across next decade (2021-2030)¹⁵.



Technological benefits

Enabling industry competitiveness through innovation-driven approach

Using active technology intelligence, notably with the assessment of the potential spin-in into the ground systems engineering and operations domain, the **Operations Directorate** pioneers the development of cutting-edge technologies. OPS currently has a strong focus on the potential adoption of Artificial Intelligence and Optical Communication to provide new world-leading capabilities in operations. The innovation-driven approach supports increased efficiency, productivity and the quality of the provided operational services while also enabling the creation of industrial spin-offs, and knowledge transfer between institutions, academia and industry.



¹³ PwC for ESA, Socio-economic impact assessment of access to space in Europe: Ariane 6 and Vega-C, 2019

¹⁴ PwC for ESA, Socio-Economic Elements of European Human Space Transportation, 2022

¹⁵ Euroconsult for ESA, Market assessment in support of the European Space Technology Harmonisation, 2022



Societal benefits

Exploiting the remarkable potential of space technology transfer

The state-of-the-art technologies, systems and know-how developed in the framework of European space programmes hold remarkable potential in the terrestrial sphere. ESA's **Technology Transfer** activities explore this potential, identifying space technologies arising from R&D contracts or inventions suitable for transfer, and answering non-space market needs¹⁶.

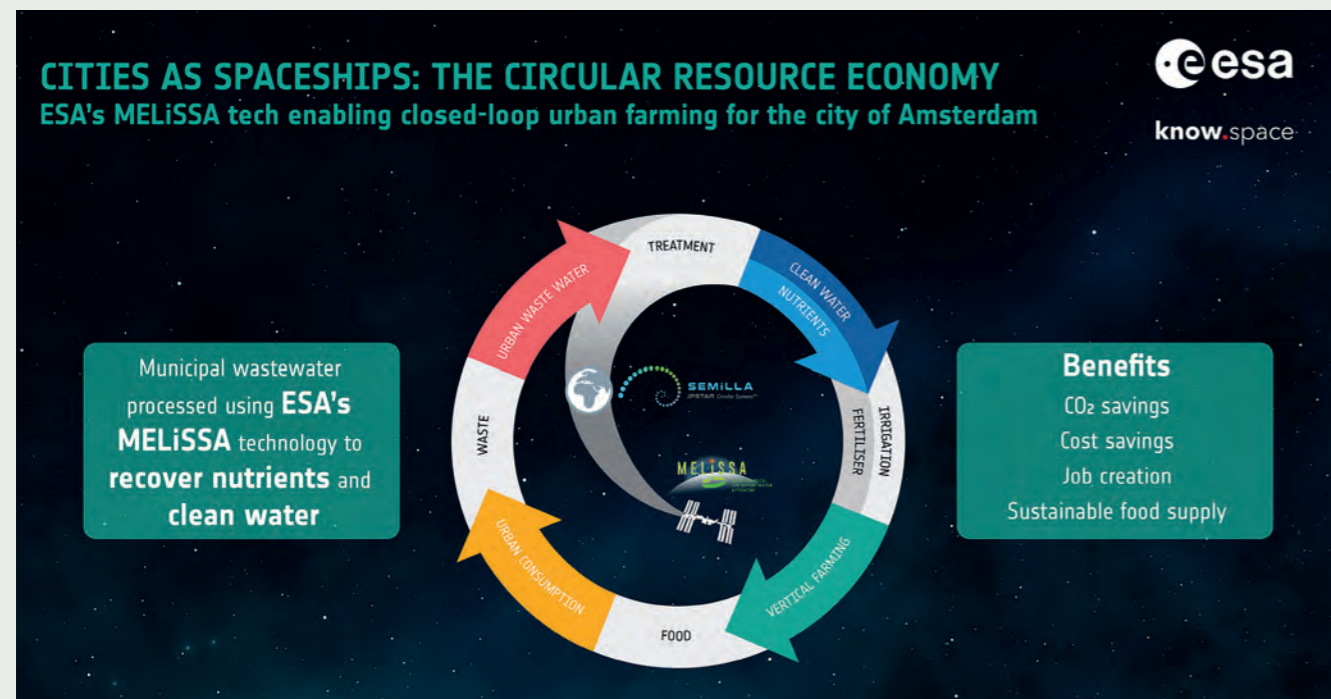
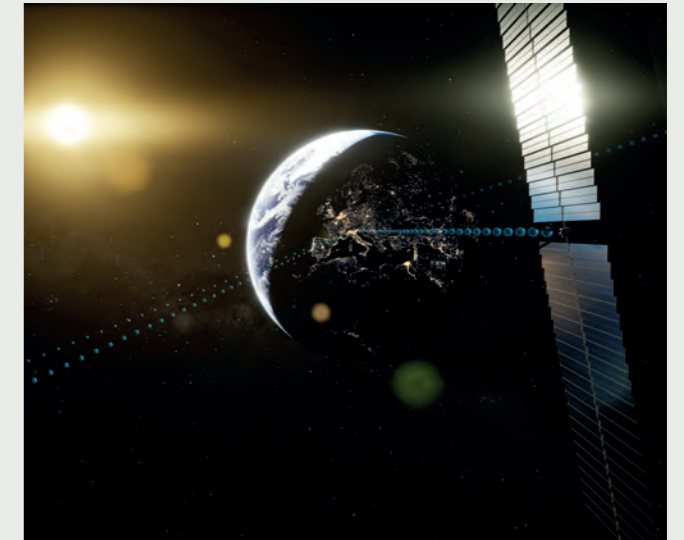
- The recovery of nutrients and cleaning of wastewater through MELiSSA technologies for the use in vertical farming was investigated. When implemented, the technology transfer could lead to a recovery of 80-90% of wastewater and reduction in food waste. The city of Amsterdam estimates such treatments could lead to a reduction of 600,000 tons of CO2 and an economic benefit of €150 million/year and 1,200 jobs created.
- Automating complex system coordination, as used for operations of satellite constellations, have proven very valuable in space. With the support of ESA, the company

EATOPS is applying its automatic code generation techniques from space mission control rooms to enable a centralized oversight for large installations, such as windfarms, natural gas or oil extraction. The solution provides a clear understanding of the system's integrity in real-time, supporting analysis and problem detection, and helping prevent disasters. EATOPS are pushing for automatic fault scenario recognition features that can foresee issues ahead of time, supporting both safety and environmental policies.

- Using ESA-patented modular deployment technology, originally designed to deploy very large support structures in space, POLAR Developments offers near-instantaneous high-capacity photovoltaic generators wherever power is needed, autonomously. Main benefits include the compact, lightweight, "plug-and-play" solutions that are easily transported, container with 176% more capacity than competitors in terms to stow kilowatt peak, 28% cheaper energy than competitors, a new spin-out created company, and 20 new jobs by 2025 that are currently forecasted.

Contributing to achieving Net Zero by 2050¹⁷

With the objective of achieving Net Zero carbon emissions by 2050, Europe is investigating ways to rapidly decarbonise its sources of electricity generation and ensure both stable and secure supply. While requiring substantial development, **space-based solar power** (SBSP) could deliver cost-competitive electricity generation, de-risking the path by providing a future source of clean, base-load energy by 2040 or earlier. The preliminary net value of a base case scenario (54 satellites by 2070) is estimated at €183 billion, with €418 billion of estimated SBSP costs and €601 billion of potential SBSP benefits (primarily avoided costs of terrestrial technologies and avoided social cost of CO2 emissions). The SOLARIS programme is meant to prepare the ground for a possible decision in 2025 on a full SBSP development programme.



AMBITIOUS SPACE FOR EUROPE'S SOCIETY AND ECONOMY

Although European public spending in space only accounts for about 0.05% of the European GDP and 0.13% of total European public expenditures, ESA programmes address some of the greatest challenges of humankind and have an ever-needed contribution in building a strong, resilient, and sustainable European society and economy by:

- Spurring innovation and driving the development of state-of-the-art European capabilities;
- Creating market opportunities;
- Accelerating economic growth, non-dependence and competitiveness of the European space industry;
- Promoting collaboration and cooperation;
- Building and sharing knowledge and European scientific excellence; and
- Enhancing safety and quality of life.

Sustained investment in the programmes of the Agency will be essential to ensure that Europe and its citizens benefits from the full value of space.

¹⁶ Know.space for ESA, Socio-economic benefits from ESA Technology Transfers, 2021-2022

¹⁷ Frazer-Nash Consultancy and London Economics for ESA, Cost-Benefit Analysis of Space-Based Power Generation for Terrestrial Energy Needs, 2022; Roland Berger and OHB, Cost-Benefit Analysis of Space-Based Power Generation for Terrestrial Energy Needs, 2022



