
esa
space economy
CREATING VALUE
FOR EUROPE
Space19

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→ EUROPEAN SPACE AGENCY PROGRAMMES: BENEFITS TO EUROPE'S ECONOMY AND SOCIETY

Space activities and capabilities fuel industrial competitiveness, economic growth and innovation and are today essential to the European economy, reaching well beyond the aerospace sector.

As space becomes more integrated into the daily lives of citizens, the impact of space activities on the economy and society is growing stronger and reaching further.

The Member States' investments in ESA programmes generate a succession of economic impacts, i.e. direct, indirect and induced ones, from the economic impact of manufacturing and launching space systems to the value created in the wider economy. Space infrastructure also delivers essential public services and is an enabler of other domains. Additional value is therefore generated by revenues that are uniquely supported by space systems. In addition, ESA programmes generate strategic impacts. For instance, they foster European leadership and promote international cooperation. They also produce scientific and technological benefits well beyond the programmes' objectives, as well as numerous societal impacts, including attracting students to science and engineering.

The present brochure highlights the socioeconomic impacts of some of the past, on-going and potential future programmes of the Agency, presented along the four pillars of Space19+.

CONTENTS

→ SCIENCE AND EXPLORATION

Exploring our Solar System and unlocking the secrets of the Universe

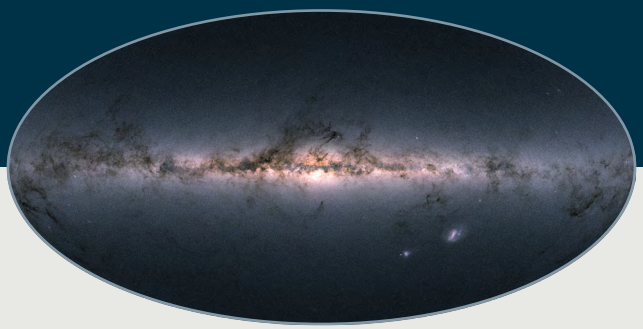
Scientific and technological benefits

Creating knowledge

In 2018, more than 2300 refereed papers were published based on data from ESA-led **science missions** (a 5% increase over 2017), GAIA being the most productive mission with 792 papers. Since the start of XMM-Newton's operations, over 6000 papers have been published, leading to 190 000 citations. For the SOHO mission, over 5500 papers have been published, leading to 180 000 citations and 20 prizes.
More than 1000 experiments have been conducted on board the **International Space Station**, with more than 1380 European researchers involved in 12 different disciplines.

Developing new technologies

Science and exploration missions have enabled the development of leading-edge technologies that have been re-used or adapted for other space missions, and in numerous other fields, including teleoperations, artificial intelligence and many more.



ESA/Gaia/DPAC

Strategic benefits

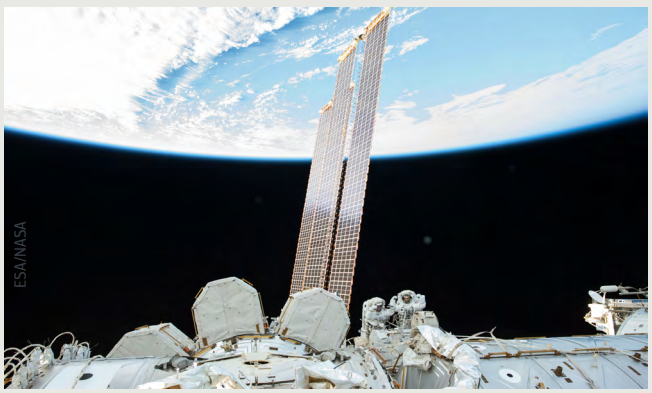
Promoting international cooperation

Science and exploration stimulate interaction among scientists, with international partners and with ESA stakeholders. **The International Space Station** brings together 15 international partners and, as of summer 2019, has been visited by 237 astronauts from 18 countries working together in international crews.

With **ExoMars**, an important partnership was developed with Roscosmos on the Trace Gas Orbiter. With the European Service Module for Orion **(ESM)**, Europe is on the critical path of NASA exploration programme.

Ensuring scientific leadership and non-dependence

ESA's **science programme** develops and operates a portfolio of missions, which ensure that the European scientific community maintains its position at the highest levels of discovery and innovation across all of space astronomy, heliophysics, planetary science, and fundamental physics. It also supports the development of new world-leading hardware and software solutions within European industry, reducing dependence on outside suppliers.



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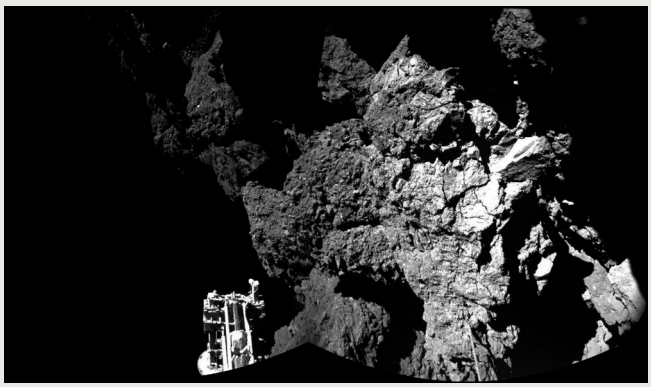


Societal benefits

Science and exploration have a strong impact on education as well as on public inspiration and awareness

Public outreach

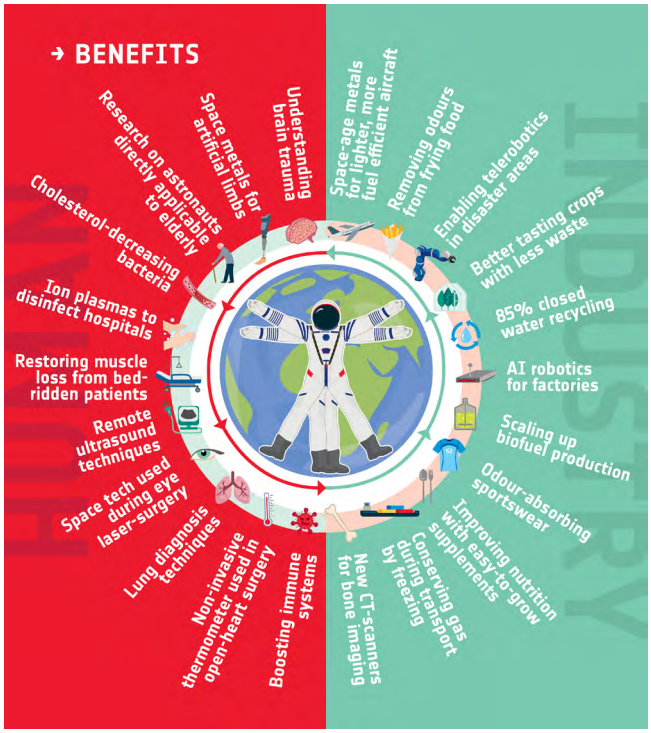
Science and exploration programmes trigger significant public interest.
The International Space Station activities have:

- 4 million followers on Facebook
- 6 million followers on Twitter
- 85 million views on Youtube

10 million people followed live the event of the Philae landing on the comet, as part of the Rosetta mission.

Inspiring and training the next generation

Thousands of PhD theses are based on ESA science missions, contributing to making STEM (Science, Technology, Engineering and Maths) more attractive to young people.
In 2018 ESA reached 600 000 school pupils through exploration themed education activities and 50 000 teachers participated to training on how to embed ESA exploration themes in the school curriculum.



Research in microgravity is leading to knowledge, technology and applications with positive impacts on both humans and industry on Earth

Economic benefits

Science and exploration programmes generate economic growth and support employment in Europe

€1 invested in ESA **science missions*** generates €1.6 in the wider European economy.

€1 invested in **Exomars** and the first European Service Module for Orion (**ESM**) generates about €2 in the wider European economy.

€1 invested in the **International Space Station** generated €1.8 in the wider European economy.

€1 invested in the upcoming period of ESA's **Exploration Programme** will generate €0.8 of government revenues.

1 person-year directly sustained by the ESA investments in **ExoMars** and **ESM** supports about 2 additional jobs in the wider economy.

** Based on an analysis of 8 Science missions in operation or under development: XMM-Newton, Rosetta, SOHO, ESA's contribution to Hubble Space Telescope, JUICE, SMILE, ARIEL and ESA's contribution to James Webb Space Telescope*

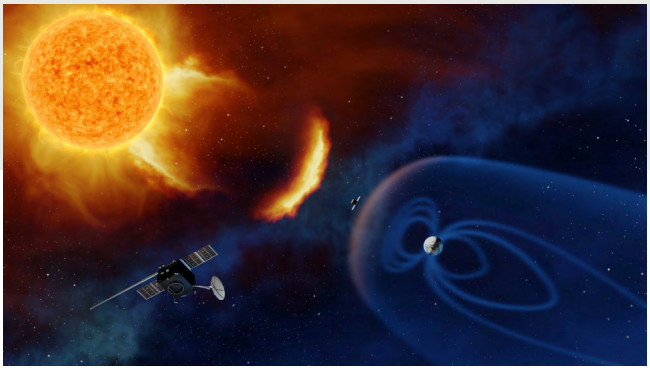
→ SAFETY AND SECURITY

Serving a safe and secure society and protecting our planetary environment

Strategic benefits

Prevention of economic losses and societal impacts caused by space hazards, like space weather events, asteroids and space debris, is an undisputed necessity. Furthermore, the sustainable use of orbital and other resources has become a prime concern for the economic viability of telecommunications and Earth observation businesses and the service reliability of navigation constellations.
With ESA's **Space Safety Programme (S2P)**, Europe will play a leading role to protect our planet, humanity and assets from dangers originating in space including the rising challenges caused by space debris proliferation. Such capabilities strengthen the competitiveness of the European space sector and answer to a strategic need to maintain access to key orbits.

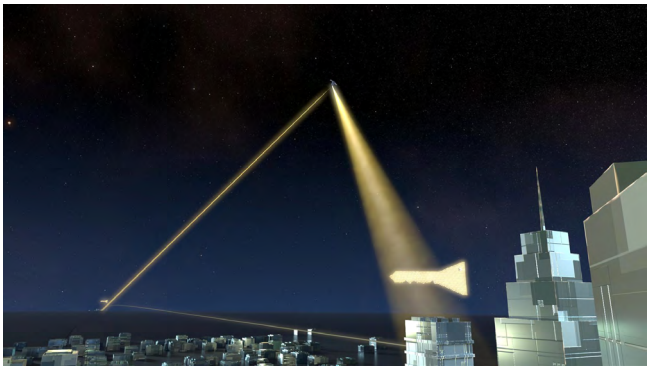
Space solutions can help improve safety and security on Earth from space. ESA's **Space Systems for Safety and Security (4S)** programme will provide European solutions, well beyond the ones delivered by ESA GOVSATCOM Precursor Programme, in response to needs of public institutions, in particular in transport and maritime safety, civil protection, border control and the Arctic. It will support European satellite communications solutions such as for highly secured encrypted communications and for increased European non-dependence.



Societal benefits

Environmental preservation and sustainable use of orbits are today priorities, as low Earth orbits could become too dangerous to launch new satellites because of space debris. S2P brings solutions by improving the debris monitoring and automated collision avoidance capabilities, minimising the production of debris with the development of 'clean space' technologies to comply with Space Debris Mitigation requirements and removing objects from space whilst also demonstrating, in-orbit, functionalities required for future in-orbit services.
S2P will continue developing the European Space Weather Service Network providing timely warnings of solar events, helping to mitigate disruption or damage to critical ground and space infrastructure. S2P will enhance European space weather capabilities with the Lagrange mission that will provide unprecedented new data.
With over 20 000 known Near Earth Objects and an estimated 1000 Near Earth Asteroids on the risk list, S2P's planetary defence activities, which include the Hera mission, will allow not only to detect but also to prevent major natural disasters from asteroid impacts.

4S is addressing the needs of European society, which increasingly relies on secure and resilient connectivity in daily life. It will support critical infrastructures entailing systemic risk, for instance in the fields of secure energy generation and distribution and clean water supply, as well as support the UN Sustainable Development Goals for "Peace, Justice and Strong Institutions".



Economic benefits

The economic damage to ground and space infrastructure caused by moderate space weather events over the next 15 years is estimated at €13 billion and could be much higher in case of extreme events. Early warning and mitigation actions could reduce this cost by €3.2 billion.
Service outages caused by collisions and collision avoidance manoeuvres in low Earth orbit will cost €1.5 billion to the European industry until 2040, creating new market opportunities. **S2P**'s developments in ADRIOS (Active Debris Removal/In-orbit Servicing) and Space Debris Mitigation technologies will help to achieve a 20% share of a market that should reach at least €2.5 billion by 2036.
Hera mission's technologies are critical in many promising space markets, including the space resource utilisation global market of at least €73 billion until 2045, as well as the CubeSat and small platforms market, expected to reach €5 billion by 2038.

4S will create new market opportunities and support the competitiveness of European and Canadian industry on a world market. The global market related to secure satcom should reach €7.4 billion in 2025 and €22.2 billion in 2040. The addressable market for European systems should grow at a faster rate than the global market from €1.7 billion in 2025 to €6.4 billion in 2040.

Technological benefits

S2P offers many firsts, overcoming a number of technological challenges and enriching the portfolio of European capabilities. These comprise the first ever mission to Lagrangian Point L5, which will conduct the first quasi-operational deep-space activities, ensuring safe and successful operations of deep-space science missions and the safety of human spaceflight (in particular Moon and Mars exploration).
Hera's key technologies and innovations will advance competitiveness of the European industry in advanced nano-satellites, close-proximity operations, vision-based navigation and small autonomous satellites.
The Active Debris Removal/In-Orbit Servicing (ADRIOS) mission will be the first of its kind and an enabler towards future, more complex, in-orbit servicing operations.

Most 4S activities develop highly innovative concepts creating opportunities to acquire knowledge and skills in a wide variety of hardware/software domains, including the SAGA project on quantum key distribution (QKD), the EDRS-Global project on data relay, ERMIS digital hub and the IRIS project on satellite-based air traffic management (ATM).

→ APPLICATIONS

Using space to benefit citizens and meet future challenges on Earth

Economic benefits

The Earth Observation (EO) market has grown consistently over the last decade. In 2017 the global market reached € 4.1 billion for EO data and value-added services and € 3.9 billion for satellite manufacturing. The downstream EO sector is now growing at about 6% globally and at about 12% within Europe. Information Products and Big Data solutions will drive growth in the short-term.

Each euro spent in the EO R&D programme of the Agency (**FutureEO**) creates €3.8 within ESA Member State economies: €1.9 from direct, indirect and induced economic impacts and €1.9 from innovation spill-overs.

The operational Copernicus programme is the largest provider of Earth Observation data in the world today, and is projected to generate at least €56 billion-worth of socioeconomic benefits in the period 2019 - 2035.[1]

In the field of meteorology, the MetOp-SG mission alone will generate socioeconomic benefits of at least €16 billion during its 20-year lifetime.[2]

FutureEO should support more than 54,500 jobs over 2013-2030 and for each new job in the space sector, 1.3 additional jobs are supported in the wider economy.

More than half of the industrial turnover of European and Canadian space industry in the upstream market relies on satcom. The global downstream satcom market value reached over €125 billion in 2015, with the European market representing a share of about 25%.

Telecommunications and Integrated Applications are conducted in partnership with industry. ARTES Partnership projects and developments are typically 50% co-funded by industry.

ARTES Partnerships Projects* generate €13.5 billion of commercial sales and €25 billion of value in the European economy over 2007-2032. ESA governments should collect €8 billion of related taxes over that period.

For each euro invested through **Business Applications and Space Solutions**, €2.8 of investment is generated by third-party investments and €7.2 of direct and indirect revenues is generated (about 49% export). €286 million invested by ESA in Business Applications and Space Solutions enable about over 10 000 direct and indirect jobs, of which over a 3000 are directly enabled in SMEs.

** 11 ARTES Partnership Projects: Alphasat, SGEO, EDRS, Electra, Spacebus NEO, EuroStar NEO, Quantum, ECO, Iris, INDIGO, ICE*

The global downstream navigation market value has significantly increased over the past years (+18% over the 5 years) to reach 105 billion euros in 2017. The European market value represented about 25% of the global one.

Significant economic benefits of **Galileo** and **EGNOS** applications have been reported by the European Union.[3] In the world almost 8 billion GNSS devices are expected to be used by 2020 (about 80% of smartphones). EGNOS and Galileo are creating nearly 50 000 annual jobs in Europe.

The **NAVISP** programme will support the European industry in succeeding in the highly competitive and rapidly evolving global market for satellite navigation and broadly Positioning Navigation and Timing (PNT) technologies and services.

Societal benefits

Copernicus data and services are increasingly and widely used across Europe to support national and European policies on climate change, in addition to environment, sustainable development and civil security.

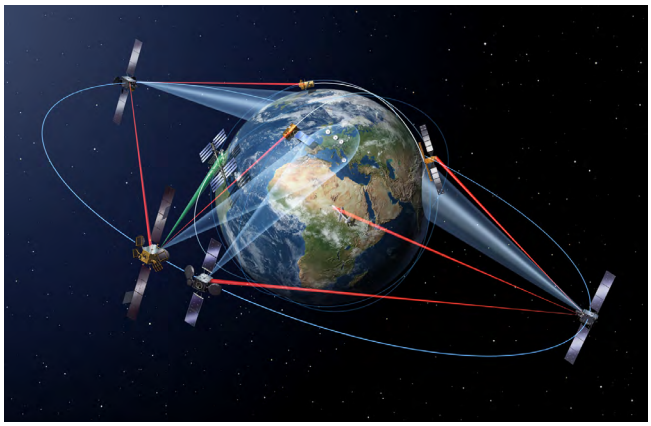
This information is helping Member States and the European Union to monitor the implementation of the Paris Climate Agreement and the UN Sustainable Development Goals. Cooperation with the International Financial Institutions (e.g. World Bank, Asian Development Bank) is being established to mainstream the use of European Earth Observation information in official development assistance.

The six Copernicus High Priority Candidate Missions will add powerful new Sentinel capabilities for monitoring CO_2 emissions, land surface temperature, agricultural production, biodiversity, sea-ice, polar snow and ice.

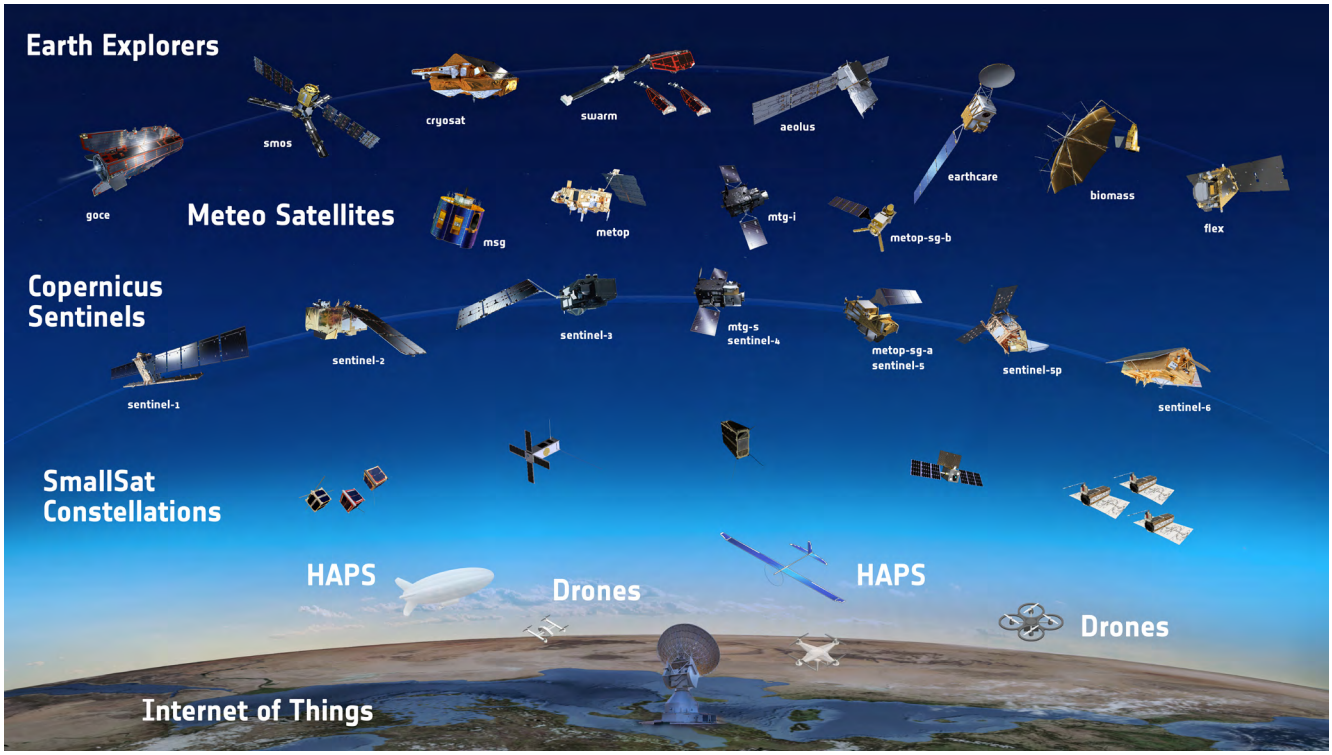
Europe's weather forecasters rely on data from ESA-developed missions. From 2022, the next generation meteorological missions will initiate a new era of numerical weather prediction, securing vital public services for Europe's citizens to 2040.

In addition to MetOp-SG, ground-breaking new capabilities, such as Lidar-based measurement of atmospheric winds pioneered by the Aeolus Earth Explorer mission, are paving the way for even more precise weather future forecasting.

ARTES supports the digital transformation of the economy with connectivity solutions and services. It enables the seamless operation of space solutions such as future 5G mobile networks and bridges the digital divide by connecting people in remote and under-served regions. It supports the Internet of Things (IoT) with billions of objects connected anytime everywhere.



Galileo, and more broadly Positioning Navigation and Timing (PNT) capabilities, are truly a global utility that positively affects the daily lives of many people around the world. As in the rest of the world, European society and many sectors of the European economy are increasingly reliant on satellite positioning, navigation and timing.



Technological benefits

The Earth Observation Programmes decided at Space19+ will enable ESA Member States to:

- Independently develop state-of-the-art critical observing technologies and sensors in the optical and microwave domains, with potential for meteorological, atmospheric, marine, terrestrial, cryosphere, climate and security applications.
- Remain at the forefront of EO without depending on third-country capacities or/and entities.
- Benefit from autonomous access to ground-breaking new data streams, thereby enabling independent development of innovative data products in Europe.

NAVISP supports European industry and ESA Member States' public activities in succeeding in the highly competitive and rapidly evolving global market for Satellite Navigation, and more broadly Positioning Navigation and Timing (PNT) technologies and services. Through NAVISP Phase 2, Member States:

- Enable the development of innovation in PNT, including new PNT concepts, navigation in Space (Moon, Mars), and space-terrestrial integration.
- Enhance the competitive position of European industry for systems, equipment and products supporting in particular increased robustness and resilience.

ARTES Partnership Projects have increased the technical expertise throughout the satcom supply chain and reinforced the strategic positioning and competitiveness of European and Canadian industry. They enable greater risk sharing and positive trade-offs between technological development and commercial constraints of the mission.

76% of the Business Applications cases analysed delivered innovation in the product and/or in the market addressed.

Scientific benefits

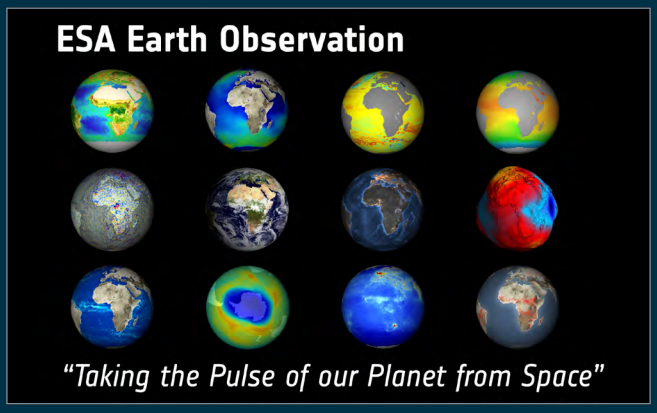
Science is the first step on the innovation pathway to new socioeconomic benefits. Annual peer-reviewed publications citing data from ESA-developed EO missions grew by 500% since 2002, reaching a 16-year cumulative total of 10 720 with 1430 papers in 2018.

Attendees to the 2019 Living Planet Symposium reached 4500 (50% more than in 2016), with 2500 schoolchildren attending education workshops, and making this symposium the world's largest EO conference of the year.

By mid 2019, the number of registered users on the Copernicus data hub amounted to 250 000 and continues to grow rapidly. Every day around 250 terabytes of EO data are disseminated worldwide. This corresponds to a data volume of around 125 million smartphone pictures. The total volume of user downloads has now surpassed the 160 petabytes mark; roughly the data equivalent of 80 billion smartphone pictures.

In addition to the GNSS services operationally delivered by Galileo and EGNOS, the GNSS system and in particular Galileo will provide scientific results.

Scientific benefits from GNSS data include in particular contributions to fundamental geodesy, ionosphere and atmospheric science and fundamental physics thanks to the ultra-precise clocks.



→ ENABLING AND SUPPORT

Guaranteeing access to space for Europe and developing the technologies for the future

Economic benefits

The global competitiveness of Europe's space businesses, large and small, benefits from major investments in the technology basis, a renewal of ESA's world-class space facilities and the entry into service of Europe's new family of launch vehicles, Ariane 6 and Vega-C.

€1 spent in the ESA development and commercial exploitation of **Ariane 6** and **Vega-C** produces €3.3 and €4 respectively in the European economy.
The Ariane 6 and Vega-C development and exploitation phases generate more than €7 billion in government revenues in the medium term.
For each new job supported by Ariane 6 and Vega-C in the space industry 0.7 additional job is supported in the broader economy.

€1 invested in basic technologies and product development through ESA **technology programmes TDE and GSTP** generates up to €3.5 of additional commercial benefits, including additional income streams and cost savings.

Each euro spent on ESA **ground segment engineering and operations** activities generated about €3 within ESA Member States economies: €1.5 of value added, €0.9 of market spill-over and €0.6 of network spill-over.
For each new job supported by ESA ground engineering and operations in the space industry, 3.2 additional jobs are supported into the wider economy.

Strategic benefits

Investment in technology is an enabler of ESA's strategy. ESA **technology programmes TDE and GSTP** make future European space missions possible and support European non-dependence. ESA can thus fulfil its objectives efficiently and effectively, and ensure the use of space to the benefit of society.

ESA **operations** are also fostering the competitiveness of European industry and strengthening its positioning on the global market. This is achieved through development of knowledge and competencies, provision of a world-class mission operations infrastructure and innovation. European access to space is critical for Europe's non-dependence in carrying out space activities.

Ariane 6 will secure independent access to space for Europe, as well as support a global and autonomous satellite-based navigation system and a secured connectivity for European citizens.

Vega-C constitutes a competitive and independent European launch vehicle dedicated to Low Earth Orbit (LEO). It will offer a launch solution for the expanding LEO institutional and commercial market, serving in particular Space Rider, a European reusable space transportation system for routine access and return from LEO.

Technological benefits

The industrial base, knowledge and know-how, seeded by ESA technology programmes TDE and GSTP feed into European space programmes.

Positive spill-over effects are also expected from the technologies developed for the **Ariane 6** and **Vega-C** programmes, which could in turn increase competitiveness and create new markets and business opportunities.

The Ariane 6 and Vega-C programmes could support the demonstration of advanced technologies and their in-orbit demonstration and validation in both geostationary and non-geostationary orbits.

ESA **ground segment engineering and operations** enables the development of innovative technologies and products, the creation of industrial spin-offs, as well as knowledge transfer between institutions, academia and industry.

Numerous technologies developed by ESA operations are considered by space and non-space actors for potential use as spin-off technologies. For example, knowledge and capabilities developed for the automation of ground and satellite activities can be transferred to industrial processes, such as in the pharmaceutical industry or for digital city concepts.

ESA is also investing in technologies and infrastructure to ensure the **cyber-security/safety** of its missions.

Societal benefits

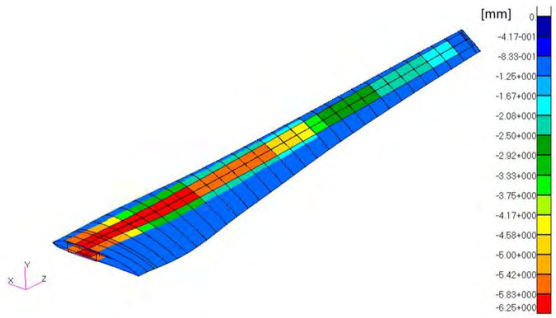
Over the past century our society has evolved thanks to investments in technology. ESA **technology programmes** produce regular spin-offs. An objective of the GSTP programme is to support opportunities for technology transfer.

Technology developments led by ESA **operations** have a wider impact on society as a whole through spin-off of knowledge and capabilities.

ESA operations contribute to the education of the next generation of European engineers and scientists through close collaboration with academia.

Some recent examples of technology developed under GSTP contracts include:

- A wearable muscle monitoring system to improve astronaut training and optimise the training of athletes.
- A new technology that makes wind turbine blades environmentally friendly and fully recyclable.



THE EUROPEAN SPACE AGENCY AS AN ENGINE OF ECONOMIC GROWTH AND EMPLOYMENT

With a contribution worth a cinema ticket per citizen per year, ESA is delivering on some of the greatest challenges in science and technology by fostering European scientific excellence, while building on 50 years of experience and preparing for future decades.

In addition, ESA's spending in industry and academia ripples throughout the European economy, supporting critical industries, creating new businesses and jobs, as well as attracting students to science and engineering.

Every euro invested in ESA programmes has a significant impact on the European economy, with up to €4 created in the broader economy. Investing in ESA programmes also generates significant governmental revenues: up to 90% of the funding of ESA programmes are returned to governments as income tax, taxes on products (including value added tax) and social security contributions.

The economic impact of space fares very well when compared to other key industrial sectors [4], which demonstrates the strong performance of the space industry in creating additional value for the European economy. A key reason for this high impact comes from the fact that the European space industry covers the full value chain. In addition, the European public funding for space is mostly spent in the domestic industry.

ESA invests in technologies and discoveries for the future. In the process, it delivers social and economic impacts that benefit Europe today. No single metric can capture the returns from ESA's activities, as their many dimensions and benefits extend far beyond space.

ESA invests in technology and the European industry in all important areas to foster **competitiveness**: R&D, technology and manufacturing. This investment generates know-how, new markets, spin-offs and technology transfers, improving the daily life of European citizens.

ESA stimulates innovation and business growth. Each euro invested in ESA programmes attracts up to 2.8 euros of additional investment from third parties. Investing in ESA programmes generates significant commercial revenues for European industry and operators .

ESA promotes collaboration and supports international relations, strengthening European and Member States' space diplomacy through collaborative research and development with international partners, supporting the European industry on the export markets, fostering a strong, innovative economy, as well as advancing international order that promotes peace and security.

ESA inspires people and young generations as a valued source of scientific data and knowledge, reaching out to scholars, students and teachers, as well as to the public through social networks and international public events.

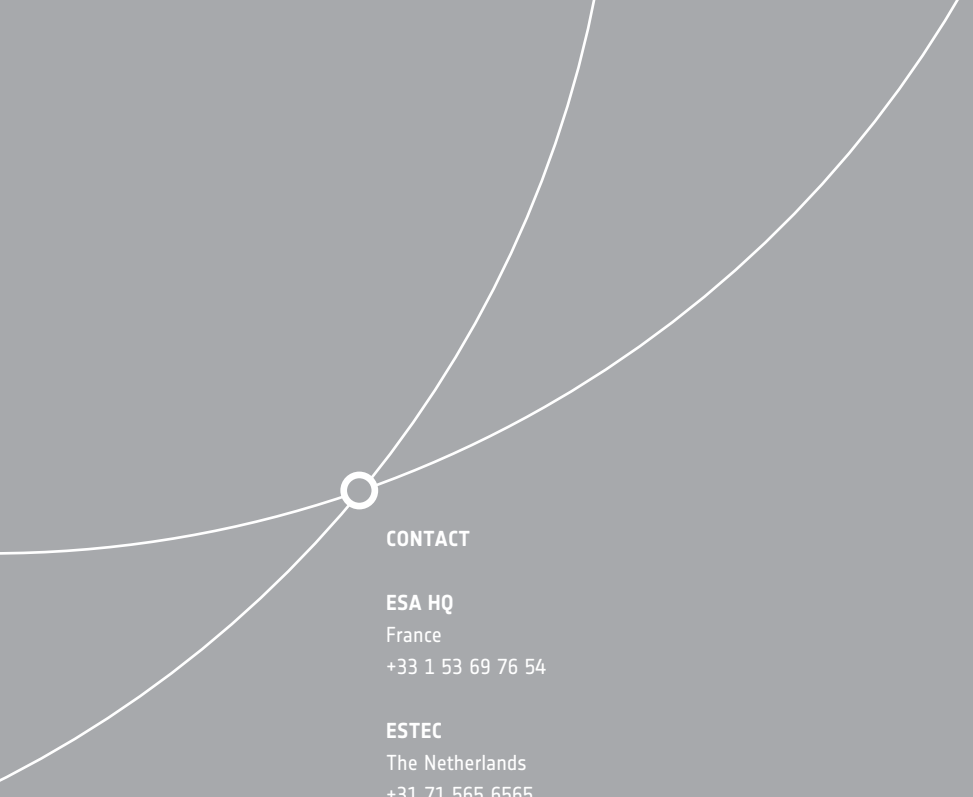
References

[1] PwC, Copernicus ex-ante benefits assessment, 2017

[2] EUMETSAT, The Case for EPS/Metop Second-Generation: Cost Benefit Analysis, 2013

[3] e.g. European Global Navigation Satellite Systems Agency (GSA), GNSS market report, Issue 5, 2017

[4] Although benchmarking across different sectors of the economy is always a difficult exercise – and needs to be handled with extreme caution – a first analysis of the available literature shows that those macro-economic multipliers associated with public spending in the European space sector rate in general terms better than in areas such as transport, education, health or defence, which show multipliers around 1.5. Europe Economics, "The Economic Case for investing in Europe's Defence Industry", September 2013, commissioned by the European Defence Agency



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