

STUDY

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Space Market

How to facilitate access and create an open and competitive market?



Policy Department for Economic, Scientific and Quality of Life Policies
Directorate-General for Internal Policies
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Abstract

This study provides an analysis of the European space market. The market size and structure of the European space industry is considered, alongside the dynamics of the new space economy. The contribution of the EU space programmes to fostering the uptake of space data, and the challenges and drivers of maximising synergies between the EU upstream and downstream space sectors are examined. The new Space-based Connectivity Initiative is also considered.

In addition, recommendations by the Court of Auditors to strengthen the efficacy of the newly-integrated EU Space Programme, and to maximise their economic and societal impacts are considered.

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LIST OF ABBREVIATIONS

AFDJ	Lower Danube River Administration
AIS	Automatic Identification System
CAS	Commercial Authentication Service
CASSINI	Competitive Space Start-ups for INnovation
CoA	European Court of Auditors
CFSP	Common Foreign and Security Policy
CSDP	Common Security and Defence Policy
DIAS	Data and Information Access Services
EARSC	European Association of Remote Sensing Companies
EDAS	EGNOS data access service
EFFIS	European Forest Fire Information System
EGNOS	European Geostationary Navigation Overlay Service
EIB	European Investment Bank
EIC	European Innovation Council
EIF	European Investment Fund
EO	Earth Observation
EOS	EGNOS open service
EPSS	Enabling Chemical Propulsion System
ES	Emergency service
ESA	European Space Agency
EUSPA	European Union Agency for the Space Programme
FFPA	Financial Framework Partnership Agreement
FPA	Caroline Herschel Framework Partnership Agreement
GNSS	Global Navigation Satellite System

GOS	Galileo open service
GOVSATCOM	European Union Governmental Satellite Communications
GPS	Global Positioning System
GSA	European GNSS Agency
HAS	High-accuracy service
IA	Innovation Action
IoT	Internet of Things
MFF	Multi-annual Financial Framework
NBR	Normalized Burn Ratio
OSNMA	Navigation Message Authentication Service
PRS	Public Regulated Services
R&D	Research and development
R&D&I	Research and development and innovation
RIMS	Ranging and Integrity Monitoring Stations
RRM	Risk and Recovery Mapping
SAR	Synthetic Aperture Radar
SBAS	Satellite Based Augmentation System
SoL	Safety-of-life
SSA	Space situational awareness
SST	Space surveillance and tracking
TRL	Technology readiness level
TS	Timing service
VAS	Value-added service

EXECUTIVE SUMMARY

This study considers the market size and structure of the European space industry, the activities and impact of the flagship EU Space Programme (Galileo, the European Geostationary Navigation Overlay Service (EGNOS) and Copernicus) in fostering the uptake of space data, as well as the challenges and drivers of maximising synergies between the EU upstream and downstream space sectors. In addition, the study examines the recommendations proposed by the European Court of Auditors (CoA) to strengthen the uptake of services and data derived from the different EU space programmes, which have been integrated into a single European Space Programme.

Europe has the second largest space industry in the world, which employs over 231,000 professionals and is estimated to be worth EUR 53-62 billion. The newly integrated EU Space Programme, supported by EUR 14.88 billion in funding, supports the EU's ambitions in space over the coming years, building on its strengths, particularly in the upstream sector, and developing the European downstream market for space services and data. The Space Programme aims to ensure high-quality, secure space-related data and services which can bring about socio-economic benefits for Europe's citizens and businesses, enhance EU security and autonomy, and strengthen the EU's role as a leader in the space sector, allowing it to compete with other leading space economies, and emerging space-faring nations. Additionally, the new Space-based Connectivity Initiative is considered. This has the potential to enhance connectivity in underserved areas of the EU and further afield and to deliver secure communications. It could also help to enhance the EU's strategic autonomy, as well as to increase digital sovereignty.

To date, Copernicus, Galileo and EGNOS have had positive socio-economic impacts, providing key Earth observation and navigation and timing services to millions of Europeans and encouraging Europe's SMEs and start-ups to develop and provide innovative services. The EU has further tools at its disposal to boost Europe's space ecosystem, such as wider EU programme funding mechanisms and legislation. The Horizon 2020 programme, for instance, provided opportunities to firms looking to bring new applications to market and through pre-commercial procurement. Horizon Europe, its successor, will seek to develop Europe's space industry further.

The new CASSINI programme (Competitive Space Start-ups for INnovation) supports space entrepreneurship and will provide EUR 1 billion of access to risk capital, which should provide a needed boost to investment by SMEs in the European space sector, and draw attention to this sector as a potential investment among venture capitalists.

Additionally, legislative measures can help to support the uptake of space services. Progress has been made in some areas, such as in the field of road safety and emergency, enabling emergency teams to respond to an accident faster, while there is a legal base encouraging the use of Earth observation for the Common Agricultural Policy. Other legislation supporting the uptake of space services include the INSPIRE Directive, which encourages the uptake of environmental data by public authorities, and the Open Data Directive and proposed European data regulation.

However, in spite of progress made in the upstream through the maturation of the EU Space Programmes, further action is required to maximise the potential of the European downstream sector, including in the non-space sectors and to overcome fragmentation. This was highlighted in the CoA report which concluded that, although Galileo and Copernicus provide valuable services and data, their uptake needs to be increased to achieve the expected societal and economic benefits from the significant EU investments made.

The report provides recommendations to strengthen the uptake of space data. These are regarded by the Commission and ESA as being useful and realistic to implement within the timeframe suggested.

The European Space Strategy also recognises that the potential of the space programmes needs to be better exploited, and argues that research activities need to address the entire space industrial value chain and Europe needs secure and safe access to space. Without the achievement of these objectives, the EU's position on the world stage would be diminished.

This study provides recommendations to boost the European space sector and to foster the uptake of space services and of space SMEs, taking into consideration the potential of the space programmes, the tools at the EU's disposal, the development of the internal market, and the need to strengthen the EU's position on the global stage.

The EU should maximise the potential of the regulatory framework to support the uptake of space data and services, whilst recognising the limitations of a prescriptive approach. Although progress has been made in some areas, such as in the field of road safety and emergency, less progress has been observed elsewhere (e.g. in road transport and logistics). It would be of value to assess those areas where EU legislation could promote the use of space data. If legislation can strengthen safety and foster the integrity of the internal market in parallel, there is potential to introduce new legislation. Additionally, the Commission should more regularly undertake studies to assess the strategic contribution of the EU Space Programme(s) towards the achievement of the broader policy objectives of the EU Space Policy (including its industrial dimension).

This would ensure a broader assessment of the space programmes in terms of their importance to Europe's economy, industry and competitiveness and future security. More regular assessments should also be undertaken of the uptake of space data and services generated through upstream space infrastructure investment and to develop more reliable methodologies to estimate the potential economic and societal benefits. This study found that there remains a lack of awareness among EU citizens and many public authorities regarding the potential benefits and capabilities of the EU Space Programmes. As such, there is a need to improve EU-wide communication about the benefits of space services. This could be achieved, for example, through events where the Commission engages with citizens to understand where the information gaps are and additional areas where space data could be used. Educational programmes, events, television and radio programmes and webinars are other methods which could be used to engage with the public.

Additionally, there is a need to enhance synergies between Member States to foster the uptake of space services. Member States should more actively work together to better understand what applications and services are used and for what purposes/fields. Europe has a strong space SME sector, which continues to grow and bring innovative solutions to the space industry, particularly SMEs serving primes in the upstream sectors and data-based service providers in the downstream sector. SMEs are also crucial to innovation and the ecosystem in the emerging new space economy. As such, the development of SME space services should be actively encouraged, as well as their procurement by public authorities and the private sector alike. This would help to create jobs, improve technological skills and boost Europe's competitiveness, which are increasingly important for the EU's twin transitions to a sustainable and digital economy. Additionally, the Commission should collect improved monitoring data on SME participation across key EU funding initiatives to better understand how SMEs contribute to the space ecosystem.

The EU should also use its position on the global stage to encourage stronger international coordination to work on issues of common interest to all space-faring nations, such as addressing concerns over the need for more active space traffic management, space debris, space mining (the

exploitation of raw materials from asteroids, comets and other minor planets, including near-Earth objects), and the potential misuse of space. Strengthening cooperation and coordination is important, given the need for international stability in space to foster an innovative European space market.

1. INTRODUCTION

The Committee on Industry, Research and Energy (ITRE) commissioned a study on “*Space market - how to facilitate access and create an open and competitive market?*”.

1.1. Objectives and scope

The overarching study objective was to provide independent expert opinion to enable the European Parliament to establish an independent view about progress made in recent years, and ongoing actions relating to the EU Space Programmes and the adequacy of measures being planned in future under the new integrated EU Space Programmes.

The specific objectives were, in summary, to provide:

- An overview of the actions planned to implement upstream space activities and to overcome obstacles to their implementation through the EU Space Programmes;
- A review of EU support for space SMEs (including start-ups and existing firms) through programmes, actions and initiatives aimed directly/indirectly at such SMEs;
- Assessment of the coherence of EU programmes, initiatives and actions in the space domain (e.g. with the EU SME strategy, EU long-term industrial strategy and broader EU policies, such as digitalisation);
- A discussion on the main recommendations in the European Court of Auditors special report on space and the feasibility of their implementation; and
- A discussion on the Space-based Connectivity Initiative and its potential to reinvigorate the space sector and its downstream users.

Based on the analysis and identification of key findings, recommendations have been developed. In particular, the study considers both previous and ongoing planned actions. Consideration is given as to how to maximise the impact of the EU Space Programme(s) in terms of:

- Ensuring that any obstacles to the successful implementation of the upstream space sector funded through the EU Space Programmes identified in 2014-2020 are overcome;
- Facilitating access to, and fostering the uptake of space data – both Earth Observation (EO) data and satellite navigation data - by users;
- Promoting the development of downstream services using EU space data;
- Creating an open and competitive European space industry;
- Assessing how far the EU Space Programmes benefited SMEs in 2014-2020 and the extent of SME targeting in the new EU Space Programme 2021-2027;
- Maximising the extent of synergies between the EU Space Programmes and research and development and innovation (R&D&I) funding for space through Horizon Europe.
- Examining the impacts of Brexit on the EU Space Programme 2021-2027;
- Considering ways in which the framework conditions for the development of the European space market and the strengthening of its competitiveness might be improved; and
- Considering any potential regulatory measures that could help to strengthen the framework conditions.

The **study scope** covers the EU-27 and EEA/EFTA countries. The time-scope is partly retrospective as the implementation of the EU Space Programmes in 2014-2020 is analysed. There is however a strong forward-looking dimension as the planned interventions to be supported under the new integrated EU Space Programme for 2021-2027 are examined.

1.2. Methodological approach

The analysis was based on a review of available literature, including previous evaluations, studies and other desk research. A list of reference documents was provided in the Tender Specifications and has been expanded (see Annex 1 – References). In addition, web research has been carried out to ascertain more about planned programming changes between the 2014-2020 and 2021-2027 programmes.

This has been complemented by an interview programme with relevant stakeholders. This included the European Commission, the European Space Agency (ESA), EU and SME space industry associations, large firms, and SMEs that are intermediate users of Copernicus space data.

2. MARKET SIZE AND STRUCTURE, COMPETITIVENESS BASELINE AND FUTURE PROSPECTS

KEY FINDINGS

The European space industry has globally-leading competitive strengths in some areas, such as in launchers (15% of the global market), the commercial satellite market, and in the design and manufacturing of nano-satellites. However, other space-faring nations, such as China and India, have been catching up rapidly, especially on launchers.

In the context of the EU's long-term industrial strategy, which emphasises strategic autonomy, maintaining Europe's independent access to space and critical space capabilities has become ever-more important. Ensuring autonomy is crucial not only for future industrial competitiveness, but also in ensuring strategic non-dependence and resilience.

The European space industry remains vibrant overall, with a dynamic and growing small and medium-sized (SME) enterprise base active both in the upstream sector (often as subcontractors) and in the downstream sector. However, the downstream space sector remains fragmented, with an ongoing need to engage user communities to foster take-up of space-based data and services.

In the context of the new space economy, there are new opportunities for SMEs as new market entrants have emerged, including those that initially started out in research and innovation, including public procurement for innovation.

Whilst the space supply chain has become dynamic, with greater involvement of SMEs, in parallel, there has been a trend towards market consolidation among the largest industry players. This has been necessary to create the necessary critical mass to compete globally.

This chapter provides an overview of the market size and structure of the European space industry, including the upstream and downstream space sectors. It examines in detail the EU Space Programme, looking in particular at the Copernicus, Galileo and EGNOS programmes. It presents an assessment of how these have performed in recent years and looks at how performance is measured, before discussing the impact of Brexit on the space programmes. The main actors and activities are explored and key statistics are provided. It aims to shed light on the current status of the European space industry and to provide context for this report.

2.1. Overview of the European space industry

This section examines the European space industry as a whole, before examining the competitiveness of the upstream and downstream sectors, as well as the burgeoning New Space sector. Key figures are provided, as well as an overview of the main players in the industry.

2.2. Supporting upstream space activities: Activities and impact

The **upstream sector** is dominated by companies from the aerospace sector, and refers to the development of space infrastructure, satellites, ground stations and their deployment and operation. The largest companies actively involved in the European upstream sector include, among others, Airbus Defence and Space, OHB, Safran, and Thales Alenia Space. Whilst **ESA** was originally the main actor investing together with its participant states in the upstream space sector to put in place the requisite space infrastructure needed to achieve societal and economic benefits, **the EU Space**

Programme has gradually assumed an ever-greater financial importance. This section now provides an overview of the EU Space Programme and the actions planned to support upstream activities.

2.2.1. The EU Space Programme 2021-2027

Europe has made immense progress in space over the last few decades and has the second largest public space budget in the world with programmes and facilities spanning various European countries¹. However, from a competitiveness perspective, it should be noted that other space-faring nations (e.g. the U.S., some of the BRICs) are also investing significantly, especially in launchers.

In April 2021, the Council and the European Parliament adopted a Regulation establishing the Union Space Programme and the European Union Agency for the Space Programme, which entered into force retroactively on 1 January 2021. The newly-integrated European Space Programme aims to ensure high-quality, secure space-related data and services which can bring about socio-economic benefits for Europe's citizens and businesses, enhance EU security and autonomy, and strengthen the EU's role as a leader in the space sector. The new EU Space Programme is part of the wider EU space policy and builds on its predecessor programmes, which were structured differently, as each had a separate Programme Regulation.

The EU has three flagship space programmes which have been integrated into a single EU Programme Regulation. These deliver services benefiting millions of Europeans²:

- **Copernicus** – the most advanced Earth Observation (EO) monitoring system in the world, it helps to save lives at sea, improves responses to natural disasters, and allows farmers to better manage their crops;³
- **Galileo** – the EU's own global navigation satellite system, providing more accurate and reliable positioning and timing information than competitor systems (e.g. Global Positioning System (GPS)) for sectors such as autonomous and connected cars, railways and aviation. Galileo has been operational since December 2016 when it started offering initial services to public authorities, businesses and citizens;⁴
- **EGNOS** – provides safety critical navigation services to aviation, maritime and land-based users throughout the EU. The positioning information is so precise that aircraft can use it to land safely. All services provided by EGNOS are fully operational and the number of users is growing. The new Space-based Connectivity Initiative is discussed separately in Chapter 4.

The **Space Programme Regulation for 2021-2027** outlines the specific objectives, including those of Galileo, EGNOS and Copernicus, as well as the services they provide. An interviewee from the Commission noted that the Regulation contains a more integrated approach than was the case previously, streamlining the different **upstream** space programmes and the two space components (e.g. SSA and GovSatCom).

Whereas Galileo provides an **autonomous global navigation satellite system** consisting of a constellation of satellites and a global network of ground stations. EGNOS is a **regional satellite**

¹ European Investment Bank. (2019). The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures.

² Council of the EU. (2021). EU space policy.

³ Copernicus is the EU's Earth observation programme, providing accurate, timely and easily accessible information to improve the management of the environment, understand and mitigate the effects of climate change and ensure civil security.

⁴ Galileo allows users to know their exact location. Everyday products such as navigation devices and mobile phones benefit from the increased accuracy that Galileo provides. EGNOS improves the performance of GPS and, with the launch of EGNOS V3, will augment Galileo signals from 2025. An EGNOS-enabled receiver provides location accuracy to within 3 metres. Without EGNOS, a standard GPS receiver only provides accuracy to 17 metres.

navigation system that monitors, corrects and improves the accuracy of open signals emitted by other global satellite navigation systems (GPS, Glonass)⁵. The objectives of **Galileo** and **EGNOS** are “to provide long-term state-of-the-art and secure positioning, navigation and timing services whilst ensuring service continuity and robustness”. Among the services provided by Galileo are⁶:

- A **Galileo Open Service (GOS)** providing positioning and synchronisation information intended mainly for high-volume satellite navigation applications for use by consumers; Galileo has an accuracy of less than one metre when using broadcast ephemeris (GPS: three metres) and a signal-in-space ranging error (SISRE) 1.6 cm (GPS: 2.3 cm, GLONASS and BeiDou: 4–6 cm) when using real-time corrections for satellite orbits and clocks⁷.
- A **High-Accuracy Service (HAS)**, intended mainly for satellite navigation applications for professional or commercial use; accuracy to one centimetre free of charge.
- An **Emergency Service (ES)** broadcasting warnings regarding natural disasters or other emergencies in particular areas; and
- A **Timing Service (TS)** facilitating the development of timing applications based on Galileo and the use in critical applications.

⁵ European Parliament, available at: [https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI\(2018\)614677](https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2018)614677).

⁶ Regulation (EU) 2021/696.

⁷ Wikipedia, available at: [https://en.wikipedia.org/wiki/Galileo_\(satellite_navigation\)#:~:text=The%20Galileo%20system%20has%20a,for%20satellite%20orbits%20and%20clocks](https://en.wikipedia.org/wiki/Galileo_(satellite_navigation)#:~:text=The%20Galileo%20system%20has%20a,for%20satellite%20orbits%20and%20clocks).

EGNOS provides services⁸ such as:

- An **EGNOS Open Service (EOS)** providing positioning and synchronisation information intended mainly for high-volume satellite navigation applications for use by consumers;
- **EGNOS Data Access Service (EDAS)** intended mainly for satellite navigation applications for professional or commercial use, offering improved performance and data with greater added value than those obtained through the EOS;
- A **SoL** service intended mainly for users for whom safety is essential, such as air navigation services for the civil aviation sector.

The objective of **Copernicus**, meanwhile, is “to deliver accurate and reliable Earth observation data, information and services integrating other data sources, supplied on a long-term sustainable basis, to support the formulation, implementation and monitoring of the Union and its Member States’ policies and actions based on user requirements”. Copernicus comprises the following elements in support of this objective⁹:

- Data acquisition, including:
 1. Development and operations of the Copernicus Sentinels;
 2. Access to third party space-based Earth observation data; and
 3. Access to in-situ and other ancillary data.
- Data and information processing through Copernicus Services, supporting environmental monitoring, reporting and compliance assurance, civil protection and security services;
- Data access and distribution; and
- User uptake, market development and capacity building.

The services provided by the space programmes aim to foster the upstream space sector and result in greater socio-economic benefits from the use of space-based data and services, while enhancing EU security and autonomy. For example, satellite-enabled applications can improve the mapping of cropland in need of irrigation, harvest forecasts, and fisheries control, ensuring better food quality and security while protecting the environment. Additionally, environmental monitoring provides information on vegetation, ocean currents, water quality and greenhouse gases, and can help to protect the environment and tackle climate change. From a security point of view, space-based applications can contribute to detecting illegal immigration, preventing cross-border organised crime and combating piracy at sea.

a. Budget of the EU Space Programmes

The budget allocated has increased over time, enabling the EU Space Programme(s) to deliver innovative services for the benefit of Europe’s citizens. Political agreement between the Council and the European Parliament over the Multi-annual Financial Framework (MFF) of the Union for the 2021-2027 period was reached at the end of 2020, with EUR 13.2 billion set aside for space activities¹⁰ (this translates to EUR 14.8 billion in current prices)¹¹.

⁸ EGNOS is a satellite-based augmentation system which improves the performance of global navigation satellite systems such as GPS and, in the future, Galileo. EGNOS improves positioning accuracy, data integrity and signal availability.

⁹ Regulation (EU) 2021/696.

¹⁰ Article 18(1) of Council Regulation (EU, Euratom) 2020/2093 of 17 December 2020 laying down the multiannual financial framework for the years 2021 to 2027.

¹¹ Science|Business (2021). Parliament finalises a €15B EU unified space programme.

The vast majority of the funding (EUR 14.43 billion) has been allocated to Galileo, EGNOS and Copernicus, with the remaining funds set aside for the European Union Governmental Satellite Communications (GOVSATCOM) and space situational awareness (SSA) investments¹². In the 2014-2020 MFF, EUR 11 billion was set aside for space activities, while EUR 5 billion was allocated to space activities for the 2007-2013 period¹³.

Thus, since 2007, the budget allocated to space activities has increased by 164%.

The European Union Agency for the Space Programme (**EUSPA**) manages the Galileo and EGNOS programmes, providing safe and secure positioning, navigation and timing services, and also develops markets for services and data offered by Copernicus, Galileo and EGNOS¹⁴. EUSPA's mission is defined by the Regulation establishing the Union Space Programme and the European Union Agency for the Space Programme¹⁵, which details the **actions planned to implement upstream activities**. These actions and their impact are examined in more detail in this report.

b. Impact of the UK's withdrawal from the EU on space planning

The UK's withdrawal from the EU had implications for the planning of the space programmes. Following negotiations on the terms of the future relationship between the UK and the EU, an agreement was reached in December 2020, which covers the UK's involvement in the space programmes through the Joint Declaration on Participation in Union Programmes and Access to Programme Services (Article 3)¹⁶. The box below outlines the implications for the space programmes and funding for UK organisations via the Horizon Europe programme.

¹² European Parliament. (2021). EU Space programme.

¹³ European Commission. (2018). Impact Assessment on the Proposal for a Space Regulation.

¹⁴ EUSPA. (2021). About EUSPA.

¹⁵ Regulation (EU) 2021/696.

¹⁶ Declarations referred to in the Council Decision on the conclusion, on behalf of the Union, of the Trade and Cooperation Agreement and of the Agreement concerning security procedures for exchanging and protecting classified information.

Box 1: The impact of Brexit on the EU space programmes^{17 18}**Galileo and EGNOS:**

The Galileo and EGNOS programmes are owned by the EU, while ESA is responsible for the development and procurement of infrastructure on its behalf. Under the terms of the Joint Declaration on Participation in Union Programmes and Access to Programme Services, the UK no longer participates in the Galileo or EGNOS programmes (Article 3). Specifically, the UK can no longer play a role in the development of these programmes, use Galileo for defence or critical national infrastructure, access the encrypted Galileo Public Regulated Services (PRS), or use the Safety-of-Life (SoL) services or EGNOS Working Agreements. However, the UK may continue to use the open position, navigation and timing services provided by Galileo and EGNOS, while businesses and organisations can use the open signal to develop products and services. There are currently two EGNOS Ranging and Integrity Monitoring Stations (RIMS) in the UK which will continue to operate. According to the UK Civil Aviation Authority, pilots will still be able to use the EGNOS signal so long as it indicates adequate integrity. In January 2021, ESA officials confirmed that the company Surrey Satellite Technology Limited had delivered its last navigation payload, the UK's final big contribution to the Galileo programme.

Copernicus:

There is an agreement in principle for the UK to continue its participation in the Copernicus programme for the 2021-2027 period, with the British government expecting confirmation in 2021 (see Article 3 of Joint Declaration on Participation in Union Programmes and Access to Programme Services)

Funding:

Under Article 4 of Joint Declaration on Participation in Union Programmes and Access to Programme Services, the UK is expected to associate to Horizon Europe, subject to ratification. Participation in the programme will give UK organisations access to funding on equivalent terms as their EU counterparts. However, as per the Horizon Europe Work Programme 2021-2022, participation in several space projects is not guaranteed. According to the eligibility criteria, Associated Countries will only be able to participate should they provide assurances concerning the protection of the EU's strategic assets, interests, autonomy or security. Six space actions are restricted to Member State participation only, while nine actions are to be assessed to determine whether they should be opened to associate countries. These include Copernicus security research and development (R&D) and actions involving technologies critical to strategic autonomy/dual-use. However, the work programme does not explicitly mention the UK, which no longer participates in Galileo and EGNOS.

In summary, as the EU owns the satellite infrastructure, an interviewee from the Commission confirmed that there are no particular outstanding issues in terms of the geo-positioning of the constellations of satellites themselves, or their ownership, as they are wholly EU-owned. However, there is a strong possibility that the UK continues to take part in the Copernicus EO sub-programme.

¹⁷ See Declarations referred to in the Council Decision on the conclusion, on behalf of the Union, of the Trade and Cooperation Agreement and of the Agreement concerning security procedures for exchanging and protecting classified information.

¹⁸ Guidance - UK involvement in the EU Space Programme - <https://www.gov.uk/guidance/uk-involvement-in-the-eu-space-programme#contents>.

As such, it is expected that UK-based businesses, academics and researchers would be able to bid for future Copernicus contracts. It is likely that UK users will be able to access most of the Copernicus data and services. However, it is expected that the UK would not have access to certain data considered security-sensitive.

2.2.2. Actions to support upstream activities and impacts

The aforementioned Regulation aims to ensure the **EU remains a global leader in the space domain**. It acknowledges that the EU needs to encourage scientific and technical progress and support the space sector's competitiveness and innovation capacity, in particular with regard to SMEs, start-ups and innovative businesses, thereby stimulating upstream and downstream economic activities.

Article 6 of the Regulation lays out actions to support the upstream sector, and an innovative and competitive space sector more generally, including the following¹⁹:

- Innovation activities to make the **best use of space technologies, infrastructure and services** and measures to facilitate the uptake of solutions;
- Activities aiming to realise the **full potential of public services** for citizens and businesses;
- Fostering **entrepreneurship** through access to finance;
- Developing a **business-friendly space ecosystem**, which brings together the space, digital and other sectors, and supports citizens and companies in developing entrepreneurship and skills;
- **Education and training activities** for professionals, entrepreneurs, graduates and students to develop advanced skills;
- The provision of **access to processing and testing facilities** for professionals, students and entrepreneurs;
- **Certification and standardisation activities**; and
- Reinforcing European supply chains through **wide participation of enterprises, in particular SMEs and start-ups** (this applies particularly to procurement and will be explored in Section 3.3).

A Commission official reiterated that Article 6 promotes various activities, such as support for start-ups in the space sector and increasing the uptake of space data and services, adding that such applications can support EU and national policies as well as SMEs.

Before examining the potential impact these actions could have on the upstream sector moving forward, it is important to view the **progress made in recent years**. According to the Galileo and EGNOS programme performance overview²⁰, the performance of the **Galileo Initial Services** has been gradually improving since becoming operational in December 2016, due to the increased number of satellites and enhancements of the ground segment. The positioning and timing of Galileo services is unrivalled compared to other Global Navigation Satellite Systems (GNSS) across the globe, although there were two service disruptions, in July 2019 (when the entire system was unavailable for use for six days), and December 2020. Though performance progressed in 2020, severe restrictions on travel and working procedures imposed by COVID-19 resulted in delays in achieving the programme's key milestones, such as the next Galileo launch (L11) and the deployment of ground infrastructure.

¹⁹ Regulation (EU) 2021/696.

²⁰ European Commission. (2021). Programme Performance Overview – Galileo and EGNOS. Available at: https://ec.europa.eu/info/sites/default/files/about_the_european_commission/eu_budget/programme_performance_overview_-_galileo_and_egnos.pdf.

Despite the pandemic, key services were delivered. The **Galileo Open Service (GOS)** demonstrated high quality and availability while the performance of the Galileo Search and Rescue service was considered “excellent” in 2020. With regard to **EGNOS**, the provision of satellite-based services to improve the accuracy of GPS across the EU has steadily increased. Only a few areas remain unserved, which should be resolved via the introduction of the EGNOS version 3 technology in 2025. Beyond the civil aviation sector, where EGNOS is used at more than 370 airports in Europe, with its usage increasing, EGNOS is enhancing the scope of GNSS applications such as precision farming, on-road vehicle management and ship navigation.

Galileo and EGNOS have made progress in recent years and the following can be considered concrete achievements:

- **Less than 10 minutes** – this is the time required by Galileo’s Search and Rescue Service to detect emergency distress beacons, compared to up to three hours previously. Less than 15 minutes is required to send an acknowledgment message to the beacon in distress;
- **Approximately two billion** Galileo-enabled devices are in use; and
- **Seven metres** – this is the range of accuracy for Galileo’s E112 location information, compared to the 2-10 km accuracy displayed by the Global System for Mobile Communications’ cell ID-based technology.

In addition, two unique new Galileo services are under development and close to deployment, namely the GOS Navigation Message Authentication and the Galileo HAS. One interviewee noted that Galileo is the most precise GNSS in the world, with higher accuracy compared with GPS (e.g. geolocational data accurate to within 40-50cm for Galileo vs. 1m for GPS).

A similar assessment was undertaken on Copernicus²¹, which concluded that it has continued to deliver on its objectives. The operating satellites, ground infrastructure and in situ networks have been successfully deployed, ensuring Europe’s role as a key international player. According to the overview, the six core services – land, atmosphere, marine, climate change, emergency and security – are all operational and providing the level of accurate and reliable geo-information expected.

Due to the availability of Copernicus data and services, the EU EO sector witnessed an annual growth rate of 14% during the 2016-2018 period, compared to the estimated 5% annual growth rate between 2013 and 2020 assumed by the original baseline scenario. Additionally, agreements were signed with various countries, complementing the EU’s role in international fora and conferences, while the Copernicus database is available through a free, full and open data policy. The overview notes that the priorities for the 2021-2027 period are the continuity of services, new missions and the evolution of services, and the development of new activities to respond to societal challenges, for example in support of the European Green Deal. The following achievements have been observed²²:

- Over 330 million gigabytes of data have been downloaded by 400,000 registered users of the Copernicus data access portals;
- 35 million data products, coming from eight Copernicus satellites, were published in 2020.
- 95 activations of the ‘Rapid mapping’ and ‘Risk and recovery mapping’ on-demand services in 2020²³;

²¹ European Commission. (2021). Programme Performance Overview – Copernicus.

²² European Commission. (2021). Programme Performance Overview – Copernicus.

²³ Rapid mapping is a service which provides on-demand geospatial information to support emergency management activities immediately after a disaster occurs. An activation is defined by one event and a location. Risk and recovery mapping supports emergency management activities not related to the immediate response phase.

- 38 million television viewers on various platforms watched daily air-quality bulletins from around Europe based on the Copernicus atmosphere monitoring service in 2020;
- 8 Copernicus satellites were in orbit in 2020;
- 60,000 registered users of the Copernicus climate change service had access to more than 70 TB of quality-controlled climate data per day in 2020;
- 185 rapid action coronavirus Earth observation dashboard economic indicators monitor the consequences of the COVID-19 pandemic²⁴; and
- 60 open information products are provided under the Copernicus land monitoring service.

It is expected that these flagship programmes will continue to progress during the 2021-2027 period, building on the achievements already made. An interviewee from a multinational aerospace firm noted that the space programmes have been very successful and demonstrate what Europe can achieve through collaboration.

Both the public and private sectors have the opportunity to enhance their usage of space data, bringing about benefits in a number of sectors and helping the recovery from the COVID-19 pandemic.

The anticipated benefits derived from the space programmes include positive impacts on GDP through employment and revenue gains, technological and scientific excellence, improved food safety and enhanced security²⁵. As an interviewee from a Member State space agency pointed out, Galileo and Copernicus are viewed as strategic tools which support the information revolution, security challenges, economic competitiveness and sustainable development.

To maximise the effectiveness of the EU space programmes, a framework has been put in place to measure their progress. The following table demonstrates the expectations placed on Galileo and EGNOS in order to achieve their objectives.

Table 1: Indicators measuring performance of Galileo and EGNOS

Indicator	Dimension measured	Source	Data availability
Accuracy of navigation and timing services provided by Galileo and EGNOS separately	Accuracy of navigation signals and timing services	EUSPA	First data in 2022; estimated lag 1 quarter; quarterly.
Availability and continuity of services provided by Galileo and EGNOS separately	Availability and continuity of services	EUSPA	First data in 2022; estimated lag 1 quarter; quarterly.
EGNOS services geographical coverage	Geographical coverage	EUSPA	First data in 2022; estimated lag 1 quarter; quarterly.
Number of EGNOS procedures published (both APVI and LPV-200).	Number of airports with EGNOS procedures	EUSPA	First data in 2022; estimated lag 1 quarter; quarterly.

²⁴ The dashboard uses EO satellite data to measure the impact of COVID-19 lockdown and monitor post-lockdown recovery. It enables the monitoring of key environmental parameters, such as air and water quality changes, and economic and human activities including industry, shipping, construction, traffic and agricultural productivity.

²⁵ OECD. (2020). Measuring the economic impact of the space sector: Key indicators and options to improve data.

Indicator	Dimension measured	Source	Data availability
EU user satisfaction with respect to Galileo and EGNOS services	User satisfaction concerning positioning, navigation and timing services	Annual user survey conducted by EUSPA	First data in 2022; estimated lag 1 year; annually (TBC).
Share of Galileo and EGNOS enabled receivers in the worldwide and the EU Global Navigation Satellite Systems/Satellite Based Augmentation System (GNSS/SBAS) receivers market	Market share	GNSS Market Report	First data in 2021; estimated lag 2 years; biannually.

Source: European Commission. (2021). Programme and Performance – European Space Programme.

The indicators measure a range of dimensions important to the development and usage of Galileo and EGNOS services. The concrete achievements made over the last few years demonstrate the progress of these services, and the EU will be keen to build on these achievements, improving the accuracy, availability and coverage of the services, as well as increasing the number of enabled devices in use. Additionally, progress will be measured in terms of user satisfaction. This is an important indicator, as high user satisfaction will encourage other users to adopt the services and strengthen the EU's capacity to compete internationally. The next publication detailing the implementation of the programme should be published in June 2022. It will be interesting to observe what progress has been made during the initial period of the 2021-2027 period, considering the new MFF in place.

A similar performance framework has been put in place to measure the progress of Copernicus services, as per the table below.

Table 2: Indicators measuring performance of Copernicus

Indicator	Dimension measured	Source	Data availability
Number of EU users of Copernicus Services, Copernicus data, and Data and Information Access Systems (DIAS) providing, where possible, information such as the type of user, geographical distribution and sector of activity	Number of users	Quarterly and Semester reports and data dissemination dashboards of the Copernicus Entrusted Entities	First data in 2022; estimated lag 1 semester; biannually.
Where applicable, number of activations of Copernicus Services requested and/or served	Number of requests for services	Quarterly and Semester reports of the relevant Copernicus Services	First data in 2022; estimated lag 1 semester; biannually
EU User satisfaction with respect to Copernicus Services and DIAS	User satisfaction	Annual user survey	First data in 2022; estimated lag 1 year; annually (TBC).
Reliability, availability and continuity of the Copernicus Services and Copernicus data stream	Reliability, availability and continuity in the provision of data and services	Copernicus Data IT dashboards, Quarterly and Semester Implementation Reports	First data in 2022; estimated lag 1 semester; biannually.
Number of information products delivered in the portfolio of each Copernicus Service	Total number of products available to users by the Copernicus services	Quarterly reports and product dissemination dashboard	First data in 2022; estimated lag 1 quarter; quarterly.
Amount of data generated by the Sentinels	IT Volume of Sentinel data	Quarterly reports and data dissemination dashboards	First data in 2022; estimated lag 1 quarter; quarterly.

Source: European Commission. (2021). Programme and Performance – European Space Programme.

The indicators listed in the table above tend to focus on increasing the number of users of Copernicus services and increasing the number of products available. Although the reliability, availability and continuity of the provision of data and services is an important factor in determining the success of Copernicus, there is an emphasis on widening the market for its usage, whereas the indicators for the Galileo and EGNOS programmes tend to focus on the accuracy and availability of services and coverage.

This is to be expected, given that Copernicus achieved its targets during the 2014-2020 period, whereas Galileo only became operational in 2016 and is either on track or has made moderate progress on the key monitoring indicators for that period²⁶.

Whilst it is too early to determine the actual impact of the EU Space Programme in 2021-2027, there is an ambitious budget of EUR 14.88 billion in place, the largest amount of EU funding allocated to date. An interviewee pointed out the political signalling effect of increasing funding for EU space and defence from a strategic autonomy perspective. It has the potential to bring about positive impacts and maintain Europe's position as the second largest space industry in the world. However, there remain obstacles to upstream space activities, which will be explored further in Section 3.2.

2.2.3. Overview of the European space industry

The European space industry is the second largest in the world, supporting the economy and facilitating R&D&I activities leading to the fostering of new and emerging technologies. The industry, which includes manufacturing and services, currently employs over 231,000 professionals and is estimated to be worth EUR 53-62 billion.²⁷ Europe remains competitive in this respect, with a third of the world's satellites being manufactured on the continent. ESA estimates that for every Euro spent, there has been six Euros benefit to society, as well as job creation²⁸.

According to statistics from Eurostat, there were 1,350 enterprises across the EU-27 in 2018 with a turnover of EUR 161 billion under the category 'Manufacture of air and spacecraft and related machinery'. This figure represents a huge increase from 2011, when the turnover stood at EUR 90.2 billion²⁹. Whilst production in 2020 under the same category was down by around eight points compared to 2015, which could perhaps be explained by the COVID-19 pandemic, up until then, production was increasing every year and was around 18% higher than in 2015³⁰. With Europe currently recovering from the economic impact of the pandemic, this figure is expected to increase looking ahead.

When examining the European space industry and its global competitiveness, a distinction needs to be made between the upstream, midstream and downstream sectors. These will now be looked at in turn.

2.2.4. The upstream European space industry

The **upstream sector** is dominated by the **large space primes**, such as Airbus and Thales Alenia Space, and includes **mid-sized players**, such as private sector players active in EO, and a **burgeoning SME and start-up sector**, who work closely with primes as subcontractors.

²⁶ European Commission. (2021). European Space Programme – Performance.

²⁷ Council of the EU. (2021). Infographic - EU in space.

²⁸ Idem.

²⁹ Eurostat. (2021). Annual detailed enterprise statistics for industry - Manufacture of air and spacecraft and related machinery.

³⁰ Eurostat. (2021). Production in industry - annual data: Manufacture of air and spacecraft and related machinery.

The table below shows the biggest European companies in the upstream sector, categorised by the following segments: **launcher**; **aerospace prime/satellite manufacturer**; and **satellite operator**. Given the limitations of this study, this section concentrates on the main actors in the upstream sector; more detailed analysis on SMEs will be provided in Section 3.

Table 3: Overview of main European companies in the upstream sector

Segment	Company	Description	Turnover/EUR (2020)	Employees	Country
Launcher	Arianespace	Europe's prime satellite launch company with three launchers – Ariane, Soyuz and Vega	1 billion	Over 300	France
Aerospace prime/satellite manufacturer	Airbus Defence and Space	Europe's leading aerospace firm. It designs and manufactures satellites and launch vehicles, and provides data services and secure communications, among others.	10.4 billion	40,000	France
	Thales Alenia Space	Provider of solutions for telecommunications, navigation, Earth observation, environmental management, exploration, science and orbital infrastructures.	1.9 billion	7,700	France
	OHB SE	Activities include building and operating satellites, manned spaceflight and exploration.	901.4 million	2,900	Germany
	Safran	Develops launch vehicles, satellites and ground stations.	16.5 billion	79,000	France
	Avio	A leading company in space propulsion. It plays a strategic role in the global space industry through Vega and Ariane 5, the biggest European launcher.	322 million	Over 1,000	Italy
Satellite operator	Eutelsat	Its 36 satellites are used for services such as video broadcasting, satellite newsgathering, broadband and maritime and aero connectivity. It serves organisations operating across Europe, Africa, Asia and the Americas.	1.2 billion	1,200	France

Segment	Company	Description	Turnover/EUR (2020)	Employees	Country
	SES	More than 70 satellites serve broadcasters, mobile network operators, peacekeepers, passengers and rural communities. It currently serves seven of the top 10 telecom companies and supports 58 government organisations.	1.9 billion	Over 2,000	Luxembourg
	Hispasat	Hispasat is a leader in content distribution in Spanish and Portuguese, distributing over 1 250 television and radio channels through its satellites. It covers the Americas, Europe and North Africa and is a key player in the Spanish aerospace industry.	160.5 million	200	Spain

Source: own research – website-based. 2020 data.

The table above provides examples of some of the largest companies working across the different upstream sectors, which includes companies of different sizes, such as SMEs. According to a report by SME4SPACE³¹. 1,069 SMEs worked in total with ESA in the 2015-2019 period. Collectively, these firms had turnover in 2018 of approximately EUR 2 billion/year. Examples of small to mid-size space European firms in the upstream include: OHB GmbH (contractors for the first generation of Galileo satellites), and high-growth start-ups such as NanoAvionics (specialising in the manufacturing of nano satellites).

According to the European Commission, **the upstream sector, which generates EUR 8.8 billion, has 43,000 jobs, representing 6% of the global space industry workforce.** Europe continues to be a strong industrial player, with around EUR 9.5 billion of satellite exports over the last ten years or so and a flourishing global commercial satellite market, while it has been estimated that 10% of the EU’s GDP relies on the use of space services. Additionally, the European launcher industry, which has accounted for 15% of global launch capacity over the last decade, has generated over EUR 10.6 billion³².

The **midstream sector** is less well covered in key literature; however, it is an economically significant part of the EU space industry.

However, commonly, the mid-stream and the upstream are closely inter-twined, for instance, ground infrastructures and operations and commercial satellite services that are dependent on upstream commercial satellite infrastructure. In the context of the Space-based Connectivity Initiative (see Chapter 4), the midstream would include providers of satellite-based internet services in remote areas.

³¹ SME4SPACE. (2020). Study on economic importance of SMEs in the space industry in ESA member states.

³² European Commission. (2020). Draft proposal for a European Partnership under Horizon Europe - Globally competitive Space Systems.

2.2.5. The downstream European space industry

The **downstream sector** refers to the acquisition and storage of space data (e.g. the development of products or services using the data, and the end-users who use navigation and timing services or EO applications). A distinction can be made between the downstream market for **EO data** and for data produced through **satellite navigation systems (e.g. GNSS data)**.

The use of space data extends beyond the space sector, as many of the potential users and economic benefits can be found in non-space sectors, in both the commercial and public sectors (e.g. monitoring in the agricultural and forestry management sectors, climate change monitoring, urban monitoring, and emergency management and response).

The downstream segment of the space economy value chain is comprised of companies that provide commercial services, products and applications to final consumers. Space data in the downstream sector is utilised by services companies, which are commonly SMEs, and by the public sector to deliver services providing a public good. The elements of the downstream sector are provided below³³:

- **Data:** EO data; GNSS; satellite communication systems; aerial imagery; ground-based data;
- **Downstream services:** mapping; applications (e.g. for smartphones); devices (e.g. GPS units); broadcasting; communications; and
- **Users:** public authorities at national, regional and local level; businesses; consumers.

EUSPA is encouraging all Member States to develop downstream activities. However, it should be stressed that the downstream market for space data is characterised by its fragmentation. Nonetheless, despite the challenges in generating the necessary critical mass to develop cost-effective services that benefit from economies of scale, there is strong economic potential. Around 10% of Europe's economy relies on space services, while the continent's companies make up a quarter of the space downstream market and billions are set to be generated by Galileo and EGNOS by 2027³⁴.

2.2.6. The market for satellite navigation services and Earth Observation data

As mentioned above, a distinction should be made between data produced through satellite navigation systems and earth observation data. The term 'geospatial services' is used to identify services and applications based on satellite data that integrate digital mapping with location-based data. These products include space imagery, navigation devices, and other services. Comprehensive estimates of recent global GNSS market size come from EUSPA, which has issued six market reports since 2010. The market report distinguishes between three groups of companies operating in the GNSS downstream industry. These are³⁵:

- **Component and receiver manufacturers**, producing chips, antennas and other inputs for receivers and receivers themselves; Hexagon and Tomtom are two EU-based companies among the top 10 companies globally based on 2017 revenues;
- **System integrators** that incorporate GNSS receivers into multifunctional devices such as cars and smartphones; Bosch and Volkswagen, headquartered in Germany, appear among the top 10 companies globally; and
- **Value-added service (VAS) providers**, which improve access and use of GNSS; Here International and Hexagon are among the top 10 companies globally.

³³ CSIL. (2016). Space Market Uptake in Europe: Study for the ITRE Committee.

³⁴ EUSPA. (2019). Europe's economy is increasingly dependent on space - ITRE committee hears.

³⁵ European GNSS Agency. (2019). GSA GNSS Market Report.

Although the US is the global leader in the GNSS market, accounting for 28% of industry revenues, according to the report, Europe is close behind, at 27%, up from 25% in 2015. China, Japan and South Korea together generate the largest revenue, with a total of 35% of global revenues. There are over 1,000 companies globally in the downstream GNSS industry.

The **EO** downstream market has evolved rapidly over the past decade due to technological changes. It can be categorised into five areas, reflecting Copernicus services: natural resource management; defence and security; land monitoring; oceanography; and meteorology³⁶.

The industry is composed of two actors:

- data providers, which own or licence commercial satellites; and
- information product providers.

The EO service value chain includes companies which sell satellite data and those providing value-added services, such as the integration of multiple data sources and interpretation and reporting.

Most clients of EO products and services are in the public sector. The 2021 EARSC (European Association of Remote Sensing Companies) survey looking at the European EO services industry found that **52.4% of the share of revenues came from public sector sources. 29.2% of revenues came from the private sector, while 7% came from International Organisations**³⁷. The survey, which covers members of the EU and ESA, found that there are 713 **companies in the European EO industry**, representing an increase of 24% over the preceding 12 months³⁸. The number of employees increased by 17% to 11,600, while **revenues are estimated at EUR 1.71 billion**, demonstrating that the EO industry is experiencing strong growth. Whilst fully disaggregated data was not available, approximately 68% of the turnover estimate is relevant to Copernicus, which provides high-resolution EO data for public sector monitoring activities and for use by a variety of industry sectors (the remainder is defence – see below).

Most of the companies included in the survey were micro (65%), while 27% were small. In terms of the location of the companies included in the survey, **the largest number of EO service companies can be found in the UK, followed by Germany, France, Spain and Italy**. The start-up sector is playing an increasingly prominent role in the market, with 229 companies having been formed since 2016³⁹.

The EO downstream sector is relatively fragmented by sector. Defence and security is the sector producing the most turnover by far, at more than 32%.⁴⁰ However, agriculture and environmental monitoring come second and third respectively, each accounting for over 10% of sales generated⁴¹. The latter two market segments as well as others such as forestry and urban monitoring are of greatest relevance from the perspective of the EU Space Programme as Copernicus provides EO data to support these sectors.

In addition to the traditional space sectors already covered here, **there is a new, burgeoning ecosystem known as “New Space”**. In the past, states tended to have a monopoly of the space sector, while investments have been highly scrutinised due to the risks involved. The recent commercialisation

³⁶ CSIL. (2016). Space Market Uptake in Europe: Study for the ITRE Committee.

³⁷ EARSC. (2021). EARSC Industry Survey 2021. <https://earsc.org/wp-content/uploads/2021/11/EARSC-Industry-survey-2021-2-2.pdf>

³⁸ Idem.

³⁹ Idem.

⁴⁰ It should be noted that the growth in this sector can be explained by the size of the players and the recent reorganisation of Airbus, where the space and defence divisions were merged.

⁴¹ Idem.

of the space sector has given rise to a new generation of space companies developing innovative and affordable solutions to access space⁴².

New Space can be defined as non-traditional space players engaging in activities making space flight, space applications or space activities faster and cheaper, and includes private launch companies, small satellite constellations or sub-orbital tourism⁴³.

Big Tech companies such as Google, Apple, Facebook and Amazon are playing an increasingly key role in the New Space ecosystem. Amazon's Project Kuiper, for instance, is an initiative to launch a constellation of Low Earth Orbit satellites providing broadband to communities across the globe lacking access to high-speed internet⁴⁴. Google Cloud has collaborated on various projects with NASA. For example, in 2017, NASA discovered an eight planet 2,500 light-years away in another solar system using Google artificial intelligence⁴⁵.

Though Europe's foray into the New Space economy is less developed than that of the US and China, it is widely acknowledged that **Europe has a significant role to play in economic growth and job creation**. Last year, the European Investment Bank (EIB) announced its first direct financing for a start-up in the sector, providing a EUR 20 million loan to Spire Global for the development and launches of nanosatellites, data analytics and high-skilled job creation⁴⁶. The EIB is also supporting the development of the New Space sector through its Advisory Services, together with the European Commission. The EIB Space Finance Lab brings together space companies and financiers, helping them to find capital sources. Spire is the voice of New Space companies at scale-up phase and has been actively contributing to the Space Finance Lab since 2019⁴⁷.

⁴² Satellite Markets & Research. Opportunities Emerging from "New Space".

⁴³ NewSpace2060. What is NewSpace?

⁴⁴ Amazon. (2020). Amazon receives FCC approval for Project Kuiper satellite constellation.

⁴⁵ Deutsche Welle. (2017). NASA uses Google artificial intelligence to discover eighth planet in distant solar system.

⁴⁶ European Commission. (2020). European Investment Bank Announces first direct financing for a start-up in the European "New Space" sector - €20 million venture loan for Spire Global.

⁴⁷ European Commission. (2020). European Investment Bank Announces first direct financing for a start-up in the European "New Space" sector - €20 million venture loan for Spire Global.

3. EU SPACE PROGRAMME: ACTIVITIES AND IMPACT

KEY FINDINGS

The implementation of the three EU space programmes in 2014-2020 has had beneficial impacts.

- Under Copernicus, there has been a strong focus on user-uptake initiatives, with partial success through DIAS, although the number of users needs to be increased; and
- GNSS data produced through Galileo/EGNOS is increasingly accessible, as mobile receivers can automatically use whichever GNSS data stream is optimal. An advantage of European GNSS services is a higher-level of precision compared with GPS (however, more needs to be done to increase the user base).

The findings from the Court of Auditors special report on space should be implemented, and appear to be realistic and timely.

The rationalisation of the EU space programmes (e.g. Copernicus, Galileo and EGNOS), which were previously separate programmes, into a single integrated EU Space Programme is a positive development.

Some planned interventions represent strong continuity (e.g. Copernicus Services, Horizon Europe pre-commercial procurement for innovation), whereas other initiatives are new (e.g. the CASSINI programme to promote space entrepreneurship, start-ups and scale-ups).

Specific SME support measures are planned to support the development of SMEs in 2021-2027. Planned support for business accelerators under Copernicus and Galileo, alongside Masters' Programmes, prizes and hackathons have potential to support SMEs and foster the market by encouraging new entrepreneurs/market entrants.

The launch of the EUR 1 billion CASSINI Seed and Growth Funding Facility providing venture capital funds to SMEs in the upstream and downstream sectors is an ambitious new initiative, with potential to support SME growth and to encourage more start-ups.

This chapter examines the measures intended to boost the downstream sector and wider space ecosystem, before looking at the impact they have. The chapter will be supported by case studies demonstrating how space data is used and how it benefits local communities (see Annex II). The chapter then looks at the main obstacles facing European space activities and discusses the recommendations proposed by the European Court of Auditors special report from 2021 "EU space programmes Galileo and Copernicus". This will include a discussion on how they could impact the efforts to strengthen user uptake and facilitate the development of downstream service and apps using EU space data. The discussion examines how realistic the recommendations are and any challenges or obstacles that could be encountered if implemented (the recommendations are further explored in Annex I). The chapter then looks at the support available to space SMEs through EU programmes, actions and initiatives.

3.1. Activities to boost the space "ecosystem", user uptake of the outputs of upstream infrastructures and their impact

This section presents a discussion on the EU actions aiming to boost the space "ecosystem", including how this might be defined, and increase user uptake of space services and data, considering the possible means of facilitating access. It also examines the impacts of these actions.

3.1.1. Main actions supporting the space “ecosystem”

Europe has a thriving space ecosystem, which consists of traditional globally-leading “primes”, such as Airbus, Thales and Safran but also includes an increasing number of start-ups and space-dedicated SMEs. Satellite companies also play a major role in this ecosystem, providing connectivity, earth observation and navigation and timing services. The ecosystem can be defined as the interplay between all these relevant actors, in the upstream sector and the downstream sector, and the impact their activities have on wider communities of citizens and businesses.

The EU has an ambitious space strategy to boost this ecosystem, which acknowledges that space technologies, data and services can support numerous EU policies and key political priorities. It adds that space policy can boost jobs, growth and investments in Europe, and help to strengthen Europe as a global player⁴⁸. To support the development and flourishing of this ecosystem, the EU will support a number of measures, centred around four key strategic goals:

- maximising the benefits of space for society and the EU economy;
- fostering a globally competitive and innovative European space sector;
- reinforcing Europe’s autonomy in accessing and using space in a secure and safe environment; and
- strengthening Europe’s role as a global actor and promoting international cooperation.

These goals will now be looked at individually.

Maximising the benefits of space for society and the EU economy

The strategy argues that the potential of Copernicus, EGNOS and Galileo must be better exploited. Specifically, the Commission encourages the uptake of space services and data, including:

- Promoting the uptake of Copernicus, EGNOS and Galileo solutions;
- Facilitating the use of Copernicus data and information by strengthening data dissemination and setting up platform services;
- Stimulating the development of space applications with a greater involvement of new actors; and
- Promoting the use of satellite communications, so as to foster ubiquitous connectivity in all Member States.

The strategy mentions that the Commission will aim to introduce Galileo in areas such as mobile phones, European critical infrastructure and aviation. The strategy notes that the Commission will use legislation to support the uptake of space services, data and applications and identify barriers. Additionally, it supports strengthening the links between the downstream and upstream sector. In this regard, it mentions that the Commission will define the limits between free Copernicus core information services and commercial downstream services. Additionally, under this goal, the strategy advocates the advancing of the EU space programmes and meeting new user needs.

Fostering a globally competitive and innovative European space sector

This goal stresses the need for research activities to address the entire space industrial value chain and support collaboration with non-space sectors. Emphasis is placed on long-term R&D needs such as low-cost and alternative access to space, while priority will be given to the development of critical space components, systems and technologies associated with technological non-dependence.

⁴⁸ European Commission. (2016). Space Strategy for Europe.

This non-dependence is of importance as it should help to strengthen Europe's autonomy in space. The main actions for the Commission are:

- Stepping up its efforts to support space R&D activities, in cooperation with Member States and ESA;
- Strengthening the use of innovative procurement schemes to stimulate the demand-side of innovation and exploring new approaches to leverage private sector investments and partnerships with industry;
- Together with Member States and ESA, promoting the use of common technology roadmaps to ensure greater complementarity of R&D projects; and
- Including space/EO in the blueprint for sectoral cooperation on skills addressing new skills requirements in the sector (this point was emphasised by an interviewee, who said that EU investment in education and training is required to help in this regard).

This goal also emphasises the need for fostering entrepreneurship and new business opportunities. Measures include:

- Supporting space entrepreneurs through EU funding programmes;
- Engaging in a dialogue with the EIB and the European Investment Fund (EIF); and
- Supporting space start-ups, including by exploring synergies with the upcoming Fund of Funds, and facilitating the emergence of space hubs and clusters across Europe.

In particular, the Investment Plan for Europe and the European Fund for Strategic Investments (EFSI) are expected to promote innovative projects. The overarching aim is to foster the right ecosystem and create a favourable regulatory and business environment encouraging businesses to develop products and services which can encourage user uptake.

Reinforcing Europe's autonomy in accessing and using space in a secure and safe environment

The strategy acknowledges the strategic importance of space for civil, commercial, security and defence purposes, as well as guaranteeing access to frequency spectrum. With new players in both the public and private sector emerging across the globe, space is becoming an ever more competitive environment, while threats such as space debris, cyber threats and space weather are also emerging. Measures include:

- Aggregating demand for launch services to provide visibility to industry and reduce implementation costs;
- Supporting research and innovation efforts, in particular to ensure Europe's ability to react to and anticipate disruptive changes (including low-cost access for small satellites and re-usability);
- Considering ways to support European launch infrastructure facilities where this is needed to meet EU policy objectives or needs (for example through the Commission's contracts for launch services);
- Encouraging the development of commercial markets for new space activities (such as low-cost small launch systems, spaceflight and space tourism);
- Ensuring the protection and resilience of critical European space infrastructure (the EU space surveillance and tracking (SST) support framework aims to address space debris and could be used to counter cyber threats or the impact of space weather); and
- Reinforcing synergies between civil and security space activities.

To facilitate the EU's autonomy in space, it plans to launch 25 satellites in the next 10-15 years, in addition to the 30 already in orbit.

The aim is to position the EU as the largest European institutional customer and create reliable, cost-effective launch solutions bringing about benefits for the civilian, commercial, security and defence sectors. One interviewee from a Member State space agency pointed out that investments in the protection of EU space assets are crucial to ensure that the EU avoids dependency on states outside the EU. Another interviewee pointed out that there is a need to strengthen security and resilience as the uptake of space data and services increases.

Strengthening Europe's role as a global actor and promoting international cooperation

The strategy recognises that, without achieving the three goals explored above, leading on the world stage in space will be weakened. It calls for Europe to be a world leader in navigating today's challenges such as climate change and disaster risk reduction, simultaneously promoting international cooperation and enhancing global governance.

The strategy stresses the need for responsible behaviour in space and promoting those principles in line with the UN and other multilateral fora. In future, there may be additional new and emerging issues that require international intervention, such as the issue of the mining of raw materials in space⁴⁹. The Outer Space Treaty provides the basic framework of international space law. Articles I and II are particularly relevant to space mining.⁵⁰ However, more specific legislation on space mining is presently lacking in most jurisdictions internationally, including the EU. Currently, the commercial use and the extraction of raw materials or other resources from space is not explicitly prohibited, but such activities could raise sustainability concerns. Allowing such activities would require international cooperation to determine the basic parameters under which such mining activities should be allowed, whilst respecting sustainability principles.⁵¹

The strategy calls for the EU to meet challenges related to the vast increase in space actors, space objects and debris in line with UN conventions. Additionally, the strategy calls on the Commission to support the EU's neighbourhood and development policies as well as the monitoring of the sustainable development goals. It also seeks to promote convergence of dual use export controls and European space technologies, solutions and expertise in countries outside the EU. Specifically, the Commission will:

- Pursue space dialogues with strategic international partners, ensure space policy is taken into account in EU export control dialogues with third countries, and use economic diplomacy and trade policy instruments to assist European companies active in global markets;
- Foster the EU's contribution to international initiatives such as the Group on Earth Observation and CEOs; and
- Together with the other EU institutions and Member States, engage with international partners to promote responsible behaviour in outer space and preserve and protect the space environment for peaceful use by all nations.

The space strategy builds on the EU Space Industrial Policy from 2013⁵². Recognising that space is a driver for growth and innovation and an integral component of wider industrial policy which can foster independence and security for the EU, the policy is centred around five specific objectives:

⁴⁹ International space law permits mining but prohibits ownership rights. See the UN's Outer Space Treaty and Moon Agreement.

⁵⁰ The Outer Space Treaty is known as the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.

⁵¹ See the article on the legal framework in outer space available at: <http://outerspaceinstitute.ca/legalframework.html> and the publication Providing a legal framework for sustainable space mining activities (2017), (Gabrielle Leterre, University of Luxembourg).

⁵² European Commission. (2013). EU space industrial policy: releasing the potential for economic growth in the space sector.

- Establish a coherent and stable regulatory framework;
- Further develop a competitive, solid, efficient and balanced industrial base in Europe and support SME participation;
- Support the global competitiveness of the EU space industry by encouraging the sector to become more cost-efficient along the value chain;
- Develop markets for space applications and services;
- Ensure technological non-dependence and an independent access to space.

Although it was published in 2013, these objectives remain relevant and can be considered long-term. The EU has certainly made progress in all areas, though challenges remain, as highlighted by the CoA report (see Section 3.3). There are a number of other measures which can help facilitate the uptake of space data. For instance:

The **INSPIRE Directive** (2007) has encouraged the take-up of environmental data by public authorities and fostered the dissemination of such data to the public and other interested parties for public good. The Directive established a specific infrastructure for spatial information in Europe to ensure that all EU Member States apply the same implementation rules. It addresses 34 spatial areas such as geology, transport networks, agricultural and aquaculture facilities, soil and mineral resources which have an impact on the environment. This binding directive strives for a harmonisation of regulations throughout the EU and thus enhances the development of applications across frontiers. There is a strong focus on making EO data available publicly through Open Access.

In line with this, the **Open Data Directive** requires the adoption by the Commission of a list of high value datasets to be provided for free, to accelerate the emergence of value-added EU-wide information products. The Commission will adopt a list of specific high value datasets in 2021, under the following categories: geospatial; earth observation and environment; meteorological; statistics; companies and company ownership; and mobility.

A related measure is **the new proposed European data regulation**, published in 2020. This aims to create a data governance framework that will allow Europe to become a leading data economy, especially for industrial data. It encourages the greater reuse of data by increasing trust in data intermediaries and strengthening various data-sharing mechanisms across the EU. It promotes the notion of “data altruism”, i.e. allowing data use by individuals or companies for the common good. The act will play a key role in fostering EU-wide data spaces in strategic sectors, such as energy, mobility and health to bring benefits to citizens across Europe. The act was one of the deliverables included in the European Strategy for Data, designed to give the EU a competitive advantage by enabling it to capitalise on its vast quantity of data.

The ability of data to cross borders will be important in fostering user uptake of space data. There is a need in this area to ensure a single market in space data, without any internal barriers, for instance in terms of data access, and the commercialisation of space data.

In addition, there are other ways in which the EU can stimulate the development of the European space industry, such as through **pre-commercial procurement for innovation**, the role of **societal criteria in upstream space procurement** and dedicated SME procurement in the space sector.

For instance, under the **Horizon 2020 Space Programme**, **direct R&D procurement for contract research** was funded as a mechanism for supporting early-stage research and demonstration activities to procure specific product needs in the upstream space sector by the likes of ESA, the European Commission and the GSA.

Similarly, the **Horizon Europe Work Programme 2021-2022** contains a number of projects to support both the upstream and the downstream sectors. Projects supported in the upstream sector include satellite communication systems, space transportation and projects related to Copernicus services, such as enhancing the quality and efficiency of the Copernicus Atmosphere Monitoring Service. Budget is also available for the development of applications for Galileo, EGNOS and Copernicus, to make best use of their capacities for EU citizens, companies and society. Projects include EGNOS and Copernicus applications fostering the **European Green Deal** and supporting the public sector as Galileo and/or Copernicus users. The latter aims to stimulate the public sector in Europe to use space downstream products and encourage the public sector to be the “first customer” for innovative space-based applications⁵³.

More generally, **societal criteria in upstream space procurement** could help to support the European space industry, including SMEs, for instance through the introduction of rules to ensure that a certain percentage of all EU space procurement benefits European industry and jobs.

3.1.2. Impact of actions on the European space sector and user uptake of space data

This section explores the impact the above actions have on the European space sector and user uptake of space data. Case studies demonstrating the actual use of space data in selected examples across the EU and how it benefits local communities are provided in Annex II.

The billions of Euros invested in European space activities have led to positive **economic benefits**, knowledge spill-overs and societal benefits. ESA estimates that for every Euro spent, there has been **six Euros benefit to society**, as well as job creation⁵⁴. There are therefore significant economic and knowledge spillover effects.

Moreover, an analysis published by PwC in 2019 estimated that Copernicus generates between **EUR 16.2 and 21.3 billion** in economic benefits through added value produced in the upstream sector, the sales of applications by downstream suppliers and the use of products by end users across the economy⁵⁵.

Moreover, a study undertaken in support of the European Commission Impact Assessment on the evolution of the Copernicus programme found that Copernicus is expected to generate **EUR 67 billion to EUR 131 billion of benefits to European society** between 2017 and 2035. Around 84% of the benefits are expected to be generated in the downstream sector and end user segments⁵⁶.

Additionally, a **third of the world’s satellites** are manufactured in Europe (according to the United Nations Office for Outer Space Affairs (UNOOSA), there are currently 8,009 satellites in orbit)⁵⁷.

The space programmes have also brought about **societal benefits**. **Environmental data** is of strong interest to EU citizens and has, for example, improved the management of air quality, monitored compliance with environmental policies and improved wildfire management. From a strategic point of view, the space programmes have **strengthened Europe’s autonomy in space**, and helped to develop **industrial competitiveness**.

⁵³ European Commission. (2021). Horizon Europe Work Programme 2021-2022: 7. Digital, Industry and Space.

⁵⁴ Council of the EU. (2021). Infographic - EU in space.

⁵⁵ PwC. (2019). Main trends and challenges in the space sector.

⁵⁶ European Commission. (2018). Impact Assessment: Proposal for a Regulation establishing the space programme of the Union and the European Union Agency for the Space Programme.

⁵⁷ United Nations Office for Outer Space Affairs. Online Index of Objects Launched into Outer Space.

The benefits of the space programmes are clear to see and, according to a survey conducted by ESA, European citizens are interested in space activities⁵⁸. Over 5,000 citizens from Germany, UK, France, Spain and Italy were questioned in the survey, which found three principal uses of space:

- Better understanding the universe;
- Observing the planet, for example to monitor climate change; and
- Making life easier, for example in transportation or communications.

Yet, the survey also found that only 40% believed they were well informed about European space activities, while many did not understand the implications of the space programmes and ESA. This point was reiterated by an interviewee, who asserted that good communication activities are required to make it known what has and can in future be achieved by the space programmes. That said, 90% of those surveyed had a positive view of space activities. Indeed, according to a Eurobarometer survey carried out in 2013, when asked about the impact of space activities on society, the following observations were made⁵⁹:

- 55% of Europeans would be interested in using space data to plan travel and outdoor activities;
- 72% think space activities can have a positive impact on environmental protection and more efficient agriculture;
- 73% believe space activities can help to understand climate change; and
- 57% think that human space exploration investment can bring about medical progress.

Although the results of this survey are dated, they demonstrate the positive view of Europeans towards the societal benefits which can be generated by space activities. Given the political, economic and societal changes which have taken place since then, such as COVID-19, Brexit and the ongoing digital transformation, it would be beneficial to undertake another survey to see how citizens' attitudes have changed over the last few years. For instance, there is more awareness today of the way artificial intelligence can process vast amounts of data, discover patterns and facilitate analysis of the data to make informed decisions.

However, despite the positive views of citizens towards space activities, there is a need to increase the uptake of space data, as highlighted by a recent report by the European Court of Auditors, which assessed the measures taken by the Commission since 2014 to promote the uptake of services derived from the Galileo and Copernicus programmes⁶⁰. The next section looks at the issues inhibiting the uptake of space data and discusses the recommendations highlighted in the report.

3.2. Obstacles facing space activities and improving access to space data

The EU has an ambitious space policy designed to provide innovative services to users, strengthen its role as a leading global player in space, boost its space industry and maintain autonomous access to space, supported by billions in funding. However, a key issue is the challenge of how the very significant investment in upstream space activities through the EU space programmes can generate economic and societal benefits through the take-up of downstream services.

Although European firms are competitive with regard to innovations that have impacted the space industry, this has rarely translated into a commercial advantage within the European space sector.

⁵⁸ European Space Agency. (2019). How much do European citizens know about space?

⁵⁹ European Commission. (2014). Special Eurobarometer 403: Europeans' attitudes to space activities.

⁶⁰ Special report of the European Court of Auditors. (2021). EU space programmes Galileo and Copernicus: services launched, but the uptake needs a further boost.

There are obstacles to the implementation of upstream activities benefiting the downstream sector in Europe. For example, European technology leaders are not active enough in space and technology transfer lacks effectiveness. Additionally, there is a lack of risk capital funds for ventures looking to commercialise their innovative technologies⁶¹. Although the recommendations of the CoA report will be explored in this section, the overarching conclusion is that, while Galileo and Copernicus provide valuable services and data, more actions can be undertaken to maximise their potential to achieve the expected benefits.

Indeed, the 2016 study “Space Market Uptake in Europe” by CSIL for the ITRE Committee, which aimed to assess the European downstream space market and shed light on the potential use of services and products based on space data, arrived at the same conclusion. According to the study, the sector’s performance had not met expectations. It found that European space policy started relatively late compared to its main competitors and Europe has been slow to react to the rapid and massive release of already processed space data. Combined with a weak and fragmented demand from public and private users, European companies in the downstream space market are generally small and domestically-oriented. According to the study, the EU still lacks an integrated and coherent space industrial policy⁶².

The CoA aims to bring added value by aiding the Commission to promote more effectively the uptake of services and to better monitor the programmes’ achievements. It made the following observations⁶³:

- A **comprehensive EU strategy** covering the uptake of space services has not yet been developed. The 2016 Space Strategy described the objectives and actions in general terms, but neither defined the benefits to be generated nor set clear targets to achieve the “maximisation” of benefits. Additionally, the report found that although the Commission uses Copernicus data well in policy monitoring, it has not yet introduced a strategy to further enhance its use. Further, coordination among Member States’ strategies supporting uptake was found to be lacking. There were substantial differences in the way national authorities integrated the space programmes into their national policies and supported the uptake;
- The EU space programmes provide **benefits, but there is limited information on the actual extent of the benefits**. A recognised conceptual framework for estimating the benefits of space infrastructure and a system for gathering data on the benefits derived from space services are lacking. Whilst there have been previous studies to assess the socio-economic impacts of upstream investment e.g. of Copernicus (formerly GMES)⁶⁴, the CoA report advocated strengthening methodologies to monitor and measure space uptake and downstream economic and societal benefits. An alternative methodology for assessing practical benefits of space was adopted by EARSC as part of the Sentinels Benefits Study (SeBS), where 20 case study examples of the impacts of Galileo on users were developed. These stressed the importance of adopting a qualitative approach to capturing impacts, including the importance of assessing softer, non-economic impacts too⁶⁵.

⁶¹ European Investment Bank. (2019). The future of the European space sector: How to leverage Europe’s technological leadership and boost investments for space ventures.

⁶² CSIL. (2016). Space Market Uptake in Europe: Study for the ITRE Committee.

⁶³ Special report of the European Court of Auditors. (2021). EU space programmes Galileo and Copernicus: services launched, but the uptake needs a further boost.

⁶⁴ Booz & Company. (2011). Cost-Benefit Analysis for GMES.

⁶⁵ EARSC. (2021). SeBS workshop ‘The Story of how Copernicus benefits European Citizens’.

An interviewee from ESA confirmed that a key finding from the SEBS project is that the main motivation of public administrations is to strengthen delivery of public services and not economic;

- There is no official definition of the value chain of the space economy, while the Commission lacks information and key performance indicators enabling the monitoring of uptake. An interviewee from a Member State space agency noted that promoting success stories where Copernicus data was used, as well as involving public authorities in the implementation and promotion of the Copernicus programme could be helpful in increasing the uptake of space services and data. According to the interviewee, there remains a lack of awareness among public authorities and institutions of how Copernicus data could be utilised in various fields. Training for technical staff on how to use data could therefore be provided to build awareness of how it can generate benefits. Similarly, the availability of results could raise awareness of the potential of the Galileo and EGNOS programmes for sectors such as transport. The need for more public authorities to become end users of space data was emphasised by another interviewee from an industry association representing SMEs. As such, there appears to be a general view that, whilst the technology is available, the public sector should be encouraged to play a bigger role in the use of space services and deliver innovative services to citizens;
- **Considerable progress has been made to enable the use of Galileo services, however key features are not yet available to maximise the benefits.** Galileo was planned to be fully operational by end of 2020, but this was not achieved. The HAS and a Navigation Message Authentication Service (OSNMA) are key features of Galileo, but their development has caused delays, while it is unclear when the Commercial Authentication Service (CAS), which provides an encrypted Galileo signal, will be operational. One interviewee from the Commission confirmed that when Galileo and EGNOS were designed, the security of the systems was not particularly high on the agenda. Security has since become extremely important and significant investments have been made to strengthen security. This has led to delays in Galileo's implementation. However, according to the interviewee, the systems are now under control. Additionally, although actions supporting the use of Galileo services were considered good quality, there is a risk that project results are obsolete by the time they are available. In some cases, potential customers lacked the funding to implement new technologies;
- There is a **lack of data regarding SME participation in upstream space infrastructure** development relating to Copernicus. Again, as is the case with Galileo/EGNOS, SMEs benefits as subcontractors working for primes which dominate contract award. A multinational aerospace firm noted that it supports the array of companies in the sector as they are all part of the same ecosystem and trying to achieve the same goal in fostering the European space sector. It works with SMEs, in particular when they offer innovative solutions, and also invests in start-ups;
- Although there have been initiatives to foster user uptake, the Commission's **actions to support the uptake of Copernicus data were somewhat fragmented and synergies were not always fully exploited.** For example, under the Caroline Herschel Framework Partnership Agreement (FPA), which enables the Commission to directly support uptake with national partners, there were several smaller and isolated actions such as workshops, training or projects. As such, its implementation was fragmented. Additionally, the report found that Copernicus data is still available on a number of platforms operated by the ESA, the Copernicus entrusted entities, Member States and private operators. The use of DIAS has been low

compared to the overall number of active users of the Copernicus services. However, it should be noted that the data could be misinterpreted, since a single organisation could have hundreds of users. Regarding payments for such services, it can be noted that whilst the core Copernicus services and also DIAS provide free data, many users wish to combine Copernicus through overlaying with other data sources, which adds value to the data, but these services are paid-for. Only a small percentage of users currently pay for services overall, but this has potential to grow;

- An interviewee from a multinational aerospace firm pointed out that the data generated by Copernicus was mainly intended for use by public authorities and not private companies. As such, the interviewee believes the expectations for uptake by the private sector are too high, though admitted that new applications have been developed using Copernicus data;
- As noted in the Space Regulation, the companies operating in the downstream sector, in particular entrepreneurs and start-ups, are a fundamental link between the EU space programmes and their end users. As such, **the Commission launched a “start-up programme” to foster the creation and development of start-ups in the downstream sector.** The EU will continue to maintain the right ecosystem with measures such as space hubs building on current capabilities and a common toolbox across these hubs, including incubators, accelerators and summer schools;⁶⁶
- According to an interviewee from a Member State space agency, start-ups can utilise their knowledge to develop and use space applications relevant to their specific field of activity, using free data. The interviewee added that fields such as agriculture, smart cities and natural disaster response all have new actors that can access space data; and
- **Regulatory measures can facilitate the uptake of EU space services** but there are still gaps. The Commission has adopted measures to facilitate the uptake of Galileo services in the field of road safety and emergency, which supported the equipping of new cars and mobile phones with Galileo compatible chipsets. After consultation with Member States, three priority areas which could benefit from regulation or standardisation were identified, namely Intelligent transport and mobility; Intelligent interconnectivity; and Intelligent infrastructures. Regarding Copernicus, the report found that the Commission does not promote the use of EO enough in regulations. Although a legal base encouraging Member States to use EO for the monitoring and implementation of the Common Agricultural Policy was adopted, minor progress was observed in other sectors which could benefit from legislation.

Additionally, the report found that the Commission lacked a systematic overview of how Member State administrations utilised space data and whether any regulatory barriers prevented their use.

Whilst moderate progress has been made on **standards development**, complementary sector-specific regulatory action is required.

Overall, the report concluded that Galileo and Copernicus are providing services and data of value, which have been supported by the Commission yet require more impetus to maximise their benefits. Since 2007, around EUR 31 billion has been allocated to space activities, yet the report found that, despite this investment, further efforts are required to make best use of it to achieve the expected societal and economic benefits. Consequently, the report arrived at four recommendations to overcome the obstacles to the implementation of the upstream activities.

⁶⁶ Regulation (EU) 2021/696.

The recommendations are very much inter-linked and overlap, but provide clear advice on the steps the Commission should take to boost the EU's space sector.

3.2.1. Recommendations made by the CoA

The CoA report made four recommendations (explained in detail, including the underlying rationale, in Annex I). These were:

- **Recommendation 1: Develop a comprehensive strategy for supporting the uptake of EU space services.** The CoA report recommends a comprehensive strategy for supporting the uptake of EU space services. Such a strategy does not currently exist, and the report advises the strategy to include all relevant stakeholders, clarify their roles and provide realistic and measurable targets by 2023. With regard to the latter, a challenge has been quantifying the benefits generated by the space programmes relative to the costs. For example, although the income generated by Copernicus and Galileo was calculated, the Commission did not estimate the consequent impacts for the downstream sector. Additionally, the report encourages the Commission to work with Member States to identify those areas where space services could improve public administrations and address the fragmented nature of the market;
- **Recommendation 2: Develop a conceptual framework for estimating the benefits of the EU space programmes and improve performance measurement.** The report advocates the development of a framework for estimating the economic and societal benefits of Galileo and Copernicus, in collaboration with international organisations and Member States, and harmonising the assessment of their benefits. Additionally, appropriate performance indicators are required to monitor the achievement of the space programmes' objectives. Since there is limited information on the extent of the benefits generated, this recommendation, if implemented, would help to shed light on how the space programmes are benefiting Europe's citizens, governments and businesses. For example, the Commission could engage with Eurostat to define a methodology and indicators for calculating, to the best extent possible, the benefits generated by Copernicus;
- **Recommendation 3: Ensure full readiness of Galileo and better targeted action on uptake of the EU space services.** The report recommends ensuring full readiness of Galileo and better targeted action on the uptake of EU space services. This can be achieved by developing the technical and legal arrangements needed to facilitate the use of Galileo; defining clearly the objectives and expected impact and pursuing complementarity with Member States; and improving access to Copernicus data and products. Although measures have been adopted in the field of road safety and emergency to accelerate the use of Galileo services, there is no indication when regulations and standards will be introduced in other priority areas. Additionally, administrative barriers can hinder the use of EO and navigation services. For example, Sentinel data may require substantial changes to administrative procedures and IT systems to use new technologies.

It should be noted, however, that greater uptake of space services is contingent on fully functioning space programmes. As noted previously, there have been two service disruptions since 2016. It is therefore crucial that any future outages are rectified as soon as possible to ensure the continuation of services provided in the downstream sector and uphold Galileo's reputation as a leading GNSS. In terms of supporting the uptake of space data, the development of local ecosystems where space companies engage with digital companies, as is the case in Brittany, could be effective. Such collaboration could facilitate the development of services and lead to increased uptake, identifying where the needs lie;

- **Recommendation 4: Better use the regulatory framework to support the uptake of EU space services.** The report recommends better use of the regulatory framework to support the uptake of EU space services. It advises the Commission to conduct an analysis of where legislation could better promote the use of space data. At present, there are few legal provisions stipulating that the best use of Copernicus and Galileo be made for data collection. The use of regulations to improve the uptake of space services was highlighted by interviewees, and they can be a useful tool in this regard. However, any regulations considered should ensure that the market for space services remains competitive and does not unfairly bar other space systems from being utilised. One interviewee from a multinational aerospace firm suggested that, initially, the European Commission could be encouraged to use space data via regulations, adding that the data should be used where it brings added value. The aforementioned analysis would help in this regard. In an interview with the Commission, the CoA recommendations were regarded as being useful, and realistic to implement within the timeframe suggested. The interviewee added that they are well-founded and evidence-based.

3.3. Supporting SMEs: Activities and impact

This section presents a discussion of the extent to which SMEs in the European space industry have received support to help structure the market and foster their competitiveness. A distinction is made in the analysis between direct and indirect support for European space SMEs. This section considers, in particular:

- EU programmes and initiatives targeting support to SMEs in the space sector directly (e.g. the EU Space Programmes and Horizon Europe Space);
- Other EU funding programmes for SMEs that are not space-targeted, but where space start-ups and SMEs may participate and benefit indirectly (e.g. SME Instrument, H2020);
- Analysis of opportunities and challenges in relation to EU support for space SMEs;
- The extent to which the expected economic and societal benefits in the upstream and downstream space sectors have materialised, focusing on SMEs;
- Analysis of the results of these actions and their coherence with wider EU space policy developments and broader EU SME support actions (e.g. EU SME strategy, EU industrial strategy), wherever data is available.

3.3.1. Overview of EU actions to support SMEs in the space sector

Regarding direct support for space SMEs, such firms benefit from the EU Space programmes both in relation to the upstream and downstream. However, the dynamics differ in terms of how SMEs are involved. A review of the main EU programmes and funding instruments for space SMEs is now provided. Reference can also be made to other studies that have mapped SME instruments for the space sector in detail⁶⁷.

⁶⁷ See for instance: European Investment Bank. (2019). The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures.

SME participation in Galileo and EGNOS

In the area of satellite navigation, in the upstream, large firms (primes) dominate contract awards in terms of the manufacturing of satellite constellations. However, medium-sized firms have also benefited, and SMEs more broadly benefit through supply chains in their role as subcontractors.

Galileo, the contract for the **first generation of satellites** was awarded in 2010 to OHB GmbH in Germany. This is an example of a successful company that has transitioned from being a medium-sized company to medium-to-large. The manufacturer OHB was responsible for 34 of the 38 first-generation Galileo satellites. The satellites were built by Surrey Satellites (UK), also a medium-sized firm. However, due to Brexit, contract award for the **second generation of satellites** was awarded to Thales Alenia Space and Airbus, both large firms. SMEs will still benefit through the supply chain. However, no data is available as to the percentage of contracts benefiting SMEs, as these large contracts are managed by primes.

User uptake activities to foster increased user among SMEs of Copernicus EO data

However, **SMEs are among the explicit target groups relating to activities to foster the uptake of Copernicus and space applications**. SMEs benefit from having free and full access to Copernicus data through its open data policy. As the market for using EO data to develop services is highly fragmented, SMEs and start-ups have a central role to play in terms of maximising the potential socio-economic benefits of Copernicus. As such, there has been support through activities such as the budget line to support user uptake in Copernicus that have benefited SMEs.

Many SMEs are intermediate users of Copernicus EO data in that they use such data alongside EO data procured from commercial providers and translate this into services for end-users. A good example in this regard is the report published by NEREUS (space data-using regions) which highlights 99 different use cases of Copernicus data⁶⁸. This includes use cases for environmental monitoring and other public services, but also for SMEs across sectors as diverse as agriculture, fisheries and forestry.

Interview feedback from SMEs in France that are users of Copernicus data stressed that there have been improvements over time in the ease of access to Copernicus data, especially since the launch of DIAS, the Data and Information Access Services. They also stressed that in order to extract maximum value from the data, it is necessary to use free Copernicus data in conjunction with other datasets, both commercial EO data, as well as in situ data available from across the different Copernicus Services (e.g. marine, emergency management), as well as other non-space data. To encourage new entrants such as SMEs into the market, Article 17 of the Space Regulation stipulates that, **for contracts above EUR 10 million, contracting authorities should aim to ensure that a minimum of 30% of the contract's value is subcontracted**, particularly to facilitate the cross-border participation of SMEs⁶⁹. This measure should increase the participation of non-traditional firms in the space market.

Horizon 2020 and Horizon Europe Space

SMEs have already benefited from **Horizon 2020 Space (2014-2020)** through support for pre-commercial procurement. Innovation procurement can drive the R&D and deployment of innovative solutions from the demand side. However, there was also a recognition that there is a challenge in SMEs taking part in such procurement compared with large firms.

⁶⁸ NEREUS, European Commission and ESA. (2018). THE EVER GROWING USE OF COPERNICUS ACROSS EUROPE'S REGIONS: A selection of 99 user stories by local and regional authorities. <https://www.copernicus.eu/sites/default/files/2018-10/copernicus4regions.pdf>

⁶⁹ Regulation (EU) 2021/696.

Accordingly, a CSA call was launched in 2018 under H2020 to encourage business and innovation support intermediaries to provide support for space hubs (through the provision of support to space start-ups)⁷⁰. The call aimed to increase the number of initiatives for start-ups, scale-ups and entrepreneurs in the downstream and upstream space sectors (e.g. through Incubators, Accelerators, Hackathons or AppCamps). The objective was to “provide solutions to accelerate the growth of space scale-ups and the commercialisation of their products, engage small and medium enterprises in space innovation, especially those not traditionally involved in it, and reduce as much as possible the technical and financial entry barriers to SMEs for Horizon 2020 to develop or adopt space-enabled solutions”. Each space hub supported benefited from EU funding of circa EUR 1 million. There will continue to be support during **Horizon Europe Space (2021-2027)** for pre-commercial procurement, and SMEs will continue to be eligible.

Copernicus market uptake (Leadership in Enabling and Industrial Technologies – Space)

Funding support for Copernicus market uptake has been provided to foster user uptake under the Leadership in Enabling and Industrial Technologies (Space) within H2020. SMEs were also eligible to take part in this sub-programme.

Some SMEs have implemented Innovation Action (IA) projects to foster user uptake. For instance, AgroApps in Greece was the lead coordinator of the **BEACON project**⁷¹, which developed a commercial service package that will enable insurance companies to exploit the untapped market potential for Agricultural Insurance, taking advantage of innovations in Earth Observation, weather intelligence and ICT/blockchain technology. The lead coordinator is an SME which specialises in developing real-life agricultural ICT solutions.

GILAB DOO BEOGRAD-PALILULA is a Serbian SME that develops geo-information solutions. It is the lead coordinator of the 3-year **AgriCapture project**, “*Developing EO-powered services to promote soil carbon sequestration through regenerative agriculture*”.⁷² The project has a budget of EUR 3.4 million (of which EUR 2.97 million in EU funding) and will be implemented between 2021-2023. The aim is to address the market need for efficient and streamlined carbon capture solutions that could be utilised in land use, land use change and forestry. Specifically, according to CORDIS, “the project will develop a systematic, robust and flexible platform for quantifying, verifying and promoting soil carbon capture. The results benefited farmers and food companies, and should allow organisations to certify, scale up and automatise their processes”.

CASSINI - Competitive Space Start-ups for INnovation

CASSINI ⁷³ is the European Commission’s new Space Entrepreneurship initiative led by DG DEFIS to support innovative entrepreneurs, start-ups and SMEs in the space industry, including New Space, during 2021-2027.

The new initiative is open to all areas of the EU Space Programme, as it encompasses both the upstream (e.g. nanosatellites, launchers, etc.) and downstream (i.e. products/services enabled by space data).

The objectives of the initiative are to:

⁷⁰ See: Space hubs (support to start-ups) - TOPIC ID: DT-SPACE-26-BIZ-2020, available at:

<https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/dt-space-26-biz-2020>.

⁷¹ See: BEACON project, available at: <https://cordis.europa.eu/project/id/821964> and lead coordinator <https://agroapps.gr/en/home/>.

⁷² See: AgriCapture project, available at: <https://cordis.europa.eu/project/id/101004282> and lead coordinator <https://gilab.rs/projects/>.

⁷³ See: Cassini Programme overview, available at: https://ec.europa.eu/defence-industry-space/eu-space-policy/space-research-and-innovation/cassini_en.

1. Expand the number of start-ups in the EU building businesses based on innovative EU space technologies, also by linking them to digital/ICT (i.e. expand a “space ecosystem”);
2. Increase their chances to succeed (with both technical and managerial support); and
3. Accelerate/secure their growth & scale up (attracting more private investors).

Some aspects of CASSINI build on efforts supported through Galileo and Copernicus during H2020 Space, such as prizes, whereas others are new and potentially very promising for SMEs, such as a EUR1 billion EU seed and growth fund.

As highlighted by a Commission official, the New Space economy (see Section 3.3.2) fosters the commercialisation of the space sector and access to finance. The official, stressing the need for more cross-border space activity, added that the CASSINI programme is intended not only to provide funding but also to connect financial intermediaries with the space sector, as they lack awareness about the sector. There was a misperception that investing in the space industry is high-risk and low-profit, as explained in detail later in this section in relation to the importance of fostering a culture of risk in Europe, including among investors.

In addition, there will be hackathons⁷⁴ and support for mentoring, a business accelerator, partnering, matchmaking and in-orbit demonstration. The first actions open for application will be published from mid-2021. There are some specific funding opportunities, such as the **Galileo Incubation Programme Masters (formerly the E-GNSS Accelerator)**, an integral part of the Galileo Masters 2021. This initiative aims to “support entrepreneurs and start-ups to move beyond idea conception into business incubation in order to develop their solutions into true commercial ventures”⁷⁵.

The **Copernicus Accelerator** helps 50 of Europe’s boldest innovators and start-ups.⁷⁶ Its 12-month tailor-made coaching programme provides a challenging, inspiring and inclusive setting for you to take your idea to the next level. The Copernicus Accelerator offers coaching, bootcamps, virtual training, access to the EO network, meeting investors and market validation.

ESA – SME procurement

ESA has a dedicated procurement policy of encouraging SME involvement in ESA activities⁷⁷. This is implemented through calls for proposals from SMEs to develop, adapt and validate technologies to satisfy space engineering requirements. According to ESA, such Announcements of Opportunity (AOs) typically concern:

- LET (Leading-Edge Technologies)-SME: AOs fully reserved for SMEs; or
- C1-C4 clause AOs (AOs with special procurements policy), applicable to a variety of technology activities.

The LET-SME programme aims to encourage the ‘spin-in’ to the space industry of leading-edge technologies from SMEs. The aim of the C1-C4 clauses is therefore to guarantee fair access to ESA’s procurements for companies irrespective of their size.

⁷⁴ Information about the Hackathons Programme funded under Cassini <https://hackathons.cassini.eu/>.

⁷⁵ Information about the Galileo Masters and Incubation Programme <https://galileo-masters.eu/incubation/>.

⁷⁶ Information about the Copernicus accelerator for start-ups <https://accelerator.copernicus.eu/start-ups/>.

⁷⁷ ESA’s SME policy - https://www.esa.int/About_Us/Business_with_ESA/Small_and_Medium_Sized_Enterprises/ESA_SME_Policy.

Several measures have also been adopted by ESA to provide technical support to SMEs, such as ESA training and technical assistance and giving access to ESA facilities and laboratories for SMEs to undertake research.

The SME Instrument

The SME Instrument, now the European Innovation Council (EIC) Accelerator, was targeted at SMEs in all sectors. However, a number of space start-ups and SMEs benefited from their participation in this programme, which supports close-to-the-market innovation and the commercialisation of research results. The SME instrument provided support through Phase 1 projects with 50,000 EUR being granted to undertake feasibility studies and research into proof of concept. A more limited number of beneficiaries were then able to gain access to greater funding – circa EUR 1 million– to fund prototype development. Some space SMEs benefits from the SME Instrument, such as the following case study:

Box 2: Case study – SME Instrument (space sector SME)

Enabling Chemical Propulsion System for the Growing Small Satellite Market (EPSS) – a project led by space university spin-off NanoAvionics in Lithuania.

Phase 1: Timeframe – March to August 2016. Funding of EUR 71,429 of which EUR 50 000 EU funding.

Activities supported: Feasibility study to investigate more green propulsion systems. Aims were to 1. Identify the market potential of the proposed propulsion system; 2. Determine customer demand and market interest and 3. Develop a technology IPR strategy, and business model for the product's development.

Phase 2: Timeframe – June 2017 – September 2019. Funding of EUR 1,679,507, of which EUR 1,175,655 in EU funding.

Activities supported: Conducted final piloting and qualification of the technology, preparation of the production infrastructure, product commercialization, and increasing the company's investment-readiness. The project will increase the technology readiness level (TRL) of EPSS to 8 by integrating it into the pilot partner's satellite, and will contribute to reaching TRL 9 by launching partner satellites into space demonstrating EPSS's capabilities in orbit.

Further examples of space SMEs supported under the SME Instrument include the ADR1EN project⁷⁸ in the area of space debris. The project also received Phase 1 and 2 funding and was implemented in 2015-2017. The project developed and tested in lab-simulated operational conditions a scaled-up demonstrator of the innovation, and developed the necessary business and commercialisation plans to reach the market.

3.3.2. Funding allocation and level of participation of SMEs

Given the number of programmes benefiting space SMEs directly/indirectly, it would ideally be helpful to have monitoring on the level of investment benefiting SMEs. For instance, the EP would like to determine the share of SMEs' participation in Galileo and EGNOS.

⁷⁸ First European System for Active Debris Removal with Nets <https://cordis.europa.eu/article/id/218655-european-smes-ready-to-clean-up-outer-space> and <https://cordis.europa.eu/project/id/666758>.

An interview with the Commission confirmed that in 2014-2020, this is not available. However, there is now a new performance framework⁷⁹ to monitor the new programme, supported by key metrics. A relevant impact indicator for SMEs is the “*Share of SMEs established in the EU as a proportion of the total value of the contracts relating to the programme*”. This would be beneficial to track, as in 2014 - 2020, there is no official monitoring data on SME participation and the value in EUR in the EU Space Programmes.

More positively, data is available from the *Interim Evaluation of Horizon 2020 Space*⁸⁰. This confirms that under H2020 Space LEIT, through an analysis of Space Open Calls in 2014-2016, SMEs received 22% of EU funding, the second highest in terms of funding allocation across different types of participants. In addition, in 2021-2027, better data ought to be available, as there are some new SME-dedicated funding streams and calls for proposals (e.g. under the CASSINI programme, the EUR 1 billion seed and venture fund, business accelerators and Masters’ programmes, all benefiting entrepreneurship, SMEs, start-ups and scale-ups etc.).

As mentioned previously, there is an emerging sector in the field called New Space, which has the potential to reinvigorate the European space ecosystem. Globally, the New Space industry has attracted investment worth billions in EUR, yet **Europe lags behind the US and China in terms of the risk capital available, while access to risk capital for European ventures remains an obstacle**. According to the EIB, the lack of specialised investors, the limited size of the European venture capital funds and their risk-averse nature are a challenge for the sector. This impacts, in particular, the growth stage of space ventures seeking to bring innovative space solutions to the market, as well as early-stage ventures⁸¹.

The EIB therefore offers direct venture financing for later-stage, fast-growing companies and supports European space start-ups at earlier development stages through venture funds. Through its Advisory Services, it supports the growth of the continent’s New Space sector together with the European Commission. The EIB’s Space Finance Lab brings together space enterprises and financiers, facilitating access to capital. A success story is that of Spire, a global space data company and Earth solutions platform which has its European headquarters in Luxembourg. Spire builds, owns and operates a constellation of nanosatellites which provide weather forecasts and track maritime and aviation movement. In 2020, **the EIB announced its first direct financing for a start-up in the European New Space sector**, awarding a EUR 20 million venture loan to Spire. The funding is intended to further develop Spire’s nanosatellites and high-quality space data and analytics, as well as create high-skilled jobs in Luxembourg⁸².

3.3.3. Analysis of EU actions targeting SMEs and their impacts

In terms of the interaction between specific EU programming in support of SMEs and how this links in with broader policy support measures, the EU’s SME Strategy and Action Plan, *An SME Strategy for a sustainable and digital Europe* (March 2020)⁸³ seeks to promote digitalisation and entrepreneurship. Moreover, the EU’s *long-term industrial strategy* aims to reinforce strategic autonomy in 14 key sectors, including space.

⁷⁹ European Commission. (2021). Programme and Performance – European Space Programme.

⁸⁰ European Commission. (2017). Interim evaluation of space research and innovation under Horizon 2020.

⁸¹ European Investment Bank. (2019). The future of the European space sector: How to leverage Europe’s technological leadership and boost investments for space ventures.

⁸² European Commission. (2020). European Investment Bank Announces first direct financing for a start-up in the European “New Space” sector - €20 million venture loan for Spire Global.

⁸³ European Commission. (2020). An SME Strategy for a sustainable and digital Europe.

Developing a resilient SME space sector in Europe through various space-related programmatic interventions and initiatives that benefit SMEs (as outlined earlier) is supportive of the objective of the broader EU policy framework to promote SMEs, encourage start-ups and scale-ups and to foster long-term industrial competitiveness.

There are however only a few evaluations that examine the impacts of EU programmatic support and actions aimed at space SMEs. Examples are the *Interim evaluation of Copernicus* and the *Interim Evaluation of Horizon 2020 Space*. There have been no evaluations covering the achievements of the EU Space Programmes as a whole, as the individual programmes were evaluated separately. However, looking to the 2021-2027 period, there will be an evaluation of the integrated EU Space Programme as this will be a legal requirement.

In terms of interview feedback, an SME industry association in the space sector suggested that the full potential of SMEs needs to be further catalysed in EU programmes, for instance by more explicit targeting of SMEs in particular calls for proposals, especially those involving the provisions of services. However, their view was that it is not necessary to put in place a dedicated SME programme.

The same industry association also pointed to it being difficult for a space SME to be successful in applying for non-space specific EU programmes because there are many specific aspects to the space industry. A further consideration is that the level of return on investment for space SMEs is much lower than in other industries, and this raises questions about whether space SMEs can take part in EU-funded projects wherever co-financing is required. An SME in the space sector noted that support programmes for start-ups should engage with the financial community and industry to ensure that the most commercially promising opportunities receive funding and investors become familiar with space technologies, space business models and their risk profiles. The SME added that funding should cover 100% of the costs through non-reimbursable grant initiatives.

A space industry association representing large firms agreed that having some funding dedicated to SMEs is important. However, if there are too many specific measures for SMEs there could be a risk of creating market distortion. Moreover, they viewed SMEs as being favoured in innovation-related competitive funding (e.g. H2020 LEITs Space), instead of the small divisions within large space businesses that may be equally innovative.

An observation was made that a relatively small percentage of personnel in the upstream sector work in SMEs, and large firms also support innovation. However, sometimes, the space businesses within large companies are relatively small and low-profit, and are therefore in some regards as fragile as SMEs. Yet, as pointed out by a Member State space agency, SMEs bring innovative solutions to today's big societal challenges and are essential to Europe's competitiveness, prosperity, economic and technological sovereignty, as well as resilience to external shocks. As such, SMEs play a critical role in progressing the EU's industrial agenda.

One interviewee from a multinational aerospace firm noted that innovation on a large scale is required to compete and it is key that the Commission avoids investing in those areas where industry has already, thereby creating competition with public money.

The initiative by the EIB is a positive step in facilitating the development of European space services and products through direct financing and could encourage the further provision of funding for ambitious start-ups in the sector. However, as pointed out by an interviewee, while a culture of risk in Europe is needed to strengthen its global competitiveness, there is **a perception that investing in space is high-risk and unprofitable**, which needs to change.

Although this cultural shift may take time, it would embolden Europe's entrepreneurs to play a strong role in the development of the European New Space sector and strengthen the EU's position as a leading global player in space.

4. SPACE-BASED CONNECTIVITY INITIATIVE

KEY FINDINGS

Early indications suggest that the space-based connectivity initiative is a very relevant solution that could deliver significant benefits to a wide range of stakeholders.

More specifically, the initiative has strong potential to enhance connectivity in areas of the EU – and further afield – that are not well served in terms of current broadband internet connectivity. This could help EU citizens living in rural areas (as well as those in third countries), and ensure access to high-speed internet for businesses and other users, such as emergency and disaster response stakeholders.

In addition, there is an important secure communications dimension which could help to deliver on objectives relating to the EU’s strategic autonomy and digital sovereignty.

Although a political commitment has been made to the initiative, there is a lack of detail available to date to be able to fully evaluate the potential of this new initiative, with key decisions still to be made on a wide range of key issues, including technical details, financing and governance. Further announcements are expected in the coming months.

This chapter discusses the space-based connectivity initiative currently being developed by the European Commission. First, we provide an overview of the context and known details of the initiative, including from the Commission’s inception impact assessment. Following this, we present an initial assessment of the relevance and potential benefits of the initiative.

4.1. Overview of the Space-based Connectivity Initiative

Industry, the wider economy, and society in the EU are going through a significant digital transformation. However, challenges persist with regard to equal access to high-speed connectivity across the EU and the increasing adoption of digitally transformative solutions, such as the Internet of Things (IoT), cloud computing and 5G. As the Commission wrote in its 2016 Communication on ‘Connectivity for a Competitive Digital Single Market – Towards a European Gigabit Society’, “while basic broadband is available to every European [...] this is no longer good enough for the ongoing digital transformation”⁸⁴. The Communication continued, highlighting the significant increase in connected devices that is anticipated in the coming years and the demands that will bring for reliable, high-capacity and high-speed connectivity.

At the same time, **cybersecurity and geopolitical threats are increasing**. In the last decade, large-scale, pan-EU cyber-attacks, many of which are considered to be state-sponsored, have become a reality, causing significant disruption.

These trends illustrate the **need not only for widespread internet connectivity, but also for secure and resilient connectivity**. President von der Leyen stressed the importance of secure connectivity in her 2020 State of the Union address, pledging to develop a more coherent European approach to connectivity and digital infrastructure deployment⁸⁵.

⁸⁴ European Commission. (2016). Connectivity for a Competitive Digital Single Market - Towards a European Gigabit Society.

⁸⁵ State of the Union Address by President von der Leyen at the European Parliament Plenary, Brussels, 16 September 2020.

As a result, in September 2021, this pledge to publish a legislative proposal on building an EU space-based global secure communication system was included in the Letter of Intent supporting the State of the Union 2021 address⁸⁶.

In addition to President von der Leyen's commitment, the **need and idea for a space-based connectivity system has been mentioned and discussed in a range of EU policy documents** in recent years, including:

- The European Commission's 2016 Space Strategy for Europe highlighted the potential for space and satellite communications to improve connectivity. The Commission pledged, together with Member States and industry, to "promote the efficient and demand-driven use of satellite communications, so as to foster ubiquitous connectivity in all Member States"⁸⁷;
- The Commission's Communication on '5G for Europe: An Action Plan', which provided support to the abovementioned Communication on Connectivity for a Competitive Digital Single Market, highlighting the need for high-capacity networks as a key asset for Europe⁸⁸;
- The European Council conclusions of 1-2 October 2020 called for strategic autonomy and new industrial alliances, including on secure telecommunication networks⁸⁹; and
- The EU's Space Regulation (EU) 2021/696, which entered into force on 1 January 2021 and establishes the EU Space Programme 2021-2027, aims to "respond to the need of secure and seamless connectivity" (Recital 4)⁹⁰. In addition, the Regulation establishes 'GOVSATCOM' as one of five key components of the EU Space Programme 2021-2027 (alongside Galileo, EGNOS, Copernicus and SSA). More detail on GOVSATCOM is provided in Annex II – supporting case studies.

Accordingly, Commissioner Thierry Breton made a speech at the 13th European Space Conference, announcing the **goal to quickly develop a space-based connectivity initiative as "a third infrastructure besides Galileo and Copernicus"**.⁹¹ This commitment was formalised in the February 2021 'Action Plan on synergies between civil, defence and space industries'⁹², which included the following commitments:

- "Secure satellite-based communication and connectivity" as a critical technology focus for the space and aeronautics sector. On this basis, the Commission committed to: i) establishing an Observatory of Critical Technologies; and ii) developing technology roadmaps for critical technologies with the aim of boosting innovation and stimulating cross-fertilisation between civil, defence and space industries; and
- Announced the launch of a flagship project on the development of an EU space-based global secure communications system.

In June 2021, at a European Commission workshop specifically dedicated to the initiative, the following **four objectives** were communicated:

- Put an end to dead zones, giving access to high-speed broadband to everyone, including Arctic and Africa;
- Avoid dependencies on the non-EU initiatives under development;

⁸⁶ State of the Union 2021: Letter of Intent.

⁸⁷ European Commission. (2016). Space Strategy for Europe.

⁸⁸ European Commission. (2016). 5G for Europe: An Action Plan.

⁸⁹ Special meeting of the European Council (1 and 2 October 2020) – Conclusions, EUCO 13/20.

⁹⁰ Regulation (EU) 2021/696.

⁹¹ Speech by Commissioner Thierry Breton at the 13th European Space Conference, 12 January 2021.

⁹² European Commission. (2021). Action Plan on synergies between civil, defence and space industries.

- Project Europe into the quantum era with protection against cyber- and hybrid threats ensuring quantum encrypted communication; and
- Keep the continent connected in a reliable, cost-effective, ultra-secure manner whatever happens, including massive attacks on the internet⁹³.

The Commission's intention is to design the space-based connectivity system as a multi-orbit initiative, combining LEO, GEO and MEO satellite constellations, with the aim of complementing and creating synergies with the EU's existing infrastructures. In this regard, the system should build on the work being done in the first phases of GOVSATCOM on building secure satellite communications infrastructures⁹⁴; for instance, the GOVSATCOM Precursor programme run by the ESA⁹⁵.

Commissioner Breton **pledged to put forward a concrete proposal to the European Parliament and the Council in 2021**⁹⁶. To that aim, the following progress has been made:

- In December 2020, the European Commission launched a project entitled "GOVSATCOM and EuroQCI⁹⁷: Building Blocks Towards a Secure Space Connectivity System"⁹⁸. This project, worth EUR 7.1 million, is being conducted over the course of 12 months by a consortium comprised of satellite manufacturers, operators and service providers, as well as telco operators and launch service providers spanning France, Germany, Spain, Italy, and Luxembourg⁹⁹. The project is studying the possible design and development of the space-based secure connectivity system, providing insights on the technical dimensions but also governance, financing, the missions, and the exact scope of the system¹⁰⁰;
- In July 2021, the European Commission published a call for tenders entitled 'New Space solutions for long-term availability of reliable, secure, cost-effective space-based connectivity'. Under this call, up to two contracts will be awarded (worth up to EUR 1.4 million each) with the aim of identifying "innovative and ground-breaking ideas, bespoke technology development or innovative combination/use of existing technologies"¹⁰¹ in relation to the four objectives of the space-based connectivity system, as highlighted above.
- In August 2021, the European Commission published an inception impact assessment on the space-based secure connectivity initiative, which reiterated and provided further detail on the above. The inception impact assessment is summarised in the below box¹⁰².

⁹³ Speech, Workshop on Space based secure Connectivity Project, 14 June 2021.

⁹⁴ EUSPA. (2021). Making Europe fit for the Digital Age with the European Connectivity Initiative.

⁹⁵ ESA. (2021). Govsatcom Precursor for security.

⁹⁶ Speech by Commissioner Thierry Breton at the 13th European Space Conference, 12 January 2021.

⁹⁷ EuroQCI (European Union Quantum Communication Infrastructure) is a European initiative that aims to deploy a European secure and resilient global communication system based on space and terrestrial components, using quantum-based technology.

⁹⁸ GOVSATCOM and EuroQCI: building blocks towards a secure space connectivity system, European Commission, DG Defence Industry and Space (DEFIS), Tender specifications, Call for tenders DEFIS/2020/OP/0008.

⁹⁹ The consortium consists of Airbus Defence and Space SAS (FR); Thales Alenia Space SAS (FR); OHB System AG (DE); Arianespace S.A. (FR); Eutelsat S.A. (FR); SES S.A. (LU); Hispasat S.A. (IT); Telespazio S.p.A. (IT); and Orange S.A. (FR).

¹⁰⁰ Speech by Commissioner Thierry Breton at the 13th European Space Conference, 12 January 2021.

¹⁰¹ New Space Solutions for Long-term Availability of Reliable, Secure, Cost-Effective Space Based Connectivity, European Commission, DG Defence Industry and Space (DEFIS), Tender information, Call for tenders DEFIS/2021/OP/0005.

¹⁰² European Commission. (2021). Inception Impact Assessment: Establishment of an EU Space-based Global Secure Connectivity System.

Box 3: Inception impact assessment: Space-based secure connectivity initiative

Key problems: i) lack of resilient, secure telecommunication infrastructures and rising threats; ii) growing data and service demands; iii) insufficient connectivity infrastructure; iv) risk of strategic dependency & loss of digital sovereignty; and v) the digital divide.

Legal basis: The initiative will take the form of a legislative intervention based on Article 189 TFEU.

General objectives: i) Support implementation of the EU policies through ubiquitous, secure, reliable and affordable connectivity; and ii) Safeguard EU sovereignty and security and avoid excessive reliance on non-EU based solutions, in particular for security-sensitive functions.

Specific objectives: i) Ensure resilient and secure connections with advanced technological features meeting EU needs on a globally competitive basis; ii) Provide high-speed broadband availability across the EU and worldwide to overcome existing gaps and addressing growing data and service demands in support of the inclusive and sustainable development of EU regions; and iii) Ensure that the considered solutions provide the EU with an appropriate level of strategic autonomy in terms of technologies, assets, operations and services.

The **policy options** proposed to achieve these objectives focus on the different models for investment, ownership and operation, rather than the technical options. They include: 1) EU owned space infrastructure; 2) fully private infrastructure; 3a) Public-Private Partnership funding model with operations ensured by a concessionaire; 3b) Public-Private Partnership funding model with conception and deployment developed solely by a private sector contractor and services provided to the EU on the basis of an availability model; and 4) Public-Private Partnership funding model used to purchase a minority stake in one of the non-EU constellations being built.

No indication of the preferred option has been presented by the Commission. The costs of building, operating and maintaining the system are still being assessed.

Building on these outputs, the European Commission will present more details on the initiative on 10 November 2021 at an event hosted by the Slovenian Presidency of the Council¹⁰³.

4.1.1. Analysis of the benefits and challenges related to the Space-based Connectivity Initiative

As highlighted above, limited information currently exists on the possible technical details, as well as the governance, financing, and exact scope, of the space-based connectivity initiative. However, it is possible to provide a **provisional assessment of its relevance and possible benefits**, for the space sector, as well as industry and EU citizens more generally.

This assessment is based on the related needs of the EU and identified problems, the objectives of the system and the anticipated impacts highlighted by the Commission through various policy documents, interviews with relevant stakeholders and other grey literature.

Considering the **relevance of the initiative**, the needs and problems identified by the Commission and detailed above are significant. Moreover, the proposed solution (i.e. the space-based connectivity initiative) appears relevant and appropriately targeted to the identified needs. The objectives of the initiative logically follow the identified needs; for instance, the aim to put an end to broadband dead zones links clearly to the first need identified above. Stakeholders interviewed for this study also responded positively regarding the relevance of the space-based connectivity initiative.

¹⁰³ Conference, Space-Based Connectivity Initiative, Slovenian Presidency of the Council of the European Union, 10 November 2021.

For instance, a satellite communications company highlighted the challenges related to Europe’s digital divide and stated that “IoT, 5G and pan-EU data spaces cannot be truly realised without the global connectivity infrastructure offered by the satellite communications industry”¹⁰⁴. An industry association representing SMEs also view the relevance of the initiative positively; more specifically stating that “it addresses the main issues that the space industry and users are confronted with”¹⁰⁵. However, given the lack of detail available to date, it is not possible to comment on the relevance of decisions related to financing, governance, scope and implementation.

Regarding **benefits**, the Commission has highlighted a wide range of positive economic, social, environmental, fundamental rights and simplification impacts they will aim to achieve through the initiative. Space industry stakeholders also expect significant benefits from the initiative. The main impacts span many stakeholder groups and can be summarised as follows¹⁰⁶:

- **More secure and reliable connectivity and communications for possible governmental and institutional users**, leading to greater effectiveness of surveillance, EU external action and crisis management activities, as well as better functioning key infrastructures. More specifically, this could improve the following services¹⁰⁷:
 1. *Surveillance*: Border surveillance and maritime surveillance and control ;
 2. *External action and crisis management*: Maritime emergencies (e.g. ‘Search and Rescue’), police interventions, civil protection, Common Foreign and Security Policy (CFSP) – Common Security and Defence Policy (CSDP) actions (e.g. election observation) and humanitarian aid;
 3. *Key infrastructures*: Institutional communications, management of transport infrastructure; management of space infrastructure; Europol communications; and data centre and critical infrastructure (e.g. water supply, healthcare management etc.).
- **Improved access to secure and resilient broadband applications for citizens and businesses**, covering at least the entire territory of the European Union, but potentially also other dead zones in the Arctic and Africa. In terms of quantifying this benefit, the 2016 impact assessment accompanying the now adopted European Electronic Communications Code provides some insight into the impact of widespread, high-speed connectivity on the economy. More specifically, it presented conservative, but significant, estimates for growth across the EU-27 plus the UK in the following areas by 2025 resulting from improved access¹⁰⁸:
 1. GDP (0.54%), consumption (0.38%);
 2. investment (0.89%) and
 3. employment (0.01%)¹⁰⁹.

These anticipated outcomes of the EU’s approach to achieving comprehensive connectivity would only be enhanced by improved space-based connectivity, as well as the implementation of 5G networks.

¹⁰⁴ Interview conducted for this study with a large satellite communications company.

¹⁰⁵ Interview conducted for this study with a space industry association.

¹⁰⁶ European Commission. (2021). Inception Impact Assessment: Establishment of an EU Space-based Global Secure Connectivity System.

¹⁰⁷ GOVSATCOM and EuroQCI: building blocks towards a secure space connectivity system, European Commission, DG Defence Industry and Space (DEFIS), Tender specifications, Call for tenders DEFIS/2020/OP/0008.

¹⁰⁸ “Improved access “in this instance refers to the introduction of an ‘accelerated fibre’ policy, where “FTTH/B [Fibre to the Home / Business] expands to account for 54% of connections in 2025”, rising from 10% in 2015.

¹⁰⁹ European Commission. (2016). Impact Assessment Accompanying the document: Proposals for a Directive establishing the European Electronic Communications Code (Recast) and a Regulation establishing the Body of European Regulators for Electronic Communications.

Furthermore, an industry association interviewed for the study highlighted that using satellites could also offer a more cost-efficient provision of connectivity than cables¹¹⁰.

- This impact aims to also bring specific benefits to the downstream space sector. For instance, a space industry stakeholder highlighted the important contributions the initiative could make to the transport industry, in particular highlighting the achievement of international Net Zero ambitions¹¹¹. However, as one industry stakeholder highlighted, this is complicated by the existence of competitors to the initiative (e.g. OneWeb)¹¹².

Improved innovation and competitiveness for space sector stakeholders, driven by the:

- *Development of innovative solutions within the space-based connectivity initiative.* As highlighted above, the European Commission has published a specific call for tenders related to the development of innovative solutions related to achieving the objectives of the space-based connectivity system. In addition, as highlighted by a space industry stakeholders interviewed for the study, the system will contribute to increased opportunities for the upstream space sector¹¹³; and
- *Development of synergies and complementarities with existing EU space activities.* For instance, the space-based connectivity system could, amongst others impacts: support secure data relay services for Copernicus satellite data; enhance the Copernicus data with new Earth observation sensors and features; enhance the resilience and accuracy, and complement the early warning system of Galileo; and host extra payload space-based sensors to perform SST directly from space¹¹⁴.

In addition, as highlighted throughout this chapter, the space-based connectivity initiative could **improve the strategic autonomy and digital sovereignty of the EU** and thus support the achievement of the EU's geopolitical goals.

To conclude, the space-based connectivity initiative is relevant to the needs and problems of the space industry and the wider EU population, and could deliver significant benefits to a wide range of stakeholders. It has also been positively received by industry stakeholders. However, the initiative is in the preliminary stages of its development, with the technical, as well as governance and other details not yet elaborated. As such, it is difficult to fully assess its potential for positive impacts.

¹¹⁰ Interview conducted for this study with a space industry association.

¹¹¹ Interview conducted for this study with a large satellite communications company.

¹¹² Interview conducted for this study with a space industry association.

¹¹³ Interview conducted for this study with a space industry association.

¹¹⁴ GOVSATCOM and EuroQCI: building blocks towards a secure space connectivity system, European Commission, DG Defence Industry and Space (DEFIS), Tender specifications, Call for tenders DEFIS/2020/OP/0008.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The European space industry is the second largest in the world and is able to compete globally with a market leading position in some sub-sectors (launchers, satellite communications, nano satellite design and manufacturing). Europe intends to maintain its competitiveness and foster the strategic autonomy in space required to compete with traditional and emerging space-faring nations.

The upstream sector is dominated by large companies in the launcher, aerospace and satellite operator sectors, who provide EO, navigation and timing services and communication services to Europeans and citizens on other continents. Meanwhile, in the downstream sector, Europe's companies are taking advantage of upstream activities to provide and develop innovative solutions to tackle pressing societal challenges such as climate change, agricultural and forestry management, urban monitoring, and emergency management and response. These applications and services have the potential to bring about both societal and economic benefits. Whilst there are many opportunities, a challenge for the downstream sector is that it is heavily fragmented given the diverse user base across many different non-space sectors that make use of EO and navigational data.

The burgeoning New Space sector has a significant role to play in stimulating the economic growth and job creation potential in Europe and in enabling the European space sector to compete internationally. Start-ups and SMEs more generally are likely to both be crucial to the competitiveness of European firms in the new space sector, as there are many new market entrants from the non-space sectors, and the sector is innovation-intensive, in which SMEs excel.

The EU has an ambitious space policy to maintain progress, strengthen its role as a leader in space, boost the space industry and foster autonomous access to space. It reaffirmed this ambition in 2021, when it adopted the integrated Regulation establishing the EU Space Programme 2021-2027. Building on its predecessor programmes, it aims to ensure high-quality, secure space-related data and services for Europe's citizens and businesses. It stresses the continuing importance of the three flagship programmes, Copernicus, Galileo and EGNOS, which the EU is supporting with a significant budget. EUR 14.88 billion has been allocated to space activities, the vast majority of which, EUR 14.43 billion, has been set aside for Galileo, EGNOS and Copernicus. Since 2007, the budget for space activities has increased by 164%, demonstrating the EU's strong ambition to strengthen the role of space in the European economy and society.

Good progress has been made towards fostering a globally-competitive and innovative European space sector, for instance through support for space SMEs in H2020 using pre-commercial procurement for innovation as a mechanism to foster the market. The dynamic nature of the implementation of the EU space programmes, and the changing environment in which these are being implemented is a further finding.

Given geopolitical developments, reinforcing Europe's strategic autonomy has become successively more important over time. Therefore, in 2021-2027, a lot more progress still needs to be made. The changing nature of geopolitics and increasing cybersecurity threats have necessitated a revision of security. When the EU space programmes were adopted in 2013, it was not foreseen that strengthening the security of space data would be such a big theme, whereas in practice, significant investment has had to be made, which has led to considerable progress, for instance, in improving the security of Galileo data. The Space-based Connectivity Initiative is a positive development which has the potential to further enhance Europe's strategic autonomy.

Less positively, although the performance of the Galileo Initial Services has been gradually improving since 2016, there have been two service disruptions, including one instance when the system was unavailable for six days. In 2020, Galileo was severely affected by travel and working procedures brought about by the COVID-19 pandemic. According to the European Commission, Galileo and EGNOS are either on track or have made moderate progress against key monitoring indicators. Copernicus however has continued to deliver on its objectives. The sentinels, ground infrastructure and in situ networks have all been successfully deployed, while the six core services (e.g. Atmosphere, Marine, Land, Climate Change, Security and Emergency) are all operational.

To foster the implementation of the space programmes and of the wider ecosystem, the EU is supporting a number of measures through the European Space Strategy, which argues that the potential of Copernicus, EGNOS and Galileo needs to be better exploited, research activities need to address the entire space industrial value chain and Europe needs secure and safe access to space. Space is of strategic importance for civil, commercial, security and defence purposes, and without the achievement of these objectives, the EU's position on the world stage will be diminished.

There are a number of other measures which complement the strategy to facilitate the uptake of space data and boost the space ecosystem. The INSPIRE Directive, for example, encourages the uptake of environmental data by public authorities and fostered the dissemination of such data for the public good. Additionally, the Open Data Directive requires high value datasets to be provided for free to foster value-added EU-wide information products. The new proposed European data regulation should encourage Europe to become a leading data economy, while the Horizon Europe Work Programme 2021-2022 contains a number of projects to support both the upstream and the downstream sectors.

However, in spite of the ambitious plans put in place by the EU, and the progress made by the space programmes, there are obstacles to the implementation of upstream activities benefiting the downstream sector in Europe. Significant investment has been allocated to the space programmes and the challenge is maximising the economic and societal benefits through increased take-up of downstream services. This was highlighted in the CoA report, which found that, while Galileo and Copernicus provide valuable services and data, more actions could be undertaken to maximise their potential to achieve the expected benefits.

The CoA report makes a number of recommendations to strengthen the uptake of space data. The interviews carried out during this report confirm that this remains an important priority to improve the efficacy and added value of the EU space programmes.

5.2. Recommendations

Recommendation 1: Maximise the potential of the EU regulatory framework to support the uptake of space data and services (whilst recognising the limitations of a prescriptive approach)

The EU's regulatory powers were highlighted in the CoA report as a mechanism for encouraging the uptake of space data and services. Progress has been made in some areas, however, such as in the field of road safety and emergency, enabling emergency teams to respond to an accident faster. While there is a legal base encouraging the use of Earth observation for the Common Agricultural Policy, only minor progress was observed in other priority areas (such as road transport and logistics, autonomous cars and drones). However, there are limits to the extent to which the Commission can initiate new legislation specifically requiring Copernicus and Galileo data to be used as this could risk undermining the technology neutrality principle in EU legislation. It would nonetheless be useful to assess those areas where EU legislation could promote the use of such data to determine how feasible the

introduction of new regulations could be¹¹⁵. For example, if EU legislation can also be used to strengthen safety and foster the integrity of the internal market, there is then stronger potential to introduce new legislation.

Recommendation 2: The European Commission should undertake periodic evaluation studies that examine the strategic contribution of the EU Space Programme towards the achievement of the objectives of the EU space policy

It is positive that an evaluation will be required of the integrated EU Space Programme. However, it would be advantageous if a broader assessment were undertaken to analyse the linkages between the EU Space Programme and EU space policy more generally. This assessment would take into consideration the objectives set out in the EU Space Industrial Policy relating to strategic autonomy, fostering the uptake of space data, and promoting a more competitive European space industry, for example. There is otherwise a risk that programme evaluations report mainly on programme implementation, without considering these broader strategic questions of relevance to Europe's economy, industry and competitiveness and future security.

Recommendation 3: Introduce more regular assessments/evaluations of the uptake of space data and services

There is generally a lack of data concerning the uptake of space data generated by the space programmes. Data, if available, tends to be either outdated or lacking detail. More regular assessments of the uptake of data, for example by Member State, sector, or type of user, could help public authorities to ascertain the effectiveness of the space programmes in delivering space services. Such assessments would also enable estimates to be made about the economic and societal benefits generated by the use of space data.

Recommendation 4: Improve EU-wide communication about the benefits of space services

A general issue is the lack of awareness of the capabilities of space among European citizens. According to the survey conducted by ESA, highlighted earlier in this report, only 40% of Europeans felt well informed about European space activities. Although many had heard about the European space programmes and ESA, it was a challenge to understand what exactly was at stake. As such, communication activities should be promoted in Member States to inform citizens about space, the space programmes and how they can benefit them. The European Commission may want to consider engaging with citizens to arrange events where information could be provided about EU space activities and feedback could be gathered to understand where the information gaps are, and additional areas where space data could be used. Such events could include SMEs to contribute to awareness-raising and demonstrate their involvement in the development and delivery of space services to citizens. The Commission could also consider engaging with national authorities and national and international media to inform the public, e.g. through educational programmes, events, television and radio programmes and webinars.

Recommendation 5: Enhance synergies between Member States to foster the uptake of space services

Europe has the second largest space industry in the world and has the technological capacity to take advantage of the vast amounts of data generated by the space programmes. To maximise the benefits of space data, Member States should more actively work together to better understand what

¹¹⁵ For example, the Commission has undertaken studies on the potential mandating of the use of Galileo GNSS data for timing and synchronisation in respect of critical infrastructures in Europe, but there is limited EU legal competence to mandate which GNSS services should be used, except in respect of pan-European critical infrastructures.

applications and services are used and for what purposes/fields. This would enable the sharing of best practice, facilitate business opportunities and foster a shared goal. It is important that any activities enable full participation by a wide range of stakeholders and do not take place in isolation, as was found to be the case previously. It is also important that the DIAS user base is increased as this is currently low compared to the total number of active Copernicus users.

The Commission should further encourage the use of Framework Partnership Agreements to foster collaboration between Member States. Activities such as awareness events and training sessions among entities from different Member States, as well as financing opportunities can support the development and procurement of space applications and enhance coordination, thereby avoiding duplication and maximising synergies. This would facilitate the provision of space services to a Member State for a particular need, such as wildfire management, agricultural management or resources management, and boost economic development and job creation in the Member State.

Recommendation 6: Encourage the use of space data by SMEs for the provision of space services

SMEs should be encouraged to take advantage of the multiple financing tools at the EU's disposal to invigorate the space ecosystem. The development of SME space services should be actively encouraged, as well as their procurement by public authorities and the private sector alike. This would help to create jobs, improve technological skills and boost Europe's industrial competitiveness.

Recommendation 7: Examples of successful venture capital investments made through the new CASSINI programme in the European space sector should be showcased to highlight the sector's potential to investors

To fully maximise the potential of European space SMEs, a culture of risk-taking should be fostered in Europe to support space start-ups and scale-ups and to encourage entrepreneurship. The communication and dissemination of good practices and success stories in risk capital financing of space start-ups and SMEs could help to catalyse investments. This could reinforce the EU's position as a leading global player in space, including in the new space economy.

Recommendation 8: The Commission should collect improved monitoring data on the extent of SME participation across key EU funding initiatives, e.g. the EU Space Programme and Horizon Europe Space (including the CASSINI Programme)

In order for policy makers to fully gain an understanding of how SMEs are involved, and what impact this has in terms of structuring the market and boosting the European space ecosystem, better data on how EU investment benefits SMEs would be a useful starting point.

Recommendation 9: Use international fora to encourage the better use of space

Fostering an innovative European space market requires stability in space. However, with ever-more actors in space, issues such as space traffic management and mining have come to the fore, as well as the potential misuse of space and the need to strengthen space security. The EU, as a prominent voice on the international stage, should use international fora to encourage best practice in space and foster international partnerships to develop cutting-edge space technology to tackle societal challenges such as climate change. Europe is a global leader in space and should use its position to encourage its better use.

Recommendation 10: Make the space-based connectivity initiative a reality

Although there is currently limited information on the technical details, governance, financing and exact scope of the space-based connectivity initiative, it has the potential to generate benefits for Europe's citizens, businesses and governments.

This ambitious initiative needs to become a reality considering the need for greater and more equal access to high-capacity broadband, to secure communication capabilities, and to avoid dependencies on non-EU initiatives under development.

Recommendation 11: Encourage the sharing of good practices on the use of space data

Through the sharing of good practices, such as the joint ESA-NEREUS publication on 99 user stories on the use of space data, public authorities should make greater use of free EU space data and provide space data-enabled services to citizens with the potential to enhance the quality of environmental and other relevant monitoring data available to citizens and where relevant, to improve public service delivery. There should however be a strong focus by public authorities at national and regional level on promoting greater institutionalisation of the use of space data, as there is a risk of a lack of sustainability if the use of such data is dependent on a small number of individuals within national, regional and local authorities that are enthusiastic about the role of space data.

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ANNEX I – RECOMMENDATIONS BY COURT OF AUDITORS

The recommendations made by the Court of Auditors and the justifications for making these are outlined below.

Recommendation 1: Develop a comprehensive strategy for supporting the uptake of EU space services

As highlighted earlier, a comprehensive strategy covering the uptake of space services has not yet been developed. As such, the report recommends developing such a strategy which would include all relevant stakeholders, clarify their roles and provide realistic and measurable targets, by 2023. A challenge has been quantifying the benefits generated by the space programmes relative to the costs, while some benefits may be over or underestimated. For example, although the income generated by Copernicus and Galileo was calculated, the Commission did not estimate the consequent impacts for the downstream sector. As such, the economic impact on growth and jobs may be underestimated due to a lack of data.

Additionally, the report suggests working with Member States to identify the areas where space services could improve public administration and address the fragmented nature of the market. One interviewee raised the issue of governance, noting that there are several administrative layers and a complex network of decision-making. Thus, a strategy clarifying the roles of all relevant actors could help to address concerns surrounding decision-making. According to the interviewee, the management costs had been very high. However, the interviewee pointed out that the new Financial Framework Partnership Agreement (FFPA) between the Commission and ESA should help in this regard, adding that it is helpful that EUSPA has a clear mandate.

Through these initiatives, the EU is moving in the right direction to support uptake of services, however it is important that the results of the programmes are measured using relevant key performance indicators. In the case of Galileo, the large number of indicators are considered to add complexity and create difficulty in interpreting them. In the case of Copernicus, only very basic information is provided on the uptake of services and do not shed light about the key objectives. A more robust evaluation process is therefore required to assess the uptake of services and provide insight into the areas where more or less efforts are required and inform a subsequent strategy.

However, as an interviewee highlighted, programmes such as Copernicus are relatively new, therefore time is required for it to generate added value. Additionally, good communication activities would benefit public administrations in terms of informing them about what can be achieved in what areas, and boost demand from national, regional and local authorities for downstream services. Such an information procedure would also benefit the wider public, boost interest from citizens and potentially lead to wider economic and societal benefits.

Recommendation 2: Develop a conceptual framework for estimating the benefits of the EU space programmes and improve performance measurement

Related to the first recommendation, the report also encourages the development of a framework for estimating the economic and societal benefits of Galileo and Copernicus, in collaboration with other actors such as the OECD, the ESA and Member States, and harmonising the assessment of their benefits. Additionally, the report proposes monitoring the achievement of the space programmes' objectives through appropriate performance indicators. These suggestions would help to address the concern that, although it is well known that the space programmes provide benefits, there is limited information on their extent. A timeframe of 2024 has been provided for this recommendation.

The report highlights that the availability of key Galileo features has been delayed, creating challenges in terms of market access and development for these services. It is unknown as yet whether the development of innovative Galileo products will result in increased market uptake over the long term. For example, by 2020, although leading suppliers representing 95% of the GNSS chipset market produced Galileo-ready chips and modules, and Galileo receivers are available in several markets and inter-operable with other GNSS, the equipment does not necessarily give priority to Galileo signals. As such, it will take time until Galileo compatible technologies have been widely adopted. One interviewee mentioned that the main political objective for the EU space sector is the development of industrial competitiveness, which could be improved through the Horizon Europe programme. This would have the potential to accelerate access to market for Galileo products, lower costs and increase uptake.

The report highlighted that the objectives and impact of the Commission's key actions for Copernicus were not clearly defined, while their contribution to user uptake was unclear and some of them lacked funding. For example, since 2017, the Commission has engaged with over 90 Copernicus Relays, which act as local champions promoting Copernicus (these include national authorities, government agencies and innovation clusters). However, they do not receive directing funding and there is no information on whether they contribute to user uptake at the national, regional or local levels. Such information would enable the monitoring of progress across the EU and determine where additional resources may be required.

Additionally, the report found that there was only a small number of projects supported under the Horizon 2020 programme, meaning the achievement of the expected impact was limited. This supports the point made earlier that the Horizon Europe programme moving forward could better support industrial competitiveness for the space sector to enhance the possibility of achieving positive societal and economic impacts. In terms of access to data, as mentioned earlier, data is currently provided through a number of platforms, however synergies are not being exploited, which would improve the efficiency and effectiveness of data gathered and could help to facilitate the development of new products and services. Additionally, it would be worthwhile clarifying how Copernicus data could be integrated into the European Open Science Cloud, which is set to gain more prominence in the 2021-2027 period.

Recommendation 3: Ensure full readiness of Galileo and better targeted action on uptake of the EU space services

This recommendation proposes that, to better support uptake and provide efficient access to space data and products, the Commission should:

- Make the technical and legal arrangements needed for full readiness of the Galileo differentiators;
- for key actions, define clearly the objectives and the expected impact and pursue complementarity with Member State actions; and
- develop, in cooperation with Member States and other relevant actors, a long-term framework for a more sustainable and integrated approach of access to Copernicus data and products, and seek the integration of Copernicus in EU cloud-based infrastructures.

As highlighted earlier, the Commission has adopted measures in the field of road safety and emergency, which could accelerate the use of Galileo services. However, other priority areas require regulations and standards to facilitate uptake yet there is no indication currently when these will be introduced.

This report mentioned that although there is a legal base encouraging the use of Earth Observation for the Common Agricultural Policy (CAP), minor progress was observed elsewhere. There are currently very few legal provisions stipulating that the best use of Copernicus and Galileo be made for data collection. Regulation 2018/841 on land use and forestry monitoring for purpose of meeting the EU greenhouse gas emission reduction target is one such piece of legislation which could be used as best practice. However, the Commission should conduct a comprehensive analysis to determine where EU legislation could better promote the use of such data. This point was reiterated by one interviewee, who stated that regulations, norms and standards can help to increase the uptake of space data.

However, regulatory or administrative barriers can hinder the use of Earth Observation and navigation services. The report cites the examples of law enforcement and procurement, where rules do not permit the use of such services. Additionally, Sentinel data may require substantial changes to administrative procedures and IT systems to use new technologies. As mentioned, the Commission had no systematic overview in place of how Member State administrations used space data and whether there were any regulatory barriers inhibiting their use. Additionally, the report found that, of the countries examined, only Italy had taken action by setting up a high-level working group to identify any regulatory barriers, though the results are not yet available. No such analysis had been undertaken by the authorities in the Czech Republic, Germany and France. As such, it would be worthwhile for Member States to conduct an analysis of the barriers to ascertain whether and how they can be overcome to facilitate the uptake of space data.

As mentioned previously, however, greater uptake of space services is contingent on fully functioning space programmes. It is therefore crucial that any future outages are rectified as soon as possible to ensure the continuation of services provided in the downstream sector and uphold Galileo's reputation as a leading GNSS. Additionally, the development of local ecosystems where space companies engage with digital companies, as is the case in Brittany, could be effective in supporting the uptake of space data. Such collaboration could facilitate the development of services and lead to increased uptake, identifying where the needs lie.

Recommendation 4: Better use the regulatory framework to support the uptake of EU space services

This recommendation reiterates the point that more effective use of regulations and standards can boost the uptake of space data generated by Copernicus, Galileo and EGNOS. It provides a timeframe of 2024. Specifically, it advises the Commission to:

- analyse where legislation or standards could increase effective use of Copernicus data and products;
- work with Member States to identify barriers hindering the uptake of space services and support them in removing these barriers; and
- put in place timeframes for relevant market sectors where regulations and standards can promote the use of Galileo services, and monitor progress.

While these points have been largely covered under recommendation 3, it appears that the Court of Auditors considered the better use of a regulatory framework to be critical in promoting the use of space services. This is unsurprising, considering that, at present, there are very few legal provisions requiring effective use of Copernicus and Galileo for data collection. Although the timeframe is ambitious, this recommendation at least encourages the Commission to start considering in which other areas regulations or standards could be used to facilitate the uptake of space services and bring about economic and societal benefits.

Using the example of Regulation 2018/841 on land use and forestry monitoring for the purpose of meeting the EU greenhouse gas emission reduction target as a best practice could act as a starting point. However, any regulations considered should ensure that the market for space services remains competitive and does not unfairly bar other space systems from being utilised. As suggested by an interviewee from a multinational aerospace firm, initially the European Commission could be encouraged to use space data via regulations, where it brings added value. The aforementioned analysis would help in this regard.

The recommendations are interlinked and cover technical, legal and administrative matters to improve the uptake of space data. It is clear that a more coordinated approach is required to develop a comprehensive strategy for the uptake of space data moving forward. In this respect, clarifying the roles of stakeholders, defining targets, identifying areas where space data can improve services and considering the use of regulations to improve uptake can facilitate Europe's development in this area over the next decade.

However, it is crucial to improve the measurement of benefits generated by the space programmes and also, more widely, measure more precisely user uptake of space data. One of the interviewees pointed out that a quantitative assessment of uptake is lacking. Regular studies could be undertaken demonstrating the use of space data across the EU, perhaps by sector, Member State and company size. Given the challenge of obtaining such statistics, it could be worthwhile to begin measuring uptake in a few sectors of importance to both public authorities and citizens, such as environmental data. The interviewee also highlighted that DIAS could be used to obtain information to better understand the level of uptake. Better promotion of DIAS may also be required, given that, as highlighted by the report, its use has been very low compared to the number of active Copernicus users. Given that the survey by ESA mentioned earlier found that only 40% of citizens believed they were well informed about European space activities, it is clear that improved communication activities are required to inform them not only about the space programmes themselves, but also the economic and societal benefits they can bring.

ANNEX II – SUPPORTING CASE STUDIES

WILDFIRE MANAGEMENT IN CROATIA

Problem definition/background

Croatia is affected with more than 100 wildfires every year, covering over 350,000 hectares. In 2017, two large forest fires took hold over the course of a couple of days in the area of the Makarska Riviera in the southern part of the country, affecting an area of 325 hectares. During this incident, local authorities made use of Copernicus data and of the European Forest Fire Information Systems (EFFIS) as part of their response to this natural disaster, by mapping the wildfires affecting the region and subsequently establishing a containment strategy. Below we provide a short case study of how COPERNICUS data was used by the Croatian local authority.

Description of how Copernicus data used

Copernicus data was used by the Croatian local authority by using Sentinel-2 imagery and EFFIS to identify areas of land affected by wildfire scarring. After locating the fires, images of the area before and after the wildfire events were downloaded from the Sentinel Scientific Hub (Sentinel-2 level C – 1 products) and used for detailed analysis. The obtained data was then processed using SNAP, a European Space Agency open-source software. Initial processing, such as resampling, band merging and subset export was carried out using SNAP followed by the Normalized Burn Ratio (NBR) technique, which was applied on images to highlight the areas covered by fire.

Activities supported

The Copernicus Emergency Management Service undertook a forest fire risk assessment in Southern Croatia in 2019, as part of its Risk and Recovery Mapping Portfolio.¹¹⁶ Risk and Recovery Mapping (RRMs) are services which consist of the on-demand provision of geospatial information. The data and information provided by these services support emergency management activities and address prevention, preparedness, disaster risk reduction and recovery. The forest risk assessment reviewed existing hazards and the levels of exposure by mapping out geomorphological characteristics, the percentage of vegetation coverage susceptible to fire and the spatial distribution of previous fire events. The risk assessment also assessed the vulnerability of the southern Croatian territory by mapping out the following:

- The split between urban and non-urban areas;
- The different types of vegetation categories (with a taxonomy of 14 different categories);
- The population and asset overlays in relation to forest hazard levels;
- Population density levels; and
- The number of potential “no-through” evacuation roads.

¹¹⁶ Available at: <https://emergency.copernicus.eu/mapping/list-of-components/EMSN059>

Good practices

Copernicus data can help local authorities respond to and prepare for future environmental hazards. Copernicus data, particularly Earth Observation data, can be very useful in the prevention, detection and management of natural disasters, including wildfires.

Beyond contributing to wildfire management, Copernicus data can also contribute to predicting fire hazards by providing important data on forest fire exposure and risk as well as on the levels of vulnerability of surrounding populations and assets. This can in turn inform the development of risk-specific mitigation measures as well as inform the development and management of first response services and infrastructures.

Conclusion:

To conclude, the risk of wildfire remains high in this Member State given that 40% of its territory is covered by forests. Wildfires will continue to pose a significant threat not only in Croatia, but in several Member States along the Mediterranean where climate change is expected to increase the frequency of these events. This example provides a clear illustration of how Copernicus can provide free spatial and mapping data in order to develop better risk assessments and help mitigate the risks against environmental hazards such as wildfires.

MONITORING THE MELTING OF ICELAND'S GLACIERS BY THE NATIONAL LAND SURVEY

Problem definition/background

Iceland is home to Europe's largest glaciers. As global temperatures are rising, Icelandic glaciers have been melting and retreating inland. The melting of the glaciers is affecting the flow of their proglacial rivers¹¹⁷, which can in turn have negative effects on the road systems and create hazards for residents and tourists in remote areas. In addition, 87% of Iceland's energy comes from renewables, of which 80% is extracted from hydropower. Most of the hydropower produced in Iceland is derived from proglacial rivers, and there is therefore a need for up-to-date monitoring data of their changing flows and patterns to ensure the effective functioning of the country's hydropower-based plants.

Description of how Copernicus data used

Data from Copernicus, derived from Sentinel imagery, offers a cost-effective solution to the need for Earth Observation in Iceland. In contrast to aerial imagery, satellite imagery can be updated frequently and has the benefit of large simultaneous area coverage. Given these advantages, the Icelandic National Land Survey has been using Copernicus data (Sentinel-2) to monitor the shape, size and patterns of Icelandic proglacial rivers.

Activities supported

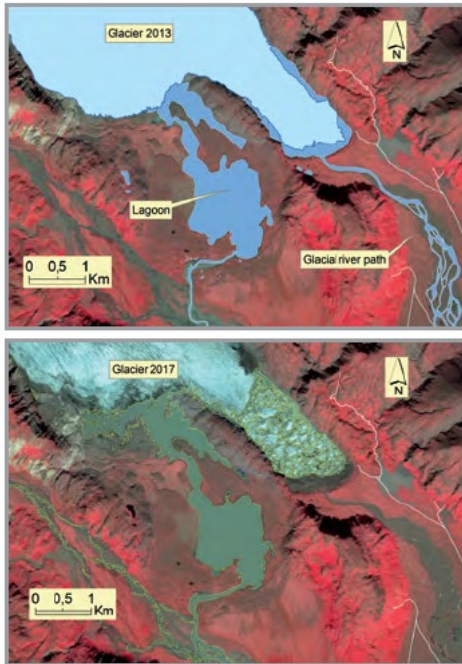
The use of Copernicus spatial data is an important resource for the Icelandic National Land Survey, who foresees Copernicus as a programme that will remain important in the coming years, in light of the acceleration of climate change and of its resulting effects on Icelandic glaciers and rivers¹¹⁸. The figure below provides an illustration of the shrinking size of the Hoffellsjökull glacier generated by Copernicus data.

Good practices

¹¹⁷ Proglacial rivers are rivers that flow from the margin of a glacier. These rivers are strongly affected by the highly seasonal water supply from glaciers and by the large supply of sediment that arrives at the glacier terminus.

¹¹⁸ National Land Survey of Iceland Annual Report 2016. Available at: <https://ggim.un.org/country-reports/documents/Iceland-2017-country-report.pdf>.

This case study provides a concrete example of how Earth Observation data provided by Copernicus can be used by land management authorities to mitigate the effects of climate change. Satellite imagery is a cost-effective solution and provides a high level of quality in terms of resolution of the images produced, which are deemed as highly beneficial by the Iceland Land survey but also by other land management authorities such as in Italy.



Hoffellsjökull glacier extent and river pattern in 2013 (above) and in 2017 (below) showing 1-2 km retreat. Credit: Contains modified Copernicus Sentinel data [2017]

The Copernicus Land Monitoring Service provides geographical information on land cover to a broad range of users in the field of environmental terrestrial applications. This includes land use, land cover characteristics and changes, vegetation state, water cycle and earth surface energy variables. The services of this division of the Copernicus programme are important for local authorities, as exemplified in this case study.

TRACKING OCEAN CURRENTS: INNOVATIVE USE OF COPERNICUS DATA BY A FRENCH SME

Problem definition/ background

With fluctuating oil prices and the long to medium term prospect of diminishing world oil supplies, improving the fuel efficiency of commercial ships is critical. In addition, in light of the acceleration of climate change, there is now a pressing need to ensure carbon emissions are reduced even further. Ensuring the optimisation of fuel consumption by vessels can be done by leveraging ocean currents to make propulsion less dependent on carbon fuels.

The French SME eOdyn¹¹⁹ was founded in 2015 by a group of entrepreneurs to provide solutions for more efficient ship navigation, following the development of a tool that allows for the monitoring of ocean and sea currents using machine learning technology.

¹¹⁹ Available at: <https://www.e-odyn.com/>.

Description of how Copernicus data used

eOdyn uses Copernicus data in an innovative way by combining space data with other types of data to provide its services. The French SME relies on Automatic Identification System (AIS)¹²⁰ data obtained from private suppliers (e.g. SPIRE and ORBCOMM) and then combines the AIS data (which is processed using a machine learning tool developed by the SME), with satellite altimetry (provided by Sentinel 3) and surface temperature data also provided by Copernicus.

After triangulating the different these data sources, the SME can provide real-time data on ocean currents with an unprecedented degree of accuracy.

Activities supported

eOdyn provides two main types of services. First, it provides monitoring services to oil and gas companies (including multinationals such as Total and Shell), aerospace companies (e.g. Thales and Airbus) and space agencies (NASA and ESA etc.). Second, the SME offers a navigation tool known as SeaWaze™ (still under development) to ship owners and charterers. SeaWaze™ collects data from boats at sea, aggregates the data collected to then calculate drift patterns before mapping these patterns on real-time maps. This allows ships to reduce their fuel consumption by up to 5%.

Lessons learned

The first interesting feature of this company lies in its innovative use of Copernicus data by integrating its application into a machine learning framework to enable a high accuracy understanding of ocean dynamics. This shows that Copernicus can be an important driver of innovation by providing raw data that can find many applications.

The second noteworthy element of this case study is around the added value of free Copernicus data. eOdyn, as an SME, needs to reduce its costs as much as possible and therefore relies on free services. The availability of Copernicus data but also the quality of the data provided by Copernicus has led to the creation of an ecosystem where companies like eOdyn can be created and contribute to solving important environmental challenges.

Conclusion

Copernicus data allows SMEs, such as eOdyn, to create new solutions to protect the environment, drive down costs, improve the safety of ships and deliver new growth. In doing so, Copernicus allows for the development of ecosystems where innovative companies can be created and grow. In light of the ever more pressing challenges posed by climate change, Earth Observation data will continue to be important to foster new innovation particularly when left accessible. The integration of new types of data such as Satellite AIS will benefit eOdyn but also other companies in providing new innovative solution to environmental and logistical challenges.

¹²⁰ The AIS is an automatic tracking system that uses transceivers on ships and is used by vessel traffic services. AIS allows ships to transmit their position so that other ships are aware of its position.

ANNEX III – LIST OF ORGANISATIONS INTERVIEWED

Stakeholder type	Organisation
Company	Airbus Defence and Space
Company	D-Orbit
Company	eOdyn
Company	Intelsat
Company	Kormap
EU institution	European Commission x 2
Industry association	ASD-Eurospace
Industry association	SME4SPACE
Intergovernmental organisation	European Space Agency
National authority	Romanian Space Agency
Regional authority	NEREUS (Network of European Regions Using Space Technologies)

This study provides an analysis of the European space market. The market size and structure of the European space industry is considered, alongside the dynamics of the new space economy. The contribution of the EU space programmes to fostering the uptake of space data, and the challenges and drivers of maximising synergies between the EU upstream and downstream space sectors are examined. The new Space-based Connectivity Initiative is also considered. In addition, recommendations by the Court of Auditors to strengthen the efficacy of the newly-integrated EU Space Programme, and to maximise their economic and societal impacts are considered.

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