Towards EU leadership in the space sector through open strategic autonomy

Cost of non-Europe

STUDY

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This 'cost of non-Europe' report looks at the potential benefits of efficient, ambitious and united EU-level action in the space sector. The report finds that to enable the European space sector to benefit from open strategic autonomy, and to ensure EU access to and use of space, including for its security, the EU must act decisively. Moving away from fragmentation could bring large benefits, amounting to at least €140 billion per year by 2050.

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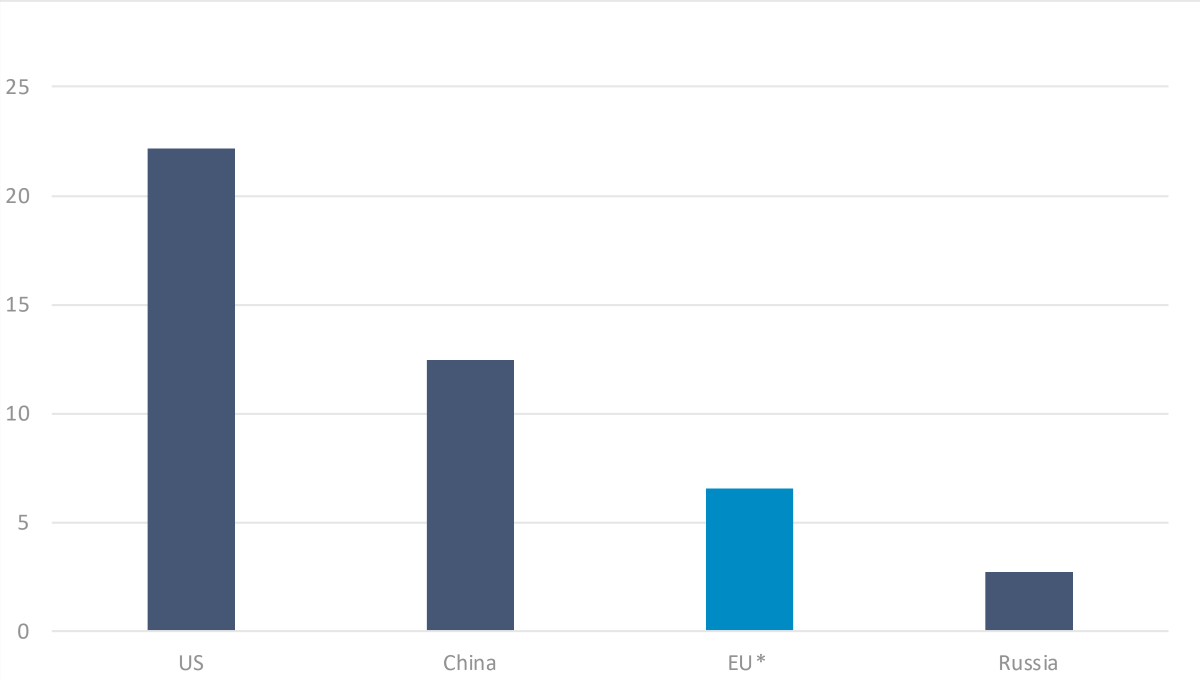
Executive summary

Space is one of the fastest developing economic sectors. Its annual average growth rate between 2005 and 2017 was 6.7 %: double the figure for annual global economic growth in the same period.[1] Although the European space sector is well placed on the global scene, it is facing a series of challenges that are hindering the full development of its potential. In particular, despite the fact that aggregated EU Member States' annual spending on civil space operations amounts to around €10 billion, the share of joint EU public funding for space is only €6.5 billion, lower than the budget put in common in the US or in China (Figure 1).[2]

Figure 1 – Estimated annual public civil space budgets of the US, China and Russia and joint spending of EU Member States through the EU and ESA budgets (€ billion)



Source: Prepared by the authors on the basis of O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.
Note: EU* is the sum of (i) the financial contribution by the EU Member States to the European Space Agency budget and (ii) the EU space budget within the EU's multiannual financial framework.

Looking at the challenges faced by the EU space sector, this 'cost of non-Europe' (CoNE) report therefore studies possibilities for gains and/or the realisation of a public common good and efficiency gains through budgetary spending and action at EU level. It attempts to identify areas that are expected to benefit from deeper EU integration and for which the EU added value is

[1] European Investment Bank, J. Toth and A. Concini, The future of the European space sector – How to leverage Europe's technological leadership and boost investments for space ventures, 2019.

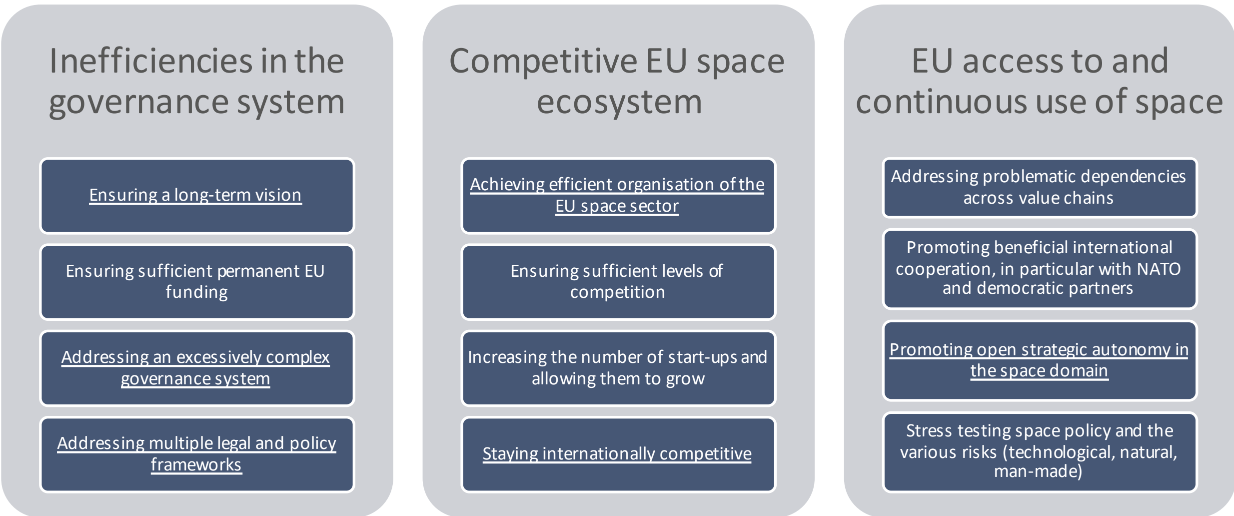
[2] The US spends €22 billion, China spends €12 billion and Russia spends €2.7 billion. The joint public spending of the EU – €6.5 billion – presented in Figure 1 is taken as the sum of (i) the financial contribution by the EU Member States who are members of the European Space Agency (ESA) to the ESA budget and (ii) the EU space budget. This amount refers to civil spending on space only and does not include EU Member States' own investment in space, which is estimated to amount to €3 billion per year. See more in Chapter 2.2.3. of O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023 (see Annex).

potentially significant. More specifically, the aim is to establish the cost of non-Europe in the space sector and addresses the following questions:

- What is the current state of play, and what are the existing challenges that prevent the EU from gearing its space policy, while strengthening EU open strategic autonomy in ensuring EU safe access to space?
- What are the adverse impacts of the current challenges in EU regulatory and budgetary action at EU level?
- What are the options for action at EU level that could address the challenges identified, what are their potential costs and benefits, and which potential EU-level interventions could have the highest European added value?

The report identifies 12 key challenges facing the European space sector from the perspective of potential EU-level action. They relate to governance, global competition and risks to EU access to and continuous use of space. Among these key challenges three overarching problems stand out (see Figure 2): i) inefficiencies in the EU space governance system, ii) the need to ensure a competitive EU space ecosystem, and iii) the need to ensure continuity of EU access to and use of space.

Figure 2 – Key challenges present in EU space sector grouped under overarching problems



Source: Prepared by the authors on the basis of O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023.

The excessively **complex governance system** in the EU space sector means that EU space initiatives are adopted in a web of organisation, increasing coordination costs significantly. This state of play does not always allow for proper future proofing of EU space policy, for instance harmonising relevant legislation in the Member States. It is also thought that the current EU space ecosystem sometimes fails to contribute fully to increasing the **competitiveness** of EU space industrial ecosystems, in particular for the upstream sector. This problem is amplified by the absence of a strong EU common budgetary capacity. The result is that EU research and innovation (R&I) investment in space does not necessarily result in the creation and or strengthening of space ecosystems across Member States, and costly duplication of research is not averted. **Risks to continuous EU access to and use of space** represent a potential EU vulnerability, owing to dependencies along value chains and potential weaknesses in cases of disruptive events impacting EU space infrastructures. On the basis of the three criteria of significance of the issue, relevance for EU action, and availability of data, four scenarios of potential EU-level action are proposed to address the key challenges identified.

Scenario 1 is a mostly siloed and fragmented approach to the development of EU space industrial ecosystems. It aims at supporting the EU space economy.[3] It might encourage a level playing field within the single market, but this will probably not occur through market forces given the large economies of scale in this sector and the importance of existing established players.

Scenario 2 is a quasi-status-quo, overhauling the EU-European Space Agency (ESA) framework and adapting EU governance. It is about improving the governance of space policies in the EU, through greater coordination between the main policy actors, as a lack of coordination seems to be one underlying issue. This is not surprising given the low level of shared budgetary resources. The expected impacts of this scenario are reduced fragmentation of space policy frameworks in the EU, and increased capacity to design a long-term vision.

Scenario 3 entails low-ambition with long-term implementation of an eventual common EU space policy to serve EU priorities. It is about designing a comprehensive EU space policy, including its civil and defence dimensions, while aiming at mainstreaming space as an enabler of the overarching EU priorities – the twin digital and ecological transition. The main expected impacts of this scenario are to start defragmenting the EU space sector, and allow for a long-term vision for EU space policy.

Scenario 4 is the most ambitious of all in terms of EU action and expected impacts.[4] It is aimed at building and handling EU open strategic autonomy in space, based on enhanced cooperation to address the challenges faced by the EU space sector collectively. It envisages the EU moving towards an open strategic autonomy approach that favours further cooperation with like-minded partners. Given the importance of the links with defence in this field, reinforcing common projects with NATO allies seems to be a natural first step. More cooperation with democratic partners would also be seen as part of this ideal-state scenario. The main expected impact of this scenario is that it would optimise the impact of Member States' investments and reduce current budgetary waste, as more spending would be collective. While distant from the current state of play, where ambition is lacking, this scenario could also be seen as encouraging competition and levelling the playing field within the single market by removing intra-EU barriers to trade, and encouraging investment.

In terms of economic impact, scenarios 1, 2 and 3 yield comparable results in gross domestic product (GDP), with a percentage increase of between 0.08 and 0.087 by 2030 and 0.14 and 0.152 by 2050 compared to the baseline (see Figure 3 below).[5] In absolute terms this represents between €17 billion and €19 billion in additional GDP by 2030 and between €42 billion and €46 billion in additional GDP by 2050. The employment impact is also positive and ranges between 233 000 and 257 000 additional jobs by 2030 and between 245 000 and 283 000 by 2050. Scenario 4 is the most ambitious in terms of action at EU level. It would bring the highest percentage increase in GDP – 0.27 by 2030 and 0.46 by 2050, which corresponds respectively to additional GDP amounts of €58 billion in 2030 and €140 billion in 2050. It would also have the strongest impact on job creation, with 671 000 additional jobs created by 2030 and up to 734 000 by 2050.

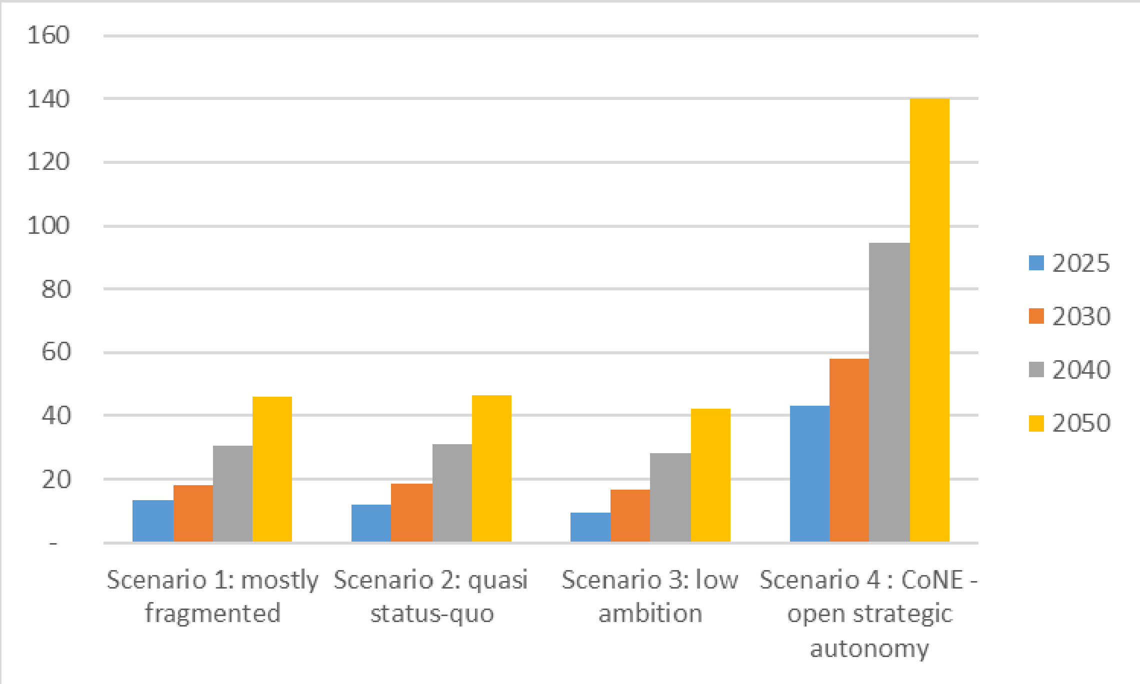
This report uses the results of Scenario 4 to compute the value of the CoNE in the EU space sector. The other three scenarios are used for analytical purposes and to demonstrate that low ambition approaches would lead to a loss of EU added value compared to the more ambitious and united vision of Scenario 4. Economic activity measured as changes in GDP at constant prices, used to measure the **cost of non-Europe in the space sector** (Figure 3), **indicates that the value of lost output could total €58 billion per year in 2030, and approach €140 billion per year by 2050.**

[3] See Chapter 4.2. on Scenario 1 in O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023 (see Annex).

[4] Scenario 4 corresponds to the ideal state scenario in the study in Annex.

[5] For details of how the baseline was quantified, see Chapter 5.1. Methodology of quantification, in the study (Annex).

Figure 3 – Quantifying the cost of non-Europe in the space sector (real GDP impact in € billion)



Source: Prepared by the authors on basis of O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

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1. Introduction

Space is one of the fastest developing economic sectors. The sector's average annual growth rate between 2005 and 2017 was 6.7 %, double the annual global economic growth rate in the same period.[6] In recent decades, space has also gained in relevance, in the European Union (EU) and across the world, as reflected in the steady increase in numbers of space launches, the emergence of private space entrepreneurs, and the number of space-faring nations and regions; at least 80 countries have put at least one spacecraft into orbit since 1957.[7]

This growth has resulted from technological drivers, lowering the cost of space operations and extending space-related activities. It is also due to the need to use space for effective defence – and climate change – the monitoring of which relies significantly on earth observation[8] (qualified as of 'vital importance' by COP27).[9] Russia's war of aggression against Ukraine has further highlighted the importance of space for intelligence-related activities and secure connectivity for the continuity of civilian and defence public policies. According to an impact assessment conducted by the European Commission to inform the proposal for the EU's 2021-2027 space programme, around 10 % of EU gross domestic product (GDP) could depend on space services: essentially communication, information, position-navigation, and space exploration and science.[10]

Although the European space sector is well placed, globally it is facing a series of challenges that are hindering the development of its potential. An ambitious EU space policy would stem from broader long-term EU policy goals that the EU leaders framed in 2019, around the priorities of: i) protecting citizens and freedoms, ii) developing a strong and vibrant economic base and harnessing the digital transformation, iii) building a climate-neutral, green, fair and social Europe, and iv) promoting European interests and values on the global stage.[11]

The aggregated annual spending of EU Member States on space amounts to approximately €10 billion, making the EU the world's third biggest space power in terms of civil public spending. However, if the figure for 2020 is broken down to show what is spent jointly,[12] the EU Member States' contributions to the ESA budget, the joint space spending of the EU, totals approximately €6.5 billion (Figure 1).[13] This is far lower than the budgets put in common in the US or China.[14] In what are currently complex and unpredictable times, the stakes are now rapidly rising for the EU to ensure safe access to and operations in space. This will also be key to ensure progress on the EU's open strategic autonomy agenda, as ensuring safe access also means mitigating risks of a different

6 European Investment Bank, J. Toth and A. Concini, The future of the European space sector : how to leverage Europe's technological leadership and boost investments for space ventures, 2019.

7 European Space Policy Institute (ESPI), ESPI Report 79 - Emerging Spacefaring Nations - Full Report, June 2021.

8 In 2022, up to 60 % of the essential climate variables assessed by the global climate observation system were provided by satellites.

9 Copernicus, COP27 draws attention to the 'vital importance' of Earth observation data, News, 18 November 2022.

10 European Commission, Impact assessment of a proposal for a regulation establishing the space programme of the Union and the European Union Agency for the Space Programme, Commission Staff Working Document, SWD(2018) 327 final.

11 European Council, A new strategic agenda 2019-2024, 20 June 2019.

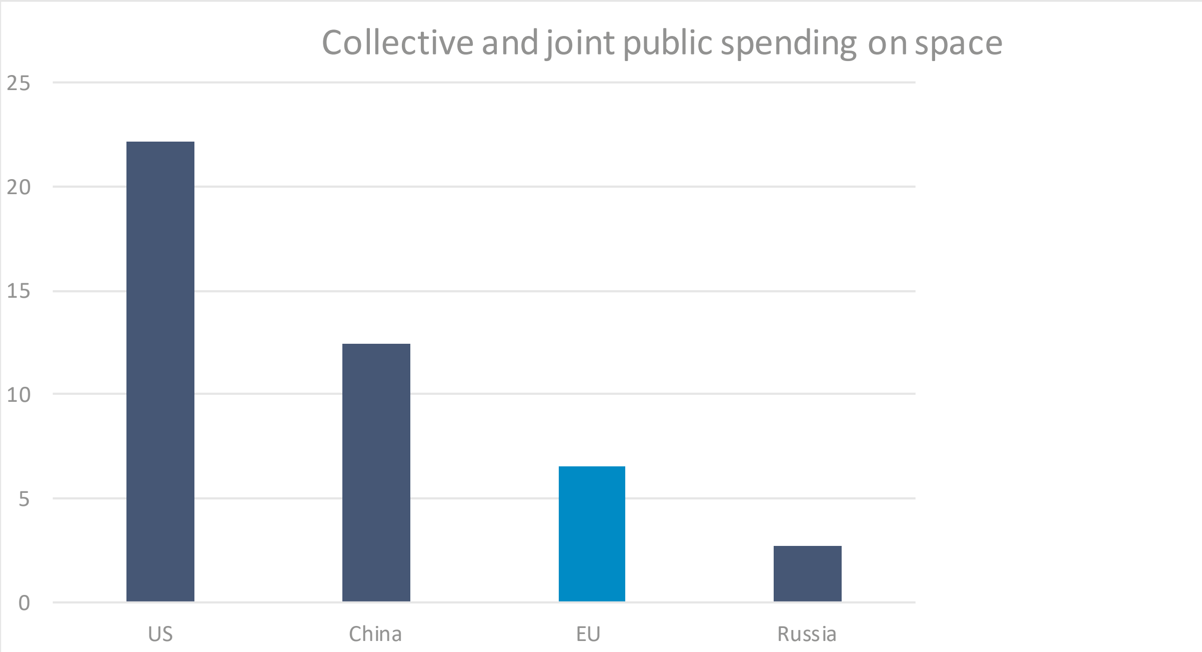
12 In addition to the EU Member States' own investment in space, which is not considered here and is estimated to amount to €3 billion per year.

13 The joint public spending of the EU on space is assumed to be the sum of the financial contribution of EU Member States to the European Space Agency budget and the EU space budget. This amount refers to civil spending on space only.

14 Considering that the United States spends €22 billion, China €12 billion and Russia €2.7 billion. See more in Chapter 2.2.3. of O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023 (see Annex).

nature (international cooperation without uncontrolled dependence on third countries) by developing the EU industrial base when relevant and promoting space sustainability.

Figure 1 – Estimated annual public space budgets of the US, China and Russia and joint spending of EU Member States through the EU and ESA budgets (€ billion)



Source: Prepared by the authors on the basis of O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

It was against this backdrop that the coordinators of European Parliament's Committee on Industry, Research and Energy (ITRE) asked the European Parliamentary Research Service (EPRS) to produce a study on the cost of non-Europe (CoNE) in the space sector.

1.1. Objectives of the report

The CoNE reports are designed to study the possibilities for gains and/or the realisation of a public common good through action at EU level. They attempt to identify areas that are expected to benefit from deeper EU integration and for which the EU's added value is potentially significant.

This CoNE report aims to establish the cost of non-Europe in the space sector. The study specifically focuses on the European space sector, including its research and innovation (R&I), which fall within the competence of the ITRE committee. It also examines security aspects of the space sector that go beyond ITRE's remit but are closely intertwined with all space activity (and might be of interest to other European Parliament bodies, such as the subcommittee on security and defence (SEDE)). Moreover, given the far-reaching nature of space activities, the aim is to serve all committees with evidence.

The report's aim is to address the following questions:

- What is the current state of play, and what are the existing challenges that are delaying or preventing the EU from optimising its space policy while strengthening EU's open strategic autonomy in ensuring the EU's safe access to space?
- What are the adverse impacts of the current challenges to EU action and regulation at EU level?

- What are the options for action at EU level that could address the challenges identified, what are their potential costs and benefits, and which potential EU-level interventions would have the highest European added value?

Following this introduction, Chapter 2 of this study describes the background and context to EU space policy, and explains why and on what basis action at EU level is suggested. Chapter 3 describes and analyses the challenges to the creation of an optimised policy framework to promote EU space policy objectives. Chapter 4 discusses and evaluates scenarios for EU action and their impacts and provides a calculation for the cost of non-Europe. Finally, Chapter 5 concludes with a summary. In the Annex to this study, there is a comprehensive analysis by Ecorys, which was commissioned to support this report.[15]

1.2. Measuring the space economy

In 2012, the first edition of the OECD handbook on measuring the space economy provided for the following definition of the space economy, which consists in 'the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space'.

In 2022, the second edition of the handbook further specified the definition to match the deployment of new technologies and activities, as well as the growing pervasiveness of space services across the economy.[16] Whereas the space sector had featured two complementary segments (the upstream and the downstream segments), the OECD extended this to three segments:

- the **upstream segment**, which entails the scientific and technological building blocks of space programmes (research and development, manufacturing of space equipment and the related subsystems, and launching activities and infrastructures);
- the **downstream segment**, which corresponds to the provision of products and services relying on space based signals and data. This includes the operation of space infrastructure and the provisions of goods and services directly relying on satellite data and signals to function);
- the **derived segment**, which corresponds to economic activities that are induced from space activities (either upstream or downstream) but are not dependent on it to function (e.g. technology transfer from the space sector to the economy, such as photovoltaic panels or wireless headsets).

The quantitative measurement of the space economic sector as a whole is complex. Many estimates of the space economy are underpinned by a revenue-based approach that adds public spending in space programmes to space companies' private revenues. As a consequence, such assessments could include a significant share of double counting of public investment. Academic and policy-driven initiatives are currently attempting to overcome this limitation, as follows.

i) Giving more visibility to space economy segments' components in national accounts

The update of national accounting methodologies at EU level would allow for better identification of new space-based products and services that would contribute to the digitalisation of the economy. For instance, the EU's statistical classification of economic activities (NACE) currently

[15] See O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023 (Annex).

[16] OECD, OECD Handbook on Measuring the Space Economy, 2nd Edition, 2022.

includes the class 'satellite telecommunications activities' (NACE 61.30), without providing further granularity to distinguish the provision of internet connections, or tracking services.[17]

ii) Providing methodological approaches to estimate the added value of space economy activities, rather than the associated revenues.

'First of their kind economic analyses' are designed to provide a more accurate estimate of the contribution of the space economy to GDP. In 2020, the US Bureau of Economic Analysis (BEA) conducted its first assessment of the US space economy, using an 'input output framework'.[18] The study uses 'supply and use' tables that for each product or service give a systematic description of the value of production, and the how the supply is used. These tables can be harnessed to identify the value of output, value added, employment, and compensation along the entire space production supply chain. They also enable exploration of the inter-sectoral effects of the space economy, such as its direct, indirect, and induced effects across industries and states. However, this methodology does not currently capture all the value created by the downstream segment of the space economy. For instance, precision agriculture cannot be identified as such in the national accounts, which lowers the overall contribution of space to the economy.[19]

The BEA study mentioned above estimates that in 2018, the space sector contributed 0.5 % (around €100 billion) of total US GDP.[20] This figure offers a useful precision to the values of the global space economy provided in this report, which are underpinned by revenue-based methodological approaches.[21] However, despite the difficulties in assessing the value of the space economy appropriately in terms of GDP, intermediate consumption or employment, the trend since 2015 towards a growing global space economy appears to be established.[22] The bulk of space investment still relies significantly on government spending, with several implementation models. In this respect, the increasing number of space-faring nations and regions is an indicator for further growth. Private sector investment is also on the rise.

In addition to the contribution of the space economy to GDP, another significant emerging measurement is aimed at capturing the extent of the dependence of the economy on space assets and services. The economy and society are increasingly reliant on space services (such as radio communication, timing and/or positioning signals or Earth observation data – see the breadth of

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[17] Eurostat, Glossary: Statistical classification of economic activities in the European Community (NACE). Interestingly the United Nations statistical commission called for the revision of the International Standard Industrial Classification of All Economic Activities (ISIC) in 2021. Among the changes proposed, the commission considered the creation of a new class K 'Telecommunications, computer programming, consultancy, computing infrastructure, and other information service activities'. However, this change would not immediately offer more granularity to the space sector.

[18] See T. C. Highfill and A. C. MacDonald, Estimating the United States Space Economy Using Input-Output Frameworks, Space Policy, Volume 69, May 2022 and European System of Accounts (ESA 2010), Chapter 9 on Supply and use tables and the input-output framework. This approach allows the accounting of all goods and services produced and consumed in a country during a given period. It relies on 'supply and use' tables that for each product or service give a systematic description of the value of production, and the how the supply is used, either as an intermediate input, either as a final product. This approach offers three sets of advantages for the space economy. First, it addresses the risk of double counting directly by accounting for goods and services at each stage of their production and use. Second, since the tables track individual goods and services, there is no need to disaggregate revenue for companies that produce both space and non-space products. Third, the input output framework allows for the estimation of many types of economic effects relating to space production, providing a more comprehensive view of the space sector than reports that measure revenue only.

[19] See United States Census Bureau, North American Industry Classification System.

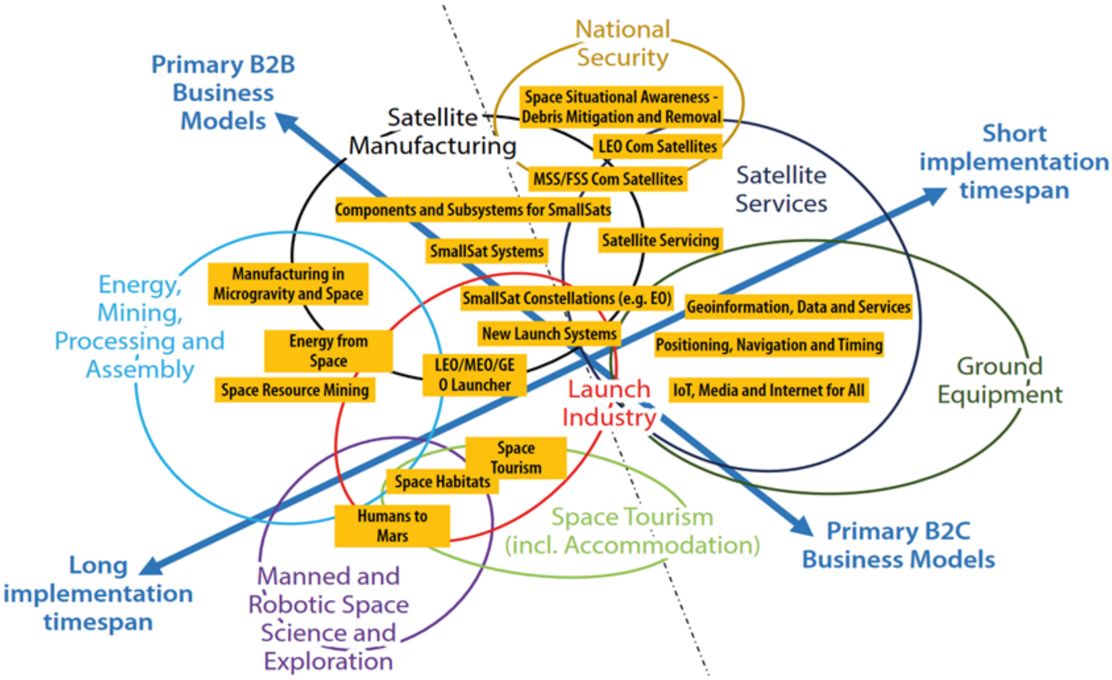
[20] This figure is to be compared with the estimate of overall public spending in space, which amounted to 0.243 % of US GDP in 2019 (Measuring the economic impact of the space sector, OECD, 2020).

[21] See Table 8 in Chapter 2.2.2 in the study, see Annex.

[22] C. Evroux, EU space policy: Boosting EU competitiveness and accelerating the twin ecological and digital transition, EPRS, European Parliament, February 2022.

space applications in Figure 2). According to the impact assessment accompanying the EU's 2021-2027 space programme, approximately 10 % of EU GDP – more than €1 100 billion – is dependent on satellite navigation signals.[23] This gives an estimation of the magnitude of the financial impact potential disruption of space services could have (owing, for instance, to the collision of a satellite with space junk).[24] The dependence on space is also to be assessed against the risk of disruption of its intermediate consummation (such as semiconductors). The EU imports a large proportion of its satellites and satellite components for its EU-based manufacturing activities (for a typical ESA satellite, the European Commission estimates that more than half of electrical, electronic and electromechanical (EEE) components are procured outside of Europe).[25]

Figure 2 – Overview of space-related goods and services



Source: EIB, The future of the European space sector, 2019.

[23] European Commission, Impact assessment of a proposal for a regulation establishing the space programme of the Union and the European Union Agency for the Space Programme, op.cit.

[24] European Commission, Galileo Incident of July 2019: Independent Inquiry Board provides final recommendations, Press release, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, 19 November 2019.

[25] European Commission, Roadmap for the research and development activities on space critical EEE components for European non-dependence in the framework of the Horizon 2020 – Space: final report, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Publications Office, 2016.

2. Background and policy context

2.1. Main drivers of space policy and activities

Three main drivers of space policy and activities can be highlighted on account of their impact on space policy frameworks and space activities. **First, technological developments have lowered space access costs**. Since 2000, the costs of accessing space and space-based services have been reduced thanks to key technological innovations, such as:

- **digitalisation**: space assets are products that include a significant share of microchips.[26] They have benefited directly from technological development. Digitalisation has also led to the updating of space industrial processes by harnessing new digital innovations together: this is the case of advanced manufacturing[27], which enables the production of pieces layer by layer. It is also the case of quantum technologies[28];
- **miniaturisation**: alongside digital developments, the development of new materials, such as carbon fibres (take for example one EU-funded Horizon 2020 collaborative project[29]) allows for the extension of the range of the space assets produced. This is especially relevant for several sizes of small satellites[30], whose production costs are limited, and which contribute significantly to space traffic[31];
- **launchers**: innovation in launching systems has also helped to reduce the cost of access to space. In particular, the development of reusable launchers and micro launchers is expected to reduce launching prices, and their environmental footprint. As highlighted by the report in the specific box on micro launchers, Horizon 2020 also supports these types of research and innovation activity.[32]

The interplay between these trends is expected to reduce the cost of space launches significantly (see Table 1 below), which still ranges between € 4 000 and €20 000 per kilo. It should also lead to the creation of new business models along the space sector value chain.

Table 1 – Outline of the indicative cost of next generation space launchers

Prior generation		Next generation		Change
Rocket	€ thousand/kg to LEO*	Rocket	€/kg to LEO	%
n/a	n/a	Falcon Heavy	1.5	n/a
Falcon 9	4.2	Falcon 9 FT	2.5	-42 %
Saturn V	20.8	SLS	3.0	-86 %
Proton	4.2	Angara A5	3.8	-9 %

26 European Space Agency, Father of the chips steering Europe's space missions, 6 December 2017.

27 European Space Agency, Advanced Manufacturing.

28 European Commission, The European Quantum Communication Infrastructure (EuroQCI) Initiative.

29 Space Carbon, The Project, European Carbon Fibres and Pre-Impregnated Materials for Space Applications.

30 NASA, NASA and Smallsat Cost Estimation Overview and Model Tools, NASA S3VI – Webinar Talk Series 06/10/2020.

31 European Space Agency, ESA's annual space environment report, 22 April 2022.

32 European Commission, The mission to build a reusable launcher for Europe, Horizon. The EU Research & Innovation Magazine, 16 March 2020.

Ariane 5	7.7	Ariane 6	4.3	-44 %
H-IIA/B	6.2	H3	4.5	-27 %
Atlas V/Delta IV	10.1	Vulcan	5.8	-43 %
GSLV	8.5	LVM3	6.8	-20 %

Source: EPRS using EIB data.
Note: LEO* - low Earth orbit.

Second, the growing pervasiveness of space in the economy calls for enhanced resilience. This trend refers mainly to the growing use of space services and / or induced technologies across the economy and society. As mentioned above, up to 10 % of EU GDP is estimated to rely partly or entirely on space assets and services. This comes with the need to avoid and mitigate the risks of space disruption. The risks vary (man-made risks such as military[33], or space weather events[34]), and can impact either ground-based or in-orbit infrastructure, or both. The extent to which critical economic sectors (such as energy, defence, finance and telecommunications) rely on space depends on their specific global navigation satellite system (GNSS) requirements. The EU Agency for the Space Programme (EUSPA) provided a comprehensive sectoral assessment of such requirements in 2019.[35] Possible mitigation measures consist of providing alternatives to EU GNSS data. This can be done either by supporting technologies compatible with other GNSS providers, or by harnessing technologies that can, on their own, provide accurate GNSS services such as timing. This is the case of the atomic clock systems (used to manufacture satellites), whose development is supported by EU research and innovation.[36] Other mitigation measures are expected to be designed and activated in orbit as well. For instance, to reduce the risks associated with space debris, the ESA is expected to launch the first mission to capture space junk by 2025.[37] The ESA and NASA are cooperating on asteroid deflection (another source of in-orbit risk), with a first mission launched in 2021.[38]

Third, the need for sustainability of space and in space. Whereas the EU is set to achieve climate net zero emissions by 2050, space is expected to contribute to this overarching objective, in a context of increasing space congestion. The reduction of the space sector's environmental footprint features among the priorities on the ESA's 2025 agenda.[39] It was also included in the provisional agreement between the EU co-legislators in the regulation establishing IRIS², the EU space-based secure connectivity programme (see Section 2.2). Beyond the environmental impact of space activities on Earth, the growing congestion of space traffic calls also for the development of technologies and solutions to improve space surveillance and tracking, as well as the design of regulatory actions to enhance space traffic management (STM), with new technological standards and rules. Indeed, increasing levels of space traffic are reducing the number of available orbits and radio spectrums for ensuring exploration, navigation and communication services. Currently, the Commission's 2022 communication on an EU approach to space traffic management estimates that in addition to 4 550 operational satellites, there are around 128 million pieces of debris smaller than 1 cm orbiting Earth.[40] The need to develop an EU approach to STM is likely to highlight the need for

33 European Commission, Statement by Thierry Breton, European Commissioner for Space, following the Russian test of an anti-satellite weapon, 17 November 2021.

34 European Space Agency, What is Space Weather?.

35 EU Agency for the Space Programme, Report on time & synchronisation user needs and requirements, 1 July 2019.

36 European Commission, M. Travagnin, Chip-scale atomic clocks : physics, technologies, and applications, Joint Research Centre, Publications Office, 2021.

37 D. Clery, *Science*, 'Europe plans space claw to capture orbiting junk', 1 December 2020.

38 European Space Agency, Catching asteroid deflection mission's first words, 22 November 2021.

39 European Space Agency, Evaluating the European space sector carbon footprint for the year 2019, 8 June 2022.

40 European Commission, Joint communication to the European Parliament and the Council, An EU Approach for Space Traffic Management. An EU contribution addressing a global challenge, JOIN(2022) 4 final.

specific governance arrangements between the EU and its Member States. This is the case for instance in multilateral forums such as the United Nations Committee on the Peaceful Use of Outer Space (COPUOS), and the International Telecommunications Union (see Section 2.4).

2.2. Rationale for EU action in the field of space

The Treaty of Lisbon established EU space policy as a shared competence of the EU and its Member States. Article 189(1) of the Treaty on the Functioning of the European Union (TFEU) reads 'to promote scientific and technical progress, industrial competitiveness and the implementation of its policies, the Union shall draw up a European space policy'. Article 189(2) TFEU provides for the European Parliament and the Council to act, applying the ordinary legislative procedure, to adopt initiatives, including a European space programme, excluding any harmonisation of the laws and regulations of the Member States. EU space policy is embedded in a policy framework that reflects the progressive extension of EU space activities and a complex governance arrangement, where Member States and International Organisations, such as the European Space Agency, are active alongside the EU institutions.

The Union's space programme, established by Regulation (EU) 2021/696, was the first integrated spatial investment framework adopted by the EU.[41] As mentioned in recital 3 of the programme, previous Union initiatives on space were conducted on the basis of a set of separate legal vehicles: 'the Union has been developing its own space initiatives and programmes since the end of the 1990s, namely the **European Geostationary Navigation Overlay Service (EGNOS)** and then **Galileo** and **Copernicus**'. These initiatives were driven by a common objective to harness EU investment to deliver space services to the EU, through the creation and operation of spatial infrastructures (including their ground sections). This policy approach is especially important on account of its capacity to support both the space sector upstream through the design and manufacturing of space assets (such as satellites for instance), and the space sector downstream, covering all uses of the new services. The scope of such services now includes positioning and timing (Galileo and Egnos), Earth observation (Copernicus), and secure connectivity (through **GOVSATCOM** and the upcoming **IRIS² constellation**). In 2017, EPRS published a reference study[42] presenting historical policy developments, from the early developments in the 1960s, to the policy design, implementation and operation of Galileo, Egnos, Copernicus and GOVSATCOM.

In addition to this main legal basis, the Treaty on the Functioning of the European Union also allows specific space activities to be conducted under the remit of the common foreign and security policy. For instance, the European Defence Agency includes space among its capability domains, which constitute the basis for its cooperative initiatives. A 2022 in-depth analysis requested by Parliament's Subcommittee on Security and Defence (SEDE) found that the EU has invested more than €270 million in space-defence capabilities since 2017, through the European Defence Fund.[43] The growing reliance of the EU economy on space services (see Chapter 3 on key challenges facing the EU space sector) in a context of geopolitical tensions, such as Russia's war on Ukraine, is likely to drive additional investment in the coming years. Following the adoption of the EU Strategic Compass in 2022, the EU is set to design a strategy for space and defence by the end of 2023.[44]

The extension of EU space initiatives and the evolution of their implementation models have taken place within a complex pan-European governance network. For the EU institutions, Treaty changes

41 Regulation (EU) 2021/696.

42 V. Reillon, European space policy: Historical perspective, specific aspects and key challenges, in-depth analysis, EPRS, European Parliament, 2017.

43 D. Fiott, The Strategic Compass and EU space-based defence capabilities, Directorate General for External Policies of the Union, European Parliament, 2022.

44 Council of the European Union, 'A Strategic Compass for Security and Defence', March 2022.

have updated the governance settings and they have evolved, notably with the creation by Council's Committee of Permanent Representatives (Coreper) of a preparatory body on space, the Working Party on Space in 2010, following the entry into force of Article 189 TFEU, mentioned above. In addition, two sets of relationships exert a significant influence on EU space policy: first cooperation between the EU and the ESA, and second, the articulation between EU space initiatives and the Member States' national policies and initiatives in space and in other multilateral organisations.

2.3. Recent EU initiatives and positions in the field of space

The EU is well aware that space and related activities will increase in importance in the coming years and that preparation for a new space race must be stepped up. In parallel to the discussion on and adoption of the EU 2021-2027 space programme, further initiatives and actions are being discussed to reinforce the EU space sector.

European Council agenda-setting for space

In March 2022, the EU Heads of State or Government underlined in the Versailles Declaration the **need to further invest in strategic enablers such as cybersecurity and space-based connectivity**, to be able to strengthen EU defence capabilities and conduct a full range of EU missions and operations.[45]

More specifically, the declaration stressed that: 'In view of the challenges we face and in order to better protect our citizens, while acknowledging the specific character of the security and defence policy of certain Member States, we must resolutely invest more and better in defence capabilities and innovative technologies. We therefore agreed to: (...) c) invest further in the capabilities necessary to conduct the full range of missions and operations, including by investing in strategic enablers such as cybersecurity and space-based connectivity; d) foster synergies between civilian, defence and space research and innovation, and invest in critical and emerging technologies and innovation for security and defence; We also need to best prepare for fast-emerging challenges by: (...) b) enhancing the security and defence dimension of space industries and activities (...)'.

On security and defence the European Council 'supports the strengthening of the **EU-NATO strategic partnership** and looks forward to the third joint declaration on EU-NATO cooperation. It should be prepared in an inclusive manner, address new threats and challenges and include, as areas for enhanced cooperation, resilience, cyber and hybrid threats, climate change and security, space, and emerging and disruptive technologies'. On the Strategic Compass: 'the European Council looks forward to the presentation of the technology roadmap requested in February 2021 and invites the Commission and the High Representative to make any further proposals necessary, including on **space security**, cyber and the fight against hybrid threats'.[46] It calls for the development of '**EU autonomy** in the space sector and a more integrated defence industrial base'.[47]

European Parliament position

In its resolution of 15 January 2020 on the European Green Deal, Parliament considered 'that the EU must maintain and further develop its flagship civilian space programmes **Copernicus and Galileo**, which provide valuable contributions to environmental monitoring and data collection'. 'It also stressed that Copernicus's climate change services should become fully operational as soon as

[45] Informal meeting of the Heads of State or Government – Versailles Declaration, 10-11 March 2022.

[46] European Council, Conclusions – 16 December 2021.

[47] European Council, Conclusions – 1 and 2 October 2020.

possible, to provide the continuous flow of data necessary for action'.[48] In its resolution of 10 June 2021 on the EU's cybersecurity strategy for the digital decade, Parliament welcomed the initiative for an EU **space-based global secure communications system** that would integrate quantum encryption technologies.[49] It also noted that the on-going efforts needed to secure European space activities should be made in cooperation with the EUSPA and the ESA.

In its resolution of 6 October 2021 on the future of EU-US relations, Parliament reiterated **the importance of EU-US space cooperation** arguing that it could help promote space safety standards and best practice across the international community. In its resolution of 25 November 2020 on a new industrial strategy for Europe, Parliament highlighted the importance of EU space policy for improving European industrial space capacities and unlocking the potential of synergies with other key sectors and policies, so as to develop cutting-edge technologies and accompany the industrial transformation.[50] In its resolution of 17 February 2022 on the implementation of the common security and defence policy, Parliament welcomed the proposal on an EU secure connectivity programme, calling for the rapid completion of this project to improve the level of telecommunications security in the EU.[51] It also underlined the growing risk of cyber- and physical attacks on European and Member State satellites, and insisted on the need to prevent such attacks, and to put defensive mechanisms in place against them.

Council of the EU

On 21 March 2022, the Foreign Affairs Council adopted the Strategic Compass for Security and Defence. The document regards outer space and cyber-space as global commons, just like the ocean, and considers satellite communication to be one of the assets on which the compass is to be deployed through the launch of the forthcoming EU secure connectivity programme. In June 2022, the Competitiveness Council adopted two conclusions to future-proof EU space programme: the first refers to the future of Copernicus[52], to ensure the appropriate funding of the infrastructure, the second, on space traffic management[53], highlights the need to ensure the sustainability of space, including by developing EU space traffic management legislation.

Cooperation between the EU and the ESA

The framework for cooperation between the EU and the ESA is laid down in a framework agreement published on 6 August 2004.[54] The agreement establishes several principles and purposes for the cooperation, including the development of an overall European space policy, but also cross-cutting goals of a strategic nature, such as 'securing Europe's independent and cost-effective access to space'. Since the adoption of the agreement, although not all the 27 Member States are full members of ESA yet, EU funding share of the ESA budget has increased substantially to rank first.[55] The current framework does not allow a simple holistic presentation of the EU and ESA's respective

48 C. Evroux, EU space policy: Boosting EU competitiveness and accelerating the twin ecological and digital transition, EPRS, European Parliament, February 2022.

49 European Parliament resolution of 10 June 2021 on the EU's Cybersecurity Strategy for the Digital Decade (2021/2568(RSP)).

50 European Parliament resolution of 25 November 2020 on a New Industrial Strategy for Europe (2020/2076(INI)).

51 European Parliament resolution of 17 February 2022 on the implementation of the Common Security and Defence Policy – annual report 2021 (2021/2183(INI)).

52 Council of the European Union, Copernicus by 2035 – Council conclusions (adopted on 10/06/2022).

53 Council of the European Union, EU approach to space traffic management – Council conclusions (adopted on 10/06/2022).

54 Framework Agreement between the European Community and the European Space Agency, Official Journal, L 261, 6 August 2004, pp. 64-68.

55 In 2022, the ESA budget amounted to €7.15 billion, including circa €2 billion from the EU and €3.88 billion from the 27 EU Member States. See ESA website.

competences. However, it is possible to indicate that although the EU has not yet adopted a strategy on space exploration and science, leaving it to the ESA (the ESA's science programme is the organisation's only mandatory programme), the ESA has become an essential partner of EU for the implementation of its space initiatives. This especially true regarding the upstream phases of initiatives (such as manufacturing of space assets and organisation of launches).

Member States' action on space and in multilateral organisations

EU Member States conduct their own space policies in parallel to the EU initiatives mentioned above. In addition to their differences, which are outlined in the study in the Annex, it is key to stress two common trends that prove challenging to the design and implementation of EU space initiatives. First, Member States are active in fields where the EU does not yet act. For instance, in the field of space exploration, as of July 2022, five Member States (France, Italy, Luxembourg, Romania and Poland) have joined the '**Artemis Accords**', a US-led initiative, whose subtitle reads 'principles for cooperation in the civil exploration and use of the Moon, Mars, comets and asteroids for peaceful purposes'.[56] The inclusion of notions such as exploration and use raises the question of their articulation with EU space initiatives, including any that are upcoming. Recently, the need to secure the orbits needed to operate the EU's upcoming $IRIS^2$ constellation[57] required a specific arrangement between the EU and at least one of its Member States, as a member of the International Telecommunication Union. In the future, the role of Member States active in the Committee on the Peaceful Uses of Outer Space (COPUOS), within the UN Office for Outer Space Affairs (UNOOSA) could prove key to ensuring that the EU can exert its influence on several matters, including space debris. However, not all 27 Member States are currently members of the committee.[58]

2.4. EU public opinion on space

Space benefits from wide interest and support among EU citizens. As shown by the surge in traffic on the ESA and NASA web domains following the release in 2022 of the first images from the James Webb telescope, public interest in space is not unique to Europe.[59] Regular surveys on the attitudes of European citizens towards space highlight their opinions on the matter. In general, space activities are well considered and supported by EU citizens, as are scientific policies. In 2021, the special Eurobarometer on European citizens' knowledge and attitudes towards science and technology found that 54 % of interviewees would like to know more about scientific developments in general.[60] Furthermore, 69 % of the interviewees agreed that the development of technologies for space exploration would have a positive impact on their way of life in the next 20 years; this represents a slight progression compared with the results of a similar question in a 2005 survey.

The results of a survey[61] of more than 20 000 European citizens (in 22 countries, including the United Kingdom – UK) conducted on behalf of the ESA in September and October 2022, gives a more precise outline of the public's interest in space activities. Space activities are seen as helping to tackle societal challenges by increasing knowledge and by providing technological solutions (such as connectivity):

56 NASA, The Artemis Accords.

57 C. Evroux, 2023-2027 EU secure connectivity programme: Building a multi-orbital satellite constellation, EPRS, European Parliament, 2022.

58 United Nations Office for Outer Space Affairs, Committee on the Peaceful Uses of Outer Space: Membership Evolution.

59 The Cloudfare Blog, How the James Webb Telescope's cosmic pictures impacted the Internet, 14 July 2022.

60 European Commission, Directorate-General for Communication, European citizens' knowledge and attitudes towards science and technology: report, Publications Office of the European Union, 2022.

61 ESA, Europeans and space activities – How do Europeans perceive issues related to space?, Survey Toluna Harris Interactive, 2022.

- 84 % of those interviewed felt that space contributed to a better understanding of Earth dynamics;
- 77 % considered that the space activities carried out in Europe to this end were effective. Regarding the future of European space policies,
- 81 % agreed that European space activities should be independent of decisions made by other major powers;
- 82 % agreed that the pooling of such space activities would be a way to achieve this.

Significantly, EU citizens – irrespective of Member State – consider that EU access to space should be a political priority. Support for European space activities grew by 17 percentage points in the five main countries covered by the study (France, Germany, Italy, Spain and the UK) between 2019 and 2022 (from 64 % to 81 %). Interestingly, 89 % of respondents considered that European space activities were important to ensure the ability of European countries to protect the confidentiality of their citizens' personal data.

3. Key challenges facing the EU space sector

This chapter outlines the most pertinent challenges facing the European space sector from the perspective of potential further EU-level action. They relate to governance, global competition, economic resources and regulation. The study in the Annex identifies a list of 11 key challenges hindering EU space policy from reaching its full potential.[62] Whilst the granularity of the list gives a grasp of the complementary dimensions of key challenges, such as the institutional settings for an effective EU space policy, it needs to be extended by stress testing space policy options and by including risks of differing natures (technological, natural, man-made) that might put pressure on EU space service continuity (Table 2). The key challenges include the complex governance system within the EU, a fragmented EU space ecosystem, and risks that could threaten continuity of EU access to and use of space. These are overarching problems that are presented in more detail below.

Table 2 – Key challenges present in the EU space sector

#	Challenge	Significance	Relevance for EU action	Availability of data
1	Ensuring a long-term vision	High	High	Medium
2	Ensuring sufficient permanent EU funding	Medium	Medium	High
3	Addressing the excessively complex governance system	Medium	High	Medium
4	Addressing the multiple legal and policy frameworks	High	High	Medium
5	Ensuring efficient organisation of the EU space sector	Medium	High	High
6	Ensuring sufficient levels of competition	Low	Low	Medium
7	Increasing the number of start-ups and allowing them to grow	Low	Medium	Medium
8	Staying internationally competitive	High	High	High
9	Addressing problematic dependencies across value chains	Medium	High	Medium
10	Arranging for beneficial international cooperation, in particular with NATO and democratic partners	Medium	Medium	Low
11	Securing open strategic autonomy in the space domain	High	High	Medium
12	Stress testing space policy and risks of varying nature (technological, natural, man-made)	High	High	Medium

Source: Based on O. Batura and A. Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

[62] See detailed analysis of gaps and challenges and how they were identified in Chapter 3 of the study in the Annex.

Inefficiencies in the governance system: this overarching challenge encompasses the first four challenges: 'ensuring a long-term vision'; 'ensuring sufficient permanent EU funding'; 'addressing the excessively complex governance system'; and 'addressing the multiple legal and policy frameworks'. The study in the Annex finds that the institutional settings for EU space policy still reflect the state of play when the EU institutions had no specific competence on space. As a result, the implementation model for EU space initiatives relies on a complex organisational framework, whose respective competences are not specific enough to minimise coordination costs. More importantly, the study estimates that this state of play does not allow for proper future-proofing of EU space policy, notably in terms of securing long-term budgets and harmonising the relevant national legislation. Although the finding on the difficulty inherent in designing EU policy initiatives efficiently in a policy field where a European intergovernmental organisation (the ESA) is operating in parallel with the EU is well-founded, the other related findings should be nuanced. As for fragmentation of the policy framework associated with Member States' differing national space policies, the state of play presented by the study might soon change, as in Estonia[63] and Poland[64] authorities have been discussing national legislation on space. Furthermore, the conclusions on Copernicus by 2035, adopted in 2022 by EU ministers in charge of space, prove that the EU is making important commitments beyond the timeframe of its current budget.

Competitive EU space ecosystem: this gap refers to the competitiveness of EU space industrial ecosystems. It gathers in the following challenges: 'ensuring efficient organisation of the EU space sector'; 'ensuring sufficient levels of competition'; 'increasing the number of start-ups and allowing them to grow'; and 'staying internationally competitive'. The EU is a major space industry power, especially in the upstream sector where, according to the Eurospace data, it generated a trade surplus between 2012 and 2021 both for launchers and satellites and for manufacturing.[65] This is to be expected from an economic point of view, given the considerable economies of scale in this sector. The study in the Annex rightly points that the upstream segment is composed mostly of actors established in a small number of regions. Furthermore, and probably owing to the lack of common EU budgetary capacity, the study highlights the fact that the EU research and innovation investment in space might not always contribute to the creation and or strengthening of space ecosystems in other Member States. For instance, the study reports that 'out of 2 953 participations in Horizon 2020, space-related projects by organisations from the largest Member States in terms of GDP (Germany, France, Italy and Spain) naturally and unsurprisingly account for 57 %' of such projects.

The risks to EU access to and continuous use of space: this challenge refers to growing congestion and global competition to secure access to space, and the capacity to deliver space services: 'addressing problematic dependencies across value chains; 'arranging for beneficial international cooperation, in particular with NATO and democratic partners', 'securing open strategic autonomy in the space domain' and 'stress testing space policy and risks of varying nature' (technological, natural, man-made). This challenge should be understood as including the adverse impact of the disruption of EU space services. On technological sovereignty and international cooperation, the study in the Annex establishes the need to adopt a value chain approach, and to map and address any critical dependency across the whole EU space ecosystem. This approach is substantiated notably in the recent proceedings of the EU-US Trade and Technology Council, not least the need for a joint approach regarding the mapping of any shortage in essential technological

63 Republic of Estonia, Ministry of Economic Affairs and Communication, Estonian contribution to Space Traffic Management, presentation.

64 B. Malinowski et al., Task Force on Polish Space Law at the Centre for Space Studies, Kozminski University, Polish space legislation: industry contra legislator? Presenting the works of Study Group at Kozminski University on Polish space law, presentation at the III International Conference Risks' engineering in space sector, 20 April 2021.

65 Eurospace, Eurospace facts and figures, 2022 edition.

components, such as chips.[66] Launchers represent a specific point of attention: indeed, together with an appropriate spaceport, they constitute a key condition for access space. The study also highlights the current challenging situation regarding the currently limited range of EU heavy launchers (before the uptake of Ariane 6 and Vega-C) respectively, while also presenting the opportunities associated with reinforced use of EU innovative small launchers.[67] The relevance of the gaps identified in the study is reinforced when factoring in the potential risks of disruption to EU space services due to an adverse event affecting EU space infrastructure. The European Parliament Policy Department in-depth analysis for the SEDE subcommittee offers a three-pronged typology for such disruption: congestion, disruption and weaponisation.[68] Whilst 'congestion' covers the risks associated with growing volumes of space traffic and space debris, the second and third categories refer to man-made events. 'Disruption' refers to the risks associated with malicious actions towards ground and spatial EU space assets, such as cyberattack, 'weaponisation' covers the emerging malicious threats to EU space assets in outer space, such as anti-satellite weapons.

In Table 2 above, 12 challenges were identified as relevant to the CONE in the space sector. The study in the Annex uses six of these challenges explicitly to calculate the CoNE while the others are addressed implicitly. This methodological approach offers a transparent and sound analytical framework, but it nevertheless presents drawbacks, as explained in the study.

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[66] US-EU Joint Statement of the Trade and Technology Council, 16 May 2022.

[67] See box on micro-launchers in the EU in Chapter 2 of the study in the Annex.

[68] D. Fiott, The Strategic Compass and EU space-based defence capabilities, in-depth analysis, op.cit.

4. Description of EU policy scenarios and related results

Four policy scenarios were modelled and assessed assuming varying levels of ambition to address the key challenges identified that are hindering development of the EU space sector. They include various policy steps, such as investment, partnership, and regulatory approaches. Some are complimentary but they can also differ in terms of thematic focus. Scenario 1 looks at a mostly fragmented approach to supporting EU space industrial ecosystems. Scenario 2 represents a quasi-status quo and focuses more particularly on a limited governance overhaul. Scenario 3 proposes low ambition and long-term thinking and implementation for a possible comprehensive EU space policy to enable EU priorities. Scenario 4 assumes an ideal setting where the challenges identified are addressed effectively and cooperatively. This is the scenario used to compute the cost of non-Europe.

4.1. Scenario 1: A siloed and mostly fragmented approach to the development of EU space industrial ecosystems

The first scenario, based on the study in the Annex, aims to support and broadly to protect the EU's space economy.[69] This might encourage competition and level the playing field within the single market, although this will probably not occur through market forces, given the large economies of scale in this sector and the importance of the existing players. The set of measures outlined in this scenario imply keeping public budgetary action mostly at national level, as no increase in common spending at EU level is envisaged. It proposes giving incentives for EU space investment to support EU technological competiveness in space, as well as protecting a network of chosen EU space ecosystems across the whole EU. In order to unlock fully the expected effects of such investments, a few ancillary regulatory approaches are also suggested.

This scenario explores the level of investment needed, as well as its target (direction) and modalities. It implicitly deems appropriate the level of space investment in the current 2021-2027 multiannual financial framework (MFF). However, to achieve a level playing field in the EU, it recommends that specific allowance should also be made for supporting newcomers in EU space activities, whether they are small or medium-sized enterprises (SMEs) and/or legal entities of Member States with fewer space ecosystems.[70] Regarding the objective of incentivising the formation of space industrial ecosystems, this scenario also envisages earmarking investment for those Member States and regions with the smallest space actors. On public procurement modalities, this scenario also envisages bundling Member States' relevant space procurement, in accordance with the principle of 'anchor tenancy' to improve the opportunities and time horizon of space businesses. At the same time, such an approach might not fully resolve the costly duplication of the existing technological development of solutions, as is the case for re-usable launchers.

This scenario also recommends applying a 'buy European principle' to increase demand in the EU space sector as a whole. This would be compatible with the World Trade Organization agreement on government procurement, which allows exceptions to open procurement in the case of national security interests.[71] It would remain to be seen in practice how this type of approach could be

[69] See Chapter 4.2. on Scenario 1, O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

[70] One step in this direction was the provisional agreement achieved on 17 November 2022 by the EU co-legislators on the proposal establishing IRIS², the EU infrastructure for resilience, interconnectivity and security by satellite. The proposal and subsequent examination provided for a minimum threshold for SMEs in procurements to be launched to manufacture the infrastructure. Council of the EU, Council and European Parliament agree on boosting secure communications with a new satellite system Press release, 17 November 2022.

[71] See Article 28 of the WTO Agreement on Government Procurement of 2012.

conducive to more cooperation with NATO allies and democratic partners. It also entails a risk of further protectionist tendencies, further fragmentation, and budgetary waste, also within the EU.

Assuming that these issues are resolved and the fiscal space to finance such a policy is found, this scenario could be implemented in a relatively short time, without any specific additional budget from the EU 2021-2027 MFF, but potentially with increasing amounts of budgetary waste at Member State level. In the study in the Annex, the year 2024 has been taken as the first implementation year and 2025 as the year when implementation is expected to be completed. The results (see Table 3) show an impact on GDP of 0.086 percentage points' deviation from the baseline in 2030 and of 0.150 percentage points in 2050. In absolute terms, this represents around €18 billion in additional GDP by 2030 and €45 billion by 2050. This is explained by some increases in investment and innovation, which would also lead to the creation of 219 000 additional jobs by 2030 and to 241 000 additional jobs by 2050.

Table 3 – Impact of implementing Scenario 1 on selected macroeconomic variables (percentage deviations from baseline scenario values)

Year	GDP	Private consumption	Employment	Capital stock
2025	0.069	0.06	0.08	0.00
2030	0.086	0.08	0.08	0.04
2040	0.119	0.12	0.08	0.10
2050	0.150	0.15	0.08	0.16

Source: O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

4.2. Scenario 2: Quasi status-quo, overhauling the EU-ESA framework and adapting EU governance

The second scenario, based on the study in the Annex, is about improving space policy governance in the EU, by means of greater coordination between the main policy actors. This is because a central underlying issue appears to be the lack of coordination or inefficiency, which is not surprising given the low amount of budgetary resources put in common.[72] Its expected impacts are a reduction in the fragmentation of space policy frameworks in the EU, and increased capacity to design a long-term vision. The scenario relies mainly on regulatory and non-regulatory approaches.

The main issue to tackle by means of a regulatory approach refers to the framework for EU-ESA cooperation. As presented in the study in the Annex, the framework currently in force was negotiated and adopted long before the adoption of space as a shared EU competence under the TFEU. Furthermore, as mentioned above, beyond the legal basis, the relationship between the EU and the ESA has shifted, as the EU share in the ESA budget has grown steadily over the last decade, and it now ranks first. While the study rightly calls for a readable breakdown of roles and missions, this updated cooperation framework would still include a policy and operational level.

The non-regulatory approaches outlined encompass improved EU capacity to plan strategically over the medium term, and better articulation between EU initiatives on space and Member States' competences in multilateral organisations. The study in the Annex considers that the EU would improve its space preparedness by upgrading its capacity to co-design an EU space strategy over 20 years, involving all EU institutions and Member State authorities, but also pan-European space

72 See Chapter 2.2.3. on investment and Chapter 4.3. on Scenario 2 in O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

actors and civil society. The EU has already launched analogous co-design schemes in other policy fields, such as research and innovation, but with a far shorter time horizon.[73] A second set of non-regulatory approaches refers to the need for Member States to facilitate the effectiveness of EU space policy through their membership of multilateral organisations, in line with Article 4(3) of the Treaty on European Union.[74]

According to the study in the Annex, although this scenario does not require additional EU investment, and could be started at any moment, its time horizon is less clear, mainly owing to the need to go through the legislative cycle. The results (see Table 4) show a GDP impact of a 0.087 percentage point deviation from the baseline by 2030 and one of 0.152 percentage points by 2050. In absolute terms, this represents around €19 billion in additional GDP by 2030 and €46 billion by 2050. This can be explained by increases in investment and innovation, which would also lead to the creation of 257 000 additional jobs by 2030 and to 283 000 additional jobs by 2050.

Table 4 – Impact of implementing Scenario 2 on selected macroeconomic variables (percentage deviations from baseline scenario values)

Year	GDP	Private consumption	Employment	Capital stock
2025	0.060	0.06	0.08	0.01
2030	0.087	0.08	0.09	0.04
2040	0.121	0.12	0.09	0.11
2050	0.152	0.15	0.09	0.17

Source: Study in Annex: O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

4.3. Scenario 3: Low ambition and long-term implementation of a possible EU space policy, to enable EU twin transitions priorities

The third scenario, based on the study in the Annex, is about designing a possible EU space policy, including civil and defence dimensions, while seeking to mainstream space as an enabler of the EU's overarching priorities: the twin digital and ecological transition.[75] The main expected impacts of this scenario are to start defragmenting the EU space sector, and to allow a long-term vision for EU space policy to form.

Once a long consultative process has been conducted, this scenario would call for investment measures, as well as regulatory approaches and other non-legislative measures.

The key characteristics of this scenario are: first, the need to provide for a comprehensive policy framework, which could also be done using a non-legislative measure such as a Commission communication. The study in the Annex refers directly to the 2016 Commission communication on

73 See: European Commission, Horizon Europe's first strategic plan 2021-2024: Commission sets research and innovation priorities for a sustainable future, Press release 15 March 2021.

74 Article 4.3 TEU: 'Pursuant to the principle of sincere cooperation, the Union and the Member States shall, in full mutual respect, assist each other in carrying out tasks which flow from the Treaties. The Member States shall take any appropriate measure, general or particular, to ensure fulfilment of the obligations arising out of the Treaties or resulting from the acts of the institutions of the Union. The Member States shall facilitate the achievement of the Union's tasks and refrain from any measure which could jeopardise the attainment of the Union's objectives'.

75 See Chapter 4.4. on Scenario 3 in O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

space,[76] which could be updated to include the latest geopolitical developments, and to offer a holistic EU strategic agenda for space, also including the associated industrial policy requirements. Second, the scenario refers implicitly to EU investment: either direct, as mentioned above with the industrial policy for space, or indirect, by mainstreaming space across EU policy agendas. Interestingly, the scenario also hints at the possibility of harnessing mission-oriented initiatives to provide European common goods, such as EU access to or support for EU launchers. Last, the scenario suggests launching the harmonisation of the regulatory framework for space activities across the EU. This view is supported by the Commission and the High Representative for Foreign Affairs and Security Policy in the joint communication on space traffic management, where the Commission commits to assess possible areas for legislation by mid-2024 (see also above the 2022 conclusions of the Competitiveness Council).

According to the study in the Annex, this scenario could be launched in 2023 and completed by 2026, without additional EU investment. Although this timeframe might be appropriate for a legislative initiative, this scenario might require additional EU investment under the current MFF, especially regarding the hidden costs of mainstreaming space across all the EU policy areas. The results (see Table 5) show a GDP impact of a 0.08 percentage point deviation from the baseline by 2030 and of a 0.14 percentage point deviation by 2050. In absolute terms, this represents around €17 billion in additional GDP by 2030 and €42 billion by 2050. This is explained by increases in investment and innovation that would also lead to the creation of 233 000 additional jobs by 2030 and 245 000 additional jobs by 2050.

Table 5 – Impact of implementing Scenario 3 on selected macroeconomic variables (percentage deviations from baseline scenario values)

Year	GDP	Private consumption	Employment	Capital stock
2025	0.05	0.05	0.06	0.00
2030	0.08	0.08	0.08	0.03
2040	0.11	0.11	0.08	0.09
2050	0.14	0.14	0.08	0.15

Source: O. Batura and A. Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

4.4. Scenario 4: EU open strategic autonomy in space – Increasing cooperation to address the challenges faced by the EU space sector collectively

Scenario 4 – which corresponds to the ideal state scenario[77] in the study in the Annex – envisages an EU moving towards an open strategic autonomy approach that favours cooperation with like-minded partners. Given the importance of the links with defence in that field, reinforcing common projects with NATO allies seems to be a natural first step. More cooperation with democratic partners could also be seen as part of this ideal-state scenario.

A substantial positive expected effect of this scenario is that it would bring about a substantial reduction in Member States' budgetary inefficiencies, since more spending would be conducted

[76] European Commission, Space Strategy for Europe, COM(2016) 0705 final.

[77] See Chapter 5 in O. Batura and A. Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

jointly. More specifically, limited national market size or the absence of an appropriate infrastructure and, more importantly, large economies of scale in this sector mean that some investments are sometimes unproductive. Scenario 4 therefore assumes an efficient transfer of resources to the EU level, where considerable economies of scales would yield higher returns in terms of added value. This scenario would encourage competition and level the playing field within the single market by removing intra-EU barriers to trade and foreign direct investment, and addressing remaining national protectionist actions in the sector, to allow for the emergence for EU players of a sufficient scale to be able to compete and engage in beneficial industrial cooperation on global markets. By encouraging risk-taking and equity investment, notably by significantly boosting venture capital at EU level, this scenario would allow for a vibrant network of start-ups in the area, able to access sufficient finance and grow rapidly, so as to benefit from the full positive effect of the single market.

Implicitly, this scenario deems insufficient the current level of space investment under the current 2021-2027 MFF and would envisage increased investment, at least to the level of global actors in the field. This approach would also envisage increased investment and activities at regional and local level, and support innovative start-ups in EU space activities. Whereas a budget-neutral approach, such as that envisaged in Scenario 1, would not necessarily increase funding in jurisdictions with fewer space ecosystems, this scenario would on the contrary seek to reduce inequalities in investment. Regarding the modalities of public procurement, this scenario also envisages a common public procurement agency, to avoid the administrative waste associated with 27 diverging administrative entities, save resources through the joint purchase of relevant items and services, and reduce home bias. Other benefits of this approach might include higher levels of joint budgetary spending on research and innovation and accelerated investment in forward-looking space innovation, viewing the EU as a potential leader in this area rather than as a follower.

This fourth scenario might also envisage a 'buy European' principle, assuming that it was fully compatible with WTO rules and agreed as part of a G7/OECD agreement, similar to that recently achieved on corporate taxation. This would guarantee a beneficial outcome benefiting all rather than a narrow-minded return to protectionism and tension between allies at a time when democracies are facing increasing pressures and challenges. The results of this ambitious scenario (see Table 6 below) show a greater GDP impact, with a 0.27 percentage point deviations from the baseline by 2030 and a 0.46 percentage point deviation by 2050. In absolute terms, this represents around €58 billion in additional GDP by 2030 and €140 billion by 2050. This can be explained by larger increases in investment and boosted innovation activities, which would also lead to the creation of 671 000 additional jobs by 2030 and to 734 000 additional jobs by 2050.

Table 6 – Impact of implementing Scenario 4 on selected macroeconomic variables (percentage deviations from baseline scenario values)

Year	GDP	Private consumption	Employment	Capital stock
2025	0.22	0.21	0.24	0.06
2030	0.27	0.26	0.24	0.16
2040	0.37	0.37	0.24	0.35
2050	0.46	0.46	0.23	0.53

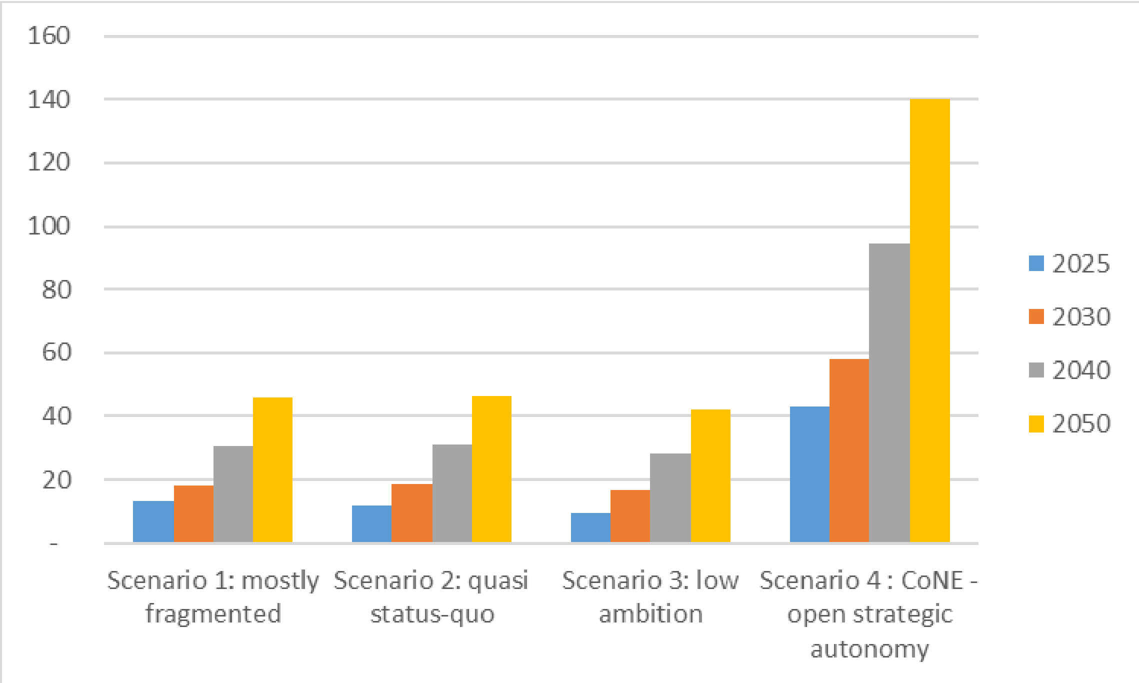
Source: O. Batura and A. Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

4.5. Quantifying the cost of non-Europe in the space sector.

CoNE evaluations are designed to study the possibilities for gains and/or for the realisation of a public common good through action at EU level. The calculation therefore focuses on identifying areas where deeper EU integration can bring benefits and for which the European added value is potentially significant. CoNE reports aim to contribute to evidence-based policy making and to the greatest extent possible try to provide quantitative estimates of the consequences of non-action at EU level. In this context, the present CoNE report seeks to provide a reliable estimate of potentially measurable gains to the EU economy from the various space-related EU policy initiatives. It does not claim to make exact predictions, but rather to illustrate the share of the benefit that could be realised from efficient and united EU action.

This report uses the results of Scenario 4 to calculate the value of the CoNE. The three other scenarios are used for analytical purposes and to describe how approaches with low ambition would lead to a loss of EU added value compared with the more ambitious and united vision of Scenario 4. Economic activity measured through changes in the GDP at constant prices, used as a measure of the **cost of non-Europe in the space sector (see Figure 3 below), indicate that the value of lost output could amount to €58 billion per year by 2030, and grow to close to €140 billion per year by 2050**.

Figure 3 – Quantifying the cost of non-Europe in the space sector (real GDP impact in € billion)



Source: Prepared by the authors on basis of O. Batura and A.Vassilev, Cost of non-Europe in the space sector, EPRS, European Parliament, 2023, see Annex.

5. Conclusion

Over the last two decades, the EU's institutional and policy framework has made it possible to harness the latest industrial, scientific and technological developments more effectively, extending the scope of the EU's space-based services. The study in the Annex shows the key importance of space for achieving the EU's overarching priorities given the growing reliance of modern economies on space and makes the case for the assessment of the cost of non-Europe regarding space policy. Russia's war of aggression against Ukraine highlights still further the positive and increasingly indispensable contribution of space.

The cost of non-Europe report confirms a positive case for matching the extension of EU space services with the establishment of a common space policy among EU Member States. This policy would be underpinned by the European added value of further initiatives, which would bolster the EU's position in the space sector while also ensuring EU access to space and the increased competitiveness of EU businesses in this area. Each scenario in this report takes a targeted approach, with differing levels of ambition, focusing respectively on boosting the EU's space economy, overhauling European space governance and harnessing space for the EU twin transitions priorities.

Scenario 4 – used for the final calculation of the CoNE – is the one scenario that refers to EU open strategic autonomy in space, with increasing cooperation to address the challenges faced by the EU space sector collectively. An advantage of this scenario is that it would ensure a substantial reduction in Member States' budgetary inefficiencies, as more spending would be carried out collectively. This scenario might assume joint spending or a more ambitious transfer of resources to the EU level, where – given the considerable economies of scales in this area – a higher return in terms of added value is guaranteed. This scenario would encourage competition and a level playing field within the single market, by continuing to remove intra-EU barriers to trade and to FDI, and addressing remaining national protectionist measures in the sector. This would allow for the emergence of competitive EU players on a sufficient scale to be able to compete and engage in beneficial industrial cooperation on global markets, in particular with NATO and democratic partners. Implicitly, this scenario deems the current level of space investment under the current MFF insufficient and would envisage increases, at least to the level of global actors in the field. Such an approach would also provide for increased investment and activities at regional and local level, and support innovative start-ups in EU space activities. Other benefits would include higher joint budgetary spending on research and innovation, accelerating investment in forward-looking space innovation, and viewing the EU as a potential leader in the area.

The results of this ambitious scenario point to a greater impact of around €58 billion in additional GDP by 2030 and €140 billion by 2050. This is explained by greater increases in investment and boosted innovation activities, which would also lead to the creation of more than 700 000 jobs by 2050.

Annex

Cost of non-Europe in the space sector

The space sector has become an indispensable part of our society and economy, offering technological solutions and addressing key societal challenges, such as climate change and the digital divide. To reap the benefits of the growing space sector, the European Union has been stepping up its efforts to develop its space power further.

This 'cost of non-Europe' study in the space sector analyses the status quo of the sector in Europe and identifies challenges hampering its full potential. Based on this examination, the cost of non-Europe is analysed qualitatively and quantitatively using a computable general equilibrium model. The cost of non-Europe in 2025 is estimated at €43 billion and would continue to grow increasingly over time, reaching up to €140 billion by 2050. The study identifies three broad policy scenarios for EU action to resolve the challenges. At the heart of the scenarios is the added value of more EU policy action. Each scenario would address the identified challenges to some extent and thus generate benefits for businesses and society.

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Executive summary

Over its relatively short history, the space sector has become an indispensable part of our society and economy. Space infrastructure offers technological solutions that open new doors for potentially addressing climate change and other key societal challenges. Some concrete examples are satellite communication services used to deliver telecommunications, internet and broadcasting, especially to the hard-to-reach areas, bridging the digital divide. Space-based Earth observation supports our efforts in fighting climate change and helps us monitor nature and the environment for biodiversity and conservation, forestry and agriculture. Satellite-based navigation and positioning services are central for transportation and logistics and vital for emergency services and disaster response. At the same time, a number of space technology applications represent potential threats to society, such as the possible use of space applications for mass surveillance or military purposes.

To reap the benefits of the growing space sector and to put itself in the position to shape its development, the European Union (EU) has been stepping up its efforts as a nascent space power and a partner for international collaboration, in particular with democratic partners and NATO allies. Against this background, the European Parliament Research Service (EPRS) commissioned Ecorys in 2022 to conduct a Cost-of Non-Europe study in the space sector. This study identifies potential challenges in the European space sector and formulates possible EU Policy Scenarios on how these could be resolved. At the heart of the policy recommendations is the added value of more EU policy action. This means that EU policy action needs to continue offering meaningful solutions to challenges that are difficult and costly to be resolved on the national, regional, local or business level.

Based on consultations with key stakeholders[1] and desk research, this study has identified the most pressing challenges in the European space sector. It assessed their significance and the potential for EU policy action. Using expert insights, the six most significant issues that present a sound case for EU policy action have been selected and further analysed.

Table 1 – Shortlist of six most pressing issues in the European space sector.

	Challenges	Possible policy measures
1	Ensuring a long-term vision	- To define a long-term vision and strategies with budgetary objectives, roadmaps and measurable targets. These long-term ambitions will be updated over time to remain valid and in line with recent developments. - High-level summits / other meetings as input for shaping a long-term vision and strategies - Closer coordination between the EU and European Space Agency (ESA) as well as at the national level, e.g. through regular meetings at the ministerial level
2	Complex governance system	- Mechanisms to ensure closer coordination between the EU and ESA - Mechanisms to ensure cooperation at the national level, regional, local and businesses level, e.g. regular meetings at the ministerial level - Enhanced cooperation
3	Fragmented legal and policy framework	- Close the gaps in space policy at the EU level - Explore the possibility of adopting legal acts

1 See list of interviewed stakeholders in the References section.

	Challenges	Possible policy measures
		- Greater cooperation/ coordination between the EU and ESA
4	Uneven distribution of the EU space sector	- Encourage growth of space sectors in all Member States, especially 'young' space nations, while avoiding large waste of budgetary resources in duplicating existing programmes and not considering economies of scale - More nuanced and inclusive approaches to space R&D&I and education programmes while avoiding multiplying costly and ineffective programmes that lack sufficient scale - Special support instruments for space SMEs, start-ups and new entrants, making sure that spending is done efficiently - Transparency/ information sharing (incl. technology transfer) - Greater coordination between national policies, funding and other efforts and more focus on reducing budgetary waste and duplication
5	Staying internationally competitive	- Ensure enhanced cooperation with democratic partners, in particular the USA and NATO to avoid costly duplication and potential waste of EU taxpayer money - Mechanisms to ensure closer coordination between the EU and ESA as well as at the national level - Develop open space industrial policy, that enhances cooperation with democratic partners and avoids budgetary waste - Transparency/ information sharing (incl. technology transfer) - Special budgetary neutral support instruments for space SMEs, start-ups and new entrants - Support the EU space industry through for instance better and more efficient public procurement, public-private partnerships
6	Strategic autonomy in the space domain	- Mechanisms to ensure closer coordination between the EU and ESA as well as at the national level - Develop open space industrial policy, that enhances cooperation with democratic partners and avoids budgetary waste - Promote healthy competition in the space sector - Special budgetary neutral support instruments for space SMEs, start-ups and new entrants - Support the EU space industry through for instance more efficient and better public procurement, public-private partnerships, tax incentives, etc.

Source: Authors' elaboration.

The Cost of Non-Europe method measures potential benefits if these challenges are addressed through EU-level actions. It is calculated through economic modelling, as the difference between the baseline and the ideal state scenario. The baseline scenario reflects the expected economic developments in the absence of any further EU policy changes, while the ideal state scenario represents a hypothetical situation where EU-level actions fully resolve the six shortlisted challenges. This exercise, therefore, highlights the importance of adequate EU-level action in the European space sector. The analysis suggests that after adjusting for price developments, the Cost of Non-Europe in the space sector for the broad Europe region considered (EU-27, the UK and the EU candidate countries prior to 2022) is an output (GDP) loss of approximately EUR 43 billion in 2025, growing to over EUR 140 billion in 2050 (in real terms, at constant 2021 prices). In terms of absolute employment gains, attaining the ideal state could bring about over 700,000 more jobs in 2050.

Table 2 – Difference between baseline and ideal state scenario for selected macroeconomic variables (absolute deviations from baseline scenario values).

Year	GDP, billion EUR constant 2021 prices	Employment, thousand persons
2025	43	653
2030	58	671
2040	94	704
2050	140	734

Source: Authors 'analysis.

The research led, based on literature review and consultations with key stakeholders, to the development of three EU-level Policy Scenarios:

Policy Scenario 1 - continue to support the EU space ecosystem

Under this Policy Scenario, the EU continue to adopt an effective policy and legal framework that supports the space economy by encouraging international competitiveness and competition. Further action would mainly involve an adjustment of the existing rules on public procurement, budgetary neutral and non-distortive start-up and SME support, R&D support and some others to the needs of the space sector.

Policy Scenario 2 - greater coordination at the EU level

The premise of this Policy Scenario is that most of the identified challenges can be resolved through improved coordination between the main policy actors (EU, ESA and EU Member States). The role of the EU would be to enable this coordination by providing a forum and supporting institutional structures.

Policy Scenario 3 - comprehensive EU-level policy and legal rules

This Policy Scenario suggests more assertive actions by the EU. The EU should use the opportunities for action within the given competences to the full extent and develop a dedicated and comprehensive space policy and more targeted space security and space industry policies, as well as streamline space through other policy areas.

The development of these Policy Scenarios takes account of the space initiatives announced up to mid-2022. The selected Policy Scenarios, therefore, go beyond those announced and point to potential new initiatives that can further eliminate the six identified challenges.

The Policy Scenarios put forward and explored are unique and differ from each other in their impacts and benefits. They target the identified challenges in different ways, have different implementation horizons and work on different levels (e.g. Policy Scenario 1 encompasses more market-oriented measures, whereas Policy Scenario 2 addresses governance). As can be seen in Table 3 below, Policy Scenarios 1-3 have broadly similar impacts. Their implementation timing is roughly comparable, and the estimated output and employment effects can be considered close. In more specific terms, the nominal GDP gains in 2050 from implementing scenarios 1 and 2 are each in the range of EUR 90 billion, while scenario 3 delivers slightly smaller gains of about EUR 85 billion.

Table 3 – Summary of the comparative assessment of all Policy Scenarios.

	Policy Scenario 1	Policy Scenario 2	Policy Scenario 3
Significant challenges addressed	++	+	+
Economic net benefits	+	+	+
Feasibility of implementation	+++	+++	++

Notes: feasibility, proportionality and subsidiarity are ranked from low (+), medium (++) to high (+++). Source: Authors.

Importantly, each Policy Scenario can be implemented independently of the other, but they are complementary and would achieve the most benefits if implemented in combination. To ensure the best outcome for the European space and adjacent sectors, this study recommends implementing these Policy Scenarios in a sequential manner. In this approach, both the complementary nature of the different Policy Scenarios and (short-run) implementation feasibility are taken into account.

The suggested implementation schedule is as follows: Policy Scenario 1 should be implemented as soon as possible, as it will bring quick benefits to the sector and does not require changes to the EU budget or negotiations on any new policies or instruments. Together with Policy Scenario 1, the implementation of Policy Scenario 2 needs to be rolled out. This is necessary not only because a longer time horizon is necessary for coordination but also because the effect of Policy Scenario 1 will be much stronger if accompanied by coordination. Policy Scenario 2 can be considered a necessary precursor for Policy Scenario 3 as more extensive national policies and rules are likely to have a greater impact if there is effective coordination between the different stakeholders in the European space sector.

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List of abbreviations

ASAT	Anti-satellite weapons
BIC	Business Incubation Centres
CGE	Computable general equilibrium
CNES	National Centre for Space Studies (Centre national d'études spatiales)
CoNE	Cost of Non-Europe
COVID-19	Coronavirus disease
DLR	German Aerospace Centre (Deutsches Zentrum für Luft- und Raumfahrt)
DoD	Department of Defense
ECA	European Court of Auditors
EDA	European Defence Agency
EDF	European Defence Fund
EDIH	European Digital Innovation Hub
EEA	European Economic Area
EEAS	European External Action Service
EGNOS	European Geostationary Navigation Overlay Service
EIB	European Investment Bank
ESA	European Space Agency
ESPI	European Space Policy Institute
ESTEC	European Space Research and Technology Centre
EU	European Union
EUSPA	European Union Agency for the Space Programme
FFPA	Financial Framework Partnership Agreement
GEO	Geostationary orbit
GMES	Global Monitoring for Environment and Security
GNSS	Global navigation satellite services
GOVSATCOM	EU Governmental Satellite Communications
JAXA	Japan Aerospace Exploration Agency
ICT	Information and communication technology
ISECG	International Space Exploration Coordination Group
ISS	International Space Station
ITU	International Telecommunications Union

LED	Little emitting diode
LEO	Low Earth orbit
LSI	Large System Integrator
MFF	Multiannual financial framework
NACE	Nomenclature des Activités Économiques dans la Communauté Européenne
NASA	National Aeronautics and Space Administration of the USA
NATO	North Atlantic Treaty Organization
OECD	Organisation for Economic Co-operation and Development
PNT	Positioning, Navigation and Timing
R&D	Research and development
R&D&I	Research, development and innovation
SME	Small and medium-sized enterprise
SSA	Space Situational Awareness
SST	Space Surveillance and Tracking
STM	Space traffic management
TEU	Treaty on the European Union
TFEU	Treaty on the Functioning of the European Union
TRL	Technology readiness level
UNCOPUOS	UN Committee on the Peaceful Uses of Outer Space
WTO	World Trade Organization

List of country codes

Belgium	BE
Bulgaria	BG
Czech Republic	CZ
Denmark	DK
Germany	DE
Estonia	EE
Ireland	IE
Greece	EL
Spain	ES
France	FR

Croatia	HR
Italy	IT
Cyprus	CY
Latvia	LV
Lithuania	LT
Luxembourg	LU
Hungary	HU
Malta	MT
Netherlands	NL
New Zealand	NZ
Austria	AT
Poland	PL
Portugal	PT
Romania	RO
Slovenia	SI
Slovakia	SK
Finland	FI
Sweden	SE
United Kingdom	UK
United States of America	US

1. Introduction

Over its relatively short history, the space sector has become an indispensable part of our economy. Satellite communication services are used to deliver telecommunications, internet, and broadcasting, especially to the hard-to-reach areas, bridging the digital divide. Space-based Earth observation supports our efforts in fighting climate change and helps us monitor nature and the environment for biodiversity and conservation, forestry, and agriculture. Satellite-based navigation and positioning services are central for transportation and logistics and vital for emergency services and disaster response. In the security and defence domain, space-based services provide secure communications, reconnaissance, and surveillance possibilities. These space technology applications have economic potential, but also represent potential threats to society through possible use for mass surveillance or military purposes.

In economic terms, space helps to save or avoid cost, especially in operations and processes, and increases productivity gains.[2] The contributions of space science to medical and biological research, chemistry and physics, materials science and our understanding of the universe and life itself are invaluable. The list of technological innovations coming from the space sector is lengthy and covers all economic segments: from solar panels to implantable heart monitors, artificial limbs, and insulin pumps, to lightweight high-temperature alloys, better car tyres, water filters and air purifiers, Light Emitting Diode (LED) technology, to wireless headsets, computer mice and many others. In short, space industrial activity is already commonplace on Earth, and its influence will only grow in the future.

To reap the benefits of the growing space sector and to shape its development, the European Union (EU) has been stepping up its efforts as a space power and a reliable international partner. Building on a strong track-record of gradually increasing involvement, the EU has recently adopted several important laws and policies, including the EU Space Programmes, and established its own space agency: the European Union Agency for the Space Programme (EUSPA; more details on this in Section 2.1). While these actions provide a strong foundation for the next few years, more intense, purposeful engagement is necessary at the EU level to meet the challenges of climate change, the energy crisis, the war in Ukraine and others, and to deliver on the common European objectives.

This study aims to contribute to evidence-based policymaking on the EU level in the area of space. It establishes the Cost of Non-Europe (CoNE) in the space sector, namely, how the EU can overcome identified challenges related to space policy, where the costs and benefits of the concerted EU-level action lie and where the EU added value is potentially significant. The study applies a time horizon until 2050.

The study is structured as follows: Chapter 2 outlines the governance, the economic and regulatory state of play of the EU space sector, including its structure, size, investment, and employment. It also discusses how the EU compares internationally and explains important international cooperation instances. Chapter 3 describes the challenges the EU faces in the space sector. It then identifies the most significant ones that are further subjected to the CoNE exercise. Chapter 4 develops policy measures, packaged in several Policy Scenarios, that could address the identified significant challenges. Chapter 5 provides a qualitative and quantitative assessment of all Policy Scenarios (CoNE exercise), discussing their potential costs and benefits. The concluding Chapter 6 provides a comparative analysis of the Policy Scenarios indicating their comparative merits and the highest EU added value they can help to achieve. It also provides recommendations on the approach towards implementation of the Policy Scenarios.

[2] See Chapter 2 in OECD, 'The space economy in figures: How space contributes to the global economy', 2019.

2. State of play of the EU space sector

This chapter sets the scene by first discussing the governance of the EU space sector, explaining how it has developed, what the EU competences are under the Lisbon Treaty and which other actors are involved (Section 2.1). Against this backdrop, Section 2.2 describes the state of the EU space sector in terms of its structure, market size, investments, and employment. While international comparisons are made throughout Section 2.2, the topic of international cooperation and competition in space is handled out further in Section 2.3.

2.1. Governance of the EU space sector

2.1.1. Historical perspectives

European activities in the space sector were driven by individual states and through intergovernmental cooperation within the European Space Agency (ESA) in the 20th century.[3] The predecessor of the EU – the European Community – became active in space policy only in the 1980s. In particular, in 1987, the European Parliament considered that 'the time had come 'for the European Community to work out a coherent policy on space activities'.[4] Until then the European Community had only indirectly supported space development via the deepening of the internal market, standardisation activities, and intellectual property rights.[5] The resolution noted that 'without autonomy in space operations Europe will be unable to derive full economic benefits from the scientific discoveries and technological innovations which it makes in this sector'[6]. It 'requested the Commission [to] draft a communication on space policy and proposed that the European Community should become a member of ESA,' which was subsequently issued in July of 1988.[7] After that, between the late 1990s to mid-2000s, collaborative efforts between the EU, the ESA and Member States intensified in the area of space policy as well as R&D. The EU also developed flagship programmes, funded by the EU and developed in cooperation with ESA, of which the most notable outcomes included Galileo[8], a world-class, new generation global satellite-based navigation system which allowed for independence from other such systems, Copernicus for earth observation, and successful missions like the landing on a comet by the Philae of the Rosetta spacecraft in 2014[9] (for an overview of EU funded programmes see Chapter 2.3). In terms of funding, the EU's contribution to research activities increased from EUR 1.43 billion earmarked for space activities under the 7th Framework Programme[10] to EUR 12.6 billion for 2014-2020[11] to over EUR 14 billion under the 2021-

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[3] See for an overview EPRS, 'European space policy - Historical perspective, specific aspects and key challenges', 2017.

[4] EPRS, 'European space policy - Historical perspective, specific aspects and key challenges', 2017, p. 6.

[5] See for an overview in Brünner C and Soucek A, Outer Space in Society, Politics and Law, studies in space policy volume 8. Springer, 2011, p. 410-412.

[6] See European Parliament Resolution on European space policy, OJ C 190 of 20.07.1987.

[7] EPRS, 'European space policy - Historical perspective, specific aspects and key challenges', 2017, p. 6; Commission of the European Communities, The Community and space: a coherent approach, COM(88) 417 of 26.07.1988.

[8] See Council Resolution of 19 December 1994 on the European contribution to the development of a Global Navigation Satellite System (GNSS), OJ C 379 of 31.12.1994; Agreement between the European Community, the European Space Agency and the European organisation for the safety of air navigation on a European contribution to the development of a global navigation satellite system (GNSS), OJ L 194 of 10.07.1998.

[9] Gibley E, 'Like froth on a cappuccino': spacecraft's chaotic landing reveals comet's softness, *Nature*, 20 October 2020.

[10] See Decision No 1982/2006/EC of the European Parliament and of the Council of 18 December 2006 concerning the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013) Statements by the Commission, OJ L 412 of 30.12.2006.

[11] EPRS, 'EU Space Program', 2021, p.5.

2027 MFF (for details on public funding see Section 2.2.3).[12] In doing so, the nature of Europe's space sector changed from being intergovernmental and geared towards national defence efforts, to one that was increasingly supranational and dynamic, marked by the interests and efforts of both private and public actors.[13]

On a policy level, such a change became evident in 2007, when it was laid down in the Treaty of Lisbon that the space domain became within the realm of EU law-making[14]. In the same year, the new European Space Policy[15], which covered previous EU-level communications and Space Council decisions, was adopted jointly by the European Commission and ESA. [16] In doing so, it creates 'for the first time a common political framework for space activities in Europe'.[17] The 2007 European Space Policy has been adopted by the Space Council, which is a joint meeting of the Council of the EU and the ESA Council at the ministerial level, established to enhance political cooperation between the EU and ESA in line with Article 8 of the 2004 Framework Agreement for EU-ESA relations.[18] Since then, various EU-level policies have become gradually more independent and pronounced. It can be argued that the EU has begun to develop into a space policy actor in its own right by establishing a distinctive EU position.[19] The latest stage of this development is the adoption of the new EU Space Programme[20] in 2021, and the creation of a special EU-level agency to manage this programme: the European Union Agency for the Space Programme (EUSPA).[21]

The EU Space Programme represents a new step in the EU's space policy, aimed at securing EU leadership in space activities, fostering innovative industries, safeguarding autonomous access to space, and simplifying governance.[22] The EU Space Programme proposes a coherent strategy for the EU, in line with the expanded budget earmarked for space for the 2021-2027 period. It rationalises

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12 See European Commission, EU space programme overview factsheet, 2022.

13 Brennan L, Heracleous L and Vecchi A, 'Above and Beyond: Exploring the Business of Space', Routledge, Oxon, 2018.

14 Béclard J, 'The Lisbon Treaty and the Evolution of European Space Governance', Institut français des relations internationals, 2012.

15 European Commission, European Space Policy, COM(2007) 212 of 26 April 2007.

16 Relevant EU-level and ESA communications and decisions preceding the 2007 European Space Policy include: Council Resolution of 22 June 1998 on the reinforcement of the synergy between the European Space Agency and the European Community, OJ C 224, 17 July 1998; ESA Council, Resolution on the reinforcement of the synergy between the European Space Agency and European Community, ESA/C/CXXXVI/Res.1 of 23 June 1998; European Commission, Europe and space: turning to a new chapter, COM(2000) 597 of 27 September 2000; European Commission, Towards a European space policy, COM(2001) 718 of 7 December 2001; European Commission, Space: a new European frontier for an expanding Union – An action plan for implementing the European Space policy: white paper, COM(2003) 673 of 11 November 2003; Council Decision of 29 April 2004 on the conclusion of the Framework Agreement between the European Community and the European Space Agency, OJ L 261 of 6 August 2004; Council of the European Union, Conclusions of the second Space Council, 9501/05 of 6-7 June 2005; Council of the European Union, Conclusions of the third Space Council, 14155/05 of 28-29 November 2005.

17 ESA, 'History of Europe in space', not dated.

18 Brünner C and Soucek A, 'Outer Space in Society', Politics and Law, studies in space policy volume 8. Springer, 2011, p. 418.

19 This is underlined through such policy documents as the Europe 2020 strategy (COM(2010) 2020), the EU space industrial policy (COM(2013) 108), the Commission communication 'Towards a space strategy for the European Union that benefits its citizens' (COM(2011) 152), the European Parliament resolution on space capabilities for European security and defence (P8_TA(2016)0267) and European Parliament resolution on space market uptake (P8_TA(2016)0268), and the European Space Strategy (COM(2016) 705).

20 Regulation (EU) 2021/696 of the European Parliament and of the Council of 28 April 2021 establishing the Union Space Programme and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013 and (EU) No 377/2014 and Decision No 541/2014/EU, OJ L 170 of 12.05.2021.

21 The European Union Agency for the Space Programme replaces the former European GNSS Agency, incorporating missions and responsibilities previously spread across multiple entities. See for an overview EUSPA's website.

22 EPRS, 'EU Space programme', 2021.

the space governance shifting responsibilities to the EUSPA from the former European GNSS Agency and focuses on bolstering the European Space Policy 'in the fields of Earth Observation, Satellite Navigation, Connectivity, Space Research and Innovation and supports investments in critical infrastructure and disruptive technologies'.[23]

In addition to Galileo and Copernicus, it does so through the development of four additional flagship components: EGNOS,[24] the European Geostationary Navigation Overlay Service; SSA[25], ensuring space situational awareness monitoring and protecting space assets, strengthening the EU's space surveillance and tracking capabilities while setting 'clear standards and regulation for a safe, sustainable and secure use of space'; GOVSATCOM,[26] providing secure satellite communications for EU security actors;

Another recent development beyond the EU Space Programme is the establishment of the EU space-based Secure Connectivity Programme. This proposal for this programme was concluded by the European Union in mid-2022 to ensure worldwide access to secure and cost-effective satellite communications services.

2.1.2. EU competences in space

The EU has acquired competence in the space area with the Treaty of Lisbon of 2009.[27] Article 189 TFEU[28] gives the EU a legal basis for activities in the space sector and outlines what objectives these activities must pursue. Article 189 (1) TFEU lists three sets of objectives:

1. promotion of scientific and technical progress;
2. promotion of industrial competitiveness; and
3. implementation of the EU's policies, in general.

EU competences in the space domain belong to the category of shared competences, which, however, does not prevent Member States from exercising their competences in the same domain (Article 4 (3) TFEU).[29] This means that the EU and Member States can exercise competencies in the space area in parallel. In addition, according to Article 189 (2) TFEU, the EU cannot harmonise national laws in the area. This construction means that the EU institutions, 'while playing an important role, cannot exhaustively condition Member States' policies on the subject'.[30] In particular, in such areas of space activities as licensing conditions, insurance policies, registration of space objects and others, EU Member States can continue to act individually or cooperate in an intergovernmental manner (e.g., through ESA) without harmonisation at the EU level.[31] At the same

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23 DEFIS, 'EU Space Programme', not dated.

24 DEFIS, 'EGNOS', not dated.

25 DEFIS, 'EU SPACE Programme Overview', 2021.

26 DEFIS, 'EU SPACE Programme Overview', 2021.

27 Treaty on the Functioning of the European Union, OJ 2012 C326 of 26.10.2012.

28 Article 189 TFEU must be read in conjunction with the Article 4 (3) TFEU.

29 Wouters J and Hansen R, 'The other triangle in European space governance: the European Union, the European Space Agency and the United Nations', KU Leiden Working Paper No. 130, 2013, pp. 2-3; von der Dunk F, 'The EU Space Competence as per the Treaty of Lisbon: Sea Change or Empty Shell?', Proceedings of the International Institute of Space Law 2011, 2012, pp. 352-353.

30 Liakopuolos D, 'The Future of the European Space Agency-EU relationship: Critical Aspects and Perspectives', *European Journal of Current Legal Issues 25:2*, 2019; Hobe S et al., 'A New Chapter for Europe in Space', Zeitschrift für Luft- und Weltraumrecht 54, 2005, pp. 346-347; von der Dunk F, 'The EU Space Competence as per the Treaty of Lisbon: Sea Change or Empty Shell?', Proceedings of the International Institute of Space Law 2011, 2012, pp. 386-389.

31 Schmidt-Tedd B, 'Authorisation of Space Activities after the Entry into Force of the EU Reform Treaty', in von der Dunk F (ed.), National Space Legislation in Europe, Martinus Nijhoff Publishers, 2011, p. 306.

time, Member States should exercise their competencies according to the principle of loyal (sincere) cooperation, in particular by facilitating the achievement of the Union's tasks and refraining from any measures that would jeopardise attaining such objectives (Article 4 (3) TEU).[32] Yet Article 189 (2) TFEU leaves the EU with many possibilities for interventions in the space domain. They can take the form of decisions, best practices, benchmarks or, as mentioned in Article 189 (2) TFEU, space programmes. The latter opportunity was used most recently by the European Commission to propose the Union Secure Connectivity Programme for 2023-2027.[33]

2.1.3. EU-ESA relationship

The ESA was created in 1975[34] by ten founding members: Belgium, Denmark, France, West Germany, Italy, the Netherlands, Spain, Sweden, Switzerland, and the United Kingdom. Seven of these were part of the European Communities at the time of ESA's establishment. Since then, ESA has grown to include 22 Member States in 2022, 19 of which are also EU Member States[35]. The other three are Norway, Switzerland, and the United Kingdom. Slovenia, Latvia, and Lithuania are ESA's Associate Members. Bulgaria, Croatia, Cyprus, Malta, Slovakia, and Canada have Cooperation Agreements with ESA.[36]

ESA was created to enable and promote cooperation among European states in space research and technology and their space applications for scientific and operational purposes.[37] ESA promotes exclusively peaceful uses of space. ESA promotes cooperation along four main lines of action: long-terms European space policy; coordination of European and national space programmes; development and implementation of space activities; development and implementation of appropriate industrial policy.[38]

Over its almost 50-year-long history, ESA has developed and/or supported European space facilities and implemented hundreds of projects. For example, in 1990, ESA founded the European Astronaut Centre in Cologne (Germany) to train European astronauts who became members of one European astronaut corps[39] (before that, individual states did the selection and organised training). The European Space Research and Technology Centre (ESTEC) in Noordwijk (the Netherlands) is the largest ESA facility that develops and launches almost all ESA missions (except rocket launches), and it has an environmental test centre for spacecraft. ESA has developed and implemented over 80 space exploration and application missions[40] that include many of the pivotal importance on the global scale.[41] The first-ever fly-by of a comet was the ESA mission Giotto in 1986. Performed in 2005, the mission Huygens was the first soft landing on another planetary body beyond Mars: it went to

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[32] On the principle of loyal (sincere) cooperation see Klamert M, 'Principle of Loyalty in EU law', Oxford University Press, 2014, esp. pp. 9-30.

[33] European Commission, Proposal for a Regulation of the European Parliament and of the Council establishing the Union Secure Connectivity Programme for the period 2023-2027, COM(2022) 57 final of 15.02.2022.

[34] Convention on the Establishment of a European Space Agency, Paris, 1975.

[35] EU Member States that are not participating in the ESA are: Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta, Slovakia and Slovenia.

[36] ESA, 'Member States and Cooperating States', 2021.

[37] Article II of the Convention on the Establishment of a European Space Agency, Paris, 1975.

[38] Article 2 of the Convention on the Establishment of a European Space Agency, Paris, 1975.

[39] The European Astronaut Corps is a group of seven active astronauts. Through the Corps, ESA aims to provide its astronauts as much training as possible, which should accumulate sufficient expertise to make them valuable assets for space missions.

[40] ESA, 'Our missions', 2022.

[41] The illustrative selection of missions is based on the ESA, 'Forty years of the ESA Convention', 2015. Mission descriptions are based on ESA, 'Giotto overview', 2006; ESA, Countdown to Cassini's Grand Finale', 2017; ESA, Rosetta: ESA' comet-chaser', not dated; ESA, 'SOHO overview', 2020.

Saturn's moon Titan. In 2014, the mission Rosetta achieved an unprecedented landing on a comet. The mission SOHO delivers detailed images of the Sun to scientists around the world. The ESA's European Space Operations Centre in Darmstadt (Germany) controls satellites in orbit, monitoring and retrieving data. Since its creation, it has managed more than 85 satellites belonging to ESA, and at any one time, it operates over 20 satellites and other spacecraft.[42] Considering the technical knowledge, expertise and achievements of ESA, the EU's involvement in space was based on cooperation with ESA from the beginning.[43] The progress in achieving productive cooperation between the EU and ESA was slow, and it was EU institutions that drove the process forward.[44] In particular, the European Parliament played a key role in shaping the legislative agenda to include space, early on recognising its importance for the economy.[45] The formal cooperation between the EU and ESA started in 2000 when the Council of the EU and ESA Council adopted parallel resolutions on the jointly elaborated European Strategy for Space.[46] According to this document, roles in space activities were divided between ESA and the EU as follows[47]: ESA would be the main European actor in space and agent for the EU; it would strengthen the foundations for space activities, and enhance space science. The EU (represented in this instance by the European Commission) would ensure that the European single market and citizens would benefit from space activities through specialised programmes, like Galileo and Copernicus – to be implemented by ESA. In this context, a study was conducted on the possible collaboration modalities between the EU and ESA, which recommended as a result that ESA could become a space agency for the EU.[48] This was not a preferable option for ESA[49] because the membership of ESA was (and is) different from that of the EU, the ESA's mode of working is intergovernmental and ESA would likely lose the possibility to remain a scientific facility and would have to focus more on practical application. On the other hand, the EU was not necessarily ready to fund ESA completely.[50] Instead, in 2003, the cooperation between ESA and the European Communities was formalised in a Framework Agreement, adopted in 2004.

The EU-ESA Framework Agreement of 2004 recognises the complementary nature of the two organisations and commits them to joint efforts to avoid duplications and ensure the coherence of

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42 ESA, 'ESOC: Where missions come alive', 2015.

43 Mantl L, 'The European Union', in: Brünner C and Soucek A (eds.), Outer space in society, politics and law, Springer, 2011, p. 417.

44 Liakopoulos D, 'The Future of the European Space Agency-EU relationship: Critical Aspects and Perspectives', *European Journal of Current Legal Issues* 25:2, 2019; Schmidt-Tedd B, 'The relationship between the EU and ESA within the framework of European Space Policy and its consequences for space industry contracts', in: Smith LJ and Baumann I (eds.), Contracting for space: Contract practice in the European space sector, Routledge, 2011, p. 25.

45 For example, see some of the earliest resolutions: European Parliament, Resolution on European Space policy, OJ C 260 of 12.10.1981; European Parliament, Resolution of European space policy, OJ C 190 of 20.07.1987; European Parliament, Resolution on European Space Policy, OJ C 305 of 25.11.1991.

46 Council Resolution of 16 November 2000 on a European space strategy, OJ C 371/2 of 23.12.2000; Ministerial Council Resolution of 16 November 2000 on a European Strategy for Space, ESA/C-M/CXLVIII/Res.1.

47 Von der Dunk F, 'European space law', in: von der Dunk F and Tronchetti F (eds.), Handbook of space law, Edward Elgar, 2015, p. 252.

48 Bildt C, Peyrelevade J and Späth L, 'Towards a Space Agency for the European Union', Report to the ESA Director General, 2000.

49 Liakopoulos D, 'The Future of the European Space Agency-EU relationship: Critical Aspects and Perspectives', *European Journal of Current Legal Issues* 25:2, 2019.

50 Alyssandrakis K, Report to the European Parliament on the Commission communication to the Council and the European Parliament on Europe and Space: Turning to a new chapter (COM(2000) 597 – C5-0146/2001 – 2001/2072(COS)), pp. 12-13.

the overall European space policy.[51] The Framework Agreement, which was ratified for four years and is extended automatically,[52] pursues two objectives:

1. coherent and progressive development of an overall European space policy; and
2. establishment of an efficient common basis and appropriate operational arrangements supporting beneficial mutual cooperation, while respecting the institutional and operational structures of the two organisations.[53]

The cooperation is focused on eight fields (science, technology, earth observation, navigation, communication by satellite, human space flight and micro-gravity, launchers and spectrum policy related to space), though new fields could be identified.[54] As methods of cooperation, the Framework Agreement foresees joint initiatives of the following types:[55]

1. the management of the EU's space-related activities by ESA;
2. the participation of the EU in an optional programme of ESA;
3. the carrying out of activities which are coordinated, implemented and funded by both parties;
4. the creation by both Parties of bodies to pursue initiatives complementary to R&D activities; and
5. various scientific activities and training and exchange of scientists.

Despite the updated cooperation structure provided by the Framework Agreements, cooperation between the EU and ESA can be characterised as on a project basis: usually, each joint initiative requires special arrangements between the Parties (outlining e.g., objectives, user requirements, work plan, management scheme, roles and financial obligations of the Parties), which makes the cooperation cumbersome and slower than is desirable.[56]

The Financial Framework Partnership Agreement (FFPA) between the European Commission, ESA and EUSPA concluded in 2021[57] should boost pan-European cooperation in space by laying out principles for financial and administrative cooperation. The FFPA is expected to rectify some shortcomings of the EU-ESA cooperation so far. In particular, the FFPA will clearly define the roles, responsibilities and obligations of the European Commission, ESA and EUSPA. It will increase transparency in the budget execution by ESA by stipulating conditions for the management of EU funds, establishing budget monitoring and control measures, and establishing principles for the remuneration of ESA for each component it executes. Procurement by ESA will include experts from the European Commission in the tender evaluation board of ESA in the future. Last but not least,

51 Based on ESA, 'European milestones', not dated.

52 Article 12 of the Framework Agreement between the European Community and the European Space Agency, OJ L 261 of 06.08.2004.

53 Article 1 of the Framework Agreement between the European Community and the European Space Agency, OJ L 261 of 06.08.2004.

54 Article 3 of the Framework Agreement between the European Community and the European Space Agency, OJ L 261 of 06.08.2004

55 Article 5 of the Framework Agreement between the European Community and the European Space Agency, OJ L 261 of 06.08.2004.

56 Article 5 (2) of the Framework Agreement between the European Community and the European Space Agency, OJ L 261 of 06.08.2004; Liakopoulos D, 'The Future of the European Space Agency-EU relationship: Critical Aspects and Perspectives', *European Journal of Current Legal Issues* 25:2, 2019; Schmidt-Tedd B, 'The relationship between the EU and ESA within the framework of European Space Policy and its consequences for space industry contracts', in: Smith LJ and Baumann I (eds.), Contracting for space: Contract practice in the European space sector, Routledge, 2011, pp. 25-34.

57 The text of the agreement is not available at the time of writing of this study. For an overview see European Commission, 'EU SPACE launch: summary and replay', press release, 24 June 2021.

ESA should take appropriate measures to ensure the protection of EU interests and comply with decisions taken to implement the EU Space Programme.[58] The FFPA also tasks ESA with continuing two of its existing missions: Copernicus – by building the Sentinel expansion missions and Sentinel next general missions, and Galileo and EGNOS – by developing next-generation technologies for them. The FFPA adds the planned GOVSATCOM space segment and the validation of a prototype for the Quantum Key Distribution satellite that should support the EU's secure connectivity to the ESA's portfolio.[59]

In sum, the relationship between the EU and ESA has been characterised by several asymmetries stemming from the differences in nature and purposes of the two organisations. In particular, membership of the organisations is overlapping yet distinct, with several important non-EU Members pursuing their own policies and interests. Furthermore, ESA focuses exclusively on the civilian use of space. This is a difficult task as such because all space technology is potentially dual-use. However, the EU is interested in both civilian and defence-related use of space, not least when its security is at stake. Moreover, although the EU is the largest ESA budgetary contributor, additional formal mechanisms are necessary to ensure that overall ESA activities are consistent with the EU policies. In this context, ESA is also not accountable to EU citizens for budget spending. The FFPA intends to rectify the issue of budgetary control by introducing monitoring requirements.

Table 4: Summary comparison between the EU and ESA

	European Union	European Space Agency
Membership	27 Member States	22 Members (19 EU Member States, Norway, Switzerland, and United Kingdom)
Participation of other states	EU candidate countries: Albania, Moldova, the Republic of North Macedonia, Montenegro, Serbia, Turkey, and Ukraine. EEA countries: Iceland and Norway.	Seat on the ESA Council: Canada. Associate Members: Slovenia, Latvia, and Lithuania. ESA Cooperation agreements: Bulgaria, Croatia, Cyprus, Malta, and Slovakia.
Objectives	Promotion of scientific and technical progress, promotion of industrial competitiveness, and implementation of the EU's policies, in general (Article 189 TFEU).	To provide for and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications (Article II ESA Convention).
Competences in space	Policymaking in parallel to EU Member States; regulatory.	Support of Member States' policies; support of cooperation; space science; development and implementation of missions.
Space activities	Civilian and military use of space.	Exclusively peaceful uses of space.
Budgetary arrangements	Programmes are funded from within the EU budget. EU Member States cannot decide to stop funding a particular programme.	Very flexible budgetary arrangements: a small core of mandatory elements funded jointly by all members (basic research, facilities, salaries etc)

[58] While the FFPA text is not publicly available, Article 31 of the Regulation (EU) 2021/696 of the European Parliament and of the Council of 28 April 2021 establishing the Union Space Programme and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013 and (EU) No 377/2014 and Decision No 541/2014/EU, OJ L 170 of 12.05.2021 outlined the mandatory elements of the FFPA.

[59] ESA, 'ESA and EU celebrate a fresh start for space in Europe', press release, 22 June 2021; Quantum Key Distribution provides a way of distributing and sharing secret keys that are necessary for cryptographic protocols, on the Quantum Key Distribution project see: ESA, 'European quantum communications network takes shape', 9 April 2019; ESA, 'Quantum communication in space moves ahead', 27 May 2021.

	European Union	European Space Agency
		and a wide range of optional programmes designed to meet the needs of member states.
Procurement	Free and open procurement. Some space procurements are limited to EU Member States on security grounds.	Specialist rules: some funds are earmarked for industry from the investing member state. The EU funds will follow the EU procurement rules.

Source: Authors' elaboration.

2.1.4. Overview of national policies

In addition to the EU space policy, most EU Member States have their own national space policies. The focus of these policies is not always the same. This subsection provides an overview of the space policies of four Member States – selected to provide insights from more established and recent spacefaring nations, accounting also for geographical and EU accession balance (i.e., France, Germany, Poland, and Luxembourg) – to illustrate this point and to look at the main motives why Member States invest in space activities.

The first objective is for defence purposes. France has historically invested strongly in space activities for this reason, and it has become an important policy objective for Poland. A second objective is commercial purposes, in terms of developing advanced industries and creating space capabilities. This is mainly the case in Poland and Luxembourg. A third objective is illustrated by the German policy agenda that is strongly guided by the added value of space activities in areas such as climate change and preserving essential natural resources. While Germany stresses the importance of space for national security, the core of its space policy is centred around scientific benefits (that are broader than commercial interests and strive through international cooperation). Turning to the means to reach policy objectives all four member states emphasise the need for international and especially European cooperation. Furthermore, both France and Luxembourg adopted policies that aim at protecting the existing space infrastructure.

France

French space policy has a strong focus on developing space infrastructures that serve the needs of society of which national defence purposes are a key example.[60] The independent access to and use of space is an important goal of the French space policy.[61] For this purpose, its space agency (Centre national d'études spatiales, CNES) has been extensively involved in the development and maintenance of the Ariane Programme (the most recent version of the heavy launcher Ariane 6), which aims at ensuring (European) independence in accessing space.[62] A stronger focus on the defence and security of existing space infrastructure is a more recent development: in 2019, France adopted the Space Defence Strategy that aims at protecting French interests in space.[63] This space strategy aims at both enhancing Space Situational Awareness and the deployment of assets that can be used to protect space infrastructure.[64] France views European cooperation within the framework of EU and ESA as 'the most pertinent framework for achieving France's objectives.'[65] For that reason, France 'plays an active part in implementation of the European Space Policy and in

[60] ESPI, 'Evolution of the Role of Space Agencies', 2019, p.14.

[61] IISS, 'France's 'strategic autonomy' takes to space', 2019.

[62] ESPI, 'Evolution of the Role of Space Agencies', 2019, p.14.

[63] French Defence Ministry, 'Space Defence Strategy', 2019.

[64] French Defence Ministry, 'Space Defence Strategy', 2019, pp.35-40

[65] French Ministry of Foreign Affairs, France's Role in European space policy', not dated.

major flagship EU programmes (Galileo and GMES).'[66] In addition, the French Space Agency signed the Artemis Accords in June 2022. Artemis outlines a set of principles for sustainable space exploration to promote the beneficial use of space for all of humanity.[67]

Germany

The most recent German Space Policy, 2010's 'Making Germany's space sector fit for the future: the space strategy of the German Federal Government' is based on the idea that space applications should offer concrete benefits for humanity, specifying that space activities must be in competition with other technological domains and be judged according to whether their high cost is adequately compensated for by the scientific, social or commercial benefits they bring[68] Accordingly, the German space agency (Deutsches Zentrum für Luft- und Raumfahrt, DLR) invests in cutting-edge research that not only pursues the commercial goals of the German space sector but also looks at how space activities can contribute to the solving (global) societal challenges (for instance by investing in Earth observation technologies).[69] In 2020, in its High-Tech Strategy, the German government awarded special importance to spaceflight because it designates space technologies as a key enabling technology, functioning as key instruments that serve modern society.[70] German space policy focuses on international cooperation, particularly within Europe to achieve mutual benefits.[71] The strategy maintains that ESA remains the primary framework for European space policy and cooperation.[72]

Poland

The Polish 2017 space strategy promotes new spending into space activities, recognising that investments in the space industry can help Poland to transform its economy into one that is based on knowledge, innovation and technological development, away from low manufacturing costs.[73] For this purpose, it defined three goals that should be reached by 2030: 1) the Polish space sector will be able to compete effectively in the European space market, meaning that its market turnover will be at least 3% of the European market turnover, 2) Polish public administration and companies will make more use of satellite data to develop space application (which contributes to the digital economy) and 3) the Polish public administration will make more use of satellite infrastructure for security and defence.[74] For the last point, in 2019, Poland signed an agreement with the United States about sharing services and data for national defence[75], and in 2022 announced that it aims to strengthen its ties with the US (for instance, through the signing of the Technology Safeguard Agreement).[76] Poland aims to actively seek international cooperation, especially with other

[66] French Ministry of Foreign Affairs, France's Role in European space policy', not dated.

[67] US Department of State, 'France Becomes Twentieth Nation to Sign the Artemis Accords', press release, 7 June 2022.

[68] German Ministry of Economics and Technology, 'Making Germany's space sector fit for the future: the space strategy of the German Federal Government', 2010, p.27.

[69] ESPI, 'Evolution of the Role of Space Agencies', 2019, p.15-16.

[70] German Ministry for Economic Affairs and Climate Action, Aerospace policy, not dated.

[71] German Ministry of Economics and Technology, 'Making Germany's space sector fit for the future: the space strategy of the German Federal Government', 2010, p.27.

[72] German Ministry of Economics and Technology, 'Making Germany's space sector fit for the future: the space strategy of the German Federal Government', 2010, p.29.

[73] Adamowski J, 'Poland unveils new space strategy', *SpaceNews*, 12 October 2016.

[74] Wajoras J, 'Polish Space Strategy accepted by government', *Kosmonauta*, 20 February 2017.

[75] SpaceWatch Europe, 'European Military Space: Poland And USSTRATCOM Agree To Share Space Services And Data', 2019.

[76] Polish Ministry of Economic Development and Technology, 'Minister Nowak: Cooperation with the USA in the space sector and new technologies is a way to increase the security in Poland', 15 March 2022.

European countries, to reach its space objectives.[77] An example of Poland's increased international orientation is its signature of the Artemis Accords in October 2021.[78]

Luxembourg

Luxembourg manifests itself as a hub for a growing space industry.[79] This is the result of Luxembourg's space policy establishing an attractive legal framework and financial tools to encourage private investment in the space sector, public investments in space education and research, and seeking international cooperation with international partners both inside and outside Europe.[80] Luxembourg's early signature of the Artemis Accords testifies to the international orientation of its space policy.[81] Luxembourg's space policy's commercial focus is underlined by the fact that the main task of the Luxembourg Space Agency is to assist the commercial space sector in Luxembourg.[82] The first important legal development is the adoption of a Space Resources Law that provides companies with the right to extract resources from asteroids. The bill is the first legal act globally that would provide space companies property rights in space.[83] A second important legal development is the Space Activities Act which allows the Luxembourg Space Agency and the Luxembourg Ministry of the Economy to authorise and supervise space activities[84] and therefore provides a legal basis to manage risks that evolve as a consequence of space activities.[85] The Space Resources Law sparked a debate on the link between two important clauses of the United Nations Outer Space Treaty[86], which has been ratified by Luxembourg in 2006. The Space Resources law, in fact, considers the possibility of owning space resources as part of the freedom to use outer space, which might conflict with another principle of the treaty, the non-appropriation of space.[87] The defence of space assets has also become an important focus point of Luxembourg's space policy which manifests itself in the adoption of the Defence Space Strategy in 2022.[88]

2.2. State of the EU space sector

The definition of the EU space sector follows the methodology of the OECD's Handbook on Measuring the Space Economy[89] which recommends taking a comprehensive approach to cover a whole range of space products and services. According to the OECD's Handbook, the space economy consists of three main segments:[90]

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77 Adamowski J, 'Poland unveils new space strategy', *SpaceNews,* 12 October 2016.

78 NASA, 'Poland Signs Artemis Accords at IAC', press release, 26 October 2021.

79 Brennan A, 'How Luxembourg is positioning itself to be the centre of space business', *The Conversation*, 16 July 2019.

80 Deloitte, 'Luxembourg, a rising star in the space industry', not dated; Luxembourg Ministry of the Economy and Luxembourg Space Agency, National Action Plan 2020-2024: Space Science and Technology, 2020, p. 8.

81 Luxembourg Government, 'Luxembourg, NASA and several other partner countries are among the first signatories of the Artemis Accords', 14 October 2020.

82 Clark S, 'The Luxembourg Space Agency: Enabling the In-Space Economy', *Asteroid Day*, 25 January 2021.

83 Grand-Duché de Luxembourg, Law of July 20th 2017 on the exploration and use of space resources - A674, 20 July 2017.

84 Luxembourg Space Agency, 'Legal framework', not dated.

85 Luxembourg Space Agency, 'Luxembourg reinforces its legal framework for space activities', 14 December 2020.

86 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies of 1967.

87 Calmes B, Schummer L and Gladysz-Lehmann B, 'The Space Law Review: Luxembourg', The Law Reviews, 9 December 2021.

88 Luxembourg Ministry of Foreign and European Affairs, Defence Space Strategy, 2022.

89 OECD, 'Handbook on Measuring the Space Economy', 2nd edition, 2022.

90 OECD, 'Handbook on Measuring the Space Economy', 2nd edition, 2022, p. 30.

1. Upstream; i.e., activities that are necessary to put assets into space,
2. Downstream; operation of space infrastructure and the 'down-to-earth' activities that use space assets to provide services, and
3. activities that are derived or induced from space activities but are not dependent on space to function.

This study focuses only on the upstream and downstream segments, as these can be considered the core space segment (as explained further below). The third segment belongs to the wider space economy, but not to the space sector because it does not depend on space for its functioning (e.g., technology transfers from the space sector to other sectors).[91] In addition, the third segment cannot be easily measured and would require additional steps of measurement and analysis that would go beyond the scope of the Cost of Non-Europe exercise.[92]

2.2.1. Structure of the EU space sector: value chain, business models, main actors

The structure of the space sector, described by the OECD, as composed of upstream and downstream segments and users (including those beyond the space sector)[93] applies to the EU space sector. The **upstream segment** comprises all those activities that are necessary to put assets into space, i.e., R&D, manufacturing of spacecraft (e.g., rockets, spaceships, satellites) and their deployment, which would also include supporting infrastructure and services (e.g., launchers need a launch pad and a ground network of radars). Correspondingly, the **downstream segment** refers to the operation of space infrastructure and the 'down-to-earth' activities that use space assets to provide services; these usually rely on satellites and space data. Usually, four main subsegments are distinguished in the downstream segment: telecommunications, broadcasting, Earth observation (remote sensing) and navigation (position and timing).[94]

The space sector can also be presented through business segments (or **business models**), around which companies active in the sector are clustered.[95] The relevant business model segments are launch; satellite manufacturing; satellite services; ground equipment; national security; space science and exploration (manned and unmanned); space tourism and habitation; energy, mining, processing and assembly. Each of these business model segments consists of several business models, each of which can be also attributed to an upstream or downstream segment (Table 5).[96]

91 OECD, 'Measuring the economic impact of the space sector: Key indicators and options to improve data', Background paper for the G20 Space Economy Leaders' Meeting (Space20), 2020, p. 5.

92 OECD, 'Handbook on Measuring the Space Economy', 2nd edition, 2022, p. 30.

93 OECD, 'Handbook on Measuring the Space Economy', 2nd edition, 2022, pp. 31-34; OECD, 'Measuring the economic impact of the space sector: Key indicators and options to improve data', Background paper for the G20 Space Economy Leaders' Meeting (Space20), 2020, p. 5; Schrogl K-U and Venet C, 'The Impact of the European Space Policy on Space Commerce', in: Smith L J and Baumann I. Contracting for space: Contract practice in the European space sector, Routledge, 2011, pp. 7-23.

94 Sometimes, a midstream sector is distinguished as comprising the first layer of the downstream sector (i.e. operation of satellites, leasing/selling of satellite capabilities and ground-support infrastructure, like network stations, data storage, processing centres). See, for example, PwC, 'Main Trends & Challenges in the Space Sector', 2nd edition, 2020; PwC, 'Main trends and challenges in the space sector', 2019; Probst L, Frideres L, Cambier B, Duval J-Ph, Roth M and Lu-Dac C, 'Space tech and services: Big Data in Earth Observation', PwC case study 64 for Business Innovation Observatory of the European Commission, 2016.

95 de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission, 2019, pp. 43-51.

96 See a slightly different presentation of business models by the European venture capital company Seraphim Capital in Seraphim Spacetech Map 2021.

Table 5: Business models across the space sector, per segment

Business model segment	Business model	Segment
Launch	Launch vehicles and facilities (e.g., launch sites, launch pads)	Upstream
	Launch operations (e.g., provision of services, operation of spaceports)	Downstream
Satellite manufacturing	Production of various types of satellites (e.g., classical, cubesats, testing)	Upstream
Satellite services	Satellite and satellite network operations (incl. megaconstellations)	Downstream
	Earth observation and remote sensing services	Downstream
	Satellite navigation applications	Downstream
	Satellite communications and broadcasting	Downstream
	Integrated applications (i.e., combined multiple satellite-enabled services)	Downstream
Ground equipment	Telemetry and telecommand (dedicated hardware and software manufacturing)	Upstream
	Mission control centres (dedicated hardware and software)	Upstream
	Earth observation and remote sensing services (dedicated hardware and software)	Downstream
	Satellite navigation applications (dedicated hardware and software, e.g., receivers, chipsets, anti-jamming systems)	Downstream
	Satellite communications and broadcasting (dedicated hardware and software, consumer equipment)	Downstream
	Integrated applications (dedicated hardware and software)	Downstream
National security	Mission control and payload operations (operation of satellite systems, provision of services and applications)	Downstream
	Earth observation and remote sensing services (dedicated hardware and software)	Downstream
	Satellite navigation applications (GNSS augmentation and anti-spoofing/ jamming systems for specific needs)	Downstream
	Satellite communications and broadcasting (dedicated hardware and software, encryption)	Downstream
	Integrated applications (dedicated hardware and software)	Downstream
Manned and unmanned space science and exploration	Crewed vehicles (transport and habitat)	Upstream
	Mission-specific space exploration vehicles (probes, orbiters, landers)	Upstream
	Mission control and payload operations	Downstream
	(Deep) space network operations	Downstream
	Space science/ exploration data analysis*	Downstream

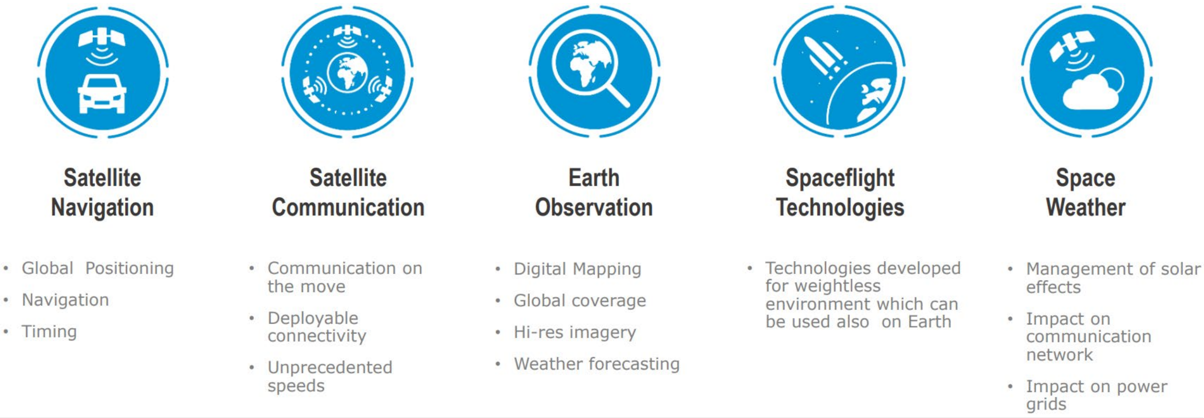
Business model segment	Business model	Segment
Space tourism	Sub-orbital space vehicles	Upstream
	Sub-orbital launch and flight operations	Downstream
	Suborbital flight services	Downstream
Energy, mining, processing and assembly	Manufacturing, assembly, integration and testing in microgravity (i.e., in space) *	Upstream
	In-situ resource utilisation*	Upstream

Source: based on de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission, 2019, pp. 45-47.

Note: Seraphim Capital considers the business models marked * as 'beyond Earth' segment of the space economy. See Seraphim Spacetech Map 2021.

The impact of the space sector on the other sectors of the economy and society is large, as space-enabled services and applications are indispensable components of many critical infrastructures on Earth.[97] Outputs from all space sector segments and business models find their uses in economic sectors, like transportation segments (road, aviation and maritime), media sector, research and education, agriculture, environment, energy, financial sector, and healthcare (see Figure 1 for examples of such applications).

Figure 1: Services and applications from the space sector for the broader economy (exemplary).



Source: Barresi B, 'Critical infrastructure', Sustainable Critical Infrastructures Feasibility Study, presentation at the ESA Business Applications Webinar, 2018, Slide 6.

An even more impressive illustration of our increasing dependency on the space sector was provided in the 2015 study of the UK space sector.[98] Figure 2 demonstrates the degree of dependency of national critical infrastructures on space by indicating where space is an enabling

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97 OECD, 'Handbook on Measuring the Space Economy', 2nd edition, 2022, pp. 34-35; Olivari M, Jolly C and Undseth M, 'Space technology transfers and their commercialisation', OECD Science, Technology and Industry Policy Papers, No. 116, OECD Publishing, Paris, 2021.

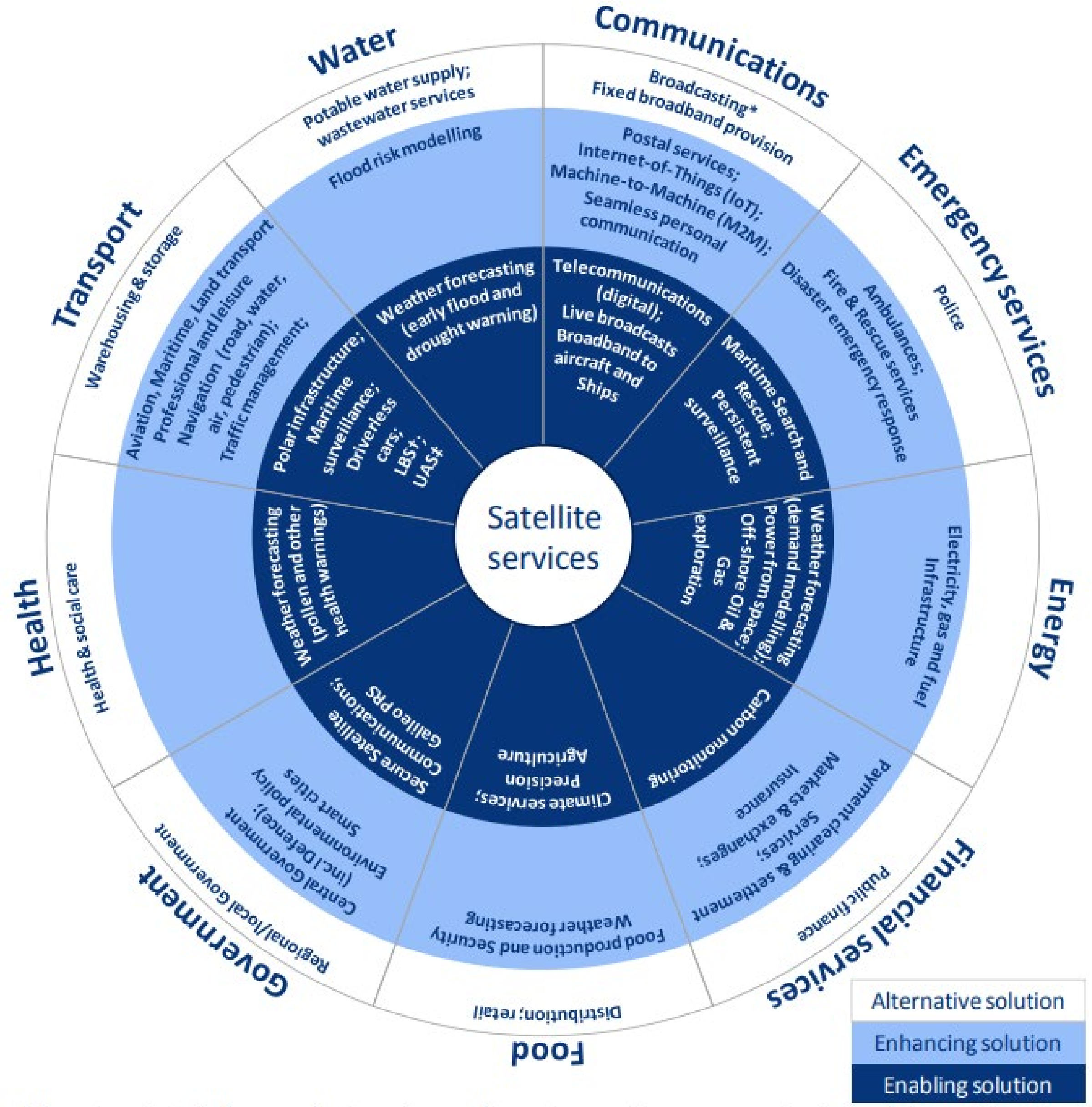
98 Sadlier G, Flytkjær R, Halterbeck M, Peycheva V and Koch L, 'The Case for Space 2015: The impact of space on the UK economy', A London Economics study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency, 2015.

solution, an enhancing solution or a mere alternative. Enabling a solution means that loss of access to space-based services would significantly impair or disrupt Earth-based operations. Enhancing solution means that, while other non-space-based options are available, space-based services offer clear cost efficiency and/or improved performance. Alternatives indicate the lowest dependency on space as the same results can be or are achieved with terrestrial solutions. We consider the situation of the UK representative for the whole EU because the other Member States designated the same national critical infrastructures,[99] and the level of technology is comparable across Europe. Figure 2

[99] See Figure 5 in EY and RAND, 'Evaluation study of Council Directive 2008/114 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection', Study for the European Commission, 2019, p. 17.

shows that dependencies are the strongest in the energy and transport sectors (both of which are also critical European infrastructures[100]) as well as in communications and emergency services.

Figure 2: Influence of space-based services and applications on critical national infrastructures (based on the UK example)



Source: Sadlier G, Flytkjær R, Halterbeck M, Peycheva V and Koch L, 'The Case for Space 2015: The impact of space on the UK economy', A London Economics study for the Satellite Applications Catapult, Innovate UK, UKspace and the UK Space Agency, 2015, p. 64.

The above serves as an illustration of the importance of the space sector for the wider economy, but the current report will focus henceforth on the core space sector (i.e., upstream and downstream segments), as explained at the beginning of this Section.

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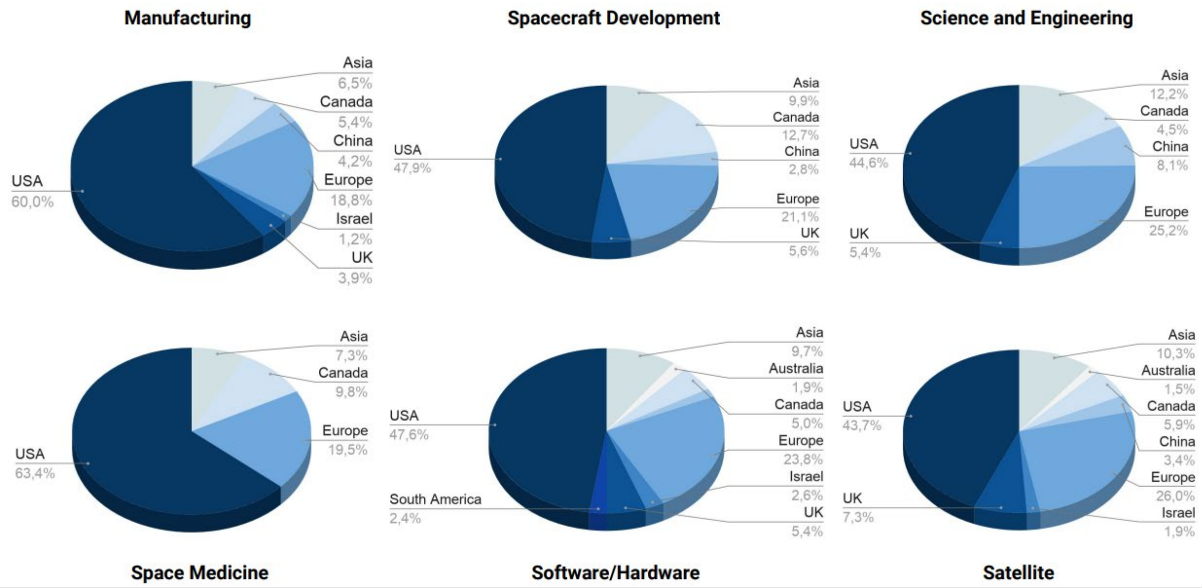
[100] Annex I of the Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection, OJ L 345 of 23.12.2008.

In the past, the main (but not exclusive) actors in the space sector were governments, and all space-related activities were controlled by states.[101] However, the commercialisation of space activities started almost immediately, specifically in the business models of satellite manufacturing and operation as well as delivery of satellite-based communication and broadcasting.[102] The technological developments (especially miniaturisation) and the increasing number of applications for space-related technologies lowered the entrance costs and prices, allowing more governments and private companies and individuals to join and influence the space sector worldwide and in Europe.[103] The space ecosystem is becoming more dynamic and innovative, and the space sector is turning into an increasingly decentralised arena, where actors from both the private and public sectors coexist and cooperate to deliver goods and services to the private and public sectors.[104]

For a better picture of the sector, it is useful to explore where space tech companies are situated (Figure 3). Globally, there were more than 10,000 space tech companies in 2021, the majority of them (5,582 or 52.1%) located in the US. In the same year, the EU was home to a bit more than 1,605 (or 15%) space tech companies, most of which were in Germany, France, Spain, the Netherlands, Italy and Sweden.[105] A majority of European space companies are SMEs, and their numbers are constantly increasing. According to the SME4Space study, the number of SMEs in the sector grew from 951 in 2013 to 1,050 in 2018, of which about half were micro-companies.[106]

Figure 3: Regional distribution of companies, by activities (2021)



Source: SpaceTech Analytics, 'SpaceTech Industry 2021 / Q2: Landscape Overview', 2021, p.19.

Note: Europe includes Russia and non-EU countries.

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101 Paikowski D, 'What Is New Space? The Changing Ecosystem of Global Space Activity', *New Space Journal* 5:2, 2017.

102 Moranta S, 'The space downstream sector: Challenges for the emergence of a European space economy', *Études de l'Ifri*, Ifri, 2022, pp. 6-7 and 9-10.

103 ESA, 'What is the Space Economy?', 2019.

104 Paikowski D, 'What Is New Space? The Changing Ecosystem of Global Space Activity', *New Space Journal* 5:2, 2017.

105 SpaceTech Analytics, 'SpaceTech Industry 2021 / Q2: Landscape Overview', 2021, pp. 2 and 18.

106 SME4Space, 'Study on economic importance of SMEs in the space industry in ESA member states: the first findings are available', 2020, p.1.

While European companies are active across upstream and downstream segments and in all business-model segments, their position in individual business-model segments varies strongly. While it is beyond the scope of this study to map all EU-based companies active across all business models,[107] it is possible to point out several considerable gaps with regard to the upstream segment. They can be considered the most significant gaps as they relate to the independent capacity to put assets into space (i.e., launches) – a pivotal bottleneck for the full-fledged competitive space sector.[108] In particular, the EU does not currently have the independent capability to send humans to space.[109] There are no launchers for small payloads (e.g., small satellites, cubesats).[110] The EU also does not have any type of reusable rockets.[111]

Table 6 and Table 7 present an overview of some notable companies in the EU space sector. The overview is incomplete and serves as a mere illustration of what companies are active in upstream and downstream segments and to what business model segments they can be attributed. The overview includes the most notable, world-leading incumbents and some of the most promising and innovative start-ups.

Table 6: European companies in the upstream segment

Business model segment	Company	Member State	Description	Employees
Launch	Arianespace	FR	Europe's prime satellite launch company with two launchers – Ariane (heavy) and Vega (middle).	Over 300
	Safran	FR	Develops launch vehicles, satellites, and ground stations.	81,000
	Avio	IT	A leading company in space propulsion. It plays a strategic role in the global space industry through Vega and Ariane 5.	2,200
	Beyond Gravity	SE, FI, DE, AT	Develops and manufactures products for satellites and launch vehicles. Formerly known as RUAG Space.	1,600
	Isar Aerospace Technologies	DE	Developing an innovative small launch vehicle: Spectrum, a two-stage, liquid-fuelled rocket. Spectrum's first flight is scheduled for late 2022.	180
	Rocket Factory Augsburg	DE	Working on the development of RFA One – an innovative multistage small launch vehicle. RFA One is scheduled to launch in late 2022.	150
	D-Orbit	IT	Market leader in space logistics and transportation services. Products developed include a D-Orbit	200

[107] See Seraphim Spacetech Map 2021 for a global map of relevant companies.

[108] Mölling C and Schimmel F, 'The Role of Space as a Global Common Good for Critical Infrastructure and Industry', A German Council on Foreign Relations Workshop Report, 2021, p. 2.

[109] CNN, 'Human spaceflight fast facts', 8 August 2022.

[110] Ceurstemont S, 'The mission to build a reusable launcher for Europe', *HORIZON: The EU Research & Innovation Magazine*, 16 March 2020.

[111] The work is ongoing though: ESA, 'Space Rider: Europe's reusable space transport system', 2019; Ceurstemont S, 'The mission to build a reusable launcher for Europe', *HORIZON: The EU Research & Innovation Magazine*, 16 March 2020; Berger E, 'Concerned about SpaceX, France to accelerate reusable rocket plans', *Arts Technica*, 12 July 2021.

Business model segment	Company	Member State	Description	Employees
			Decommissioning Device (D3) – an innovative space debris solution – and the ION Satellite Carrier – a satellite dispenser that can place hosted satellites individually in orbit.	
Satellite manufacturing	Airbus Defence and Space	DE, FR, ES, IT, NL	Europe's leading aerospace firm. It designs and manufactures satellites and launch vehicles, and provides data services and secure communications, among other things.	40,000
	Thales Alenia Space	FR, IT	Provider of solutions for telecommunications, navigation, Earth observation, environmental management, exploration, science, and orbital infrastructures.	8,900
	OHB SE	DE	Activities include building and operating satellites, manned spaceflight, and exploration	2,900
	ICEYE	FI	Manufacturer of microsatellites. Developing and launching synthetic-aperture radar (SAR) satellites, generating SAR data and imaging.	420
	Berlin Space Technologies	DE	Provider of small satellite systems and technologies, including the LEOS-50 platform – a satellite that can carry a vast number of payloads.	30
Ground equipment	Jena-Optronik	DE	Provider of attitude and orbit control sensors for satellites and spacecraft and space optics and electronics.	250
	SpaceIt	EE	Provider of a cloud-based platform for mission control and ground station services, offering Mission Control-as-a-Service.	14
Manned and unmanned space science and exploration	The Exploration Company	DE	Working on the development, manufacturing, and operating of Nyx – a modular, reusable orbital vehicle. Nyx can be refuelled in orbit and carries cargo.	20
	Active Space Technologies	PT, NL	Provider of space instrumentation and structural and thermal control systems for space applications in challenging environments, among other things.	Over 40
Space tourism	Copenhagen Suborbitals	DK	Crowdfunded non-profit organization aiming to fly an amateur astronaut to space and back in a space capsule on its Spica rocket. So far, the organisation flew five home-built rockets and two mock-up space capsules.	50-60 volunteers
	ARCASpace	RO	Developing EcoRocket – a reusable, ecological water-based propulsion, orbital vehicle designed to launch commercial payloads. The first orbital flight is scheduled for 2022	-
	PLD Space	ES	Developing two reusable launch vehicle technologies to provide commercial orbital and	115

Business model segment	Company	Member State	Description	Employees
			suborbital services to small payloads and small satellites.	
	Zero 2 Infinity	ES	Developing high-altitude balloons, aiming to lift heavy commercial payloads into near space and low Earth orbit.	12
Energy, mining, processing and assembly	Space Mining Technologies	NL	Researching and developing technologies for sustainable space exploration and future settlements on the Moon and Mars.	6

Source: Authors' own elaboration based on Whittle M, Sikorski A, Eager J and Nacer E, '[Space Market – How to facilitate access and create an open and competitive market](#)?', Study for the ITRE Committee of the European Parliament, 2021, Table 3; the respective companies' official webpages, section 'About Us'; the respective companies' profiles on CrunchBase and LinkedIn.

Table 7: European companies in the downstream segment

Business model segment	Company	Member State	Description	Employees
Satellite services	Eutelsat	FR	One of the world's largest satellite operators with 36 satellites in GEO. Provides video broadcasting, satellite newsgathering, broadband and maritime and aero connectivity. It serves organisations operating across Europe, Africa, Asia and the Americas	1 200
	SES	LU	One of the world's largest satellite operators with 70 satellites in GEO and MEO. Provides broadcasting, supports mobile network operators, and communications for peacekeepers, passengers and rural communities. It currently serves seven of the top 10 telecom companies and supports 58 government organisations.	2 000
	Syntony-GNSS	FR	Developing Global Navigation Satellite System (GNSS) Positioning, Navigation and Timing (PNT) solutions and products with Software-Defined Radio (SDR).	44
	Mynaric	DE	Manufacturer of laser communication systems for aerospace communication networks, including satellite constellations.	250
	SpaceKnow	CZ	Develops an AI-powered satellite imagery analytics platform to track global economic trends from space.	50
	SatRevolution	PL	Building small, lightweight, nanosatellites to collect Earth-observation data. The company plans to create a constellation of 1,000 Earth-observation satellites by 2026.	50
Ground equipment	Leaf Space	IT	Provides Ground Segment-as-a-Service, operating a growing distributed ground station network and assisting satellite operations.	27

Business model segment	Company	Member State	Description	Employees
	Satlantis	ES	Designing and manufacturing Earth and Universe observation payloads for small satellites to generate Very High Resolution (VHR) satellite images.	Over 50
	Telespazio	IT, FR, DE, ES, RO	Joint venture owned by Leonardo and Thales. Designing and developing satellite communications, geo information and satellite systems and operations.	2 500

Source: Authors' own elaboration based on Whittle M, Sikorski A, Eager J and Nacer E, 'Space Market – How to facilitate access and create an open and competitive market?', Study for the ITRE Committee of the European Parliament, 2021, Table 3; the respective companies' official webpages, section 'About Us'; the respective companies' profiles on CrunchBase and LinkedIn.

2.2.2. Size of the global and EU space market

The size of the space market, in general, is quite difficult to determine. First, there is no separate category in national accounts or international industrial classification for space-related activities. Usually, the term 'aerospace' is used, which includes aeronautics.[112] Secondly, in the downstream segment, it is extremely difficult to distinguish between the space industry and the wider economy using space-based services and applications. As discussed by the OECD, too narrow and too broad definitions both have drawbacks.[113] Importantly, neither of them can provide a reliable estimate of the market size.[114]

By way of illustration, Table 8 provides a list of global market estimates by leading specialised consultancies, all of which use the methodology combining stakeholder surveys of the industry and public budgets. The table also shows that estimates of the market as a whole vary considerably as well as the estimates of the size of individual market segments and even of public budgets. However, all estimates have two things in common: first, the market is very large, and second, the downstream segment is significantly larger than the upstream segment.

Table 8: Range of estimates of the global space market

Source	Year	Market estimate (global)	Elements of the estimate
Bryce Tech[115]	2020	EUR 325 bn	Upstream: EUR 15 bn Downstream: EUR 222 bn Public budgets & human spaceflight: EUR 88 bn
Euroconsult[116]	2021	EUR 285 bn	Upstream: EUR 31 bn

[112] For example, Eurostat, 'Aerospace equipment production statistics - NACE Rev. 1.1', Archived article, 2009.

[113] See an extensive discussion of the challenging in measuring the space economy and the relevant methodological recommendations in OECD, 'Handbook on Measuring the Space Economy', 2nd edition, 2022.

[114] Some interviewed stakeholders explained that European national space agencies, Eurostat and European national statistical offices are currently studying the issue of how to measure the size of the space market. They intend to develop a suitable methodology. However, it is a difficult task and may take several years.

[115] Bryce Tech, '2021 State of the Satellite Industry Report', 2021.

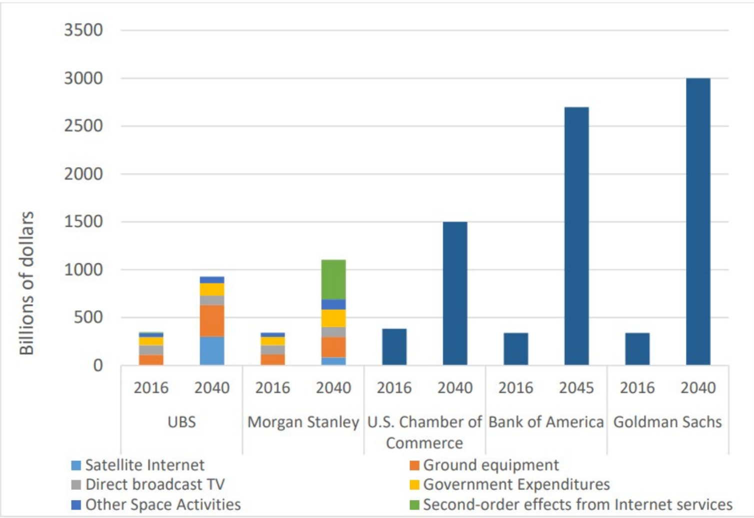
[116] Euroconsult, 'Euroconsult estimates that the global space economy totaled $370 billion in 2021', 2022.

Source	Year	Market estimate (global)	Elements of the estimate
			Downstream: EUR 254 bn
PwC[117]	2020	EUR 325 bn	Upstream: EUR 20 bn Downstream: EUR 233 bn Public budgets: EUR 72 bn
Space Foundation[118]	2020	EUR 392 bn	Upstream: EUR 120 bn Downstream: EUR 192 bn Public budgets: EUR 79 bn
SpaceTech Analytics[119]	2020	EUR 333 bn	n/a

Source: All estimates were converted from USD to EUR, using ECB data on conversion rate averages for the year of the estimation. Available on: ECB, Euro foreign exchange reference rates, 2022.

Projections of how the space market will grow over the next 20-25 years also vary wildly, as Figure 4 shows. The common feature of all projections is that the market will grow considerably. Where the breakdown by segments or elements is provided (i.e., by UBS and Morgan Stanley), it is clear that the largest growth will come from increased demand and use of satellite-based services in the downstream segment. Though scholars find these predictions optimistic and caution policymakers and investors from relying on them too much,[120] the studies show clear indications that overall the space market is growing in size and significance and that the EU needs to ensure strong participation in it.

Figure 4: Estimates 2016 versus 2040 projections of the size of the global space economy



	2016	2040/2045
UBS	EUR 307 bln	EUR 837 bln
Morgan Stanley	EUR 306 bln	EUR 994 bln
U.S. Chamber of Commerce	EUR 347 bln	EUR 1,356 bln
Bank of America	EUR 306 bln	EUR 2,441 bln
Goldman Sachs	EUR 307 bln	EUR 2,712 bln

Source: Crane KW, Linck E, Lal B and Wei RY, 'Measuring the Space Economy: Estimating the Value of Economic Activities in and for Space', Institute for Defense Analyses, 2020, p. 34. ECB data on average conversion rate in 2016 used to convert USD estimates to EUR estimates.

117 PwC, 'Main Trends & Challenges in the Space Sector', 2nd edition, 2020, p. 7.

118 Space Foundation, 'The Space Report: Global Space Economy Nears $447B', 2021.

119 SpaceTech Analytics, 'SpaceTech Industry 2021 / Q2: Landscape Overview', 2021, p. 20.

120 Crane KW, Linck E, Lal B and Wei RY, 'Measuring the Space Economy: Estimating the Value of Economic Activities in and for Space', Institute for Defense Analyses, 2020, p. 41.

Turning to the question of what share the EU has in the global space market, and what projections for its future development can be made, we encounter the same methodological difficulties as mentioned above. However, it is possible to explore individual elements of the EU space market and put them into the perspective of the global numbers cited earlier. A prominent element is the 2018 EU Space Programme, presented by the EU between 2021 and 2027. This Programme has an average annual budget of EUR 2.1 billion over the reference period – a detailed description of this Programme is provided in Section 2.2.3.[121]

In addition, for the same period, there is a separate budget of EUR 13.46 billion for research funding under Horizon Europe's Cluster 4 'Digital, Industry and Space'[122] and EUR 1.35 billion from NextGenerationEU – jointly representing an annual average of EUR 2.1 billion – which will be partially earmarked for space research.[123] The planned budget for space research calls under these funds amounts to almost EUR 450 million in 2021-2022, which is over 10% of the total annual budget.[124] As a rough estimate based on the 2021-2022 budget, this would add up to a total of EUR 1.58 billion until 2027.

Overall, the EU public funding translates to 4%-4.5% of the annual global public sector budget while main global actors like China (EUR 12 billion) and the United States (EUR 22 billion) have significantly higher annual budgets. A detailed cross-territory comparison of annual budgets is included in Figure 6 in Section 2.2.3 on investment.

The share of EU launchers in the global orbital launch market has been shrinking (see Figure 5). The global market grew from 74 orbital launches in 2010 to 146 in 2021, while Europe only saw between 5 and 9 annual launches in this period, carried out by Ariane 5 and Vega rockets.[125] For 2020-2021, this translates to only 4% (i.e., 6 launches annually) of the billions-worth global market.

121 See the explanation on the budget and conversion of prices at Legislative Train Schedule, 'EU Space Programme', 2022.

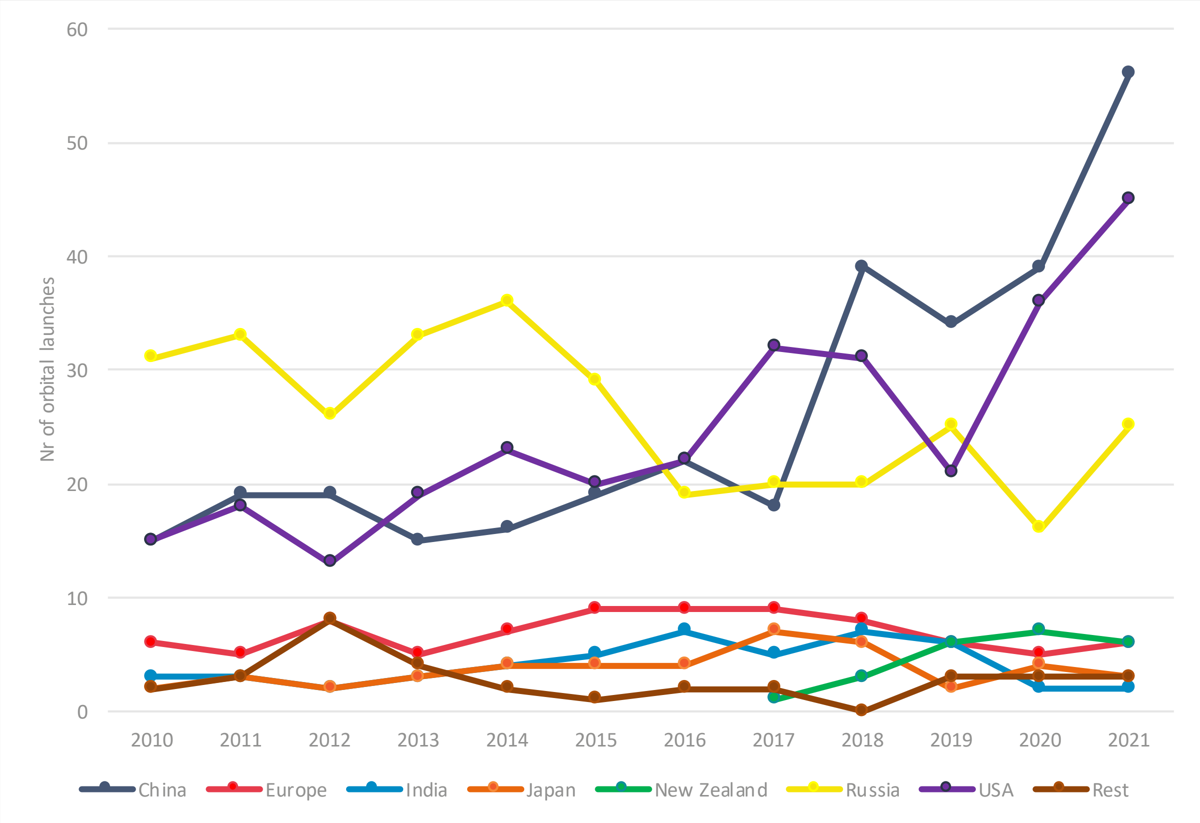
122 Article 12 of Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013, OJ L 170 of 12.5.2021.

123 European Commission, 'EU Space Research', not dated.

124 European Commission Decision C(2022)2975 of 10 May 2022 on Horizon Europe Work Programme 2021-2022, 7. Digital, Industry and Space, p. 304.

125 Numbers of launches differ based on whether all launches are counted or only successful launches, including what can be considered a successful launch. The numbers in this report are based on Gunther's Space Page, Orbital launches.

Figure 5: Number of orbital launches, per jurisdiction (2010-2021)



Source: Gunther's Space Page, Orbital launches.

Note: category 'rest' includes Iran, Israel, North Korea, South Korea, Ukraine and International (Sea Launch).

Europe, in general, and the EU, in particular, occupy a much stronger position in the downstream segment. In the Earth observation market,[126] the EU's revenues from data transactions were EUR 82 million in 2021, representing 15.4% of the global market. This is less than North America (44.1%) and the Asia-Pacific region (20.4%) but more than Russia and the non-EU part of Europe (8.8%).[127] While the global data revenues are predicted to grow by 48.6% by 2031, the EU's relative share is projected to decrease slightly (-0.8%), as will the shares of North America (-3.1%) and Russia and the non-EU part of Europe (-0.6%). The market share of the Asia-Pacific region is expected to go up by 3.6% by 2031.

Data on value-added service revenue shows a similar relative EU footprint in the global market of 15.3% in 2021, equalling EUR 342 million. North America's share is once again larger (48.5%), while the difference with the Asia-Pacific region is minor (16.0%) and the share of Russia and the non-EU part of Europe (7.2%) is considerably lower.[128] As with data revenues, the global revenues for value-added services are expected to increase significantly (+108.5%). Again, however, the relative share of the EU will decline (-1.1%), as will the share of Russia and the non-EU part of Europe (-0.2%). North

126 The Earth observation market is defined by EUSPA as 'activities where satellite EO-based data and value-added services enable a variety of applications across multiple segments'. See EUSPA, 'EO and GNSS Market report', 2022, p. 9.

127 EUSPA, 'EO and GNSS Market report', 2022, p. 10.

128 EUSPA, 'EO and GNSS Market report', 2022, p. 10.

America (+0.6%) and the Asia-Pacific region (+0.5%) are expected to claim the revenue share lost by the EU over this period.[129]

The particular strength of European companies lies in the area of Data Analysis, Insights & Decision Support, in which the European continent held over half of the global market in 2019 (52%), compared to nearly a third for North America (31%) and a sixth for Asia and Russia.[130] Other domains Europe is strong at are the Data Acquisition and Distribution market (42%) and the global Data Processing market (34%).[131]

In the global navigation satellite services (GNSS) market,[132] the EU is responsible for 25% of global device revenues and 18.2% of the global services revenues in 2021.[133] Important competing regions for devices revenues and services revenues were North America (respectively 25.6% and 23.4%) and especially the Asia-Pacific region (respectively 35.7% and 39.8%). Russia and non-EU Europe are less prominent on the market (respectively 5.6% and 4.9%.

EU revenues for both devices (up from EUR 12.1 billion to EUR 21.6 billion) and services (up from EUR 27.4 billion to EUR 53.7 billion) are expected to double nearly until 2031, in absolute terms. Despite this growth, a decline in the relative EU share is expected for global device revenues (-0.2%) and particularly services revenues (-4.9%), because the global market grows at a faster rate (9.2% annually) than EU revenues.[134] This is in line with historical data, which shows that the EU's share has been declining over the last years: the share of combined GNSS revenues was 23.1% in 2015, 25.5% in 2019 and 19.9% in 2021, and is expected to be 15.3% in 2031.[135]

[129] EUSPA, 'EO and GNSS Market report', 2022, p. 10.

[130] The data presented on this statistic in the EUSPA report do not include the segment share for regions beyond Europe, North America, and Asia & Russia. Source: EUSPA, 'EO and GNSS Market report', 2022, p. 14.

[131] EUSPA, 'EO and GNSS Market report', 2022, p. 14. For these statistics, there is no information available on other regions.

[132] The GNSS market is defined by EUSPA as 'activities where GNSS-based positioning, navigation and/or timing is a significant enabler of functionality' and comprises device revenues and revenues derived from augmentation and added-value services. EUSPA, 'EO and GNSS Market report', 2022, p. 17.

[133] EUSPA, 'EO and GNSS Market report', 2022, p. 18.

[134] EUSPA, 'EO and GNSS Market report', 2022, pp. 18 and 21.

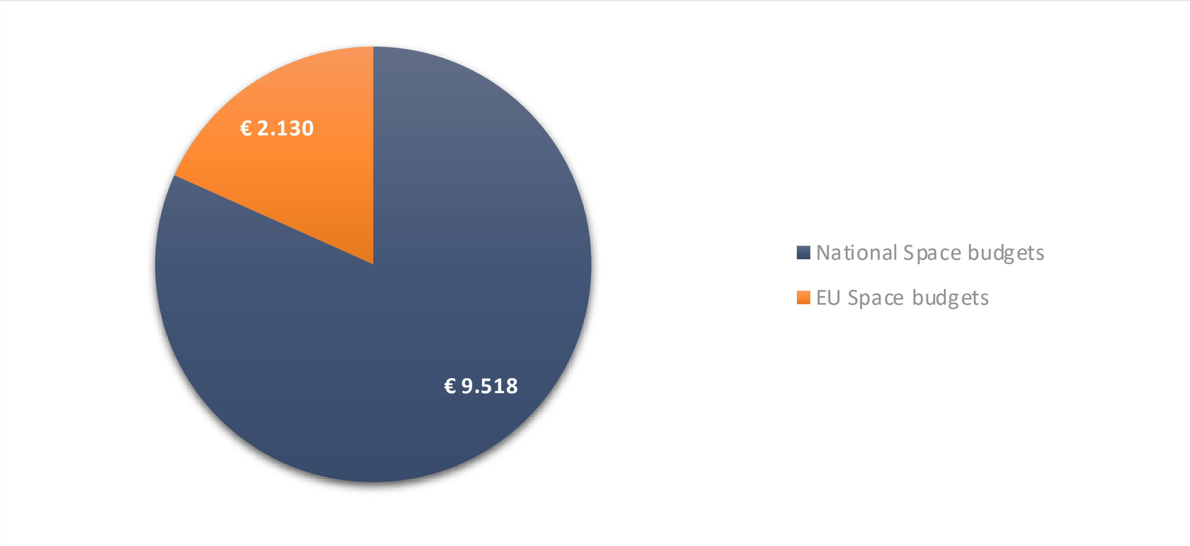
[135] GSA, 'GNSS Market Report', 2019, p. 6; GSA, 'GNSS Market Report', 2017, p. 6.

2.2.3. Investment

Common public spending and investment

Public investments in the space sector stem from two sources in Europe: EU space budgets and national space budgets of the ESA and EU member states. In 2020, the total European space budgets amounted to EUR 11.6 billion, with the contribution from the national space budgets at nearly five times the EU space budgets (EUR 9.5 billion against EUR 2.1 billion).[136]

Figure 6: Composition of European space budgets in 2020



Source: ESPI, 'Yearbook 2020: Space Policies, Issues and Trends', 2021, p. 148; ESPI, 'Yearbook 2021: Space Policies, Issues and Trends', 2022, p.131.

This section explores in more detail existing sources of investment from European institutions, national governments, and private actors.

The European Union's space-related investments

The budget for the EU's New Space Program for the MFF 2021-2027 amounts to EUR 14.8 billion in current prices, representing an average annual budget of EUR 2.1 billion, divided among five pillars: Galileo and EGNOS (EUR 9.01 billion), Copernicus (EUR 5.42 billion) and SSA and GOVSATCOM (EUR 1.2 billion). [137] Its value is roughly equal to the previous MFF 2014-2020, in which the budget for the EU space programme was EUR 12.6 billion, which is EUR 14.9 billion in current prices when corrected for inflation.[138]

In addition to these public expenditures, the EU also has been fostering the region's public funding landscape, developing new programmes, such as Horizon Europe and InvestEU that aim to drive further the region's upstream and downstream (space) sectors and activities. These new programs build 'on the success of Horizon 2020 and the European Fund for Strategic Investments (EFSI), which

136 ESPI, 'Yearbook 2021: Space Policies, Issues and Trends', 2022, p.148.

137 See the explanation on the budget and conversion of prices at Legislative Train Schedule, 'EU Space Programme', 2022.

138 EPRS, 'EU Space Programme', 2021, p.5. Value of the budget corrected for inflation rate between 2014 and 2022.

mobilised funds for research and innovation.'[139] For the period 2021-2027, the EU invested EUR 95.5 billion into Horizon Europe intending to contribute to Research and Innovation[140], of which EUR 1.5 billion is budgeted for space research.[141] Under the flag of its predecessor Horizon 2020, the EU invested roughly EUR 967 million into space research.[142] Main recipients were large EU programmes such as Copernicus, Galileo, and EGNOS. Specifically, a large share of the Horizon 2020 budget earmarked for Space went into establishing and further developing a European Space Surveillance and Training service provision function. Between 2014 and 2020, the EU allocated a total of EUR 115 million for five projects contributing to this objective.[143] The European Commission also launched the CASSINI Space Entrepreneurship Initiative in 2022, a 1 billion euro fund aiming to boost the European space sector.[144] The funding for this initiative is structured as a 'fund of funds' and consists of funds from the MFF, EIB and InvestEU (composed of MFF and Next Generation EU). This set-up mimics the structure of the earlier initiative InnovFin Space Equity Pilot (ISEP)[145], which brought together funding from the Commission and EIB to boost venture capital funds across the EU to support companies commercialising new products and services in the space sector. The new CASSINI Initiative is aimed at EU start-ups and SMEs in space. Through the initiative, the EU wants to cater to the needs of space companies by improving access to investments and professional networks.[146]

Figure 7 uses McKinsey's estimates[147] to provide an overview of the annual government space budgets of EU Member States, the UK, Switzerland, and Norway.[148] The estimates are in most cases for 2021, but in some cases also for 2020 or 2019. No data is available for Bulgaria, Croatia, Cyprus, Lithuania, Malta, and Slovenia. All Member States with an annual contribution below EUR 100 million are accumulated into the 'Rest' category, adding to nearly EUR 600 million.

[139] Innovation Finance Advisory and European Investment Advisory, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', 2019, p. 9.

[140] European Commission, 'Horizon Europe', not dated.

[141] HaDEA, 'About the Horizon Europe - Space programme', not dated.

[142] European Commission, 'Funding & Tender opportunities: R&I Projects', not dated.

[143] The five EU project contributions were PASS, 3SST2015, 2SST2015, 2-3SST2016 and 2-3SST2018-20, contributing to the EUSST project.

[144] DEFIS, 'CASSINI Space Entrepreneurship Initiative', not dated.

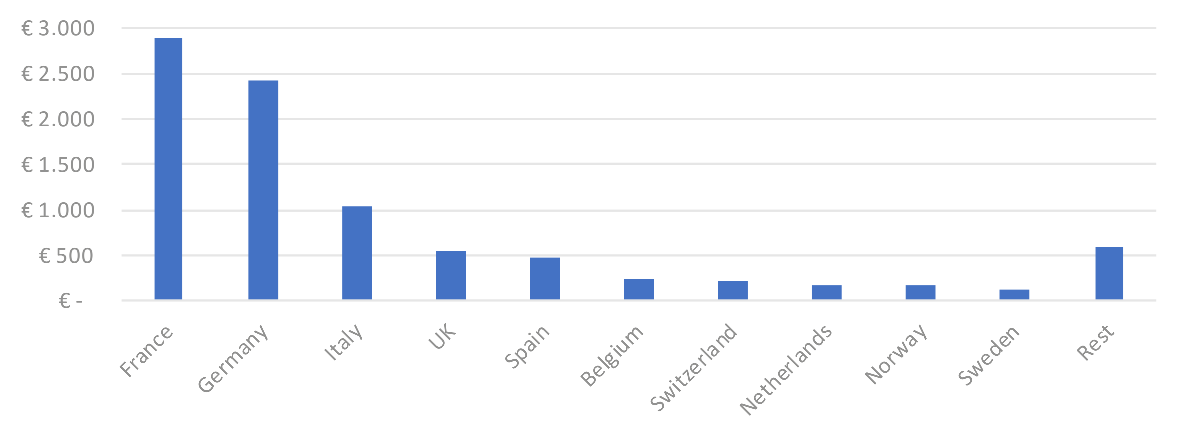
[145] EIB, 'European Commission and European Investment Bank Group join forces to boost space sector investment with EUR 200 million of financing', press release, 21 January 2020.

[146] EIB, 'European Commission and European Investment Bank Group join forces to boost space sector investment with EUR 200 million of financing', press release, 21 January 2020.

[147] McKinsey, 'Space Around the Globe', 2022.

[148] The national budget estimates are composed of a country's ESA contribution plus other space activities undertaken by the country.

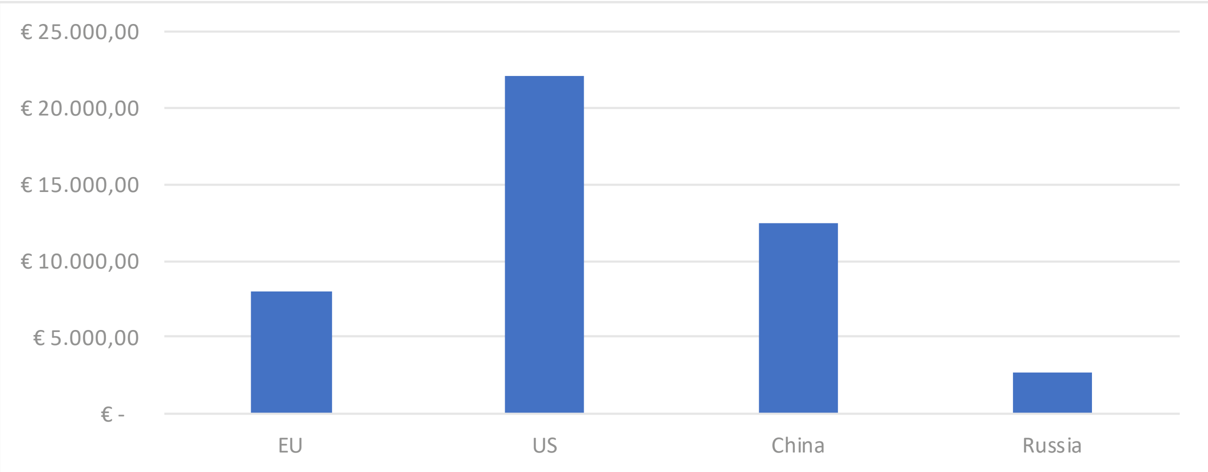
Figure 7: Estimated annual space budgets of selected EU Member States, Norway, Switzerland and the UK (in mln EUR), top 10 countries



Source: Own calculations based on data for 2019-2021 in McKinsey, '[Space Around the Globe](#)', 2022.

The McKinsey data allows for a comparison of the aggregate of national budgets of EU member states with the government budgets of other important space actors, like the United States, China, and Russia. The aggregate of national budgets of EU member states adds up to a total of EUR 7.9 billion. Figure 8 shows that the EU aggregate budget is below the budgets in China and the United States, equalling roughly a third of the estimated US government space budget (EUR 22.1 billion) and nearly two-thirds of the Chinese national budget (EUR 12.4 billion). The combined EU Member States' budgets are however nearly three times the size of the Russian national space budget (EUR 2.7 billion).

Figure 8: Estimated annual space budgets of the US, China, Russia and the aggregate of national budgets of top 10 EU Member States (in mln EUR)

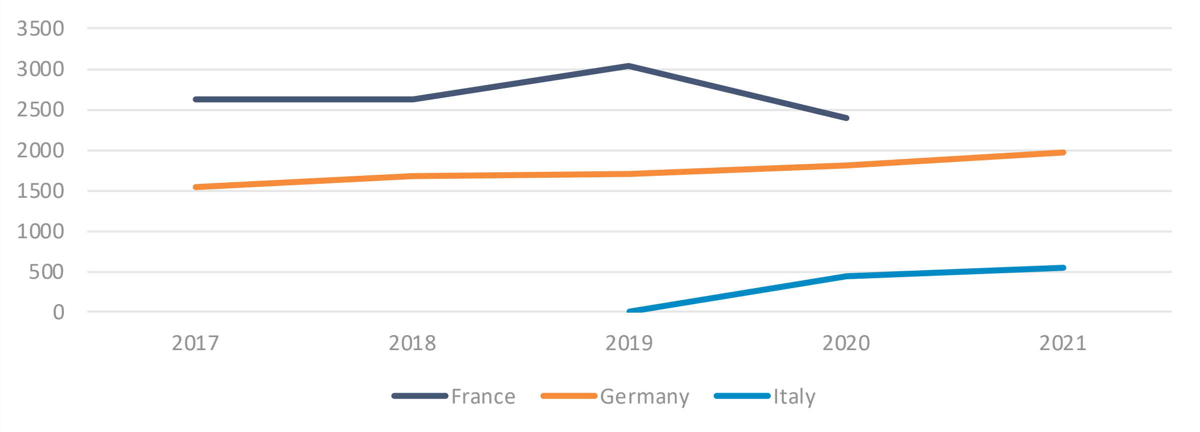


Source: Own calculations based on data for 2019-2021 in McKinsey, '[Space Around the Globe](#)', 2022.

To illustrate the development of state-level investments in the space sector, it is instructive to look at the annual budgets of France, Germany and Italy – the most sizeable space economies of the EU. Considering all expenditures of the annual budgets that directly touched upon a space-related topic –involving both civilian (including funding for ESA and national space agencies) and military space-related budget lines – government investments grew in the three countries until 2020 (see Figure 9). For instance, the German annual budget for space-related investment rose from EUR 1.5 billion in 2017 to EUR 2.0 billion in 2021. Similarly, the French budget increased from EUR 7.8 billion in 2017 to EUR 9.1 billion in 2019.

Given the broad range of space-related expenditures included in this analysis of annual budgets, there are discrepancies with the McKinsey estimates – especially regarding the French budget. Particularly, military space-related expenditures account for a large share of the discrepancy. This seems to indicate that, in France, military spending constitutes a significant part of government space investments. For instance, military expenditures constitute EUR 4.4 billion worth of government space investments in 2020 in France, on a total of roughly EUR 6.8 billion.

Figure 9: Development of civilian space budgets in France, Germany and Italy (2017-2021)



Source: Own calculations based on annual budgets in France: 2017, 2018, 2019, 2020; Germany: 2017i, 2017ii, 2018, 2019, 2020, 2021; Italy: 2019, 2020, 2021.

All in all, space budgets constitute only a fraction of the national GDP in EU Member States. For example, France spent only 0.12% of its GDP on space and is the biggest spender in the EU.[149] Germany spent just about 0.05% of its GDP and Italy about 0.03% of its GDP in 2021. In comparison, the OECD estimates that the levels of spending in the US (roughly 0.25% of its GDP) and Russia (approximately 0.21% of its GDP) are substantially higher. However, these estimates include spending on defence programmes.[150]

European Space Agency

The ESA runs two types of programmes: mandatory and optional programmes.[151] Mandatory programmes are financed through the ESA's general budget, which member states contribute to based on a distribution key. The main mandatory programme, financed through member state contributions, is the Science programme, which is complemented by mandatory funding streams for, among others, the Basic Technology Research Programme and basic infrastructure. Optional programmes are financed outside the general budget, and member states are free to determine their level of involvement. In total, roughly 80% of member state contributions are dedicated to optional programmes, of which prominent examples include Space Transportation, Earth Observation, Telecommunications and Integrated Applications, crewed flights, and the International Space Station.

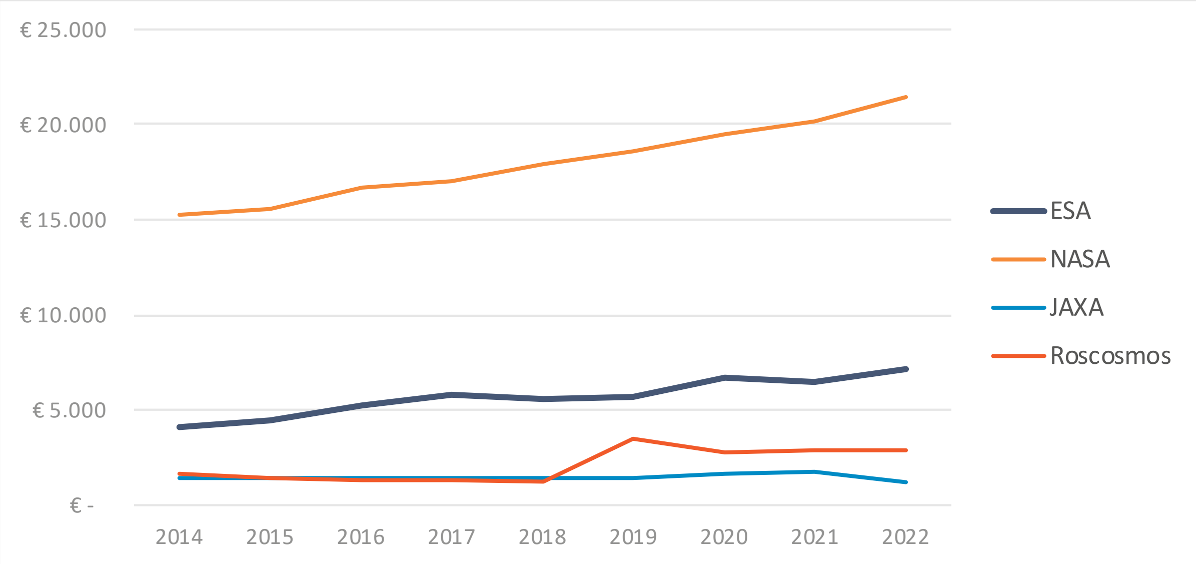
149 GDP numbers are according to Eurostat, 'GDP and main components (output, expenditure and income)', 2022.

150 OECD, 'Handbook on Measuring the Space Economy', 2nd edition, 2022, p. 63.

151 ESA, 'ESA, an intergovernmental customer', not dated.

Figure 10 provides an overview of the overall development of the ESA budget between 2014 and 2022. For reference, we added the budget of its American, Japanese, and Russian counterparts: NASA, JAXA, and Roscosmos. All budgets are civilian space budgets.

Figure 10: Annual budget of ESA and international counterparts between 2014-2022 (in mln EUR)

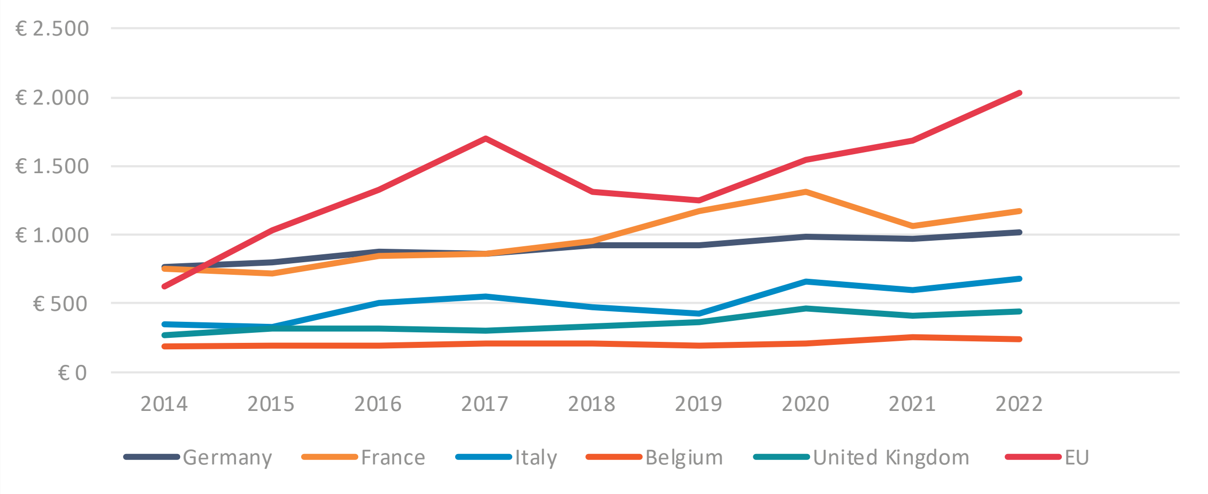


Source: Own calculations based on: European Space Agency budgets from 2022, 2021, 2020, 2019, 2018, 2017, 2016, 2015, 2014; The Balance, 'NASA Budget, Current Funding, History, and Economic Impact', 2022; Statista, 'Annual budget of the Japan Aerospace Exploration Agency (JAXA) from fiscal year 2013 to 2022', 2022; Aliberti M and Lisitsyna K, 'Russia's Posture in Space: Prospects for Europe', *European Space Policy Institute*, Springer, 2019; TASS, 'Russia plans to spend more than 600 billion rubles on space in 2020-2022', 2019.

Notes: Supplementary budget for 2022 has not been added to the Japanese 2022 budget. Roscosmos budgets for 2020 to 2022 are based on proposed budgets and not on actual expenditures. Roscosmos, NASA and JAXA budgets converted to euros, using the average conversion rate for the 2014-2022 period. For Russia, the end date is February 1st, 2022.

Figure 11 shows how annual contributions to the ESA budget by the largest ESA state-contributors developed over time. These trends can be considered indicative of national space budgets in general. Except for 2014, the EU has been the largest contributor and showed the greatest growth in its contribution (+225%) over the reference period. Zooming in on the member states, we see that France has the highest contribution in absolute terms, followed by Germany. Italy has been catching up quickly in recent years. Relative to country size, Belgium had a significant contribution, especially in 2014. Over time we see that its contribution increased at a slower pace than those of other countries (+26% over the reference period). As indicated, the Italian budget grew the quickest (+94% between 2014 and 2022), followed by the United Kingdom (+62%).

Figure 11: Developments in annual contributions to the ESA budget for top 5 contributing member states (in mln EUR, 2014-2022)



Source: European Space Agency budgets from 2022, 2021, 2020, 2019, 2018, 2017, 2016, 2015, 2014.

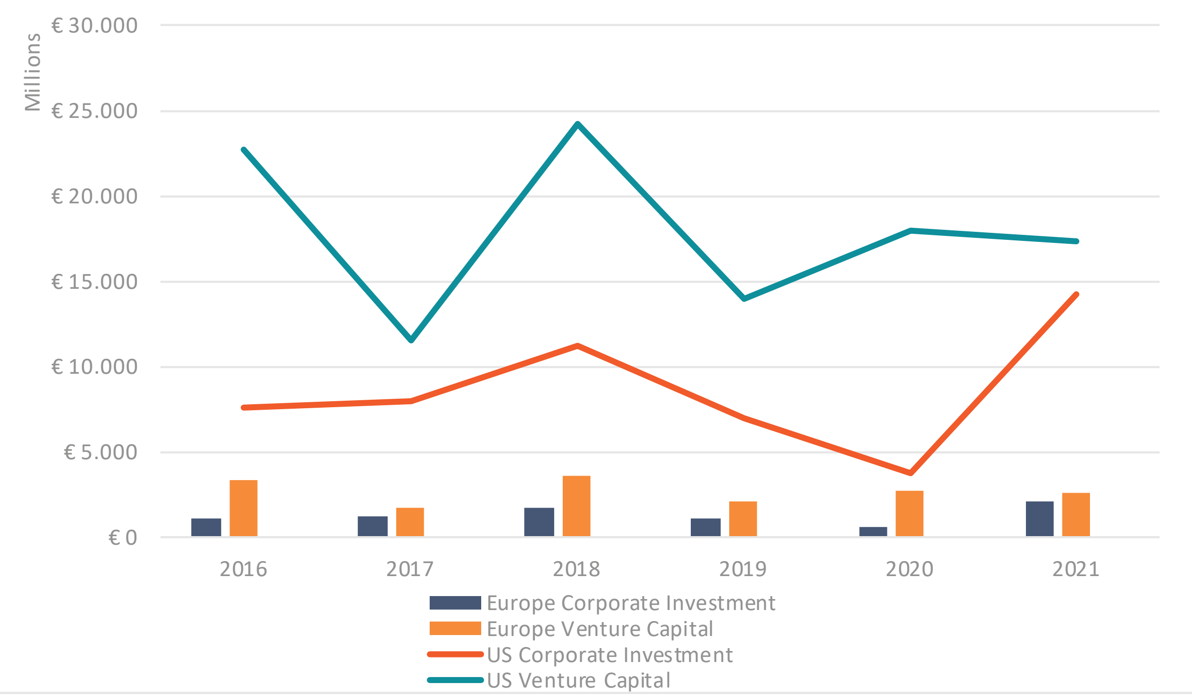
Private investments

Figure 12, provides an overview of the developments in private investment in the EU space sector between 2016 and 2021. Venture capital company Space Capital documents the total amount of private investments in the form of corporate and venture capital into the global space economy.[152] These estimates from Space Capital are adjusted for the EU by using the ESPI's finding that Europe is responsible for 15% of global space production (2018).[153] The figure indicates that there is a clear variation with respect to the annual amount of capital that private investors supply to the European space sector. In the years 2016, 2018 and 2021, the annual amount of private investment in the European space sector exceeded EUR 4 billion while in the years 2017, 2019 and 2020, this was only around EUR 3 billion.

[152] Space Capital, 'Space Investment Quarterly', not dated.

[153] ESPI, 'European Space Strategy in a Global Context', 2020, p. 9.

Figure 12: Estimated private investments in the EU space sector (in mln EUR, 2016-2021)



Source: Own calculations based on Space Capital, 'Space Investment Quarterly', not dated, and ESPI, 'European Space Strategy in a Global Context', 2020, p. 9. ECB data on average conversion rate in 2016-2021 used to convert USD estimates to EUR estimates.

2.2.4. Employment

The EU space sector workforce encompasses the workforce in the upstream and downstream segments. Available estimates primarily provide numbers for the upstream segment, because it is difficult to draw the line between space and ICT in the downstream segment.

A 2016 study on the socio-economic impacts of space activities in the EU estimated the overall employment in the upstream and downstream segments to be in the order of 230,000 people in 2014, including space public administrations, 'manufacturing industry, direct suppliers to this industry and the wider space services sector (mainly telecommunications)'.[154] It should be noted that the 2016 study does not provide the methodology of how this employment number was calculated and does not explain what segments of the telecommunications sector were considered in the estimate. Due to the lack of reliable numbers for the downstream segment, the estimates of employment in the EU space sector remain incomplete.

In the upstream segment, the employment numbers for the space sector need to be separated from employment in the aeronautics sector in general. Eurostat collects on the national level the number of employees by industry (by using the NACE classification). NACE classification code C303 provides data on the number of employees that are active in the manufacturing of "air and spacecraft and related machinery" for the EU member states, the United Kingdom, Norway, and Switzerland.[155] Using this data by considering the relative sizes of the aeronautics (i.e. EUR 130 billion[156]) and

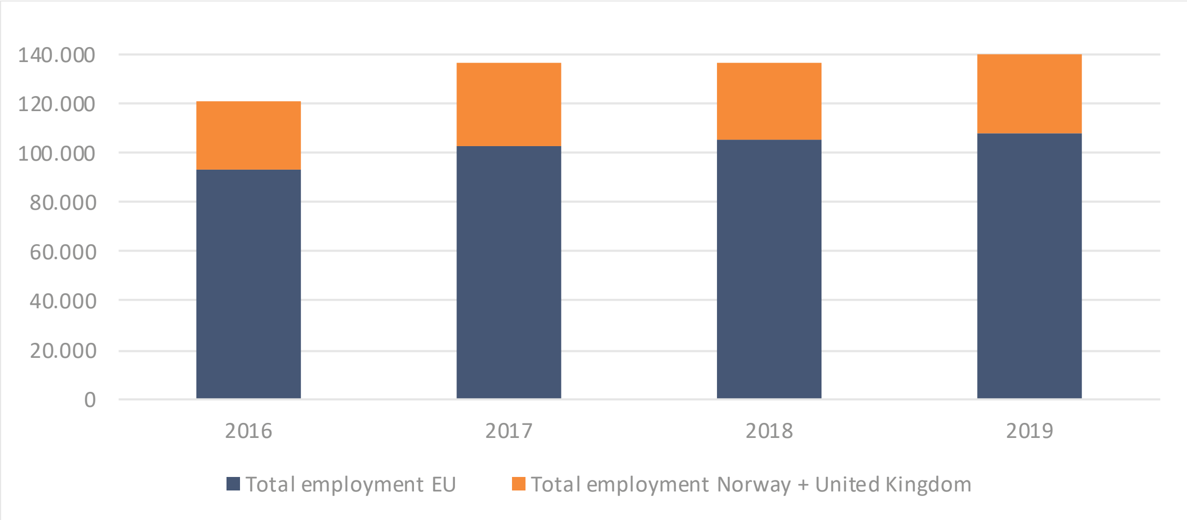
[154] PwC, Socio-economic impacts from space activities in the EU in 2015 and beyond, Study for the European Commission, 2016, p. 61, see also pp. 245-246 demonstrating the lack of nuanced estimates.

[155] Eurostat, 'Industry by employment size class', 2022.

[156] European Commission, 'EU Aeronatics Industry', not dated.

spacecraft sectors (between EUR 53 and EUR 62 billion [157]) in the EU, provides country-level estimates of the number of employees active in the manufacturing of spacecraft. In order to address missing data two strategies have been employed. Firstly, if for a country in a certain year no number has been provided, then it has been assumed that the number of employees equals the number of employees in the last registered year. Secondly, if no numbers for people employed in the spacecraft sector are given for a country, then the country is excluded from the analysis (this is the case for Sweden, Switzerland, and Cyprus). Based on these calculations, it can be estimated that employment in the space sector grew from 93,000 in 2016 to 108,000 in 2019 (Figure 13).

Figure 13: Total number of employees in spacecraft manufacturing



Source: own calculations based on Eurostat, European Commission and Council of the EU.

These numbers can be contrasted with the workforce statistics from those EU Member States that have large space economies. For example, according to the Federal Association of the German Aerospace Industry, which represents 250 German aerospace companies including such globally important enterprises as Airbus, Arianegroup, OHB, Jena-Optronik, and Telespazio, the number of people working in the aerospace industry in 2018 was 111,500, in 2019 – 114,000, in 2020 – 105,000 and in 2021 – 100,000. Of these, only 9,300 worked specifically in the space sector in 2018; in 2019 this number grew to reach 9,700, but dropped back down to 9,300 in 2021. [158] The proportion of the workforce in the French sector is similar. According to the National Institute of Statistics and Economic Studies (Insee), in 2020, there were 263,000 persons employed in the aerospace industry, of which 12% (or 31,560) worked specifically in the space sector. [159] The Association of the French Aeronautic and Space Industries (GIFAS) gives an even smaller proportion of the space workforce in 2021: out of 188,000 employed in the aerospace industry only 8.8% (or 16,500) worked specifically in the space sector. [160] While the employment numbers for Italy were not available, Spain provides numbers both for the upstream segment and operations subsegment in downstream. The employment there has been steadily growing, from 2,451 workers in 2006 to 3,909 workers in

[157] Council of the European Union, 'EU in space', Infographic, 2021.

[158] See Bundesministerium für Wirtschaft und Klimaschutz, 'Aktuelle Entwicklungen', 2019; Bundesverband der Deutschen Luft- und Raumfahrtindustrie e. V., 'Annual Report 2020', 2021; Bundesverband der Deutschen Luft- und Raumfahrtindustrie e. V., 'Annual Report 2021', 2022.

[159] Institut national de la statistique et des études économiques, 'La filière aéronautique et spatiale en France en 2020', 2021.

[160] GIFAS, 'Chiffres clés: emploi et formation', not dated.

2018[161], and up to 4,230 workers in 2019.[162] In Belgium, in 2017, the aeronautics sector in general employed some 10,000, of which about 3,000 were directly employed in the space industry.[163]

The quoted national workforce statistics correlate well with the employment numbers reported by Eurospace, which sums up the Europe-wide direct industry employment (including Norway, Switzerland, and the UK) to just over 47,895 Full-Time Equivalents in 2019.[164] It needs to be borne in mind that these numbers do not yet take into account the employment in the downstream sector, which represents a substantial part of overall space-related employment.

Many workers are employed by SMEs working in the space sector. According to the association SME4Space, in 2014, 951 space-related SMEs were employing about 15,300 people, while in 2018, 1,050 such SMEs were employing about 18,200 people.[165]

National statistics mention some other characteristics of the workforce in the space sector. Most people employed in the space sector are highly skilled and highly educated. The gender balance in the industry is skewed: over 70% of workers are male.[166] The median age of workers in the upstream segment is between 45 and 55 years old, but workers tend to retire later when compared to other economic sectors. This age distribution has been stable since 2009, according to Eurospace.[167]

2.3. International context: cooperation and competition

Discussions about the space sector in a global context are often framed as a (new) 'space race',[168] revolving around comparing the relative positions of various space powers in this contest and discussing the role or place of commercial actors in it. However, besides competition, the space sector is also defined by a high degree of international cooperation. The EU's space sector is internationally significant and at times even crucial, both in terms of competition and cooperation.

2.3.1. Global position of the EU space sector

The EU space sector's global position is difficult to determine in definite terms because many different criteria can be used for the comparison leading to different results. For example, currently, the EU and its Member States have never developed an independent capability for human spaceflight and have to rely on the services of partners to bring European astronauts, for example, to the International Space Station (ISS).[169] Currently, only three countries in the world have capabilities for human spaceflight: China, Russia, and the US. Only in February 2022 did Europe –

161 TEDAE, 'Agenda Sectorial de la Industria Espacial Española', 2019, p. 34.

162 Europa Press, 'El sector espacial español facturó 863 millones de euros en 2019 y el empleo creció más de un 8%, según TEDAE', 2020.

163 Decoster W and Vander L, 'Belgian aerospace', Belgian Foreign Trade Agency, 2018, p. 7.

164 Eurospace, 'The European space industry in 2019', 2020, p. 7.

165 SME4Space, 'Study on economic importance of SMEs in the space industry in ESA member states: the first findings are available', 2020, p.2.

166 See, for example, GIFAS, 'Chiffres clés: emploi et formation', not dated; Henry C, 'Europe's space workforce: Same age, less crisis', *SpaceNews*, 3 May 2018.

167 Henry C, 'Europe's space workforce: Same age, less crisis', *SpaceNews*, 3 May 2018.

168 Howell E, 'The New Space Race', *Britannica*, 2019; Mack E, 'In 2022, the new space race will get more heated, crowded and dangerous', *CNET*, 2022.

169 ESPI, 'Europe and Human Spaceflight: new context, new strategy?', Executive Brief No 53, 2021.

through the ESA – kick off the process of developing independent human spaceflight capability, and the EU and ESA are now working to reach a political consensus on this issue.[170]

Another area where the EU lags is sustainable spaceflight. More ecologically friendly rocket fuel is an issue of R&D for the space industry globally, and there are several projects in the EU working in the area.[171] However, reusable rockets have been used for several years, while there are only a few in development in the EU: micro-launcher Miura 5 (test flight planned for 2024) by PLD Space[172] and Themis by ArianeGroup (test flight planned for 2023).[173] The US (i.e. SpaceX) is currently leading in reusable launch technology, with Falcon 9 and Falcon Heavy reusing their first stages (i.e., they are partially reusable rockets) for human and cargo spaceflight, respectively.[174] SpaceX is working on the fully reusable spacecraft Starship.[175] RocketLab (NZ/US) is already testing whether it can reuse the first stage for its small launcher Electron.[176] The US also has two suborbital reusable launch vehicles (New Shepard by Blue Origin, SpaceShipTwo by Virgin Galactic). There are several orbital and reusable suborbital launchers in development in the US. China is developing at least three different reusable launchers (e.g., RLV-T6 by LinkSpace, Long March 8 by the Chinese Academy of Launch Vehicle Technology, Hyperbola by I-Space), one of which is to be tested in 2022.[177]

[170] Aschbacher J, ESA Director General, Speech at the Space Summit of 16 February 2022; speech by the French President Emmanuel Macron on 16 February 2022 as reported by Foust J, 'ESA to set up committee to study human space exploration options', *SpaceNews*, 17 February 2022; Grudler C, 'European human spaceflight: The next step in our European Access to space?', *The European Files*, 8 March 2022.

[171] Pultarova T, 'The environmental impact of rocket launches: The 'dirty' and the 'green'', *space.com*, 28 October 2021; examples of green propellant projects in Joly J, 'Move over, SpaceX: ArianeGroup to make Europe's first reusable and 'eco-friendly' rockets', *Euronews*, 5 July 2022.

[172] Next Spaceflight, Miura 5, not dated.

[173] Joly J, 'Move over, SpaceX: ArianeGroup to make Europe's first reusable and 'eco-friendly' rockets', *Euronews*, 5 July 2022.

[174] Wall M, 'SpaceX Falcon 9 rocket aces record 13th flight in Starlink satellite launch', *space.com*, 17 June 2022.

[175] Rincon P, 'What is Elon Musk's Starship?', *BBC*, 17 November 2021.

[176] Reuters, 'Rocket Lab tried to catch a falling rocket with a helicopter to reuse it. It didn't work this time', *Euronews*, 5 May 2022.

[177] Jones A, 'LinkSpace returns: Chinese startup plans rocket launch and landing this year', *space.com*, 6 May 2022; Jones A, 'China prepares its Long March 8 rocket for second mission', *space.com*, 31 January 2022; Clark S, 'Chinese startup suffers third consecutive launch failure', *Spaceflight Now*, 13 May 2022.

Micro-launchers in the EU

Launch vehicles are used to carry payloads (e.g., satellites) into space. Very small payloads of up to 350 kilogrammes can be brought to the Low Earth Orbit (LEO) by a special type of launcher called micro-launcher. Broadly speaking, there are two types of micro-launchers: land-based launch systems (from mobile or static platforms) and aerial launch systems (from planes and balloons). Older models of micro-launchers have four stages, whereas more recently developed launchers have two or three stages. Most launcher engines run on solid propellants or kerosene, but new hybrid and methane rocket engines are being developed.

Micro-launchers have been developed for decades, but interest has sharply increased in the last decade in response to growth of the small satellite market due to the satellite miniaturisation. Small satellites usually ride as a secondary payload on larger launch vehicles, leading to low flexibility of launch schedules, long waiting times and higher costs for the owners of small payloads. Micro-launchers offer a cost-effective and flexible alternative and facilitate small satellite missions. Micro-launchers can be developed relatively quickly, building on existing launch technologies, and launched on-demand and in the country of development, from different launch platforms.

Since the early 2000s, over 100 micro-launcher projects have been announced globally. Most of these projects are in the development or concept phase. Interesting developments in the market include the increased interest in the reusability of micro-launchers and the use of more sustainable propellants. The US leads the micro-launcher market, with 44% of the projects based there; Asia (primarily China and India) is in second place with 33% of the projects, followed by Europe with 23% of the projects. A relatively large number of projects are underway in the United Kingdom. In the EU, France, Germany, and Italy have several promising launcher start-ups. In Germany, Rocket Factory Augsburg, HyImpulse and Isar Aerospace are working on micro-launchers supported by the German Aerospace Center (DLR) and the Federal Government. The EU is supporting the development of cost-effective and reusable micro-launchers, for example through the Horizon 2020 Recovery and Return-To-Base European Reusable Micro-Launcher Project. This project, which runs until May 2023, is working on cost-effective micro-launchers that can be reused up to ten times using a novel landing system and more sustainable propellants (liquid oxygen and liquid methane). However, EU public and private investments in micro-launcher technology much lower than, for instance, investments in the US.

Despite the developments and investments in the micro-launcher market, Roland Berger predicts that most micro-launcher projects will be terminated in the coming years, due to limited market demand. This may have to do with the fact that no cost-effective micro-launchers are operational to date, due to immature technology and relatively high launch costs per payload kilogram. The technology of launch vehicles is complex, and this technology and the associated costs are not scalable, or only to a very limited extent. As a result, micro-launchers are still relatively expensive to develop compared to the weight of payload they can bring into space, and the cost per payload kilogram carried by micro-launchers is generally higher than the costs of the cheapest rideshare missions. It remains to be seen to what extent the technology for micro-launchers will continue to develop in the coming years. More mature technology could potentially reduce the costs of micro-launcher development while increasing their economic viability.

Sources: ESA, 'Microlaunchers: new ways to access space', 2018; PwC, 'Micro-launchers: what is the market?', 2017; Kulu W, 'Small Launchers - 2021 Industry Survey and Market Analysis', 2021; Governale G, Rimani J, Viola N and Fernandez Villace V, 'A trade-off methodology for micro-launchers', *Aerospace Systems 4*, 2021; Hader M, How Europe can develop and secure a small-satellite launcher solution', *Roland Berger*, 2021; DLR, 'The DLR microlauncher and payload competition', 2022; CORDIS, 'Recovery and Return-To-Base European Reusable Micro-Launcher Project', 2022; CORDIS, 'Revolutionary small satellite launcher technology provides low-cost access to Space', 2019; Afilipoae T, Neculăescu, A, Onel A, Pricop M, Marin A, Perşinaru A, Cişmilianu A, Munteanu C, Toader A, Sibri A, Bennani S and Chelaru T, 'Launch Vehicle - MDO in the development of a Microlauncher', *Transportation Research Procedia 29*, 2017.

An important geographic limitation needs to be noted: the EU is lacking launch sites that are situated both close to the production sites and transportation infrastructure, preferably close to the equator and at the same time at a safe distance from populated areas. The prime European spaceport is in Kourou (French Guiana), for Ariane and Vega rockets. In addition, there is a commercial Spaceport Sweden in Kiruna that can be used for small launchers,[178] and a process for building launch capacities on the island of Santa Maria (Azores, Portugal) is ongoing.[179] Via ESA, the EU has access to the Norwegian spaceport Andøya Space, and seven launch pads in the UK.[180] By contrast, the US has more than 10 spaceports on its territory, and Russia and China have four each.[181]

The comparison of public spending on space puts the EU in third or even fourth place. The US budget for space was EUR 42 billion in total. China's public spending on space is not publicly available but is estimated to be about EUR 7.8 billion in 2020. Russia allocated EUR 2.4 in 2020 to its space program.[182] As mentioned above, the EU had an average annual budget of EUR 1.8 billion for the budget period 2014-2020 (total of EUR 12.6 billion) and planned EUR 2.1 billion for 2021-2027 (total of EUR 14.8 billion). In addition, the EU contributed over EUR 2 billion to the annual ESA budget in 2022. Private financing sources are also less developed than in the US and China,[183] though improvements to the funding of start-ups are expected with such initiatives as CASSINI and EIB's direct financing.[184] An extensive description of public and private funding in the EU and other countries is presented in section 2.2.3.

The EU (mainly through the ESA) is a leader in space exploration and space science. For instance, a pioneering and unique achievement was the landing on a comet by Philae of the Rosetta spacecraft in 2014.[185] The Gaia mission has the ambitious aim to create a 3D map of our galaxy.[186] BepiColombo is on its way to Mercury to comprehensively study this planet.[187] Many other space science missions are in the pipeline. The EU can also rely on a network of tier-one space science facilities, such as CERN, the European Spallation Source, and the International Thermonuclear Experimental Reactor.

The EU Earth observation (first and foremost, Copernicus) and satellites (Sentinel) are top-of-the-line. Under the aegis of ESA, Earth observation has been extended dramatically in recent years and now covers the entire value chain, from upstream elements (e.g. sensors, satellites, supporting technologies and ground segment) to downstream elements (e.g. operations, data exploitation and

178 Pozdnakova A, 'Space Infrastructure for a Sustainable Arctic: Opportunities and Challenges of Spaceport Development in the High North', The Arctic Institute, 2022.

179 PTSpace, 'Azores ISLP', not dated.

180 Patel D, 'UK Spaceports – Making British Spaceflight History', UK National Space Centre, 2022; Hogan C, 'Upcoming UK Spaceports and the Future of Collaboration for Launches in Europe', in: Froehlich A (eds.), Spaceports in Europe, Springer, 2021.

181 See Spaceports & Launch sites 2022 list.

182 Azarova N, 'In the New Space Race, Will Russia and China Triumph Over America?', Carnegie Endowment for International Peace, 2021; Geospatial World, 'Euroconsult's flagship research shows government space program budgets have maintained growth trajectories', 2020. ECB data on average conversion rate in 2020 used to convert USD estimates to EUR estimates.

183 Whittle M, Sikorski A, Eager J and Nacer E, 'Space Market – How to facilitate access and create an open and competitive market?', Study for the ITRE Committee of the European Parliament, 2021, p. 29.

184 European Commission, 'European Investment Bank Announces first direct financing for a start-up in the European 'New Space' sector - €20 million venture loan for Spire Global', press release, 3 December 2020.

185 Gibley E, 'Like froth on a cappuccino': spacecraft's chaotic landing reveals comet's softness', *Nature*, 28 October 2020.

186 ESA, 'Gaia', not dated.

187 ESA, 'BepiColombo', not dated.

data-based services).[188] In 2018, there were already 450 companies working in the Earth observation sector, most of which were SMEs with less than 10 employees.[189]

The EU has a world-class, new-generation global satellite-based navigation system in Galileo, which not only makes the EU independent in this regard but delivers better service in some respects than other such systems. Galileo provides more accurate positioning for the receiving device and delivers better timing for more resilient synchronisation for time-critical events for such time-sensitive areas as aviation, telecommunications, as well as financial and power distribution systems. It also allows for detecting emergencies much faster (e.g., from distress beacons): within 10 minutes compared to 3 hours by other systems. Galileo is also interoperable with other international systems such as the US GPS which adds to its resilience and accuracy.[190]

2.3.2. Participation in the major international space-related activities

The EU and its Member States actively participate in major international space-related activities, in the operational area, policy coordination and development of international norms. ESA and seven national space agencies of the EU Member States participate in the International Space Exploration Coordination Group (ISECG),[191] which aims to advance the Global Exploration Strategy[192] – a framework coordinating national space exploration efforts. European countries will be participating in the Artemis Lunar exploration Programme led by NASA. Five EU Member States (France, Italy, Luxembourg, Poland, and Romania) also have signed the Artemis Accords – a non-binding declaration of principles and rules for responsible exploration of outer space.[193] This document is supposed to provide a common framework for the Artemis participants. ESA signed a Memorandum of Understanding with NASA and will contribute essential elements to the space station Gateway in lunar orbit.[194] ESA will deliver two European Service Modules and several launchers.

Compared to other jurisdictions, European space activities (including by the individual EU Member States) are still mostly civilian, which has to do with the competencies of the ESA and the legacy stemming from its long history. The few national military space activities are mainly limited to information collection for strategic purposes[195] (as opposed to kinetic and non-kinetic anti-satellite (ASAT) capabilities developed by China, Russia, and the US[196]). This means that, while EU earth observation and navigation systems play an important role in collective security and defence, the EU needs to rely on the counterspace capabilities of its partners to protect its space assets.[197] Both

188 Silvestrin P, 'The Earth observation programmes of the European Space Agency (ESA): overview of current and future concepts', Presentation at the Proc. SPIE 11858, Sensors, Systems, and Next-Generation Satellites XXV, 2021.

189 Lukaszczyk A, 'Five Takeaways From Europe's Earth Observation Revolution', *Planet*, 26 February 2018.

190 Based on EUSPA, 'Galileo', not dated; Zanda G, 'What Is the Galileo Global Navigation Satellite System?', *Telit blog*, 14 July 2021.

191 ISECG, 'About ISECG', not dated.

192 ISECG, 'The Global Exploration Roadmap', 3rd edition, 2018; ISECG, 'Global Exploration Roadmap: Lunar surface exploration scenario update', 2020.

193 US Department of State, 'France Becomes Twentieth Nation to Sign the Artemis Accords', press release, 7 June 2022.

194 ESA, 'Gateway MoU and Artemis Accords – FAQs', 2020.

195 Pasco X, 'A European Approach to Space Security', American Academy of Arts and Sciences, 2009.

196 See an overview of the current counterspace capabilities in Weeden B and Samson V, 'Global Counterspace Capabilities: An Open Source Assessment', Secure World Foundation, 2020.

197 Darnis J-P, Pasco X and Wohrer P, 'Space and the Future of Europe as a Global Actor: EO as a Key Security Aspect', Instituto Affari Internazionali, 2020.

Copernicus and Galileo have been developing special security services for defence and security users, with an aim to be able to support military operations fully.[198]

The US is one of the EU's most important strategic partners in space and in general. The US-European cooperation (through ESA) dates back to the 1970s and is marked by a number of outstanding joint achievements, from the reusable laboratory SpaceLab to the International Space Station, the Hubble Space Telescope, and the James Webb Space Telescope most recently. With the EU, the US cooperated on the Galileo system and Earth observation, and a regular US-EU Space Dialogue is being held on topical issues.[199] Parts of the space-related value chains of both jurisdictions are inextricably interlinked. For instance, Europe currently relies on the US for human spaceflight, but in the past, after the space shuttle Challenger disaster, the US had to complement their launch capabilities with the Ariane rocket.[200] In the private sector, satellites for the NEXT Constellation built by the American company Iridium are manufactured by Thales Alenia Space in France.[201]

US-European cooperation in the space security and defence domain is especially close. The US has the most resources for SSA activities, including space traffic management (STM). The US Space Surveillance Network maintains the largest number of sensors and the most complete catalogue of space objects, data on which are shared with allies and commercial partners via special agreements under the SSA Sharing Program.[202] In addition to the assets of the US Department of Defense (DoD), it can rely on the fast-growing number of US commercial providers.[203] EU Member States also use the secure communication system US Wideband Global SATCOM.[204] The recently adopted Roadmap on critical technologies for security and defence[205] that includes space technologies will strengthen this close cooperation. The Roadmap aims to boost such technologies through mutually beneficial coordination with like-minded partners, specifically the US and NATO.

Linked to the above point, the EU is putting considerable effort into the resilience and security of space-based infrastructure and sustainability of the space environment by developing Space Surveillance and Tracking (SST). The EU's efforts are directed at reusing existing capabilities, developing new technologies and assets and developing guidelines, best practices and legal rules on the international forums to solve congestion problems and an increasing number of space objects in Earth's orbit.[206] Since 2015, specialised networks of sensors and radars have been gradually implemented by several EU Member States that are members of the SST Consortium[207] and the data from them is shared and jointly used to support safe traffic in space. These national efforts were coordinated and funded at the EU level (via Horizon 2020, Galileo, and Copernicus programmes). There are now 44 various sensors (radars, telescopes, and laser ranging stations)

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198 Council of the EU, 'A Strategic Compass for Security and Defence - For a European Union that protects its citizens, values and interests and contributes to international peace and security', 7371/22, 21 March 2022.

199 US Department of State, 'United States hosts US-EU Space Dialogue', media note, 29 June 2022.

200 For more examples see Ganote S, Yurechko J, Jack D and O'Shea C, 'Reenergizing Transatlantic Space Cooperation', Atlantic Council, 2019, pp. 3-5.

201 Iridium, 'Iridium NEXT: in Review', 2019.

202 Singer K, '100th space sharing agreement signed, Romania Space Agency joins', news item by US Strategic Command, 26 April 2019; Chow T, 'Space Situational Awareness Sharing Program', An SWF Issue Brief, 2011.

203 Stickings A, 'The future of the EU-US cooperation in space traffic management and space situational awareness', Chatham House of the Royal Institute of International Affairs, Research paper, August 2019, pp. 5-6.

204 Ganote S, Yurechko J, Jack D and O'Shea C, 'Reenergizing Transatlantic Space Cooperation', Atlantic Council, 2019, p. 6.

205 European Commission, Roadmap on critical technologies for security and defence, COM(2022) 61 final of 15.02.2022.

206 Foust J, 'European Union lays out plan to bolster space traffic management capabilities', *SpaceNews*, 20 February 2022; EUSST, 'EU SST is the key operational capability for the EU approach to Space Traffic Management', not dated.

207 SatGen, 'EU Space Surveillance and Tracking (SST) service portfolio now available', not dated.

located on all continents except Antarctica.[208] They significantly contribute to the international STM, can be integrated with the US SSA system and will be its valuable civil complement.[209] Not only will these initiatives contribute to the EU's technological sovereignty, but they will also make it an even more attractive partner for international security cooperation.

Another important partner for the EU in space is the United Kingdom (UK). Not only was the UK instrumental in the development of the EU's Copernicus and Galileo, but it could also enhance the EU's space capabilities, for example, by offering more spaceports,[210] SSA capacity and space technology. After Brexit, the relationship between the EU and UK with regard to space cooperation has become very strained and complicated.[211] A sustainable solution needs to be found urgently, due to the heightened importance of the space security dimension and as a model for space relationships with non-EU countries that are ESA Members.[212]

In the international arena, the EU promotes inclusive access to space and its sustainable use. In particular, the EU promotes[213] the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) Space Debris Mitigation Guidelines[214] and Guidelines for the Long-term Sustainability of Outer Space Activities[215] – both developed with the active participation of the EU Member States. However, the EU's impact on the development of international space law is limited, not least due to the different interests of its Member States, through which it is represented in the relevant international arena (see, as an example, the differences in the ratification of the main international agreements related to space by Member States, Table 9). In space-related official development assistance between 2000 and 2018, EU institutions made up the highest number of space-related donors across the G20, followed by France and the USA.[216]

Table 9: Ratifications by EU Member States of the main UN agreements related to activities in outer space

UN agreement	Ratifications by EU Member States
Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty) of 1967	Ratified by 25 Not ratified by two (Croatia, Latvia)
Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue Agreement) of 1968	Ratified by 23 Not ratified by 4 (Estonia, Latvia, Luxemburg, Malta)

208 See the map of sensors at EUSST, 'About us', not dated.

209 Stickings A, 'The Future of EU–US Cooperation in Space Traffic Management and Space Situational Awareness', Research paper of the International Security Department of the Royal Institute of International Affairs, 2019; Peldszus R and Faucher P, 'European Union Space Surveillance & Tracking (EU SST): State of Play and Perspectives', *Space Policy*, 2022.

210 Patel D, 'UK spaceports – making British spaceflight history', blog by UK Space Centre, 17 February 2022.

211 For summary see ESPI, 'The urgent need for sustainable EU-UK relations in space', Executive Brief No. 58, 2022.

212 Marshall W, 'Space co-operation offers the prospect of warmer EU-UK relations', *Financial Times*, 16 August 2022.

213 Council of the EU, EU approach to space traffic management - Council conclusions, 10071/22, 10 June 2022; Decision No 541/2014/EU of the European Parliament and of the Council of 16 April 2014 establishing a Framework for Space Surveillance and Tracking Support, OJ L 158 of 27.05.2012.

214 UNCOPUOS, 'Space Debris Mitigation Guidelines', 2010.

215 UNCOPUOS, 'Guidelines for the Long-term Sustainability of Outer Space Activities', 2018.

216 OECD, 'Measuring the Economic Impact of the Space Sector – Key Indicators and Options to Improve Data', 2020, p. 8.

UN agreement	Ratifications by EU Member States
Convention on International Liability for Damage Caused by Space Objects (Liability Convention) of 1972	Ratified by 25 Not ratified by two (Estonia and Latvia)
Convention on Registration of Objects Launched into Outer Space (Registration Convention) of 1975	Ratified by 21 Not ratified by six (Croatia, Estonia, Ireland, Latvia, Malta, Romania)
Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement) of 1979	Ratified by 3 (Austria, Belgium, The Netherlands) Not ratified by 24

Source: UNCOPUOS, Status of International Agreements relating to activities in outer space as at 1 January 2022.

3. Existing gaps and challenges

Although it has experienced significant growth and thematic expansion over the past decades, the EU space sector currently faces various gaps and challenges (collectively addressed as challenges in the report) that, to varying extents, stand to influence its future development if not addressed. This chapter discusses the various gaps and challenges identified in the literature and in consultation with experts and stakeholders.[217] Section 3.1 contains a long list of the identified challenges: each of them is described in detail, including its impacts on the EU's economy and society. In Section 3.2, a selection of challenges for the Cost of Non-Europe analysis is made. Section 3.2 describes the criteria of assessment applied to the long list and presents the resulting short list of challenges.

3.1. Long list

3.1.1. Ensuring a long-term vision

The space industry is a high-technology domain that relies on cutting-edge technological developments and advancements in many scientific fields. At the same time, technologies used in space need to be extraordinarily robust and resilient, hence they require multiple tests and experiments before being implemented in a space mission. Due to the complexity of technological requirements, time is also necessary to find appropriate engineering solutions. For example, the development of the Ariane 6 launcher started in the early 2010s and its maiden launch is expected only in 2023.[218] Space exploration missions also require a lot of time in implementation and operation. For example, the Rosetta mission[219] was approved in 1993 and officially ended in 2016, of which the spacecraft spent 10 years travelling to the comet, where the lander Philae then successfully landed. NASA's Voyager 1 is probably the longest-running mission.[220] The spacecraft was launched in 1977, visited Jupiter and Saturn and then left into interstellar space in 2012. It has been flying for more than 44 years and still collects data.

It goes without saying that such long-term planning and implementation require long-term strategic vision, including the mainstreaming of space policy in other policy areas (i.e., which policy areas can support space and how, and how other policy areas can benefit from space). EU policy planning is shorter than that of other leading space powers, such as the US[221] or Japan,[222] which plan and design policies with a 20-30-year horizon. Long-term planning is necessary and important to ensure certainty for all stakeholders and to give them actionable cues on where, when, and how to spend resources.

The difficulty of ensuring a long-term vision may be linked to low interest in and lack of fascination for space among the general public, which translates to the lack of political demand from voters toward the elected politicians.[223] Large space-related projects (and their outputs) fail to meet the

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[217] Stakeholders consulted include representatives from the industry, Member States, space agencies, and thematic experts. See list of stakeholders included in Chapter 6.

[218] Berger E, 'The Ariane 6 debut is slipping again as Europe hopes for a late 2022 launch', *ArsTechnica*, 21 June 2021; Berger E, 'Europe's major new rocket, the Ariane 6, is delayed again', *ArsTechnica*, 16 June 2022.

[219] The history and technical and scientific background of the Rosetta mission, see the ESA official webpage.

[220] NASA, 'Voyager 1', not dated.

[221] Atlantic Council, 'The future of security in space: A thirty-year US strategy', 2021.

[222] Nippon.com, 'Japan's Space Policy', 2021.

[223] On the usefulness of public discourse in support of space policy, see Schrogl K-U, 'The political context for human space exploration', in: Landfester U, Remuss NL, Schrogl K-U and Worms JC (eds.), Humans in Outer Space — Interdisciplinary Perspectives. Studies in Space Policy, vol 5., Springer, 2011, pp. 3-14.

expectations of the public and generate enough public support and enthusiasm, which results in a vicious cycle of reduced political attention and, therefore, funding leading to fewer space projects.[224] Most space missions lack the drama of the early days of space exploration and, having become a routine, fail to grip people's imagination.[225] Even when space exploration is perceived as important and necessary, many taxpayers find it too expensive compared to the benefits it produces or think that public money is better spent on other issues.[226] While NASA, for example, enjoys higher support from their constituents based on its[227] Many European citizens do not know much about European space activities and applications and do not necessarily use products resulting from them, beyond very few applications (like navigation). The importance of the outputs from space research and science for Earth's economy and society is not visible or comprehensible to the general public.[228]

The lack of a long-term European vision for space has **economic impacts**: as explained above, long-term strategy provides the necessary framework for the economic actors (e.g., investors, companies, start-ups, R&D&I organisations) to plan when, where, and how to space their resources. The absence of a long-term strategy may cause uncertainty for the economic actors and lead to gaps, overlaps and duplication of their efforts. Another potential impact is the **fragmentation of policies**: a long-term overarching strategy at the EU level should also provide a framework for the coordination of national policy efforts. In the absence of the EU-level strategy, Member States are more likely to design policies geared more towards national needs.

3.1.2. The difficulty of ensuring long-term funding for space activities beyond MFFs

Researchers remark that the lack of public support for space exploration may translate to the lower readiness of the elected politicians to spend money on this less popular issue. This is a long-standing challenge that was already present in the early days of space exploration in the US.[229] Even the part of society that thinks space is important does not necessarily agree that it deserves substantial public investment.[230] The growing commercialisation of space may contribute to the view that public money should not be spent because space activities are seen as 'risky, expensive and not very useful by a large part of the [European] population';[231] private money should be spent on such an enterprise instead. A vast majority of European citizens also overestimate the cost of space activities

224 Naja-Corbin G, Summerer L and Johansson M, 'Space 2030 – Research trends as input for long-term planning', Paper presented at the 59th International Astronautical Congress, 2008, p. 7.

225 Lewis JA, 'Space Exploration in a Changing International Environment', Center for Strategic and International Studies (CSIS), 2014.

226 Relevant studies have been regularly conducted in the US. See, for example, Ipsos, 'Attitudes toward space exploration', 2019; Konicki J and Pethokoukis J, 'Do Americans Care About Space? Making sense of six decades of public ambivalence about the final frontier', *The New Atlantis*, 2022; ROPER, 'Fly Me to the Moon – The Public and NASA', not dated.

227 Ehrenfreund P, Peter N and Billings L, 'Building long-term constituencies for space exploration: The challenge of raising public awareness and engagement in the United States and in Europe', *Acta Astronautica,* 2010, pp. 502-503.

228 ESA, 'How much do European citizens know about space?', 2019.

229 Ehrenfreund P, Peter N and Billings L, 'Building long-term constituencies for space exploration: The challenge of raising public awareness and engagement in the United States and in Europe', *Acta Astronautica,* 2010, p. 503.

230 While there is a lack of relevant European studies, public attitudes in the US may be indicative. See, for example, Ipsos, 'Attitudes toward space exploration', 2019; Konicki J and Pethokoukis J, 'Do Americans Care About Space? Making sense of six decades of public ambivalence about the final frontier', *The New Atlantis*, 2022.

231 Ehrenfreund P, Peter N and Billings L, 'Building long-term constituencies for space exploration: The challenge of raising public awareness and engagement in the United States and in Europe', *Acta Astronautica,* 2010, p. 503.

towards the budget of their countries.[232] Sector stakeholders note that the role of space-based services for Earth's economy is also not always known to all public servants.

At the EU level, it is difficult to ensure long-term funding for all components of its space programme, not least due to structural and technical reasons. The EU's long-term budget has a period of seven years within the MFF. This offers a significant financial perspective for most activities, but the space sector may need an even longer financial horizon to be able to plan R&D and implement projects. Spaceflight beyond Earth's orbit and launch segments are especially affected, but downstream segments are affected too, such as data from Earth observation where – according to stakeholders – public contracts are only short-term and do not correspond to the cadence and speed of activities. Another aspect of the challenge of planning for very long periods is that it is difficult to quantify the economic relevance of the EU space sector in terms of generated output and employment. There is a lag between the initial investments and realised outcomes, as well as difficulty in separating the financial output of the space sector from other economic sectors.[233] Specifically, due to lacking common quantifiable standards and thus data, there is a lack of internationally comparable economic data.[234] Lastly, it is mainly a specific type of long-term funding and support that is lacking. In particular, while fundamental science and lower and middle TRLs are covered fairly well, the financing opportunities for higher TRLs, commercialisation and ventures and start-ups are less widespread.[235] Financial incentives to support the growth and new entrants in the space sector are also missing (e.g., from Member States with a space sector in its infancy or emerging space companies). This includes not only direct financial contributions but also tax incentives and special procurement, which – according to stakeholders – could be better than grants for the companies.

These combined factors make it difficult to foster interest and support in (particular) space activities among all Member States and ensure adequate long-term investment. It may help maintain or even increase the disparities between Member States (see Section 3.1.5) in terms of space access and space use, as it is more difficult for them to benefit from EU funding initiatives.

The lack of long-term funding and special types of funding has **negative economic and R&D&I impacts**, especially for EU competitiveness and innovation in the long run, according to the interviewed stakeholders. Space-related R&D&I and, in particular, space science also cannot be done on the necessary scale or cannot be scaled up to the necessary extent. The number of space companies and space start-ups in the EU is lower when compared to the US, as space companies have a very long development path and distant profits and returns on investment. The lack of funding also increases the risk that small companies, in search of investment, are sold to incumbents, especially space incumbents and digital giants from non-EU countries (usually the US). Alternatively, they may decide to go public, which usually requires disclosing core know-how. **Indirect negative impacts** can be also felt **for society and the environment**. Fewer space companies and R&D&I will translate into fewer jobs for highly qualified scientists and engineers, who may also immigrate to non-EU countries with better financial/regulatory climates for space

232 ESA, 'How much do European citizens know about space?', 2019.

233 OECD, 'Measuring the Economic Impact of the Space Sector – Key Indicators and Options to Improve Data', 2020; OECD, 'Handbook on Measuring the Space Economy', 2nd edition, 2022, p. 120.

234 OECD, 'Measuring the Economic Impact of the Space Sector – Key Indicators and Options to Improve Data', 2020, pp. 8-9.

235 de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission, 2019, pp. 61-62. The new Horizon Europe should improve the situation somewhat as it has many calls for TRL 6-8 for space related projects, see European Commission Decision C(2022)2975 of 10 May 2022, Horizon Europe, Work Programme 2021-2022, 7. Digital, Industry and Space.

entrepreneurs and space science.[236] Space services and innovations linked to space technology are important for the EU's green transition. Slowing down these innovations or lack of them would endanger the implementation of the EU's Green Deal.

3.1.3. Complex governance system of the space sector

European governance in the space area has a high degree of complexity. As explained in Section 2.1.3, next to the EU, the ESA is a long-standing intergovernmental cooperation in which many but not all of the EU Member States and a few non-EU countries participate and through which the EU itself implements space-related projects. Within the EU, several actors are responsible for space policy. Besides the co-legislators, the European Commission is responsible for implementing the EU's space programme,[237] and the recently created EUSPA is responsible for Galileo, EGNOS, Copernicus, and GOVSATCOM. The European Defence Agency (EDA) is responsible for space-related defence capabilities (i.e., Satellite Communications, aspects of Earth Observation, Positioning, Navigation and Timing (PNT), and SSA)[238]. The EU shares its competencies in space with Member States, and many but not all Member States have their own space agency and space policy (see Table 10) that may pursue different objectives from EU-level policy and thus increases the complexity of the governance structure. The overall complex governance structure means that the governance of individual aspects (e.g., critical space assets) is also complicated (the surveyed stakeholders gave an example of Very High-Resolution Earth Observation as such a complex governance issue).

The increasing role of private actors in the space sector further exacerbates the governance complexity. Public-private cooperation is necessary for the development, implementation and adherence to regulations and standardisation of new technologies and services. Recently, attempts have been made to streamline the governance through a stronger alignment between the EU and ESA via the FFPA (see Section 2.1.3 for details).

The creation of EUSPA, with the task of overseeing all EU space programmes, has simplified the governance structure somewhat. Despite these attempts, European governance of space remains complex and may not be clear, especially for the stakeholders outside Europe who are better familiar with ESA and a few established national space agencies (e.g., DLR, CNES, and Agenzia Spaziale Italiana (ASI, Italian space agency)) than with the EU.[239] This is because space stakeholders are linked by contractual and work contacts with ESA and some national agencies, know a long history of involvement in the space sector and have specific expertise in the development and implementation of space missions. A common European approach to space is still lacking or, rather, is divided between the EU, ESA, and their Member States. While synergies can be achieved thanks to the FFPA and coordination at the EU level, duplications, gaps and dissociated activities among different actors can still happen.[240]

The interplay with ESA is complicated because not all EU Member States participate in ESA, and not all ESA Members are also EU Member States (most notably the UK). The UK is a key participant in many projects of key importance for the EU (e.g., Copernicus). Also, ESA adopted an approach of collaboration building on technical competencies. However, the growing security dimension of space and its heightened importance for some countries challenge this approach and requires new

[236] Posaner J, 'Europe's space pioneers struggle to lift off', *Politico*, 14 January 2020; de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission, 2019, pp. 76, 78 and 85-86.

[237] European Commission, 'Defence Industry and Space', not dated.

[238] EDA, 'Space', not dated.

[239] As reported by stakeholders contacted during the development of this study.

[240] ESPI, 'European Space Summit 2022: What is at stake?', Executive brief No. 52, 2021.

political solutions for governance and cooperation. If no solutions are found, these political challenges may lead to more ad-hoc cooperation of a sub-set of states.

The complexity of the governance of the space sector increases the need for and the cost of coordination between different actors while making such coordination more difficult (i.e., **economic and political impacts**). The number of actors involved makes the development of a long-term vision for the sector more challenging and may **exacerbate the fragmentation** of the policy framework and, ultimately, of the single market (see Section 3.1.4). This may lead to more difficult or slower finding of a common position on important international issues and thus **weaken the EU's geopolitical role**. At the same time, the risks of overlaps, duplications and fragmentation of efforts, inefficient use of limited resources and missing of important opportunities increase. A further economic impact is that the complexity by itself may represent a difficulty for the economic actors to plan their investments, funding applications, business development and the like. This may **reduce the space sector's competitiveness and innovativeness**.

3.1.4. Fragmented legal and policy framework

The policy and legal framework for space in Europe is fragmented, mainly in two ways. On the one hand, there is no comprehensive EU-level space policy. For instance, the newly adopted EU Space Programme covers only a few areas of space policy, while many important policies (e.g., space security and defence, space industrial policy) are lacking, and many segments remain unaddressed.[241] There is no common EU position on the fundamental issues covered by the basic five UN conventions related to outer space (e.g., the peaceful use of space, registration of space objects, liability, and debris). The European Commission noted the fragmented approach to Space Traffic Management, as some countries already have respective national legislation.[242] The European Court of Auditors (ECA) found a similar situation with regard to the long-standing EU GNSS programmes.[243] The ECA noted that, in 2019, only four Member States had specific national programmes to support the uptake of Galileo and EGNOS services but did not coordinate them with the responsible EU-level agency. There was also no comprehensive strategic approach for the uptake of Copernicus' services.

On the other hand, the EU and Member States exercise their competences in the space domain in parallel (Section 2.1.2), and Member States are not obliged to coordinate their national space policies or measures with each other or the European Commission.[244] As a result, there is a lot of inconsistency in the space ambitions of individual Member States and in the regulation of space activities. In particular, not all EU Member States have national space policies or national space laws (see Table 10), and the existing national policies and laws cover different aspects that are most relevant for the country and leave a lot of gaps. The state of ratifications of the basic UN space-related conventions by Member States differs significantly across the EU (see Table 9). The lack of consistency and coherence at the national level can be partially attributed to the lack of EU-level frameworks that would provide for a common set of principles, positions, objectives and guidance

[241] This gap was already identified and analysed in 2011. Delponte L, Pellegrin J, Sirtori E, Gianinetto M and Boschetti L, 'Space Market Uptake in Europe', Study for the ITRE Committee of the European Parliament, 2016, p. 40.

[242] European Commission and High Representative of the Union for Foreign Affairs and Security Policy, An EU Approach for Space Traffic Management: An EU contribution addressing a global challenge, Joint Communication to the European Parliament and the Council, JOIN(2022) 4 final of 15.02.2022, p. 11.

[243] ECA, 'EU space programmes Galileo and Copernicus: services launched, but the uptake needs a further boost', Special report 07, 2021, pp. 25-26.

[244] ECA, 'EU space programmes Galileo and Copernicus: services launched, but the uptake needs a further boost',

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for Member States. However, the ECA found that there were also significant differences in how the common EU space policy was integrated into national policies.[245]

Table 10: Non-exhaustive overview of national space laws, policies and agencies of the EU Member States

	National space legislation	National policy/ strategy	National space agency/ unit
AT	Law on Authorization of Space Activities and the Establishment of a National Space Registry of 2018 Regulation of the Federal Minister for Transport, Innovation and Technology in Implementation of the Federal Law on the Authorisation of Space Activities and the Establishment of a National Space Registry of 2018	Austrian Space Strategy 2030+ of 2012	Austrian Space Agency (1972)
BE	Law on the Activities of Launching, Flight Operations or Guidance of Space Objects of 2014	N/A	Belgium Federal Science Policy Office (BELSPO)
BG	N/A	N/A	Ministry of Economy and Industry
HR	N/A	N/A	Croatian Space Agency (2002)
CY	N/A	Cyprus Space Strategy 2022-2027 (draft)	None
CZ	N/A	National Space Plan 2020 – 2025	Czech Space Office (2003)
DK	The Danish Outer Space Act of 2016 The Danish Executive Order on requirements in connection with approval of activities in outer space of 2016	Denmark's national space strategy: Update of strategic objectives of 2021	Danish National Space Center (DTU Space) (2007, predecessor DSRI in 1968)
EE	N/A	Estonian Space Policy and Program for 2020-2027	Estonian Space Office (2010)
FI	Act on Space Activities of 2018 Decree of the Ministry of Economic Affairs and Employment on Space Activities of 2018 The Government Decree on the Finnish Space Committee of 2019	National Space Strategy: Finland 2025 of 2018	Finnish Space Committee (2019)
FR	Law No. 61-1382 of 20 December 1961 Statute of the National Centre for Space Studies Decree concerning the Creation of the Space Committee of 1989	Space Defence Strategy of 2019	National Center for Space Studies (CNES) (1961)

245 ECA, 'EU space programmes Galileo and Copernicus: services launched, but the uptake needs a further boost', Special report 07, 2021, pp. 26-27.

	National space legislation	National policy/ strategy	National space agency/ unit
	French Space Operations Act of 2008 Decree No. 2009-643 of 9 June 2009 on the authorisations issued in application of law No. 2008-518 of 3 June 2008 on space operations Order of 3 September 2019 on the creation and organisation of the space command		
DE	Law governing the transfer of administrative functions in the sector of outer space activities of 1998 Satellite Data Security Act of 2007	For a sustainable German space travel: The Federal Government's Space Strategy of 2010	German Aerospace Center (DLR) (1997, predecessor DARA in 1989)
EL	Law on Authorization of space activities, Registration in the National Register of Space Objects, Establishment of a Greek Space Organization and other provisions of 2017	N/A	Hellenic Space Center (2019)
HU	N/A	Hungary's Space Strategy of 2021	Department for Space Research and Activities of the Ministry of Foreign Affairs and Trade (2018, predecessor - Hungarian Space Office (HSO) in 1992)
IE	N/A	National Space Strategy for Enterprise 2019-2025	Department of Enterprise, Trade and Employment (DETE) and Enterprise Ireland
IT	Law for the implementation for the Convention on International Liability for damages caused by space objects of 1983 Law on Registration of space objects of 2005 Law Decree on Reorganisation of the Italian Space Agency of 2003 Measures for the coordination of space and aerospace policy and provisions concerning the organisation and operation of the Italian Space Agency of 2018	Strategic Document of National Space Policy – DSPSN 2020-2029 Strategic vision for space 2020-2029	Italian Space Agency (ASI) (1988)
LV	N/A	The Space Strategy of Latvia 2021-2027	Latvian Space Office
LT	N/A	Concept for the development of the Lithuanian space sector of 2022	Lithuanian Space Office (2019)
LU	Law of 20 July 2017 on the exploration and use of space resource Law of 15 December 2020 approving the Convention on the Registration of Objects Launched into Outer Space Law of 15 December 2020 on Space Activities	National Action Plan 2020-2024 for Space Science and Technology	Luxembourg Space Agency (LSA) (2018)

	National space legislation	National policy/ strategy	National space agency/ unit
MT	N/A	National Space Policy of 2017	Space Directorate at the Malta Council for Science and Technology (2012)
NL	Rules Concerning Space Activities and the Establishment of a Registry of Space Objects of 2006 Decree of 13 November 2007 containing rules with regard to a registry of information concerning space objects Order of the Minister of Economic Affairs of 7 February 2008, no. WJZ 7119929, containing rules governing license applications for the performance of space activities and the registration of space objects Decree of 19 January 2015 expanding the scope of the Space Activities Act to include the control of unguided satellites	Space policy paper of 2019	Netherlands Space Office (NSO) (2008)
PL	Act of 26 September 2014 creating the Polish Space Agency	Polish Space Strategy of 2017	Polish Space Agency (POLSA) (2014)
PT	Decree-Law no. 16/2019 on legal regime of access to and exercise of space activities Regulation no. 697/2019 on access to and exercise of space activities	Portugal Space 2030 of 2018	Portugal Space (2019, predecessor Science and Technology Foundation - Space Office in 1987)
RO	N/A	Space is a part of the national strategy for science, innovation and smart specialisation 2021-2027	Romanian Space Agency (ROSA) (1991)
SK	N/A	A conceptual framework of space activities in the Slovak Republic for 2020+	Slovak Space Office
SI	Space Activities Act of 2022	N/A	Internationalisation, Entrepreneurship and Technology Directorate at the Ministry of Economic Development and Technology
ES	Royal Decree 278/1995, dated 24th February 1995, establishing in the Kingdom of Spain of the Registry foreseen in the Convention adopted by the UN General Assembly on 2nd November 1974	N/A	National Institute for Aerospace Technology (INTA) and Center for the Development of Industrial Technology (CDTI) (1978)
SE	Act on Space Activities of 1982 Decree on Space Activities of 1982 Ordinance with Instructions for the Space Board of 1996	A strategy for Swedish space activities (2017)	Swedish National Space Agency (SNSA) (2018, predecessor SNSB in 1972)

Source: UNOOSA, 'Index of national space law based on submissions made by states', 2022; Kim DH, 'Global Issues Surrounding Outer Space Law and Policy', *IGI Global*, 2021, pp. 84-108; Sagath D, Vasko C, van Burg E and Giannopapa C, 'Development of national space governance and policy trends in member states of the European Space Agency', *Acta astronautica* 165, 2019, pp. 45-53

The most important **economic impact** of fragmentation is that it **impairs the achievement of the single market** in space. This leads to companies not being able to benefit fully from the economies of scale and scope, and a reduction in their **competitiveness and innovation**. The fragmentation also leads to **gaps in funding**. The EIB notes that 'a coherent and integrated suite of dedicated funding instruments' is lacking and emphasises that early-stage investments, commercialisation, scaling-up of companies and upstream space segments are not adequately addressed.[246] Because of fragmentation, **space assets** (in particular for defence and security purposes) **are underused or used inefficiently** and accorded different degrees of importance nationally.[247] An indirect impact of fragmentation is that it **endangers the achievement of other EU objectives**, particularly the green and digital transition, for which space is instrumental. Fragmentation of the single market also **weakens the international role** of the EU that it could have otherwise played in promoting common international legal standards and regulation on such urgent issues as peaceful and sustainable use of space.

3.1.5. Uneven distribution of the EU space sector

The problem of uneven distribution of the EU space sector across Member States has been known for a long time.[248] This is not a trivial problem, as policy support and involvement in driving a unified vision for space are influenced by an inconsistent ability of national governments, institutions and companies to access the EU space sector.[249] Various stakeholders emphasised different aspects of inequality in the interviews and publicly available materials.

Due to their long presence in the space sector, the industrial capacity for the upstream segment is provided almost entirely by France, Germany and Italy (in this order),[250] which means that employment and investment are also concentrated in these countries (see Sections 2.2.3 and 2.2.4). The uneven distribution is linked to the main production being done by a few companies: eight medium-to-large industrial groups are responsible for 65% of European capabilities.[251] SMEs tend to consolidate around the established industrial base, meaning they are more present in the same countries and grow faster there, while some countries have no space-related industry.[252]

Similarly, space-related R&D&I is also heavily skewed by a few Member States. Out of 2,953 participations in Horizon 2020 space-related projects by organisations from EU Member States,

246 de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission, 2019, pp. 9, 12 and 61-62.

247 Eurodefense Association, 'A space policy for the defence of Europe', Working paper, 2015, p. 2; ECA, 'EU space programmes Galileo and Copernicus: services launched, but the uptake needs a further boost', Special report 07, 2021.

248 Schrogl K-U and Venet C, 'The impact of the European Space Policy on space commerce', in: Smith LJ and Baumann I (eds.), Contracting for space: Contract practice in the European space sector, Routledge, 2011, p. 20; Csernatoni R, 'The EU's Rise as a Defense Technological Power: From Strategic Autonomy to Technological Sovereignty', Carnegie Endowment for International Peace, 2021.

249 Hansen R and Wouters J, 'Towards an EU industrial policy for the space sector. Lessons from Galileo', *Space Policy* 28, 2012, pp. 94–101.

250 Eurospace, 'The current structure of the European space manufacturing sector', 2021, p.2; Schrogl K-U and Venet C, 'The impact of the European Space Policy on space commerce', in: Smith LJ and Baumann I (eds.), Contracting for space: Contract practice in the European space sector, Routledge, 2011, p. 20.

251 Gili A and Fanciulli D, 'A Strategy for the EU and Italy in the Space', 2020.

252 Eurospace, 'The current structure of the European space manufacturing sector', 2021, pp.2-3; Council of the EU, Space for everyone - Council conclusions 14307/21, 26 November 2021, p.3.

France, Spain, Italy, and Germany jointly account for 57%. A handful of companies and organisations from the same Member States are responsible for the top 10 Horizon 2020 participations, namely the DLR (Germany) with 62 participations, Thales-Alenia Space (France) with 49 participations, CNES (France) with 47 participations and Airbus Defence and Space (France and Germany) with 54 participations.[253] At the same time, countries like Malta, Croatia and Slovakia have participation in space-related Horizon 2020 projects in the low single digits. Although the geographical performance gap is a problem for all areas of Horizon 2020,[254] it is clearly present for space-related projects exacerbating the unequal distribution of the space sector.

Such differences among EU Member States are exacerbated by additional factors, such as varying entrance costs (i.e., countries with no pre-existing space industry and organisations that bear much higher costs), national histories of involvement in the EU space sector, and national space policies. EU Member States with space sectors in their infancy usually also do not have political expertise and experience and may not have a well-developed national space policy, which limits their participation in the formulation and implementation of the EU-level policy.

Uneven distribution of the space sector may result in a vicious cycle: A lower level of involvement in the space sector correlates with a limited understanding and/or awareness of the public and businesses about the value of space-related services for the economy and society as well as the positive impact generated by such services, which translates into disengagement and lack of political prioritisation of space (as discussed under Section 3.1.2).[255] Willingness to integrate and further develop common EU-level policies on the topic is, therefore, uneven and primarily found among Member States that are already politically and/or economically active in space exploration and exploitation.[256] The differences between Member States may even stand in the way of common European projects such as the European Launcher Alliance, which was finally launched in 2021, after several years of discussions.[257]

The uneven distribution of the space sector across EU Member States may **impede the sector's growth** and **reduce competition and innovation** by creating market access barriers for new entrants. The R&D&I activities may remain concentrated within a few countries and a few players and fail to spread out across the wider economy. This translates to **lower competitiveness** of the EU space sector overall. Politically, it makes it **more difficult to achieve common positions and develop common visions** and approaches because Member States that lack capacities, expertise and experience in space need more time and more effort to develop genuine national approaches. This may weaken the EU's performance in relevant international forums.

3.1.6. High degree of concentration in the space sector

The uneven distribution of the space sector is linked to the high degree of concentration of the European space industry, especially the upstream segment (i.e. launch, satellite manufacturing in some segments, satellite services, and services for national security).[258] As mentioned in Section

253 All numbers according to the Horizon 2020 Dashboard.

254 For analysis and reasons see Pazour M, 'Horizon 2020: Geographical balance of beneficiaries', Briefing for the CONT Committee of the European Parliament, 2020.

255 OECD, 'Space 2030 - Tackling Society's Challenges', 2005, p. 8.

256 Machay M and Pochylá J, 'European attitudes toward space exploration and exploitation', *Astropolitics* 11:3, 2013, pp. 203-217.

257 Moranta S, 'The space downstream sector: Challenges for the emergence of a European space economy', *Études de l'Ifri*, *Ifri*, 2022, p. 27; SpaceWatch.Global, 'Breton launches European Launcher Alliance and CASSINI fund', 13 January 2021.

258 See Table 11 at p. 51 in: de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission,

3.1.5 above, a handful of companies are prime contractors and responsible for the bulk of space capabilities in Europe. While they maintain their main presence in a few countries, they also expand to Member States with limited or no space industry.[259] These companies are characterised by a high degree of vertical integration (Large System Integrators - LSIs). The example of the launch segment can illustrate the situation. ArianeSpace manufactures the Ariane launcher, with Safran developing the propulsion system. Out of about 40 European suppliers involved in the manufacturing, 25 heavily depend on the Ariane business.[260] At the same time, European incumbents also acquire or heavily invest in (European) space start-ups across different segments,[261] which contributes to the concentration in the industry and stops new developments.

The geographical distribution, concentration and vertical integration of the space market can be attributed mostly to sound economic and financial practices and let companies benefit from the economy of scale and scope (in particular in the upstream segment). However, they are also consequences of the decades of government-led industry, politics of supporting national champions and national procurement programmes for space in certain Member States, while others prefer to ride free on available outcomes for their own purposes.[262]

According to the consulted stakeholders, this presents a **serious difficulty for market entrants.** As the LSIs control or even own the supply chain, independent suppliers find it challenging to plan for future needs due to the **lack of transparency on the market** and experience **difficulties in obtaining funding**. This leads to **lower competition, competitiveness and innovation,** especially in the downstream segment, which is usually spurred by new entrants and start-ups.

3.1.7. Increasing number of new (private and public) actors in space

Technological and scientific advances of recent years – miniaturisation, standardisation, new materials and new manufacturing techniques (e.g. 3D printing) – and as well the adoption of business models and processes from other sectors (e.g. ICT) have led to the possibility of mass production of (some) components for space assets and a significant reduction of the associated costs, especially entry costs to the market.[263] This enabled many new actors to enter the space sector who previously did not have the scale, resources or specific know-how. These new actors comprise not only the public sector (i.e. governments that previously did not have a space industry in their country) but also a variety of private actors, from specialised start-ups in the upstream and downstream to established SMEs discovering the space market for themselves (e.g. being able now to supply parts for mass production) to NGOs[264] that assist with building space capacity and promote policy-making to private investors that rival not only public spending but also government policy visions.[265]

Due to the increased role and influence of the new public and private actors, incumbent actors are facing **increasing competition** in the development and application of space-related services and

2019; European Commission, Towards a Space Strategy for the European Union that benefits its citizens, COM(2011) 125 of 04.04.2011, p. 8.

[259] Eurospace, 'The current structure of the European space manufacturing sector', 2021, p. 3.

[260] Hayward K, 'The Structure and Dynamics of the European Space Industry Base', ESPI Perspectives 55, 2011, pp. 2-3.

[261] For instance, Airbus' venture fund has 43 portfolio companies, see Unicorn Nest on Airbus Ventures.

[262] Eurospace, 'The current structure of the European space manufacturing sector', 2021, p. 4.

[263] Denis G, Alary D, Pasco X, Pisot N, Texier D and Toulza S, 'From new space to big space: How commercial space dream is becoming a reality', *Acta Astronautica 166*, 2020, pp. 431-443.

[264] Lukaszczyk A and Williamson R, 'The role of space related non-governmental organizations (NGOs) in capacity building', *Advances in Space Research 45:3*, 2010, pp. 468-472.

[265] For scenarios of possible billionaires' plan for space see Darnis J-P, 'Space as a Key Element of Europe's Digital Sovereignty', *Notes de l'Ifri, Ifri*, 2020.

technologies and in policymaking.[266] While the **stronger competition** on the market can have **positive impacts in terms of lower prices, better products and services and innovation**, more actors are now competing **for public R&D funding and contracts** that remain constrained and have fixed planning cycles, according to stakeholders. Further **market disruptions and the creation of new markets** can be expected from technological innovation, including due to the partial merging of ICT and space sectors and leveraging the market power of digital giants to certain space segments (e.g., via the communications and Earth observation data value chains).[267] Due to the complex space governance structure, the **risk of duplication and fragmentation** of efforts is growing, which is especially counterproductive in the face of limited resources. The role and future of international and supranational organisations and space agencies, including the EU and the EUSPA, have become less clear. **Without further policy alignment**, adequate governance structures and strategic **cooperation** between the various public and private actors, the development of a long-term, realistic and **coherent vision for the EU space sector, technological sovereignty and competitiveness of the EU is problematic**.[268]

3.1.8. Staying internationally competitive

Global competition in the space market has intensified significantly, not only due to a large number of new actors joining in (Section 3.1.7) and technological innovation that disrupts the market but also due to some of the critical finite space resources becoming congested. The latter refers primarily to frequencies and orbital positions in GEO and LEO that are also becoming overloaded with mega-constellations and polluted with space debris.[269] In this context, some experts are asking whether space competition could become a 'winner-takes-all' race and threaten space as a common province of mankind useable by anyone.[270]

Facing market disruptions resulting from technology and business model innovations by new space actors, European companies need to keep up the speed, innovate, broaden their customer base, attract investments from various sources and look for suitable partnerships.[271] Access to funding is crucial, considering that Europe traditionally lags in terms of availability and amount of public and private money (see Section 2.2.3 for more details).

Besides the company-level competition, the broader competitiveness of the EU relates to furthering strategic partnerships with other regions and countries where the sector is strong and/or developing (e.g., China and the US). This is necessary because, in the space sector, competition rages between jurisdictions as much as between businesses and, at the same time, great interdependencies exist. The EU needs to develop balanced and beneficial interaction with non-EU partners from the public and private sectors while building alliances that allow EU space actors further market access and lessened restrictions. For instance, to remain competitive in the area of

[266] Mölling C and Schimmel F, 'The Role of Space as a Global Common Good for Critical Infrastructure and Industry', Workshop results paper, DGAP Report, 2021, p. 3-4.

[267] Darnis J-P, 'Space as a Key Element of Europe's Digital Sovereignty', *Notes de l'Ifri*, *Ifri*, 2020; Rapp L, 'Major changes coming over the horizon for the global space industry', *Phys.org*, 21 December 2020; Moranta S, 'The space downstream sector: Challenges for the emergence of a European space economy', *Études de l'Ifri*, *Ifri*, 2022.

[268] Council of the EU, Space for everyone - Council conclusions 14307/21, 26 November 2021.

[269] Boley A and Byers M, 'Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth', *Nature*, 2021; Mölling C and Schimmel F, 'The Role of Space as a Global Common Good for Critical Infrastructure and Industry', Workshop results paper, DGAP Report, 2021, p. 3-4.

[270] Mölling C and Schimmel F, 'The Role of Space as a Global Common Good for Critical Infrastructure and Industry', Workshop results paper, DGAP Report, 2021, p. 3-4.

[271] de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission, 2019, p.20; Mölling C and Schimmel F, 'The Role of Space as a Global Common Good for Critical Infrastructure and Industry', Workshop results paper, DGAP Report, 2021, p. 3-4.

STM and SSA, the EU work together with its allies because the EU would need access either to their territories to place sensors or the data collected by their networks. To be an attractive partner in such cooperation, the EU need to stimulate R&D&I in relevant new technologies, services as well as comparable measurement standards and subsequent data that can be used across the global space sector.

Staying internationally competitive is **important for the growth and development of the EU's space sector** – as well as other economic sectors that depend on the inputs from space. **Geopolitically**, a competitive space sector will contribute to the EU's technological sovereignty and strategic autonomy, ensuring that the EU can retain or even enhance its **influence** in the space domain **in the relevant international arenas** (e.g., for international standard setting and rules development).

3.1.9. Technological sovereignty across value chains in the space sector

Technological sovereignty has emerged as a means of promoting European leadership and autonomy and is one of the political priorities for 2030.[272] Technological sovereignty can be defined as 'Europe's ability to develop, provide, protect and retain the critical technologies required for the welfare of European citizens and prosperity of European businesses, and the ability to act and decide independently in a globalised environment'.[273] Space is decisive for the EU to achieve technological sovereignty as it is a small but critical sector of the economy that provides indispensable support to other economic sectors (see Figure 1 and Figure 2). More specifically, it provides communications infrastructure and data for various civilian and defence and security purposes. Space technology inevitably finds its way into the most mundane consumer devices, and the adaptation cycle of this technology is increasing.[274]

At the same time, the EU space sector itself needs to be technologically sustainable, resilient and sovereign. The EU must be able to provide for its space-related needs without getting into one-sided dependencies from non-EU countries. This ability currently is not given across all value chains. For example, due to the retiring of Ariane 5 and delays in the maiden launch of Ariane 6,[275] the EU is risking staying without a heavy launcher that can put into orbit large European payloads. Another example is the successfully launched new Vega C rocket. It uses a Ukrainian-made upper-stage booster, whose supplies might be endangered due to the Russian war of aggression on Ukraine. While another engine is already in development for the next generation of Vega, it will arrive only after several years.[276] A (temporary) loss of launchers may impair the functioning of the EU Earth observation and GNSS systems, for instance, if one of the satellites is broken and requires a replacement. The COVID-19 pandemic demonstrated weak spots and dependencies on foreign suppliers in almost all segments of the EU space sector.[277]

272 European Commission, State of the Union: Commission proposes a Path to the Digital Decade to deliver the EU's digital transformation by 2030, press release, 15 September 2021.

273 Ramahandry T, Bonneau V, Bani E, Vlasov N, Batura O, Flickenschild M, Lämmel P and Noerger M, 'Key enabling technologies for Europe's technological sovereignty', Study for the Panel for the Future of Science and Technology (STOA) of the European Parliament, 2021, pp. 2-3.

274 Darnis J-P, 'Space as a Key Element of Europe's Digital Sovereignty', *Notes de l'Ifri, Ifri*, 2020, pp. 2-3.

275 Berger E, 'The Ariane 6 debut is slipping again as Europe hopes for a late 2022 launch', *ArsTechnica*, 21 June 2021; Berger E, 'Europe's major new rocket, the Ariane 6, is delayed again', *ArsTechnica*, 16 June 2022.

276 Zisk R, 'Arianespace May Experience Vega C Engine Shortages', *Payload*, 28 March 2022; Foust J, 'ESA studies options for Vega C upper stage engine ahead of first launch', *SpaceNews*, 7 July 2022.

277 Scatteia L and Perrot Y, 'Resilience of the Space Sector to the COVID-19 Crisis An assessment of the impacts and resilience to the COVID-19 crisis of the various domains in the space sector', PwC Study for ESA, 2020; ESPI, 'COVID-19 and the European space sector', ESPI Special Report, 2022.

As already mentioned, the lack of technological sovereignty in space has a **negative impact on the achievement of technological sovereignty** by the EU **overall**. While cooperation in space is common and even necessary, such strong dependencies on non-EU countries **endanger European independent access to space and the use of European space assets** for the benefit of various economic sectors and society. Furthermore, they weaken European **defence and security capabilities** and its **position in the international arena** as an international space power.

3.1.10. Ensuring balanced and mutually beneficial international cooperation in space

The emergence of a large number of new private and public actors requires a revision of the established governance systems and rules. This is necessary for inclusive and fair access to space and the use of space resources. Jurisdictions that started space exploration first enjoy an undeniable advantage not only in technology and engineering but also due to 'land grabbing' of scarce resources. For instance, the most valuable (from an Earth economy perspective) space resources – orbital positions and frequencies – are distributed on a first-come-first-served basis by the UN agency International Telecommunications Union (ITU).[278] The most developed jurisdictions have occupied the GEO with thousands of satellites, leaving few slots for new space nations.[279] The same is happening in the LEO, where companies like SpaceX and OneWeb quickly send mega-constellations occupying the available slots and adding to space debris.[280]

Inclusive and fair use of other space resources is also at risk. Space mining for highly valuable materials is a new topic on which some jurisdictions move ahead alone,[281] with little or no efforts to create international rules for this and ensure fair participation and distribution.

Experts are also observing the creation of space blocs – jurisdictions organised around common goals and rules for future space exploration.[282] On the one hand, there is a stronger regional consolidation with the creation of the African Space Agency, Latin American and Caribbean Space Agency and Arab Space Coordination Group. On the other hand, there is a new geopolitical competition and race for the Moon between the countries joining the Artemis Program and Artemis Accords, on the one hand, and the Sino-Russian lunar cooperation, on the other.

The **negative impacts** of these developments are felt mainly in **geopolitics and international space law and relations**. Although collaboration in the space area is welcome and even necessary (to share costs, resources, and know-how), **moving away from an inclusive international environment**[283] and established institutions like UNCOPUOS means increased **fragmentation and duplication of efforts and bears potential for conflicts**. It could make the positions of the parties more entrenched and **reduce trust, complicating reaching compromises and agreeing on common rules**. Space that is supposed to be a province of all mankind becomes increasingly governed by (often fleeting and changing) national interests. Prime evidence for this is that since

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[278] Lewis J, 'Space procedures: A closer look at the international framework for satellite networks', *ITU News magazine*, not dated.

[279] Purity N, 'Spectrum & Orbital Slotting – A case for African Countries', *AfricaNews.Space*, 3 December 2020.

[280] Ogden T, 'Wealthy nations are carving up space and its riches – and leaving other countries behind', *Britannica*, 2022.

[281] Hardy M, 'Luxembourg's Bold Plan to Mine Asteroids for Rare Minerals', *The Wired*, 29 August 2019; Wall M, 'Trump signs executive order to support moon mining, tap asteroid resources', *space.com*, 6 April 2020.

[282] Ben-Itzhak S, 'Space Blocs: The future of international cooperation in space is splitting along lines of power on Earth', *The Conversation*, 21 April 2022.

[283] Some experts qualify the Artemis Accord as an attempt by one nation to be in control of the exploitation of natural resources in space, which would end the international approach that has existed in this context so far. See Green JF, 'The Final Frontier Soon May No Longer Belong to All of Us', *The New York Times*, 28 July 2022.

1979, no new international agreement on space could be adopted, and the 1979 Moon Agreement has only 18 ratifications, mostly from non-spacefaring nations.[284]

3.1.11. Strategic autonomy in the space domain

Besides implementing the EU's green and digital transition, the space domain is essential for the EU to achieve its geopolitical goal of strategic autonomy, as recently emphasised by the President of the European Council Charles Michel[285]. Strategic autonomy is usually defined as the 'ability to act autonomously and to choose when, in which area, and if, to act with like-minded partners'.[286] In the EU, strategic autonomy was associated with space policy from the beginning[287] and is still considered by many its most important domain.[288] The EU is already a major space power with many flagship projects, such as Galileo, Copernicus and EGNOS. The EU is also rolling out more high-profile, unique projects, such as creating a space-based secure connectivity communication system[289] and enhancing the EU (technological and regulatory) STM capacity.[290]

However, maintaining strategic autonomy in space is increasingly challenging for several reasons. First, space becomes more contested and congested due to technological and market developments that result in more and different actors entering the governance arena (see Section 3.1.7). The EU needs an ambitious long-term vision and clear governance structures to maintain its global position. Second, the lack of technological sovereignty (see Section 3.1.9) negatively affects the EU's strategic autonomy. Technological sovereignty is a precondition for strategic sovereignty because it fosters technological innovation and international competitiveness which underpin the EU's ability to influence global developments.[291] The EU needs to channel additional efforts towards responding to emerging challenges (e.g., space debris, protection of space assets, militarisation of space). Third, while space has always been important in the context of security and defence, the Russian war against Ukraine has given this issue a new significance – and urgency.[292] On the one hand, the dependency on Russian launch capacities for European space projects[293] concerns a critical point for the EU achieving its strategic autonomy in access to space. On the other hand, the

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284 UNCOPUOS, Status of International Agreements relating to activities in outer space as at 1 January 2022.

285 Michel C, 'Space action at the heart of European strategic autonomy', Speech at the 13th European Space Conference, 2021.

286 Anghel S, Immenkamp B, Lazarou E, Saulnier JL and Wilson AB, 'On the path to 'strategic autonomy': The EU in an evolving geopolitical environment', EPRS study, 2020, p. 3.

287 On the origins of the concept of strategic autonomy see Darnis J-P, 'The European Union between strategic autonomy and technological sovereignty: impasses and opportunities', Fondation pour la Recherche Stratégique, 2021, pp. 2-3; Csernatoni R, 'The EU's Rise as a Defense Technological Power: From Strategic Autonomy to Technological Sovereignty', Carnegie Endowment for International Peace, 2021.

288 See discussions in Fiott D, Poitiers N, Puglierin J and Alcaro R, 'Achieving Strategic Sovereignty for the EU', Materials of the workshop by the Policy Department for External Relations of the European Parliament, 2021.

289 European Commission, Proposal for a Regulation of the European Parliament and of the Council establishing the Union Secure Connectivity Programme for the period 2023-2027, COM(20220 57 final of 15.02.2022.

290 European Commission and High Representative of the Union for Foreign Affairs and Security Policy, An EU Approach for Space Traffic Management: An EU contribution addressing a global challenge, Joint Communication to the European Parliament and the Council, JOIN(2022) 4 final of 15.02.2022.

291 Crespi F, Caravella S, Menghini M and Salvatori C, 'European Technological Sovereignty: An Emerging Framework for Policy Strategy', *Intereconomics* 56:6, 2021, pp. 348-354.

292 Von Ondarza N and Overhaus M, 'Rethinking Strategic Sovereignty: Narratives and Priorities for Europe after Russia's Attack on Ukraine', SWP Comment 2022/C 31, 2022.

293 For example, the fate of the ExoMars mission is now uncertain as the ESA ended its cooperation with Roscosmos in the wake of the war, and the rover that should have been flown by the Russian Proton rocket and landed with a Russian-built lander now has to look for other solutions. See Wall M, 'Europe ending cooperation with Russia on life-hunting Mars rover', *space.com*, 13 July 2022.

importance of satellite services has grown exponentially for security and defence. Although the establishment of secure communications, observation of the battlefield, navigation and positioning enabled by satellites have been an indispensable element since the first Gulf War, the war in Ukraine has demonstrated how important having one's own satellite fleet is for a jurisdiction,[294] given the capacities of the modern satellite technology and the central role of private actors in the provision of the services named above (especially when combined with the military space-based capabilities).[295]

It follows that the lack of strategic autonomy in space has **negative impacts on the EU's security and defence capability** and on the **EU's role as an international space power**.

[294] Krutov M and Dobrynin S, 'In Russia's War On Ukraine, Effective Satellites Are Few And Far Between', *Radio Free Europe – Radio Liberty*, 11 April 2022.

[295] Sauzay A, 'Space: A Forgotten Battleground of the Ukraine war?', Institut Montaigne, 2022; Borowitz M, 'War in Ukraine highlights the growing strategic importance of private satellite companies – especially in times of conflict', *The Conversation*, 15 August 2022.

Table 11: Summary of the long list of gaps and challenges

#	Gap or challenge	Short description	Impacts
1	Ensuring a long-term vision	Short-term thinking in space policy, inability to develop a long-term comprehensive strategy for the whole EU and mainstreaming space policy and its objectives across various policy areas	Economic: lack of framework for companies and investors, legal uncertainty in business planning and development, inefficiencies in terms of gaps, overlaps and duplications of efforts Political: fragmentation at the national level
2	Difficulty to ensure long-term funding beyond 2027	Ensuring a level of funding, appropriate for the objectives of the space policy and needs of the space sector and going beyond the current MFF 2021-2027	Economic: lower competitiveness, SMEs and start-ups bought by incumbents (from non-EU countries) R&D&I: less innovation, scaling up and commercialisation Society and environment: missing the objectives of the green and digital transition
3	Complex governance system	Presence of many overlapping governance structures at national, EU, and European level leading to more difficult coordination of efforts, lack of transparency, confusing for the market actors and international partners and allowing countries to pursue diverging national policies	Economic: higher cost for market players, lack of transparency, inefficient use of resources; gaps, overlaps and duplication of efforts; reduction of competitiveness and innovation Political: more need for coordination, increasing fragmentation Geopolitics: weaker international position of the EU
4	Fragmented legal and policy framework	Lack of a comprehensive policy and legal framework for space at the EU and national level, gaps in coverage of issues and segments; diverging approaches to space policy and law nationally	Economic: lack of the single market, lower competitiveness and innovation, inefficient use of resources (funding and assets) Political: endangers the achievement of EU objectives Geopolitical: weaker international position
5	Uneven distribution of the EU space sector	Member States, institutions and companies not having equal and equitable access to space capacities	Economic: lower growth of the sector, less competition in the market, higher costs of market entry R&D&I: less innovation and space science Political: higher efforts and costs for policy making and implementation
6	High degree of concentration	Concentration of space sector (upstream segment, R&D&I) around few companies	Economic: lower competition, competitiveness, and market transparency R&D&I: lower innovation
7	Increasing number of new actors	Growing number of public and private actors in the space domain	Economic: stronger competition, disruption of markets, but also lack of funding and risks of inefficiencies

#	Gap or challenge	Short description	Impacts
			Political: greater coordination needs and costs, risks of duplication of efforts
8	Staying internationally competitive	International competition is growing in different space industry segments (e.g., launch services) – not only from the public sector but also from private companies	Economic: growth and competitiveness of the sector Geopolitical: weaker international position, lower technological sovereignty and strategic autonomy
9	Technology sovereignty across value chains	Dependency on third countries in key value chains (e.g., access to space)	Geopolitical: weaker international position, lower technological sovereignty, strategic autonomy, weaker defence, and security capabilities
10	Ensuring balanced and mutually beneficial international cooperation	Inclusive and fair access to space and use of space resources are under threat; lack of international cooperation and start of geopolitical competition	Geopolitical: less cooperation, fragmentation and duplication of efforts, risk of conflict, more difficult to reach agreements on international norms, moving away from international negotiation fora
11	Strategic autonomy in space domain	Maintaining strategic autonomy in space becomes more difficult due to other challenges and the changed geopolitical situation	Geopolitical: weaker international position, weaker defence, and security capabilities

Source: Authors' elaboration.

3.2. Selection of key gaps and challenges

In this section, we distil a final selection of gaps, problems and challenges as input for the Cost of Non-Europe exercise in Chapter 5.

3.2.1. Criteria for selection of gaps and challenges

The development of **criteria for the selection of the most significant challenges** followed two main considerations. The first is practical relevance, meaning that the criteria should help us select challenges suitable for the CoNE exercise (for instance, data needs to be available for the econometric modelling). The second is prioritisation: while many issues affect the EU space sector, the study's limited scope dictates the focus on the most important issues for the EU. Based on these considerations, the following three selection criteria are used:

<u>Significance of the issue</u>: This criterion estimates the prominence with which a gap or challenge is reported by experts and stakeholders. To this end, a group of over 25 experts and stakeholders was surveyed with a question of which of the issues identified through the literature review posed a gap or challenge for EU policy in the space sector. Subsequently, the experts considered the selected issues Very important, Quite important, or Least important. We will grade the importance of each issue as High, Medium, or Low based on the aggregated outcomes of the experts' and stakeholders' opinions.

<u>Relevance for EU action</u>: This criterion relates to the presence and impacts of an observed gap or barrier across the EU space industry but focuses on whether there is room for the EU to act. The indicator maps whether the EU *should* and *can* intervene. First, it analysed whether the issue has relevance to the EU space sector as a whole. Where the same challenge pertains to all Member States or the EU as a jurisdiction, the rationale for an EU-level intervention may be stronger, especially if it can be shown that such action delivers more than initiatives by individual Member States. Second, we analysed whether there is a clear possibility to do so in light of 1) its previous activities (e.g., existing legal framework, policy initiatives, alliances, or proposals) and 2) the nature of the challenge. For instance, if a challenge is purely technical, there might be less room for EU policy to resolve it.

We will grade this criterion as High, Medium, or Low. This grading is based on two sources. First, in the survey mentioned above, experts and stakeholders were asked about which of the ten identified issues were most relevant for EU policy action in the space sector. And second, the survey responses were validated based on the literature review.

<u>Availability of sources/data</u>: The availability of sources/data on a particular challenge is key for their selection for further analysis, as the Cost of Non-Europe can only be calculated if sufficient and relevant (preferably, quantitative) data is publicly available. The availability of sources/data is determined based on estimates by various publications and statistics (e.g. Eurostat). The authoritativeness of the source (e.g., reports from institutions such as the European Commission, European Parliament, OECD, ESA, EUSPA and others) as well as the accuracy of statistical indicators to address a gap or challenge, play an important role. We will grade this criterion as High, Medium, or Low based on the data available in the reviewed literature and identified through desk research.

3.2.2. Short list of gaps and challenges

We applied the three selection criteria presented in the previous section to the long list to distinguish a selection of the most relevant challenges for the CoNE exercise and have come to a final selection of gaps and challenges as presented in Table 12. The selection is highlighted in bold.

In coming to the final selection, each of the three selection criteria had equal weight. In particular, we focused on selecting those challenges that, on aggregate, score most on the criteria. The selected challenges are all prevalent throughout the EU space sector and are relevant for the EU as a whole in terms of achieving its objectives. Moreover, each challenge in the final selection scores at least two 'Highs' and one 'Medium' on the three criteria.

Table 12: Final selection of identified challenges

#	Gap or challenge	Significance	Relevance for EU action	Availability of data	Selected for CoNE
1	**Ensuring a long-term vision**	**High**	**High**	**Medium**	**Yes**
2	Difficulty to ensure long-term funding beyond 2027	Medium	Medium	High	No
3	**Complex governance system**	**Medium**	**High**	**Medium**	**Yes**
4	**Fragmented legal and policy framework**	**High**	**High**	**Medium**	**Yes**
5	**Uneven distribution of the EU space sector**	**Medium**	**High**	**High**	**Yes**
6	High degree of concentration	Low	Low	Medium	No
7	Increasing number of new actors	Low	Medium	Medium	No
8	**Staying internationally competitive**	**High**	**High**	**High**	**Yes**
9	Technology sovereignty across value chains	Medium	High	Medium	No
10	Ensuring balanced and mutually beneficial international cooperation	Medium	Medium	Low	No
11	**Strategic autonomy in space domain**	**High**	**High**	**Medium**	**Yes**

Source: Authors' elaboration.

4. EU-level Policy Scenarios

The identified challenges to the EU space sector hamper the achievement of the objectives of the EU space policy as they lie precisely in the same area. The objectives of Article 189 (1) TFEU for the EU activities in the space sector (see Section 2.1.2) were rendered more precise in the 2016 EU Space Strategy and 2021 EU Space Programme. As Table 13 demonstrates, some of the declared objectives correspond exactly to the challenges identified in the study (i.e., the objective of simplifying space governance corresponds to the challenge of complex governance). Other declared objectives are more specific by comparison to the identified challenges (i.e., the objective of the autonomous access to space is narrower than and just one of the issues of the challenge of the strategic autonomy in space overall).

Table 13 Objectives of the 2016 EU Space Strategy and 2021 EU Space Programme

2016 EU Space Strategy	2021 EU Space Programme
Strengthening Europe's role as a global actor and promoting international cooperation	Securing EU leadership in space
Fostering a globally competitive and innovative European space sector	Fostering innovative industries
Reinforcing Europe's autonomy in accessing and using space in a secure and safe environment	Safeguarding autonomous access to space
Maximising the benefits of space for society and the EU economy	Simplifying space governance

Source: Authors' elaboration.

Moreover, the identified challenges may also reduce the effectiveness of other EU policies, to which the space sector contributes. This refers first and foremost to the achievement of the goals of the green and digital transition and post-pandemic recovery. However, the goals of the EU policies in the areas of transport, environment, security and defence and connectivity may also be in danger as these sectors heavily rely on space-based products and services (see Section 2.2.1).

The 2016 EU Space Strategy and 2021 EU Space Programme already outline some solutions to the identified challenges within the limits of the scope of these documents. However, the EU policy-making needs more and fresh policy options for the following reasons. The 2016 EU Space Strategy needs an update due to the changed geopolitical situation, post-pandemic recovery needs, green and digital transition goals, and rapid technological developments of the last few years. The 2021 EU Space Programme provides such an update only partially, focusing on only six topics.

The subsequent Section 4.1 presents an approach to the development of Policy Scenarios that can address broader significant challenges identified in this report. After that, Sections 4.2-4.4 describe three possible Policy Scenarios and their content (i.e., individual policy measures) in detail highlighting their relevance for addressing challenges to the EU space sector.

4.1. Development of Policy Scenarios

Based on the literature review and consultation with stakeholders, we developed a set of targeted policy measures to address each key challenge identified. While not comprehensive, Table 14 provides a concise summary of considered measures.

Table 14: Summary of policy measures to address the key challenges (exemplary)

Gap or challenge	Possible policy measures
Ensuring a long-term vision	Defining a long-term vision and strategies with roadmaps and measurable targets, which should be updated regularly High-level summits / other meetings to shape such vision Mechanisms to ensure closer coordination between the EU and ESA as well as at the national level, e.g., regular meetings at the ministerial level
Complex governance system	Mechanisms to ensure closer coordination between the EU and ESA as well as at the national level, e.g., regular meetings at the ministerial level Clearer delimitation of competences between all actors and better communication of who is responsible for what
Fragmented legal and policy framework	Close the gaps in space policy at the EU level Mainstreaming space in other policies and vice versa Explore the possibility of adopting legal acts where a common approach is possible Coordination of national policies Greater cooperation/ coordination between the EU and ESA
Uneven distribution of the EU space sector	Encourage growth of space sectors in all Member States, especially 'young' space nations More nuanced and inclusive approaches to space R&D&I and education programmes Special (financial) support instruments for space SMEs, start-ups, and new entrants Transparency/ information sharing (incl. technology transfer) Greater coordination between national policies, funding, and other efforts
Staying internationally competitive	Mechanisms to ensure closer coordination between the EU and ESA as well as at the national level Develop space industrial policy Transparency/ information sharing (incl. technology transfer) Special (financial) support instruments for space SMEs, start-ups, and new entrants Support the EU space industry through procurement, tax incentives, etc.
Strategic autonomy in the space domain	Mechanisms to ensure closer coordination between the EU and ESA as well as at the national level Develop space industrial policy Promote competition in the space sector Special (financial) support instruments for space SMEs, start-ups, and new entrants Support the EU space industry through procurement, tax incentives, etc.

Source: Authors' elaboration.

These policy measures can be packaged into several Policy Scenarios that signify different approaches to support the EU space sector and reflect different degrees of EU-level intervention. At the same time, each Policy Scenario will address several key challenges directly and the rest indirectly. The Policy Scenarios also will address those challenges that were not included in the final selection for the CoNE exercise.

While each Policy Scenario is stand-alone, they can also be combined (as further explained in Section 6). Alternatively, individual policy measures can be mix-and-match.

The subsequent Section describes each Policy Scenario in more detail, outlining various policy measures that can be adopted at the EU level. The Policy Scenarios are presented in the order of the intensity of the EU-level action, from the lowest to the most ambitious.

4.2. Policy Scenario 1 – Supporting the EU space ecosystem

This Policy Scenario is based on the premise that many gaps can be closed and challenges met if an appropriate and effective policy and legal framework support the space economy, encouraging competition and levelling the playing field within the common market.

The EU has already adopted many different measures to support the economy in general; R&D&I and the competitiveness of SMEs and start-ups that will also benefit the space sector. Examples of such measures include the SME strategy,[296] innovation procurement,[297] Horizon Europe[298] and funding and investment opportunities under Next Generation EU. Many of these new measures contain instruments targeting specifically the space sector. For instance, under the SME strategy, the Space Entrepreneurship Initiative CASSINI was launched in 2022 which provides seed and growth funding for space start-ups. Horizon Europe has a special Cluster 4 'Digital, industry and space' that supports R&D to reach strategic autonomy along the whole value chain, namely in developing, deploying, and using global space-based infrastructures, services, applications and data.[299]

However, the existing measures can be gauged and adjusted even more to address the specific needs of the space sector.

In space, governments remain the biggest customers, which makes **public procurement** a key support instrument[300] that can be adjusted in many ways to foster the sector development, to strengthen its competitiveness and support SMEs and start-ups.

To support demand, the EU could introduce a '**buy European**' rule **when purchasing certain space-related services**. For example, all publicly procured satellites should be launched only with European rockets. Such a rule is likely to be in compliance with the EU's obligations under the WTO Agreement on Government Procurement as the latter allows exceptions from open procurement in the case of national security interests.[301] Many space technology and applications are dual-use, which would fall under this security exception.

More EU-level **public procurement should be used instead of, or in addition to, conventional R&D support** under Horizon Europe. The commercialisation of space-related technologies and applications in Europe is problematic. On the one hand, there is a lack of adequate funding for high TRLs and commercialisation. On the other hand, research performed at lower TRLs often fails to link

296 European Commission, An SME Strategy for a sustainable and digital Europe, COM(2020) 103 final of 10.3.2020.

297 European Commission, Guidance on Innovation Procurement, C(2021) 4320 final of 18.06.2021.

298 Regulation (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013, OJ L 170, 12.5.2021.

299 See European Commission Decision C(2022)2975 of 10 May 2022, Horizon Europe, Work Programme 2021-2022, 7. Digital, Industry and Space.

300 Brichta M, 'Spin-In and Procurement Support as Key Components for Industry Development in Emerging Space Countries', *New Space 10:3*, 2022.

301 See Article 28 of the WTO Agreement on Government Procurement of 2012.

up to market needs. To overcome this, outcome-based procurement could be used as well as procurement targeting the development of capabilities.[302] For this type of procurement to be successful, it is necessary to have a clear vision of what capabilities need to be developed, and outcomes must be defined (i.e., policy and/or market needs to be identified first). It is important to focus on procuring a product or services and remain technology-neutral as this will attract the largest number of competitors and spur innovative solutions.[303] The additional positive impacts of such procurement is that it allows for the innovation of solutions, signals realistic demand for R&D and requirements to the market, supports the development of necessary skills and market segments, and is likely to encourage closer public-private cooperation.

To guarantee a certain take-up of a space-based product or service, the **anchor tenancy** approach should be used in procurement, for which the demand from various Member States could be bundled at the EU level. Anchor tenancy means a multi-year contract and guaranteed government business for a commercial entity. It allows SMEs and start-ups to validate their operational concepts, reduces legal uncertainty, provides revenue, helps raise more money on the market and, ultimately, helps the companies grow and mature.[304] The approach pioneered by NASA has greatly stimulated the growth of commercial space companies in the US and led to innovations in space launch and Earth observation.[305]

While the described procurement measures will support the competitiveness of the EU space sector from an international perspective, they are also likely to enhance competition in the EU market by providing more opportunities to new entrants to the market, SMEs, and start-ups. However, even more targeted measures could be adopted to support new entrants, SMEs, and start-ups and to grow the space economy in the EU overall.

To continue with the procurement domain, **special procurement programmes or calls** could be designed, for which **only SMEs and start-ups** may apply. These can be based on the SME instrument at Horizon Europe, European Defence Fund (EDF)[306], or inspired by specialised NASA programmes.[307] Participation of SMEs and start-ups could be encouraged by using **special reimbursement schemes** (e.g., SMEs and start-ups get 100% cost covered, while incumbents get less). Consortiums with **meaningful SME and start-up participation could be awarded extra points** in the selection procedures, although it needs to be ensured that such participation is effective and not just a formality. To promote **diversity and democratise the market** even further, similar incentives can be introduced, for example, for minority- or female-owned businesses. **All these measures could also be introduced for R&D funding for space-related research.**[308]

302 Lofgren E, 'NASA sets a model using high-level requirements and letting private companies innovate', *Acquisition Talk*, 10 June 2020.

303 de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission, 2019, p.12.

304 See also Bryce Tech, 'Innovative public procurement in space – Phase 1', summary report for UK Space Agency, 2021.

305 de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission, 2019, pp. 101-103; Werner D, 'NASA Anchor Tenancy Change Encourages Commercial Space Backers', *Space News*, 6 June 2011.

306 See a summary of EDF's inceptives for SMEs.

307 See NASA programs Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR).

308 The new Women TechEU initiative under the European Innovation Ecosystems work programme of Horizon Europe is a step in the right direction, but the current calls aim more at the business development of women-led start-ups and provide fairly small funding relative to the demands of the R&D&I in the space sector (EUR 75,000 per grant). See calls HORIZON-EIE-2021-SCALEUP-01-03: Women TechEU and HORIZON-EIE-2022-SCALEUP-02-02: Women TechEU in European Commission Decision C(2022)2975 of 10 May 2022, Horizon Europe, Work Programme 2021-2022, 10. European Innovation Ecosystems (EIE).

Stakeholders from small countries and countries with nascent space sectors emphasised the importance of the geographical return scheme practised by ESA in its procurement.[309] It helps develop the space sector and raise awareness of space-related capabilities across ESA Members while retaining focus on national priorities. Both countries and companies are gaining experience with cooperating on high-profile missions. While replicating the **geographical return** at the EU level may not be possible due to legal requirements of competition and State aid rules, the mechanism **should be studied to see what elements could be adjusted and used**.

According to the interviewed stakeholders, SMEs, and start-ups from countries with a nascent space sector often experience difficulties entering the greater EU market and bidding for large Horizon Europe (Horizon 2020) grants and procurement projects. Some interviewed stakeholders suggest that, for EU projects that require high-TRL suppliers, a scheme could be used where Member States first take stock of capabilities and eligible companies internally, select the most promising and then support their bid at the EU level. This way, SMEs and start-ups can focus on their technical offers, which the public sector supports the administrative part of. For Member States, this would provide an opportunity to have a full overview of national capabilities and take decisions about their development.

The described procurement and R&D measures will help to develop a level-playing field for all actors in the space sector and competitiveness. However, space companies need support at all stages of their development, and it has been found that European space companies are less advanced and with unproven business models in comparison to their counterparts in other countries. Hence, more **financial instruments** should be developed **to support start-ups** and new entrants. The entrepreneurship fund CASSINI is an important first step in the right direction, but more needs to be done to unlock private and public financing in the EU to reach the levels of the leading non-EU countries.[310] Special mechanisms and instruments need to be designed to meet the needs of the sector that is characterised by very high risk and long RoI. An extensive study and **recommendations** have been provided on the matter and remain topical **by the EIB**.[311]

To support the development of space start-ups, **dedicated incubators and accelerators** are necessary, considering the specifics of the sector. There is a network of Business Incubation Centres (BICs) run by ESA.[312] The EU does not need to duplicate them but should focus on **closing the gaps and enhancing this network**. For instance, there are no ESA BICs in many Central, Eastern, and Southern European countries (e.g., Bulgaria, Latvia, Lithuania, Romania, Poland, Slovakia, and Slovenia), so the EU could step in to fill the gap there. Initiatives like Astropreneurs – a three-month bootcamp for space entrepreneurs – should be extended and supported.[313] A **link with European Digital Innovation Hubs** (EDIHs) should be established or EDIHs could be opened for space

309 In essence, geographical return means that an ESA Member can expect to receive back, in contracts, a minimum coefficient of 0.85 of the money contributed to ESA. For a concise overview, see ESA, 'Industrial policy and geographical distribution', 2018. This policy is one of the drivers of ESA's success.

310 Naujokaitytė G, 'SMEs look to play a bigger part in EU space industry', *Science Business*, 7 October 2021.

311 See Recommendation 4 in de Concini A and Toth J, 'The future of the European space sector: How to leverage Europe's technological leadership and boost investments for space ventures', Study of the EIB for the European Commission, 2019.

312 See ESA, 'ESA Business Incubation Centres', not dated.

313 The initiative Astropreneurs Accelerator was a Horizon 2020 project that ended in 2020.

entrepreneurs as there are a lot of synergies between the digital and space sectors in terms of talent, solutions, business models and technology.[314]

To support a wider space ecosystem and to grow the market, a **technology transfer** policy should be developed. Making technology available to SMEs and start-ups, and enabling space technology transfer **to related sectors (i.e. spin-in**, to automotive, transport, logistics, forestry agriculture and others) have proven successful measures in the US[315] and are already used in some EU Member States (e.g. Slovakia).[316] Such measures effectively support new entrants to the sector and also boost non-space industries while providing many opportunities for the cooperation, mutual learning and marketing of space products and services.

4.3. Policy Scenario 2 – Greater coordination at the EU level

The premise of this Policy Scenario is that most of the identified challenges could be resolved through greater coordination between the main policy actors as lack of coordination or inefficiency seems to be a central underlying issue. Coordination should be improved both between competent regional organisations (i.e., EU and ESA), the EU and Member States, and between the Member States themselves. Besides active participation, the role of the EU would be to enable this coordination by providing a forum and support for it (e.g., mechanisms, and institutional structures). Coordination measures will help reduce gaps, overlaps and duplications in the activities of the policy actors and more effectively and efficiently utilise the limited resources available.

Coordination and cooperation at the regional level are already organised and institutionalised, not least through the 2004 EU-ESA Framework Agreement, 2022 FFPA and EU Space programmes. However, it would be advisable to **communicate clearer the division of competences and roles towards stakeholders**. In particular, it is often unclear to the consulted stakeholders what the different EU bodies do in the space domain and how their roles differ (e.g., delimitation of competences between EDA and DG DEFIS). According to the stakeholders, a welcome **simplification of governance** would be the designation of one EU body as the responsible counterpart for all space policy and implementation activities or an explicit division between policy and implementation assigned to two different EU bodies. In practical terms, a map or organigramme highlighting links, competences, responsibilities, and hierarchies would be advantageous for all space sector stakeholders.

The majority of interviewed stakeholders noted that the current legal framework for the coordination and cooperation between the EU and ESA is insufficient and needs to be improved, to provide a solid foundation for the future development of the space sector. The 2004 EU-ESA Framework Agreement has been completely overtaken by the Lisbon Treaty and does not reflect the EU's new competences anymore. The 2021 FFPA enables an operational partnership between the EU and ESA, but it is limited to the EU Space Programme. However, the EU and ESA need to coordinate more both at the policy level (i.e., ministerial meetings need to have continuity) and operational level (e.g., programmes and projects). It is necessary to **update the 2004 EU-ESA Framework Agreement**, based on the experience of working together, to articulate the role of each regional organisation in the space domain comprehensively, how they will collaborate in future and

[314] This was one of the recommendations from space experts for the Biden administration: Ganote S, Penn A, dale Rose ND and O'Shea C, 'Buying 'New-Space-Smart': Space acquisition advice for the Biden administration', *Avascent Perspectives*, 2020.

[315] Nakahodo SN and Gonzalez S, 'Creating startups with NASA technology', *New Space 8:3*, 2020; Nurton J, 'Tech transfer at NASA: bringing NASA technology down to earth', *WIPO Magazine*, 2022; Balasubramaniyan A, 'NASA Initiative Puts Space Age Technologies At Entrepreneurs' Fingertips', *TechCrunch*, 30 November 2015.

[316] Brichta M, 'Spin-In and Procurement Support as Key Components for Industry Development in Emerging Space Countries', *New Space 10:3*, 2022.

how they will achieve synergy of their efforts for the benefit of their Members and building on the strengths of each organisation. The roles of non-EU Members of ESA need to be clarified.

Coordination between the EU and Member States is crucial because of how competences are distributed in the space policy domain (see Section 2.1.2). Also, the national ambitions of Member States differ significantly based on the space legacy, state of the industry, geopolitics, and other considerations. The EU must drive greater coordination to achieve the general objectives of European integration and the specific goals of the EU in space. Such coordination is necessary both at policy and implementation levels as it will reinforce the alignment of national and EU policies.

At the **policy level**, a **cohesive approach** needs to be developed at least **on the most pertinent issues** (e.g., green transition, anti-satellite weapons, space diplomacy). The EU could also coordinate Member States' positions/responses on the Artemis Accords as many countries are currently considering this document. This can be done in the form of Council conclusions that set coordinated positions or express a common political position regarding a particular event. Such agreed positions can then be incorporated consistently in national policies and also argued or presented by Member States in international organisations and other international arenas. This could build a basis for national policy alignment and effect change in the international context. The EU could facilitate the process of identifying such common messages or positions by analysing national policies and laws and developing guidelines. It also has many opportunities to negotiate common messages and positions (e.g., in the European Parliament and Council). The EEAS has an important role in delivering such common positions to the world.

Coordination and cooperation at the **operational** level can be facilitated by tools for **information exchange and sharing and mutual learning** designed and supported at the EU level. Different stakeholders are involved in space policy implementation (as well as policy-making) – from ministries of industry to ministries of culture and science to national space agencies. A **specialised network, platform or thematic working groups** can be organised for them, under the aegis of the European Commission, following the example and experience with similar structures in other areas. National space agencies (or other responsible units) could meet regularly under the aegis of the EUSPA to discuss the optimisation of the EU Space programme implementation. To support the less experienced space nations, a **twinning programme** for competent authorities could be organised.

On an even more practical level, **coordination between civil and military (security and defence) procurement** should be encouraged, which allows for leveraging government buying power and reducing or avoiding duplication and redundancy. This type of interagency coordination has worked well in the US, saving time and money for NASA and the Department of Defense (DoD) and enabling mutual learning.[317] It also led to the development of the successful Shuttle program.[318] The role of the EU under this measure could be to study best practices and mechanisms and to provide recommendations and guidance on this to the Member States, as well as to coordinate its own civil procurement with the military procurement of Member States.

Another necessary practical exercise in information sharing and cooperation would be **taking stock of national capabilities** relevant to the EU Space Programme and key elements of the space sector (e.g., ground infrastructures, like sensors and radars, or testing facilities). The EU could coordinate by creating and maintaining a (secure) inventory or database. This would demonstrate the competitive strengths of each country, help identify gaps that need to be closed, and thus encourage cooperation as well as facilitate planning at the EU and national levels.

[317] US Government Accountability Office, 'Space Launch: Coordination Mechanisms Facilitate Interagency Information Sharing on Acquisitions', 2017.

[318] Harris E, 'Standard Spacecraft Procurement Analysis: A Case Study in NASA-DOD Coordination in Space Programs', RAND Report, 1980.

This Policy Scenario could culminate in the development of a **long-term strategy** or vision **for the EU in space**. This should be a strategic document for 20+ years, with an inbuilt mechanism for regular adjustment to reflect technical, political and market evolution (e.g., periodic reviews). The development of a long-term strategy is difficult to operationalise. However, precisely because it will take long and involve many stakeholders, the process should be started as soon as possible. **Discussions among Member States** (e.g., various responsible ministries) and with other stakeholders would be important to identify different countries' positions on and ambitions in space and to understand the changing role of space in the current geopolitical circumstances. **ESA** should be a part of this process from the beginning because ESA is a vital component of the EU's space efforts and, ideally, the EU and ESA long-term strategies should be strongly aligned. This will help to have more resources for working on common goals. The process for the development of a long-term strategy will serve as a coordination measure in itself because it will make EU Member States more aware of each other's plans and capabilities.

4.4. Policy Scenario 3 – Comprehensive EU-level space policy and legal rules

This Policy Scenario is more ambitious than the previous ones and suggests more assertive actions by the EU. It is based on the premise that the EU does not use the opportunities for action within the given competences to the full extent.

The EU needs to **adopt a comprehensive policy on space that would cover both civil and military uses** of space. The 2016 EU Space Strategy and EU Space Programme are steps in the right direction, and the EU should build on them to develop a future document. The EU Space Programme is an operational document limited to only six areas and largely brings under one umbrella projects that have been going on for years. It is not future-proof enough and does not spell out the EU's role across all space-related topics. The 2016 EU Space Strategy needs to be updated, given the new geopolitical situation and become more operational across all topics as it is quite vague on implementation currently. The future comprehensive space policy must include **clear and concrete objectives** (preferably for short, medium, and long term) and a **structured way of how they can be achieved and measured**. It also needs to define many terms describing the EU's ambitions.[319] For example, does 'freedom of action and autonomy' mean completely independent access to space or does it include a possibility for a strategic partnership? What are the main dependencies in space the EU needs to overcome? Can we set criteria or standards for assessing levels of dependencies and develop a problem-solution tree to decide how to treat them? Last but not least, the new comprehensive space policy needs to address the governance of the space sector and the role of ESA in supporting the EU in delivering its objectives.

As such a comprehensive document will take time to draft, in preparation for it, the EU can also **adopt several dedicated policies on important space domains**. Examples of such domains where an EU-level action is advisable and even urgent – in particular due to the geopolitical situation – are **policies on security and defence in space, sustainability in space, and industrial policy**. Work on these policies can draw on the recently adopted EU-level policies that already indicate the relevance of space. For instance, a space industrial policy should build on the new EU industrial strategy[320] and the Action Plan on synergies between civil, defence and space industries[321] that

[319] See examples in ESPI, 'Security in Outer Space: Rising Stakes for Europe', Report 64, 2018, pp. 66-67.

[320] European Commission, A new Industrial Strategy for Europe, COM(2020) 102 final of 10.3.2020.

[321] European Commission, Action Plan on synergies between civil, defence and space industries, COM(2021) 70 final of 22.02.2021.

foresees actions at the level of programmes, technologies, innovation, and start-ups. The EU Global Strategy,[322] EU Security Union Strategy[323] and Roadmap on critical technologies for security and defence[324] provide inspiration for security and defence in space.

The next measure under this Policy Scenario is to **mainstream space in other Union policies**. Space as a critical infrastructure is instrumental for the performance of many other sectors of the economy (see Section 2.2.1). Incorporating space into the policy measures targeting other sectors will raise awareness of the significance and uses of space, help towards creating or increasing demand for space-based products and services, and improve outcomes of those other policies. Space is already mentioned in some policy documents, but this is not done **consistently**. For example, the recently adopted EU Biodiversity Strategy for 2030[325] does not mention the use of space technologies at all, even though space imagery can be used for monitoring biodiversity and ecosystems with high precision and GNSS can track wildlife, enabling evidence-based policy and regulation, ecological modelling and quick decision-making.[326] The development and use of cases of space-based applications could have been included in the EU Biodiversity Strategy and other documents to signal demand to the space sector and encourage users' uptake. The EU-level documents should **provide more detail, examples, best practices, or guidance** on the use cases and applications because the awareness of the public sector and other potential users is relatively low.

Finally, the EU should also **explore adopting legal rules** in the space domain.[327] While the EU cannot adopt harmonising legislation, there are possibilities of other legal acts **as well as soft law**. For example, within the framework of the Common Foreign and Security Policy, general guidelines and decisions can be issued. Legal rules strengthening cooperation between Member States can be adopted on all topics related to the space sector. The EU can also issue technical measures, recommendations, and guidelines. In this context, work at the EU level can start with low-hanging fruit, i.e., adopting legal rules in those areas where there is a consensus among Member States (e.g., based on the international agreements ratified). It would be also important to address pertinent international issues, such as space debris or sustainability in the space sector. Considering the growing interest in the Artemis Accords among the EU Member States, it may be advisable for the EU to draft a position on it as well, especially because some legal experts qualify them as a polarising development and an end of multilateralism in space law-making.[328]

322 European Commission, Shared Vision, Common Action: A Stronger Europe A Global Strategy for the European Union's Foreign And Security Policy, 2016.

323 European Commission, EU Security Union Strategy, COM(2020) 605 final of 24.7.2020.

324 European Commission, Roadmap on critical technologies for security and defence, COM(2022) 61 final of 15.02.2022.

325 European Commission, EU Biodiversity Strategy for 2030: Bringing nature back into our lives, COM(2020) 380 final of 20.05.2020.

326 See, for example, UNCOPUOS, Space Technologies for Monitoring and Protecting Biodiversity and Ecosystems, 2015; Williams C, 'Applications of satellite technologies for biodiversity conservation', *Medium*, 6 November 2021; Pennisi E, 'Getting the big picture of biodiversity', *Science*, 18 November 2021.

327 The European Commission is already planning to do this in the area of Space Traffic Management. See Action 7 in European Commission and High Representative of the Union for Foreign Affairs and Security Policy, An EU Approach for Space Traffic Management: An EU contribution addressing a global challenge, JOIN(2022) 4 final, 15.02.2022.

328 Nelson JW, 'The Artemis Accords and the Future of International Space Law', *American Society of International Law* 24:31, 2020; Azcárate Ortega A, 'Artemis Accords: A Step Toward International Cooperation or Further Competition?', *Lawfare Blog*, 15 December 2020; Green JF, 'The Final Frontier Soon May No Longer Belong to All of Us', *The New York Times*, 28 July 2022; Ben-Itzhak S, 'Space blocs: The future of international cooperation in space is splitting along lines of power on Earth', *The Space Review*, 25 April 2022.

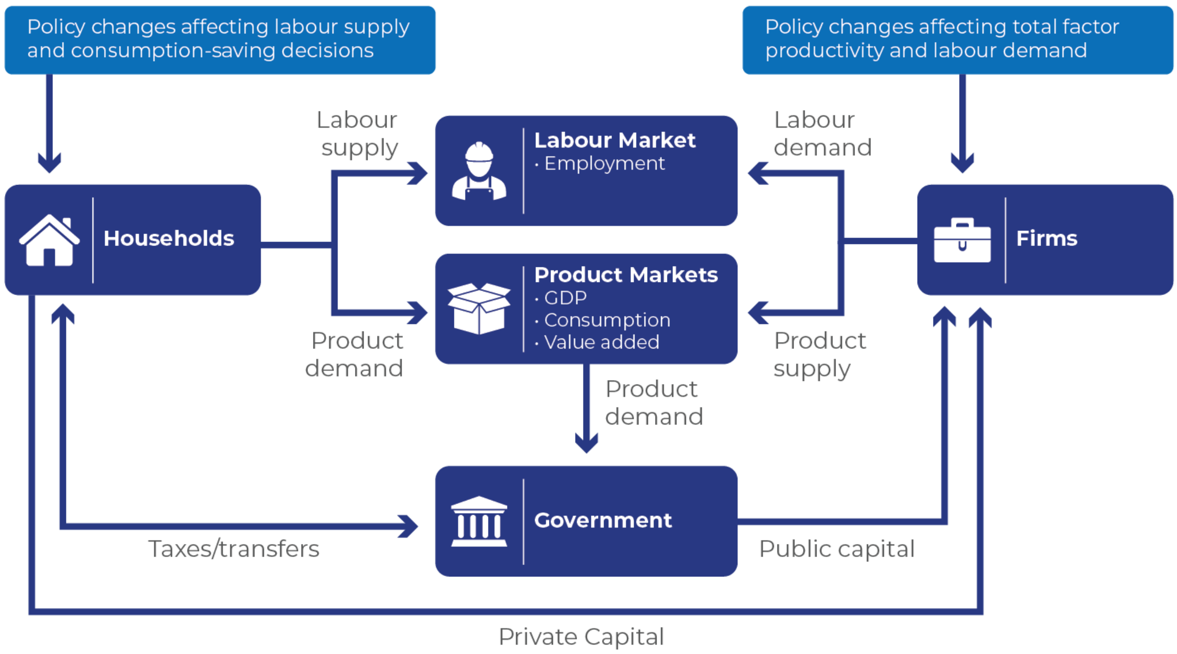
5. Cost of Non-Europe in space

This chapter assesses how the different Policy Scenarios affect the EU economy and what kinds of costs and benefits are expected. The impacts of each Policy Scenario are assessed separately, quantitatively and qualitatively. The quantification of impacts is conducted through a computable general equilibrium (CGE) model; the methodological note on CGE can be found in Annex I. Qualitative assessment discusses how well a Policy Scenario addresses gaps and barriers and what other, non-quantifiable impacts it has. Additionally, the feasibility, proportionality and subsidiarity of Policy Scenarios are discussed.

5.1. Methodology of quantification

The quantification of impacts is conducted through a computable general equilibrium (CGE) model. The main structure of the model that serves to compute per-period outcomes is augmented with a set of dynamic equations that allows the calculation of the impact of shocks over a specified time horizon at an annual frequency. The CGE model is an open economy model with a tailor-made sectoral breakdown and a government sector. Calibration is carried out using recent data for the EU's economy. More information on the model structure and calibration is presented in Annex I. The following chart illustrates the functioning of the key components of the CGE model.

Figure 14: Main economic mechanisms in the CGE model.



Source: Authors' elaboration.

The choice of a CGE model over alternative approaches is motivated by the fact that the CGE model relies on a structural modelling paradigm. It explicitly specifies the motivation and incentives of economic agents, which makes it suitable for studying situations characterised by structural changes or featuring the implementation of alternative policies. In contrast, purely data-driven techniques rely on extracting patterns from the past and may be limited by the need to rely on specialized datasets. When considering alternative states of the world and Policy Scenarios, CGE models are suitable because they are based on explicit microeconomic foundations, which helps trace the channels of impact and provides a degree of robustness against over-reliance on pattern extraction and extrapolation from the past. At the same time, sectoral interlinkages allow the measurement of indirect effects arising from changes in a specific sector of the economy.

The Cost of Non-Europe is calculated as the difference between the baseline and the ideal state scenario, considered over the horizon 2022-2050. The **baseline scenario** reflects expected economic developments in the absence of further policy changes at the EU level. It is constructed using responses on the status quo from the Delphi method survey reported in Evas and Lomba (2020)[329] for the respective channels of impact, updated with information from the survey (see Annex I and Annex II for a detailed description). This accounts for the dynamics of current developments and facilitates the capturing of currently observed trends that can be expected to continue in the absence of EU-level policy changes. Thus, the baseline scenario is not stationary, but its changes reflect a projection of already observed developments and confirmed future changes. The baseline scenario by design takes into account information on approved policy actions that was available as of mid-2022. It also reflects the integrated assessment of Delphi survey respondents and space survey respondents as to the combined impact of these policy actions on selected inputs to the model, e.g., productivity or labour market characteristics.

The **ideal state scenario** represents a hypothetical situation where no shortlisted challenges (see chapter 3 for an overview of the challenges) related to the space sector exist and there are no setbacks or obstacles to the development of the space sector in the EU and associated economies that can be removed by policy actions at the EU level. To measure this, we created a simulation in which the respective gaps from the final selection are lifted immediately and fully. In doing so, the analysis can estimate the extent of the gap between the actual situation (baseline scenario) and the potential size of the ideal state scenario. It is important to note that our current modelling approach is based on the assumption of non-diminishing gaps between the baseline and the ideal state. This implies that the gaps tend to accumulate, and the divergence becomes more pronounced over time.

It should also be noted that the ideal scenario does not necessarily represent an implementable situation but provides a framework to account for the economic consequences of the challenges under consideration. Removing some of these gaps in their entirety may be out of reach because of implementation costs, political complications, or timing considerations. Thus, the ideal scenario provides a theoretical upper bound that may not be attained in practice.

In order to quantify the economic effects of removing the gaps and barriers, we asked participants in follow-up interviews to fill in a special questionnaire detailing expected effects per gap, based on their assessment as experts in the area (see Annex II). The final sizes of the effects are obtained after the appropriate rescaling of aggregated responses, described in more detail in Annex I.

5.2. Measuring the Cost of Non-Europe – the ideal state scenario

5.2.1. Economic impact of the ideal state scenario

The removal of the shortlisted gaps would have an overall positive economic impact, which would primarily be manifested through productivity, investment, the labour market, and demand for goods and services. A key contribution to this improvement is expected to come from investment, which could mainly be boosted by eliminating challenges related to strategic autonomy in the space domain, staying internationally competitive and ensuring a long-term vision. The elimination of these challenges would also be a contributing factor to an increase in productivity. The removal of the challenges would also stimulate the labour market, where demand for labour can be expected to increase as long-term prospects and stability are improved. This effect will likely be mirrored on

[329] Evas T and Lomba N, European framework on ethical aspects of artificial intelligence, robotics and related technologies (European added value assessment), EPRS, 2020.

the supply side, both in activities directly related to the space sector and also through second-hand effects on other sectors. Elimination of the challenges will also stimulate consumer demand and boost consumption.

The estimated impacts of the removal of the shortlisted gaps challenges or the ideal state scenario in terms of GDP, consumption, employment, and capital stock are shown in Table 15. The absence of the six gaps considered could bring about a real output that is about 0.2% higher than the baseline in 2025. As some potential improvements are manifested through increased total factor productivity, the difference between real GDP in the baseline and the ideal state scenario grows over time and could be as high as 0.5% by 2050.

Private consumption, being a key component of GDP, follows a similar path to real output. As a result, we can expect to see private consumption exceed its baseline value by over 0.2% in 2025. In line with the evolution of real GDP, in the ideal state private consumption can be higher than its baseline value by about 0.5% in 2050.

Similar developments could materialise with respect to the capital stock. As higher economic activity is associated with a more robust investment, this boosts the capital stock level under the ideal state scenario, inducing a deviation that grows over time. While the difference is initially modest due to capital accumulation lag, it increases and reaches about 0.5% over the baseline at the end of the simulation horizon.

In contrast to output and its components, labour market reaction is estimated to be fairly uniform over the period considered. In the ideal state scenario, employment could exceed its baseline value by 0.2-0.3%.

Table 15: Difference between baseline and ideal state scenario for selected macroeconomic variables (percentage deviations from baseline scenario values)

Year	GDP	Private consumption	Employment	Capital stock
2025	0.22	0.21	0.24	0.06
2030	0.27	0.26	0.24	0.16
2040	0.37	0.37	0.24	0.35
2050	0.46	0.46	0.23	0.53

Source: Authors' analysis.

5.2.2. Cost of Non-Europe

The Cost of Non-Europe refers to the costs borne by EU citizens, public organisations, and businesses due to the identified potential challenges that can be addressed by Union-level policy actions.[330] The ideal state scenario addresses shortlisted challenges while they exist in the baseline scenario. Therefore, the Cost of Non-Europe could be quantified as the difference in monetary value between baseline and ideal state scenarios. In other words, if the current situation in terms of the presence of the shortlisted challenges remains (baseline scenario), the monetary value of lost output due to the presence of such challenges is the Cost of Non-Europe. The monetary estimates are based on model deviations from GDP projections derived from the EC Spring 2022 Forecast[331] and the IMF April 2022

[330] The economic analysis of policy options assesses the results of implementation, while abstracting away from the costs that implementation itself will entail. However, these costs are likely to be of a smaller order of magnitude compared to the net benefits presented here.

[331] European Commission, Spring 2022 Forecast, 2022.

World Economic Outlook.[332] They, therefore, take into account the latest cyclical developments in the EU27 economy and neighbouring countries, including the impact of the COVID-19 pandemic and recent geopolitical developments.

Table 16 reports the absolute differences between the baseline and the ideal state scenario for GDP and employment. Economic activity measured through the changes in the GDP at current prices, used as a measure of the **Cost of Non-Europe** in the space sector, indicates that the value of lost output could amount to tens of billions of euros per year in the first years of the horizon considered and grow to close to EUR 300 billion by 2050. After adjusting for price developments[333], the estimate of the Cost of Non-Europe in the space sector in real terms (at constant 2021 prices) is about EUR 43 billion in 2025, growing to nearly EUR 140 billion in 2050.

In terms of absolute employment gains, attaining the ideal state could bring about as many as 730,000 more jobs in 2050.

Table 16: Difference between baseline and ideal state scenario for selected macroeconomic variables (absolute deviations from baseline scenario values)

Year	GDP, m EUR current prices	GDP, m EUR constant 2021 prices	Employment, thousand persons
2025	51,541	43,211	653
2030	77,977	57,849	671
2040	154,615	94,299	704
2050	281,878	140,278	734

Source: Authors' analysis.

5.3. Policy Scenario 1 – Supporting the EU space ecosystem

5.3.1. Economic impacts of Policy Scenario 1

The impact of the Policy Scenarios considered depends on the starting time of implementation, duration of implementation, as well as the extent to which a scenario, once fully implemented, will remove the different challenges, and thus move the economy closer to the ideal state. Estimation of the impact requires an assessment of these parameters for each scenario.

In our assessment, Policy Scenario 1 (described in Section 4.2) can be implemented in a relatively short time. The preparatory period before the start of implementation is also considered to be short. Thus, we took 2024 to be the first implementation year and 2025 as the year when implementation is expected to be completed. The extent to which Policy Scenario 1 will remove the different challenges varies by challenge. The challenges related to the uneven distribution of the EU space sector, international competitiveness and strategic autonomy in the space domain are expected to be reduced by 50% each. This Policy Scenario will have a small impact on ensuring a long-term vision and improving the complexity of the governance system. For these two challenges, the extent to which they will be removed is estimated at 5%. Policy Scenario 1 will have a slightly higher impact on the removal of the challenge related to the fragmented legal and policy framework, which our analysis places at 10%.

332 International Monetary Fund, April 2022 WEO, 2022.

333 The adjustment is done by deflating the corresponding nominal value by the GDP deflator.

Policy Scenario 1 overall impacts the EU economy positively.[334] Its implementation is expected to contribute to investment, particularly through the alleviation of challenges related to staying internationally competitive and having strategic autonomy in the space domain. It will also have a positive impact on the demand for labour, as said challenges, along with the uneven distribution of the space sector, are among the more important obstacles towards increasing the number of job openings in the economy. The same effect will be at work for productivity. This Policy Scenario may have a somewhat muted effect on the supply of labour and on consumer demand since it addresses to a limited extent the challenge of lack of a clear long-term vision of European space, which is identified as important for household decisions. In particular, having long-term vision increases the attractiveness and predictability of working in the space sector, as well as in other sectors through second-round effects on the labour market. It also creates enhanced prospects of having higher quality goods and services assisted by space technologies, which can be expected to boost consumer demand.

Table 17 reports the estimated effects on a set of key macroeconomic indicators. Real output can exceed the baseline value by about 0.1% in 2025. Positive deviation in real GDP can reach 0.15% in 2050. Similarly, private consumption can be marginally higher than the baseline in the first years of the simulation (less than 0.1%), with a deviation reaching 0.15% by 2050. The capital stock deviations also track real GDP developments. The implementation of Policy Scenario 1 can bring about employment increases that are of the order of 0.1% of the baseline employment.

The absolute effects of the implementation of Policy Scenario 1 are given in Table 18. The increase in nominal GDP compared to the baseline could be around EUR 16 billion in 2025, reaching EUR 90 billion by 2050. In terms of employment, this Policy Scenario could bring about gains of the order of 210-240,000 additional jobs.

Table 17: Impact of implementing Policy Scenario 1 on selected macroeconomic variables (percentage deviations from baseline scenario values)

Year	GDP	Private consumption	Employment	Capital stock
2025	0.07	0.06	0.08	0.00
2030	0.09	0.08	0.08	0.04
2040	0.12	0.12	0.08	0.10
2050	0.15	0.15	0.08	0.16

Source: Authors' analysis.

334 The economic analysis of the policy options assesses the results of implementation, while abstracting away from the costs that implementation itself will entail. However, these costs are likely to be of a smaller order of magnitude compared to the net benefits presented here.

Table 18: Difference between baseline scenario and Policy Scenario 1 for selected macroeconomic variables (absolute deviations from baseline scenario values)

Year	GDP, m EUR current prices	GDP, m EUR constant 2021 prices	Employment, thousand persons
2025	16,012	13,424	213
2030	24,578	18,234	219
2040	49,809	30,378	231
2050	92,173	45,870	241

Source: Authors' analysis.

5.3.2. Qualitative assessment of impacts

Policy Scenario 1 directly addresses the more economy- or market-related challenges identified above. In particular, among the significant challenges selected for the CoNE exercise, this Policy Scenario targets the uneven distribution of the EU space sector across Member States (Section 3.1.5), the necessity to stay internationally competitive (Section 3.1.8) and to increase strategic autonomy in the space domain (Section 3.1.11). In addition, it will also address some of the issues that were considered less significant, namely, dealing with the problem of concentration in the space sector, the growing number of actors, and promoting technological sovereignty across the value chain.

The proposed policy measures will support established space companies that can compete internationally by providing them with stronger, guaranteed demand from EU customers and giving them space and resources to innovate and experiment. This will provide additional backing for their international endeavours and risk-taking as well as leverage to use on the global market.

The proposed policy measures also extensively address support for new entrants of all kinds and start-ups, in particular, thereby increasing competition in the EU market and creating a strong ecosystem for the space industry, which would also support international competitiveness. More beneficial conditions for new entrants, SMEs and start-ups will lower the barriers to entry and democratise the market, leading to more transparency, innovation and, ultimately, growth of the EU space sector.

The feasibility of implementation of Policy Scenario 1 is very high because it builds on existing instruments and legal rules and requires only their adjustment to the needs of the space sector. Only minimal budgetary adjustments would be necessary (for example, even accelerators and EDIHs can be implemented within the current framework). Also, according to stakeholders consulted for this study, political support for such a package of measures would be quite high, and industry stakeholders would welcome them. Many of the interviewed stakeholders even considered this Policy Scenario an urgent one, taking into account the current geopolitical situation coupled with economic and post-pandemic developments. At the same time, interviewed stakeholders noted that the effectiveness of this Policy Scenario is high but will be limited if it is not accompanied by Policy Scenario 2 or Policy Scenario 3, which bring more lasting and also necessary political changes, delivering the right signals to the market and providing more legal certainty. However, this Policy Scenario could lead to quick results in the identified fields.

Table 19: Summary assessment of Policy Scenario 1

	Policy Scenario 1
Significant challenges addressed	++
Other	++
Economic net benefits	+
Feasibility of implementation	+++

Notes: feasibility, proportionality and subsidiarity are ranked from low (+), medium (++) to high (+++). Source: Authors.

5.4. Policy Scenario 2 – Greater coordination at the EU level

5.4.1. Economic impacts of Policy Scenario 2

According to our assessment of stakeholder estimates, implementation of Policy Scenario 2 can start with very little prior preparation and its time to completion is estimated at about four years. We, therefore, assume that implementation will start in 2023 and will be completed by the end of 2026. This Policy Scenario is envisaged to remove the challenge related to long-term vision completely and to reduce the challenge associated with the complex governance system by 50%. Policy Scenario 2 is expected to have a smaller impact on the other short-listed challenges, reducing the challenge related to the fragmented legal and policy framework by 30%, the challenges related to the uneven distribution of the EU space sector and international competitiveness by 10% each, and the strategic autonomy challenge by 20%.

Policy Scenario 2 is likely to increase investment by eliminating the long-term vision challenge, which is among the important impediments to additional investment. The same effect can be expected to occur with respect to productivity, which will be increased through the implementation of the scenario. As Policy Scenario 2 prioritises the reduction of governance and especially long-term vision challenges, the latter being important for household decisions (see explanations in Policy Scenario 1), it will probably have a more pronounced effect on the supply of labour and on consumer demand. Conversely, the challenges addressed by this scenario have a somewhat less marked effect on the demand for labour and the boost in the number of job openings could be smaller.

Policy Scenario 2 offers net economic benefits compared to the baseline. Table 20 indicates that real GDP can be up to 0.1% higher than the baseline in the first years of the simulation. This difference could be close to 0.15% by the end of the horizon considered. Relative deviations in private consumption follow a similar path, as do deviations of capital stock from baseline. As with other simulations, the employment response is more uniform, with employment being about 0.08% higher than the baseline in 2025, and the deviation increasing marginally to about 0.09% in 2050.

In absolute terms, implementing Policy Scenario 2 can bring about nominal GDP gains of roughly EUR 14 billion in 2025, growing to around EUR 90 billion in 2050 (Table 21). The corresponding gains in employment range from 200 to 280 thousand persons.

Table 20: Impact of implementing Policy Scenario 2 on selected macroeconomic variables (percentage deviations from baseline scenario values)

Year	GDP	Private consumption	Employment	Capital stock
2025	0.06	0.06	0.08	0.01
2030	0.09	0.08	0.09	0.04
2040	0.12	0.12	0.09	0.11
2050	0.15	0.15	0.09	0.17

Source: Authors' analysis.

Table 21: Difference between baseline scenario and Policy Scenario 2 for selected macroeconomic variables (absolute deviations from baseline scenario values)

Year	GDP, m EUR current prices	GDP, m EUR constant 2021 prices	Employment, thousand persons
2025	13,849	11,611	205
2030	25,067	18,597	257
2040	50,595	30,858	270
2050	93,367	46,464	283

Source: Authors' analysis.

5.4.2. Qualitative assessment of impacts

The measures under Policy Scenario 2 primarily focus on the significant challenges related to coordination and governance, namely ensuring a long-term vision (Section 3.1.1) and improving the complex governance system (3.1.3). Indirectly, with closer coordination, these measures will also help to address the challenge of the fragmented legal and policy framework (Section 3.1.4). In addition, this Policy Scenario will also help to deal with two less significant challenges, namely the increasing number of new actors and ensuring balanced and mutually beneficial international cooperation.

Measures to improve the cooperation between EU Member States and between the EU and ESA will result in greater efficiency and effectiveness of national and European policies. Overlaps, duplications and gaps in efforts will be reduced, which might lead to saving money and time (or rather these can be invested elsewhere). The quality of policies and their implementation are likely to increase because of a higher level of transparency and information.[335] This will ultimately improve trust between the EU Member States and is likely to lead to more joint projects and actions. For the EU as a whole, this will allow a stronger presentation and advocacy of its interests and values in the international arena, where all EU Member States will speak with one voice, shaping the development of space law and policy in a concerted manner.

Stronger coordination will reduce the fragmentation of policy and legal frameworks, which will positively impact the creation of a single market, creating better conditions for the economies of scale and scope that are important in some segments of the space economy (e.g., upstream). It will

[335] The benefits of policy coordination among EU Member States have been discussed in application to many policy areas, for example, Braga de Macedo J, 'Reform Complementarity and Policy Coordination in Europe: A View from Portugal', CIGI Papers No. 132, June 2017; Borota T, Defever F and Impullitti G, 'Innovation union: costs and benefits of innovation policy coordination', CEP Discussion Papers dp1640, Centre for Economic Performance, LSE, 2019.

also provide market participants with a more transparent and clearer framework and structure, which will help them better plan their resources and business strategies. The increased legal certainty will be helpful for the market participants (e.g., investors, SMEs, start-ups).

The feasibility of this Policy Scenario is likely to be very high but slightly lower than Policy Scenario 1, as indicated by consulted stakeholders. On the one hand, there is a strong agreement about the necessity of greater coordination between the space policy actors mentioned above, and the means to achieve such coordination are realistic. On the other hand, stakeholders acknowledge how difficult some coordination measures will be due to extremely different national starting positions based on histories and legacies in space, the importance of the sector, and expertise. Nonetheless, coordination is possible but may require time to reach agreements. Considering the urgency of the issue, actions towards, e.g., updating the EU-ESA Framework Agreement and negotiating an EU long-term vision need to start immediately.

While this Policy Scenario is a necessary step, it is not very effective if adopted alone. Its effectiveness would be much higher if it were coupled with Policy Scenario 1.

Table 22: Summary assessment of Policy Scenario 2

	Policy Scenario 2
Significant challenges addressed	+
Other	++
Economic net benefits	+
Feasibility of implementation	+++

Notes: feasibility, proportionality and subsidiarity are ranked from low (+), medium (++) to high (+++).
Source: Authors.

5.5. Policy Scenario 3 – More extensive EU-level policies and rules

5.5.1. Economic impacts of Policy Scenario 3

Similar to Policy Scenario 2, our analysis, based on the estimates of the surveyed stakeholders, indicates that implementation of Policy Scenario 3 can start in 2023 and span a period of four years, ending in 2026. Most of the impact of this Policy Scenario will be related to the long-term vision and fragmented legal and policy framework challenges. Each of them is expected to be reduced by 50%. Policy Scenario 3 will also affect the uneven distribution of the EU space sector challenge and the international competitiveness challenge, reducing them by 30%. Smaller impacts are expected for the strategic autonomy challenge (a reduction by 20%) and the complex governance system challenge (a reduction by 15%).

The implementation of Policy Scenario 3 will contribute to an increase in investment and productivity. However, as this scenario tries to address the shortlisted challenges in a more balanced way and therefore targets more uniformly and moderately the challenges identified, the investment and productivity effects are likely to be somewhat muted compared to the other scenarios. Along the same lines, this scenario addresses challenges that are important for stimulating demand for labour only partially and, therefore, the latter can be expected to respond in a more subdued way to the implementation of the scenario. Consumer demand and labour supply would also increase upon implementation, with the increase on par with that induced by Policy Scenario 1.

Policy Scenario 3 can be expected to bring about net economic benefits if implemented. Real GDP can increase by up to 0.1% over the baseline in the first years of the simulation (Table 23). This difference can grow to about 0.14% by 2050. Private consumption and capital stock follow similar paths, with relative differences compared to the baseline accumulating over the simulation horizon. Policy Scenario 3 offers small positive effects on employment of up to 0.15% over the baseline.

Table 23: Impact of implementing Policy Scenario 3 on selected macroeconomic variables (percentage deviations from baseline scenario values)

Year	GDP	Private consumption	Employment	Capital stock
2025	0.05	0.05	0.06	0.00
2030	0.08	0.08	0.08	0.03
2040	0.11	0.11	0.08	0.09
2050	0.14	0.14	0.08	0.15

Source: Authors' analysis.

Table 24 provides information on the absolute gains in output and employment from Policy Scenario 3. The scenario can deliver nominal GDP gains of roughly EUR 11 billion in 2025, growing to EUR 85 billion in 2050. Employment gains start from about 160 thousand persons and increase to just below 250 thousand persons.

Table 24: Difference between baseline scenario and Policy Scenario 3 for selected macroeconomic variables (absolute deviations from baseline scenario values)

Year	GDP, m EUR current prices	GDP, m EUR constant 2021 prices	Employment, thousand persons
2025	11,397	9,555	163
2030	22,715	16,852	223
2040	45,873	27,978	235
2050	84,702	42,152	245

Source: Authors' analysis.

5.5.2. Qualitative assessment of impacts

Similar to Policy Scenario 2, Policy Scenario 3 addresses two significant challenges directly: ensuring a long-term vision (Section 3.1.1), and the fragmented legal and policy framework (Section 3.1.4). However, Policy Scenario 3 approaches the challenges more forcefully, developing its own frameworks at the EU level instead of merely coordinating. Hence, it is likely to have impacts along the same lines as Policy Scenario 2, but more intensely (in the sense of closing the gaps or eliminating challenges to a higher degree). The impacts of Policy Scenario 3 are summarised in Table 26.

In addition to the impacts described for Policy Scenario 2, this Policy Scenario will have a much stronger impact on the market. This is because it will provide a more detailed and clearer framework along which market participants can orient themselves. Furthermore, by mainstreaming space policy across other EU policies, demand for space-based services and products will be realised, providing more opportunities in the EU market and promoting competitiveness.

This Policy Scenario is likely to provide much stronger support for the achievement of EU political objectives (e.g., green and digital transitions) because space policies developed will be much better incorporated with other policy measures.

In terms of impacts on other challenges, it can be expected that this Policy Scenario will improve technological sovereignty across value chains, ensuring balanced and mutually beneficial international cooperation and strategic autonomy in the space domain. These positive impacts can be expected because policies are likely to provide better frameworks than mere coordination. They will help to identify more precisely specific issues, solutions, and actions, add legal certainty and limit the opportunities for divergent interpretation. This would be beneficial, especially for geopolitics, security and defence, and space diplomacy.

Policy Scenario 3 requires a more ambitious use of its existing competences in the space domain from the EU, which unfortunately means that it is also less feasible than Policy Scenarios 1 and 2. At the same time, as mentioned before, many steps have been already taken that could lead to the policy measures under this Policy Scenario (e.g. preparation of the space security and defence policy and other examples in Section 4.4). Just like Policy Scenario 2, implementing this Policy Scenario is just a question of time, and it will be more effective if coupled with Policy Scenario 1.

Table 25: Summary assessment of Policy Scenario 3

	Policy Scenario 3
Significant challenges addressed	+
Other	+++
Economic net benefits	+
Feasibility of implementation	++

Notes: feasibility, proportionality and subsidiarity are ranked from low (+), medium (++) to high (+++). Source: Authors.

6. Comparative analysis of EU-level Policy Scenarios

Comparing the proposed Policy Scenarios makes it clear that they are not alternatives but complements. They target different challenges in different ways, have different implementation horizons and work on different levels (e.g., Policy Scenario 1 encompasses market-oriented measures, whereas Policy Scenario 2 addresses governance). As mentioned in the assessment of individual Policy Scenarios, more feasible Policy Scenarios seem less effective (see the summary Table 26).

In terms of net economic benefit, Policy Scenarios 1-3 have broadly similar impacts. Their implementation timing is roughly comparable, and the estimated output and employment effects can be considered close. Specifically, the output gains from implementing Scenarios 1-3 are each in the range of EUR 80-90 billion. Employment gains delivered by the three Policy Scenarios towards the end of the time window considered are of the order of 240-280,000 people.

Table 26: Summary of the comparative assessment of all Policy Scenarios

	Policy Scenario 1	Policy Scenario 2	Policy Scenario 3
Significant challenges addressed	++	+	+
Other	++	++	+++
Economic net benefits	+	+	+
Feasibility of implementation	+++	+++	++

Notes: feasibility, proportionality and subsidiarity are ranked from low (+), medium (++) to high (+++). Source: Authors.

To avoid making a trade-off between the effectiveness and feasibility of each scenario, the Policy Scenarios can be implemented in combination in successive order, from 1 to 3. In this way, the best outcome can be ensured for the space sector and adjacent sectors. Table 27 summarises the impact of the three Policy Scenarios on the identified gaps and challenges.

Policy Scenario 1 should be implemented as soon as possible as the most feasible scenario that also will bring quick benefits to the sector. It does not require changes to the EU budget or negotiations on new policies or instruments. Many of the policy measures proposed are familiar or have been successfully tried and tested in other jurisdictions or other domains in the EU. If nothing else, pilots can be started, with more permanent measures adopted based on the first results.

Together with Policy Scenario 1, the implementation of Policy Scenario 2 needs to be staggered. This is necessary not only because a longer time horizon is necessary for coordination but also because the effect of Policy Scenario 1 will be much stronger if accompanied by coordination. Policy Scenario 2 can be considered a necessary prerequisite for Policy Scenario 3. Coordination activities and instruments can be used to develop space policies and rules proposed under Policy Scenario 3. They will also strengthen coordination by providing a common purpose for it, namely the development of concrete, realistic EU policies. At the same time, it will ensure that the development is inclusive and follows bottom-up processes by involving all relevant stakeholders engaged in policy and implementation.

Table 27: Impact on the significant gaps and challenges by Policy Scenario.

Challenge / Proposed Policy Scenario	Policy Scenario 1	Policy Scenario 2	Policy Scenario 3
Ensuring a long-term vision	+	+++	++
Complex governance system	+	++	+
Fragmented legal and policy framework	+	+	++
Uneven distribution of the EU space sector	++	+	+
Staying internationally competitive	++	+	+
Strategic autonomy in the space domain	++	+	+

Source: Authors.

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Interviewed stakeholders

(in alphabetical order)

Airbus Defence and Space
Marco Aliberti (ESPI)
Angelina Bekasova (Space & Innovation Policy Expert at Latvian Ministry of Economics)
Michal Brichta (Slovak Space Office)
Aleksandra Bukała (POLSA)
Chris Chaloner (Trym Systems)
Pascal Claudel (EUSPA)
Steve Greenland (SME4Space)
Kaja Hopej
Rene Kleeßen (DLR)
Hans-Jörg Koenigsmann (independent expert, supervisory board of OHB and Mynaric)
Max Kroymann (German Ministry of Economic and Climate Affairs)
Mathias Link (Luxembourg Space Agency)
Pierre Lionnet (Eurospace)
Malta Council for Science and Technology
OECD
Salvatore Pignataro (Italian Permanent Representation to the EU)
Luís Serina

ANNEX I Methodology

This Annex provides an overview of the structure and calibration of the modelling framework employed for the quantification of Cost of Non-Europe. The impact of various scenarios (ideal state scenario and different Policy Scenarios) is estimated using a computable general equilibrium model (CGE). The model was enhanced with dynamic equations that allow the computation of the impact of a set of shocks over a specified time horizon. The model structure features an open economy with a sectoral breakdown that is tailored to the specific analytical requirements at hand. The model also includes a government sector. Supplementary computations are done to take on board expected cyclical developments and the evolution of quantities of interest in absolute terms. The datasets used in the modelling exercise comprise recent data and forecasts for the economies covered, depending on data availability for the different variables.

Model structure

The theoretical structure of the model follows the one described in WIK-Consult, Ecorys and VVA Consulting study of 2016.[336] It is assumed that the economy is divided into sectors, each producing a specific product.[337] We present the main model components below. To use suggestive notation, whenever possible we use the subscript i to refer to products, the subscript j to refer to sectors and t denotes time. Time in the model is discrete and the time step is assumed to be one year.

Household

The household in the model consumes a bundle of the products in the economy and supplies two types of labour (skilled and unskilled). It is described by the following per-period utility function:

$$U_t = \sum_{i=1}^{n} \theta_i \ln C_{it} - \sum_{j=1}^{n} \xi_j \frac{N_{jt}^{\rho+1}}{\rho+1} - \sum_{j=1}^{n} \pi_j \frac{H_{jt}^{\rho+1}}{\rho+1} + \kappa \ln S_t.$$

Here C_{it} is the consumption of a product i in period t, N_{jt} is unskilled labour supplied in a sector j, H_{jt} is skilled labour supplied in a sector j and S_t is household savings. The rest of the notation refers to weights of the different components or convexity/concavity parameters in the component functions.

The household faces the following budget constraint:

$$\sum_{i=1}^{n} P_{it}\, C_{it} = (1-td) \sum_{j=1}^{n} (PN_{jt}N_{jt} + PH_{jt}H_{jt} + PKPR_{jt}KPR_{jt}) + ror \cdot A_t + tr_t - S_t,$$

where P_{it} is the price of product i, including indirect taxes, td is the (implicit) direct tax rate on income, and PN_{jt} and PH_{jt} are respectively the prices of unskilled and skilled labour in a sector j. It is assumed that the return on private capital KPR_{jt} in sector j is transferred to the household through the rental rate $PKPR_{jt}$. Additionally, the household receives interest ror on its assets A_t and transfers from the government tr_t.

The household's problem is to maximize utility U_t with respect to C_{it}, N_{jt}, H_{jt} and S_t subject to the above budget constraint.

336 WIK-Consult, Ecorys and VVA Consulting (2016). Support for the preparation of the impact assessment accompanying the review of the regulatory framework for e-communications. European Commission.

337 Sometimes sectors are referred to as 'activities', while products are referred to as 'commodities', following established terminology in the CGE literature.

Representative firm in sector j

The representative firm in a sector j strives to maximize profit by employing skilled and unskilled labour, as well as renting public and private capital. Its profit function is

$$\Pi_{jt} = PVA_{jt}VA_{jt} - PN_{jt}N_{jt} - PH_{jt}H_{jt} - PKPR_{jt}KPR_{jt} - PKPU_{jt}KPU_{jt},$$

where PVA_{jt} is the price of value added, VA_{jt} is the real value added produced and $PKPU_{jt}$ is the rental rate of public capital KPU_{jt} in sector j.

The production technology available to the firm is a two-level one. First, skilled and unskilled labour are combined through a constant elasticity of substitution (CES) aggregator to produce the overall labour input L_{jt}:

$$L_{jt} = \sigma_{jt}^{L}\left(\beta_j^L N_{jt}^{\nu_j^L} + (1-\beta_j^L)H_{jt}^{\nu_j^L}\right)^{\frac{1}{\nu_j^L}}.$$

Similarly, public and private capital stocks are combined through a CES-type aggregator to obtain the total capital input K_{jt} for the sector:

$$K_{jt} = \sigma_{jt}^{K}\left(\beta_j^K KPU_{jt}^{\nu_j^K} + (1-\beta_j^K)KPR_{jt}^{\nu_j^K}\right)^{\frac{1}{\nu_j^K}}$$

Second, value added is produced by means of a production function that in turn combines L_{jt} and K_{jt}. The specific form of the production function is given by

$$VA_{jt} = \sigma_{jt}^{VA}\left(\beta_j^{VA} L_{jt}^{\nu_j^{VA}} + (1-\beta_j^{VA})K_{jt}^{\nu_j^{VA}}\right)^{\frac{1}{\nu_j^{VA}}}.$$

The variable σ_{jt}^{VA} is total factor productivity for sector j. Its evolution over time is described in the following sections.

Foreign trade aggregators

The supply Q_{it} of a product i on the domestic market is formed by combining imports of the product, denoted QM_{it}, and quantities QD_{it} produced locally for the domestic market (Armington assumption). Formally, the composite product aggregator is given by

$$Q_{it} = e_i\left(\beta_i QM_{it}^{-\sigma_i} + (1-\beta_i)QD_{it}^{-\sigma_i}\right)^{-\frac{1}{\sigma_i}}.$$

The inputs to the above aggregator are determined through a cost minimization problem that produces the optimal mix between domestically produced and imported products:

$$\frac{QM_{it}}{QD_{it}} = \left(\frac{PD_{it}}{pm_{it}\frac{\beta_i}{1-\beta_i}}\right)^{\frac{1}{1+\sigma_i}}.$$

Here pm_{it} is the price of imports of commodity i and PD_{it} is the domestic price.

The domestically produced quantities of product i, denoted QP_{it}, are either exported or supplied locally. The allocation constraint between the domestic and export markets is

$$QP_{it} = f_i\left(\eta_i QE_{it}^{\gamma_i} + (1-\eta_i)QD_{it}^{\gamma_i}\right)^{\frac{1}{\gamma_i}},$$

where QE_{it} is the quantity for the export market.

The optimal allocation between domestic and exported products is again obtained through solving an appropriate cost minimization problem, which results in the relationship

$$\frac{QE_{it}}{QD_{it}} = \left(\frac{pe_{it}}{PD_{it}}\frac{1-\eta_i}{\eta_i}\right)^{\frac{1}{\gamma_i - 1}},$$

with pe_{it} denoting the export price of product i.

Government

The government in the model collects revenues R_t from direct taxes, indirect taxes (at the implicit rate of τ_i per product i), the return on public capital and the return on net government assets AG_t:

$$R_t = \quad td\sum_{j=1}^{n}(PN_{jt}N_{jt} + PH_{jt}H_{jt} + PKPR_{jt}KPR_{jt}) + \sum_{i=1}^{n}\tau_i\frac{P_{it}}{1+\tau_i}Q_{it} + \sum_{j=1}^{n}P\,KPU_{jt}KPU_{jt} + ror \cdot AG_t.$$

Government expenditures G_t are allocated between three spending categories: purchases of product i, transfers to households and capital expenditures KE_t. Formally, government expenditures are given by the equation

$$G_t = \sum_{i=1}^{n} P_{it}\,cg_{it} + tr_t + KE_t,$$

where cg_{it} denotes the volume of purchases of product i.

The budget balance BB_t is given by

$$BB_t = R_t - G_t.$$

The budget balance is accrued to net government assets AG_t to ensure intertemporal consistency, as explained in the section on model dynamics.

Model closure and equilibrium

Foreign savings in the model are defined from the standpoint of the external sector. Thus, revenues for the external sector comprise the domestic economy imports and interest on net foreign assets AF_t (again vis-a-vis the domestic economy). Expenditures are computed as the sum of nominal domestic exports by product. Foreign savings FS_t are given by the equation

$$FS_t = \sum_{i=1}^{n} p\,m_{it}QM_{it} + ror \cdot AF_t - \sum_{i=1}^{n} p\,e_{it}QE_{it}.$$

We also impose the typical requirement that the total supply of each product is equal to its uses. This is implemented by means of the supply-use balancing equation

$$Q_{it} = \sum_{j=1}^{n} I\,C_{ijt} + C_{it} + cg_{it} + ID_{it} + QE_{it} + QT_{it},$$

where IC_{ijt} is intermediate consumption of product i by sector j, ID_{it} is investments demand and QT_{it} is the use of product i to cover trade and transport margins.

It is assumed that savings and investment are balanced at the sectoral level, with nominal investment for sector j taken as part of total saving, using the share of sectoral capital in the total capital stock as the proportionality coefficient. The savings-investment balancing equation takes the form

$$\overline{PK}_t II_{jt} = \frac{K_{jt}}{\sum_{j=1}^{n} K_{jt}} (S_t + KE_t + BB_t + FS_t - ror(A_t + AF_t + AG_t) - \sum_{i=1}^{n} P_{it} Z_{it} - DUMMY_t),$$

where II_{jt} denotes sectoral investment in real terms, Z_{it} is the change in inventories of product i and the variable $DUMMY_t$ plays a technical role and should be zero in equilibrium.

Prices in the model are normalized by requiring that they aggregate to the overall price level:

$$\text{plevel}_t = \sum_{i=1}^{n} w_i P_{it}.$$

Dynamics

Agents in the model optimize intratemporally. However, the model contains a set of dynamic equations that ensure consistent evolution of variables over the specified time horizon. These include stock-flow relationships and the dynamics of total factor productivity.

Public capital by sector j is taken to evolve over time according to a standard capital accumulation equation:

$$KKPU_{j\,t+1} = (1 - \delta) KKPU_{jt} + IPU_{jt}.$$

Here δ stands for the annual depreciation rate and IPU_{jt} is public investment in sector j.

Private capital follows the same type of law of motion:

$$KKPR_{j\,t+1} = (1 - \delta) KKPR_{jt} + IPR_{jt},$$

with IPR_{jt} denoting private investment in the sector j.

The change in private sector assets reflects savings. The accounting identity is

$$A_{t+1} = A_t + S_t.$$

Similar accounting identities hold true for foreign assets and government assets:

$$AF_{t+1} = AF_t + FS_t,$$

$$AG_{t+1} = AG_t + BB_t.$$

Total factor productivity changes according to an exogenously specified growth rate γ_t^A:

$$\sigma_{j\,t+1}^{VA} = (1 + \gamma_t^A) \sigma_{jt}^{VA}.$$

Model calibration

Most of the model coefficients are calibrated using public data from Eurostat, with a limited number of coefficients calibrated on theoretical grounds with values taken from the relevant literature. The bulk of the calibration is implemented by constructing a social accounting matrix (SAM) that measures the flows between different institutional sectors of the economy for a selected base year. Additional data-based calibrations outside the SAM framework were carried out again using Eurostat data.

In order to ensure reproducibility of the computations and facilitate future updates of the model, the calibration process was implemented through a system of R language scripts.[338] These scripts sequentially carry out the following steps:

- Automatic retrieval of the necessary data tables from the Eurostat website;
- Sectoral aggregation according to a predefined grouping and temporal aggregation for a selected set of years;
- Aggregation of country-level data to EU level or to another predefined regional grouping;
- SAM balancing and coefficient computation.

Specifically, the following tables are downloaded from the Eurostat database for use in the calibration exercise:

- **naio_10_cp15;**
- **naio_10_cp16;**
- **gov_10a_main;**
- **gov_10a_exp;**
- **lfsa_eisn2;**
- **earn_ses14_49.**[339]

The inputs required for the model calibration have been constructed for an approximation of the EU economy and other closely associated economies. This is done by aggregating data on 25 EU countries (Bulgaria and Ireland are excluded due to data constraints), as well as the UK, Serbia and North Macedonia. As the model exploits the structure of the data rather than the absolute numbers, this level of coverage is considered satisfactory.

The calibration year is taken to be 2018, which is deemed to be an acceptable compromise between recency and coverage. Notably, while a single year was used in this case to give prominence to the most recent period of acceptable coverage, the system in principle allows for the use of average values over several years.

The SAM, as directly constructed from the statistical data sources, is unsuitable for CGE modelling, since the presence of statistical discrepancies will violate accounting identities in the model. It is therefore necessary to distribute these discrepancies so that the SAM is balanced (row sums are equal to column sums). There exist different balancing procedures and for this modelling exercise the procedure recommended by Hosoe et al., Ch. 4, is used.[340] This procedure is readily implementable by optimization software and helps ensure consistency in the balancing approach across datasets and calibration updates. More specifically, the procedure for balancing the SAM involves the following problem:

$$\min_{x_{kl}} \sum_{k} \sum_{l} \left(\frac{x_{kl} - x_{kl}^{0}}{x_{kl}^{0}} \right)^{2}$$

subject to

$$\sum_{l} x_{kl} = \sum_{l} x_{lk}, \forall k,$$

[338] The R Project for Statistical Computing (n.d.). Official website.

[339] The following data was downloaded: Supply table at basic prices incl. transformation into purchasers' prices, Use table at purchasers' prices, Government revenue, expenditure and main aggregates, Central government expenditure by function, Employment by occupation and economic activity, Mean annual earnings by sex, economic activity and occupation respectively. The tables were last accessed in July 2022.

[340] Hosoe, N., Gasawa, K. and Hashimoto, H. (2010). Textbook of Computable General Equilibrium Modelling: Programming and Simulations. Palgrave Macmillan.

where x_{kl} denotes the entry in the k-th row and l-th column of the adjusted matrix, while x_{kl}^0 is the corresponding entry in the unadjusted SAM, taken as a parameter. The procedure is applied to the non-zero entries of the original SAM.

At the end of the calibration procedures, a balanced SAM and an additional set of model parameters are available to be provided as input for the main model code.

Sector and group definitions

Table 28 presents the definition of the sectors used in the model in terms of the corresponding NACE codes used in the aggregation.

Table 28: Model sector to NACE code mapping

Model sector	NACE codes included
Agriculture, forestry and fishing	A
Industry (except construction and manufacturing)	B-E excl. C
Manufacturing	C
Construction	F
Wholesale and retail trade, transport, accommodation and food service activities	G-I
Information and communication	J
Financial and insurance activities	K
Real estate activities	L
Professional, scientific and technical activities; administrative and support service activities	M_N
Public administration, defence, education, human health and social work activities	O-Q
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	R-U

Source: Authors.

The mapping in Table 29 shows the distribution of occupations into skilled and unskilled labour categories as used to calibrate the shares of skilled and unskilled labour in the model.

Table 29: Labour type classification by ISCO08 code used in the model

ISCO08 code	Labour type classification in model
NRP	unskilled
OC0	unskilled
OC1	skilled
OC2	skilled
OC3	skilled
OC4	unskilled
OC5	unskilled
OC6	unskilled
OC7	unskilled
OC8	unskilled
OC9	unskilled

Source: Authors.

Baseline calibration

The baseline scenario reflects a situation of keeping the status quo, where the term 'status quo' should be understood in a dynamic sense. The baseline includes the key policy measures that, as of mid-2022, were known to have been approved for implementation over the simulation horizon, regardless of the moment in which they become effective. This implies that the changes incorporated in the baseline scenario reflect the changes induced by the known policy measures, depending on when they become effective and how their implementation propagates through the economy.

Since incorporating various pieces of legislation into the baseline on a case-by-case basis requires the development of a large number of sub-scenarios, which is impractical, the baseline scenario takes the existing policies on board in an integrated fashion. To calibrate the baseline for the simulations in this report, we adapted the baseline calibration of a version of the CGE model that uses a similar sectoral breakdown[341]. The source model is calibrated based on a comprehensive set of responses to a Delphi method exercise that covers the main sectors of the EU economy. The questions from the Delphi method that are used to calibrate the baseline cover the key channels of impact of extant policies, such as consumer demand, investment, labour supply and demand, production efficiency and innovation. The expert assessments from the Delphi method cover a medium-term horizon of five years, which is deemed sufficient to reach the full impact of the measures considered.

As the Delphi method survey was conducted in 2020, we introduced an additional update based on a subset of questions in the survey that cover the key channels of impact from above (labour supply and demand, consumer demand etc.) as of 2022. The questions concern only the aggregate impacts in 10 years from the present, as the respondents are not experts representing the various sectors of the economy. Thus, the aggregated responses from the survey are used to recalibrate the aggregate

[341] Evas T and Lomba N, European framework on ethical aspects of artificial intelligence, robotics and related technologies (European added value assessment), EPRS, 2020.

level of the respective impact, while sectoral distributions are still obtained on the basis of the responses from the Delphi method exercise.

The advantage of this approach is that the baseline calibration of the source model incorporates sector-specific expert assessments and expectations, while updating them with more current information and over a longer time horizon. This ensures both consistency of the baselines between different model versions and efficient use of available information by economic sectors. The time horizon of the Delphi method survey is sufficiently long to capture effects from delayed implementation of certain policy measures, as well as lags in the adaptation of the economy to the measures. Thus, the calibration of the baseline using the Delphi method responses allows the inclusion of the effects of both upcoming and recently implemented policy measures in an integrated manner via the sector-specific expert responses. A limitation of this approach is that it will not take on board sector-specific impacts of policy measures that have been implemented after the Delphi survey was conducted.

Ideal state scenario construction

The ideal state scenario is constructed by aggregating responses to a dedicated questionnaire that was filled by interviewed stakeholders as part of conducted interviews. The questionnaire asks about the effect that the absence of a particular short-listed gap would have on the main model channels of impact. The effect is measured in terms of relative deviations from the baseline value of the respective indicator, which enables the computation of shock size corresponding to the particular impact channel. Annex II reports the aggregated results on the ideal state scenario from the interviews.

The computation of the shock size takes the following general form. Let X_k denote a variable of interest (e.g., the quantity of a product demanded) and X_{-k} denotes the rest of the model variables. Likewise, let α_m denote the coefficient to be shocked and α_{-m} denote the other coefficients in the model. In the baseline, a model equation will take the form

$$F_i(X_k, X_{-k}; \alpha_m, \alpha_{-m}) = 0.$$

If the relevant effect from the literature is denoted by Δ_k, then the corresponding size of the shock is computed as the value ϵ_m that solves the equation

$$F_i(X_k(1+\Delta_k), X_{-k}; (\alpha_m + \epsilon_m), \alpha_{-m}) = 0.$$

It is worth noting that the ideal state scenario is not a mechanical addition of the effects of the individual gaps, as represented by the selected shocks in the model. The nonlinear nature of the CGE model introduces interactions and higher-order effects, which will, in general, produce a difference between the sum of partial simulations (for example, featuring only one shock or representing the removal of one gap), and the simulation for the ideal state scenario as a whole, which involves the simultaneous effects of several shocks.

A problem identified in the course of the interviews concerned the respondents' inability to clearly differentiate the effect of removing a particular gap on the main economic channels of impact. This can partly be attributed to interactions between the different gaps but may also be due to the interviewees perceiving the gaps and barriers as an integrated bundle of obstacles rather than a set of distinct problems. As a result, responses tend to inflate the individual impact of the removal of a single gap because of implicit 'leakage' of the other gaps into the one under consideration.

In order to correct for this upward bias in the responses, we employed an approach that re-anchors the size of shocks to an already validated set of shocks used in Lomba et al (2022). We used shocks associated with digital transformation from this study and applied a constructed measure of the size of the space economy relative to that of the digital economy to obtain a bound on the reported shocks from the interviews.

To this end, we first constructed an estimate of the size of the space economy relative to the size of the total digital economy. More specifically, we collected different estimates in the literature on the sizes of the space and the digital economy, as well as their expected growth rates. We then constructed ranges of estimates of the sizes of the space and digital economies as of 2021. Combining the two sets of estimates, we obtained an array of values for the space-to-digital economy ratio. For the subsequent computations we used the ratio of the average estimates of the respective sizes, equal to 5%.

The above ratio is then used to scale down the maximum value of the shocks used for the construction of the ideal scenario in the CoNE on digital transformation, grouped by year. These downscaled values are not used directly in the model but applied as upper bounds on the respective shocks for the CoNE space ideal scenario, which are still taken from interview questionnaires with an appropriate adjustment for each group adjusted to preserve the relative magnitudes. Following this adjustment, the updated set of shocks is fed into the CGE model to obtain relative deviations of the ideal state scenario from the baseline.

Policy Scenario scenarios construction

Our assessment of the potential of different Policy Scenarios to bridge the identified gaps provides the starting and final year of the implementation, as well as the maximum achievable percentage of each gap that can be eliminated by implementing the respective Policy Scenario. We have no prior indications of the speed of implementation. Therefore, we assume that implementation starts from the baseline value of the respective shock in the year preceding the first implementation year and proceeds linearly until reaching the maximum achievable percentage in the final implementation year. As an example, this means that if implementation starts in 2024 and ends in 2025, bridging 80% of a certain gap, the respective shocks will be at their baseline values prior to 2024; they will stand at 40% between the baseline and ideal state shock values in 2024, and at 80% in 2025.

Formally, the above implies that, if α_t is the percentage of the gap bridged in year t, we have

$$\epsilon_O = (1 - \alpha_t)\epsilon_B + \alpha_t \epsilon_I,$$

where ϵ denotes the value of the shock and the subscripts O, B, I stand for the Policy Scenario, baseline and ideal state scenarios.

Quantification of the impacts in absolute values

The computation of the values of the macroeconomic indicators under the ideal state scenario and the effects of the Policy Scenarios under consideration in absolute terms requires the values of respective variables in the baseline scenario. The country coverage of the CGE model, while sufficient for the purpose of approximating the structure of the total set of economies under consideration[342], precludes the direct use of the baseline from the model. Moreover, the baseline scenario from the CGE model does not take into account cyclical fluctuations in the variables induced by shocks such as the COVID-19 pandemic or the war in Ukraine. Therefore, the values of the variables of interest in the baseline need to be obtained through additional computations.

The values from 2022 to 2050 in the baseline for total employment, nominal and real GDP were calculated in the following way. We use the respective values for 2021 from Eurostat as a starting point (specifically datasets nama_10_gdp and lfsa_eisn2 for the latest available data). The nominal GDP values for 2022 and 2023 for EU27 and the UK are computed using real GDP growth and GDP

[342] These are EU27, the UK, Turkey, Serbia, Albania, North Macedonia and Montenegro.

deflator projections from the Spring 2022 Economic Forecast of the European Commission.[343] The nominal GDP values for the period 2024-2027 are computed using real GDP growth and GDP deflator projections from the April 2022 World Economic Outlook of the IMF.[344] Nominal GDP values after 2027 are computed by applying the average annual real GDP growth and GDP deflator for each of the economies considered using data from the timespan 2000-2021, subject to availability constraints in each case. The real GDP and total employment are calculated using the same approach.

In the absence of projections for real value added and employment by sector, the respective baseline paths are constructed using the computed baseline values of nominal GDP, real GDP and employment and applying the assumption of constant structure over time, using the respective sector shares from 2021. This enables the use of the most recent data available to account for the sectoral structure of the economy. A limitation of this approach is that it cannot capture sectoral differences in cyclical or structural developments in the baseline. This limitation is partially mitigated by the fact that such structures are relatively slow changing.

The computation of absolute deviations for the respective variables is carried out by applying percentage deviations from baseline of real GDP, real value added and employment as obtained from the CGE model to the baseline paths described above and rescaling appropriately to ensure additivity of the sectoral results to the total. In the case of nominal variables, the absolute deviations are computed by applying the percentage deviations for the respective real variables.

343 European Commission (2022) Spring 2022 Economic Forecast, available at https://economy-finance.ec.europa.eu/economic-forecast-and-surveys/economic-forecasts/spring-2022-economic-forecast-russian-invasion-tests-eu-economic-resilience_en.

344 International Monetary Fund (2022) April 2002 World Economic Outlook, available at https://www.imf.org/en/Publications/WEO/Issues/2022/04/19/world-economic-outlook-april-2022.

ANNEX II Summary information on the conducted survey and interviews

For the study's purposes, a limited consultation with space sector stakeholders was conducted consisting of an online survey and interviews.

Survey

The survey ran between 7 July 2022 and 1 August 2022. Over 70 stakeholders were invited, from national space agencies, EU bodies and European organisations, space industry (associations, incumbent companies, SMEs, and start-ups), academia and independent experts. The survey was conducted on the basis of confidentiality. 27 responses were received from stakeholders from different categories and Member States.

The survey's aim was to collect information for the assessment of challenges to the EU space sector and for the definition of the baseline for economic modelling.

The following details the questions asked about the baseline:

The following questions refer to a situation where no further policy actions in the space sector are taken at the EU level. Thus, existing measures, as well as already approved policy actions that will come into effect at some point in the future, are assumed to be in place, but no further changes to the policy framework regulating the space sector will be implemented. We refer to this situation as the (dynamic) status quo. Assume that the EU economy continues to develop under the currently existing set of space policies (preservation of the status quo). Please answer the following questions **about this situation**. Whenever you do not know the exact answer, please give your best estimate.

1. In 10 years from now, the number of job openings in the EU economy in the situation described above is likely to:
   - increase substantially (3-5%) compared to the present
   - increase moderately (1-3%) compared to the present
   - remain roughly unchanged compared to the present
   - decline moderately (- 1-3%) compared to the present
   - decline substantially (- 3-5%) compared to the present

2. In 10 years from now, the number of people who are qualified and willing to work in all professions in the EU economy in the situation described above is likely to:
   - increase substantially (3-5%) compared to the present
   - increase moderately (1-3%) compared to the present
   - remain roughly unchanged compared to the present
   - decline moderately (- 1-3%) compared to the present
   - decline substantially (- 3-5%) compared to the present

3. In 10 years from now, demand for all products or services in the EU economy in the situation described above is likely to:
   - increase substantially (3-5%) compared to the present
   - increase moderately (1-3%) compared to the present
   - remain roughly unchanged compared to the present
   - decline moderately (- 1-3%) compared to the present
   - decline substantially (- 3-5%) compared to the present

4. In 10 years from now, productivity in the EU economy in the situation described above is likely to:
   - increase substantially (2-4%) compared to the present
   - increase moderately (1-2%) compared to the present

- remain roughly unchanged compared to the present
- decline moderately (- 1-2%) compared to the present
- decline substantially (- 2-4%) compared to the present

Interviews

Two rounds of interviews were conducted for this study.

The first round of interviews took place between end of May 2022 and end of June 2022. Seven interviews were conducted with EU and national space agencies, international organisations, experts, and industry representatives. The aim of these interviews was to validate the literature review's findings related to the primary challenges for the EU space sector.

The second round of interviews took place in September 2022. Twelve interviews were conducted with national space agencies, academia, experts, and industry representatives. The aim of these interviews was to collect information for the assessment of policy options.

The questionnaires for the interviews differed based on the aim of the interview and the types of stakeholder. All interviews were conducted on the basis of confidentiality.

The stakeholders were asked to fill in a table that provides answers to the following question: 'Consider a series of situations in which the gaps listed below are removed one at a time, with the removal of the respective gap happening immediately and completely. In your assessment, what would the effect be relative to the current situation (the status quo) for each of the five areas of impact in the table?' The table below presents the average of provided responses:

Table 30: Average responses provided

	Area of impact				
Gap/barrier	1. Number of job openings	2. Number of people who are qualified and willing to work in all professions	3. Demand for all products or services	4. Productivity	5. Investment
Ensuring a long-term vision	1.5%	2.3%	1.8%	1.7%	2.3%
Complex governance system	0.2%	0.5%	0.5%	1.3%	0.8%
Fragmented legal and policy framework	0.7%	0.7%	0.8%	1.0%	1.3%
Uneven distribution of the EU space sector	1.2%	1.3%	1.0%	1.5%	1.5%
Staying internationally competitive	2.2%	2.2%	2.2%	2.5%	2.5%
Strategic autonomy in space domain	3.0%	2.0%	2.0%	1.5%	3.0%

The following stakeholders were interviewed over the course of the study (in alphabetical order):

- Airbus Defence and Space
- Marco Aliberti (ESPI)
- Angelina Bekasova (Space & Innovation Policy Expert at Latvian Ministry of Economics)
- Michal Brichta (Slovak Space Office)
- Aleksandra Bukała (POLSA)
- Chris Chaloner (Trym Systems)
- Pascal Claudel (EUSPA)
- Steve Greenland (SME4Space)
- Kaja Hopej
- Rene Kleeßen (DLR)
- Hans-Jörg Koenigsmann (independent expert, supervisory board of OHB and Mynaric)
- Max Kroymann (German Ministry of Economic and Climate Affairs)
- Mathias Link (Luxembourg Space Agency)
- Pierre Lionnet (Eurospace)
- Malta Council for Science and Technology
- OECD
- Salvatore Pignataro (Italian Permanent Representation to the EU)
- Luís Serina

ANNEX III Selected quantitative results by sector

Ideal state scenario

Table 31 shows the ideal scenario impact on employment at the disaggregated sector level. Overall, the sector that reacts the most in relative terms is construction, where deviations from the baseline employment values are as high as 0.7% in 2050. As our modelling exercise considers shocks that are uniform across sectors, this effect can be attributed to the structure of the economy rather than a differentiated impact of the removal of gaps and barriers on construction.

Notable differences in employment under the ideal state can be expected in the information and communications technology (ICT) sector (close to 0.4% higher than the baseline in 2050) and professional and scientific activities sector (again close to 0.4% higher than the baseline in 2050).

Conversely, the sector 'Public administration, defence, education, human health, and social work activities' records the most muted response to the removal of the gaps.

Table 31: Difference between baseline and ideal state scenario for employment by sector (percentage deviations from baseline scenario values)

	2025	2030	2040	2050
Agriculture, forestry and fishing	0.24	0.22	0.19	0.15
Industry (except construction and manufacturing)	0.29	0.27	0.22	0.18
Manufacturing	0.24	0.24	0.25	0.26
Construction	0.60	0.61	0.64	0.67
Wholesale and retail trade, transport, accommodation and food service activities	0.21	0.21	0.21	0.21
Information and communication	0.39	0.39	0.40	0.41
Financial and insurance activities	0.27	0.27	0.26	0.25
Real estate activities	0.38	0.37	0.34	0.32
Professional, scientific and technical activities; administrative and support service activities	0.31	0.32	0.34	0.36
Public administration, defence, education, human health and social work activities	0.14	0.13	0.10	0.07
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	0.23	0.23	0.22	0.22

Source: Authors' analysis.

The deviations between baseline and the ideal state scenario for real value added by sector are reported in Table 32. The construction sector is expected to post the highest deviation from the baseline, followed by several sectors that are projected to have roughly comparable positive deviations – ICT, real estate, industry, professional and scientific activities. The smallest, albeit still positive, deviations from baseline are expected in the 'Public administration, defence, education, human health and social work activities' sector.

Table 32: Difference between baseline and ideal state scenario for real value added by sector (percentage deviations from baseline scenario values)

	2025	2030	2040	2050
Agriculture, forestry and fishing	0.17	0.23	0.35	0.45
Industry (except construction and manufacturing)	0.18	0.25	0.38	0.49
Manufacturing	0.24	0.28	0.36	0.43
Construction	0.31	0.38	0.50	0.60
Wholesale and retail trade, transport, accommodation and food service activities	0.22	0.27	0.35	0.43
Information and communication	0.29	0.34	0.45	0.54
Financial and insurance activities	0.23	0.28	0.39	0.47
Real estate activities	0.11	0.19	0.35	0.49
Professional, scientific and technical activities; administrative and support service activities	0.28	0.33	0.42	0.51
Public administration, defence, education, human health and social work activities	0.20	0.23	0.29	0.35
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	0.21	0.27	0.37	0.46

Source: Authors' analysis.

Table 33 and Table 34 present expected developments under the ideal state scenario at a disaggregated level and in absolute terms. The results reflect the combination of the deviations that are expected to materialise under the ideal state scenario and the size of the different sectors. Thus, the highest absolute gains in real value added at the end of the simulation horizon can be expected in manufacturing, trade and transport, followed by real estate, professional and scientific activities, as well as the 'Public administration, defence, education, human health and social work activities' sector. Conversely, the absolute increases in real value added will be modest in agriculture and in the 'Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies' sector.

The most sizeable absolute employment gains from the removal of the gaps and barriers can be seen in trade and transport (over 150,000 additional jobs in 2050) and professional and scientific activities (about 140,000 additional jobs in 2050). Modest employment gains are expected in industry and real estate activities.

Table 33: Difference between baseline and ideal state scenario for real value added by sector, absolute deviations from baseline scenario values in constant 2021 prices, m EUR

	2025	2030	2040	2050
Agriculture, forestry and fishing	495	747	1,359	2,107
Industry (except construction and manufacturing)	1,040	1,555	2,837	4,425
Manufacturing	7,291	9,418	14,575	20,928
Construction	2,734	3,590	5,709	8,312
Wholesale and retail trade, transport, accommodation and food service activities	7,028	9,278	14,815	21,689
Information and communication	2,967	3,883	6,144	8,945
Financial and insurance activities	1,943	2,633	4,329	6,436
Real estate activities	2,074	4,031	8,837	14,773
Professional, scientific and technical activities; administrative and support service activities	5,457	7,065	11,077	16,074
Public administration, defence, education, human health and social work activities	6,545	8,063	12,188	18,069
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	1,071	1,471	2,462	3,694

Source: Authors' analysis.

Table 34: Difference between baseline and ideal state scenario for employment by sector, deviations from baseline scenario values in thousand persons

	2025	2030	2040	2050
Agriculture, forestry and fishing	28	27	24	20
Industry (except construction and manufacturing)	12	12	10	9
Manufacturing	90	93	102	112
Construction	105	110	123	137
Wholesale and retail trade, transport, accommodation and food service activities	132	137	145	155
Information and communication	33	34	37	40
Financial and insurance activities	16	17	17	18
Real estate activities	10	10	10	10
Professional, scientific and technical activities; administrative and support service activities	104	111	125	139
Public administration, defence, education, human health and social work activities	87	84	72	54
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	36	36	38	40

Source: Authors' analysis.

Policy Scenario 1

Policy Scenario 1 can bring about output gains in all sectors of the economy. As shown in Table 35, construction is likely to post the largest relative increases in real value added over the baseline scenario, starting at about 0.1% in 2025 and reaching 0.2% in 2050. The ICT sector and professional and scientific activities can also be expected to record among the highest relative gains if the scenario is implemented. More modest relative gains are likely to materialise in the 'Public administration, defence, education, human health and social work activities' sector.

The relative gains from implementing Policy Scenario 1 are translated in absolute gains in monetary terms, while taking into account the size of the different sectors (Table 36). Trade and transport, as well as manufacturing, can see the biggest increases in real value added over the entire simulation horizon. Real estate, professional and scientific activities, as well as the public administration sector are also expected to contribute significantly. The smallest absolute gains in real value added are projected in agriculture and industry.

Table 37 reports the simulated relative effects of implementing Policy Scenario 1 on sectoral employment. Mirroring the results for value added, construction records the largest relative deviations over the simulation horizon, followed by ICT and professional and scientific activities. The 'Public administration, defence, education, human health and social work activities' sector shows the smallest improvements relative to the baseline in this simulation.

The absolute deviations in employment, as given in Table 38, indicate that the largest gains in terms of additional people employed can be expected in trade and transport, professional and scientific activities, and construction. The smallest absolute employment effects are foreseen in the real estate and industry sectors.

Table 35: Impact of implementing Policy Scenario 1 on real value added by sector (percentage deviations from baseline scenario values)

	2025	2030	2040	2050
Agriculture, forestry and fishing	0.05	0.07	0.11	0.15
Industry (except construction and manufacturing)	0.05	0.08	0.12	0.16
Manufacturing	0.07	0.09	0.12	0.14
Construction	0.10	0.12	0.16	0.20
Wholesale and retail trade, transport, accommodation and food service activities	0.07	0.08	0.11	0.14
Information and communication	0.09	0.11	0.15	0.18
Financial and insurance activities	0.07	0.09	0.12	0.16
Real estate activities	0.03	0.06	0.11	0.16
Professional, scientific and technical activities; administrative and support service activities	0.09	0.10	0.14	0.17
Public administration, defence, education, human health and social work activities	0.07	0.07	0.09	0.12
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	0.07	0.08	0.12	0.15

Source: Authors' analysis.

Table 36: Impact of implementing Policy Scenario 1 on real value added by sector (deviations from baseline scenario values, constant 2021 prices, m EUR)

	2025	2030	2040	2050
Agriculture, forestry and fishing	145	228	433	687
Industry (except construction and manufacturing)	306	474	900	1,435
Manufacturing	2,292	2,995	4,723	6,879
Construction	840	1,123	1,833	2,715
Wholesale and retail trade, transport, accommodation and food service activities	2,209	2,950	4,799	7,123
Information and communication	924	1,226	1,981	2,927
Financial and insurance activities	599	827	1,393	2,104
Real estate activities	507	1,151	2,757	4,768
Professional, scientific and technical activities; administrative and support service activities	1,717	2,245	3,583	5,270
Public administration, defence, education, human health and social work activities	2,136	2,626	3,973	5,909
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	330	461	792	1,207

Source: Authors' analysis.

Table 37: Impact of implementing Policy Scenario 1 on employment by sector (percentage deviations from baseline scenario values)

	2025	2030	2040	2050
Agriculture, forestry and fishing	0.08	0.08	0.06	0.05
Industry (except construction and manufacturing)	0.10	0.09	0.08	0.06
Manufacturing	0.08	0.08	0.08	0.08
Construction	0.19	0.20	0.21	0.22
Wholesale and retail trade, transport, accommodation and food service activities	0.07	0.07	0.07	0.07
Information and communication	0.13	0.13	0.13	0.13
Financial and insurance activities	0.09	0.09	0.08	0.08
Real estate activities	0.12	0.12	0.11	0.10
Professional, scientific and technical activities; administrative and support service activities	0.10	0.10	0.11	0.12
Public administration, defence, education, human health and social work activities	0.04	0.04	0.03	0.02
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	0.08	0.08	0.07	0.07

Source: Authors' analysis.

Table 38: Impact of implementing Policy Scenario 1 on employment by sector (deviations from baseline scenario values, thousand persons)

	2025	2030	2040	2050
Agriculture, forestry and fishing	9	9	8	7
Industry (except construction and manufacturing)	4	4	4	3
Manufacturing	29	31	33	37
Construction	34	36	40	45
Wholesale and retail trade, transport, accommodation and food service activities	43	45	48	51
Information and communication	11	11	12	13
Financial and insurance activities	5	6	6	6
Real estate activities	3	3	3	3
Professional, scientific and technical activities; administrative and support service activities	34	36	41	46
Public administration, defence, education, human health and social work activities	28	28	24	18
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	12	12	13	13

Source: Authors' analysis.

Policy Scenario 2

Expected developments in real value added by sector are reported in Table 39. Similar to the results for the other simulations, construction is expected to increase the most relative to the baseline. Other notable sectors include ICT, industry, finance and insurance, and professional and scientific activities. The smallest relative increase in real value added at the end of the simulation horizon is observed in the 'Public administration, defence, education, human health and social work activities' sector.

Table 40 provides counterpart information to Table 39 in absolute terms. Policy Scenario 2 can be expected to bring about the largest gains in real value added in trade and transport and manufacturing. Real estate, professional and scientific activities, and the public administration sector also could post high absolute increases in real value added. Conversely, the smallest gains are observed in agriculture.

The biggest relative gains in employment by sector can be expected in construction (see Table 41), followed by ICT and professional and scientific activities. Modest increases in employment are envisaged in the 'Public administration, defence, education, human health and social work activities' sector.

Table 42 documents the absolute effects on sectoral employment from implementing Policy Scenario 2. The largest increases in employment over the baseline are expected in the trade and transport sector. Professional and scientific activities, construction and manufacturing also post notable employment gains. Minimal employment increases in absolute terms are expected in agriculture, industry, finance, and insurance, as well as real estate.

Table 39: Impact of implementing Policy Scenario 2 on real value added by sector (percentage deviations from baseline scenario values)

	2025	2030	2040	2050
Agriculture, forestry and fishing	0.04	0.07	0.11	0.14
Industry (except construction and manufacturing)	0.05	0.08	0.12	0.16
Manufacturing	0.06	0.09	0.12	0.14
Construction	0.08	0.12	0.16	0.20
Wholesale and retail trade, transport, accommodation and food service activities	0.06	0.09	0.12	0.14
Information and communication	0.08	0.11	0.15	0.18
Financial and insurance activities	0.06	0.09	0.13	0.16
Real estate activities	0.02	0.05	0.11	0.15
Professional, scientific and technical activities; administrative and support service activities	0.08	0.11	0.14	0.17
Public administration, defence, education, human health and social work activities	0.06	0.08	0.10	0.12
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	0.06	0.09	0.12	0.15

Source: Authors' analysis.

Table 40: Impact of implementing Policy Scenario 2 on real value added by sector (deviations from baseline scenario values, constant 2021 prices, m EUR)

	2025	2030	2040	2050
Agriculture, forestry and fishing	120	223	428	681
Industry (except construction and manufacturing)	259	471	899	1,435
Manufacturing	1,985	3,065	4,805	6,970
Construction	720	1,133	1,845	2,728
Wholesale and retail trade, transport, accommodation and food service activities	1,903	3,002	4,868	7,208
Information and communication	808	1,265	2,031	2,988
Financial and insurance activities	522	848	1,421	2,140
Real estate activities	391	1,063	2,658	4,650
Professional, scientific and technical activities; administrative and support service activities	1,494	2,310	3,665	5,368
Public administration, defence, education, human health and social work activities	1,896	2,785	4,175	6,165
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	284	468	801	1,220

Source: Authors' analysis.

Table 41: Impact of implementing Policy Scenario 2 on employment by sector (percentage deviations from baseline scenario values)

	2025	2030	2040	2050
Agriculture, forestry and fishing	0.08	0.09	0.08	0.06
Industry (except construction and manufacturing)	0.10	0.11	0.09	0.08
Manufacturing	0.08	0.09	0.10	0.10
Construction	0.17	0.21	0.22	0.24
Wholesale and retail trade, transport, accommodation and food service activities	0.07	0.08	0.08	0.08
Information and communication	0.12	0.15	0.15	0.15
Financial and insurance activities	0.09	0.10	0.10	0.10
Real estate activities	0.12	0.14	0.13	0.12
Professional, scientific and technical activities; administrative and support service activities	0.09	0.12	0.12	0.13
Public administration, defence, education, human health and social work activities	0.05	0.05	0.05	0.04
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	0.07	0.09	0.09	0.09

Source: Authors' analysis.

Table 42: Impact of implementing Policy Scenario 2 on employment by sector (deviations from baseline scenario values, thousand persons)

	2025	2030	2040	2050
Agriculture, forestry and fishing	9	11	10	9
Industry (except construction and manufacturing)	4	5	4	4
Manufacturing	28	36	39	43
Construction	31	39	44	49
Wholesale and retail trade, transport, accommodation and food service activities	42	53	56	59
Information and communication	10	13	14	15
Financial and insurance activities	5	7	7	7
Real estate activities	3	4	4	4
Professional, scientific and technical activities; administrative and support service activities	32	41	46	51
Public administration, defence, education, human health and social work activities	30	36	33	27
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	11	14	15	16

Source: Authors' analysis.

Policy Scenario 3

Table 43 indicates that real value added in construction is expected to increase the most relative to the baseline. In close correspondence to the results for Policy Scenario 2, the next largest relative increases in real value added could be observed in ICT and professional and scientific activities. The 'Public administration, defence, education, human health and social work activities' sector is expected to post the smallest relative increase.

If Policy Scenario 3 is implemented, the most substantial absolute increases in real value added would materialise in trade and transport, and in manufacturing (Table 44). The 'Public administration, defence, education, human health and social work activities' sector, along with real estate and professional and scientific activities, are also expected to post substantial increases in real value added, especially toward the end of the simulation horizon. The smallest absolute gains are likely to be obtained in agriculture.

Table 45 documents expected relative deviations in sectoral employment. The largest ones are to be observed in construction, followed by professional and scientific activities and ICT. The smallest relative increases in employment could be observed in the 'Public administration, defence, education, human health and social work activities' sector.

Expected absolute deviations in sectoral employment are reported in Table 46. Trade and transport, and professional and scientific activities are projected to post the highest increases in terms of number of persons employed if this scenario is implemented. Negligible employment increases in absolute terms are expected in agriculture, industry, finance, and insurance, and in real estate.

Table 43: Impact of implementing Policy Scenario 3 on real value added by sector (percentage deviations from baseline scenario values)

	2025	2030	2040	2050
Agriculture, forestry and fishing	0.03	0.06	0.10	0.13
Industry (except construction and manufacturing)	0.04	0.07	0.11	0.14
Manufacturing	0.05	0.08	0.11	0.13
Construction	0.07	0.11	0.15	0.18
Wholesale and retail trade, transport, accommodation and food service activities	0.05	0.08	0.11	0.13
Information and communication	0.06	0.10	0.13	0.16
Financial and insurance activities	0.05	0.08	0.11	0.14
Real estate activities	0.02	0.05	0.10	0.14
Professional, scientific and technical activities; administrative and support service activities	0.06	0.10	0.13	0.15
Public administration, defence, education, human health and social work activities	0.05	0.07	0.09	0.11
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	0.05	0.08	0.11	0.14

Source: Authors' analysis.

Table 44: Impact of implementing Policy Scenario 3 on real value added by sector (deviations from baseline scenario values, constant 2021 prices, m EUR)

	2025	2030	2040	2050
Agriculture, forestry and fishing	101	205	391	622
Industry (except construction and manufacturing)	216	430	818	1,306
Manufacturing	1,636	2,783	4,364	6,332
Construction	593	1,027	1,674	2,477
Wholesale and retail trade, transport, accommodation and food service activities	1,570	2,729	4,424	6,552
Information and communication	661	1,140	1,834	2,703
Financial and insurance activities	429	767	1,287	1,940
Real estate activities	337	983	2,436	4,252
Professional, scientific and technical activities; administrative and support service activities	1,225	2,086	3,314	4,861
Public administration, defence, education, human health and social work activities	1,543	2,496	3,749	5,544
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	235	425	728	1,109

Source: Authors' analysis.

Table 45: Impact of implementing Policy Scenario 3 on employment by sector (percentage deviations from baseline scenario values)

	2025	2030	2040	2050
Agriculture, forestry and fishing	0.06	0.08	0.07	0.06
Industry (except construction and manufacturing)	0.08	0.10	0.08	0.07
Manufacturing	0.06	0.08	0.08	0.09
Construction	0.14	0.19	0.20	0.21
Wholesale and retail trade, transport, accommodation and food service activities	0.05	0.07	0.07	0.07
Information and communication	0.09	0.13	0.13	0.13
Financial and insurance activities	0.07	0.09	0.09	0.08
Real estate activities	0.10	0.12	0.12	0.11
Professional, scientific and technical activities; administrative and support service activities	0.08	0.10	0.11	0.11
Public administration, defence, education, human health and social work activities	0.04	0.05	0.04	0.03
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	0.06	0.08	0.08	0.07

Source: Authors' analysis.

Table 46: Impact of implementing Policy Scenario 3 on employment by sector (deviations from baseline scenario values, thousand persons)

	2025	2030	2040	2050
Agriculture, forestry and fishing	7	9	8	7
Industry (except construction and manufacturing)	3	4	4	3
Manufacturing	22	31	34	37
Construction	25	34	39	43
Wholesale and retail trade, transport, accommodation and food service activities	33	46	48	52
Information and communication	8	11	12	13
Financial and insurance activities	4	6	6	6
Real estate activities	3	3	3	3
Professional, scientific and technical activities; administrative and support service activities	25	36	40	45
Public administration, defence, education, human health and social work activities	23	30	27	22
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	9	12	13	13

Source: Authors' analysis.

Examples of impact of space sector on other sectors

Finally, we present in the textbox below a number of examples of how the European space sector can impact the European economy's other sectors.

Space Investment and Added Value: three examples

All three policy scenarios estimate investment in the European space sector will have a positive impact on the European economy's other sectors. To provide an indication of where this growth comes from, it is informative to have a closer look at how the space sector influences other sectors. Below, examples of agricultural, transportation and insurance sectors are provided. In this regard, it is important to stress that these examples are not derived from the econometric model used in the study but merely serve to contextualise its results.

Space and Agriculture

Satellite data is increasingly being used to predict environmental hazards, which enables farmers to adjust their activities accordingly. Farmers can significantly improve their output by having more accurate information on future climate, weather and environment conditions which helps them to define, for instance, start and end dates of the planting and harvesting seasons. Space data also becomes more precise and localised. Data from Earth observation satellites improves, for instance, water management and crop fertilisation in local areas. This type of data helps indicating where water needs to be redistributed to avoid over-irrigation and informs using more fertiliser would be required in which fields in order to increase their yield. In addition to predicting future conditions, satellite communications also provide for the possibility of machine-to-machine communication in remote areas where terrestrial networks are not always reliable.

Sources: ESA, 2018. How Space Data is enabling the Agritech sector; FAO, n.d. WaPOR: remote sensing for water productivity ; Dos Santos, G.M. et al. (2019). Water Management in Irrigation Systems by using Satellite Information, In Eds. - Rustamov, R.B. Satellite Information Classification and Interpretation; NASA, 2021. Satellites help improving crop yields in India; Spacenus, 2021. How satellite imaginery can help farmers save money and improve their fertilizing strategies.

Space and transport

Satellite technology has considerably improved the quality of the communication data that covers areas where terrestrial communications are absent or unreliable. A way to use this improved communication data is the development of Internet of Things (IoT) solutions. This involves constant communication between vehicles and their surroundings (i.e., vehicle-to-vehicle and vehicle-to- (road) infrastructure interactions): the so-called 'connected car'. This type of technology can thus contribute to the efficiency of planned routes by taking into account, among other things, vehicles' positioning and weather conditions.

Sources: ESA, 2018. ESA, 2018. The Impact of Space Data on Smart Transport & Logistics; European Commission, 2015. Business Innovation Observatory: Internet of Things – Connected Cars; Technology.Org, 2018. How Satellites will affect Smart Transport and Logistics.

Space and the insurance industry (InsurTech)

The recent initiative Global Events Observer (GEO) launched by McKenzie Intelligence Services highlights the potential use of space infrastructure in the insurance industry. GEO provides highly accurate geotagged data by combining data from space and ground-based sensors that can be used for identifying and tracking damage to property and infrastructure with the consequence that insurance assessments no longer need to occur onsite. In addition, satellite infrastructure also facilitates the calculation of risk profiles, as it improves the risk forecasting of, for example, natural disasters and extreme weather events. The better insurance companies are able to establish risk profiles of customers, the more accurately it can establish the risk premiums that customers need to pay for the insurance.

Sources: ESA, 2022. Assessing Insurance risk and damage in the digital age, ESA, 2021. Space in support for the insurance sector, InsurTech, 2021. Space Data for Insurance: How it changes the Insurtech game

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This 'cost of non-Europe' report looks at the potential benefits of efficient, ambitious and united EU-level action in the space sector. The report finds that to enable the European space sector to benefit from open strategic autonomy, and to ensure EU access to and use of space, including for its security, the EU must act decisively. Moving away from fragmentation could bring large benefits, amounting to at least €140 billion per year by 2050.

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