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Developing a space economy thematic account for Europe

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Executive summary

The European space economy thematic account aims to provide a harmonised framework for the generation of reliable and comparable space economic statistics in Europe with the purpose of supporting regulators, policy makers, investors and business owners in making better-informed decisions. The dedicated thematic account will cover main Gross Domestic Product (GDP) indicators, such as output, gross value added and employment of the space sector, thereby opening up a wide range of possibilities for economic analyses and measurement of the space economy in Europe.

During the last decade, the space economy has been gaining increasing interest due to its important role in modern societies and the rising number of countries and enterprises involved in space activities. This growing importance has subsequently increased the demand for reliable and timely statistics on the space economy. Nonetheless, a robust economic measurement of the space economy is hampered by the scarcity of economic data on space and the lack of consistent methodology for its measurement. To enable the establishment of comparable data and a more accurate quantification of the space economy, a thematic account for space economic activities can be developed by relying on national and inter-country space economy Supply and Use Tables (SUTs), following international accounting standards.

The present publication focuses specifically on the methodological aspects of developing such a space economy thematic account for Europe. It provides insight into the definition and scope of the European space economy and the steps required to construct national space economy SUTs and inter-country space economy SUTs, both aligned with the Eurostat's inter-country Supply, Use and Input-Output (FIGARO) tables. Furthermore, it explores the possibility of constructing space economy institutional sector accounts to identify the space business governance by institutional sector and the relationships between different types of direct investment and ownership/control.

This publication reflects the outcome of the work carried out by the European Space Agency (ESA) and the European Commission´s Directorates-General Eurostat and the Joint Research Centre (JRC) on the construction of a methodology for the development of the European space economy thematic account. The report builds on existing efforts of the United States Bureau of Economic Analysis (US BEA) on the construction of a space thematic account for the United States, the handbooks of the Organisation for Economic Cooperation and Development (OECD) for measuring the space economy, the United Nations Guidelines to account for Global Value Chains Satellite Accounts, and the lessons learned from the compilation of other thematic accounts in the EU.

The success of the compilation of the European space economy thematic account, as described in this report, relies on a joint effort among national and international institutions and space agencies as well as the European space industry.

1 Introduction

1.1 Objective

The development of a European space economy thematic[1] account aims to capture the actors, economic activities, products, and transactions of the space economy in a harmonised way at European level.

Measuring the size of the space sector is crucial as the space economy is playing an important role in the functioning of modern societies and their economic development. Satellite technologies enable the functioning of several common products and services such as navigation, mobile phones, streaming services, weather forecasts and international videoconferencing. However, given the challenges related to the definition and measurement of the space economy, having an accurate quantification of the space economy and monitoring its evolution over time are not straightforward. Establishing a harmonised approach is therefore of utmost importance. This would allow for reliable and comparable space economic statistics inside the European Union (EU) that can support regulators, policy makers, investors and business owners in making better-informed decisions.

A dedicated European space economy thematic account would cover main Gross Domestic Product (GDP) indicators, such as output, gross value added and employment of the space sector, in order to quantify the size of the space sector in the total economy. In addition, it would open up possibilities for a wide range of economic analyses on the space sector. Example of such analyses are the accurate evaluation of the economic benefits of the EU Member States' investment in the European Space Programme, the impact assessment of European policy changes on the space economy and the analysis of the overall employment attributable to the space economy.

This report provides an overview of the methodological work conducted by the European Space Agency (ESA) together with the European Commission´s Directorates-General Eurostat and Joint Research Centre (JRC) in developing a thematic account for the European space economy. The report defines the space economy, outlines the methodology for building a thematic account, and emphasises the contributions of individual countries in identifying pertinent activities and products.

1.2 Importance of the space economy

The early days of the space economy were dominated by enabling missions for defence, military and space exploration purposes. Most efforts were focused on the development of the first rockets, ballistic missiles, spy satellites and attempts to put the first human in space. During this time, space represented the unknown, far removed from the daily lives of citizens. This began to change in 1980 due to the uptake of civilian and commercial space applications. More actors became involved and started to explore the possibilities of transferring traditional space technologies to various industries,

[1] The updating of the System of National Accounts (SNA) 2008 is leading to a change in the denomination of the term 'satellite account' into 'thematic account' in the SNA 2025. Consequently, the term 'thematic account' is being used throughout this document.

both inside and outside the space sector. Improvements within computing power capabilities, microelectronics, material sciences, additive manufacturing, and the declining costs and risks of relevant space technologies further drove the development of new mass-market space applications (Wooten & Tang, 2018). These developments opened up previously unexplored avenues to growth and innovations that once seemed too expensive or too complicated.

Nowadays, the space economy is playing an important role in modern societies and their economic development. Space technologies enable various applications that play a crucial role in meeting many of the societal, technical and environmental challenges that the world is facing today (OECD, 2019). For example, space technologies are used for monitoring and responding to natural disasters, assisting search and rescues, enhancing security and defence, enabling climate change and environmental monitoring and enabling high-level digital and communication developments. While many of these indirect and direct space applications are often overlooked in everyday life, they are of tremendous (societal) value.

In 2017, the global space economy was valued, in terms of output, at EUR 309 billion. Its annual growth was estimated to 6.7 %, and thereby almost twice as fast as the global total economy growth between 2005 and 2017. Within the same year, the European space economy was valued in the range EUR 53-62 billion and employed over 231 000 professionals(2) making it the second largest space economy in the world. Space-enabled services alone currently support 6 % to 9 % of the European economy indicating the importance of space in economic growth and job creation(3). In addition, the large private and public investments within European space activities have led to positive economic benefits, knowledge spill-overs and societal benefits (e.g. in the form of enhanced decision-making, increased feeling of security and cost efficiencies). Prospects for further development of the European space economy are positive, with growing investments from private sources that signal the increasing attractiveness of the commercial part of the space economy (European Investment Bank, 2019) and many promising innovations and new space technology systems such as potential future ones that will enable in situ resource utilisation and space-based solar power.

National governments and European institutions generally acknowledge the role of the space economy in the generation of economic growth and the creation of jobs and societal benefits. At national level, several initiatives have been taken regarding the implementation or change of space policies and projects in order to fully benefit from the latest space developments (e.g. Danish National Space Strategy(4), Swiss Space Policy(5), the government's strategy for Norwegian space activities(6) and the Strategy for Swedish space activities(7)). Within Europe, both the European Space Agency (ESA) (e.g. the ESA Agenda 2025(8) and the preparation of ESA Accelerators(9)) and the European Union (EU) (e.g. Space Strategy for Europe(10) and the EU Space Programme (2021-2027)(11)) are promoting the development of the space economy and boosting the space commercialisation and business development. Both institutions aim to foster and maintain a strong and resilient European space economy that benefits society. Moreover, they acknowledge the potential of the space economy to facilitate several of the political priorities in the areas of security and defence, industry and digital technology, environmental change and economic recovery.

The growing importance of the space economy has increased demand for reliable and timely statistics on the space economy. These statistics can aid companies, institutions, policy makers, investors, researchers and the public in many ways. From a business perspective, the measurement

(2) https://www.consilium.europa.eu/en/infographics/eu-in-space/
(3) The reported numbers include products and activities that fall outside the scope of the space economy definition used for the construction of the space economy thematic account. They are merely reported to illustrate the general importance of the space economy.
(4) https://ufm.dk/en/publications/2021/denmarks-national-space-strategy
(5) https://www.sbfi.admin.ch/sbfi/en/home/research-and-innovation/space/swiss-space-policy.html
(6) https://www.romsenter.no/Aktuelt/Publikasjoner/The-Government-s-strategy-for-Norwegian-space-activities
(7) https://www.government.se/contentassets/ea187b8c0a814ac09c36b8a43154eb49/a-strategy-for-swedish-space-activities.pdf
(8) https://esamultimedia.esa.int/docs/ESA_Agenda_2025_final.pdf
(9) https://vision.esa.int/category/ambition/accelerate-the-use-of-space/
(10) https://ec.europa.eu/transparency/documents-register/detail?ref=JOIN(2023)9&lang=en
(11) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0696

of the space economy can help navigate companies towards particular business opportunities while also increasing awareness of the recent developments within space leading to better business and investment decisions. From a political perspective, an accurate measurement of the space economy is crucial to support national and international evidence-based policies. Not only can it increase the understanding of the economic impact of space programmes, it can also ensure insight into particular hurdles that may require extra policy attention, such as the management of space debris. Therefore, it enables more informed policies, informed decision-making on investments in national and European programmes and a more accurate steering of public investment. Nonetheless, a robust economic measurement of the space economy is hampered by the scarcity of economic data on space and the evolving nature of the space economy.

1.3 Main characteristics of the European space economy thematic account

To obtain reliable and comparable space economic statistics, a ‘thematic account’ for space economic activities can be developed. A thematic account highlights a particular economic theme or function that is otherwise hidden in the central national accounting framework. Via the rearrangement of concepts from the central statistical framework and complementing this with supplementary information derived from other sources, it can isolate the economic theme under consideration. Once established, a thematic account allows for comparability over time and countries enabling the estimation of an otherwise invisible economic theme or function to the larger economy (van de Ven, 2021). Nevertheless, its establishment heavily relies on the consensus on the statistical definition and the availability of highly disaggregated information on the particular economic theme.

Notwithstanding these difficulties, the practice of developing thematic accounts for measuring particular economic themes is not new. While the idea of thematic account development first emerged in 1980 along with the development of a first thematic account for tourism in Canada, it was only set out formally in the System of National Accounts (SNA) in 1993. Since then, many thematic accounts have been developed for a variety of economic themes such as health care, environment, tourism and the ocean economy, both inside and outside of the European Union.

For the space economy, the Bureau of Economic Analysis of the United States (US BEA) constructed a US space economy thematic account in 2019 using official national statistics (Highfill et al., 2020). Being the first space economy thematic account, it has proven to be of high value in providing robust and useful data on the actual contribution of the US space sector to the US economy. Its construction has been the starting point of many worldwide initiatives to develop national space thematic accounts.

To explore the possibility of setting up a European space economy thematic account, a collaborative effort between the ESA and the European Commission´s Eurostat and JRC was launched on the 1st of March 2022. On that day, a first project workshop was held where the three partners proposed a work programme to representatives from the space sector (the ESA Delegations) and statistical offices of the EU Member States.

A preliminary methodology was set up and presented at several workshops hosted by the ESA and the European Commission´s Eurostat and JRC. This methodology is based on the SNA Supply and Use framework. This framework includes the Supply and Use Tables, which depicts the domestic production process and the transactions of products (imports and exports) with the rest of the world. It helps to provide a complete and comprehensive description of the theme under consideration. The Supply and Use framework will help to capture the direct, indirect and induced contribution of the space sector to GDP and employment, using official statistics. The dedicated European space economy thematic account will cover output, gross value added (GVA) and employment of the space sector, unravelling the role of the space sector in the economy in terms of supply (producers) and demand (consumers).

The methodology of the thematic account for the European space economy will follow the approach of the US BEA (Highfill & MacDonald, 2022). Furthermore, it will take into account the lessons learned from the establishment of other thematic accounts within the EU, the guidelines provided by the OECD handbooks of measuring the space economy (OECD, 2012; OECD, 2022) and the UN Guidelines for compiling Global Value Chains Satellite Accounts (2019). Based on these guidelines, several methodological steps for constructing the European space economy thematic account were identified for which some needs to be performed at country level by the National Statistical Offices, with the help of National Space Agencies while others are more efficient to be done at European level. This report aims to explain in detail the methodology and to serve as a (conceptual) guide for the construction of the European space economy thematic account at the national and aggregated European level, taking into account that data availabilities may vary from country to country. Further details will also be explored to compile a type of thematic accounts that could enable the analysis of the position of the European space economy in the global value chains (GVCs).

In terms of country coverage, the thematic account for the European space economy aims to encompass the 27 EU Member States (including 19 ESA Member States, four ESA associate states and five ESA cooperating states, except Canada) as well as the three other ESA Member States that are not EU Member States. This implies including the following countries in the European space economy thematic account: Austria, Belgium, Bulgaria, Czechia, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

The next chapters present the definition and scope of the space economy in Europe, the methodological steps that have to be taken at national and European level as well as the data sources used to develop the European space economy thematic account. Chapter 2 includes a detailed description of the obtained European space economy definition, with its associated activities and products. Chapter 3 describes the main methodological elements from national accounting and extended Supply, Use and Input-Output Tables, highlighting the importance of the Supply and Use framework. Chapter 4 explains the required methodological steps for the construction of the space economy thematic account to be taken at national and European level. Chapter 5 discusses the measurement of the (socio-) economic impact of the space economy and Chapter 6 presents some possible applications of the thematic account in the impact assessment of EU space policies. Lastly, Chapter 7 presents some concluding remarks.

2 Definition and scope of the space economy in Europe

2.1 Challenges in defining the space economy

With the growing interest in the space economy, a wider range of space-related statistics became available, such as data provided by the ESA, the European Space Policy Institute (ESPI), the OECD or the Eurospace organisation. Nevertheless, measurement challenges remain due to several limitations and constrains.

A first challenge is related to the lack of a unified definition to measure the space economy. Despite many attempts by governmental organisations, institutions and private companies, there is currently no harmonised definition on what constitutes the European space economy and its included economic activities or products. While some definitions have been extensively used in various types of space reports (e.g. OECD, 2022), they leave room for interpretation regarding the inclusion of economic activities and products, causing them to be insufficient for statistical purposes. Moreover, the many aspects of the space economy have resulted in the adoption of different definitions, which gave rise to the use of various data collection methods (e.g. surveys, publically available reports or government budget documentations) and other methodological approaches depending on the focus of the analysis and the availability of information. In many cases, it remains unclear what exact approach is used to obtain statistical estimates. Nevertheless, even small differences in definitions or methodologies can cause large discrepancies in statistics, compromising comparability at national level. At European level, discrepancies can be even larger due to the need to preserve additional comparability between countries. Hence, the wide variety of approaches makes it difficult to evaluate the validity of statistical estimations, especially since there is no harmonised methodological approach that guarantees their accurate measurement.

A second challenge is caused by the statistical classification of products and economic activities. The European Classification of Products by Activities (CPA) and the Statistical classification of economic activities (NACE) present a structured set of mutually exclusive and well-described categories of products and economic activities. However, the relatively small size and highly dispersed nature of the space economy causes space-related products and activities rarely to appear as a separate category within these existing statistical classification systems. Instead, they are embedded within aggregated categories of economic products and activities (OECD, 2022). In some cases, national or regional classification systems can provide more granular space-related classifications, but remain insufficient to isolate the entire space economy. This causes the need to use alternative measures to obtain space statistics such as the usage of simplifying assumptions or estimations, measure of proxies, in-depth stakeholder interviews and case studies (OECD, 2022). The resulting statistics frequently tend to be either incomplete or incomparable with national economic account statistics and on the wider European level, thereby raising questions in terms of validity and reliability.

A third challenge is linked to the recent developments within the European space economy, which require the revision of some of the existing definitions and lead to additional measurement challenges. Over the last few years, the European space economy has seen a progressively higher participation of private companies and start-ups that focus on the commercialisation of space technologies to benefit from the opportunities offered by space for their business. By exploring the applicability of traditional space technologies and space infrastructure capabilities in various other industries, these companies have managed to expand and diversify the space market far beyond the economic activities and products that are traditionally associated with space (e.g. usage of bandwidth, repeaters, signals and data within satellite television and navigation). This cross-fertilisation between space and non-space industries is further encouraged by the increasing cooperation between non-space and space companies (e.g. recent collaborations between Google and SpaceX aimed at installing ground stations to increase the running time of applications). This growing inclusion of actors, economic activities and products has caused several existing definitions to become too limited or specific in terms of characteristics, requiring the establishment of a broader definition to capture the changing nature of the space economy.

At the same time, the increased embeddedness of space technologies, capabilities and systems within many consumer applications and services have resulted into additional measurement difficulties. Many of the enterprises producing these commercial applications have a core business that is now partially related to space while, simultaneously, many traditional space companies have a core business that is no longer fully related to space. This blurred line between space and non-space has caused difficulties in deciding which revenue threshold a company should reach to be considered a true space company (OECD, 2012) or how to separate revenues derived from space economic activities from those obtained elsewhere. All of these decisions can have large consequences for statistics given that a considerable share of the European space industry revenues relies either directly or indirectly on these space application-related markets (Moranta, 2022). Not taking into account particular companies or revenues can result in a gross underestimation, while taking them on board in their entirety can lead to gross overestimations of the industry size and value.

2.2 Defining the space economy

A good definition sets the boundary on what should and should not be included within the space economy so that it becomes easier to determine which goods, services, economic activities and actors are involved. It directly influences the data and methods used to develop statistics in later stages. Several attempts have been made in the past to define the space economy, most of them focussing on the (aero)space sector and specific space or in-orbit products (such as rockets and satellites) and activities (such as launch services and satellite services). One generally accepted definition of the space sector is the following: '*The space sector includes all actors involved in the systematic application of engineering and scientific disciplines to the exploration and utilisation of outer space, an area which extends beyond the Earth's atmosphere*' (OECD, 2012).

However, over the years, the space economy underwent a number of aforementioned important changes that caused it to reach much further than the traditional space sector. As a result, many early definitions have become too limited, specific or prescriptive in characteristics (OECD, 2012) to capture the full extent of the space economy. Governmental institutions have been putting forward several broader definitions based on the lessons learned from other sectors. These definitions aim to encompass the different dimensions and changing nature of actors, activities and products within the space economy. They go beyond the traditional space sector, including the broader use of space derived technologies and applications thereby taking into account that commercial considerations and socio-economic benefits may drive the further development of the space economy.

While there still is no one internationally agreed definition of the space economy, the definition of the OECD (OECD, 2012; OECD, 2022) has been dominantly used in existing space literature. The OECD defines the space economy as '*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. Hence, it includes all public and private actors involved in developing, providing* *and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities. It follows that the space economy goes well beyond the space sector itself, since it also comprises the increasingly pervasive and continually changing impacts (both quantitative and qualitative) of space-derived products, services and knowledge on economy and society'.*

This definition was established by building on the existing definition of the National Aeronautics and Space Administration (NASA[12]) with increased focus on value chains. Since its introduction, it has been used as a basis for defining the space economy of the United States, Australia (Australian Space Agency, 2020), New Zealand (Deloitte, 2019), and the United Kingdom (Department for Science, Innovation & Technology, 2023) and for several space economy related projects such as the UN Space Economy Initiative (2020).

To define the European space economy, the same definition is proposed to be used as a basis to ensure comparability and consistency with other international space economies. However, in line with the definition used for the development of the US space economy thematic account, space-derived activities and products, i.e. those that are only indirectly related to the space economy, are excluded from the scope of the European space economy thematic account. The inclusion of direct space activities and products is further discussed in the next sections.

2.3 Identification of space-related activities, goods and services

Using the definition proposed by the OECD (2022) for statistical purposes requires the identification of relevant activities and products. This is not an easy task because the space economy is highly dispersed across a wide number of economic activities.

Some traditional and common space-related activities and products are easily identifiable such as satellite communication, space manufacturing, navigation and positioning, space transportation, earth observation, space exploration, space science (OECD, 2022) and their included products. However, other space-related activities and products are lumped with non-space-related products as many space activities are increasingly using space-related goods and services as intermediary input for the development of applications. These applications are enabled by more traditional space activities and, although they may rely on satellite data or signals to operate, they are no longer strictly related to the core space sector (e.g. environmental management services). Even though they typically offer a wide variety of societal and economic benefits, they do not necessarily fulfil the functions of a space programme or support space activities. This poses the need to disentangle the space sector from other sectors and to make a decision on where to limit the scope of the space economy.

2.3.1 The space value chain for defining activities

A good starting point for defining space economy activities is the value chain framework, which describes the full chain of activities in the creation of a good or service. Value chains can provide insight into the complex and interdependent network of activities, sub-activities and the relationships between them. A simplified space value chain consists out of two complementary segments, an upstream and downstream segment (European Investment Bank, 2019), each including activities involved in the design, development, production and use of space-related goods and services.

[12] https://www.nasa.gov/pdf/214030main_columbus_future_forum_FINAL_2-22-08.pdf

The upstream segment includes activities such as the manufacturing of ground-based facilities and equipment, spacecraft, satellites and other products used in space, maintenance services, launch activities, the monitoring of space debris, scientific and engineering support or fundamental and applied space research. The downstream segment includes the daily operations of space infrastructure and space-enabled activities that directly rely on the provision of space satellite technology, signals or data to exist and function. This may include activities such as the operation of space and ground systems or the manufacturing of devices (e.g. GPS or GNSS receivers and GIS software) or services (e.g. satellite television broadcasts) supporting consumer markets. While some definitions of the downstream segment include the exploitation of the provided services (e.g. satellite imagery or data exploitation), it was decided to exclude it for the construction of the European space economy thematic account.

In some cases, existing literature on the space economy has introduced two additional complementary segments: a midstream segment and a segment including the independent activities derived from space (OECD, 2022). The midstream segment includes activities that can be placed between the upstream and downstream segment. It generally captures activities that link satellites to terrestrial infrastructure such as ground system operations, satellite operation and the lease or sale of satellite capacity, but also supporting activities in the form of network management, data storage, processing or dissemination. However, in many cases, and to construct the European space economy thematic account, these activities are classified as either upstream or downstream activities.

The segment including independent activities derived from space includes all activities that are derived from space, but are not dependent on it to function. These activities are often the result of, but not limited to, transferring technologies from the space sector to other sectors. A well-known example is a phone with GPS system. While the manufacturing of the equipment enabling these services are taken into account (e.g. GPS receiver), the product in which it is incorporated (e.g. phone) is not included within the scope of the European space economy for two reasons. First, they go beyond the chosen space economy definition in the sense that they are not crucial in the course of exploring, understanding, managing and utilising space. Second, from a national accounting point of view, the inclusion of both the manufacturing of the space devices and the products in which they are incorporated may lead to double counting and is in violation of national accounting best practices[13].

Hence, in line with reports on the European space economy (European Investment Bank, 2019) and discussions taking place on the OECD Space Forum and within the ESA Space Economy Steering Committee, a space value chain including only the upstream and downstream segment is used as a reference point for the development of this thematic account. By taking into account both the upstream and downstream segment, one can identify both the primary activities, i.e. activities performed in the space industry, and secondary activities, i.e. space-related activities carried out as secondary activities in other industries or the own space industries. These secondary activities would otherwise remain hidden as they are combined with the primary activities. For example, the space economy does not only cover the primary activity of space transport of passengers and freight, but also related activities such as the direct support of spacecraft operations or launchers. Outlining these activities sets the scope of measurement and the production boundaries of the European space economy thematic account.

2.3.2 From space-related activities to goods and services

By first defining the space value chain and pertinent economic activities, a preliminary list of relevant products can be identified. The activities provide insight into which goods and services are supplied by the space economy and which are used by the space economy for providing their outputs. Following the definition of the OECD (2011), space economy-related goods and services include those that are: (1) used in space or directly support those used in space, (2) require direct input from space to function or (3) are associated with space study (Highfill & Surfield, 2020).

(13) https://unstats.un.org/unsd/nationalaccount/sna2008.asp

2.3.2.1 CHARACTERISTIC AND CONNECTED PRODUCTS

To evaluate which products are space-related, it is customary to identify and distinguish characteristic and connected products based on the significance of their link to the industries. Characteristic products are those that are typical to the defined industries. Within the space economy, these are often the more traditional products associated with those produced by upstream industries such as spacecraft and spacecraft launch vehicles, ground stations and equipment, satellite communication services and research and experimental development in the area of space. These are products that do not exist in meaningful quantities or for which the level of consumption is significantly reduced if the space economy did not exist.

In contrast, connected products are those that are not typical, either by nature or because they are classified in broader product categories. These are goods and services produced in other industries, but used in the main industry. They are fundamental to support the space economy and its growth. For the space economy, this may include industrial gases such as hydrogen or liquid oxygen, consulting services or financial and insurance services. In some cases, it can also include products that are considered as space-related in a given country but not on a worldwide basis.

2.3.2.2 ANCILLARY AND HOUSEHOLD SERVICES

In addition to the characteristic and connected products, companies may rely on ancillary, non-commercial or in-house services to support space economic activities. Ancillary services are supporting services, which are produced and consumed within the same enterprise. They enable the provision or production of characteristic or connected products and ensure that the company can operate effectively. Examples of such enabling services are transportation, data processing, storage or maintenance amongst others (§5.35 of the 2008 SNA). Although these activities are part of the operating expenses involved in conducting the main business of companies, they are not traditionally captured in isolation, as they are not explicitly charged to the users of these services inside the company. Therefore, even though these services have a cost, it is difficult to assign them an exact price.

In addition to ancillary services, unpaid household activities are actively disputed in the System of National Accounts (SNA). Unpaid household activities capture the production of activities by households for their own consumption. While some of these activities can be considered important to fully capture the production of particular services related to a particular economic theme (e.g. health care), the high cost and specialisation required for the production makes it unlikely that household services play an important role within the space economy. In fact, none or very few companies can engage in these activities at a low cost (Danish Agency for Science, Technology and Innovation, 2008). Furthermore, these activities are very difficult to measure causing them to be intentionally excluded from the scope of the SNA, especially given the lack of official data recommendations that allow for their adequate inclusion. Moreover, even if it is attempted to estimate these activities, their inclusion would extend the production boundary of the SNA, which falls out of the scope of the construction of a thematic account. It was therefore decided not to take these activities into account when constructing the European space economy thematic account, a decision that also falls in line with the approach taken by the US BEA on the construction of the United States space economy thematic account.

2.3.2.3 MISSING MARKETS

Another difficulty within the space sector is the existence of a missing market or unpriced effect, i.e. a situation where a public good clearly provides a benefit to consumers, but is unlikely to exist naturally without intervention of public entities given the impossibility of charging consumers at the point of consumption.

Given its large role in monitoring, certain space activities may provide unique information related to biodiversity, aquatic resources and atmospheric quality that do not have a well-defined price (Adilov et al., 2022). While part of this information is often used internally (in-house services), this information can also be given to third parties in the form of a global public good. This public good is provided as a service from the government to its population, free of charge and frequently open for public use. Some particular examples are the services created by Copernicus, i.e. one of the flagship space programmes in Europe. Copernicus is the most advanced earth observation monitoring system in the world. It provides accurate and reliable earth observation data, information and services and is therefore frequently used to support environmental monitoring, detecting natural disasters, and civil protection. These data and services are made freely available to third parties for commercial and societal applications.

Although EU Member States contribute to the overall EU Space Programme, no specific price is put on this public information. This makes these services hard to evaluate in monetary terms (see London Economics (2022) as one attempt). While space assets in missing markets may play an essential role in generating societal benefits (Adilov et al., 2022), they are difficult to estimate and often represent only a small component of the entire socio-economic value chain of a good or service (OECD, 2004). For these reasons, activities or products related to missing markets will not be taken into account for constructing the European space economy thematic account.

2.4 Defining the space economy for Europe

To identify the relevant space products for European statistics, the ESA has built upon past research and definitions used by the US BEA and the OECD. The US BEA developed the world's first definition of the space economy, suitable for input-output modelling, as part of the development of the first space economy thematic account (Highfill et al., 2020). Following this definition, the US BEA descripted the US space economy in activities and products according to the US classification system based on the internal analyses of industries identified by the OECD, various private sector reports, and consultations with international space agencies, industry experts, and education facilities. The publication by the US BEA forms the starting point for determining the economic activities and products in the European statistical framework and corresponding classification system.

2.4.1 Identification of NACE and CPA codes

The work of the US BEA identified 201 space product (US commodity) codes in the United States. These products can be aggregated to 54 unique economic activities, expressed in North American Industry Classification System (NAICS) codes, which is the standard classification for economic activities in the US. Using the official correspondence table[14] and internal expertise, the US economic activity (NAICS) codes can be translated to 53 European economic activity (NACE Rev. 2[15]) codes. Within Europe, the Statistical Classification of Economic Activities (NACE) is the standard for classifying economic activities. These identified NACE codes are linked to 333 product (CPA 2.1[16]) codes that are considered to be candidates for space-related products in the European space sector. Similar to NACE, the Statistical Classification of Products by Activity (CPA) categorises goods and services. CPA and NACE are fully aligned with one another and identical up to the four-digit level. At each level of aggregation, CPA reflects the principal products of the activities according to the NACE codes.

Based on this list of 333 candidates, multiple products can readily be considered part of the space economy based on prior identification efforts reported in the OECD handbook on measuring the space economy (OECD, 2022). For the remaining candidates, the ESA conducts a critical evaluation in cooperation with several ESA experts in the fields of navigation, earth observation, telecommunication and various technical domains with the purpose of identifying the correct CPA codes corresponding to the original US product codes. This evaluation process also leads to the identification of additional European space products, known to be part of the European space sector

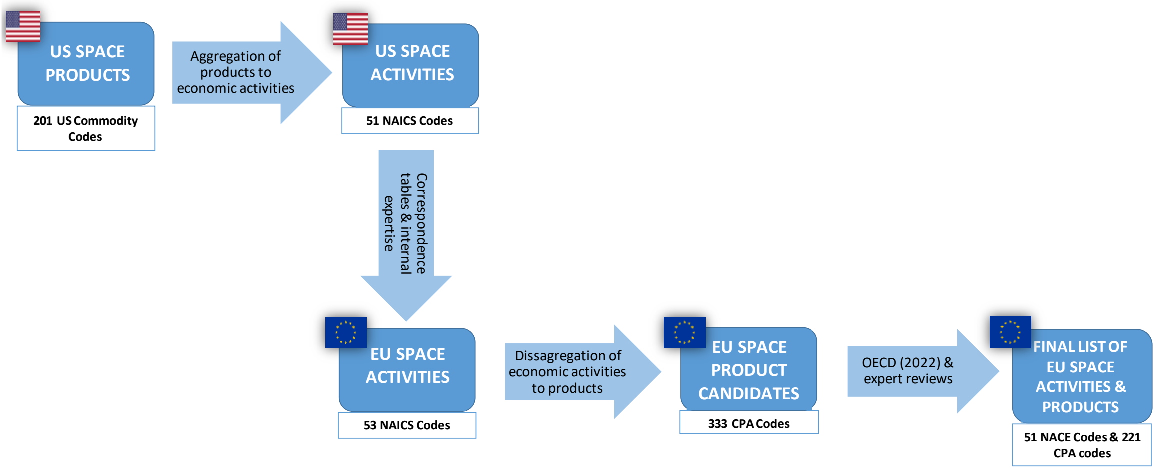
(14) https://ec.europa.eu/eurostat/web/metadata/classifications#Statistical%20classification%20of%20economic%20activities%20(NACE)
(15) https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/ks-ra-07-015
(16) https://ec.europa.eu/eurostat/de/web/cpa/cpa_2.1

and in line with the chosen definition, but not included in the original correspondence tables (Figure 2.1).

Due to the continuous and open exchange between the ESA, the European Commission´s Directorates-General Eurostat and JRC, the OECD and the US BEA during this evaluation, the final list of 51 unique space-relevant four-digit level NACE codes and 221 unique space-relevant six-digit CPA codes, representing a complete picture of the European space economy, have been identified. The majority of the CPA codes fall under the *section C – Manufactured products* (83 codes), *section J – Information and communication services* (57 codes), and section M – Professional, scientific and technical services (34 codes). Moreover, CPA codes were identified within the sections *F – Construction and construction works* (16 codes), *O – Public administrative and defence services; compulsory social security services* (12 codes), *P – Educational services* (12 codes), *H – Transportation and storage services* (3 codes), *K – Financial and insurance services* (2 codes), and *R – Arts, entertainment and recreational services* (2 codes).

The full list of codes can be consulted within the first ever joint report by the OECD, the US BEA, the ESA and the European Commission´s Directorates-General Eurostat and JRC on statistical tables to support the measurement of the space economy at international, North American and European levels (see ESA et al. 2023).

Figure 2.1: Stylised process to identify European space-related products and activities



Source: Own elaboration.

2.4.2 Identification of HS codes for goods

In addition, as the trade statistics are expressed in terms of Harmonised System (HS) codes at six-digit level, which is a standardised numerical method for classifying traded products, an exercise has been done by the ESA, the European Commission´s Directorates-General Eurostat and JRC to convert the obtained list of space-relevant six-digit CPA codes into a list of six-digit HS codes. This link has been established using the Eurostat RAMON nomenclature server database[17].

While there is no readily available correspondence table from CPA to HS, an alternative table from CPA to Combined Nomenclature (CN) can be used. Therefore, finding the right correspondence between CPA to HS consists out of two intermediary steps:

- A first step requires establishing a link between the HS and CN classifications. This is a straightforward process given that the CN codes are directly compatible with HS codes at six-digit level. CN and HS both aim to provide statistics for trade within the EU and between

[17] https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/RAMON

the EU and the rest of the world. The CN codes only include an additional two figures to HS codes to apply more specific export measures for certain categories of goods.

- A second step requires linking the six-digit CPA codes to the six-digit CN codes using the existing correspondence table. However, this process is less straightforward as direct or unequivocal correspondence is not always possible between the CPA and CN codes. This gives rise to the existence of different types of relationships between the six-digit CPA and CN codes: (1) a direct one-to-one relationship, (2) a many(CPA)-to-one(CN) relationship, (3) a one(CN)-to-many(CPA) relationship and (4) a many(CPA)-to-many(CN) relationship. For the 193 CN codes identified via the correspondence table, 25 showed a direct relationship, one showed a many(CPA)-to-one(CN) relationship, 155 items showed a one(CPA)-to-many(CN) relationship and 13 items showed a many(CPA)-to-many(HS) relationship.

This approach has several limitations. First, the HS codes have only been developed for goods; they not are not available for services. This implies that even though the space economy is characterised by some services, these services cannot be included in the list of space-related HS codes. Nevertheless, for services, the CPA codes can be used for the purposes of establishing the thematic account. Second, as previously mentioned, linking CPA to HS codes requires the usage of a correspondence table (RAMON) due to the lack of an unequivocal conversion table. Therefore, an exact correspondence (one-to-one relationship) between the six-digit CPA and HS codes cannot be guaranteed.

For the full list of CPA codes provided in the publication of the ESA et al. (2023), 25 HS codes show a direct relationship with a space-related CPA (one-to-one relationship) while one HS code is linked to multiple space-related CPA codes (one-to-many relationship). For these HS codes, there is a similar level of disaggregation compared to the CPA codes causing the product definition of CPA to match the one of HS. Therefore, a clear link with the space economy can be assumed as the HS codes correspond directly to the information provided for the CPA codes.

However, for the remaining CPA codes, there is a link with multiple HS codes (many-to-one or many-to-many relationship) leading to the identification of additional 169 HS codes. In this case, the HS codes are much more disaggregated and narrowly defined compared to the CPA codes (see Table 2.1 for an example). Therefore, it remains uncertain whether each of the identified HS codes is truly related to the space economy (e.g. HS code 880730 includes parts, aeroplanes and helicopters). To overcome this limitation, the ESA is conducting a proper review of the identified space-relevant six-digit HS codes among those identified as potentially, but not necessarily related to the space economy. Ruling out HS codes that are not related to the space economy allows for the construction of more accurate and reliable statistics on the space economy. The thorough review of HS codes falls outside of the scope of the current ESA et al. (2023) publication, but will potentially be included in future revisions.

Table 2.1: CPA to HS correspondence for CPA code 30.30.50

CPA code and description	HS code and description
30.30.50 - Other parts of aircraft and spacecraft	*880710* - Aircraft and spacecraft; propellers and rotors and parts thereof
	880720 - Aircraft and spacecraft; under-carriages and parts thereof
	880730 - Aircraft and spacecraft; parts of aeroplanes, helicopters or unmanned aircraft
	880790 - Aircraft and spacecraft; parts thereof
	940110 - Seats; of a kind used for aircraft
	940191 - Seats; parts, of wood, (other than for use in the assembly of motor vehicles, other than automotive)
	940199 - Seats; parts, (of other than wood) for use in the assembly of motor vehicles

Source: CPA 2.1 and HS

The aforementioned scope and framework of the space economy in Europe are the basis for the conceptual methodology to construct the European space economy thematic account. Before explaining this methodology into detail, the national accounting concepts of thematic account and Supply and Use framework on which the methodology is built, are presented in the next chapter.

3 Concept and construction of thematic accounts

3.1 Thematic accounts in the System of National Accounts

The System of National Accounts (SNA) provides the framework for the measurement of the economic activities of countries. It follows specific economic principles and methodological recommendations, which are internationally agreed, to facilitate comparability across countries worldwide. The SNA describes a coherent, consistent and integrated set of macroeconomic accounts based on concepts, definitions, classifications and accounting rules that serve to build up the main aggregates of the Gross Domestic Product (GDP) and other related macroeconomic statistics to facilitate economic analysis and policy formulation. The SNA consequently provides a powerful basis for measuring economic themes in a manner that is consistent with and comparable to broader economic (national and international) statistics.

However, national accounts are typically collected and published at a level that is too aggregated to readily identify parts of certain economic themes such as the space economy. If certain aspects of the economic theme are hidden within industry aggregates, a more granular classification of activities and products is required to allow for the estimation of the economic theme.

For the measurement of these specific domains, which requires more flexibility and insight, the SNA incorporates the concept of thematic (satellite) accounts (SNA 2008, Chapter 29). Thematic accounts involve the rearrangement of central classifications and the inclusion of complementary elements without altering the globally accepted framework or underling concepts of the SNA in a fundamental way. Hence, they do not expand or supplement the concepts of the SNA nor do they involve the use of new classification systems and presentations. The main reason for the development of thematic accounts is that they are able to capture details of interest, providing a broader and more complete perspective of an economic theme, without overburdening the standard system by including too many subdivisions and detail (van de Ven, 2021). In essence, they bring forward many elements that are invisible in the central accounts thereby expanding the scope of national accounts to cover a specific area of interest. At the same time, their results will remain directly comparable with established National Account aggregates.

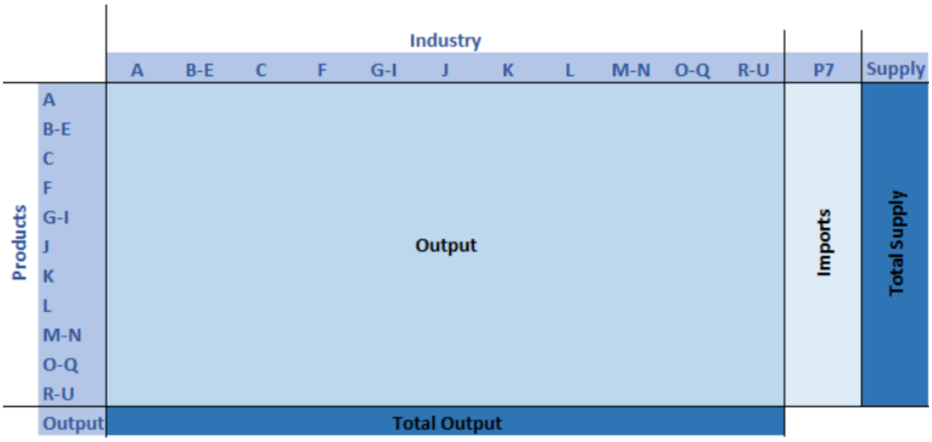
The thematic account has become a popular tool to accurately measure economic activities, functions or themes. Over the years, many thematic accounts have been developed including those for the education, health, travel and tourism, culture, digital economy, transport, aviation and ocean economy amongst many others. The construction of these thematic accounts contributes to the improvement of relevant theme-related statistics and analyses, including insights on interactions with the total economy.

3.2 Supply and Use framework

For the construction of thematic accounts, the Supply and Use framework is typically used as a starting point (van de Ven, 2021) given that it provides a comprehensive description of economic transactions. The Supply and Use framework consists out of Supply and Use Tables, which generally describe the domestic production process and the transactions of products (imports and exports) with the rest of the world.

As defined in the United Nations handbook on Supply, Use and Input-Output tables (United Nations, 2018), the Supply Table shows the output (by product) produced by economic activities and the imports from abroad, all of which makes the total supply of goods and services by industry. In other words, the Supply Table also provides information about the total supply by domestic industries and imports of products. The table captures both the primary and secondary activities of industries as each industry can produce different products that can be either related or not related to the specific economic theme, such as space. An illustration of a simplified Supply Table[18] is presented in Figure 3.1.

Figure 3.1: Simplified Supply Table



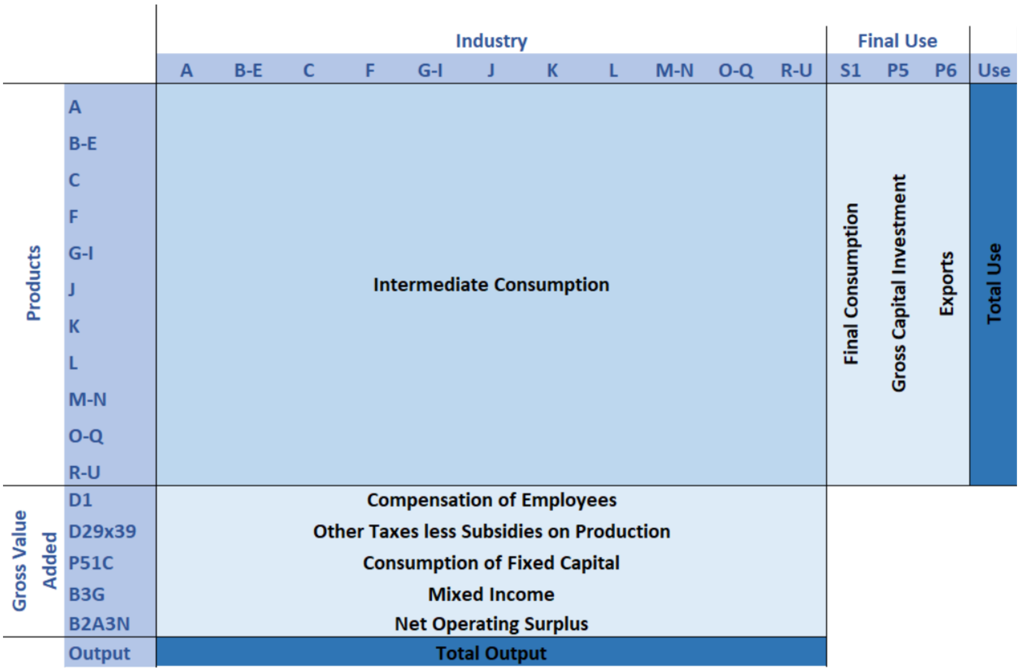
Source: Own elaboration based on United Nations (2018)

A Use Table shows information about the uses of the different products, by either industries (intermediate consumption or gross capital formation), households, government and non-profit institutions serving households (final consumption), or non-residents (exports). Furthermore, the Use Table provides information about the components of gross value added by industry, namely compensation of employees, other taxes less subsidies on production, consumption of fixed capital and net operating surplus.

The Use Table shows the goods and services required to produce the primary and secondary industry outputs. Generally, some products may be used in various industries while other products may be required in only one or a few industries. This is also likely the case for the space economy. A few examples of products that may be used as intermediate input in various industries are industrial gases, such as hydrogen or liquid air, while those that will be rarely used as intermediate input are space transport services of passengers. An illustration of a simplified Use Table is presented in Figure 3.2.

[18] With NACE A - Agriculture, Forestry and Fishing, B - Industry (except construction), C - Manufacturing, F - Construction, G-I - Wholesale and retail trade, transport, accommodation and food service activities, J - Information and Communication, K - Financial and Insurance activities, L - Real Estate activities, M-N - Professional, scientific and technical activities; administrative and support service activities, O-Q - Public administration, defence, education, human health and social work activities, R-U - Arts, Entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies

Figure 3.2: Simplified Use Table



Source: Own elaboration based on United Nations (2018)

Once balanced, the Supply and Use Tables (SUTs) can be integrated into a single framework, as shown in Figure 3.3. As stated in the United Nations handbook on Supply, Use and Input-Output Tables (United Nations, 2018), this framework shows the two basic identities linking the SUTs. The total supply by product equals the total use by product and the total outputs by industry are identical in both SUTs. Furthermore, Supply and Use Tables bring together the GDP main components from the production, income and expenditure approaches and, by definition, a single estimate of GDP, too. The SUTs also ensure the consistency and coherence of the national accounts components, namely, goods and services account, production account (by industry and by institutional sector) and generation of income account (by industry and by institutional sector). For further details, see Chapter 2 of the United Nations handbook (United Nations, 2018).

Generally, the SUTs allow for a complete and comprehensive description of a specific economic theme (e.g. space, tourism, etc.), providing details about their linkages with the rest of the economy and therefore, allowing for the calculation of both direct and indirect or induced impacts via the use of input-output analyses. As the construction of SUTs is bounded to requirements in terms of consistency and comprehensiveness, it serves as the best possible input for the construction of thematic accounts (van de Ven, 2019).

The SUT framework presented in this section is a general presentation that does not need to reflect all the details aimed for thematic accounts. For instance, it is generally difficult to estimate mixed income from the total compensation of employees and the consumption of fixed capital from the gross operating surplus, by activity. Moreover, the simplified framework is valued at purchasers' prices, i.e. including trade and transport margins and taxes less subsidies on products, in all production and trade flows, that will also require breaking them down into space and non-space-related activities. Beyond the SUT framework, other important economic variables such as investment and capital stock are often provided next to the SUTs by economic activity, depending on the country's data availability. To the extent possible, these should also have a proper breakdown between space and non-space-related activities.

Figure 3.3: Simplified Supply and Use framework

		Products	Industry	Final Use	
		A B-E C F G-I J K L M-N O-Q R-U	A B-E C F G-I J K L M-N O-Q R-U	S1 P5 P6	Total
Products	A B-E C F G-I J K L M-N O-Q R-U		Intermediate consumption by Product and Industry	Final consumption Gross capital formation Exports	Total Use by Product
Industry	A B-E C F G-I J K L M-N O-Q R-U	Output by Product			Total output by Industry
Gross Value Added	D1 D29x39 P51C B3G B2A3N		Compensation of employees Other Taxes less Subsidies on Production Consumption of fixed capital Mixed Income Net operating surplus		Total Gross Value Added
	Imports	Imports by Product			Total Imports
	Total	Total Supply by Product	Total supply by Industry	Total final uses	

Source: Own elaboration based on United Nations (2018)

4 Methodology

4.1 Introduction

The construction of thematic accounts offers the ability to bring forward elements that are invisible in the core accounts. Many aspects of the space economy lay behind industry aggregates and the construction of a thematic account offers the necessary granularity to isolate the space economy and enable a more accurate quantification. The construction of this thematic account offers several additional benefits (OECD, 2022) for the estimation of reliable and comparable space economic statistics.

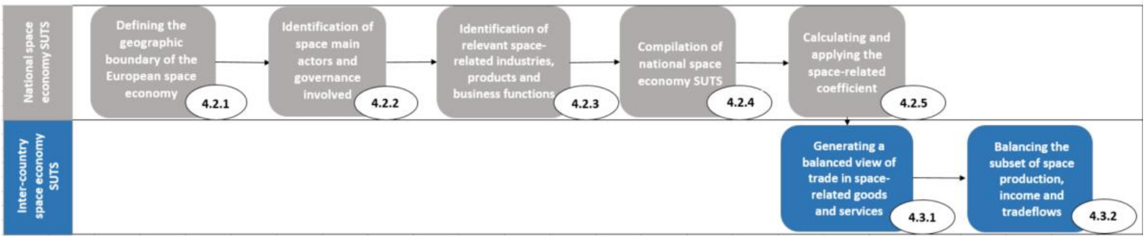
A first benefit is the establishment of comparable data. The space economy thematic account is, in essence, a reorganisation of information within national accounts. As the information listed within these national accounts has to undergo a rigorous process of validation and quality checks and abide by specific rules, it reduces the risk of double-counting and over-estimating values. Hence, once established, a thematic account allows for comparability over time and countries. For these reasons, it is an excellent basis for reliable and trusted analysis of the role of the space economy within the entire economy.

A second benefit is that it allows for a more extensive analysis of the production of space-related goods and services as well as how they are consumed, providing greater insight into the interconnections within and functioning of the space economy. Amongst others, this enhances the assessment of monetary value in terms of changes and their relationship to other industries, better decision making related to financing and related infrastructure and the assessment of the need for human capital investment within the space economy. Furthermore, it enables a range of economic analyses (e.g. input-output analyses or the use of general equilibrium models) that are difficult to achieve at present.

Based on the United Nations Guidelines to account for Global Value Chains Satellite Accounts (United Nations, 2021), this chapter describes the steps needed for compiling a thematic account for the European space economy by presenting each of the methodological steps that need to be performed at the national and European level (see Figure 4.1 for an overview of steps).

The European space economy thematic account comprise national space economy SUTs and inter-country space economy national SUTs, both aligned with the Eurostat's Full International and Global Accounts for Research in Input-Output analysis (FIGARO) tables. Complementarily, space economy institutional sector accounts, following the sequence of the national accounts (production, generation of income, etc.), could also be explored for identifying the space business governance by institutional sector and the relationships between different types of direct investment (financial and non-financial assets) and ownership/control.

Figure 4.1: Methodological steps for the European space economy thematic account



Source: Own elaboration

4.2 Space economy Supply and Use Tables

Following United Nations (2021), the European space economy can be associated to a specific global value chain (GVC) of specific industries and related products for intermediate and final uses. Other examples found in the literature are automotive industries and electronics. Each industry-specific GVC has its own characteristics in terms of GVC governance, activities and products involved and geography, so it is very important to specify at the outset the scope of value chain to be considered in the GVC-specific space SUTs, i.e. the extent to which the value chain includes upstream and/or downstream activities(19).

Next, the following steps are suggested to specify the scope of the value chain and to compile European space economy SUTs:

- Define the geographic boundary of the European space economy (see section 4.2.1);
- Identify the firms and main actors involved in the production of the space final products and the corresponding producers and suppliers of intermediate goods and services and classify them according to their role within the space economy: lead firms, affiliated suppliers (associated or subsidiaries), non-affiliated suppliers (see section 4.2.2);
- Identify the relevant space-related industries and products (goods and services), both final and intermediate products as well as business functions, to the extent possible, and map them to relevant classifications: United Nations International Standard Industrial Classification of all economic activities (ISIC) / EU Nomenclature of Economic Activities (NACE) / United Nations Central Product Classification (CPC) / EU Classification of Products by Activity (CPA) (see section 4.2.3);
- Compile a national GVC-specific European space economy SUT with a breakdown by GVC related space industry and related products. If possible, further breakdowns could be possible by business functions and firm ownership (national vs. foreign) (see section 4.2.4).

The next subsections, further elaborate the aforementioned steps. Once these steps are completed, the national European space economy SUTs (compiled for the space-relevant countries) should be integrated into inter-country space economy SUTs by incorporating explicitly and reconciled detailed trade statistics of the space-related products among such countries, and consistent with the Eurostat's FIGARO tables (see section 4.3).

4.2.1 Space geographical boundaries

Space value chain related activities are carried out across national boundaries on a global scale. Ideally, a European space economy thematic account would capture detailed information from each economy involved but the information required may not be available at the appropriate level of detail. A practical approach, instead, relies on the identification of the main relevant partner countries of the

(19) See Chapter 2 for more details on the decisions made regarding the European space economy.

space economy and the availability of data. As suggested by United Nations (2021), a threshold for inter-country trade flows is going to be established, such as the combined inter-country trade between the selected countries making up at least 50 % of the intermediate inputs into the space economy. While the trade flows within the selected countries will be explicitly identified, other trade flows might be collapsed as trade with the rest of the world.

4.2.2 Space main relevant players and governance

As a second step, it is suggested to identify the firms and main actors involved in the production of the space final products and the corresponding producers and suppliers of intermediate goods and services and classify them according to their role within the space economy: lead firms, affiliated suppliers (associated or subsidiaries) and non-affiliated suppliers[(20)]. The main data sources for this step are production data from business surveys, national SUT data, customs registers and trade statistics.

The space economy is characterised by a set of interrelated activities (or business functions) performed by firms across countries and governed by a lead firm that brings the space products from their conception (e.g. Research and Development (R&D)) to its final use and beyond (e.g. marketing sales and after-sale services). Therefore, different types of firms operate within the space economy as lead firms, controlling the value chain, and as suppliers across the world. Moreover, both lead firms and suppliers may have different ownerships and control relationships with other suppliers. The concept of business governance is applied here to the space economy SUTs by looking at the specific relationships between lead firms and their suppliers, of which the latter can be distinguished between affiliated firms and non-affiliated firms.

According to the Balance of Payments Manual (BPM6[(21)]) and the 2008 System of National Accounts, lead firms are those having the ultimate control over the enterprises that invest directly within the space value chain. They are typically classified as non-financial institutions. Activities of the lead firm are to be recorded in the country of its residence. In practice, depending on the complexity of the value chain, lead firms can refer to large enterprise groups (global group head). In contrast, supplier firms typically provide intermediate products or other semi-finished products and/or partially assembled components to the supply chain. Affiliated firms are those suppliers that are in a foreign direct investment relationship with the lead firm and non-affiliated firms are those that are not. Affiliates can also control/own further affiliates.

Besides these production and business line considerations of the space economy, financial relationships and tax considerations between space lead firms and suppliers are also important to identify the space economy value chain. Typically, lead firms use holding corporations or special purpose entities in low tax countries that determine the shape of the financial flows of the value chain opposite to the production flows that rely more on comparative advantages in labour and raw materials (developing countries) and R&D, design and marketing (developed countries).

Regarding the residence of multinational enterprise groups, it is preferable to separate institutional units within the enterprise group by economic territories where the centre for predominant economic interest lies (i.e. country where the economic entity has the strongest connection).

National Statistical Offices play a crucial role in providing detailed information about who the main players and governance of the space economy are, including what the role of other institutional sectors such as general government and households is.

[(20)] This classification of business roles is in line with the Balance of Payments Manual (BPM6), 2008 System of National Accounts, UNECE Guidelines on Statistical Business Registers and the OECD Benchmark Definition of Foreign Direct Investment (fourth edition).
[(21)] Balance of payments and international investment position manual (BPM6) - Statistics Explained (europa.eu)

4.2.3 Space-relevant products, activities and business functions

4.2.3.1 SPACE-RELEVANT PRODUCTS AND ACTIVITIES

The focus and value of national space economies tend to depend on the level of sector development and the degree of investment within a particular country (UN Office for Outer Space Affairs, 2020). While many countries are involved in space activities for military and security purposes, some may also experience the emergence of newer space markets in the areas of space travel and tourism, mining and manufacturing (Brennan et al., 2018). As a result, some countries have a space industry that is more oriented towards the downstream space economy while others are more oriented towards the more traditional upstream or manufacturing-based economy. For this reason, the list of codes (NACE, CPA and/or HS codes) identifying space-relevant products and activities at European level needs to be country-specific tailored to their actual national space activities. However, when integrating all of them into an inter-country setting, there must be a common list of space-related codes of products and activities across all participating countries.

Given the fact that the list of space-related codes has been internationally established taking into account a broad spectrum of possible space-related activities and products (ESA et al., 2023), the main task is expected to be limited to the identification of the relevant codes existing in national space activities and country-specific production. For example, if a certain country does not perform any space transport activities (NACE 51.22), the code may be excluded as a space economic activity for that particular country to obtain a country-specific set of space-related activities and products. Similarly, if a country does perform satellite communication activities (NACE 61.30), but does not produce any satellite telecommunication services (CPA 61.30.10), this product may be excluded as a space economic product for that particular country. For goods, the same approach can be taken in terms of HS codes.

In some cases, since all EU Member States use NACE, CPA and HS classifications, then national and regional classification systems may involve additional subclasses resulting in a higher granularity. As a result, they may provide more details in comparison to broader classifications, potentially allowing for a better identification of space-related activities or products. For example, while NACE 52.23 is considered relevant for the European space economy, it may still include activities that are not entirely relevant for space at national level. In this case, National Statistics Offices may rely on the more disaggregated classification codes, i.e. 52.23.1 or 52.23.2 to split service activities incidental to air transportation into two subcategories: (1) air transport operation services, air traffic control services and other services incidental to air transportation and (2) services incidental to space transportation. This split allows a more accurate accounting for space-relevant NACE codes. This level of detail should be maintained to the extent possible for the compilation of the space economy SUTs.

The identification of the relevant space-related intermediate and final products is as important as identifying and mapping participating enterprises in the global enterprise groups and space-related activities to ISIC/NACE. Following OECD (2022), it may be of interest to focus on the value chains of upstream or downstream activity groups. For instance, upstream activity groups such as: “research, engineering and other services”, “space manufacturing” and “space launch and transportation” and/or downstream activity groups such as: “operations of space and ground systems”, “supply of devices and products supporting the consumer markets” and “supply of services supporting the consumer markets”. Then, the constituent elements of those activity groups will have to be mapped into standard classification systems such as ISIC/NACE, CPC/CPA and HS (ESA et al, 2023).

4.2.3.2 SPACE RELEVANT BUSINESS FUNCTIONS

In order to compile the European space economy SUTs, business functions need to be mapped to the reference classification of products and activities, too. Following United Nations (2021), business functions are the activities controlled by the lead firm, which can be divided into core functions and support business functions, both carried out by the lead, affiliate and non-affiliated firms.

Core business functions are the activities of the lead firms producing the space final goods or services for the market or for third parties. These are typically the primary activity of the lead firm although it can also include secondary activities. As mentioned in section 2.3.2.2, support business functions are ancillary activities supporting the core business functions. The outputs of support business functions are not necessarily intended for the market or third parties directly. These can be subdivided into (United Nations, 2021):

- Transportation, distribution and logistics services;
- Marketing, sales and after-sales services;
- Information and communication technology services;
- Administrative and management services;
- Engineering and related technical services;
- Research and development services.

United Nations (2021, pp.71-74) provides a correspondence of support business functions with the CPC 2.1 product classification. Interestingly, while the mapping of support business functions may not change when looking at different thematic accounts, such as the case of the space value chain, the mapping of core business functions highly depends on the scope of the space value chain and the list of space relevant products and activities identified.

4.2.4 Compilation of the national space economy SUTs

The European System of Accounts 2010 Transmission Programme[22] requires countries of the European Statistical System (ESS)[23] to deliver Supply, Use, and Input-Output Tables for 64 industries and products, following the NACE and CPA classifications. However, for the construction of the space economy thematic account, only the information on activities and products related to the space economy, as defined in this report, is necessary. To obtain this information, the national Supply and Use Tables (at basic prices – see Box 1) need to be extended to cover space-related and non-space-related industries and products at the most disaggregated level possible and according to data availabilities within each country (Figure 4.2). Complementarily, total investment, capital stock and capital services are usually available as complementary information outside the national Use table (see Box 2 for further details).

For the Supply Table, the space economy thematic account requires the identification of the space-related goods and services supplied to the economy. This implies isolating the following information:

- Domestic output by space-related product (CPA/CPC) and space-related industry (NACE/ISIC) – (P1);
- Imports by space-related product (CPA/CPC) – (P7).

For the Use Table, the space economy thematic account requires identifying the space-related goods and services used and demanded in the economy. This implies isolating the following information:

- Intermediate consumption of space-related products (CPA/CPC) and by space-related economic activity (NACE/ISIC);
- Consumption of space-related products (CPA/CPC) for final uses (including households, government and non-profit organisations) – (S1);
- Gross capital formation by space-related products (CPA/CPC), including fixed assets such as spacecraft and launch facilities – (P5);
- Exports of space-related products (CPA/CPC) – (P6);

[22] https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-01-13-429-3A-C
[23] https://ec.europa.eu/eurostat/web/european-statistical-system

- Compensation to employees working in the space-related economic activities (NACE/ISIC) including mixed income, unless available data – (D1);
- Other taxes raised and subsidies on production paid by the space-related activities, households, government and external trade (NACE/ISIC) – (D29x39);
- Gross operating surplus[24] by the space-related economic activities (NACE/ISIC) – (B2A3G);
- Non-monetary information on the space economy, such as the number of jobs (part-time and full-time) supported by the space economy or the number of satellites.

If all economic activities and products identified at European level are considered relevant for the national space economy, this would lead to a set of SUTs containing information on 26 space-related industries (for two-digit level NACE/ISIC) and 26 space-related products (for two-digit level CPA/CPC). At the most disaggregated level of NACE and CPA codes at European level, it would include information on 51 space-related industries (for four-digit level NACE/ISIC), 221 space-related products (for six-digit level CPA/CPC) and 193 space-related goods.

Figure 4.2: Simplified Supply and Use framework for the European space economy

		Space Products	Non-Space Products	Space Industry	Non-Space Industry	Final Use			Total
		A B-E C F G-I J K L M-N O-Q R-U	A B-E C F G-I J K L M-N O-Q R-U	A B-E C F G-I J K L M-N O-Q R-U	A B-E C F G-I J K L M-N O-Q R-U	S1	P5	P6	Total
Space Products	A B-E C F G-I J K L M-N O-Q R-U			Intermediate consumption by Space Product and Space Industry	Intermediate consumption by Space Product and Non-Space Industry	Final consumption of Space Products	Gross capital formation of Space Products	Exports of Space Products	Total Use by Space Product
Non-Space Products	A B-E C F G-I J K L M-N O-Q R-U			Intermediate consumption by Non-Space Product and Space Industry	Intermediate consumption by Non-Space Product and Non-Space Industry	Final consumption of Non-Space Products	Gross capital formation of Non-Space Products	Exports of Non-Space Products	Total Use by Non-Space Product
Space Industry	A B-E C F G-I J K L M-N O-Q R-U	Output by Space Product and Space Industry	Output by Non-Space Product and Space Industry						Total output by Space Industry
Non-Space Industry	A B-E C F G-I J K L M-N O-Q R-U	Output by Space Product and Non-Space Industry	Output by Non-Space Product and Non-Space Industry						Total output by Non-Space Industry
Gross Value Added	D1 D29x39 B2A3G			Compensation of Space employees Space Other Taxes less Subsidies on Production Space Gross Operating Surplus	Compensation of Non-Space employees Non-Space Other Taxes less Subsidies on Production Non-Space Gross Operating Surplus				Total Gross Value Added
	Imports	Imports by Space Product	Imports by Non-Space Product						Total Import
	Total	Total Supply by Space Product	Total Supply by Non-Space Product	Total supply by Space Industry	Total supply by Non-Space Industry	Total final uses			

Source: Own elaboration based on United Nations (2018)

[24] This is the sum of net operating surplus and consumption of fixed capital.

Box 1 – From purchasers' to basic prices in the European space economy thematic account

Figure 4.2 shows a simplified SUT framework at purchasers' prices. However, the European space economy SUTs must be valued at basic prices, which means estimating the amount of taxes on products, subsidies on products and the trade and transport margins associated to all the space economy SUT elements.

Taxes and subsidies on products

Given the difficulty to find space-related (detailed) information about the taxes and subsidies on products and margins paid in each transaction flow by product and activity, this approach, instead, uses the national SUTs at basic prices and aims to breakdown the total amount of taxes and subsidies on products aggregated by activity into space and non-space-related activities.

Following the 2008 SNA, taxes are compulsory, unrequited payments, in cash or in kind, made by institutional units (e.g. households, enterprises) to the government. Taxes on production and imports consist of taxes on products and other taxes on production [similar for subsidies]. Taxes on products consist of taxes on goods and services that become payable due to the production, sale, transfer, leasing or delivery of those goods or services, or as a result of their use for own consumption or own capital formation (SNA, par. 7.73). Instead, other taxes on production consist mainly of taxes on the ownership or use of land, buildings or other assets used in production or on the labour employed, or compensation of employees paid. Ad valorem taxes and VAT are considered taxes on products.

National SUTs at basic prices record intermediate and final uses free of taxes less subsidies on products that are reported as separate items in the Supply Table. Therefore, it is very important to collect information from the amount of taxes on products paid and/or subsidies on products received by the space economy activities. Sometimes, a pragmatic approach can be to apply the legal tax rates to the amounts consumed by the space economic activities, once these are separated from the industry aggregate. Information from national government accounts on the details about who and how much subsidies space economy related activities have received are extremely important.

For the monitoring of the space economy, these taxes and subsidies on products are of high relevance as many EU Member States provide national aid to companies focussing on space. The space economy is characterised by a variety of national and local grants that complement the funding at European level. In 2016, the ESA estimated that each year around EUR 180 million is made available for space technology R&D by national Space Programmes in grants and subsidies (ESA, 2018). Popular financial incentives include direct financial subsidies, R&D grants for companies with innovative ideas for space, the setup of funds to provide specific funding for space companies (e.g. the European Angel Fund) and, in some cases, tax incentives or tax investment credits.

At European level, there are two main players in the field of space funding: the European Commission and the ESA. In Horizon 2020[(1)] of the European Commission, around 244 space projects were funded covering EUR 1 534 million. Within the ESA[(1)], several programmes enable space funding, covering a total annual budget of EUR 250 million. Both organisations provide many other funding opportunities for space businesses with new initiatives and funding programmes arising almost on a yearly basis to stimulate the uptake of private space investments.

Box 1 – Continued

In this respect, the information about how these subsidies have been allocated to space-related activities and countries is very valuable.

Trade and transport margins

For trade and transport margins, a space-related coefficient should be calculated to single out the space-related value for economic activities and products. This should be calculated in a way that those margins should not be included in the transaction flows anymore as in other non-space-related products. However, it will be assumed that the Use Table at basic prices have already done such reallocation of space and non-space-related margins to trade and transport activities and therefore, only the row and column elements of the trade and transport activities in the national SUTs at basic prices will be broken down.

The main data sources for the compilation of the space economy SUTs are production data from business surveys, national SUT data, customs registers and trade statistics. If access to firm level micro-data is limited, space/industry level ratios or shares will be used (i.e. space coefficients, see section 4.2.4). These ratios indicate the share of an industry's inputs supplied by upstream and downstream space-related suppliers or the share of an industry's output that relates to the space economy (as for intermediate or final use).

Box 2 – Investments and capital stock in the European space economy SUTs

Capital stock and investments represent the accumulation of equipment and structures available to produce goods and services. In the case of the space economy, public investments still represent the bulk of space economy investments (OECD, 2019) as many of the installations of space activities are of public nature. Common investments in infrastructure are laboratories, launch pads, facilities for dedicated space centres or spaceports or equipment for national space missions. At European level, specific examples of investment and capital stock are the space infrastructure related to the Copernicus Earth Observation Programme and the Galileo Navigation Satellite Programmes. At national level, examples include satellites used for environmental management projects and national telecommunication infrastructure.

Having more details on national space infrastructure and different types of space equipment is beneficial to adequately map information related to the space economy, especially since space economy industries rely on the use of capital formation, such as spacecraft and launch constructions. While detailed information on the investments and capital stocks by economic activity is typically missing in Supply and Use Tables, there may be information at national level.

Nevertheless, due to the diversity of sources, capital stocks and investments may generally be difficult to estimate. In these cases, existing literature has often used proxies to provide a measurable indication (e.g. OECD, 2011).

4.2.4. Calculating the space-related coefficients

After isolating the space-related activities and products, it becomes important to determine their share over the total economy. Some activities and products are fully in-scope to the space economy thematic account and can be directly identified in the underlying details of the Supply and Use Tables. As they can be considered fully related to space, their entire value can be allocated to the space economy without further information. However, this only applies to a handful of space economic activities and products. At European level, NACE Rev. 2 code 51.22 ‘Space transport’ and NACE Rev. 2 code 61.30 ‘Satellite telecommunication activities’ are the only economic activities which are entirely related to space and of which all products are also related to space.

For the majority of the identified NACE codes, there is only a partial relation to space. ’Manufacture of other transport equipment’ (NACE 30) could be considered space-related at the two-digit level given that it contains information on the ‘Manufacture of air and spacecraft related machinery’ (NACE 30.30). Nevertheless, it also includes the manufacture of many different types of ships, trains, aircraft, military fighting vehicles and transport equipment. As the production of ships, trains or military fighting vehicles are not considered to be space-related, aggregated data would need to be split between space and other means of transportation. This requires determining the share that can be attributed to the space economy, i.e. the part that meets the definition of space economic activity. To reveal the space economy related values, the existing literature on the construction of thematic accounts recommends the use of two complementary approaches: (1) breaking down the national Supply and Use framework and (2) complementing this with external sources. The same approach can be applied to products (CPA) and, in some cases, to goods (HS).

4.2.4.1 BREAKING DOWN THE SUPPLY AND USE FRAMEWORK

Using a top-down approach, a first direct separation of the space and non-space-related economic activities would require a detailed breakdown of the present two-digit level NACE/ISIC and CPA/CPC information at the most disaggregated level possible within the country. In many cases, National Statistical Offices have access to the more disaggregated data that underlies the construction of the SUTs. Building on the example of NACE Rev. 2 code 30 ‘Manufacture of other transportation equipment’, the use of disaggregated information could allow isolating the space-related NACE Rev. 2 code 30.30 (see Figure 4.3, indicated in blue) ‘Manufacture of air and spacecraft and related machinery’ from non-space-related manufacturing under NACE 30.11 from those that are not related to space (see Figure 4.3, indicated in grey). Hence, further disaggregating information from two-digit level NACE to four-digit level NACE allows for a separation of space and non-space components at the economic activity level.

However, by only distinguishing economic activities related to space from those that are not related to space, there would be a default assumption that all products and services produced in the selected economic activities are related to space. This is not necessarily the case. Within NACE Rev. 2 code 30.30 ‘Manufacture of air and spacecraft and related machinery’, there are five products that are not related to space at European level, namely CPA 30.30.14 ‘Ground flying trainers and parts thereof’, 30.30.31 ‘Helicopters’, CPA 30.30.32 to 30.30.34 ‘Aeroplanes and other aircraft, of an unladen weight’ (see Figure 4.3, in grey). Therefore, a similar disaggregation needs to take place at the level of products, disaggregating information from two-digit level CPA up to six-digit level CPA, and at the level of goods if possible. Naturally, the number of products related to space produced by a certain economic activity can differ significantly. Accordingly, the fewer space-related products in an economic activity, the more important the disaggregation of information to avoid taking into account non-space-related products in the space economy.

The possibility to make this distinction depends on the granularity of data available in each country. Some countries may have detailed information up to the four-digit NACE, six-digit CPA codes or even six-digit HS codes. Countries may also use their national or regional classification to derive subclasses resulting in the inclusion of more granular classifications (e.g. five-digit NACE or six-digit NACE codes) allowing for more space-related detail (as discussed in section 4.2.3). The higher the level of detail, the more accurately the space coefficients (shares or ratios) can be calculated. Figure

4.3 shows the importance of the distinction process in reducing overestimations. When not disaggregating space economic activities on a granular level, all values in grey are taken into account in the calculation of the space economy value, while after further disaggregation only the values in blue are taken into account. In several cases, this process can minimise the use of applying coefficients to separate space from non-space as they allow for a direct calculation of space-related values. Indeed, the process should lead us to a middle-point between a bottom-up and a top-down approach.

Figure 4.3: **Importance of breaking down the Supply and Use framework**

Economic Activity	30-Manufacture of other transportation equipment							
	30.1-Building of ships and boats		30.2-Manufacture of railway locomotives and rolling stock	**30.3-Manufacture of air and spacecraft and related machinery**	30.4-Manufacture of military fighting vehicles	30.9-Manufacture of transport equipment		
Commodities	30.11-Building of ships and boats	30.12-Building of pleasure and sporting boats	30.20-Manufacture of railway locomotives and rolling stock	**30.30-Manufacture of air and spacecraft and related machinery**	30.40-Manufacture of military fighting vehicles	30.91-Manufacture of motorcycles	30.92-Manufacture of bicycles and invalid carriages	30.93-Manufacture of other transportation equipment
30.11-Ships and floating structures								
30.12-Building of pleasure and sporting boats								
30.20-Products of railway locomotives and rolling stock								
30.30.11-Aircraft spark ignition engines								
30.30.12-Turbo-jets and turbo-propellers								
30.30.13-Reaction engines, excluding turbo-jets								
30.30.14-Ground flying trainers and parts thereof								
30.30.15-Parts for aircraft spark-ignition engines								
30.30.16-Parts of turbo-jets and turbo-propellers								
30.30.20-Balloons and dirigibles; gliders and hang gliders								
30.30.31-Helicopters								
30.30.32-Aeroplanes and other aircraft, of an unladen weight < 2 000 kg								
30.30.33-Aeroplanes and other aircraft, of an unladen weight >2 000 kg but <15 000 kg								
30.30.34-Aeroplanes and other aircraft, of an unladen weight >15 000 kg								
30.30.40-Spacecraft (including satellites) and spacecraft launch vehicles								
30.30.50-Other parts of aircraft and spacecraft								
30.30.60-Overhaul and conversion services of aircraft and aircraft engines								
30.30.99-Sub-contracted operations as part of manufacturing of air and spacecraft and related machinery								
30.40-Military fighting vehicles								
30.91-Motorvehicles								
30.92-Bicycles and invalid carriages								
30.93-Other transport equipment n.e.c.								

Source: Own elaboration based NACE Rev. 2 and CPA 2008

4.2.4.2 COMPLEMENTING WITH EXTERNAL DATA SOURCES

If data are available only for 64 product and industry categories, additional information is required to distinguish space and non-space-related products activities. In other words, a certain NACE code (e.g. NACE 30) cannot be split further than the two-digit level, although this would be required to separate space-related activities under NACE 30.3 from non-space economic activities (NACE 30.1, NACE 30.2, NACE 30.4 and NACE 30.9). Alternatively, it may be that even the most disaggregated level of information is still considered too broad to accurately capture the space economy. For example, the product ‘Other parts of aircraft and spacecraft’ (CPA 30.30.50) has been identified as a space-relevant product, perhaps including also some goods (HS codes) that may be used only for airplanes production and not necessarily for spacecraft. In this case, other data sources can be used to complement the existing sources and methodologies for compiling national accounts estimates.

To collect complementary information, a popular choice is the construction of specialised surveys based on a sample of productive units operating within the space economy. The key principles and guidelines for conducting such surveys are well documented in the space economy literature (e.g. OECD, 2019) and in the *Frascati (OECD, 2015)* and *Oslo (OECD, 2018) Manuals* while an overview of best practices in constructing a new survey and a model survey are also provided in the second handbook of measuring the space economy (OECD, 2022). These key reference documents should enable organisations to construct and conduct their own surveys as well as to collect the necessary information on key actors and their outcomes and outputs. After this collection, organisations often rely on simplifying assumptions and scaling approaches to assign a portion of a broader aggregated product or activity to the space economy.

Although surveys can generally provide the required primary input, response rates can be limited. In many cases, they rarely suffice to allow for an accurate split between space and non-space, causing the need to supplement them with public sources of financial information or government budget documents to fill in the gaps. Nevertheless, this data may be flawed due to several complications. First, an accurate measurement of the space economy would require a separation between space-related revenues from non-space-related revenues. Such a separation may not be straightforward and may require additional estimations or assumptions. Second, using private revenue in combination with government budgeting can lead to double counting as government spending is both included in the private company's revenue and the government budget. Due to the size of government spending in space-related production, this may lead to skewed estimates.

Another possibility would be to rely on existing estimates of the global and international space economy or other official statistics made available by various private and governmental organisations and revert to their qualified expert opinion. Many organisations produce annual or bi-annual surveys or collect relevant micro-economic data and statistics to map the value chain of the space economy and provide information on particular space economy segments in the process. An overview of possible data sources on the space economy at European level is presented in Table 4.1.

Using this information as a basis, simplifying assumptions can be used to designate a portion of broader economic activities to the space economy. However, it is important to be aware of the used methodological approaches and estimations. While many national studies are based on national economic statistics, they may differ largely in the methods used to isolate space economic activities depending on their priorities in terms of definitions and measurement (OECD, 2019). Therefore, the use of these statistics may not be optimal in regards to maintaining the consistency and comparability of the space coefficients across countries.

In line with the recommendations made for the construction of the Tourism Satellite Account (2010), estimations should always be based on reliable statistical sources that are produced on an ongoing basis and are comparable over time within the same country. However, the limited availability of space statistics showing these type of characteristics may call for the usage of more experimental statistics. In many cases, the reliability of these statistics cannot match those of official statistics. They can serve nevertheless as first estimation until better information can be used (van den Ven, 2019). Naturally, this would imply the need for thorough documentation and communication about the quality of estimates and methods used to obtain the unofficial statistics.

Table 4.1: Overview of available data sources at European level

Space economy statistics		
Data source	**Description**	**Responsible Entities**
Reports and Financial Statements	Reports and statements made by space companies within the Member States	Private entities
European Space Industry Reports	Annual reports with facts and figures about the European Space Industry	Eurospace
The ESA Annual reports	Report on major activities taken place in the ESA, published on a yearly basis	European Space Agency (ESA)
The ESPI Public Reports and Yearbook	Reports offering in-depth perspectives and analysis on specific space topics or issues and overview of recent space developments	European Space Policy Institute (ESPI)
State & Health of European EO Service Industry	Biennial survey with facts and figures about the European Earth Observation services industry	European Association of Remote Sensing Companies
The EO & GNSS Market Report	Market reports with facts and figures about the dynamic, global Earth Observation and Global Navigation satellite System market, published every two years	European Union Agency for the Space Programme (EUSPA)
The ASD Facts & Figures Report	Annual reports with facts and figures about the European Aerospace, Security and Defence industries	The representation of Aerospace, Security and Defence Industries in Europe (ASD)
In-house surveys by national space agencies	Report with facts and figures about the national space economy	National Space Agencies
Studies by consulting firms	Studies performed to explore the specific economic effects of space activities	Several consulting firms (e.g. Deloitte, PwC, etc.)

Source: Own elaboration based on existing data sources

4.2.4.3 SPECIAL CASES: EDUCATION, BOOK PUBLISHING AND R&D

Particular difficulties may occur when trying to separate the space-related higher education, book publishing and R&D from the broader categories of education, book publishing and R&D. In these cases, information at the NACE four-digit or CPA six-digit level is often too broad, reflecting information that belongs to general education or book publishing that is not necessarily related to space. Further complicating the issue is the difficulty to determine the particular part that is related to space, as details such as the topic of education, book or research is not present in national statistics or in structural surveys. However, this type of information may be available in country studies, which tend to be more specialised surveys carried out by National Statistical Offices. Another method to overcome the data gap is to use simplifying assumptions via proxies. Some of the examples of proxies that can be used, are discussed in the next paragraphs.

For educational activities, existing thematic (satellite) accounts (e.g. INE, 2020) have used educational statistics to determine the participation in programmes related to the economic theme under consideration. Primary and secondary education often provide a too generic level of education that is not necessarily targeted towards the space economy. However, some higher education institutions offer educational trajectories that focus on space or technical subjects important to space (e.g. engineering). In that case, coefficients can be calculated as the ratio of the number of teaching hours in space courses in the institution over the total teaching hours (INE, 2020). Additional data on education and trainings may be obtained from governmental space training programmes.

For book publishing, publishers often work with a range of publishing categories and genres. Books that are relevant for the space economy are most likely to occur in the category or genre of scholarly and educational books and academic publishing related to space. Some countries may have access to detailed revenue information by book genre while others could resort to the use of a national database for publication metadata that allows for an indication of the amount of books published in a particular field and year (e.g. via the national legal repositories system, bibliographic databases or data obtained from national libraries).

For R&D related to the space economy, scientific infrastructure and capacity is difficult to map at the country level given its overlap with other fields of science and technology. According to the *Frascati Manual*, space expands into a variety of scientific fields among which astronomy, aerospace engineering, mechanical engineering, applied mechanism, thermodynamics, meteorology and atmospheric sciences, climate research and nanotechnology. Hence, space-related R&D production will most likely be present in most industries related to the space economy. In line with the US BEA (2019), it is recommended to measure the R&D activity as the sum of its production or input costs and record R&D activity in the industry that performs the R&D.

4.2.4.4 CALCULATING THE SPACE-RELATED VALUE COEFFICIENT

Based on the collected information, the space-related share can be calculated to single out the space-related value for economic activities and products. For economic activities and products, a commonly used approach is to divide the total value of disaggregated economic activity Z that belongs to the space economy, by the total of the more aggregated economic activity Z. This translates into the following formula for economic activity, but the same logic can be followed for the product (or even good, using the HS codes) and for other components within the SUTs, such as employment, taxes less subsidies, etc.

$$Space\ Share\ of\ Industry\ Z = \frac{Total\ value\ of\ Industry\ Z\ related\ to\ space\ economy}{Total\ value\ of\ Industry\ Z}$$

As previously mentioned, the accuracy of the resulting share entirely depends on the level of detail of the underlying information. The most accurate share is obtained if a space-related share can be calculated for each component separately, in order to have a space share for each industry and product, and a space share for taxes less subsidies, compensation of employees, operating surplus, value added, etc. Nevertheless, it may be that a further breakdown of value added components is not possible. Given the range of information required for complete and detailed SUTs, isolating space economic activities may be a challenge. Therefore, it is often deemed a good start to use the same coefficient as for industry or products uniformly. In some cases, it may be that the available information is insufficient to construct a reliable space share. Therefore, it may be necessary to rely on coefficients constructed by other countries that face the same industry structure or have a comparable space economy composition than the country under consideration.

In general, the construction of this space-related share is often characterised by a trial and error phase that can provide insights into best practices and how to obtain an internationally comparable method. Therefore, experimenting with deriving the space share is considered an important part of the research process and the harmonisation of methods.

After compiling the space-related coefficients, they have to be applied to all components of the Supply and Use Tables. This implies that for every component, there will be now two distinct values: one value that is related to space and one value that is not related to space. This is represented by both a row-wise and column-wise expansion of the national SUTs, as for extended SUTs (United Nations, 2021). An applied example taking into account NACE 30 is provided in Figure 4.4.

After separating space from non-space values at the highest detailed level as possible, these values will be re-aggregated again (NACE/CPA). This aggregation of information has the advantage of taking into account potential confidentiality issues that may arise when using the more disaggregated information. This is the final step to be conducted at the country level.

Figure 4.4: Example of space-related value coefficients in NACE 30

Economic Activity	30-Manufacture of other transportation equipment								
	30.1-Building of ships and boats		30.2-Manufacture of railway locomotives and rolling stock	**30.3-Manufacture of air and spacecraft and related machinery**		30.4-Manufacture of military fighting vehicles	30.9-Manufacture of transport equipment		
Commodities	30.11-Building of ships and boats	30.12-Building of pleasure and sporting boats	30.20-Manufacture of railway locomotives and rolling stock	**30.30-Manufacture of air and spacecraft and related machinery**		30.40-Manufacture of military fighting vehicles	30.91-Manufacture of motorcycles	30.92-Manufacture of bicycles and invalid carriages	30.93-Manufacture of other transportation equipment n.e.c.
30.30.11-Aircraft spark ignition engines				**Space-related Value**	Non-Space Related Value				
30.30.12-Turbo-jets and turbo-propellers				**Space-related Value**	Non-Space Related Value				
30.30.13-Reaction engines, excluding turbo-jets				**Space-related Value**	Non-Space Related Value				
30.30.14-Ground flying trainers and parts thereof				Non-Space Related Value					
30.30.15-Parts for aircraft spark-ignition engines				**Space-related Value**	Non-Space Related Value				
30.30.16-Parts of turbo-jets and turbo-propellers				**Space-related Value**	Non-Space Related Value				
30.30.20-Balloons and dirigibles; gliders and hang gliders				**Space-related Value**	Non-Space Related Value				
... (Other commodities of NACE 30.30, relevant for space)				**Space-related Value**	Non-Space Related Value				

Source: Own elaboration based on NACE Rev. 2 and CPA 2008

At this point, we remind here the need to define the geographical boundaries and the selected space-related activities and products, while other non-space-related countries, activities and industries may be aggregated into a rest of the world region or a group of activities/products, thus reducing the data requirements of the national space economy SUTs. In this sense, it is of utmost importance to estimate, to the extent possible, a common set of macroeconomic aggregates of the space economy before moving into the next step for the compilation of inter-country SUTs.

4.3 European space economy inter-country SUTs

By combining national space economy SUTs into a common inter-country space economy SUT framework, the interrelationships in global production arrangements in the space economy become apparent. In this way, all the production process, from conception to final use, and international trade of space-related goods and services from the offshoring core and supporting functions are fully accounted for. Besides, the control structure of the participating firms in the production processes is made explicit, too. Most importantly, complementarily to national space SUTs, an inter-country framework show how imported products from countries are supplied to other countries for the production of upstream and downstream space activities.

It is important to note that major efforts have to be channelled to compile the best quality national space SUTs since they will determine namely the GDP, value added and employment of the space economy of each country. These national space SUTs also include estimates of exports and imports of space and non-space-related goods and services but, however, neither bilaterally, from one country to another, nor with a knowledge about who is importing the goods and services in the partner country (intermediate and/or final uses).

Hence, the first step to compile space economy inter-country SUTs is to generate a balanced view of international trade of space-related goods and services. With this purpose, the European Commission´s Directorates-General Eurostat and the JRC have compiled a first estimation of the balanced view of exports and imports of the space economy based on the list of specific space-related CPA codes provided by ESA et al. (2023).

Ideally, a number of challenges will also have to be addressed in order to have a good geographical view of the international trade of space-related goods and services by trading partners. This will highly depend on the availability of the data. For instance, these are the reconciliation of trade asymmetries, the CIF/FOB valuation adjustment, goods sent abroad for processing and merchanting, the estimation of imports by country of origin and product, and the estimation of international distribution margins, among others (United Nations, 2021). However, these adjustments are challenging even for the compilation of standard inter-country SUTs, such as the Eurostat's inter-country Supply, Use and Input-Output Tables, also called FIGARO ('Full Integrated and Global Accounts for Research in input-Output analysis'). Therefore, as the FIGARO tables are already adjusted for all those methodological issues, the European space economy inter-country SUTs will be benchmarked to the FIGARO tables in order to use them as benchmark for the final estimation of the space economy thematic account.

4.3.1 Trade of space-related goods and services

The FIGARO tables are the result of a cooperation between Eurostat and the JRC (Rémond-Tiedrez & Rueda-Cantuche, 2019). They provide an integrated and globally consistent picture of the world GDP across main economic aggregates. More specifically, they report supply and use relationships for 64 product and 64 industry categories for EU Member States, 18 main trading partners and an aggregate for the rest of the world. Since 2021, the FIGARO tables are produced by Eurostat as EU official statistics and therefore, they are benchmarked to the latest available official macroeconomic aggregates and fully aligned with countries' national accounts official statistics.

By using the underlying balanced view of international trade of the FIGARO tables (more specifically, by using the QDR methodology([25]) for goods), the space-related trade shares (exports, imports and totals) can be computed for each year from 2010 to T-2 (where T is the current year) at EU level and for each EU Member State.

As a first exercise, the results for goods were calculated after a proper conversion from the FIGARO trade dataset in HS codes at six-digit level to the CPA codes at six-digit level, as was the list of space-related products provided by ESA et al. (2023) (using the correspondence method between CPA and HS codes described in section 2.4.2).

Based on the converted list of space-related HS codes, it is possible to estimate the space-related exports and imports in the FIGARO trade dataset by year, country of origin and country of destination. By aggregating this data by country of origin and destination, the total value of space-related imports and space-related exports were estimated by year, which were then put into perspective by calculating their shares over the total imports and exports of a particular EU Member State on a yearly basis.

These results have to be seen as a first approach to estimate the inter-country space SUTs since it has three main limitations. First, the HS classification only covers the goods, so the services are not included in this first exercise. Second, the conversion from CPA to HS is not totally accurate since there is no one-to-one correspondence between the two classifications. Finally, for the time being, it is not possible to isolate the space-related share of the included HS codes. Indeed, the majority of space-related economy products are not fully in-scope to the space economy thematic account. The information necessary to calculate the share of values that can be assigned to the space economy (i.e. space economy coefficient) will only be available at a later stage in the construction of the thematic account. Consequently, these first results assume that all the value of space-related products is entirely linked to space, while the same products or components could be used by other parts of the economy, such as aeroplanes and helicopters.

Given that these first results highly overestimate the space sector, a second attempt was made limiting the exercise to the HS code 30.30.40 'Spacecraft (including satellites) and spacecraft launch vehicles' that is entirely space-relevant (coefficient equals to 100 %). Comparing the obtained results with figures published by Eurospace (Eurospace, 2022), the second attempt gives good hopes for

(25) https://cros-legacy.ec.europa.eu/content/qdr-methodology-understanding-trade-flows-eu-pedro-martins-ferreira_en

the methodology.

However, thanks to National Statistical Offices, space-related coefficients are expected to be calculated for the CPA codes identified as part of the space economy by ESA et al. (2023). This would allow to perform a similar exercise without facing the three limitations of the first attempt mentioned here above.

The resulting balanced view of trade in space-related goods and services would then provide a good overview of the geographical distribution of exports and imports of space-related products within the space geographical boundaries, as specified for the space economy thematic account.

4.3.2 Balancing space-related production, income and trade

The overall total of space-related exports and imports by country and product can be estimated by National Statistical Offices based on business registers, business surveys data, national accounts and other data sources (see earlier sections of this chapter). Therefore, the next step is to balance[26] the subset of space production, income and trade flows by product, country of origin, country of destination and import user (industries, households, government consumption or investment) in order to match the main macroeconomic aggregates previously estimated for each country´s space economy. Else, the other non-space-related products and activities can be re-organised and/or aggregated in the most convenient way.

In some cases, an additional aggregation to the desired space-related products may be required (see Figure 4.5 for NACE/CPA).

Figure 4.5: Re-aggregation of NACE information in FIGARO

Division	Group	Class	Label	In Figaro?
30			**Manufacture of other transport equipment**	**YES**
	30.1		Building of ships and boats	NO
		30.11	Building of ships and floatig structures	NO
		30.12	Building of pleasure and sporting boats	NO
	30.2		Manufacture of railway locomotives and rolling stock	NO
		30.20	Manufacture of railway locomotives and rolling stock	NO
	30.3		Manufacture of air and spacecraft and related machinery	NO
		30.30S	**Manufacture of air and spacecraft and related machinery**	**NO**
		30.30XS	Manufacture of air and spacecraft and related machinery, except space	NO
	30.4		Manufacture of military fighting vehicles	NO
		30.40	Manufacture of military fighting vehicles	NO
	30.9		Manufacture of transport equipment	NO
		30.91	Manufacture of motorcycles	NO
		30.92	Manufacture of bicycles and invalid carriages	NO
		30.93	Manufacture of other transportation equipment n.e.c.	NO

Division	Group	Class	Label	Extended Figaro
30			**Manufacture of other transport equipment**	**NO**
	30S		**Part of Manufacture of other transport equipment related to Space**	**YES**
	30XS		Part of Manufacture of other transport equipment not related to Space	YES

Source: Own elaboration based on NACE Rev. 2

As a result, the European space economy inter-country SUTs will capture the global interdependencies of space and non-space-related industries and national economies, although with a focus on the space economy, as defined in this report. By linking this information to the FIGARO tables, it is therefore possible to conduct a detailed product/industry analysis that could provide insights into the economic and social gains of the European space economy and its global value chains.

[26] Eurostat uses the multidimensional nD-GRAS method (Valderas-Jaramillo and Rueda-Cantuche, 2021) designed specifically for applications to multiregional input–output frameworks.

5 Measuring the size of the space economy

5.1. Direct, indirect and induced contribution

To calculate the actual contribution of the space economy to the global economy, the direct, indirect and induced impacts have to be taken into account. However, these may not always be evident or immediately observed. In general, direct effects reflect the immediate impact on output, value added, employment, or compensation of employees resulting from an initial increase in the spending of final demand. An example could be the impact on income and profits due to government purchases of space satellites. Indirect effects reflect the impact on the entire supply chain (e.g. metal parts of satellites) while induced effects are the subsequent impacts on the wider economy due to additional income gains from the production of additional space satellites. An example of an indirect effect could be the monetary benefits generated by non-space companies (e.g. metallurgy factories) that are supplying metal parts to produce satellites. An example of induced effects is the spending generated by employees of the space industries (and other suppliers) that have obtained additional gains from the areas additional production of satellites by the government.

In order to measure the contribution of the space economy to the economy as a whole, both the indirect and induced effects have to be taken into account. The space economy generates these effects in multiple ways. First, the space sector is closely intertwined with the aerospace industry, civil aeronautics and military aeronautics (Guffarth & Barber, 2017). These industries overlap in terms of several aspects such as participating actors, employees, technologies and facilities to a level that they easily influence one another. From a statistical point of view, this makes it likely that investments or actions taken in the space sector will manifest in these related industries. Secondly, the space sector is growing and evolving rapidly into new services and products enabling the development of services and applications into countless other industrial sectors. It thereby actively contributes to the growth of these sectors. The extension of space-related developments or achievements to other areas in an unanticipated manner is a well-known phenomenon with demonstrated cases in the areas of health and medicine, environment monitoring, agriculture and food and transport and manufacturing (OECD, 2019).

The FIGARO tables lend themselves to adequately capturing the direct, indirect and induced economic effects. They capture direct economic effects involved in the production of space-economic goods and services, but also enables the estimation of upstream production of intermediate goods and services necessary for the production of a particular space-economic product. By establishing the links between specific industries and/or specific countries with respect to the production of space-related goods and services, it allows for an accurate measurement of the aforementioned indirect and induced effects of the space economy. As a result, it would accurately quantify the economic impact of the production of European space economy related goods and activities while also providing additional insight on global value chains related to the space economy[27]. This offers a large benefit to the construction of the thematic account as other types of thematic accounts mainly

[27] It is acknowledged that additional benefits can be found further downstream in the value chain due to space-derived applications, which generate value for non-space application sectors and the society. Nevertheless, this framework does not include space-derived applications.

concentrate on the direct impact (e.g. ICAO, 2019), thus not being able to capture the total economic impact and often referring to other means such as input-output analysis or social accounting matrices that can be applied to the thematic accounts.

5.2. Contribution for the society

Besides creating spill-overs to other economic sectors, the space economy can also create benefits for the economy as a whole (ESA, 2019; ESA, 2022). The space sector is a research-intensive industry characterised by dense collaboration networks that have the potential to generate knowledge externalities and technology spill-overs via scientific contributions or the development of new technologies. These can benefit society as a whole via decreased transaction times, costs savings and improved productivity or efficiency, but also via the provision of new means to address global challenges (ESA, 2022). Furthermore, the type of applications they develop bring large benefits to society by providing wider access to and higher quality of information. This information can improve forecasts and decision-making processes and can adequately assess societal threads, challenges, costs and losses while generally improving daily life.

The creation of social welfare is deemed to be one of the most important socio-economic benefits of the space economy (OECD, 2019). However, the actual measurement of these valuable social impacts remains difficult and its quantification falls outside the scope of this project. Nevertheless, this will have an implication on the measurement of the space economy impact and on the extent to which the outputs of the thematic account can be used. While providing a quantification of the economic impact associated with the production of space-related activities and goods, it does not allow for the quantification of the benefits of these goods to consumers or citizens in their daily life.

5.3 Socio-economic indicators

A large benefit of constructing a thematic account is the possibility to include supplementary information from other sources that may give more insight into a particular economic theme such as the space economy. This enables a more accurate measurement of socio-economic impacts of the space economy. This type of measurement is a topic of growing demand and one that has received a lot of attention in the existing literature on the space economy. As a result, many (socio-economic) indicators have been put forward. These include, amongst others, several indicators regarding space infrastructure (e.g. the number of market applications or the number of launched satellites), indicators on output of investments (e.g. patents and publications), indicators on the effects of investments on society (e.g. national or regional growth, cost avoidances, multiplier effects) as well as several company-level indicators.

The European space economy thematic account focusses on providing information on output, value added and employment associated with the production of space-related goods and services. These indicators could complement the current efforts directed towards quantifying the economic impact of space activities (e.g. PwC, 2019; Florida Tech, 2022). Hence, the inclusion of these indicators can provide insight on the space economy relative to economy as a whole while also facilitating impact analysis taking into account policy or other structural changes. Generally, the economic impacts are expected to vary depending on the country and its level of specialisation.

5.3.1 Output

Output can be measured as the value of goods and services that are produced within an economy. Direct increases in the output of an economy may be caused by direct increases in the products and services produced in the space economy. This may for example be due to increased demand of governments or other type of customers, increased industrial activity, space programmes driving the discovery of new space services or products through R&D development, which may directly increase the output (OECD, 2007). The direct increase in output in one part of the space economy can also result in indirect increases in output via spill-over effects to other industries, e.g. by increasing the need for supplying additional components. The thematic account provides information on the value, in euro, of output per economic activity per country. The thematic account also enables insight into upward and downward spill-overs of changes in output on to other industries and countries.

5.3.2 Value added

Value added represents the value of the output of an industry minus the cost of inputs used for production. It is also the sum of the compensation of employees, other taxes less subsidies production and gross operating surplus. Focussing on the space economy in particular, the value added reflects the value of space economic goods and services produced minus the value of expenses incurred for its production. Therefore, it describes the size and direct economic contribution of the space economy.

Several factors within the space economy may affect value added. According to the OECD (2007), most impact on value added is expected via the increase of revenue or jobs, efficiency improvements and cost avoidances via better resource management or cost prevention. In many cases, these changes due direct decisions or actions taken by a single actor in the space economy (e.g. through new commercial activities, uptake of industrial activities, procurement, etc.). Consequently, these direct decisions may cause a spill-over of economic activity throughout the supply chain. Therefore, decisions taken in one part of the space economy, may indirectly influence the enabled revenue, jobs or efficiency improvements in another part of the space economy. While emphasis is usually put on the direct effects, indirect or induced effects of the space economy should not be underestimated.

The thematic account provides information on the value, in euro, of the gross value added and its components per country and economic activity. The thematic account is able to provide insight in the upward and downward spill-over on the value added across industries and countries via the mapping of trade flows.

5.3.3 Employment

A direct impact on employment would be the increase in full-time or part-time employment opportunities related to the space sector workforce, such as employment in companies or organisations that produce space-related products and services. This direct impact can be the result of procurement, an uptake in market activities or any attempt to meet the increased demand of company offerings. Indirect benefits can be created via the full-time or part-time employment opportunities generated due to the direct impact on employment in other companies. For example, the increase in employment needs to manufacture inputs for other companies, the creation of new downstream products and services that depend on space technologies or infrastructure to function, and the generation of services that are offered to the space sector workforce (e.g. local shops in the neighbourhood of space facilities). Most of the jobs within the space economy are technical, scientific or engineering jobs while business and legal positions are becoming more represented (OECD, 2019). Nevertheless, with the increased diversification and internationalisation of the space economy, the demand for skilled labour is high. Within many countries, the space economy is facing strong competition from other high-technology sectors that compete for the same types of skills and education (OECD, 2022) causing difficulties in attracting and retaining qualified staff. This competition may influence the effects on employment resulting from decisions or actions in the space economy.

The thematic account provides information on the number of people in full-time and part-time employment and on compensation per economic activity per country. The thematic account also enables insight into upward and downward spill-overs of changes in employment on to other industries and countries.

5.4 GHG emissions

The inability to perform a full life cycle assessment on the Greenhouse Gas (GHG) emissions or environmental footprint of in-space activities is currently being addressed in other instances at EU level. Nevertheless, the thematic account for the European space economy can provide aggregated sectorial information on environmental externalities associated with the production of space-related goods and services, in particular in terms of GHG, presented in CO_2 (carbon dioxide) equivalent emissions.

Although GHGs are not the only source of environmental impact, limiting – and decreasing – the emissions is the most important short term challenge to tackle climate change and to contain the rise in average global temperature to 1.5°C relative to preindustrial averages (see United Nations Framework Convention on Climate Change (UNFCCC) 2015[28]). Thus, emissions are the key indicator to assess a company's exposure to climate risks. In a life-cycle approach, the exposure of a company to climate risks is not only a function of its internal manufacturing processes but also of the raw materials it uses, the quantity and nature of the energy it consumes (inputs) and finally the products and services it sells to its customers (outputs).

The measure of GHG emissions is called 'carbon footprint'. The GHG Protocol[29] identifies three types of GHG emissions:

- scope 1 emissions: All direct GHG emissions.
- scope 2 emissions: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- scope 3 emissions: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g., transmission and distribution losses) not covered in Scope 2, outsourced activities, use of sold products, waste disposal, etc.

The carbon footprint emissions of the space economy can also be divided in two different emission moments, linked to different life cycle assessment phases. A first type of emissions are those emitted on earth through the economic activities of companies undertaken to provide space products and those emitted using these products. A second type of emissions are those emitted in space due to active space activities (e.g., space missions). The next sections explain both types of GHG emissions and the ability to track (space-related) GHG emissions in more detail.

5.4.1 GHG emissions on earth

The production of space products by companies, whether they will eventually be used on earth or launched in space, requires companies to engage in economic activities that produce a certain amount of GHG emissions. For example, when companies manufacture a satellite, they do not only emit CO_2 through the final assembly of the satellite, but they also generate GHG emissions associated with the range of raw materials to complicated integrated circuits necessary to construct the satellite components, the design and building efforts by employees and GHG emissions associated with the quantity and nature of the energy consumed throughout the production process.

When the satellite production is finished, the satellite needs to be launched into space. As this requires the use of a rocket, companies produce extra GHG emissions through both the manufacturing of this rocket, the transportation of the rocket to a launchpad and the eventual launch in space. In addition, extra GHG emissions are generated through selling satellite related services to consumers. While economic metrics used to study the space economy often focus on output and employment, input-output analysis can also provide a useful framework to understand the global use of natural resources in the corporate production process. By adding environmental data on

[28] https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf
[29] https://ghgprotocol.org

CO_2 equivalents related to overall corporate production activities and households to the thematic account, it is possible to account for both the natural inputs into an activity and the flow of residuals into the environment. This enables the analysis of the direct, indirect and induced effects of corporate space production and activities on the generation of greenhouse gas emissions at a macro-aggregated (corporate) level. It does, however, not replace the calculation and measurement of the environmental footprint at product level.

5.4.2 GHG emissions in space

GHGs are primarily a product of combustion in the presence of oxygen, which is absent in space. Hence, in orbit GHG emissions are not a significant concern because the vacuum of space lacks the necessary conditions for traditional combustion and the creation of such gases.

However, there are other environmental concerns related to activities taking place in space. One issue is space debris, which consists of defunct satellites, spent rocket stages, and other fragments resulting from collisions or disintegration of objects in orbit. While space debris itself doesn't emit GHGs, it poses a threat to operational satellites and space missions. Indeed, with the increasing number of objects launched into space, the number of inactive objects and fragments that orbit the earth will also increase (ESA, 2017). The presence of this debris can pose large risks to other functional infrastructure or spacecraft that are floating through space (UNOOSA, 2018). While the majority of the debris would burn up when entering the atmosphere, there is a persistent risk that larger structures will crash onto earth thereby causing significant damage to people and installations.

Like climate change, the challenges posed by space debris require coordinated efforts on a global level. Efforts are underway to address the growing issue of space debris through international guidelines and the development of technologies to mitigate debris generation. However, these aspects cannot be taken into account in the space economy thematic account.

5.4.3 Tracking earth GHG emissions via space data

Tracking earth's (GHG) emissions through space data has become a pivotal tool in understanding and mitigating climate change. Using satellite technology, scientists can monitor and measure key atmospheric components, such as carbon dioxide and methane, providing a comprehensive view of global emissions. This space-based approach enables real-time and accurate data collection on a large scale, allowing for more informed policy decisions and targeted interventions to reduce emissions. By leveraging the power of space technology, it is possible to enhance our understanding of the earth's changing climate and work towards a more sustainable future.

Therefore, the Copernicus Climate Change Service[30], is being implemented by European Centre for Medium-Range Weather Forecasts (ECMWF) as part of The Copernicus Programme with the objective to provide reliable access to high-quality climate data. It aims to support society by providing authoritative information about the past, present and future climate in Europe and the rest of the World. One of the indicators provided is the GHG concentration.

Also, a new constellation named European CO_2 Monitoring and Verification Support Capacity (CO2MVS)[31] is being developed by the ESA and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The new constellation has the objective to measure concentrations of carbon dioxide and methane, the two most common GHGs, and to identify the sources of these emissions. The European initiative is accompanied by additional efforts to track CO_2 emissions across the world via satellites and satellite imagery (e.g. NASA's Orbiting Carbon Observatory or GHGSAT). These efforts will enable a better understanding of the sources of emissions and contribute to reducing CO_2 emissions, but they cannot be measured using Input-Output Tables and, hence, cannot be taken into account within the space economy thematic account.

(30) https://climate.copernicus.eu/
(31) https://www.coco2-project.eu/sites/default/files/2021-11/REPORT%20Copernicus%20CO2MVS%20description.pdf

6 Economic impact of space policies

6.1 Economic impact analysis of the EU Space Programme

The European Space Programme implements space activities in the fields of Earth Observation, Satellite Navigation, Connectivity, Space Research and Innovation. It encourages and supports innovation and competitiveness through investments in critical infrastructures and disruptive technologies. While striving to strengthen European space assets and services, it also drives space entrepreneurship and innovative solutions based on space technologies, data and services with targeted investments towards European start-ups and SMEs via the development of initiatives such as CASSINI. The EU Space Programme is backing the European space industry and research by bringing together existing stakeholders and contributing to the emergence of a European 'New Space' eco-system.

The European Space Programme is implemented by the European Commission in close cooperation with the EU Member States, the European Union Agency for the Space Programme (EUSPA), the European Space Agency (ESA), the EUMETSTAT and many other stakeholders with the purpose of optimising the impact of European policies and investment in space. The EU Space Programme[32] aims to encourage and support innovation and competitiveness in European space industry and research by focussing on four strategic goals: (1) maximising the societal and economic benefits of space, (2) fostering a globally competitive space sector, (3) reinforcing strategic autonomy in space and (4) strengthening Europe as a global actor and promoting international cooperation.

To reach these goals and to serve the needs of EU citizens, the EU has launched several flagship programmes. These include Copernicus[33], the European Earth Observation (EO) system that supports environmental management and aims to help mitigate the effects of climate change, Galileo[34], the global navigation satellite and positioning system (GNSS), and the European Geostationary Navigation Overlay Service (EGNOS[35]) that aims to improve the performance of GNSS. Additional initiatives of the EU Space Programme include GOVSATCOM[36], providing reliable, secure and cost-effective government satellite communication services, and SSA², providing comprehensive knowledge and understanding about space hazards. In 2023, the EU added IRIS²[37], Europe's new Infrastructure for Resilience, Interconnection and Security by Satellites, to their portfolio.

Since their launch, the EU has made significant investments in these programmes. From 2014 to 2020, the total investment on Copernicus, Galileo and EGNOS covered an amount of EUR 12.5 billion in addition to the investments through the ESA and the investments by Member States on their

(32) https://defence-industry-space.ec.europa.eu/eu-space-policy/eu-space-programme_en
(33) https://defence-industry-space.ec.europa.eu/eu-space-policy/copernicus_en
(34) https://defence-industry-space.ec.europa.eu/eu-space-policy/galileo_en
(35) https://defence-industry-space.ec.europa.eu/eu-space-policy/egnos_en
(36) https://defence-industry-space.ec.europa.eu/govsatcom_en
(37) https://defence-industry-space.ec.europa.eu/eu-space-policy/iris2_en

national space strategy (European Union, 2018). For the Multiannual Financial Framework (MFF) of 2021-2027, this budget is expanded to EUR 16 billion directed towards projects related to Copernicus, Galileo, EGNOS and GOVSATCOM amongst others.

Given these significant and long-term costs for the EU budget, several reports and evaluations have been conducted to assess the importance of space programmes for the EU economy. These evaluations are crucial, as the European Commission is committed to better exploit the potential of the EU Space Programme by maximising its benefits for the EU economy. Nevertheless, the space economy is hampered by various measurement difficulties that prevent sound estimations, consistent methodologies and the use of realistic data. The current classification system does not report on space as a separate classification leading to the unavailability of useable and high-quality statistics. To fill in the data gaps, one has often relied on European-wide surveys, case studies, expert opinions and that primarily report on company-related data or self-assessment of additional revenues, requiring the collection of complementary information or the use of extensive modelling. The lack of a unified, harmonised approach to evaluate space programmes have resulted into different assessments of the same benefits (European Union, 2018) and, in some cases, even inaccurate estimations of actual benefits.

The European space economy thematic account will deliver harmonised and consistent economic data on the space economy in Europe by ensuring consistency with national accounts, the methodology for measuring the space economy as proposed by the OECD and the lessons learned from the development of the US space economy thematic account by the US BEA. By abiding by these recommendations and best practices, the European space economy thematic account can serve as an excellent statistical framework, ensuring comparability over time and countries, and providing clear input-output relations between countries and industries (van de Ven, 2021). This allows the accurate measurement of direct, indirect and induced economic impacts of space programmes on upstream and downstream space activities and products falling under the space economy definition, as stipulated in Chapter 2. While it is acknowledged that the EU Space Programme exists to improve the life of EU citizens and that the measurement of societal effects is not in scope of the thematic account itself, an adequate impact assessment of any programme would also require the identification of the full-extent of benefits on the EU economy besides the benefits on society. To this extent, the European space economy thematic account can contribute in several ways:

First, the European space economy thematic account can aid in evaluating the current EU Space Programme by measuring its economic effects on the EU economy by country and industry with greater granularity and increased accuracy compared to prior evaluations. It can provide a reliable quantification of economic impact in terms of output, value added, employment, as well as environmental repercussions related to space economy production, economic activities, exports, imports and demand. Besides evaluating the existing programme, the European space economy thematic account can aid in optimising future EU Space Programmes by performing ex-ante impact assessment of the continuation of the programme in future MFFs. Given that a dedicated part of the budget of the EU Space Programme is allocated to supporting the provision of new services that address new EU priorities (2.5 %) and the development of new activities (3.1 %), an ex-ante impact assessment can also shed light on expected economic returns from these new activities.

Second, the European space economy thematic account can aid in the measurement of the impact of EU and the ESA space programmes on the economy of Member States. Both the EU Space Programme and the ESA programmes play an important role in the delivery of national objectives for space. As a result, a large share of public investment in space is made via both programmes (European Investment Bank, 2019). The evaluation of the impact of participation in the ESA or EU space programmes may be a topic of interest to both the investing country and for the ESA and the EU. An impact analysis of space programmes on the national economy can provide insight on the economic benefits generated through the ESA/EU space investments and their potential additionality to national space programmes. This can help to justify the large share of public budgets directed towards participating in these programmes by investing countries while for the ESA/EU, which have the responsibility to create value for society, it may be an instrument to ensure that Member States get a fair return on their investments.

Third, the thematic account can aid in the impact assessment of policies directed towards the improvement of certain aspects in the space economy. Two topics that have received a lot of attention are: (1) the education and labour policies (European Commission, 2023) to boost the availability of highly skilled labour in space, and (2) the impact of GHG emissions of space economy activities (e.g. OECD, 2007 and the ESA Clean Space initiative) in line with European environmental legislation.

A general shortage of highly skilled professionals and expertise in space exists across the EU and its Member States. With older space experts retiring and new space programmes being launched, there is a large amount of opportunities to work in space. Nevertheless, the space sector faces strong competition from other high-technology sector that rely on similar fields of expertise and knowledge in science, technology, engineering, and mathematics (STEM) disciplines for which enrolment is low in many countries. This has resulted in issues of recruiting and retaining employees (OECD, 2021). In the Industrial Strategy of 2020(38), the EU announced to strengthen its workforce to meet the needs of the EU labour markets by attracting skilled workers from outside of the EU, enabling intra-EU mobility and promoting the development of more fit-for-purpose STEM and ICT higher education programmes amongst others. In addition, in May 2023, it was announced that the Pact for Skills has initiated a major Skills Partnership in the space sector thereby uniting businesses, education, and research to address skill gaps and enhance workforce expertise. This collaborative effort aims to fuel innovation and meet the evolving demands of the rapidly advancing space industry(39). Hence, with accurate data on employment in space provided by the thematic account, it would be possible to track the ongoing developments for strengthening the workforce in the EU on the space economy.

In addition, the Space agencies have been trying to increase awareness of the environmental impact of the space activities through the provision of environmental data on performed activities. As stipulated in section 5.4, the space economy thematic account provides aggregated data on the generation of GHG and CO_2 equivalent emissions related to the production of space products and activities and their use on earth. It reports on the overall direct, indirect and induced CO_2 equivalent emission impacts of this production(40). This type of information can provide some insight into the trade-off between the positive and negative economic effects of the existing and future space programmes, or more generally the production of space products and the space economic activities.

6.2 Economic impact analysis of research and innovation funding of space activities

The EU Space Programme aim to support economic development and citizen wellbeing in Europe by turning different types of data into timely and actionable information and value added activities in various fields depending on the specific Programme. Copernicus supports services in the field of agriculture, climate, security and surveillance, Galileo supports services in the fields ranging from agriculture and transportation to border management and rescue services while EGNOS mostly focusses on services for aviation, road, rail, maritime and precision farming, amongst others. Within the EU Space Programme, a part of the total budget is dedicated towards market development. Therefore, the European Commission has set up and funded a variety of dedicated actions to encourage the use of EU space services, data and/or applications offered by Copernicus, Galileo and EGNOS via the Framework Programme for Research and Innovation (Horizon 2020 and Horizon Europe), the Fundamental Elements Programme(41), led by EUSPA, and via the space programmes themselves.

Between 2014 and 2020, the market uptake for Copernicus was largely funded by Horizon 2020,

(38) https://single-market-economy.ec.europa.eu/industry/strategy_en
(39) https://ec.europa.eu/social/main.jsp?langId=en&catId=89&furtherNews=yes&newsId=10562
(40) see also section 5.3.4 for limitations to this measurement
(41) https://www.euspa.europa.eu/opportunities/fundamental-elements

granting EUR 194 million to 79 projects with a specific focus on market uptake and evolution of Copernicus services. This represents 63 % of the Commission budget directed towards this goal and 55 % of the entire budget spent on market uptake, taking into account both the contribution of the European Commission and those of entrusted entities (European Union, 2018). For Galileo, EUR 141 million was awarded to a similar amount of projects under Horizon 2020, representing 77 % of the total Commission budget dedicated towards encouraging market development and uptake for Galileo. Hence, it is clear that Horizon 2020 was an important pillar in the efforts of the Commission to support the market uptake of both space programmes. Horizon 2020 is now followed by Horizon Europe in which the Commission committed to yearly investing an amount of EUR 20 million for space purposes between 2021 and 2027. This amount is not exclusively allocated towards EU Space Programme market development, but also includes the support towards other projects linked to upstream (e.g. new technologies for satellites and access to space) as well as science-related projects.

The implementation of space projects is relatively new in EU Framework Programme compared to the support received by other domains in the past. As a result, there are currently no known assessments of the impact of these funded projects on the EU economy nor an indication on whether they have achieved their goal of increasing market uptake. Such an assessment could, provide valuable insights on the effectiveness of allocating budgets to space investment in mobilising additional public and private investment and the impact of the space investments on the EU economy. These insights can be of great importance to the implementation of space projects under future Framework Programmes.

6.3 Economic impact analysis of national space programmes

Along the same lines as the impact assessment for the European Space Programme or its funding through the Framework Programmes for Research and Innovation, it is possible to perform an economic impact assessment of national space programmes on the national economy of the Member State. Within the EU, Member States are not obliged to coordinate space programmes with the EU, meaning that they can often implement their own space programmes according to their national space strategy. This space strategy can be adopted in parallel with the strategy at EU level, provided that they compile with the principle of loyal cooperation, i.e. the legal principle that binds the EU and its Member States to assist each other in fulfilling the tasks and objectives outlined by the EU (Article 4(3) of the Treaty of the European Union[42]).

As the space sector is characterised by large technological and financial risks and typically requires multi-year investments before a return is realised (SEO Economic Research, 2012), an impact assessment of the effects of public investments into particular space activities or programmes can be crucial to guide and optimise future investment decisions. For the EU, such an analysis may shed light on the different national space strategies in terms of characteristics and respective impacts thereby providing valuable lessons and insight on the integration of these national space strategies into a common regulatory approach at EU level.

6.4 Economic impact analysis of EU policy scenarios towards open strategic autonomy

With the increasing importance of space services and induced technologies across the EU economy and their importance in several EU sectoral policies, there is a need to avoid and mitigate the risk of space disruptions. As a result, the EU has taken significant strides towards enhancing its strategic

(42) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A12012M004

autonomy in space over the last decade [43]. As part of this initiative, the EU has launched the EU Space Programme with the intent of ensuring strategic autonomy in satellite navigation and earth observation. Nevertheless, to ensure both the autonomous deployment of these programmes and general strategic autonomy in space, the EU needs to ensure reliable and cost-effective access to critical technologies and resources. Dependence on non-EU resources or technology sources often implies vulnerabilities and increased exposure to supply chain shocks and shortages, which could result in detrimental economical and employment effects along with negative impacts on the wellbeing and security of EU citizens.

To build fully resilient EU supply chains, it is important to establish a list of critical resources, i.e. resources that are essential to the development of EU space infrastructures for the European space sector, to assess possible supply risks and to get insight on which supply chains may be vulnerable to interference by competitors. This requires a better understanding and a more structural monitoring of the EU dependency on space. The space economy thematic account enables such an analysis of strategic dependencies by allowing a detailed analysis of the production and consumption of space-related goods and services (that fall under the scope detailed in section 2.2) and the ways in which they are consumed across industries and countries. Therefore, it enables a clear understanding of the importance of interrelationships within the economy, making it perfectly capable of identifying dependencies on foreign suppliers by assessing the diversification in suppliers, measuring the importance of EU imports in total demand and assessing the substitutability of extra EU imports within EU production.

With this type of analysis, the space economy thematic account can contribute to the existing and ongoing analysis of strategic dependencies and resilience of the EU value chains in the space ecosystem. Furthermore, it can serve as a starting point for addressing the identified significant strategic dependencies via various policy instruments and initiatives, such as the Important Projects of Common European Interests (IPCEI). This way, critical inputs can be traded from alternative supplier countries or incentivised to be produced domestically within the EU.

6.5 Regular production of indicators to monitor the space economy

A more general form of application of the space economy thematic account is the development of space indicators. Indicators are powerful tools that are crucial for the monitoring and evaluation of space programmes. Nevertheless, the development of such indicators is hampered by the aforementioned measurement difficulties and incomparability of data over time. One example is the lack of official employment statistics in space (OECD, 2012). Some industry associations have tried to improve the data provided by official statistics, but in many cases, the information remained limited to the space manufacturing industry while neglecting the service sectors. Similarly, space economy exports and imports related to the space economy are not frequently reported due to the strategic nature of several space-related activities. As a result, the reported information on imports and exports of one country did not match those reported by its trading partners due to confidentiality issues. This again caused the need to combine a variety of data sources from official authorities and industry associations (OECD, 2012).

The framework of the European space economy thematic account provides a good basis to develop guidelines on how to produce regular indicators, in terms of production, value added, exports, imports, jobs and environmental repercussions, amongst others. It eliminates the need to combine different datasets to obtain these statistics while ensuring comparability and consistency across Member States and time. The production of these indicators can serve as an important input to the monitoring of the relevance of the space economy in Europe.

[43] https://defence-industry-space.ec.europa.eu/technological-non-dependence_en

7 Conclusions

This report presents the methodological aspects linked to the development of an European space economy thematic account. It provides a harmonised framework for the production of reliable and comparable space economic statistics for the European Union.

The report provides insight into the definition and scope of the European space economy. It explains the steps required to construct national and inter-country space economy SUTs, both aligned with the Eurostat's inter-country Supply, Use and Input-Output (FIGARO) tables, and following international accounting standards. It also emphasises the contributions of countries in identifying space-related activities and products.

The developed space economy thematic account is covering the main Gross Domestic Product (GDP) indicators, such as output, gross value added and employment of the space sector, thereby opening up a wide range of possibilities for economic analyses and measurement of the space economy in Europe. Example of such analyses are the accurate evaluation of the economic benefits of the EU Member States' investment in the European Space Programme, the impact assessment of European policy changes on the space economy and the analysis of the overall employment attributable to the space economy. The overall purpose is to support regulators, policy makers, investors and business owners in making better-informed decisions.

The success of the compilation of the European space economy thematic account, as described in this report, relies on a joint effort among national and international statistical institutions and space agencies, as well as the European space industry. The ESA, the national space agencies and Eurospace are crucial for the provision of the required detailed data for the compilation of the European space thematic account. National Statistical Offices and international statistical institutions (Eurostat and OECD) provide the official statistics benchmark to the other source data in order to make them consistent with the overall country´s economic statistics, while the JRC develops and coordinates the methodology and the possible applications for better supporting EU space policies.

This report constitutes one of the first steps towards a closer collaboration between the main actors involved in the development of a European space economy thematic account, and aims to be a powerful tool to steer the EU space policies.

This pioneering work may still evolve in a near future but we hope it provides sufficient clarity and guidance for readers about the work to be done in the coming years. Feedback from users are welcome to improve the methodology continuously; this is particular useful when it comes to the definition of the space economy and the identification of space-related products and activities.

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Acronyms

BPM	Balance of Payments Manual
CN	Combined Nomenclature
CPA	Classification of Products by Activities
CPC	Central Product Classification
ECWMF	European Centre for Medium-Range Weather Forecasts
EGNOS	European Geostationary Navigation Overlay Service
EO	Earth Observation
ESA	European Space Agency
ESPI	European Space Policy Institute
EUSPA	European Union Agency for the Space Programme
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FIGARO	Full International and Global Accounts for Research in Input-Output analysis
GDP	Gross Domestic Product
GNSS	Global Navigation Satellite and positioning System
GHG	Greenhouse Gases
GVA	Gross Value Added
GVC	Global Value Chains
HS	Harmonised System
IRIS	Infrastructure for Resilience, Interconnection and Security by Satellites
IPCEI	Important Projects of Common European Interests
ISIC	International Standard Industrial Classification
JRC	Joint Research Centre

MFF	Multiannual Financial Framework
NACE	Nomenclature of Economic Activities
NAICS	North American Industry Classification System
NASA	National Aeronautics and Space Administration
OECD	Organisation for Economic Cooperation and Development
R&D	Research & Development
SNA	System of National Accounts
SUTs	Supply and Use Tables
US BEA	Bureau of Economic Analysis of the United States

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Developing a space economy thematic account for Europe

The space economy has been gaining increasing interest due to its important role in modern societies and the rising number of countries and enterprises involved in space activities. Nevertheless, a robust economic measurement of the space economy is hampered by the data scarcity and the lack of a consistent measurement methodology. This publication explores the development of a European space economy thematic account to provide a harmonised approach for generating reliable and timely space economic statistics that allow for an accurate quantification and monitoring of the space economy within Europe. Written collaboratively by the European Space Agency and the European Commission´s Eurostat and Joint Research Centre, it aims to serve as a conceptual guide for the construction of the European space economy thematic account at country and inter-country levels, following international accounting standards.

For more information
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