Co-Programmed European Partnership on

Globally Competitive Space Systems
-
Strategic Research and Innovation Agenda

Version 2.0

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Modifications since the last version: This version includes the high level Roadmap provided as a technical annexe (chap. 6.2.1.12). The detailed activities of the Roadmap are being collected and will be reviewed to prepare the further iteration.

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Note: The content of this document is derived from the Strategic and Innovation Agenda for EU-funded Space research supporting competitiveness (2020) and limited to the topics covered by the co-Programmed European Partnership on Globally Competitive Space Systems[1]. Additionally, sections on the description of the intervention logic, monitoring framework including Key Performance Indicators and information on the planned updates of the SRIA have been added to the document.

[1] The Scope of the Partnership has been agreed with the Member States in the Horizon Europe Cluster 4 Programme Committee on 09/12/2021 and is defined in the ‘Common Understanding with Experts of Cluster 4 Programme Committee on a proposal for a Co-Programmed European Partnership on Globally Competitive Space Systems’

1 INTRODUCTION

1.1 Contribution of Space to the EU policy and EU citizens

In 2016, the European Commission published a 'Space Strategy for Europe', with the following main objectives: maximizing the benefits of space for society and the EU economy, fostering a globally competitive and innovative European space sector, reinforcing Europe's autonomy in accessing and using space, and strengthening Europe's role as a global actor. To implement this strategy, a proposal for a Space Programme for the period 2021-2027 was published in June 2018. The proposal includes the continuation of the flagships programmes Galileo, EGNOS and Copernicus, adds two new components Space Situational Awareness (SSA) and secure governmental satellite communications (GOVSATCOM), with an overall budget of EUR 16 billion.

The added value of the space sector for EU economy and society, EU policies and EU citizens is obvious. Today we enjoy increasingly accurate global navigation services for all transport modes and users, extended Earth monitoring for land, marine, atmosphere and climate change, global meteorological observation and accurate cartographies of a wide number of variables. Space also makes important contributions to security crisis management and emergency services. These are key assets for the EU policies on climate, environment, transport, agriculture and secure society (e.g. Maritime Strategy, the Arctic Strategy, the Digital Agenda, the Common Security and Defence Policy, the Sustainable Development Strategy). Space technologies, data and services have also become indispensable in the daily lives of European citizens when using mobile phones and car navigation systems, watching satellite TV or withdrawing cash. Finally, the space sector is a source of economic growth, jobs and exports with the potential to spin-out a number of innovations in other sectors and to create a wealth of downstream applications and services.

The Space Partnership's contribution to the EU policies

Globally competitive Space Systems: Space is a strategic sector for the European Union. This partnership aims at delivering key contributions to the objectives set by the Space Strategy for Europe. It will contribute to foster the global competitiveness and shortening the time-to-market of EU space systems, to reinforce European capacity to access space and to accelerate the pace of innovation. It will develop and enable the uptake of the next-generation space technologies. By 2030, the Partnership is expected to contribute to the development of competitive end-to-end systems for satellite communication and Earth observation and smart technologies for EU launcher systems. Thus, the Partnership activities strengthen key assets for the EU policies on climate, environment, transport, agriculture and secure society.

1.2 Importance of the sector for the EU economy and jobs

Since the late 1990s, a significant market for commercial satellite services, mostly reliant on geostationary communication systems for TV and broadcast applications has developed. Today, the global space activity worldwide has stabilised around two main pillars: institutional programmes (including human space flights) representing about two thirds of spacecraft launched every year, and privately funded programmes worth the remaining third.

With more than 53000 jobs, the upstream segment of the European space industry, i.e. manufacturing of launcher and spacecraft, represents 6% of the global space industry workforce[2] and generates EUR 8.2 billion of consolidated revenues.

With EUR 22 billion of estimated exports for satellites in the last decade and a well established market share on the global commercial satellite market, European industry is a strong global competitor and achieved unique leadership positions in the expanding market of exports for civil and military observation systems. Today, Europe has a world-class space sector, including a strong satellite manufacturing industry, which captures around 30-40 % of the open world markets.

The European launcher industry is also of strong economic and strategic importance. In the past decade, it provided 35% of the total launch capacity worldwide, generating accumulated revenues above EUR 10.6 billion, of which half were for non-European customers.

The space systems manufacturing and launch sectors are net contributors to the EU trade balance, providing over 10B$ in net trade surplus over the past decade. In addition, the capacity to access and use space is a strategic asset for Europe and its Member States.

Relying on these upstream space assets, much broader mid-stream and downstream sectors can develop a wealth of services. Today, it is estimated that 10% of the EU's GDP depends on the use of space services. The overall European space economy (upstream, mid-stream and downstream) is estimated to employ over 230 000 professionals generating a value of EUR 46-54 billion or 21% of the worldwide business in the sector[3].

It is therefore a critical and strategic sector for the EU economy, which opens up many business opportunities especially in combination with digital technologies and other sources of data.

1.3 Trends and stakes

The global context of the space industry is undergoing profound changes. Since the beginning of the 1990s, private customers emerged progressively, with commercial space programmes now representing a growing share of mass deployed in orbit[4]. Space activities are also seeing more private investments in the areas of satellite communications, Earth observation and even launchers.

Over the last years, a significant growth of the number of launches of micro and nano-satellites emerged. This reflects a new approach to the use and operation of satellites, triggered by enhanced demand for lower communication latency and freshness of the information, up to persistence. New LEO and MEO constellations are emerging with the possibility to lower the costs of individual satellites when built in series, with also adverse consequences of a shorter life-cycle with new issues of orbital congestion and debris proliferation to be addressed as well as the incerased environmental impact of space business. Innovative industrial processes are revolutionising the sector.

[2] Facts & Figures , Eurospace, 2023

[3] Socio-economic impacts from Space activities in the EU in 2015 and beyond, PWC study, 2016. This figure only tracks the value of commercial space services and system procurement activities; it does not include the implicit value of free space services (such as the Galileo signal or the 16Tb of Copernicus data generated every year).

[4] In 2023 2/3 of total mass launched in orbit was deployed by SpaceX for its Starlink constellation. This is a profound evolution of launch activity at global scale.

The changes mentioned above open up new opportunities to develop innovative products, services and processes which can benefit the community in all Member States, creating new capacities and adding value in and outside the space sector. Dynamic global challengers such as the USA, China, Japan and India already started to seize these opportunities. As an indicator of this trend while 6 EU vehicle launches were performed in 2010 and 3 in 2023, China performed 15 launches in 2010 and 68 in 2023. In the USA, the private company Space X, founded in 2002, undertook 15 launches in 2010, and 98 in 2023 (out of the total 115 launches from the USA).

The institutional demand for space infrastructure and services remains limited in Europe, whereas other space powers consider it a very important protected market, which is fuelling domestic industrial competitiveness. European governments efforts represents much less than half of NASA budget, and probably less than one third of the total US space budget. Overall, the European space industry is facing a growing competition on the global market.

Beyond economics, the capacity of accessing and using space remains a strategic asset for many Member States in relation to security and defence, but also in the context of enabling EU control over future communications and big data infrastructures, as well as critical applications for environment monitoring and climate assessment.

Maintaining and expanding our competitive edge across all space actors while reducing our dependence in accessing and using space in the coming years is therefore of utmost importance.

1.4 Role and Approach of the Strategic Research and Innovation Agenda

In order to stay ahead in a dynamically changing global context, marked by growing competition and major technology shifts, the EU space sector requires continued, smart and coordinated investments strategies in cutting-edge technologies, innovation and skills.

The main purpose of this agenda is to provide coordinated guidance and recommendations for the EU research and innovation framework programme Horizon Europe (2021-2027), in particular for the Work Programmes 2025-2027, proposed by the SPACE partnership. The identification of R&I needs for the Space Programme components (EGNSS, Copernicus, SSA and GOVSATCOM) will emerge from their own governance.

The agenda has been drafted in close consultation with R&I actors including industry (large companies and SMEs), research centres, academia and institutional actors such as national space agencies. ESA has observed the consultation process and provided clarifications related to ESA programmes and ESA-led European processes.

Update plan

This SRIA will be regularly updated, subject to approval by the Partnership Board. This work will be one of the main tasks to be conducted by the Partnership, via a wide involvement of all the members of the association. R&I priorities will be reviewed and updated periodically in line with progress in the industry, RTOs and academia as well as the developments EU space policy. As the SRIA will be taken as the reference framework to identify the key space R&I priorities for the next Horizon Europe Work Programmes, the document will be updated before each prioritisation process. The planning of the next steps can be seen in Table 1.

Date	Action
October 2023	Stable version of the SRIA (adopted in the Governing Board Meeting)
December 2024	SRIA update 1
December 2027	SRIA update 2
March 2029	SRIA update 3

Table 1 Indicative update timeline of the SRIA for the Space Partnership

2 Vision and Objectives

The current situation of the European space sector in the global context as described above puts into evidence two main problems:

1. The EU Space sector is under a specific global competitive pressure
2. Our capacity to access space with a high level of autonomy is currently strongly challenged by the global context and competition

Problem drivers

EU Space sector is under a specific global competitive pressure

- The fact that other regions of the world (e.g. US, Russia, China, India) made the choice to have strong institutionally driven and supported space sectors, with a protected national market, places European stakeholders on an unfavourable level playing field. Space systems markets are not only globally heavily regulated but also domestically protected. They are not subject to international trade agreements and they are supported by national policies worldwide. As a matter of comparison, European space budget represents 0.06% of its GDP, while the USA Space budget is 0.23% of its GDP.

- Europe is the lead contender to the USA in commercial telecom and has a leadership position in commercial Earth observation. Consequently, it is a net exporter of space systems and launch services and a net positive contributor to the EU global trade surplus. However, although the value of space systems exports has grown by 30% in the past two decades, the European market shares have not improved. USA products are supported by technical advance developed in many labs and have unique performance and cost advantages due to high volume production supported by institutional domestic programmes. Hence, while European systems exports increased, the value of European imports grew even more. As a result, the satellite net trade balance did not grow as much as it could. Today the net surplus provided by satellite trade is in the order of EUR 350 million a year, and about 500 million for launch services.

- There is a new trend in commercial satellite markets, focusing on the use of smaller, lighter satellites in very large numbers (constellations and swarms). Although European industrial players have been the leading suppliers for the first operators of constellation systems in the 1990s and 2000s or in the development of new technologies, they are today not leading in the emerging 'New Space' paradigm, that has seen the emergence of reusable launchers and mega-constellations of small/micro/nano satellites. This also due to also due to a lack of institutional support from large procurement programmes at EU, ESA and national level.

Competition is now worldwide with a dominance of US players, having a large capacity to adapt to new users' requirements. Unlike in the USA, there is a lack of public support for the 'New Space' sector in Europe. China is also supporting the emergence of Chinese commercial companies initially relying on their own domestic market critical mass.

- Research centres are innovators and are pioneering many technological developments that have later found commercial applications supporting the manufacturing sector. They have partly initiated large-scale innovative scientific or technological space missions. Outside Europe, other regions are strongly supporting their domestic research centres to develop these technological capabilities and their human capital to support the development of a national industrial base. This is also impacting the competitiveness of the European space sector.

Capacity to access space with a high level of autonomy

- The massive US institutional space programmes create the conditions for a locally protected demand, which is the highest in the world[5]. This enables, for example, the development of an ecosystem of launch services by commercial industrial players offering unparalleled economic conditions, that are then brought to the global market with unmatched prices and services. Similarly, satellite systems are supported by high volume local productions, generating low unique costs and volume effects that are then passed on to the commercial segment and create distortion in the global competition. New technological paradigms are being supported by a strong cooperation between institutional labs and the private sector.
- It is essential for EU launch service providers to balance and complement the limited demand from European institutional programmes by capturing a significant share of the global commercial market. This strategy enables the distribution of fixed costs on larger volumes and maintain the launch service cost efficiency, sustainability and reliability.
- New innovative technological concepts have been investigated by other regions and particularly in the field of reusability to lower the costs of access to space.
- The massive flow of R&D and innovation promoted by the US institutional programmes created a technology gap with Europe, with consequences on innovative concepts, systems performance and costs. This situation is now worsening with the step up of Chinese efforts in space and their introduction of breakthrough and innovations in the sector (for instance the first Quantum satellite ever launched was Chinese). As a result, a number of EU space programmes are now dependent on foreign technologies and solutions to achieve their cost and performance objectives. This dependence situation has market and political consequences, and it requires targeted policies supporting the European industry and research centres for its reduction.

2.1 Common vision and ambition

The co-Programmed Partnership on Globally Competitive Space Systems will make a key contribution to these challenges by gathering for the first time in the context of EU funded research

[5] The Space Report (2019 edition) estimates that the global institutional demand for space programmes is in the order of $86 billion, of which the USA alone represent 55%, and Europe 14. The European local institutional demand is about 4 to 5 times lower than the American one.

a wide, diverse and complementary R&I Stakeholders community of academic, research centers, SMEs and industry around a commonly agreed strategic agenda with institutional stakeholders.

The reliance on an inclusive Strategic Research and Innovation Agenda and a multi-annual-roadmap based approach has the potential to take EU funded research to a higher level of integration. This will happen through larger projects, higher leverage, targeting higher TRL levels up to flight demonstrators, with a shortened R&I and development times and involving all space stakeholders (primes and midcaps, SMEs, research centers and academia). This will all contribute to build up operational capacity much faster (at medium term), and to the development of new innovative and breakthrough paradigms in the longer-term.

The partnership will then be able to coordinate and monitor to outcome and impact of the R&D projects. The programmatic guidelines developed by the partnership will allow having a better balance between high and low TRL. This will include bottom-up R&I activities at lower TRL to open the potential for long-term opportunities and to ensure the continuity along the TRL chain for evolutionary maturation of individual technologies and stimulating the emergence of disruptive technologies.

Some activities towards these objectives have been initiated by Space Agencies, Industry and Research Centers but there is a need for coordination and to accelerate the path to improve EU competitiveness. Co-programming of EU funded R&I activities with all the relevant stakeholders is essential to maximize the impact based on common objectives, agreed roadmaps and leverage of resources all across EU.

Our vision is structured along two technology-based activity lines, comprising the Key Development Areas:

- 'Foster Competitiveness of space systems' to maintain and further strengthen Europe’s capacity to conceive, develop, operate and exploit competitive state-of-the-art space systems, associated services and applications and develop new system approaches, ensuring freedom of action and autonomy,

- 'Reinforce Access to Space' to ensure that Europe maintains and improve autonomous, reliable and cost-effective access to space.

To address the identified problems and head towards the vision the intervention logic shown in Figure 1 has been designed.

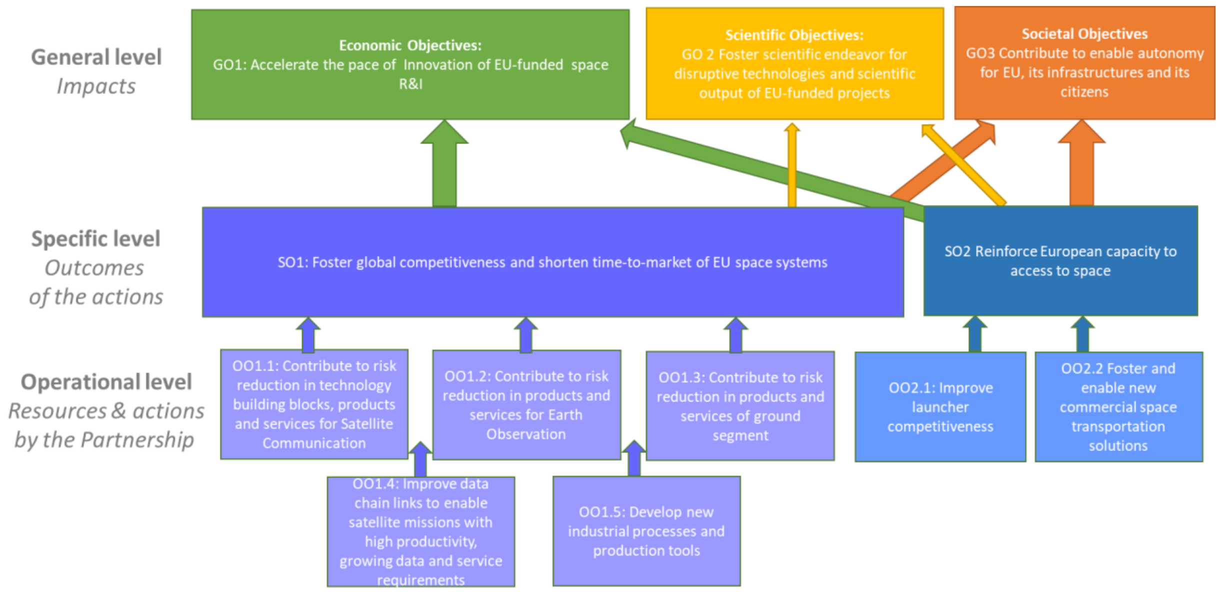

Figure 1 Intervention logic for the SPACE Partnership

2.2 Objectives

The **general objectives** of the European Partnership are defined as follows:

<u>Technological and economic objectives</u>

GO1 Accelerate the pace of Innovation by adopting a different way of working between stakeholders, incentivizing additional private investments and new approaches (e.g. New Space), opening new commercialisation opportunities, pulling resources together, bringing more coherence in the programming and/or more effectiveness in the implementation and enhancing technology transfers and/or commercial maturation of disruptive technologies.

Potential indicators:

- Additional in kind-contribution and additional private investment
- Reinforcing synergies with other sectors
- Number of patents to which the Partnership will have contributed

<u>Scientific Objectives</u>

GO2 Foster scientific endeavour for disruptive technologies and scientific output of EU-funded projects to improve Europe competitiveness and accelerate technology transfer to industry.

Potential indicators:

- Number of projects and estimate of EU-funding having contributed to the GO
- Number of scientific publications issued by projects related to the Partnership

<u>Societal Objectives</u>

GO3 Contribute to enable autonomy for the EU, its infrastructures and its citizens, as well as contribute to unlock the added value of space for EU policies like digitalization, climate, environment, transport, agriculture, or security.

Potential indicators:

- Contribution to autonomy provided over the duration of the Partnership
- Result exploitation per research action

The **specific objectives** of the European Partnership are defined as follows:

SO1 Foster global competitiveness and shorten time-to-market of EU space systems by concentrating R&I efforts on domains with strong global competition (e.g. end-to-end-systems for telecommunications, commercial Earth observation, reducing production costs with a short-term impact).

Potential indicators:

- EU actors' competitiveness
- Shortening time to market and reducing costs
- SRIA Key Development Areas (KDAs) covered by the calls for proposals

SO2 Reinforce European capacity to access space by focusing the R&I efforts on specific domains, in complementarity and coherence with ESA and Member States to contribute to rapidly improve launch competitiveness by 2030.

Potential indicator:

- Contribution to improve launch competitiveness by 2030

The **operational objectives** of the European Partnership are defined as follows[6]:

OO1.1 Contribute to risk reduction in technology building blocks, products and services for Satellite Communication and be closer to the market thanks to the definition by supply chain partners of the best top-down reactive roadmap based strategic planning in an evolutive market driven approach.

OO1.2 Contribute to risk reduction in products and services for Earth Observation by maturing technology building blocks and progress towards demonstration to be closer to the market.

OO1.3 Contribute to risk reduction in products and services of ground segment by maturing technology building blocks and progress towards demonstration to be closer to the market for any kind of mission in the perspective of end-to-end demonstrators.

[6] In order to increase competitiveness, activities will primarily concentrate on high TRL actions, close to the market but also, encompass low and mid TRL ranges when they fall under the selected scope of the partnership and are part of the corresponding roadmaps.

OO1.4 Improve data chain links to enable satellite missions with high productivity, growing data and service requirements by developing an inclusive approach that integrates i) on-board satellite data handling (e.g. processing, storage, compression, optimisation), ii) data transmission between the satellite and other terminals that can be located on ground or air-borne platforms and on-board other satellites, and iii) data handling and transmission on the ground, and possibly back to the satellites for autonomous mission planning based on real-time observations.

OO1.5 Develop new industrial processes and production tools with reduced production cost and cycle time reduced and deployment over the whole supply chain and commercial programmes by 2030 using methods of Industry 4.0, digitalisation and automation, manufacturing, assembly, integration and testing at larger-scale, Lean qualification processes

OO2.1 Improve launcher competitiveness by smart technologies such as enabling higher launcher autonomy, in-flight configurability, and modular wireless avionics architecture with smart sensors.

OO2.2 Foster and enable new commercial space transportation solutions by new space transportation services and concepts, in particular those for improving versatility, cost reduction and flexibility, new services requiring re-entry, standardisation of services and actions promoting the use of Commercial Off-The-Shelf (COTS) components.

Potential indicators:

- Number of projects, EU-funding and Partners contributions having contributed to the OO
- Gains of performance enabled by the projects
- Gains in cost and time reduction enabled by the projects
- TRL achieved for the technologies developed
- Level of impacts of new industrial processes and production tools

2.3 The innovation roadmap for the Partnership in Horizon Europe (2025-2027)

The partners propose to focus the first three years of the partnership on cohesive activities in the domain of digital developments under the grand heading of **Digitalisation for Commercial Space solutions** (see Annex 6.2 for more details)**.**

The Digitalisation goals will be articulated around the following main domains:

- **Collaborative and synergetic Earth Observation and Satcom missions for Space solutions**
    - **Satellites as Smart Network Nodes:** this domain will support the realization of key competitiveness development goals identified in the Partnership scope, covering the commercial communications including the seamless integration with terrestrial networks. The domain (further described herewith) will enable to roll out and demonstrate key space and ground technology building blocks in state-of-the-art areas such as cloud in space and edge computing, network protocols (5G&6G), distributed systems, automatic/intelligent data processing, inter-satellite links, innovative resources management software and orchestration of multi orbit space assets.
    - **Contributing to SO1, OO1.1, OO1.3, OO1.4**

- **Digitalization to maximize Observation imagery performance and timeliness and future exploitation:** this domain will address end-to-end commercial observation systems. In particular, it will enable the maturation of the most time-efficient high power end-to-end processing chains, together with significant imagery performance enhancements. Besides, efforts towards space data interoperability at all levels in both space and ground segments are still needed to enable future exploitation of space data from heterogeneous sensors.

- **Contributing to SO1, OO1.2, OO1.3, OO1.4**

- These two subdomains are fitting the corresponding sections of the Space's Strategic Research and Innovation Agenda. However, as far as possible, the space partnership endeavours to address them jointly to reinforce their synergies and to foster market-demanded innovations from either commercial or institutional customers edging from such a combined approach.

- **Digital solutions for launcher autonomy for space transportation systems, design and simulation tools**: focusing on a narrow scope of activities supporting competitiveness innovations for space transportation services, and aiming at enabling technologies able to support a wider range of new systems and services. The domain (further described herewith) would support two key development areas, the advanced technologies and digital sensors for new space transportation and the eco-design software tools enhancing.
  - **Contributing to SO2, OO2.1, OO2.1**

The focus on digitalisation answers most of the requirements for the current Partnership while allowing the participation of a wide range of actors and fits with the budget envelope considered. Most of the demonstrators envisaged could be realised on ground or via a testbeds approach taking benefit of available in space infrastructures.

3 FOSTER COMPETITIVENESS OF SPACE SYSTEMS

To meet the challenge of fostering EU competitiveness, the proposed objectives are to invest in cutting-edge technologies, associated current and future services, integrated applications, and capacities and undertake actions leading to cost and risk reduction.

3.1 Foster competitiveness of end-to-end systems and associated services

The European space sector and space economy needs to capture new markets, adapt to rapidly changing markets and stay competitive in the established telecom and Earth observation sectors, with a short time-to-market perspective of typically 3 to 5 years. The technological developments should be justified by a thorough market analysis and a solid identification of the users/clients and their needs.

[Why] **Telecommunication systems** is the main European commercial segment and export market (EUR 1.7 billion sales in 2020[7]). End-customers need ever increasing capacity, new applications

[7] Space Economics, Euros

and services owing to a quickly evolving digital context such as cloud network community, internet of things, the arrival of 5G, increasing competition and lowering costs.

[What] This requires accelerating the pace of a number of developments guided by a technology top-down approach targeting the final user application. In particular, end-to-end flexible solutions are needed in a novel efficient 'system of systems' approach, including multi-layer capacity and an extended range of solutions from large to medium and small satellites. On-orbit mission flexibility, very high and ultra-high throughput capacities, enhanced cybersecurity as well as decreased costs are necessary to address key customer demands. This calls for new technology solutions for payload such as advanced active antennas, digital processing, photonics and optical communication. Impacts for the design of the satellite platform should also be considered.

[How] Synergies and complementarities with respect to existing programmes are to be sought, in particular with the ARTES programme from ESA. It is recommended to address R&I topics targeting mainly mid-high TRLs, defined by roadmaps responding to short- to mid-term industry needs related to current and expected user demands and targeting well-defined market scenarios, with a short-term market perspective for exploitation (3-5 years). In terms of implementation, competitive calls for collaborative projects are considered the most suitable tool. At the same time, opportunities to programme topics that offer fast reactivity should also be considered as well as support to less mature potentially disruptive technologies (for instance novel telecom applications of Artificial Intelligence).

[Why] **Earth observation** (EO) is the second commercial market for EU industry. The market demand is expected to grow quickly in the next 10 years on both high-end very high resolution satellite market (spatial) and lower end high resolution high revisit market (typically smaller satellites in constellations).

[What] Systems should target higher end-to-end performance at lower cost, which can include multi sensor systems solutions (such as new advanced optical and radar sensors), and/or multi-layers capacity with various orbits and platforms (e.g. High Altitude Platforms) carrying multiple payloads. Also, innovation is needed to enable higher reactivity of the observation systems and massive data acquisition and processing capacity. This requires highly reconfigurable and autonomous satellites as well as making full use of the now mature concepts of multiple “small” satellites and the opportunities for new and enhanced services and products.

[How] Synergies should be sought with the EU Copernicus Earth Observation programme and with relevant ESA programmes while addressing well-defined civilian market scenarios and use cases with a short-term market perspective for exploitation (3-5 years), which calls for a structured roadmap-based approach driven by industry and users. Opportunities to programme topics which offer fast reactivity should also be considered as well as support to less mature potentially disruptive technologies (for instance novel applications of Artificial Intelligence).

[Why] **Ground segment aspects** must be integrated in these “end-to-end” approaches for telecom and Earth observation but aspects of ground control centres and operations, data handling and terminals need to be considered explicitly. If the capacities of the ground segment are not developed to match those of the space segment, the performance of the system will be limited. In addition, the ground segment can play an important role owing to the increasing volumes of data to be processed from space imagery, the growing number of satellites used in constellations or the integration with the ground telecommunication network. Security aspects should also be fully considered in all targeted developments.

[What] Future ground segment should handle a range of new needs, providing scalable and resilient solutions while reducing costs. These needs stems from the arrival of larger constellation of satellites, multiple sensors, ever increasing data rates, more flexible payloads, on-board and on-ground autonomy (mission planning) and mission re-configurability. Technological development should ensure full interoperability and integration of satellite communications into 5G and/or upcoming evolutions of terrestrial communication networks. The ground segment covers control centers and operations, ground data handling and processing as well as ground stations and terminals.

Finally, infrastructure protection, security and specifically cybersecurity is of ever increasing importance and cut across all these aspects.

[How] Ground segment aspects need to be addressed in conjunction with and with similar implementation modes as corresponding end-to-end space solutions, e.g. satellite communication and Earth observation. A dedicated agenda implementing a multi-annual roadmap for the ground segment is necessary, in parallel to the end-to-end developments stemming from telecommunications and earth observation specific needs.

[Why] Novel approaches to **data chain aspects** are needed to enable satellite missions with high productivity and growing data and service requirements.

[What] An inclusive approach should be developed that integrates i) on-board satellite data handling (e.g. processing, storage, compression, optimisation), ii) data transmission between the satellite and other terminals that can be located on ground or air-borne platforms and on-board other satellites, and iii) data handling and transmission on the ground, and possibly back to the satellites for autonomous mission planning based on real-time observations. For this purpose, technologies and systems for high-speed data handling, processing, storage and transfer are required with an increasing role for artificial intelligence. This includes addressing the demand for near real-time data for specific applications.

The combination different types of platforms (GEO satellites, LEO constellations, airborne systems and ground systems) and of the main space-based services (geo-localisation, telecommunications and Earth observation) will enable the emergence of new services.

[How] EU-funded projects are in principle well suited for collaborative work at pre-competitive level with contributions from different disciplines and stakeholders and can provide an appropriate environment for end-to-end developments.

3.2 New industrial processes and production tools

[Why] New user needs such as faster responsive mission, higher production volumes, on-demand flexible manufacturing and cost reduction call for major changes in the way Manufacturing, Assembly, Integration and Testing (MAIT) is performed. These changes are further justified with the arrival of large constellations of smaller satellites. European players are already engaged in this work. Although industrial processes and production tools are cross-cutting for many domains, it is important they are addressed specifically for space technologies because of the specificities of the space environment (e.g., radiation), the extremely high-quality standards required and the need for full traceability in different processes.

[What] Digitalisation and automation will significantly affect the MAIT processes by addressing connected supply chain and quality issues, workforce efficiency, production flow optimization and

end-to-end operations steering. Advanced design and manufacturing methods and "Digital Twins[8]" have also the potential to enhance and accelerate considerably these processes. Modular approaches including the introduction of plug and play modules and standard interfaces will significantly enhance the degree of automation resulting in a more sustainable space ecosystem with a strong potential for cost reduction.

[What] Manufacturing, Assembly, Integration and Testing at larger scale requires significant reductions in mass, cost, emission, energy consumption and development time as well as the development of alternative manufacturing routes, at the same time adhering to the stringent space requirements and specificities. These are for example ALM/3D printing, design compactness, miniaturisation and integration of components, making use of multi-functional materials and structures with increased reliability and enhanced thermal dissipative properties. Also, an upfront design-to-AIT effort has to be made in order to facilitate series integration. The best use of suitable Commercial Off-The-Shelf (COTS) components should also be sought, while thoroughly assessing the associated qualification effort.

[What] Lean qualification processes are needed to adapt to these emerging trends and specific needs of constellations (from small to mega), minimising time, efforts and costs, at the same time delivering the necessary space quality standards.

[How] The developments are cross-cutting and should be performed in synergy with the other areas of the SRIA, such as Competitiveness of end-to-end systems, on-orbit operations, access to space. Moreover, concrete links with non-space sectors should be drawn and exploited, in particular with the Factories of the Future initiative. An overview survey activity that will identify concrete and justified needs would bring maximum added value to the sector while adhering to the space-related quality requirements would be very beneficial before the launch of R&I activities.

4 REINFORCE ACCESS TO SPACE

[Why] The specific challenges are: (i) the highly competitive global launch service market landscape characterised by an increasing number of competitors with new capacities from USA, Japan, China, India, etc., proposing attractive launch service prices on the commercial market; and (ii) the emerging opportunities in space transportation that are not yet seized by European actors characterised by new uses of space (e.g. small satellites, larger constellations) new destinations (e.g. direct GEO). In this context, the main objective is:

- to expand commercial space transportation, offer and services in order to maintain and improve independence and affordability of access to space through global competitiveness and growth on new commercial markets. The objective is to contribute to double the accessible space transportation market to European industry over a decade.

A technical and programmatic coordination with ESA would avoid unwanted duplications of actions.

Two lines of research and innovation activities are proposed to contribute to these objectives.

[8] "Digital Twin" refers to a digital replica of physical assets, processes, people, places, systems and devices

4.1 Innovation for launchers competitiveness targeting initial operational capability by 2030

This subsection is limited to the sub-area that falls within the scope of the partnership.

The following domains were identified where practical solutions could be deployed by 2030 and make a significant impact to competitiveness.

[What] **Smart technologies** such as enabling higher launcher autonomy, in-flight configurability, and modular wireless avionics architecture with smart sensors would also contribute to reduce cost of the launch systems. Provided Return of Investment is attractive, maturation of smart technologies shall include fault detection isolation & recovery, health monitoring system, use of Artificial Intelligence, Flight Management Software, advanced data system, new Instrumentation concepts, Guidance, Navigation & Control (GNC), advanced Telemetry, Tracking, Command (TM/TC), modular distribution and architecture as well as electrification all over the launcher and new generation power.

[How] R&I actions should result from identified specific challenges/objectives and priorities driven by cost-effectiveness (including cost reduction). The actions should rely on a roadmap approach. These could need a continuous support all along the MFF period[9], potentially up to flight demonstrators as well as technology demonstration at component, subsystems or system level[10], to maximise the benefit of EU Space Programme. The development strategy could be, with quick iterative loops between design, test & analysis and early flight tests. Also, in order to minimise development risks, it is proposed to adopt a "Scaled & Stepwise" effort whenever possible.

4.2 Fostering and enabling new commercial space transportation solutions

[Why] Future systems for access to space should be capable of addressing new commercial needs, offering the potential to grow European industry's business on worldwide markets and to improve the coverage of user's needs. As of today, a lot of commercial initiatives are on –going worldwide, including mini-micro launchers and commercial spaceports.

[What] R&I activities are needed that encourage and enable **new space transportation services and concepts**. This includes launch systems concepts dedicated to small satellites (e.g. micro launchers and launch facilities, evolution of rideshare services, including motorised solutions), or launch systems concepts like kick-stages evolution dedicated to new types of payloads (e.g. cargo, fuel, in-orbit servicing payloads), or new types of space routes.

In order to foster the development of European micro launcher solutions some of the key areas to be mastered in Europe are technologies enabling low-cost systems for launchers and associated launch facilities, improving versatility and flexibility, quick refurbishment, low-cost propulsive system, modular and low-cost avionics, low shock separation systems.

Rideshare/piggyback concepts should evolve towards modular, flexible and smart dispensers for multi-satellites launch solution.

[9] this does not exclude funding priorities on shorter period

[10] this excludes full launcher development and full launch facility

R&I activities should also address versatile kick stages with additional services regarding extended services to payload, better payload comfort, including lower shock separation mechanisms and smarter separation systems as the number of payloads increase on the vehicle.

[What] **New technologies** should be developed, which enable new concepts, in particular those **for improving versatility, cost reduction and flexibility** of launch systems. Reliability, safety and payload transfer capability can be improved by allowing the launcher to autonomously monitor its performance during the launch. Payloads of multiple sizes and masses will have to be delivered to a large variety of destinations, through in-space highways with variety of delta-velocities. The key enabler to reach any point using those routes will be in-space propulsion. Long orbital transfers between commercially strategic nodes (e.g. LEO, GEO, cislunar orbit) will necessitate long energy storage/energy generation, improved thrust control and thermal management (e.g. green, clean, storable propulsion, long duration energy storage, long term cryogenic storage, autonomy of the launch vehicle).

[What] For **new services requiring re-entry**, some other key areas would need R&I activities such as precision lander (e.g. Earth) guidance, navigation and control, including reliable sensing capabilities, Earth re-entry vehicle and ground logistics, power and thermal management and communication system through relay.

[What] **Standardisation** of services and actions **promoting the use of Commercial Off-The-Shelf (COTS) components** will have a positive impact on cost.

[How] R&I actions should result from identified specific challenges/objectives and priorities, driven by commercial business growth. The actions should rely on a roadmap-based approach and be targeted at enabling an operational commercial capability during the MFF period. These could need technology demonstration at component, subsystems or system level[11]. The actions shall include inducement prizes, new funding models (e.g. venture capital funds, loans, EU as anchor customer, blended finance,) and co-funding by other parties such as industry.

In coordination with ESA, a limited number of transportation products and technologies should be defined and used as building blocks of European end-to-end space transportation service portfolio.

5 COLLABORATION WITH OTHER EUROPEAN PARTNERSHIPS

The SPACE Partnership undertake to set up and maintain a clear strategy and plan for the interfaces and joint activities of the Co-programmed European Partnership with the other relevant European Partnerships, as well as with the broader European research and innovation system and communities. The detailed plan will be provided and described in this section in the updated version of the SRIA.

At this stage the plan to establish a regular collaboration with the following other European Partnerships:

- **European Partnership for Smart Networks and Services:** Telecommunications satellites can provide connectivity where terrestrial communications are insufficient, to serve remote areas or areas where it is difficult and/or/ very expensive to deploy a ground infrastructure

[11] this excludes full launcher development and full launch facility

- **European Partnership Made in Europe**: Partnership works on future digitally based manufacturing technologies (e.g industry 4.0) that the space sector needs to enhance its manufacturing processes with flexibility and to extend reconfiguration capabilities for both satellites and launchers. Space is usually working with a very limited number of units (e.g. compared to automotive or aeronautic) but with higher levels of quality, reliability and prices. Specific developments are therefore needed.
- **European Partnership for Photonics**: Photonics have the potential to enhance radically the transmission capacity of future satellites. Ultra-High bandwidth capacity at affordable prices has the potential to give the EU satellite manufacturers a key competitive advantage.
- **European Partnership for Key Digital Technologies (KDT)**[12]: Partnership is promoting the development of electronic components and software by the EU and in the EU. The space sector is particular dependent on EEE components manufactured elsewhere than in Europe, without which European industry would not be able to produce satellites and launchers. The reduction of European dependence in this field is of utmost importance.

The SPACE Partnership will report specifically on these collaborations in the annual reporting.

[12] See also the Commission Communication on the related European Chips Act:

European Chips Act: Communication, Regulation, Joint Undertaking and Recommendation | Shaping Europe’s digital future (europa.eu)

6 ANNEXES

6.1 Monitoring and Evaluation Framework of the Space Partnership

In order to provide an overview of the outcomes that could reasonably be expected from the SPACE Partnership and in order to be able to monitor and report on the progress of the partnership towards its objectives, the list of Key Performance Indicators (KPIs) was elaborated within the SPACE Monitoring Framework (Table 2).

The following table provides a summary of the main KPIs that will be tracked to monitor the impact and progress of the partnership. Targets that are marked *TBC* will be updated in the first months of the partnership, in collaboration with the experts in the SPACE partnership board. The SRIA will be assessed as part of the monitoring exercise and updated if needed according to the update plan (section 0).

Being successful in achieving the targets suggested in this Monitoring Framework will not entirely rely on the SPACE Partnership actions. While the partnership will carry out additional activities to tackle some of the above-mentioned challenges related to market, societal and regulatory uptake, many of them are not under the control of the partnership and will also need to be carried out in parallel. The SPACE Partnership will also bring a major contribution to broader additional outcomes not listed (for example on standardisation and qualification of components, and parts).

Table 2 Monitoring and Evaluation Framework

<table>
<tr><th colspan="3">Space Partnership</th><th colspan="4">Monitoring and evaluation framework
12/2023</th></tr>
<tr><td colspan="7"><u>Overall vision:</u> Space is a strategic sector for the European Union. This partnership aims at delivering key contributions to the objectives set by the Space Strategy for Europe. It will contribute to foster the global competitiveness and shortening the time-to-market of EU space systems, to reinforce European capacity to access space and to accelerate the pace of innovation. It will develop and enable the uptake of the next-generation space technologies. By 2030, the Partnership is expected to largely contribute to the development of competitive end-to-end systems for satellite communication and Earth observation and smart technologies for EU launcher systems. Thus, the Partnership activities strengthen key assets for the EU policies on climate, environment, transport, agriculture and secure society.</td></tr>
<tr><th colspan="2">Objectives</th><th>What is a measure of success? (KPI)</th><th>Which is the data source and methodology used [project data, study, ….]</th><th>Who is responsible for monitoring and providing the data / information When will it be collected?</th><th>Baseline 2020</th><th>Target 2030</th></tr>
<tr><td rowspan="2">General Objectives
(Impacts)</td><td rowspan="2">GO1
Accelerate the pace of Innovation</td><td>Additional in kind-contribution and additional private investment</td><td>Internal data collection (Partnerships collect data from each partner)
Data available through public portals (e.g. CORDIS)
Data provided by EC</td><td>Partnership association. Part of the ex-post evaluation.</td><td>End of H2020 without partnership</td><td>Leverage >= 1.2</td></tr>
<tr><td>Reinforcing synergies with other sectors</td><td>Internal data collection (Partnerships collect data from each partner)
Data available through public portals (e.g. CORDIS)</td><td>Partnership association.</td><td>Situation at the end of H2020</td><td>Non-space sector involvement:
% of EU funds received >0
% of partners >0</td></tr>
</table>

						% of leverage brought by non-space partner(s) >0 N° of meetings with other partnerships >0 N° of joint calls (e.g. robotics, photonics, …) >0
		Number of patents to which the Partnership will have contributed	Internal data collection (Partnerships collect data from each partner) Data available through public portals (e.g. CORDIS) Data provided by EC	Partnership association. Part of the ex-post evaluation.	Situation at the end of H2020	Suggest not to assess: Patenting in Space is not a good indicator for innovation.
	GO2 Foster scientific endeavour for disruptive technologies and scientific output of EU-funded projects	Number of projects and estimate of EU-funding having contributed to the GO	Internal data collection (Partnerships collect data from each partner) Data available through public portals (e.g. CORDIS) Data provided by EC	Partnership association.	Timeframe in HE without partnership	Self-assessment (project manager checks relevant line in survey) >0
		Number of scientific publications issued by projects related to the Partnership	Internal data collection (Partnerships collect data from each partner) Data available through public portals (e.g. CORDIS) Data provided by EC	Partnership association.	Timeframe in HE without partnership	Number of scientific publications >=1 per awarded project

	GO3 Contribute to enable autonomy for the EU, its infrastructures and its citizens	Contribution to autonomy over the duration of the Partnership	Internal data collection (Partnerships collect data from each partner) Data available through public portals (e.g. CORDIS) Data provided by EC	Partnership association. Part of the ex-post evaluation. Market studies to investigate evolution of market shares and influence of demonstrator mission.	Timeframe in HE without partnership	Synergies with the JTF technologies: Number of identified synergies with current JTF list (at call or project level) >0
		Result exploitation per research action	Internal data collection (Partnerships collect data from each partner) Data available through public portals (e.g. CORDIS) Data provided by EC	Partnership association. Part of the ex-post evaluation.	Situation at the end of H2020	TRL growth after project closure >= 2 TRL steps in 3 years
Specific Objectives **(Outcomes)**	SO1 Foster global competitiveness and shorten time-to-market of EU space systems	EU actors' competitiveness	Internal data collection (Partnerships collect data from each partner) Data available through public portals (e.g. CORDIS) Data provided by EC	Partnership association. Part of the ex-post evaluation. Market studies to investigate evolution of market shares and influence of activities.	Situation at the end of H2020	No of technologies developments turned into products>0
		Shortening time to market and reducing costs	Internal data collection (Partnerships collect data from each partner) Data available through public portals (e.g. CORDIS) Data provided by EC	Partnership association. Part of the ex-post evaluation. Market studies to investigate evolution of market shares and influence of activities.	Situation at the end of H2020	Average TRL start of selected projects > 5 Average TRL targets of selected projects > 7 Average TRL growth of selected projects > 2 steps

		SRIA Key Development Areas (KDAs) covered by the calls for proposals	Internal data collection (Partnerships collect data from each partner) Data available through public portals (e.g. CORDIS) Data provided by EC	Partnership association.	SRIA KDAs	>= 1 KDA per awarded project >= 2 KDA per call scope
	SO2 Reinforce European capacity to access	Contribution to improve launch competitiveness by 2030	Internal data collection (Partnerships collect data from each partner) Data available through public portals (e.g. CORDIS) Data provided by EC	Partnership association. Part of the ex-post evaluation. Market studies to investigate evolution of market shares and influence of activities.	Situation at the end of H2020	>= 1 KDA per awarded project >= 2 KDA per call scope
Operational Objectives **(Resources, processes and activities)**	OO1.1 Contribute to risk reduction in technology building blocks, products and services for Satellite Communication	Number of projects, EU-funding and Partners contributions having contributed to the OO	Internal data collection (Partnerships collect data from each partner)	Partnership association.	Timeframe in HE without partnership	Number of projects>7 Average TRL start of selected projects > 5 Average TRL targets of selected projects > 7 Average TRL growth of selected projects > 2 steps
	OO1.2 Contribute to risk reduction in products and services for Earth Observation	Gains of performance enabled by the projects	Internal data collection (Partnerships collect data from each partner)	Partnership association.	Timeframe in HE without partnership	Number of projects>7 Average TRL start of selected projects > 5 Average TRL targets of selected projects > 7

		Gains in cost and time reduction enabled by the projects				Average TRL growth of selected projects > 2 steps
	OO1.3 Contribute to risk reduction in products and services of ground segment	TRL achieved for the technologies developed	Internal data collection (Partnerships collect data from each partner)	Partnership association.	Timeframe in HE without partnership	Average TRL start of selected projects > 5 Average TRL targets of selected projects > 7 Average TRL growth of selected projects > 2 steps
	OO1.4 Improve data chain links to enable satellite missions with high productivity, growing data and service requirements	Level of impacts of new industrial processes and production tools	Internal data collection (Partnerships collect data from each partner)	Partnership association.	Situation at the end of H2020	Average TRL start of selected projects > 5 Average TRL targets of selected projects > 7 Average TRL growth of selected projects > 2 steps
	OO1.5 Develop new industrial processes and production tools		Internal data collection (Partnerships collect data from each partner)	Partnership association.	Situation at the end of H2020	Average TRL start of selected projects > 5 Average TRL targets of selected projects > 7 Average TRL growth of selected projects > 2 steps
	OO2.1 Improve launcher competitiveness		Internal data collection (Partnerships collect data from each partner)	Partnership association.	Situation at the end of H2020	Number of projects>3 Average TRL start of selected projects > 5 Average TRL targets of selected projects > 7

						Average TRL growth of selected projects > 2 steps
	OO2.2 Foster and enable new commercial space transportation solutions		Internal data collection (Partnerships collect data from each partner)	Partnership association.	Situation at the end of H2020	Average TRL start of selected projects > 5 Average TRL targets of selected projects > 7 Average TRL growth of selected projects > 2 steps

6.2 Digitalisation for commercial space solutions: Space partnership recommendations for Horizon Europe 2025-2027

Preamble

The Globally Competitive Space Systems partnership is about to be launched in 2024, with moderate budget prospects and a short window of operations, targeting the calls 2025, 2026 and 2027 of the Horizon Europe work programme.

In light of the challenging calendar and budgetary environments, the partners propose to focus the efforts of the first version of the partnership (as implemented in Horizon Europe) on activities pursuing the following objectives:

- Address up to date challenges for commercial space solutions
- Achieve synergetic developments across the areas covered by the partnership scope
- Promote high yield, low risk, short timeline developments and deployments
- Target rapid deployment towards high TRL and demonstration activities
- Promote the involvement of all partners, large and small, institutes and corporate entities, demonstrated our capacity to work together at European scale
- Enable a scalable building blocks approach, towards a ready-to-bid status (possibly through demonstration missions) for commercial markets in the medium term.

With these objectives in mind, the partners propose to focus the first three years of the partnership on cohesive activities in the domain of digital developments under the grand heading of **Digitalisation for Commercial Space solutions.**

The Digitalisation goals will be articulated around the following main domains:

- **Collaborative and synergetic Earth Observation and Satcom missions for Space solutions**
  - **Satellites as Smart Network Nodes:** this domain will support the realization of key competitiveness development goals identified in the Partnership scope, covering the commercial communications including the seamless integration with terrestrial networks. The domain (further described herewith) will enable to roll out and demonstrate key space and ground technology building blocks in state-of-the-art areas such as cloud in space and edge computing, network protocols (5G&6G), distributed systems, automatic/intelligent data processing, inter-satellite links, innovative resources management software and orchestration of multi orbit space assets.

  - **Digitalization to maximize Observation imagery performance and timeliness and future exploitation:** this domain will address end-to-end commercial observation systems. In particular, it will enable the maturation of the most time-efficient high power end-to-end processing chains, together with significant imagery performance enhancements. Besides, efforts towards space data interoperability at all levels in both space and ground segments are still needed to enable future exploitation of space data from heterogeneous sensors.

  - These two subdomains are fitting the corresponding sections of the Space's Strategic Research and Innovation Agenda. However, as far as possible, the space partnership endeavours to address them jointly to reinforce their synergies and to foster market-demanded innovations from either commercial or institutional customers edging from such a combined approach

- **Digital solutions for launcher autonomy for space transportation systems, design and simulation tools**: focusing on a narrow scope of activities supporting competitiveness innovations for space transportation services, and aiming at enabling technologies able to support a wider range of new systems and services. The domain (further described herewith) would support two key development areas, the advanced technologies and digital sensors for new space transportation and the eco-design software tools enhancing.

The focus on digitalisation answers most of the requirements for the current Partnership while allowing the participation of a wide range of actors and fits with the budget envelope considered. Most of the demonstrators envisaged could be realised on ground or via a testbeds approach taking benefit of available in space infrastructures.

Collaborative Earth Observation and Satcom missions for Space solutions

6.2.1.1 Background

6.2.1.1.1 Satellites as Smart Network Nodes (Cloud/Edge computing, ISLs, AI/ML, real time, tasking, …)

The satellite Telecom market moved from a stable landscape with established value chain actors and roles to a moving environment similar to the terrestrial telecom market. Indeed, new entrants in the value chain have established themselves as disruptive and daring suppliers of new services targeting Earth observation, space data transfer, broadband and narrowband (IoT and mobility) applications for professional and consumer markets (B2B, B2G and B2C). The introduction of multi-orbit/multi-payload systems provide an additional challenge for orchestration and seamless integration into the network. In the future, assets in space will require new capabilities to cope with the continuous demand shift of consumers such as a seamless as possible integration of space networks with the terrestrial networks.

New entrants are combining manufacturer, operator and service provider ambitions, blurring traditional industry boundaries. This positions them to better respond to the challenge of tremendous data volume increase (especially driven by higher spatial and spectral resolution, HD video traffic etc.) and leverage on the deployment of newer standards such as 5G and 6G. Satellite operators will target increased flexibility and lower total cost of ownership to enhance their competitiveness in the global telecom landscape. Ownership itself is being challenged, with new approaches around satellite as a service, offering access to space infrastructure without the need to effectively own payloads or satellites.

6.2.1.1.2 Digitalization to maximize Observation imagery performance and timeliness

The EO commercial market is two-fold. On one hand, end-to-end operators are developing or procuring their space assets, and selling data and analytics solutions. On the other hand, manufacturers are selling end-to-end (E2E) infrastructures to commercial (or public) operators or through ground two ground agreements across the World (Export to governments looking for sovereign E2E assets). The downstream imagery data and analytics market is a very complex target (congested, segmented/captive, still in need of customer evangelisation/education), most of the vertically integrated end-to-end operators now also diversify to selling infrastructure; this is notably the case in the USA and in China. The competition on the E2E infrastructure market is thus getting harsher inside Europe and world-wide; customers are looking for the best value for money, the value being measured in terms of resolution and timeliness (including freshness of the information). Competitive differentiators will benefit from data and analytics rapidity of execution, data availability for user/customer insights, and data/analytics earliest delivery to the user/customer, notably thanks to edge-computing. The integration into a global networked digital workspace with computing, cataloguing, repositories, analytics capabilities will drive future EO systems competitiveness.

6.2.1.2 Digital trends

6.2.1.2.1 In Communications satellites

On-board satellite data processing capabilities, coupled with enhanced ground data processing capabilities have become core enablers thanks to the digitalisation of the satellite payloads. Smart and cost-effective solutions are growingly in demand from by satellite operators and service providers as they face the increasing market pressure. The future satellite networks will need to adapt to evolving mission requirements as well as more complex multi-orbit/multi-payload space infrastructure. These types of space network will require new technologies that enable and facilitate the integration into the ground network architecture. Key technology enablers are optical inter satellite links, digital processors, hybrid antennas, on board and space software, high-performance space-to-ground links. The success of a space network will also require agile and dynamic routing of the traffic and adoption of proper terrestrial standardized communication protocols. This traffic processing capabilities is required by almost all the mission types from any kind of orbit: data security, broadband connectivity, data and/or TV broadcast, network backhauling, Internet of things and machine to machine networks, secured governmental applications, data transfers, etc.

6.2.1.2.2 In Earth Observation satellites

New concepts for multi-layers (various orbits with satellites and High-altitude platform station HAPS) multi-sensors (e.g. hyperspectral, thermal, optical and radar) allowing freshness up to persistence of the observations create needs for increased data integration, using digital/SW solutions.

6.2.1.2.3 Synergies

Enhanced robustness and Cyber Security are also needed, for system resilience and data integrity. Increased connectivity between satellites themselves and ground enables responsiveness and resilience, and optimisation of board vs. ground data processing, with cloud for global system competitiveness.

It will be important that the Space Partnership also works on the AI/ML chain covering both imagery and signal data. This is needed for operational on-board intelligence and autonomy, starting with the availability and access to validated training data for new AI/ML algorithms to AI/ML training infrastructure (which today depends a lot on non-European resources) to actual inference software frameworks.

Today most of the underlying technology and data needed to successfully implement new AI/ML algorithms – which are needed to reach desired on-board intelligence / autonomy – are either simply not or highly limited available or heavily depends on non-European Infrastructure (Training Computer resources and inference frameworks). It is therefore important to address those topics within the overall objectives.

To ensure European competitiveness for the worldwide market and its forthcoming requirements, the industry needs to further develop a systemic approach which will allow massive tasking of satellites by end-users, therefore demanding generalization of communications capabilities and standards between EO and communication satellites, on-board treatment of data, agile and collaborative management of request. It will be required to improve the industrialization and the whole value chain aspects to reduce the production cost and achieve lower system life cycle costs. New digital approaches need to be adopted to increase efficiency in the satellite development and in the Assembly Integration and Test (AIT) and operations.

6.2.1.3 Expected outcomes (Objectives of the call)

6.2.1.3.1 In Communications satellites

Objectives are:

- To enable the European Space Industry to maintain a significant share of the global connectivity market by increasing the performance of space satellite networks, new type of control and ground segments being fully integrated into the terrestrial networks. This will also be needed in enabling the European Space Industry to maintain its global leadership role in Earth observation missions and systems.
- To target new commercial services and applications enabling a digitalisation of space solutions. Such solutions could be addressing in synergy the requirements of data transfer for analytics and observation system, and deploying a 5G/6G network in space, enabling massive data repatriation, direct to device services (D2D, i.e. satellite communications with unmodified smartphones) and non-terrestrial network (NTN) integration, Quantum applications, … A continuous development of key technology stacks will ensure European sovereignty in the future and will strengthen the industry against the competition from USA,China and others.

6.2.1.3.2 In Earth Observation satellites

Objectives is:

- To develop advanced Earth observation payloads, technologies and processing means (on ground and in space), for all types of observation missions.

Digitalisation is a major enabler for enhancing the value of an E2E EO system. Indeed, processing applied to the multi-sensor data, on-board or on-ground, with or without calling for IA, can significantly enhance the resolution of the final data set and resulting image/analytics (e.g. digital SAR back-end electronics, optical images post-processing etc.). Besides, persistent imagery modes (e.g burst, video) require new generations of digital processors and on-board memories. Furthermore, digital optimisation of the data flow (autonomous decision, selective downlink, ground-segment efficiency) directly improves the E2E timeliness of an EO system (from request to delivery). Lastly, the enhancement of E2E data resilience and integrity calls for digital technologies on-board and, on the ground, end-to-end objectives

6.2.1.4 Operational objectives

6.2.1.4.1 In Communications satellites

- Improving ground and space data distributed computing and processing
- Edge computing/cloud capacity close to the payload (ground-space segments optimisation)

6.2.1.4.2 In Earth Observation satellites

- Digitally enhance EO imagery performance and mission timeliness

- Advanced EO-payload systems and technologies, including onboard and ground processing

6.2.1.4.3 Synergies

- Direct tasking by end-users and on-board treatment of data
- Harmonisation of building blocks interfaces
- Enhancing data security and system resilience in Space and Ground Infrastructures
- Advanced space network architectures allowing, through in-orbit resources sharing, for lowering the environmental impact of future missions.

6.2.1.5 Development goals

- Mid to High TRL targets for developments, with a need for a quick raising of the Low to Mid TRL levels for critical technologies of EO & Satcom required building blocks
- On-ground and in orbit demonstration and/or market readiness
- Focus on software and digital tools (e.g algorithms), supporting HW (e.g processors, electronics) from design to operation phases

6.2.1.6 Scope (Development activities)

The areas of R&I, which need to be addressed to tackle the above expected outcomes are one or several of the following ones:

6.2.1.6.1 For Communications satellites

- End to End Mission capabilities
  - Satellite network interconnectivity
  - Seamless integration into the terrestrial networks
- Energy efficient connectivity and compatibility with 5G & 6G waveforms.
  - Constellation and Network software management system
  - Optical communication
- Satellites as network nodes in a distributed system
  - Flexible and modular testbed: Multi-orbit and terrestrial integrated satcom architecture
  - Need common protocols across the comms chain. (similar to SDA standard but for civil)
  - Faster reaction time between the acquisition and the availability of data
  - Ubiquitous use of orbital resources
  - Distributed computing – do the computing where the data is, how best to combine final result

6.2.1.6.2 Earth Observation satellites

- On-board processing to optimize EO missions' performance or timeliness
  - Standardized software framework to host embedded edge-computing applications (AI, Machine Learning, ...)
  - Data/signal image processing to optimise algorithms, AI-based or not (e.g addressing compression, autonomous action, front-end/back-end performance etc.)
  - Enhanced downlink and uplink capabilities (e.g. for better reactivity)
- EO ground segment interfaces and data flows standardisation and adoption (evangelisation)
  - Development of ground-segment digital building-blocks in coherence with adopted standards
- Smart multi-source EO intelligence information fusion

        - Innovative intelligence information extraction and fusion exploiting multiple data sources (EO sensors and other space-based data along with ground-based data)

6.2.1.6.3 Synergies

- Maturing high performance processing payload H/W to support space network capabilities including an improvement in downlink and tasking capabilities of the European infrastructure.
    - In-orbit re-configurability
    - Network resilience
        - Multi-band transmission
        - Interference: detect, identify, locate and isolate
        - Vulnerability assessment of spacecrafts systems
        - Space weather free communications
    - Data integrity
    - Data security
        - Low-cost Cyber Security
            - Genuine European low-cost solutions
            - Quantum technologies chips and sensors
        - Data encryption
    - Data authentication
    - AI/ML chain covering both imagery and signal data
- Maturing technologies and products improving system security and threats identification
    - Host/Network Intrusion Detection/Prevention Systems for space systems and networks (space segment)
    - Security engineering of space systems architecture (end to end)
    - Capability to safely operate systems by different users with strict security boundaries
    - Improve the interoperability of our systems to enhance their mutualisation in system of systems
- Resources usage optimization
    - Operational optimization: increase the mission envelope and lifetime thanks to a better knowledge of the system in real time based on digital twinning
    - Design optimization: increase future systems efficiency thanks to a better use of the operational return of experience of legacy systems
    - Advanced techniques for large system of systems or multi-missions' operations optimization
- Environmental impact minimization of future missions
    - Tools to support the measure of key environmentally driven criteria through increased resource sharing: minimization of the mass to be launched, development cycle reduction, digital nodes sharing through several missions, optimization of the ground systems for a lower environmental footprint, etc.

Digital solutions for autonomy for space transportation systems, design and simulation tools

6.2.1.7 Background

The European space transportation segment is undergoing radical transformations under the pressure of new players in the sector proposing disrupting new systems, particularly small and micro launchers, and with the expectations for the development of a wider array of new market segments for transportation to space, in space and between orbital locations.

Since other European institutional initiatives are addressing the on-orbit services and the space transportation, the development areas are proposed to be articulated around advanced technologies and digital sensors for new space transportation (smart avionics for modularity and reusability, smart sensors for health monitoring systems) and eco-design (guidelines and software design tools).

Competitiveness is the common driver for all the new space transportation systems. Cost reduction, enhanced availability, and improved reliability must be reached by harnessing the advantages of modularity and systems digitalization. Smart avionics necessitates the incorporation of novel functions, such as Health Monitoring System (HMS), which have long been established in the aviation sector but are pioneering in the realm of launch systems.

This shift underscores the demand for readily accessible off-the-shelf modular solutions and products, catering to the needs of all launcher manufacturers. The maturation of these solutions and products through practical demonstrations is crucial for their successful integration.

Besides, the European space industry is increasingly focusing on minimizing its environmental impact, a critical factor in maintaining its competitive edge. This shift aligns with both Space Law and the implementation of the Product Environmental Footprint policy.

Currently, eco-design practiced in the European space sector lack uniformity. Various tools, often borrowed from sectors like automotive, are being used; however, these are not specifically tailored for eco-design teams and they fail to address specific space sector segment requirements and space sector regulations.

The key challenge is to sustain a the New Space Transportation Services using as much as possible existing European transport systems commonalities and enhancing technology synergies and reuse.

The new space transportation services also shall be more sustainable with long term goals and SMART objectives, including synergies across systems, and ground facilities for a more efficient supply chain.

6.2.1.8 Digital trends for new space transportation services

Access to space is now calling for development of technologies and functional building blocks, with a focus on digital solutions for smart sensors, efficient avionics and eco-design guidelines and software tools adapted to the space sector.

Key areas for service improvement are health monitoring systems, enabling real time subsystem monitoring through all mission phases, including predictive maintenance and refurbishing in case of reuse.. For Structural Health Monitoring addressing HMS, two main new issues require innovative technologies: thermo-mechanical monitoring and damage detection. The focus is on diverse sensor types and their measurement systems that must be made available on the shelf and functioning in a plug-and-play manner.

There is also a pressing need for a comprehensive eco-design strategy in the space industry. This strategy should enable informed technical decision-making and trade-offs, grounded in thorough environmental impact assessments. It calls for the integration of best practices in the development and utilization of simplified eco-design tools tailored for the European space sector, leveraging insights from proven Life Cycle Assessment (LCA) approaches and eco-design expertise.

6.2.1.9 Expected outcomes (Objectives of the call)

6.2.1.9.1 Operational objectives

- Improving space systems and launcher developments sustainability
- Reducing cost and operational constraints
- Improving monitoring and autonomy

6.2.1.9.2 Development goals

- Mid to High TRL targets for developments
- On-ground demonstration and/or market readiness
- Focus on software and digital tools

6.2.1.10 Scope (development activities)

- Advanced technologies and digital sensors for new space transportation:
    - Smart avionics with modularity and reusability drivers
    - Health monitoring system and smart sensors
    - Structural health monitoring addressing thermo-mechanical monitoring and damage detection
- Eco-design
    - Guidelines for end-to-end aspects
    - Software design tools integrating the guidelines and leveraging eco-design expertise to enable informed technical decision-making and trade-offs

Work programme structuring with budget proposal

The tables are the current allocations of the 100M€ budget of EU funding, organised by topic and by year. For each topic and year, we propose a typical budget allocation per project (max and min project size) from which we derive the potential number of projects that could be funded under each call.

6.2.1.11 The proposal

The proposal detailed below takes into consideration the recommendations provided by DG DEFIS, where NSTS is less funded than Communisation and Earth Observation topics. The split considers 15% for NSTS and 85% for Communication and Earth Observation.

Note that in this proposal, the funding per call is defined

- with a growth curve for the Communication and Earth Observation topics
    - attributing 20% of the total budget for the call year 2025, allowing for 80% to be allocated on the 2026 and 2027 calls.
- with a major portion of the NSTS topic budget allocated in the first year to allow for fewer but still ambitious projects

- attributing 2/3 of the total budget for the call year 2025, allowing for 1/3 to be allocated on the 2026 and 2027 calls.

TRL Targets

- Within each topic/call we propose to implement the budget via projects defined by Maturity target. i.e. as IA (innovation action) or RIA (research and innovation) type of instrument.
  - Low Mid TRL targets are up to TRL 3-5 (RIA)
  - Mid high TRL targets are up to TRL 6-8 (IA)
- In the proposal the theoretical budget split would be in the order of
  - 25% for low/mid TRL development targets (typically implemented via RIA type of actions)
  - 75% for mid/high TRL development target (e.g. IA type of actions).

Important: Low TRL activities should be selected among the most promising/disruptive candidates to answer the Partnership objectives. They should be further developed with the appropriate budget for maturation in the next iteration call(s).

6.2.1.12 The roadmap

This proposal contains a high-level roadmap outlining the planned Research and Innovation Actions (RIA) and Innovation Actions (IA) across the core thematic areas of the Partnership: Earth Observation, Satellite Communications, Synergies between EO and SatCom, and New Space Transportation Solutions. Covering the period from 2025 to 2027, this roadmap is intended to serve as a basis for review and discussion ahead of the detailed planning phase. Feedback from stakeholders will inform the development of a more granular version, which will replace this high-level overview once validated.

GCSS HL SRIA - Roadmap		**Maturity level and call year**		
Topic	**Scope High level**	**2025**	**2026**	**2027**
1. EO	Harmonization enabling interoperability among multiple EO missions	**RIA**	**RIA**	**IA**
1. EO	Breakthrough digitalised technology steps	**RIA**	**RIA**	**IA**
1. EO	EO ground segment interfaces and data flows standardisation and adoption	**IA**		**IA**
1. EO	LEO or VLEO Earth Observation technologies, equipment and subsystems	**RIA**	**RIA**	

1. EO	LEO or VLEO Earth Observation applications and services		**IA**	**IA**
1. EO	Miniaturised instruments design (for affordable EO constellations to address emerging markets)	**RIA**	**RIA**	**IA**
1. EO	Digital techniques and technologies to support novel operational approaches	**RIA**	**IA**	
1. EO	On-board processing to optimize EO missions' performance or timeliness	**IA**		**IA**
1. EO	Data processing design based on fast data acquisition			
1. EO	Smart multi-source EO intelligence information fusion	**RIA**	**IA**	**IA**
2. SatCom	End to End Satcom Mission capabilities	**RIA**	**RIA**	**IA**
2. SatCom	Energy efficient connectivity and compatibility with 5G & 6G waveforms			**RIA**
2. SatCom	Radio-frequency payloads (including Software Defined Radios, antennas)		**IA**	
2. SatCom	Secure Satcom services and Satellites as network nodes in a distributed system	**IA**		**IA**
2. SatCom	Secure Satcom services and Satellites as network nodes in a distributed system		**IA**	**IA**
3. EO/SatCom synergies	Environmental impact minimization of future missions	**RIA**		
3. EO/SatCom synergies	Lower maturity building blocks and processes common to EO and Satcom systems	**RIA**		**RIA**

3. EO/SatCom synergies	Lower maturity building blocks and processes common to EO and Satcom systems	**RIA**	**RIA**	
3. EO/SatCom synergies	High performance processing payload H/W to support space network capabilities including an improvement in downlink and tasking capabilities of the European infrastructure.	**RIA**	**RIA**	**IA**
3. EO/SatCom synergies	Maturing high performance processing payload H/W to support space network capabilities including an improvement in downlink and tasking capabilities of the European infrastructure.		**RIA**	**IA**
3. EO/SatCom synergies	Technologies and products improving system security and threats identification	**RIA**		**IA**
3. EO/SatCom synergies	Maturing technologies and products improving system security and threats identification			**IA**
3. EO/SatCom synergies	RF and optical hybrid ground stations for anchoring services		**RIA**	**IA**
3. EO/SatCom synergies	Quantum technologies for space applications		**RIA**	
3. EO/SatCom synergies	Next generation operation systems	**RIA**	**IA**	
3. EO/SatCom synergies	Tip & cue capabilities		**IA**	
4. NSTS	Advanced technologies and digital sensors for new space transportation	**IA**		
4. NSTS	Support the development of disruptive/game changing digital technologies	**RIA**		**IA**

6.2.1.13 The budget allocations

The elements defined above have been used to prepare the following tables allocating the budget envelopes to topics and calls, and deriving implementable proposal in terms of size and number of projects that could/would be funded within each call.

6.2.1.13.1 Budget allocation scheme per topic and call

The table below propose the budget allocation scheme reflecting the above proposal.

Budget (m€) repartition per call years and topics							
Topic n°		Topic title	TRL target	2025	2026	2027	TOTAL (m€)
Topic 1	EO / Satcom	Collaborative Earth Observation and Satcom missions for Space solutions	Low to Mid (RIA)	6	12	4	22
Topic 1	EO / Satcom	Collaborative Earth Observation and Satcom missions for Space solutions	Mid to High (IA)	11	26	26	63
Topic 2	NSTS	Digital solutions for autonomy for space transportation systems, design and simulation tools	Low to Mid (RIA)	3	-	-	3
Topic 2	NSTS	Digital solutions for autonomy for space transportation systems, design and simulation tools	Mid to High (IA)	12	-	-	12
		TOTAL (m€)		32	38	30	100

6.2.1.13.2 Budget allocation schemes per topic, call and project

The table below expand the budget allocation scheme to determine what could realistically be achieved in terms of number of projects and project size within each call.

Overview of the min/max budg. per project and min/max number of project				2025 budg./proj. (m€)		2025 # Proj.		2026 budg./proj. (m€)		2026 # Proj.		2027 budg./proj. (m€)		2027 # Proj.	
Topic n°		Topic title	TRL target	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Topic 1	EO / Satcom	Collaborative Earth Observation and Satcom missions for Space solutions	Low to Mid (RIA)	1	5	1	6	1	2	6	12	1	2	2	4
Topic 1	EO / Satcom	Collaborative Earth Observation and Satcom missions for Space solutions	Mid to High (IA)	2	6	2	6	5	10	3	5	5	10	3	5
Topic 2	NSTS	Digital solutions for autonomy for space transportation systems, design and simulation tools	Low to Mid (RIA)	1	3	1	3	2	5	-	-	2	5	-	-
Topic 2	NSTS	Digital solutions for autonomy for space transportation systems, design and simulation tools	Mid to High (IA)	4	6	2	3	1	5	-	-	2	5	-	-