A Strategic Research and Innovation Agenda for EU-funded Space research supporting competitiveness

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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.

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 43000 jobs, the upstream segment of the European space industry, i.e. manufacturing of launcher and spacecraft, represents 6% of the global space industry workforce[1] and generates EUR 8.8 billion of consolidated revenues.

With EUR 9.5 billion of estimated exports for satellites in the last decade and a growing 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 33 % of the open world markets.

[1] Space Economics, Eurospace, 2018

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 are for non-European customers.

The space systems manufacturing and launch sectors are net contributors to the EU trade balance. 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[2].

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, ordering almost 33% of the mass launched in 2017[1]. Space activities are increasingly open to 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 necessity to lower the costs of individual satellites and the consequence of shorter life and clean space issues to be addressed. Innovative industrial processes are revolutionising the sector. Space is now part of a global value chain that increasingly attracts new companies and entrepreneurs, known as “New Space”, which are pushing the traditional boundaries of the space sector. Moreover, the last few years saw the emergence of promising applications linked to on-orbit operations (e.g. in-orbit servicing/assembly) that have the potential to generate new business cases and open new frontiers.

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 8 in 2018, China performed 15 launches in 2010 and 39 in 2018. In the USA, the private company Space X, founded in 2002, achieved 21 launches in 2018. Furthermore, US industry is beginning to develop the first in-orbit servicing capabilities and initiatives such as CONFERS have been setup to research, develop, and publish non-binding, consensus-derived technical and operations standards for servicing and rendezvous, and proximity operations.

[2] 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).

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. In addition, Europe imports a non-negligible part of its satellites.

Security of supply and industry's ability to export its products are affected by high dependence on non-European components and technologies. On a typical ESA satellite, more than half of the costs associated with Electrical, Electronic and Electromechanical (EEE) components are procured outside of Europe[3], some of these being critical.

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 next EU research and innovation framework programme Horizon Europe (2021-2027) on the strategic R&I needs to support the competitiveness of the EU Space Sector and reinforce independent access and use of space. 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.

2 VISION

Our vision is structured along two technology-based activity lines:

- '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.

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[3] ESA European Space Technology Master Plan 2018

In addition, this agenda provides recommendations on approaches to synergies, governance and funding:

- 'Promote Synergies' between space and non-space sectors and between civil and security space activities' and

- 'Strengthen Opportunities' to identify the right instruments for the right purpose and make full use of available funding opportunities under Horizon Europe and in other programmes.

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 3.5 billion sales in 2017[4]). End-customers need ever increasing capacity, new applications 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), with an estimated US$33 billion in manufacturing market revenue[5].

[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

[4] Space Economics, Eurospace, 2018

[5] http://www.euroconsult-ec.com/earthobservation

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 Future space ecosystems: on-orbit operations, new system concepts

[Why] Future space ecosystems will largely benefit from sustainable, flexible, modular, highly-automated and maintainable space infrastructure. The availability of such economically viable infrastructure and related services will enhance commercial opportunities in space, also for challenges such as debris mitigation/removal further to the protection of the future in-space ecosystem. At the same time, synergies with terrestrial sectors will be exploited and enhanced.

In the short to mid-term, the availability of on-orbit servicing solutions will allow Europe to compete in a global context characterized by rapid technology and market changes, promoting the development of more sophisticated, flexible and cheaper space infrastructures.

Robotic technologies, coupled with the adoption of new industrial processes, modular spacecraft architectures and approaches, digitalisation, automation and artificial intelligence will be at the core of this paradigm shift towards intelligent space systems. Modularisation, understood as the process that will enable a system's components, sub-systems or functionalities to be separated and recombined in space, will change the way spacecraft and space infrastructure are designed, produced, tested, transported and operated. Ultimately, increased and advanced spacecraft modularity will unlock and generate new markets. It is of the utmost importance that the European space sector is placed at the forefront of this market generation, by introducing the new standards that will become applicable for such future space ecosystems. At the same time, a better understanding of the risk drivers for sustainable operations in orbit should be established.

[What] **New services including de-orbiting and active debris removal** are needed aiming at the establishment of space logistics and space sustainability including debris mitigation. More specifically, short to mid-term developments in orbit-to-orbit transportation, end-of-life operations and de-orbiting, and active debris removal are expected to push technologies closer to market. The increase in the number of objects in the most crowded orbits may see the emergence of a new market for this type of technologies.

[What] **On orbit servicing, assembly, manufacturing** are key elements for a sustainable space infrastructure and European competitiveness. Satellite inspection, in-orbit maintenance, repair, and refuelling, robotised deployment and in-orbit assembly and manufacturing will allow putting structures and systems in space that are not possible with the current launch constraints. The development of robotic solutions, in combination with advances in artificial intelligence for autonomous operations, precise in-orbit guidance and GNC as well as development of new generation of sensors and data processing are key to achieve these challenges. This will profit both commercial space and space science and can also act as an enabler for In Situ Resource Utilisation (ISRU).

[What] **New systems concepts** including modularity will enable the evolution from application-specific spacecraft design toward a more long-term vision of an automated, flexible and sustainable space infrastructure, based on modular, adaptable and maintainable spacecraft.

Adaptive, intelligent and highly modular systems with compartmentalised functionalities will enable re-configuration and re-use of spacecraft hardware and software for different mission purposes, marking a paradigm shift in space infrastructure, considering the protection of the future in-space ecosystem. Moreover, the establishment of open modularity standards for plug-n-play experiments, and a platform or family of different complementary platforms supporting them, will allow faster and cheaper demonstration of technologies.

For all the areas identified above, it is very important to pursue a continuous market analysis to allow a timely understanding of the dynamics of the emerging market opportunities, and to consolidate solid business cases, adapting the technological development base as appropriate.

[How] Where appropriate, a roadmap-based approach building on the results of previous projects will be pursued (e.g. Strategic Research Clusters under H2020), in close coordination with ESA and EU Member States. The approach shall include in-orbit demonstration and validation, so as to further mature and de-risk these disruptive technologies but also to bootstrap the market generation. Activities under 'Synergies' should tighten the links with the field of robotics and result in effective actions. Some of the innovative operations developed could make use of novel innovation procurement tools if they reach sufficient maturity. Calls should also include more open/bottom-up topics to complement the roadmap-driven approach, and should also include actions agile enough to accommodate urgent market needs and to ensure a competitive advantage timely.

3.3 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[6]" 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,

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

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.

3.4 Enabling technologies (cross-mission, space and ground)

[Why] A growing trend of technology spin-in and risk-taking approach is pervading the space sector and accelerating space business. Coherence and complementarity with European actors, and a right balance between bottom-up and top-down approaches are therefore necessary. The identification, further maturation, testing and qualification of enabling technologies, for the space and ground segments will be key for our future competitiveness, while the exploration of new disruptive ideas and concepts may bring unexpected breakthroughs leading to entirely new solutions and markets.

[What] The identification and selection of **disruptive technologies and concepts** should be pursued to bring breakthrough innovation to the space sector. Such cross-cutting technologies span from very low to mid/high TRL and a wide range of areas such as power generation, distribution and storage, new approaches to propulsion, including electric propulsion, thermal management and control, innovative materials, artificial intelligence, system autonomy, on-board data processing, quantum communications, space resources utilisation, etc. Their identification should take into account different criteria such as radical improvements in performance/costs, and at the same time compliance to specific mission constraints and market relevance.

[What] Criteria for **technology maturation in the view of qualification** should be established, which take into account both short-term strategic mission and market needs, and long-term development needs. Maturation instruments should be better allocated and synchronised among different European actors, and make best use of available qualification facilities. Support to qualification processes could be sought where a strategic interest is proven.

[What] **In-Orbit Demonstration and Validation programmes** are required to demonstrate new concepts and applications and to de-risk new technologies and products that cannot be demonstrated on ground or by heritage. We should capitalise on Horizon 2020 activities aiming at in-space validation opportunities and develop effective identification of technologies in urgent need of in-space demonstration and validation, as well as support commercial initiative aimed to provide a regular access to space for In-Orbit Demonstration and Validation of technologies, in

particular when this contributes to the implementation of the SRIA (e.g. critical technologies for non-dependence, see section 5.1).

[How] Enabling technologies need to be developed though a balanced approach allowing systematic incremental maturation and qualification of already existing technologies as well as stimulating the emergence of disruptive technologies and concepts. For the former a roadmap based approach is adequate while the latter is better supported by bottom-up competitive calls for proposals, with provisions for a fast-track to address shorter-term market needs. Both elements are to be supported by regular opportunities for in-orbit demonstration and validation. A proper estimation of IOD/IOV actions needed for the SRIA implementation and other needs like bottom up calls shall be performed periodically.

3.5 Contribution to space science

[Why] Excellence in space science contributes to the mid to long-term competitiveness in the space sector by developing new concepts and tools pushing the technical envelopes to answer major scientific challenges. The EU can also bring a useful contribution to space science in particular for a better exploitation of data gathered from space missions, the development of new scientific instrumentation and other technologies for future space missions.

[What] There is a strong need for the **exploitation of mission and science data** readily available from European space missions and instruments with the development of associated models and tools. When relevant, this should be carried out in conjunction with international missions, integrating acquired and available data provided by such missions and adding scientific value through analysis. This will foster new scientific discoveries and enable the development of higher-level data products.

[What] **Cutting-edge scientific instrumentation in support of space missions** should be developed in cooperation between scientific, engineering and industrial teams, within and outside Europe. This is needed to widen the field of space science and planetary exploration. Synergies between space and ground-based observations should also be stimulated by combining and reusing different technologies, techniques and methodologies.

[What] To capitalise on the work already performed in this field under H2020, a further investment in the **development of advanced planetary robotic exploration techniques** is necessary, focusing on cross-cutting technologies such as robotics, artificial intelligence and system autonomy. Field tests should be considered for the maturation of such technologies. This will augment the potential of space exploration introducing to the sector the benefits of very promising technologies that are already revolutionising everyday life.

[What] In addition to these activities, it is foreseen to contribute to scientific missions through **early development work for potential future science and human and robotic exploration missions**, including contributions to exploitation of space resources.

[How] Research activities, preferably carried out in collaborative projects, should be done in close coordination with the programmatic outlook and roadmaps established by ESA and EU Member States, exploiting potential for transfer of results to the commercial sector, and where possible, in cooperation with international partners. For the case of planetary exploration, a roadmap-based approach building on the results of previous projects (e.g. Strategic Research Clusters under H2020) will be considered, with a strong focus on building concrete synergies with the terrestrial robotics sector in order to fully reap the benefits of spin-in and spin-out potential.

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 two main objectives are:

- to rapidly improve launch competitiveness (cost, increased flexibility); the overall objective is to contribute to reduce the cost/price of launch services by 50% in the next decade; increased flexibility may be related to elements such as the variety of space missions and payloads and the launch rate.
- 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.

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

4.1 Innovation for launchers competitiveness targeting initial operational capability by 2030

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

[What] **Reusability concepts including required technologies** have a strong potential for cost reduction, starting with the recovery of the most expensive components such as propulsion systems. It can also increase launch flexibility by reducing lead-time from order to launch by helping to adapt efficiently the launch rate and the performance to market variations. In addition, reusability would contribute to align space economy with the ecological transition to sustainability, e.g. engine reusability and throttling, guidance, navigation and control. Specific topics required for stage recovery and refurbishment shall also be investigated and matured, such as ground operations, maintenance repair & overhaul (MRO) of reused parts, airspace integration and safety and environment aspects.

[What] The propulsion systems represent a significant part of launch system costs. It is necessary to mature **new or optimised low cost** (lower number of parts, better operability), **high performance** (high thrust to weight ratio, high specific impulse) **and green propulsion concepts,** technologies and propellants for high and low thrust engines, green manoeuvring rocket engines (distancing, attitude and precision landing control).

[What] **Next generation structural concepts** could also benefit to recurring cost and mass reduction, enabling more efficient vehicle concepts such as new cryo-tanks, composite or metallic, hot primary structures and new thermal protection concepts, smart structures, as well as large and multi-material Additive Layer Manufacturing (MM-ALM).

[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.

[What] **Optimisation of existing and/or development of new design, system engineering & mission preparation tools** are necessary for achieving a more agile development and capacity building.

[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[7], potentially up to flight demonstrators as well as technology demonstration at component, subsystems or system level[8], 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 Disruptive concepts for access to space (starting at low TRL)

[Why] To prepare globally competitive European Space Transportation beyond 2030, actions with large potential to improve access to space should be initiated today.

[What] Actions should start developing **disruptive concepts for access to space**. This include technologies, components, system concepts for accessing space which would have a significant impact on capacity (e.g. payload size, time to destination) and competitiveness.

[How] R&I actions should rely on a fully bottom-up approach and lead to additional technology/concepts maturation resulting from competitive calls for proposals. The calls should be organised in order to achieve strong impact through the MFF period and beyond.

The actions shall include inducement prizes, new funding models (e.g. venture capital funds, loans, blended finance).

4.3 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

[7] this does not exclude funding priorities on shorter-period

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

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.

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[9]. 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.

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

4.4 Modern, flexible and efficient European test, production and launch facilities, means and tools

[Why] Europe needs to improve the cost efficiency of the ground facilities and of launch systems production and operations. It could benefit from the industry 4.0 transformational wave, which has the potential to exploit digitalisation and advanced data management for lowering the cost of low production rate facilities and further improving quality.

[What] **Digitalisation and advanced data management** are areas of activities with high potential positive impacts towards cost reduction, improvement of responsiveness, flexibility and configurability of launch systems. These will enable seamless engineering, supply chain logistics, Manufacturing Assembly Integration and Testing (MAIT) of the launcher, launch preparation and operations, including maintenance of facilities. R&I activities would contribute to the development of real time solutions based on advanced Internet of Things (IoT) sensors, maintenance logs and real time data analysis supporting decision making of predictive maintenance for interconnected devices, thanks to possible introduction of artificial intelligence, material and process modelling, and simulation. R&I activities would be also needed in the area of human centric factory and operations through informational assistance to workers.

[What] **Innovations in Europe's existing spaceports**, ground systems, infrastructures and test facilities will be considered if there is a need for the EU Space Programme. R&I activities should also address the ground segment configurability including standardisation of hardware, modularity of systems and components. In this way, ground systems will be able to serve multiple launchers including the recovery phase for launcher parts re-entry. Wireless connections can bring new approaches to logistics, maintenance, safety and control.

[What] Solutions for improving **flexibility and configurability of launch systems** should be promoted. The main aspects to be considered are communication and control systems. For this purpose, smart ground stations systems should be developed that are based on sensor network and wireless technologies, modular and customisable parts. This will allow the adaptation of missions, including for different launchers. More user-centric systems enabling an easier management of human turnover and assignment flexibility regarding resources optimisation should also be addressed. Cybersecurity shall be reinforced without decreasing the benefits of digital means for cost reductions.

[What] Finally, innovation could also **promote the use of** space test and launch **facilities for new actors and concepts.**

[How] R&I actions should result from identified specific challenges/objectives and priorities, driven by cost-effectiveness. The actions should rely on a roadmap approach, leading to, if needed, a continuous support all along the MFF period.

5 PROMOTE SYNERGIES

There is a number of areas where European space R&I funds can complement each other and synergies between R&I actors and programmes can be established. This also applies between space and non-space technologies (e.g. artificial intelligence, 5G, etc.). Actions are needed to identify areas where to establish such synergies and to define and implement the most effective approach. In particular, a number of areas have been identified in the previous sections where synergies and complementarity with relevant ESA programmes would be beneficial and for which adequate mechanisms should be put in place. Coordination mechanisms could also be envisaged with EU Members States and other relevant organisations (e.g. EUMETSAT, EDA, etc.).

5.1 Technology non-dependence

[Why] The dependence issue is widely recognised and shared among European space and defence stakeholders, constraints and risks being related to foreign countries export control regulations. In order to coordinate the European efforts, the European Commission, ESA and EDA established a Joint Task Force to address Critical Space Technologies for European Strategic Non-Dependence. Since 2009, the JTF has set and run a well-structured and solid process to define a common list of priorities for critical space technologies, leading to a shared list of actions. The three institutions implement the actions via their own programmes in a complementary way, working towards non-restrained availability of critical space technologies and products for the European space programmes.

[What] **A coordinated long-term road mapping and end-to-end research and development plans for the non-dependence action list** would support continuity and enhance effectiveness of the implementation.

[How] Recurrent topics should be funded dedicated to critical space technologies from the European Non-dependence lists, starting with the List of Actions for 2021-2023, which the JTF will issue in December 2019. A long-term roadmap should be developed in the context of the COM-ESA-EDA Joint Task Force to provide for each action indications of recommended timeline and implementation approach, as for instance collaborative research, co-financed grants, procurement, partnership, economic diplomacy. Where appropriate specific actions for short to medium term (3-5 years) end-to-end development plans should be undertaken. The plans will specify top-level technical and programmatic requirements, the recommended implementation approach, as well as synergistic implementation among COM, ESA and EDA. These road mapping and planning activities may be supported by a coordinated and support action under Horizon Europe.

[What] O**bservatories of needs, markets and supply chain**s, including non-dependence trade policies, will support the selection of the priority actions and associated implementation instruments, the specification of the high-level requirements, including time to market, the identification of potential for synergy with non-space players. Last but not least, the monitoring of potential presence of gaps or weak elements of the critical space technology supply chains. Attention shall be given to supply chains particularly prone to acquisitions.

[How] This should be organised and supported through dedicated coordinated and support actions involving all R&I actors. Alongside, a coordination mechanism shall be put in place to ensure full consistency with the Joint Task Force and the ESA Harmonisation contexts.

[What] **Supply chain sustainability actions** may be undertaken based on cost-benefit analyses. Actions for outreaching and awareness raising may also be undertaken.

[How] Actions should be implemented in synergies with the other EU programmes, as for instance the Space Programme and InvestEU. Among others, innovation procurement and anchor tenancy might be investigated.

[What] Space compatibility shall be based on **mechanisms of qualification and certification** meant to guarantee a sufficient level of quality and reliability.

[How] Existing mechanisms should be explored, as for instance the European Space Component Coordination to ensure space compatibility and adequate level of quality and reliability to the non-dependence R&D products. Grant, procurement or delegation actions may support the implementation of the identified approach.

[What] **IOD/IOV opportunities** offers a channel for rapidly build space heritage and help promising technologies to demonstrate their performance in space.

[How] EU shall ensure IOD/IOV mission opportunities in line with paragraph 3.4 (Enabling Technologies) that would allow, both enabling and non-dependence technologies, to be demonstrated or validated in space as well as rapidly build space heritage.

5.2 Dual use and synergies with defence

[Why] Most space technologies, infrastructure and services can serve both civilian and defence objectives. Although some space capabilities have to remain under exclusive national and/or military control, in a number of areas synergies between civilian and defence can reduce costs, increase resilience and improve efficiency. The EU needs to better exploit these synergies.

[What] Common requirements and commonalities under **dual use and synergies with defence** should be identified and synergies with the goal to reduce costs, increase the market and improve the efficiency should be developed. As well, the demand for space and defence markets should be aggregated.

[How] A coordinated approach on R&D of common technologies serving civilian and security / defence purpose is needed. For instance, the critical space technologies for non-dependence action list could be enlarged to include technologies of interest for defence and security. Where appropriate, investments in terms of technology feasibility studies, proof of concept and demonstration in a lab environment shall be done jointly. A possible approach is as follows:

i) <u>Observe</u>. Develop a systematic space and defence market observatory for critical technologies building on the Joint Task Force (JTF) process. While maintaining the JTF process, this observatory should enable to set up an approach that integrates technology R&I for space and defence. This action may supported by a coordinated and support action or by collaboration agreements.

ii) Build. Development, validation and certification of critical technologies under the space technology non-dependence chapter for which dual use application or synergies with security and defence could be implemented via combination of funding's and projects by Horizon Europe and research under the European Defence Fund, including co-funding and joint projects. As more commonalities can be found in the lower part of the TRL scale, the aim is to mature technology in the low up to medium TRL with a shared approach between space and defence.

iii) Preserve and protect. A European capacity/supply chain, via the purchase of critical technologies or, in case of critical dependency, of raw materials supplies, for instance, through first client approach or innovation partnerships including multiple sourcing should be supported, if needed and sustainable. This should be implemented preferentially through the Space Programme and European Defence Funds and supported by coordinated and support actions under the research programme.

Complementary actions as foreign direct investment screening, aiming at protect European developed capacities on critical technologies from acquisition by entities established in third countries. Coordination with related activities, implemented by DG-TRADE, shall be envisaged.

5.3 Technology transfer

[Why] Space is a sector which uses many different technologies developed for non-space applications and develops technologies that can be spin-off to other sectors. Spin-in and spin-off technology transfer allows to optimise investments and to maximise return in an environment where R&I needs exceed by far the available funds.

There is a need to enhance the coordination and reinforce the presence of space in other parts of Horizon Europe and to create synergies by sharing relevant requirements and technologies between space and non-space sectors and potentially harmonize agendas and roadmaps. Transfer activities encompass different processes with the common objective to promote growth, competitiveness and valorise investments in space and non-space sectors.

[What] **Spin-in activities** from non-space will consist in prospecting, promoting, demonstrating and qualifying technologies developed for other use or markets than space and for example make best use of Commercial Off-The-Shelf (COTS) components. As a first step, there is the need to analyse the spin-in potential of existing and emerging technologies based on the current state of the art. This information shall complement the mapping of space technology state of the art (e.g. European Harmonisation Process) with data on spin-in potential. As well, it shall enable to build the European technology transfer catalogue.

[What] **Spin-off activities** will match space technologies with non-space needs and support the transfer. Under this chapter, funding may be provided to support projects for early spin-off of space technologies or existing European technology transfer initiatives.

[What] To establish **synergies,** sets of common requirements between space and non-space sectors should be identified and co-developments and cross-fertilisation promoted. This applies to a number of technologies such as micro/nano electronics, materials, additive manufacturing and processes, mining, digitalisation, virtual and augmented reality, robotics, artificial intelligence,

and biotechnologies. Technologies for recycling and saving Earth resources, including air, water and waste management, should be sought with high priority in view of creating links with the circular economy. Priority consideration should be given also to technologies supporting environmental sustainability and in general UN global goals for sustainable development. Constantly monitoring, by for example building European catalogues of space and non-space technologies with potential of transfer to and from space may be encompassed, as well as actions for thematic technology transfer.

[What] Cross-fertilization and co-development should be stimulated by incentives for joint projects between space and non-space industry and research and technology organisations, including **proof of concept based on demonstrators and from labs-to-industry approaches**.

[How] Coordination and support actions and/or collaboration agreements would enable to develop a stable framework for technology transfer purposes. This framework should create permanent links among space and non-space sectors and promote synergies. Participation and exchanges with non-space technology platforms should be organised. Where the potential is clear, joint R&I funding on topics which are jointly formulated by the space and non-space sector could be mobilised. Additional funding should be mobilised for projects aiming at bringing COTS components into Space application. Support to specific actions aiming at evaluating compatibility of aeronautics, automotive, commercial parts with space requirements and at building a shared European industrial knowledge may be envisaged.

5.4 Building on common technology roadmaps

[Why] A technology platform and common roadmaps database would help to reinforce the sector co-operation among all R&I actors. As well, this would enhance coordination and reinforce the presence of space requirements in other agendas.

[What] **SRIA-driven high-level roadmaps** will support the implementation of the SRIA priorities, aiming to ensure continuity of funding and to pursue long-term objectives. These high-level roadmaps should be reflected in the **Harmonisation Technical Dossiers and Roadmaps at technology level.** EU-funded topics on space technologies should consider the state-of-the-art and the aims described in the Harmonisation Technical Dossiers and project results fed back in the dossiers. A common roadmaps database, integrating technology, competitiveness and research roadmaps could be developed. Where not covered by existing roadmaps, common technology roadmaps shall be created.

[How] This action could be supported by a coordinated and support action or by delegation agreements to other services. The actions should be carried out in close cooperation and coordination with the ESA Harmonisation framework.

5.5 Standardisation and qualification approaches

[Why] Standards can create faster and easier market uptake. European standardisation activities are key for the consolidation of the Single Market and for consolidating the competitiveness of European companies. Standards play a major role in the space sector as they ensure the security and reliability of the space-related infrastructure. As well, standards have a positive impact on the

competitiveness of the European Space industry as they certify the use of best-practices recognised by users, manufacturers and developers.

[What] Actions under Horizon Europe should complement on-going European standardisation initiatives, in support of the **uptake and the enhancement of upstream and downstream space standards.** Building upon existing standards, extending to areas not covered and adapting to new scenarios, the development of solutions to identified space standardisation gaps should be supported through research and innovation. The actions should focus on areas as EGNSS downstream, harmonisation of processing and formatting of Copernicus data, SSA data processing, GOVSATCOM user segment.

[What] **Qualification and qualification mechanisms**, inspired by practices derived from automotive and aeronautics, should be explored as they may support the establishment of space compatible supply chains and ensure the quality level of parts at reduced costs, including commercial of the shelf. Digitalisation of space standardisation systems should be supported too.

[How] Collaborative research in areas where standardisation needs are to be investigated and requirements are to be specified further should be pursued. Hand hover to the standardisation organisations of the outcomes of the research shall be ensured with the aim to translate identified need and requirement into standards. The digitalisation of space standardisation system may be supported through a delegation of activities to standardisation bodies e.g. CEN/CENELEC.

5.6 Education & continuous professional development (training and qualification)

[Why] Competitiveness of the EU space sector depends on the availability of skilled professionals across a range of qualifications and the possibility to for these professionals to upgrade and update their skills. The quality of the results and impact of EU-funded research projects also depends on this, including for the implementation of this Strategic Research and Innovation Agenda. The EU also plays a role in the harmonisation of educational degrees so as to promote the mobility of professionals and offer them wider beyond the country where they graduated.

[What] Actions should be undertaken to make sure that the sector needs are matched with an adequate skilled workforce. This requires promoting and fostering high-level and consistent space educational standards, sustainable training and staff qualification / certification, ensuring highly qualified personnel, which guarantees the continuous development of cutting-edge space technologies. Among possible actions are support to curricula and skills development, foster the cooperation between academics active in the space sector for graduate training and research organisations for post-graduate training and promote within EU-funded R&I projects activities which contribute to enrich the educational and training curricula including in the frame of professional development.

[How] A targeted set of Coordination and Support Actions and/or appropriate agreements to develop a stable framework should be put in place to tackle the above issues.

6 STRENGTHEN OPPORTUNITIES

In order to foster competitiveness of space systems and reinforce access to space whilst promoting dual use, synergies with defence and synergies between space and non-space sectors, different governance and funding schemes are available in the R&I landscape.

6.1 Governance schemes to increase cooperation within the space sector

Collaborative Research has been the main R&I vector for space research and innovation under Horizon 2020.

Roadmap-based research and innovation has been carried out under Horizon 2020 to strengthen the competitiveness of the European space sector, including in the two strategic fields of space robotics technologies and electric propulsion, taking the form of Strategic Research Clusters (SRCs). In SRCs, a roadmap is developed for the field of activity. The implementation is achieved through individual projects targeting different elements of the roadmap that is built on continuity.

Horizon Europe proposes three types of **European Partnership Initiatives.**

Co-funded Partnerships gather external entities managing and/or funding research and innovation programmes, other than Union funding bodies. In this case, the EU finances at least 30% of the eligible costs. While other sectors have made extensive use of this instrument in Horizon 2020 (e.g. ERA-Net Smart Energy Systems), up to now, this scheme has proved to be difficult to use in the space sector.

Co-Programmed Partnerships are based on memoranda of understanding or contractual arrangements among partners. These include the identification of complementary research and innovation activities to be implemented by the partners and by the Programme. Relevant examples under Horizon 2020 are the contractual public and private partnerships (cPPPs) on robotics in Europe SPARC and Factories of the Future.

Institutionalised Partnerships are based on Articles 185 or 187 of the TFEU for Joint Undertakings (JUs), and on the European Institute for Technology and Innovation (EIT) Regulation for the Knowledge and Innovation Communities (KICs).

i) Article 187 refers to the possibility to set-up a *Joint Undertaking* (i.e. an entity that is separate from the European Commission) for the efficient execution of Union research, technological development and demonstration programmes. In the Horizon Europe proposal, partners should bring a contribution (financial and/or in-kind) of at least 50% of the budget. Although the setting-up of a JU requires significant initial efforts, partners have a strong say on the programming, and the JU structure allows a tighter and faster implementation. Relevant examples are the Clean Sky JU in the field of Aeronautics and the SESAR JU in the field of Air Traffic Management.

ii) *Knowledge and Innovation Community* (KIC) is an independent entity under the EIT that gathers experts from industry, academia and research organisations. The budget to set up new KICs comes from Pillar III of Horizon Europe on Open Innovation.

There is broad and strong support from the stakeholders community to continue with Collaborative Research under Horizon Europe as well as to maintain a good balance between bottom-up and top-down (i.e. more roadmap-based) research. The SRC type of roadmap-based approach is strongly supported by space agencies. Partnerships are seen as good opportunities to gather critical mass, create leverage and focus on long-term objectives building on continuity. To be noted that there is a heritage of using Partnerships for technology development in the framework programmes, notably in the Digital, Industry and Space Cluster. The possible establishment of a Partnership in Horizon Europe shall consider interests of private partners whilst still ensuring openness and transparency for smaller actors. In addition, the role of Member States, national agencies and ESA in the governance shall be clearly defined. Partnerships in the form of KICs shall establish synergies and complementarity with existing ESA Space Solutions such as the Business Incubation Centres.

6.2 Exploiting different sources of funding at EU and national levels and leveraging on private investments

Under the European Union Financial Regulation different **forms of EU funding** are possible.

Grants are direct financial contributions, which cover part or all direct and indirect costs.
Innovation Procurement can deliver solutions to challenges of public interest. *Public Procurement of Innovative solutions (PPI)* is used when challenges can be addressed by innovative solutions that are nearly or already in small quantity in the market and do not need new R&I. *Pre-Commercial Procurement (PCP)* can be used when near-to-the-market solutions do not exist yet and when new R&I is needed. PCP can then compare the pros and cons of alternative competing solutions. This will in turn enable to de-risk the most promising innovations step-by-step via solution design, prototyping, development and first product testing.

Prize is an award attributed to whoever best meets a given challenge. Currently, a prize on Low-cost Space Launch is open with a EUR 10 million award under the European Innovation Council pilot. This instrument is foreseen to continue under Pillar III of Horizon Europe on Open Innovation.

Financial instruments are included in the Union budget and are implemented, inter alia by the European Investment Bank (EIB) and European Investment Fund (EIF) via financial intermediaries and addressing different type of entities (start-ups, SMES, large companies) as beneficiaries as well as different phases of business development. These include products such as loans, venture capital, or guarantee schemes.

In Horizon Europe, grants shall remain the main form of funding for space R&I activities. The blending of different forms of funding is a new feature embedded in all Union programmes whose benefits for space need to be further defined. Innovation Procurement (PCP/PPI) is positive for technologies and services that have benefitted from a grant but need further development to integrate in the commercial market. However, further reflection is needed on TRL and IPR aspects. Lessons learnt from experience on the use of innovation procurement under Horizon 2020 in support of space services enabled by Copernicus and Galileo will be used to determine how it can be further used in the future.

EU funding is implemented by means of **programmes**.

In the next MFF, space is explicitly addressed in the Space Programme, Horizon Europe and InvestEU.

Space research under ***Horizon Europe*** is foreseen in Pillar II 'Global Challenges and Competitiveness', under the Cluster Digital, Industry and Space which hosts 10 areas of intervention dealing with different types of technologies such as materials, manufacturing and ICT. The proposed budget for the cluster amounts to EUR 15 billion. Grants, prizes and procurement, including PCP/PPI are the main forms of funding. To be noted that opportunities for space research can also be carried out in other Clusters of the same Pillar as well as under Pillar I 'Open science' and Pillar III 'Open innovation' (e.g. through EIT and EIC).

The ***Space Programme*** brings under one umbrella the two Union flagship programmes Galileo/EGNOS and Copernicus. Two new components have been introduced: Space Situational Awareness and GOVSATCOM. The proposed budget is EUR 16 billion. R&I actions for the Space Programme components are expected to be carried out through Horizon Europe.

The ***InvestEU*** programme brings under the same umbrella all financial instruments for the Union budget. It aims at supporting financing and investments for sustainable infrastructure, research, innovation and digitisation for SMEs, small mid-cap companies and social enterprises and markets. It is composed of four policy windows and a number of eligible sectors. Space is included under the sustainable infrastructure policy window and as an eligible sector in line with the objectives of the Space Strategy.

Other relevant programmes/funds are the EUR 13 billion European ***Defence fund*** and the EUR 9.2 billion ***Digital Europe Programme***.

The European Regional Development Fund (ERDF) offers a valuable opportunity to bridge actions at European and national or regional levels. Noteworthy are possibilities such as the seal of excellence initiative or support for the development of R&I infrastructures, testing and launch facilities and local supply chain. The ***Common Provision Regulation*** sets out common provisions for seven funds (including ERDF and the Cohesion Fund).

A gap has been identified in the European venture capital market landscape including for the space sector.

It is important to increase access to finance opportunities for the space sector making a smart and synergistic use of the Union Programmes such as InvestEU and ERDF, Horizon Europe and the Space programme. There is a significant window of opportunity in the upcoming two years, which will be the programming phase, to identify synergies and related actions for the respective programmes.