

EUROSPACE FP9 POSITION PAPER

BACKGROUND INFORMATION

This position paper has been prepared by the Eurospace FP9 Task force formed in April 2017 by mandate of Eurospace Council. The Position paper was formally endorsed by Eurospace Council on 20 November 2017.

This position is complemented by a set of annexes providing more details on specific areas of the paper. In particular the RIAP outline annex provides the Eurospace proposals for the expected scope of activities to be addressed by a JTI.

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POSITION PAPER

PREAMBLE - SPACE IS AN ESSENTIAL ASSET FOR EUROPEAN POLICIES

"Europe needs to maintain and further strengthen its world-class capacity to conceive, develop, launch, operate and exploit space systems. To ensure this, the Commission will support the competitiveness of the whole supply chain and actors from industry to research organisations. It will also foster the emergence of an entrepreneurial ecosystem, opening up new sources of financing, creating new business opportunities, and making sure this will benefit businesses in all Member States."

Space Strategy for Europe

"Research, development and innovation not only are key elements of space industrial competitiveness, but also essential ingredients of a sustainable economic growth, be it in the short run as in the long run, with effects on the ability of the European Union to remain competitive in an increasingly globalised economy"

Communication of the EC on EU space Industrial Policy - Releasing the potential for economic growth in the space sector, February 2013 - COM(2013) 108 final

When the leaders of the 27 Members states met in Rome in March 2017 to celebrate 60 years of European constructions, they acknowledged¹ the main global and domestic challenges that Europe is facing in the next decade, and they pledged to work together towards making the European Union *safe and secure, prosperous, competitive, sustainable and socially responsible, and with the will and capacity of playing a key role in the world and of shaping globalisation*, providing its citizens *new opportunities for cultural and social development and economic growth*.

Space systems deliver services and applications that play critical roles in supporting these essential policy goals:

- **Sustainability:** European remote sensing systems for operational meteorology, resources, ocean and atmosphere monitoring are providing the Union with autonomous assessment capabilities supporting EU commitments at COP21 and the capacity to act on the global scale.
- **Safety and Security:** Space systems contribute to securing European borders, and to the global safety of European citizens. The capacity for Europe to intervene in situations of crisis management, within and outside our borders, while maintaining appropriate visibility of operations and secure communications is also supported by space systems and services. Furthermore, extending the notion of security to the protection of our assets in Earth orbit is essential for the preservation of this operational capability.
- **Competitiveness:** The European space industry has established strong competitive positions on the global scale, with its excellent penetration of commercial space markets for both telecommunications and observation applications and for commercial launch services. This leadership enables the development of high profile employment in the sector, and keeps Europe at the forefront of space global markets. Notwithstanding, aggressive strategies from new players in the USA and China are challenging European positions, supported by national policies and growing institutional budgets.

¹ Council of the EU - The Rome Declaration - 25/03/2017 Press Release 149/17

- **Prosperity and cultural and social development:** The digital revolution is providing new areas of growth and development for Europe, but with the digital divide still strong in the Union all citizens cannot benefit from it equally. Space infrastructures will contribute to bridge the divide, and support the spread of networks for enhanced connectivity and mobility for all European citizens.
- **Geostrategic outreach:** space systems and the European autonomous access to space contribute to giving Europe a leading geopolitical dimension. Space exports are a growing tool for economic diplomacy and for the establishment of soft power in international relations.

Space infrastructure programmes & assets vs the Rome Declaration	A safe and secure Europe	A prosperous and sustainable Europe	A social Europe	A stronger Europe on the global scene
European GNSS	YES	YES		YES
European access to space	YES	YES		YES
Govsatcom	YES			YES
Bridging digital divide		YES	YES	YES
Remote sensing for security and relief	YES	YES	YES	YES
Space Science and exploration		YES	YES	YES
Climate & Environment Monitoring (incl. Meteorology)	YES	YES	YES	YES
SSA (incl. SST)	YES			YES

EUROSPACE RECOMMENDATIONS FOR FP9

With the relatively limited funding available for space technology development in Europe, the matter of its effectiveness is absolutely crucial. Developments should be appropriately targeted and correctly performed, avoiding unnecessary duplications whenever possible.

It is absolutely essential that more efforts in coordination be undertaken to clarify the understanding of needs and issues and ensure maximum effectiveness of public and private investments in space technology with the establishment of focused initiatives - such as the Strategic Research Clusters (SRC) approach or Joint Technology Initiatives (JTIs) - with well identified objectives and leaving appropriate room for industry involvement in the definition of development plans. These efforts shall also provide for synergetic developments and continuity with opportunity driven (bottom-up) research activities.

FP9 shall support the space sector in addressing medium to long-term challenges in an evolving geopolitical and market environment. A budget envelope for FP9-Space in the order of 2 Billion Euro should be made available, of which 1.5 earmarked for space (upstream) RDT&I², and 0.5 for market development, outreach and other actions.

FP9-Space shall focus on: technology readiness for institutional/EU programmes and international cooperation; autonomy and non-dependence for critical technologies, building blocks and access to space; competitiveness and innovation for space

² RDT&I: Research Development Technology & Innovation

systems and services; safety and sustainability of operations in the orbital and industrial environments; and promoting the take up of space services, applications and uses of space data.

Key recommendations:

- Ensure the preservation of a dedicated Space line in FP9 to address the unique European challenges of space technology development.
- Establish a global and inclusive vision for FP9-Space with the involvement of all stakeholders, public and private, large and small.
- Ensure the appropriate involvement of all technology stakeholders, suppliers, promoters and users of space technology alike;
- Address all areas of space RDT&I needs, from competitiveness support at components, equipment and system level, for market driven activities, for EU institutional programmes and for the take up of space services and the exploitation of space data, with appropriate instruments, tools and budgets.
- Organise FP9 to support the appropriate identification of RDT&I needs and suitable coordination and implementation mechanisms for different RDT&I strands (see the 4 Pillars organisation in the Programmatic overview)
- Support the emergence of a JTI for Space, providing opportunities for larger and more ambitious projects, and enabling the expression of industry driven priorities for a competitive and sustainable industrial base and supply chain, and add leverage to industry investment for innovation in space components, materials, equipment, software, manufacturing processes for spacecraft, launchers and ground segments. The JTI is expected to enable larger projects

INTRODUCTION

Since decades, the Space sector has reached a level of maturity that allows reliable access to space, extraordinary Space and Earth science, and fully operational programs delivering services strategic for the governments and answering the citizens' needs. Satellites imagery and satellite communications (including localisation) have become the norm for a range of major applications such as for meteorology, for disasters monitoring, for surveillance purposes, for providing localisation, navigation and cartography software and services, for emergency and/or secured communication, for delivering connectivity everywhere (in-flight and to the most isolated places), just to mention a few. Many of those applications address Europe societal challenges (such as the Maritime Strategy, the Arctic Strategy, the Digital Agenda, the Common Security and Defence Policy, the Sustainable Development Strategy etc.).

The recent years have illustrated European industry's ability to deliver performing solutions to address all the space applications, be they governmental (e.g ultra secure satellite communications, very high resolution surveillance, navigation), scientific (e.g unrivalled Earth and universe observatories, asteroid landing world première) or purely commercial (world leader of the communication market). European industry develops and flies systems in any orbit (from LEO to the outer planets) through any architecture (from single satellites to constellations and recently mega-constellation for the so-called "new space customers) and using the whole portfolio of satellites (from nanosat to multi-tons communications satellites).

The continuous innovation efforts of the space sector were instrumental to realise those achievements. In a more and more globalised while less secure world, fed by exponentially performing technologies, eager for digitalisation, and where fierce competition is the commercial rule, the need for innovation further increase and becomes a condition for survival.

Through an FP9-Space programme, and in complement to space agencies, the European Union will seize the opportunity to ensure that those challenges are addressed in the most efficient manner in the mid term.

LOOKING AHEAD TO FP9-SPACE

FP9-SPACE GOALS

The objective for industry is that European space technology policies ensure the on-time availability of needed/advanced technologies - with the appropriate maturity, the required level of non dependence, and at competitive conditions - for risk mitigated implementation in European (institutional) and global (commercial) programmes.

Europe shall be able to bridge the gap and keep ahead of its competitors. This can only be achieved with appropriate funding effort, and with a stronger and sustainable commitment of all stakeholders, under industrial leadership, to the definition, implementation and coordination of activities for sustainable European systems competitiveness.

A dedicated FP9-Space programme, addressing the appropriate areas of space technology development with the appropriate (grant-based) instruments and in coordination with all stakeholders (agencies, industry, research establishments and institutes) is needed to further the achievements of H2020.

FP9-Space shall rely on the convergence of existing coordination schemes, and shall enhance them with an industry driven Research and innovation Action Plan (RIAP) for implementation in a Joint technology Initiative (JTI). This situation would allow technology suppliers, promoters and users to maximise the impact of developments, each being able to contribute to the definition of programme priorities, within their specific areas of responsibility and expertise.

WHY AN FP9 DEDICATED FOR SPACE?

Space systems are highly complex systems integrating a wide range of technologies from many other sectors³. They have specificities and unique features that require dedicated development programmes before they can be used to deliver operational services and applications. Throughout FP7 and FP8 this approach has yielded positive results that need to be pursued through FP9 with maximum impact on space system readiness, efficiency and industry competitiveness.

The space systems industry is one of the most RTD-intensive sectors in Europe. This is due to the high technological constraints of space systems (spacecraft and launchers). All space programmes have promoted and implemented innovation since the beginning of the space age, space sector acts as a technology integrator, adapting state of the art technology to space requirements and promoting space innovations for advances in space systems. Space technology and product development thus require important investments in industrial equipment (including test equipment), software, design and modelling tools and protocols development and maintenance, not to mention the scientific and technological competences required within industry, agencies, research centres and laboratories.

Space technology is Sensitive: Space technology is dual use (military and civil) by sheer nature, and as a result, space activities and space technology exports are highly regulated by the governments of all space fairing nations, and by inter-governmental agreements: all

³ See also the Annex on The unique features of space technologies

space technology is excluded from the WTO agreement; and more specifically, launcher technology exports are strictly regulated by MTCR (Missile Technology Control Regime).

Space technology aims at Optimisation: Space technology is on a constant evolution path, achieving growing levels of complexity and integration. At System level the key drivers include the increase of functionalities, growth in electrical/thermal power, size and capabilities (e.g. large Geo satellites), but at the same time we witness the trend in reduction of mass, size, power consumption (e.g. formation flying/constellation concepts, nano-satellites). These trends are also visible at equipment level, where the demand for mass/size reduction, calling for functional hybridisation and for standardisation of designs and interfaces, with larger production volumes is growing.

Spacecraft systems technologies and drivers

Spacecraft technology is driven by the constraints of operations in space environment for a long duration (several years) of time without maintenance. The absolute limitations on mass and volume (launcher constraints, launch costs) and the necessity to withstand the duress of launch are also major constraints.

Key technology drivers for spacecraft will thus include autonomy, radiation hardening and particle protection, thermal constraints, and operations in the vacuum. Core technology areas for spacecraft include technologies for the platform (thermal, propulsion, power, stability etc.) and technologies for the payloads to perform the missions (with a variety of technology domains depending on the mission). Particular constraints will often apply, such as high stability (thermal, mechanical, electrical), high temperature control, complex deployable systems, high power computing, reconfigurability etc.

Neighbouring technologies and synergies can be found in a variety of technological areas. optical/IR sensors, computing, RF and radio wave propagation/amplification/modulation technologies, thermal control, actuators, position sensors, small mechanisms, robotics, autonomy, guidance, etc.

Launcher systems technologies and drivers

Launcher technology is driven by the need to operate faultlessly in extreme physical condition & short lifetime (minutes to hours). The main constraints for launcher technology are: high energy density, mass sensitivity, vibration, acoustics, atmospheric/orbital environment, high energy density, extreme temperatures (cryogenics vs. extreme heat), autonomy and of course safety and reliability.

Ground systems technologies and drivers

Ground System is the interface between the Space Infrastructure, and the end-user; it is the key enabler to provide new space data-based innovative services.

Ground systems technologies are driven by the growing data bandwidth and data rate requirements of space systems, the required reactivity and timeliness for user needs to end-user product delivery, the need to automate the system and reduce operational costs, the need for end-to-end security, and face new challenges required by satellites constellation management.

They encompass telemetry and command needs, where data security and integrity are key requirements, as well as mission data management (uplink and downlink, processing, storage) where data rate and bandwidth requirements drive ground station development: the mission and user ground segment is a critical component of the space infrastructure.

For the specific case of launchers, the ground segment is starting from the final assembly and test, up to the integration and launch pad. It is therefore an important part of the full launch system, in all its functional aspects but also considering the severe specific load cases caused by the activities at the launch pad.

FP9-SPACE CORE OBJECTIVES FOR INDUSTRY RDT

It is a main goal of the European space strategy for Europe to maintaining and further strengthening its world-class capacity to conceive, develop, launch, operate and exploit space systems – the EU needs to enhance its industry technological readiness and competitiveness through a consistent leverage to its RDT investments.

The leverage to RDT answers a political objective, and should therefore take the form of an instrument allowing a top down, focused, approach achievable only through a dedicated and well-defined budget line. Therefore, in line with the objectives of the Space Strategy for Europe, **Industry strongly recommend the EU to strengthen its leverage to space RDT by furthering a dedicated line under FP9 (as with H2020-Space);** more specifically:

- When it comes to the preparation and development of potential new operational capacities under EU leadership (such as SSA or Govsatcom) as well as the evolution of existing EU programmes (in order to remain competitive and cost-effective in the long term), space industry considers that the related RDT activities must be driven by the EC in a way that offers sustainable plans and programmes.
- When it comes to leveraging the European space competitiveness on the commercial markets, the main expectation from Industry is to increase the impact of FP9-Space in comparison to H2020-Space, by improving the consideration of industry needs. The leverage to industry competitiveness is supported by close monitoring of market needs and expectations, that can only be achieved through a structured involvement of the manufacturers that are in contact with their customers, whether private (commercial operators) or public (export markets).
- Both individual competition and global competition need to be maintained within the FP9-Space program either by existing RTD instruments as in H2020-Space-Space (as a collaborative research) or new PPP based instruments such as the forthcoming JTI for space. The space industry recommends to making public private partnerships (PPPs) an integral part of FP9-Space - in addition to traditional mechanisms - as an effective tool to prioritising specific pre-operational space activities with a potential for industrialisation and commercialisation.

The existing H2020-Space program and other existing space research and technology programmes need to be expanded and improved in FP9-Space

- EC Space program evolution: Today technology development activities are organized to support the sector readiness in EU driven programmes. This is typically the case of Galileo and Copernicus, and may include space surveillance, Govsatcom and the preparation of future planetary exploration (human and robotic) despite the lower level of definition of these areas. FP9 still needs to take care of technology for these space programs by focusing on system level, programme-driven activities with multi-annual coordination of projects, and interlinking of projects.
- Competitiveness and Demonstration in Space: Today H2020 technology development activities are driven by sector competitiveness goals, addressing transversal aspects, including dependence aspects, building blocks and product-driven approaches, maturity considerations. An evolution of existing H2020 program needs to be introduced for IOD/IOV (In Orbit Demonstration/In Orbit Validation) and to give the appropriate focus to grand challenges identified by the industrial sector. The existing program concept should be complemented by other concepts such as PPPs to prepare the future competitive European space products.
- Collaborative and complementary Space Research: H2020 supports regular collaborative space research with partners which are complementary to ESA program by definition. It is of high value to keep the spirit for long term objectives (beyond ESA

programs) and the transversality with other sectors such as energy, aeronautics and automotive. An evolution of the existing program may consider stronger social issue compliances such as REACH and other regulations.

Eurospace advocates the preservation of a space sector specific line for FP9-Space including upstream segment RDT&I and downstream market and services development.

FP9-SPACE, PROGRAMMATIC ORGANISATION

FP9-Space should provide a balanced and coherent approach to support the technology readiness of future systems and applications, and to stimulate the take up and development of new services and applications.

An organisation of FP9-Space in 4 pillars would suit these needs.

Competitive and sustainable industrial base and supply chain

- Research and technology for component, equipment, building blocks, software and innovative design & manufacturing
- Entire supply chain
- Implementation: Grants through JTI, driven by RIAP
- Budget 500 M€

Innovation in system and architecture for market driven competitiveness

- Research, development and concepts for system level competitiveness
- Commercial and export markets
- Implementation: Grants through PSA/SRC
- Budget 500 M€

Readiness for institutional and flagship EU programmes

- Copernicus evolution
- Galileo evolution
- SSA preparation
- IOD/IOV service
- Science & Exploration
- Implementation: SRC/EGEP type
- Budget 500 M€

Market, Services and applications development

- Earth Observation downstream applications
- Data distribution & networks
- Galileo services
- Implementation: Grants/Programme Committee
- Budget 500 M€

The 4 Pillars:

- **Competitive, sustainable and non-dependent industrial base and supply chain:** for a competitive common technology base, where technology development activities identified by all the actors will be driven primarily by sector competitiveness goals, and combining the transversal aspects of the two other pillars. Synergies will be sought with the identification of technological solutions that may serve multiple purposes (spin-in/spin-off). It would include dependence aspects, and development on components, materials, building blocks, equipment, software, industrial processes, for spacecraft, launchers and ground segments. Maturity considerations (including IOV where needed) and sustainability aspects will be driving the developments, to ensure that developments are providing effective capacity in terms of implementable innovation for products. Ideally this core technologies pillar would be managed in the context of a PPP⁴ involving all technology suppliers with an industry leadership. A commitment to technology roadmapping and the funding of activities together with the European Union will be enabling factors for this pillar. **This pillar is proposed for**

⁴ Public-Private Partnership

implementation in the context of a JTI for space. A technical annex is provided in the form of a RIAP⁵ scoping paper to support further discussions in view of the establishment of a JTI.

- **Innovation in system and architecture for market driven competitiveness:** where Space systems/ product maturations roadmaps are defined by competitiveness needs (including IOV where deemed necessary) giving the appropriate focus to commercial markets (such as exports, launcher competitiveness, telecommunications markets etc.). This pillar could be implemented optimally with an approach inspired from the PSA/SRC approach tested in H2020, but with a strong involvement of industry.
- **Readiness for institutional and flagship EU programmes:** Research for EU-institutional programs. In this pillar technology development activities are organized to support the sector readiness in specific, well-identified institutional programmes. This is typically the case of Copernicus continuity and next generation and Galileo next generation. It will be the case for Govsatcom related development if the program is adopted next year. It could also be relevant, to include the preparation of the preparation of a European IOD/IOV service, the future planetary exploration (human and robotic) and space situational awareness in this branch. This pillar will focus on system level, programme-driven activities with multi-annual coordination of activities, and interlinking of projects within a single area. This pillar will benefit from the best possible levels of coordination among European institutions for overall technology planning and programme implementation aspects.
- **Market, services and applications development:** the take up of space services markets and the enhanced utilisation of space data are essential to a healthy space sector and for the efficient exploitation of European space infrastructures. The upstream sector is committed to supporting emerging services and unlocking applications through innovation and research. FP9-space should provide the appropriate budgets, programmes and instruments for the downstream sector, in the public and private domains, to reap the benefits of investments in space RDT.

The organisation in four pillars of FP9-Space will enable the consistent expression and identification of essential RDT&I needs. It will address:

- Activities for the competitiveness of the European industrial base and supply chain for space systems (driven by industry together with its RDT&I stakeholders, in particular research establishments)
- Activities for the readiness to support future European public infrastructures and programmes (driven by the promoting agencies, mainly ESA and the EU)
- Activities promoting the development and take up of space services and data (driven by the user segment).

The many synergies and complementarities between the four pillars justify the setting up of a global vision for FP9-Space able to embrace, with the contribution of all stakeholders, public and private, the global research needs of Europe in space. **The elaboration of a European long-term vision for European space technologies would allow the best coordination and consistency of all investments in space research and the identification of key development strands for Europe.**

FP9-SPACE STAKEHOLDER INVOLVEMENT

FP9-Space will have to ensure the appropriate balance of involvement of **technology suppliers** (industry, research establishments, academia and laboratories), **institutional**

⁵ *Research and Innovation Action Plan*

supporters (EU, ESA, Eumetsat, National space agencies and other national/regional public institutions) and **technology users** (EU programmes, ESA, Eumetsat & National programmes and commercial customers).

Technology suppliers are the core targets for FP9-Space. This community is composed by all entities performing the development of space technologies, products and systems (including the supply and operations of test, modelling and integration tools) for both institutional and commercial programmes.

Technology suppliers include:

- **The industrial sector:** composed of handful of large enterprises (with space employment above 1000), a few tens of medium size enterprises (with space employment between 1000 and 250) and a vast network of hundreds of SMEs (with a majority of micro-enterprises), the industrial sector is the main actor of technology development in Europe, focusing on the higher end of the TRL scale.
- **The Research Establishments and institutes:** research establishments (such as the DLR institutes, Onera, Inta, NLR, Cira, TNO, TecNALIA, etc.), have been key players in space RDT&I since the first steps of European space programmes. They are mostly involved in low to mid TRL research and provide supporting infrastructure for a vast array of test and integration activities.
- **The academic and scientific community** is also involved in the full RDT&I supply chain, as it provides low TRL research where now concepts can be validated for applications, but also as a key provider for the development of scientific payloads and missions. A wide range of laboratories are already participating in European space programmes.

By providing the appropriate mix of programmatic activities in the low, mid and high TRL range, with a variety of instruments, focusing on grants, FP9 shall ensure the inclusion of the full scope of technology suppliers in the European space sector.

PUTTING FP9-SPACE IN THE CONTEXT OF EUROPEAN SPACE RDT&I ACTIVITIES AND POLICIES

Investment in space can help drive solutions to major societal and global challenges and contribute to jobs, growth, innovation and competitiveness. Space is a strategic asset for Europe's security. That is why the European Commission is putting space high on the political agenda. Together with the European Space Agency, member states and industry stakeholders, the Union is working to ensure that investments in space bring tangible benefits to European citizens and businesses. At the end of October 2016, the Commission published its vision for a "Space Strategy for Europe": **"Europe needs to maintain and further strengthen its world-class capacity to conceive, develop, launch, operate and exploit space systems. To ensure this, the Commission will support the competitiveness of the whole supply chain and actors from industry to research organisations. It will also foster the emergence of an entrepreneurial ecosystem, opening up new sources of financing, creating new business opportunities, and making sure this will benefit businesses in all Member States."**

Excellence in space technology is critical for Europe to remain at the forefront of global space developments, enabling us to reap the benefits of space research, science and exploration. Europe needs to maintain a strong and innovative industrial base to deliver the potential. Cooperation between European space actors is essential.

In a dynamically changing global context, marked by growing competition and major technology shifts, the space sector requires continued investments in cutting-edge

technologies, innovation and skills in order to stay ahead. It needs a smart and coordinated approach for investment.

FUNDING MECHANISMS AND BUDGETS FOR SPACE RDT&I IN EUROPE

FP9-Space shall take stock of the complex and multifaceted situation of the space institutional framework (space is a shared competence of the Union) with the articulation of space RTD programmes managed in a national context (national space agencies), in an intergovernmental context (ESA & Eumetsat) and in the EU context (FP/Space, Copernicus, Galileo). Achieving strong coordination of RDT&I activities shall be a stated objective of FP9. The synergy between all RDT&I strands is a key requirement for maximum efficiency.

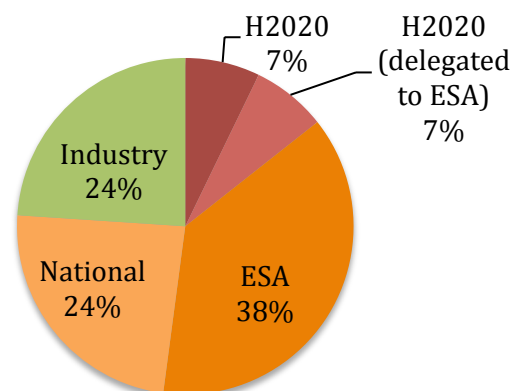
In Europe there are 4 main budget sources to support technology development and readiness or space programmes: EU programmes, ESA programmes, National programmes and industry investment. The vast majority of these programmes are implemented in industry usually in cooperation with research establishments and specialised laboratories.

ESA and civil national space agencies (such as CNES, DLR etc.) have specific programmes devoted to technology development activities. These programmes can be generic (such as ESA's TRP and GSTP programmes) i.e. targeted at developments with potential use with a wide variety of space applications, or specific to certain applications needs (such as ESA's ARTES, for telecommunications, FLPP for launchers and so on). The European Union, with the H2020-Space programme also provides leverage to technology development with the COMPET and SPACE TEC calls (and with the calls delegated to ESA for next generation Galileo activities). Due to the relevance of space technologies for security and defence there might be also some space related technology developments in the upcoming RDT&I activities within the EU Defence Plan.

The European space industry co-funds with space agencies and the EC a number of technology developments (within EU's H2020 programme for instance, but also in some elements of ESA's ARTES or GSTP), and, of course, funds internal efforts in research, development and technology.

Funding sources for Space RDT&I in Europe

Overall, public budgets made available to support research and technology for space programmes in Europe have been estimated by ESA at 680 M€/year⁶. Eurospace has assessed that private industry investment in space RDT&I contributes an additional 200 M€/year to the global funding context for space RDT.



THE JTI FOR SPACE: PRELIMINARY SCOPING AND OBJECTIVES

In the rapidly changing environment of space markets and applications, the space sector must adapt to new challenges. Research, development, technology and innovation are part of the solution, and the JTI approach for space, promoted today by the European Union, is a

⁶ Source ESA European Space Technology Master Plan 2016 edition.

welcome addition to the European context of space RDT&I programmes, as a strong leveraging tool for quick and fast adaptation of the industry to the market needs. The JTI is also expected to provide opportunities for projects of a size sufficient enough to allow for the development of real “game-changers” in technologies/processes/materials...

The JTI will be better connected to markets, and will provide a more flexible and agile environment for Space RDT&I. It will ensure a product-oriented focus, it will promote spin-in and the take up of COTS in space systems, it will ensure that all developments are brought to the appropriate maturity for integration in products, it will address environmental concerns, with appropriate solutions to comply with environmental regulations affecting industrial activities and the overall issue of orbital debris mitigation. And last but not least, the JTI will enable the conditions for industry to go beyond 4.0, with new integrated processes, new models, new tools.

It will be an industry driven instrument aiming at supporting the development of a more competitive industrial base and supply chain. It will address issues such as technology readiness, dependence reduction, and innovation, with a strong focus on components, materials, equipment, software and processes.

The JTI is proposed as a complement to existing RDT&I programmes established at ESA, national and EU levels. Innovation is necessary to face competition; technology roadmaps elaborated by Industry can be implemented at most partially because of shortage or fragmentation of funding; there is therefore a demand for further funding, and the JTI concept goes in this direction.

Eventually, an industry-driven JTI will accelerate innovation, provide more focus, more agility and more budgets for research through a coordinated approach to achieve competitiveness goals because the investment by industry will be leveraged by the Union. This is the positive basis of the JTI partnership.

ANNEX - THE UNIQUE FEATURES OF SPACE TECHNOLOGY

SPACE TECHNOLOGIES REQUIRE DEDICATED DEVELOPMENT PROGRAMMES ADDRESSING UNIQUE CHALLENGES AND ISSUES

Space systems (spacecraft, launchers and supporting ground systems) are complex technology integrators (today 70% of technologies used in space are spin-in from other sectors), with unique requirements and drivers that set them aside from technologies used and developed for terrestrial uses (such as radiation hardening, use in vacuum, no maintenance, autonomy, extreme temperatures, exposure to dust & micro-meteoroids, extreme acoustic environment, multiple-G then absence of gravity...).

Space technology is very diverse, especially since it is not a technology per se, but the integration of a wide range of technology domains (propulsion, mechanisms, electronics, software, materials, ...) with a common set of requirements for operations in space and to withstand launch to space.

Space technology is also strongly segmented from a product point of view, with launchers on one side and spacecraft on the other⁷. Technical differences between these two families of products are driven by two largely different sets of requirements/drivers.

SPACE TECHNOLOGY DOMAINS

Launcher technology is driven by the need to operate faultlessly in extreme physical condition & short lifetime (minutes to hours). The main constraints for launcher technology are: high energy density, mass sensitivity, vibration, acoustics, atmospheric/orbital environment, high energy density, extreme temperatures (cryogenics vs. extreme heat), autonomy and of course safety and reliability.

Core technology areas for launchers include:

- Structure and mechanical technologies: materials, design, separation, architecture and system studies, structural dynamics, tanks, cryogenics....
- Propulsion: engines, thrusters, propellants, energetic materials, chemicals...
- Flight Physics: Orbit dynamics, mission analysis, trajectography, aero(thermo)dynamics, propellant management...
- Functional chain & Software: COTS, processors, sensors, telemetry, power systems, software engineering, GNC
- Manufacturing, Assembly, Integration and Test (MAIT) and Ground systems: ground infrastructure design, system operation, ground support equipment and launching support
- Design & System Engineering, Simulation & Tests

Spacecraft technology is driven mainly by the constraints of operations in the harsh space environment for a long duration of time without maintenance. Spacecraft systems are also required to withstand the duress of launch. Key technology drivers include autonomy,

⁷ Human systems are a family by their own, due to the additional requirements they generate on safety and retrieval. They share some characteristics with the spacecraft systems with a number of additional technology areas: pressurisation, chemical management, life support, closed loop systems... there are commonalities with the submarine sector.

radiation hardening and particle protection, thermal constraints, and operations in the vacuum. Core technology areas for spacecraft include:

- Spacecraft platform technologies:
 - Stability, thermal control, energy production/storage/distribution, propulsion (electric/chemical), on board computing (processors, data storage, data transmission...) and autonomy, mechanical aspects (deployable panels and thermal screens, tribology, motors...) etc.
- Payload technologies: very specific technical challenges posed by the mission requirements:
 - Instrument technologies (IR, Optical Hyperspectral, etc), RF and optical communications technologies , radar technologies, frequency and time generation technologies, etc.
 - Some may pose specific constraints, such as cryo-cooling for laser instruments, ultra stable structures for antenna pointing, ultra light materials for large reflectors, mechanical constraints for unfurlable/deployable structures, etc.
 - Interfaces: thermal, power, data...
- Neighbouring technologies and synergies: optical/IR sensors, computing, RF and radio wave propagation/amplification/modulation technologies, thermal control, actuators, position sensors, small mechanisms, robotics, autonomy, guidance, ...

Ground systems technologies from ground support for integration & test activities and mission system preparation & operation to tracking, telemetry & commanding and mission support. Ground technology will embrace launcher system support technologies and safety. These technologies are driven by the growing data bandwidth and data rate requirements of space systems. From tracking, telemetry and command needs, where data security and integrity are key requirements - to mission data management (uplink and downlink) where data rate and bandwidth requirements drive ground station development, the mission and user ground segment is a critical component of the space infrastructure. Ground technologies will embrace:

- Ground segment technologies (mission control and operations, payload data processing and user segment)
- Modelling and design tools
- Test and integration equipment
- Manufacturing tools

For the specific case of launchers, the ground segment is intended to start from the final assembly and test up to the integration and launch pad, in consideration of its functional aspect and specific load cases at launch pad.

SPACE TECHNOLOGY CHARACTERISTICS

The space manufacturing industry is one of the most RTD-intensive sectors in Europe. This is due to the high technological constraints of space systems (spacecraft and launchers). All space programmes have promoted and implemented innovation since the beginning of the space age, the space sector acts as a technology integrator, adapting state of the art technology to space requirements and promoting space innovations for advances

in space systems. Space technology and product development thus require important investments in industrial equipment (including test equipment), software, design and modelling tools and protocols development and maintenance, not to mention the scientific and technological competences required within industry, agencies, research centres and laboratories.

Space technology is Sensitive: Space technology is dual use (military and civil) by sheer nature, and as a result, space activities and space technology exports are highly regulated by the governments of all space fairing nations, and by inter-governmental agreements: all space technology is excluded from the WTO agreement; and more specifically, launcher technology exports are strictly regulated by MTCR (Missile Technology Control Regime).

Space technology aims at Optimisation: Space technology is on a constant evolution path, achieving growing levels of complexity and integration. At System level the key drivers include the increase of functionalities, growth in electrical/thermal power, size and capabilities (e.g. large Geo satellites), but at the same time we witness the trend in reduction of mass, size, power consumption (e.g. formation flying/constellation concepts, nano-satellites). These trends are also visible at equipment level, where the demand for mass/size reduction, calling for functional hybridisation and for standardisation of designs and interfaces, with larger production volumes is growing.

ANNEX - SPACE MARKETS SITUATION AND GAME CHANGERS IN SPACE

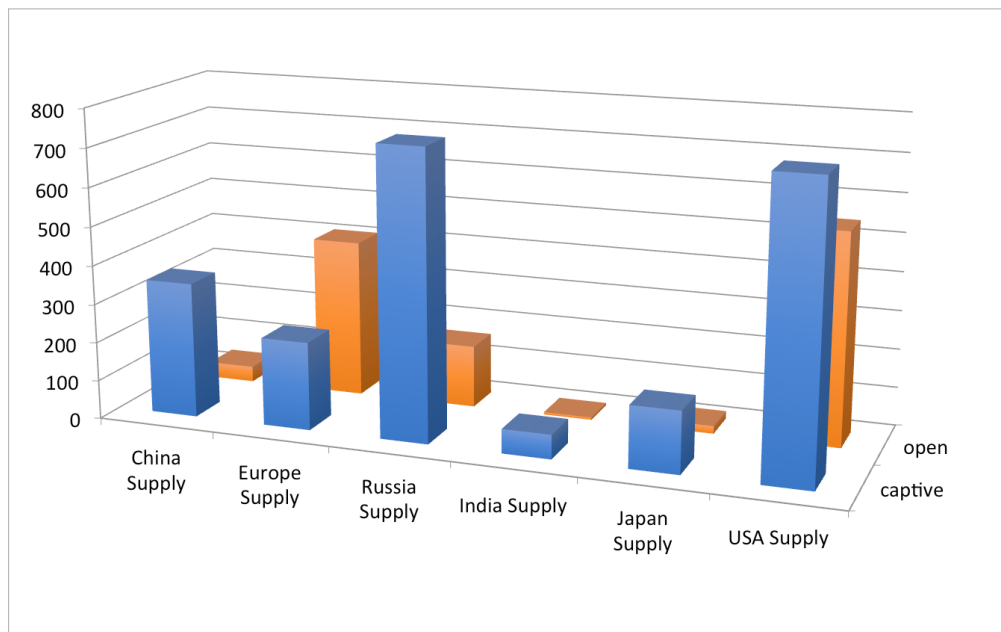
THE MARKET SITUATION AND OUTLOOK

SPACECRAFT MARKETS

Over the past decade almost 1800 satellites have been launched to orbit, including a growing number of cubesats and nanosats (800) usually produced by student organisations.

The core spacecraft market (i.e. 99,7% of the mass launched to orbit) is thus composed of approximately 100 larger satellites (>50 kg) of all types launched every year. This activity is still relevant in majority to government-sponsored programmes (66% of the total), a market segment which is qualified as 'captive' insofar as its demand is only accessible to domestic suppliers. Captive markets create strong externalities to spacecraft markets worldwide.

Captive vs open spacecraft markets 2007-2016 (tons)



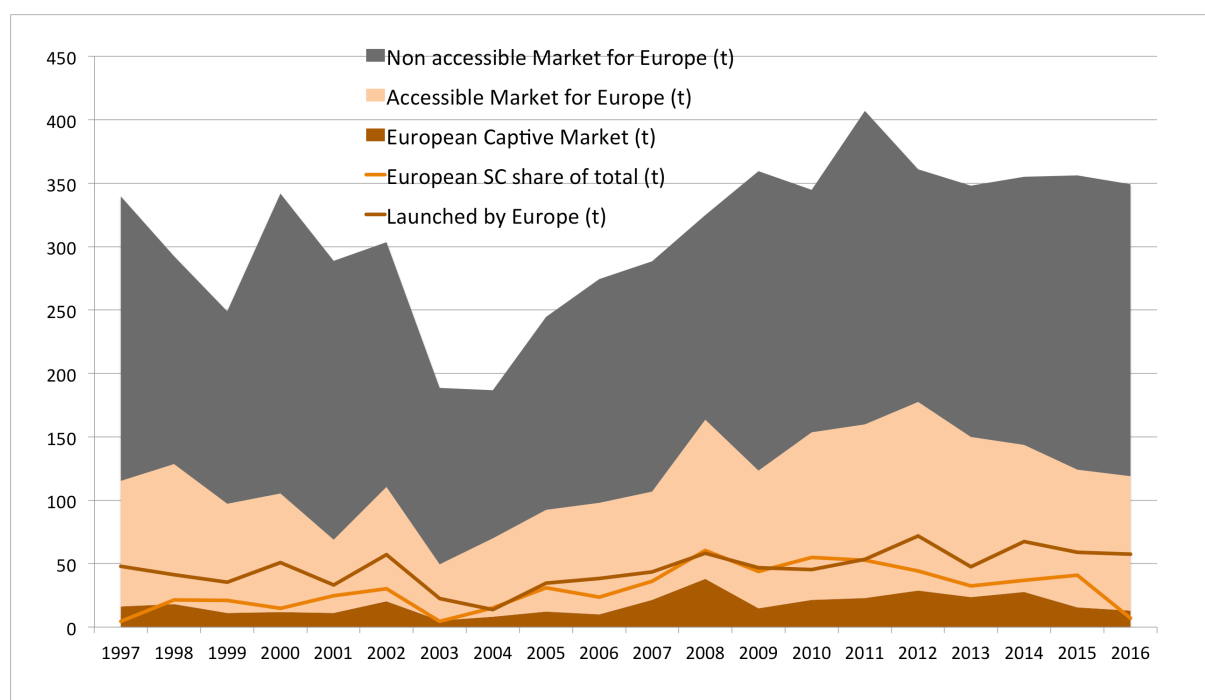
Source: Eurospace LEAT database

The largest spacecraft production volumes are in the USA and Russia, followed by Europe and China. For Russia and the USA a large share of this production (resp. 63% and 24%) is associated to crew and cargo systems for ISS servicing, otherwise the majority of the satellites are communications and observation systems (55% in mass, 63% in number).

Industrial sectors worldwide are not exposed to the same market dynamics, and while the Chinese Russian and Japanese industries are mostly serving a captive domestic demand, European and US industries are also competing on the global market. But only in Europe the captive market represents a lower volume of activity that the open market.

As a whole, Europe position accounts for approximately 30% (in volume) of the overall space accessible market.

European accessible market and market penetration (in tons at date launch)

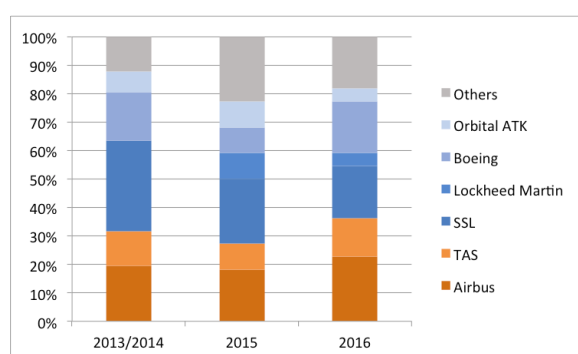


Source: Eurospace LEAT database

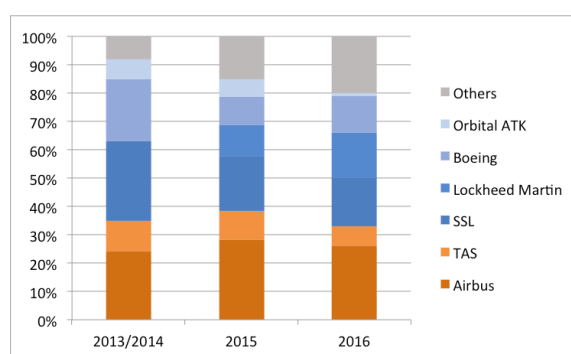
A key component, in both volume and value, of the open market is the commercial demand for large geostationary communication satellites. This is a market segment where European companies have been improving their market share against US competitors in the past decade, and where new entrants (China) are increasingly challenging established positions.

Order intake - GEO commercial market

Main suppliers share (% of value)



Main suppliers share (# of satellites)



Source: Eurospace LEAT database

LAUNCHER AND LAUNCH SERVICES MARKETS

Independent access to space with Ariane and Vega has been a true European success, providing Europe with a strategic and commercial space sovereignty, supporting autonomy for applications in security and defence, meteorology, resources monitoring, positioning, crisis response, and telecom, improving the effectiveness of EU policies and the quality of life of European citizens

Arianespace results prove that European launchers are competitive, reliable, and highly capable. Market share is over 50%, and Ariane 5 has set world records with 81 successful

launches in a row (as of 29 September 2017) and 10.7 t payload in geostationary transfer orbit (GTO). Similarly, VEGA has demonstrated faultless operations since its maiden launch and is now attracting commercial customers.

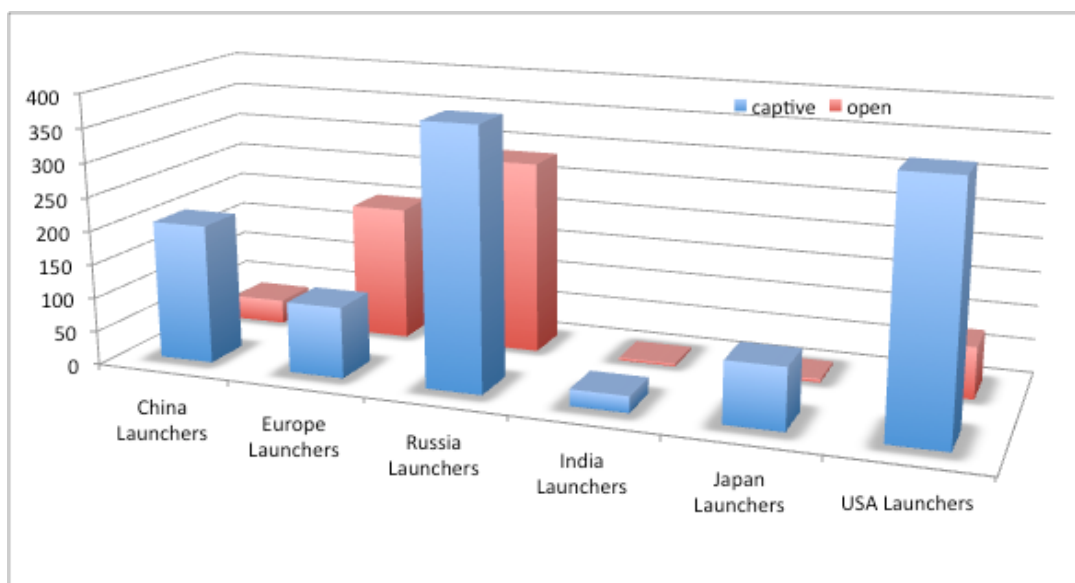
The European launcher industry is committed to remain competitive and continue this success story with a more efficient organization and new rockets in development, Ariane 6 and Vega C, slashing the cost of access to space. But this will require levelling the playing-field, and ensuring fair competition.

Today, only 25% of the world market for launch services is accessible to European launchers. Indeed, most spacefaring nations fly their institutional payloads on their own domestic launchers. For instance virtually all NASA or US DoD missions are reserved to American launchers at very interesting prices compared to the current commercial rates. This captive market (up to 15 institutional launches per year) enables American companies to be more aggressive on the international open market. The new administration is expected to maintain this approach.

In contrast, in the past decade, only 32 out of 138 of European institutional missions (but worth 57% of the total launched mass) were flown on European launchers. This rationale led to a general agreement for the purchase by European institutions of an average of five launches per year on Ariane 6 and two on Vega C, reached at the ESA ministerial conference of 2014, as a key condition to secure target production rate and prices.

US investors and other key Space powers (including new entrants) across the world are enabling a new ecosystem of businesses which is not paralleled elsewhere.

Captive vs open launch services markets 2012-2016 (tons)



Source: Eurospace LEAT database

The figure above illustrates the difference of level playing field between Europe and the rest of the world concerning the relative exposure to open or captive markets for launch services.

CURRENT GAME CHANGERS

In the few last years, the attractiveness of space-based services have tremendously increased because of:

- The eagerness of the consumers for always more digital services (continuous flow of new usages)

- The commercial market willingness to increase its share by addressing all the potential customers on Earth.

The intrinsic global coverage of satellite services and recent significant technology progress (ie Miniaturisation, High processing performance, etc.) thus triggered the interest of a new type of customers stemming from the “Big Players of the Web Planet”, players with huge financial capacity and an approach to risk totally disruptive in comparison to the traditional space sector.

Those new actors show a strong appetite for LEO (mega) constellations and are characterised by:

- Investment decisions dictated by added-value on content creation and even sometimes by a true taste for adventure (Mars colonization or asteroid mining projects)
- Wide distribution and a hard design-to-cost approach with challenging targets
- Faster product life cycles
- Access to spectrum resources (especially for constellations) versus established operators
- New solutions for quick and lower cost access to Space

Stakeholders of the GEO telecommunication market, stable in the last decade (about 20 GEO orders per year), have entered a profound reflection period: many ways are explored to best address the need for solutions that can adapt to an extremely moving market throughout their life time. Payload flexibility and design-to-cost approaches are key, but more impactful trade-offs are also on-going which have strong design consequences (e.g one very large GEO for 15 years vs several small GEO launched every few years).

On Earth Observation Europe has proven success in exporting space-based Earth observation Systems/infrastructure and Services. This is a first significant step but new challengers like Israel, Korea, Russia, China and US (with its huge public funding support) are strongly pushing on the worldwide market. On these export markets Europe can only survive by cutting edge technologies and low cost and smart approaches.

On Orbit Services concepts are being discussed worldwide, which is supported by an increased interest in Space based infrastructure and In Space operations. Such services are requesting potential lower cost solutions for access to space, in orbit transportation and delivery, in orbit maintenance and repair, de-orbiting and debris removal.

In the launcher and launch services market new disruptive approaches are being proposed by international competitors, notably via the introduction of re-usability concepts and the vertical integration of supply chains to achieve leaner, faster and cheaper production and the overall reduction of launcher life-cycle costs. Within this context Europe is promoting an updated industrial organisation for launcher development and production and will look closely at all aspects enabling competitiveness increase for European launch services, including system and architecture improvements, new manufacturing approaches and modern production schemes.

US investors and other key Space powers (including new entrants) across the world are enabling a new ecosystem of businesses that is not paralleled elsewhere.

All these game changers in Space do necessitate pursuing a competitiveness and innovation effort harder than ever together and add-on a design-to-cost- approach and more industrial agility to keep Europe at a leading position. A strong and reactive future FP9-Space Work Programme should support those goals. Industry leadership for a reactive planning is mandatory.

ANNEX - EUROPEAN SPACE RDT&I FUNDING SITUATION

EU PROGRAMME FOR SPACE TECHNOLOGY DEVELOPMENT

The EU has established with H2020-Space a comprehensive programme supporting the improvement of European space sector readiness. This programme has three main components: activities in support of industry competitiveness, activities supporting the market uptake and services development for European flagship programmes (Galileo and Copernicus) and preparatory technology development for the evolution of GNSS. **Overall the amounts available for grants in the context of H2020-Space represent 170 to 200 M€/year, of which 60-70% (120 M€/year in average) are relevant to space system research and technology development.** Within the context of H2020, as with previous Framework Programmes of the Union, support for research is provided in the form of grants proportionally leveraging private sector investment.

ESA PROGRAMMES TECHNOLOGY SUPPORT

The primary goal of the ESA technology programme is to support technology development up to mainly TRL 4 & 5, more rarely 6 and above (higher TRL – namely 8/9 – being necessary to complete the development cycle). ESA, through the funds provided by its member states, is the main provider for research and technology developments for space programmes in Europe. **The average research and technology budget available annually through ESA is in the order of 390 M€.**

The TRP, ARTES, GSTP and FLPP schemes represent three quarters of the ESA RDT&I effort:

- The TRP is one of the two mandatory programmes (with the CTP) and is the only one to cover the entire spectrum of ESA technical activities. With an average annual budget of 68M€, the TRP typically targets developments up to TRL 3-4. The TRP 2016-2017 Work Plan is led by generic technologies (42%), earth observation (15%), science (13%) and exploration (12%). The TRP scheme also includes the Innovation Triangle Initiative (ITI), an approach focusing on on innovation and spin-in. With a yearly budget of 2M€, it targets TRL from 2 to 5 (depending on the type of the contracts).
- The GSTP is the second major generic program of ESA. It targets TRL 6 and above, with an approximate 90 M€ yearly budget. Unlike the TRP which is based on a two-year cycle, the GSTP cycle runs for five years.
- The ARTES context allows ESA to work on telecommunications RDT&I activities, mainly through ARTES Advanced Technology (AT, 20M€, TRL 3-6) and ARTES Competitiveness & Growth (C&G, 90M€, up to TRL 8). ARTES allows for very close cooperation with industry and involves a share of industry investment in the developments.
- The FLPP⁸ aims at developing future technologies for launchers; it targets TRL 4-6 with a 40M€ yearly budget.
- Other targeted technology programmes are EOEP, CTP, ETHEP, EGEP, ELIPS, ETP and ECI.

⁸ Ariane 6, a major development programme, is not included here, as it focuses on system rather than on technology.

NATIONAL PROGRAMMES FOR TECHNOLOGY SUPPORT

It is difficult to achieve a consolidated view of the nationally funded space RDT&I due to the variety of programmes and the differences in definitions for RDT&I in the main countries. It is however confirmed that France and Germany are the largest investors in national space RDT, with lower relative contributions to ESA budget. **In total the average annual budget available for research and technology support through European national programmes is estimated at 150-250 M€ depending on the TRL and areas considered.**

- France 36M€⁹: RDT&I activities funded nationally focus on demonstrators for orbital systems and strategic electronic components; it is worth noting that launchers demonstrators and thematic RDT&I (e.g. telecom, earth observation) are excluded from this budget.
- Germany 135M€¹⁰: the German national support to RDT&I includes a large share of supporting funds for DLR institutes where activities for space research focus on exploration robotics, laser communication, multistage propulsion, telecom payload/platform technology in-orbit demonstrator, test platform for new telecom technologies (high TRL).
- Italy 15M€: Italy's investment in support of national RDT&I is mostly organised through the Agenzia Spaziale Italiana (ASI). ASI's RT&D developments mainly follow a mission-oriented approach, meaning that technology and innovation are focused on the improvement of available products and new enabling technologies. In particular ASI support to RT&D includes semiconductor devices, sensors, materials, small satellites (with a main focus on high TRL technologies to be embarked and qualified), Navigation, Aerocom, SAR for Earth Observation and Exploration. RT&D activities (up to TRL 6-7), including the internal contribution, amount to about 20% of the production (data from *Distretto virtuale of ASI*). In the next three years, more than 1 billion euro will be invested in the frame of the Strategic Plan of the Space Economy. A substantial part of this budget will be allocated to RT&D activities.
- Spain 9 M€: Spain manages to promote, on top of its investment in ESA a small strategic RDT&I programme at national level. It currently supports EO instruments aiming at a promoting readiness for complete EO space system (national GMES/Copernicus contribution), telecom payloads, in-orbit demonstration (high TRL), space surveillance and tracking systems.
- United Kingdom (no budget info): from exploratory ideas (low TRL) to flagship projects (high TRL; e.g. small sat constellation, new maritime telecom infrastructure).

⁹ Limited to non-thematic activities (source: ESTMP 2016).

¹⁰ Based upon DLR Facts and Figures 2015.

ANNEX - H2020-SPACE FEEDBACK

H2020-Space positive points

- H2020-Space is supported by a good financial envelope for Industries, academia and SMEs.
- Surely H2020-Space has been able to gather multiple interests: MS, Academia, Sciences, Industries, and year after year to enforce links with other H2020 Work Programmes: space is now also considered in activities dealing with Sustainable Food, Security research, Navigation applications, Climate Action, Environment, Resource Efficiency and Security.
- H2020-Space has implemented a top-down approach for the research and innovation on strategic topics as Electrical propulsion and Space Robotics: the two specific Strategic Research Cluster (SRC) involve Agencies, Industry, Academia, for providing a vision but also pragmatic Roadmaps.
- H2020-Space Work Programmes have evolved towards an always better understanding of industry and researchers needs demonstrating the capability to adapt the topics /instruments to these requests
- H2020-Space is supporting cutting edge research and technological developments and has allowed for fast reactions to important developments like Electrical Propulsion, Big Data as well as new class of EU high performance microprocessors and optical communication.

H2020-Space, areas for improvement

- Workprogramme definition process insufficiently open to industry recommendations, the Programme Committee has not promoted a coordinated European vision for the future of Space.
- Lack of technology roadmapping, definition of priorities, coordination and feedback loops.
- Need to set up programmatic guidelines to strike the appropriate balance between high and low TRL.
- Need to organise a pan-European coordination scheme for space RDT&I to reduce the fragmentation of funds and promote a critical mass for actions directed to integration of technology. A global vision for European space RDT&I would be required, with the active consultation of all stakeholders.
- Enable appropriate consideration for the development of dual use technologies.
- Improve the leverage factor by promoting an end to end roadmap from technology to market and products.
- Improve the ratio of good/excellent proposals vs. funded proposals: a low success ratio discourages the participation, and wastes resources leaving a number of high quality proposals unfunded. A solution for recovering high quality unfunded proposals shall be found.
 - In the 2016 COMPET calls, a total of 85 projects were retained after evaluation (with score above 11), but only 24 were eventually funded.
- Costs of participation are lower than in previous FPs but further simplification measures a (e.g. cost reimbursement) could help in reducing these expenses.

ANNEX - TASK FORCE MEMBERS AND MANDATE

The Eurospace FP9 Task Force was created by decision of Eurospace Council of December 2016. It was led by Pierre Lionnet (Eurospace Research Director).

MANDATE

The FP9 Task Force is established in view of supporting the preparation of a consolidated position of Eurospace on FP9-Space. The work shall be complete before the end of 2017. The TF will then be disbanded.

The Task Force is led by Eurospace Research Director.

TASKS

Produce by Q4 2017 a position paper to support the industry vision for FP9-Space, including elements promoting the political, institutional and industrial acceptance of a TBD JTI for space. To this end the position paper will include a technical annex where providing preliminary scoping for the JTI/ contents aiming at supporting the emergence in the MFF of the appropriate budget.

FRAMING CONDITIONS

The outline and preliminary contents of the position paper have been already prepared and agreed by Eurospace Policy Committee on February 8th (see Annex 1).

The Task Force activities were organised with 2 parallel strands supported each by a specific TF Sub-group with joint meeting points.

- Strand 1 - Policy Sub (PSUB): tasked to provide the high level political context of FP9 addressing (in order of importance): Political justification and political framing context for FP9-Space, overall FP9-Space budget, suitable FP9-Space mechanisms (with a focus on PPPs and JTI), FP9-Space coordination/articulation with other programmes (particularly JTI), success rate, IPR policy, open data policy, etc.
- Strand 2 - SRA Sub (SSUB): tasked to provide with the appropriate level of detail an outline SRA to justify the budget commitment for the JTI. The outline will be further expanded, refined and detailed in a TBD process to be defined/implemented in 2018-2020.

TF ORGANISATION

The TF was composed of the reunion of all members from the Policy sub (PSUB) and the SRA Sub (SSUB). Each sub was expected to be composed of a maximum of 10-15 active members.

- A call for TF candidate was launched using the mailing lists of the Policy Committee and of the Technology Policy Working Group of Eurospace to populate (respectively) the PSUB and the SSUB.
- The Co-chairs of SRTC, TPWG and THP are de facto members of the SSUB, and members of the TF.

TF MEMBERS' COMMITMENT

- TF members understand and accept that it is of the utmost importance that a suitable position paper is elaborated to support appropriate budget and political context framing for FP9-Space in the multi-annual financial framework (MFF) of the Union.
- TF members understand and accept that the overarching goal of the position paper is to support the emergence of a JTI for space (with the appropriate framing conditions). The FP9 context is the overarching context.
- TF members accept the rules of the Task Force as described below:
 - Task Force members will strive at reaching consensus
 - Task Force will support timely review and approval of all documents
 - TF members commit to the TF calendar and will support all meetings (webex support will be available)

TF MEMBERS

1. ARIDON, Giuseppe - SVP Strategy & Marketing - Telespazio (Italy)
2. AYUSO BAREA, Antonio - Aerospace department - SENER Ingeniería de Sistemas (Spain)
3. BELLOFIORE, Paolo - Chief Technical Office Department - Telespazio (Italy)
4. BISERNI, Mario - CTO Technologies & H2020 Italy - Thales Alenia Space (Italy)
5. BRANCATI, Marco - Chief Technology Officer - Telespazio (Italy)
6. BUTHION, Lucas - Head Brussels Office - Eurospace (France)
7. CAMPAGIORNI, Paolo - Sales Manager - Thales Alenia Space (Italy)
8. CARAMAGNO, Augusto - Business Development Manager - Space programs - SENER Ingeniería de Sistemas (Spain)
9. CESARETTI, Giovanni - Sales and Business Development Manager - SITael S.p.A. (Italy)
10. COLAITIS, Olivier - VP ATM & SSA - Airbus Defence and Space (France)
11. D'HEILLY, Agnes - Institutional Relations - Ariane Group (France)
12. DURAND, Yves - Director of Technology - Eurospace SRTC and TPWG Co-Chair - Thales Alenia Space (France)
13. FAGERLIND, Viktor - System Engineer - Eurospace TPWG Co-Chair - RUAG (Sweden)
14. FERRANDON, Olivier - Directeur Propulsion Electrique Spatiale - Safran Aircraft Engines (France)
15. FLAMENBAUM, Serge - Head of Space R&D - Eurospace SRTC and THP Co-Chair - Airbus Defence and Space (France)
16. FROEBEL, Ludger - JTFP/ Head of RT institutional partnership & fundraising - Ariane Group (Germany)
17. GONZALEZ, Pablo - NATO & European Defence programmes - INDRA (Spain)
18. HAGEMANN, Gerald - Head of Site Ottobrunn. Head of Liquid Propulsion Engineering - Ariane Group (Germany)
19. JANOVSKEY, Rolf - Director Predevelopment, Space System Studies & Proposals - Eurospace THP Co-Chair - OHB (Germany)
20. LEMAITRE, Olivier - EU Relations - Thales Alenia Space (Belgique)
21. LINMANN, Andreas - Head of Security, Defence & EU Space R&D - Airbus Defence and Space (Germany)
22. LIONNET, Pierre - Research Director - Eurospace (France)
23. MACRET, Jean-Luc - Senior Expert R&T Plan - Ariane Group (France)

24. MARCOS, Jesus - Space business development- Space Market director - TECNALIA (Spain)
25. MARZOCCHI-POLIZZI, Sylvie - Institutional Relations Manager - Ariane Group (France)
26. MICHEL, Cyril - Telecom R&D Director - Thales Alenia Space (France)
27. MONTESANO, Carlos - Company Portfolio and R&D Manager - Airbus Defence and Space (Spain)
28. MORSILLO, Giuseppe - Secretary General - Eurospace (France)
29. PAVESI, Brunella - CTO Department - Telespazio (Italy)
30. PEREZ, Guy - Chief Technology Officer - OHB (Germany)
31. PONCELET, Lionel - VP EU Affairs - OHB (Belgium)
32. RADULOVIC, Serge - R&T Management - Institutional partnership & fundraising - Ariane Group (Belgium)
33. REGNIER, Sylvie - Senior Manager European R&T Institutional Affairs - Airbus Defence and Space (France)
34. SALVATORI, Agnes - KAM for European Affairs - Telecommunication satellites - Airbus Defence and Space (France)
35. SÁNCHEZ, Almudena - Business Development Executive - GMV (Spain)
36. SFORZA, Patrizia - Funded Research Manager - SITAEL S.p.A. (Italy)
37. STROBL, Gerhard - Director Business Development - AZUR Space (Germany)
38. TREUET, Jean-Charles - Technology Strategy Manager - Eurospace (France)
39. VALENTE, Cristina - Coordination - Telespazio (Italy)
40. VALES, Marc - Head of Future Programmes - Ariane Group (France)
41. VIEDMA, Emilio - Business Development - INDRA (Spain)

TF INFORMATION POLICY AND REPORTING

- All DRAFT and working documents elaborated in the context of the TF will be shared among all TF members through a dedicated webspace at www.eurospace-members.org. All DRAFT and working documents of the TF will be treated confidentially and shall not be disseminated outside the TF.
- The FP9 TF reports to Eurospace Council. Intermediate reporting is provided to Eurospace Policy Committee and Eurospace TPWG as required.
- Eurospace Director of Research is tasked with enforcing the TF information policy and status reporting.

TASK FORCE MEETINGS CALENDAR

- *Meeting 01 – April 20th*
- *Meeting 02 - May 17th*
- *Meeting 03 - June 16th*
- *Meeting 04 - July 18th*
- *Meeting 05 - September 8th*

ANNEX - RIAP OUTLINE, BUDGET AND BOUNDARY CONDITIONS

BACKGROUND OF THIS PAPER

This paper is a technical annex to Eurospace FP9 position paper. It is intended to provide preliminary scoping of activities with a view to the future setting up of a JTI for Space. It was prepared by the FP9 Task Force of Eurospace, the Association of the European space industry (the Space Group of ASD). It provides a preliminary framing context for the future elaboration of a **Research and Innovation Action Plan (RIAP)** for a TBD JTI for Space.

PRINCIPLES AND GENERAL SCOPE

The **RIAP** shall embrace all research, development and technology (RDT) activities for implementation with FP9 instruments having all the following characteristics:

- Activities driving industry competitiveness and sustainability through the full supply chain in launchers, spacecraft and ground systems, as well as in the development, manufacturing, integration and test processes.
- Activities aiming at the development, characterisation and/or validation of materials, processes, components, building blocks, software and equipment, exclusive of system level research
- Activities with potential for industry co-investment together with the EU, through grants, in the context of FP9 mechanisms
- Activities suitable for industry coordinated road-mapping. It is understood that the RIAP should focus in general and whenever possible on common user requirements for technologies and building blocks developments. European double sourcing and/or multiple technological competitive solutions can also be envisaged if considered necessary.

The driving principles for the establishment of the RIAP are presented in the introduction, they respond to the well-identified need to **promote readiness and innovation for materials, processes, components, building blocks and equipment to support competitive European space systems.**

DRIVERS FOR THE RIAP

The Eurospace Task Force has identified 7 key drivers for space systems RDT&I, all aiming at improving the competitiveness of the European space systems supply chain.

MADE IN EUROPE

Space systems and related technologies are highly regulated goods, which cannot be traded freely at international level. Unrestricted access to state of the art solutions can only be guaranteed in the long range by developing domestic capabilities with the suitable levels of readiness (maturity) and competitiveness (cost/performance mix). **Whenever a technological solution is required to perform a critical function on a European space system but cannot be procured in Europe a situation of dependence is created with dire political and economic consequences.** Since 2009 European institutions (ESA, EC, EDA) have decided to address the critical dependence situations from a political perspective aiming at reducing critical dependence situations. A permanent monitoring process (The Joint Task Force for critical technologies - JTF) enables the identification of critical technologies with dependence situations with the support of all stakeholders. A dedicated

line in Horizon 2020-Space specifically targets dependence reduction, but can only address a subset of the critical situations.

The **'made in Europe' approach for all critical products and technologies is an important driver** of the RIAP. It will complement and enhance the current efforts for critical dependence reduction.

PRODUCT-ORIENTED FOCUS

Historically space systems have been produced in rather limited numbers every year¹¹, giving a strong emphasis on customer driven optimisation at all levels of the system, from the overall system architecture down to the specification of components, equipment and building blocks supporting the various system functions (power, thermal control, propulsion, computing, data handling etc.). This situation resulted in a supply chain mostly geared at providing tailored solutions for each system, with limited standardisation and few commonalities of requirements¹².

The evolution of space markets where customers are more drawn to services and more focused on life cycle costs, as well as the development of applications requiring the production of batches or series of identical systems in (for constellations e.g.) introduces a new paradigm where low level components, building blocks and equipment can now be produced in much larger quantities than before. This trend has to be supported by product-driven RDT&I, promoting, e.g., **commonalities of requirements, the standardisation of interfaces, and product re-use across various sub-system designs and architectures**. Furthermore, a product-oriented focus shall enable the production in large batches and even long series when the demand allows it. To this end **the streamlining of the quality process is an essential enabler, supported by the reduction/optimisation of testing, solutions for quality increase and lower rejection of parts**. Successful products developed for successful markets are the key to **supply chain sustainability**.

FAST TIME TO MARKET

Space based services and space data are playing a growing role in the global digital economy (e.g. Earth resources data and imaging, climate monitoring, device tracking, border control, fast data transmission, mobile communications, location based services etc.). Space systems must keep up with the fast paced innovation of digital services that drives modern economies. **Solutions for fast track innovation in space systems and services shall be promoted, to reduce the lead production time of space systems at large, through the promotion of an integrated innovation to development and production processes**.

SPIN-IN AND COTS

Space technology and products are required to withstand the harshness of space environment (extreme temperatures, radiations, micro-particles, vacuum...) for long time durations ensuring the continuity of operations. To this end, components, technologies and products undergo incremental development cycles before they can be qualified for use in space systems, resulting in higher costs, lower production rates, and slow integration processes. **The use of Commercial-off-the-shelf (COTS) components can be a solution to improve the readiness and competitiveness of European space systems**, particularly for large satellite series and for applications where cost and performance trade-offs are

¹¹ In average European space industry delivers 20-30 spacecraft and 8-10 launchers to the launch pad every year, with associated ground segment infrastructures

¹² This is particularly true for spacecraft systems but much less as far as launcher and ground systems are concerned

necessary. Notwithstanding, **the integration of COTS products in space systems requires specific research to ensure the appropriate delta qualification, to validate their use in the space environment and to certify and validate new materials and production techniques.**

MATURITY AND IRL (INTEGRATION READINESS LEVEL)

The maturity of a technology is an essential factor for the reduction of risks associated to the introduction of innovations in space systems. A specific technology readiness levels (TRL) scale has been elaborated for space technologies, with 9 steps, from the moment where the basic scientific principles have been demonstrated up to the eventual demonstration of the technology in operational conditions. While space systems are often developed as prototypes pursuing science and technology missions for which taking some technological risks is acceptable, whenever space systems are expected to pursue an operational service the introduction of technological risks is unacceptable. For this reason all space technologies must be brought to the appropriate maturity level in the TRL scale to allow their integration in operational systems. This maturity level is the integration readiness level (IRL). Achieving IRL is an essential target of product driven research activities. Depending on the type of system and on the customer/service expectations the IRL will be associated to a TRL of 5 and above. **The objective of achieving proper maturity and IRL is to avoid the need for delta-qualification for the introduction of technological advances in space products and systems.**

The technology readiness scale for space

Readiness Level	Definition	Explanation
TRL 1	Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development.
TRL 2	Technology concept and/or application formulated	Once basic principles are observed, practical applications can be invented and R&D started. Applications are speculative and may be unproven.
TRL 3	Analytical and experimental critical function and/or characteristic proof-of-concept	Active research and development is initiated, including analytical / laboratory studies to validate predictions regarding the technology.
TRL 4	Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that they will work together.
TRL 5	Component and/or breadboard validation in relevant environment	The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment.
TRL 6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)	A representative model or prototype system is tested in a relevant environment.
TRL 7	System prototype demonstration in a space environment	A prototype system that is near, or at, the planned operational system.
TRL 8	Actual system completed and "flight qualified" through test and demonstration (ground or space)	In an actual system, the technology has been proven to work in its final form and under expected conditions.
TRL 9	Actual system "flight proven" through successful mission operations	The system incorporating the new technology in its final form has been used under actual mission conditions.
TRL 9	Actual system "flight proven" through successful mission operations	The system incorporating the new technology in its final form has been used under actual mission conditions.

ENVIRONMENTAL CONCERNS AND REGULATIONS

The world has become increasingly environmentally conscious, and space is no exception, particularly when considering how much space systems have contributed to the understanding of the global eco-system. In Europe the REACH¹³ regulation is spearheading the reduction of the environmental impact of industrial activities. The regulation affects the way and pace systems are designed and produced by phasing out progressively all chemical substances causing 'very high concern'. The space sector is a high-end integrator of many technologies, and is **highly affected by many substances subject to REACH** (for surface treatment, propellant, adhesives, cleaning etc.). Specific RDT actions are taken to identify and qualify for space use suitable substitutes, and/or to reduce the overall impact of using substances with environmental concerns by applying **eco-design and eco manufacturing** techniques.

END OF LIFE REQUIREMENTS & DEBRIS MITIGATION

The protection of Earth environment now stretches beyond the Earth atmosphere, and growing concerns are arising regarding the pollution of the Earth orbital environment: what is generally called the **space debris situation**. Space debris can be created by satellites having reached their end of life, by unexpected/unavoidable collisions with already existing debris or by operations for the satellite insertion in orbit. Space debris pose a real threat to the safety of operations in orbit, and their reduction and mitigation has now become a major commitment of European space stakeholders. For instance, regulation is now introduced for the controlled removal of satellites from their operational orbit when the mission is over. This regulation is enforced for the majority of European institutional programmes.

To pursue the goal to mitigate space debris¹⁴ growth in the future, and abide to current regulation, targeted research is required in such areas as **equipment and subsystem demise-ability, the characterisation of materials in the context of controlled orbital re-entry as well as controlled break-up solutions**.

INNOVATION AND BREAKTHROUGH

Each and every product and application in modern economies seek the opportunity for breakthrough and disruptive innovations, game changers that will broaden the horizon of applications, or enable new markets and services. **The pursuit of innovation is thus a major driver for space research and technology development**. The careful evaluation of technologies at very low maturity levels, the assessment of **disruptive solutions**, the elaboration of **new concepts and new product designs**, the introduction of advanced technologies and **new approaches in modelisation, test, and manufacturing** will support the medium to long term evolution of space systems, services and applications.

Activities that provide breakthrough solutions or new horizons for space systems and missions, include **low TRL research, new mission concepts ground breaking innovations in development and manufacturing techniques, models improvements** etc.

¹³ <https://echa.europa.eu/regulations/reach>

¹⁴ *De-orbiting is a pilot topic identified for implementation in the upcoming Pilot Project for Space technologies funded by the European Union as a prototyping approach for a future JTI in the space sector.*

FIVE CHALLENGES FOR A COMPETITIVE AND SUSTAINABLE INDUSTRIAL BASE AND SUPPLY CHAIN

*The Eurospace FP9 Task Force has identified 5 main challenges for a competitive space industrial base focusing on technology, building blocks, equipment, and software in the next decade. This list is not limitative, and does not preclude the further identification of actions of interest for implementation in the context of a JTI for space, such as the two topics already proposed by European Parliament in the context of the Pilot Project: **Critical materials and De-orbiting**.*

The five challenges are:

- Components, materials & tools for non dependence and leading edge
- Equipment supply chain and a stronger technology base
- Beyond (Space) Industry 4.0
- Affordable, greener, adaptable access to space
- Innovative Ground Segment

The total EU contribution required to address key challenges in the context of FP9-Space is estimated between 0.5 and 1,25 Billion Euro, to leverage investment by the private sector. The current working assumption is FP9 duration of 7 years.

Important note: budget estimates proposed to address each challenge are inclusive of both private sector and EU contribution. They are rough orders of magnitude and shall be further expanded and refined when the industry action plan is expanded into an actual planning and roadmapping of activities.

COMPONENTS, MATERIALS & TOOLS FOR NON DEPENDENCE AND LEADING EDGE

EEE¹⁵ components are key elements in the competitiveness of European space systems: they are found in most space equipment, whereas all space equipment are significantly driven by EEE components w.r.t. cost, performance, reliability and timely availability.

The EEE components is an area where widespread technological dependence provides programme uncertainties; indeed, components with high levels of performance and reliability are often sourced outside Europe, and are associated to trade and export limitations that eventually hamper European system competitiveness. Today, the readiness of European solutions for EEE components is still an issue, despite the significant efforts already pursued in the past decade, and the results achieved so far to reduce the recourse to non-European components for European programmes.

The good alignment of all component related initiatives, programmatic actions and efforts would support the emergence of a sustainable European supply chain for high-reliability/high-performance components. In complement, developments aiming at introducing COTS components in space systems with less demanding performance and reliability requirements should be considered as well.

Materials and processes are providing the foundations of industry competitiveness.

Materials, such as composite, ceramics, metals, and alloys are used for their many properties in the thermal, mechanical and electrical domains. Materials provide space systems with specific solutions, often un-dissociable from the production and design process itself. Like components, materials are an area where supply chain and dependence issues

¹⁵ Electric, Electronic and Electromechanical

are common, with dire impact on industry competitiveness. The continued investigation, assessment and development of materials, and advanced manufacturing techniques need to be pursued.

For the efficient introduction of new materials and components in new products, the challenge needs to be complemented by suitable **advances in design, engineering and modelling tools**.

The components materials & tools is a critical challenge for the European space systems supply chain.

Areas for development

Within this challenges it is recommended to support the **development of a complete supply chain for European components and materials, including the relevant engineering, modelling and validation tools** for a sustainable and competitive industrial base. In all areas, the concerns of thermal stability, high temperature (and high voltage) operations, the susceptibility to space environment and abidance to European environmental regulations will be paramount.

Recommended development strands

- EEE components
 - Hybrids and micro packaging
 - Digital and analogue
 - Optoelectronics active and passive
 - Power components
 - PCBs
 - Microwave and Millimetre wave
- Materials
 - Light metal alloys
 - Ceramics
 - Composites
 - Critical materials¹⁶ e.g. greases, adhesives, solvents etc
- Specific engineering & analysis tools
 - Radiation, environment, outgassing, venting etc.
 - Validation of the models (radiation, environment etc.)

Expected impacts:

- A fully qualified and sustainable components and materials supply chain, including engineering, environmental and modelling tools
- A sustainable European EEE components supply base for state of the art systems and performance through the full data handling chain.
- New enhanced and qualified materials, with advanced properties.
- Better design and modelling capacities, faster development to production process, improved engineering margins for system optimisation.

Indicative budget

¹⁶ This is the subject identified as N28 in the latest JTF assessment and a topic that will be addressed as a prototype within the upcoming Pilot Project for Space technologies funded by the European Union

A total budget in the order of 250-300 Meuro is expected to appropriately cover this challenge.

EQUIPMENT SUPPLY CHAIN AND A STRONGER TECHNOLOGY BASE

Combined Innovation in Systems and Enabling/baseline Technologies is necessary to develop products with leading edge performance to meet customer expectations. The competitiveness of the global supply chain, and its ability to innovate is strongly driven by the integration of new state of the art technologies and innovation in manufacturing processes for the design, development and production of space equipment. A competitive equipment supply chain provides the essential foundation to European space systems performance and worldwide competitiveness. **The supply chain is thus expected to be proactive, reactive, innovative, reliable and sustainable.**

European equipment are also expected to support new challenges for space markets, and in particular shorter lead times, adaptability to market evolutions, production in larger series or batches, with global quality control, and a higher potential for re-use, considering interfaces, standard designs and applicability across a variety of systems, missions and applications.

The progressive integration of newly developed components, the use of innovative materials and the recourse of innovative models and engineering tools provide for strong synergies of this challenge with two other challenges in the RIAP: "Beyond (Space) Industry 4.0" and "Components, Materials & Tools For Non Dependence And Leading Edge".

Research for the strengthening of the European equipment supply chain will address two main areas:

- Incremental RDT, aiming at the adaptation, verification and qualification of incremental improvements to existing equipment and functions for spacecraft, launcher and ground systems; including the progressive integration of newly developed components and building blocks.
- Innovation or disruptive RDT, aiming at the introduction of more radical innovations in technology and/or or processes in the equipment supply chain for spacecraft, launcher and ground systems.

Areas for development

This challenge shall address RDT on equipment and building blocks (and related software) for:

- Spacecraft systems, focusing on payload and platform functions (including robotics and GNC)
- Launcher systems, focusing on all functional areas, including structures, avionics and propulsion

Recommended development strands

Equipment, technologies and building blocks (and related software) for system competitiveness:

- Propulsion for satellites, probes, landers, ascent vehicles, transfer stages
- In orbit refuelling building blocks
- Power, incl. generation, storage, power control & distribution technologies, digital control
- GNC/AOCS sensors and actuators

- Avionics equipment, on-board processing
- Thermal solutions, incl. deployable radiators, advanced heat transport systems, etc.
- Software components (protocols, operating systems, algorithms...)
- Payload generic equipment and building blocks (amplifiers, receivers, reflectors,...)
- Secure communication solutions (service and TT&C) counteracting threats (interference, jamming, spoofing) inc. active antennas, spread-spectrum, geolocation systems, etc
- Advanced mechanisms and structures
- E2E Cyber-security technology

Expected impacts

In all areas the key impacts will be the improvement of the cost/performance competitiveness mix, the enlargement of the demand base, the sustainability of the supply chain and the compliance to agreed debris mitigation guidelines. In some areas where space is at the forefront of research spin-off from space to Earth is another potential positive impact.

The expected impact will be further appreciated with respect to the functional areas concerned, for example:

- Electric Propulsion Technologies
 - High power and performance, versatility, ...
 - Low cost small EP systems,
 - Propulsion system building blocks competitiveness and independence (e.g. valves)
- Chemical Propulsion Technologies
 - REACH compliance, 'green' propellant formulations, low-toxicity/high-performance...
 - Propulsion system building blocks competitiveness and independence,
- Power
 - Improve system power density and cost
 - Innovative solutions for power system performance, new concepts, new technologies, disruption
 - Overall Power systems capability improvement
- Avionics
 - Data handling system performance, fast processing, fully digital data handling
 - Formation flying solutions for new system approaches, distributed payloads
 - Miniaturised and cost effective IMU
 - Miniaturised/integrated functions, hybridisation
 - Stability, pointing & accuracy, enablers for new missions
 - Autonomy and system performance,
- Telecommunications Payloads and TT&C
 - Digital payloads, bandwidth, flexibility, throughput, power and overall lifecycle efficiency for customer satisfaction
 - Improvement of QoS in terms of confidentiality, integrity and availability.
- Remote sensing payloads (all bands)
 - Thermal and mechanical stability, performance, support to new missions, market driven solutions...

Areas with high potential for spin-offs:

- Power systems (generation, storage, management)
- Processes (epitaxy, Advanced manufacturing, integrated testing, system health management)
- Hybridisation, and miniaturisation of functions (position sensors, attitude sensors, micropackaging for electronics...)

Indicative budget

A total budget in the order of 200-250 Meuro is expected to appropriately cover this challenge.

BEYOND (SPACE) INDUSTRY 4.0

Digital technology has become essential to competing in the space industry. Today, many companies in the sector are investigating digital capabilities, they are prioritizing digital investments and investing significantly in specific areas to gain competitive advantages and must take a **comprehensive, integrated approach to digital adoption and for the introduction of processes for innovative manufacturing, from concepts development to the final output.**

New digital technologies that have high potential for applications in the space sector:

- Advanced and cooperating industrial robotics
- Additive and innovative manufacturing such as 3-D printing
- Horizontal data integration across companies in the supply chain promoting fast development and integration process throughout an automated value chain
- Solutions for augmented reality enabling higher quality, new designs and enhanced workforce efficiency and productivity
- Simulation, modelling, virtualisation for faster/better design to product and integration of production
- Innovative approaches to address data processing challenges and 'big data' management

The expected solutions shall also become enablers for the transition of the space industry towards **larger production batches and, when applicable, series and integrated production lines.**

Areas for development

This challenge shall address the development and take up of European design models and tools for system and architecture development and optimisation, in engineering, system virtualisation, simulation, and modelling.

It shall also promote new manufacturing approaches in all areas of space systems, from concept to design, development and production, and from the component to the final system.

Key areas for development are: European tools for system, subsystem and equipment design, simulation, engineering and integration, and solutions for simulation, virtualisation, performance modelling.

Recommended development strands:

- Streamlined industrialisation, manufacturing and testing processes
 - 'Digital' space manufacturing plant

- Design and modelling tools
- AIT & AIT-support technology
- Integration of augmented reality for space systems AIT
- Built-In Test Equipment (BITE) for space systems
- Evolution of ground support equipment for test handling and integration (EGSE/MGSE)
- Next generation check out common elements
- Advanced Test facilities: Functional verification & environmental verification
- Robotisation and automation
- Quality and dependability
 - Smart inspection and control

Expected impacts: fast design to product, fast time to market, embedded quality control, large production series, reduced environmental impact

Beyond industry 4.0 expects to unfold key productivity gains for the space sector with high impact at all levels of industry including the possibility to deliver production in larger batches or series with enhanced cost efficiency and fully controlled quality processes and products.

Changes will affect in depth the way space systems are conceived, designed, elaborated and effectively produced. Better integration in the value chain will result in shorter lead times with higher quality outputs. Automated processes will support unit cost reduction. The optimisation of designs, will support identifying & reducing over-margins (from system level to end-to-end operations).

Other benefits will include: the optimisation of trade offs between ground and space segment, the standardisation of approaches with more cross-platform solutions, unified approaches and lower environmental impact of industrial activities.

Indicative budget

A total budget in the order of 200-250 Meuro is expected to appropriately cover this challenge.

AFFORDABLE, GREENER, ADAPTABLE ACCESS TO SPACE

The challenge for an affordable, greener and adaptable access to space is considered in the context of the European next generation launchers development programmes. It addresses a subset of activities aiming at the preservation of a European independent access to space within a highly competitive environment, and it looks at the future. Overall, **European launch services competitiveness and reliability are driving factors for this challenge.**

Improvements and evolutions are expected to contribute to propulsion improvement and to system and architecture level. Key areas will involve structure and materials at large (composites, REACH mitigation etc.), re-usability aspects, the propulsion system and advances in process and manufacturing at all levels of the supply chain.

Areas for development

Within this challenge, it is proposed to address functional studies for innovation in launch services, and developments for building blocks and technologies for a stronger and competitive launcher system supply chain.

Recommended development strands:

- Functional studies and system performance analysis
 - GNC

- Advanced data system
 - Solutions for system re-usability (concepts)
 - Re-entry solutions
- Technologies and building blocks
 - Function channel and avionics (e.g. hybridisation of sensors, digitalisation)
 - Propulsion technologies (main and secondary, incl. alternative oxidiser/fuel combinations)
 - Performance
 - Re-ignitability
 - Throttle-ability
 - Re-usability
 - Clean and/or alternative propellant formulations
 - Structures, materials and manufacturing (new materials, hybrids, AM impact...)
 - Advanced Manufacturing
 - Composite materials qualification and implementation
 - REACH compliance/mitigation
 - Smart Materials
 - Materials, Processes & Manufacturing: new methods, new materials
 - Advanced Manufacturing
 - Composite materials qualification and implementation
 - REACH compliance/mitigation
 - Smart Materials
- Engineering tools
 - Tools for system engineering and simulation
 - Tools and simulation for flight physics
 - Health monitoring and management for re-usable systems

Expected impacts

- Improve launch service/system end-to-end competitiveness, from development and manufacturing aspects, to cost reduction strategies at system, subsystems and equipment levels
- Support full life cycle cost assessment, minimise environmental impact of launch service, from development to manufacturing and operations
- Develop re-usability aspects and modelling/engineering tools for global cost effectiveness of space launch services.

Indicative budget

A total budget in the order of 200-250 Meuro is expected to appropriately cover this challenge.

INNOVATIVE GROUND SEGMENT

Ground systems are integral part of the space infrastructure. During programme operations ground systems provide the capacity to interface with the space segment for mission control (telemetry and command) and for mission operations (data downlink and uplink; data processing, distribution and networks).

In Earth observation, the performance of ground infrastructures and distribution platforms (data and services) becomes paramount with the huge increase of space imagery data to be processed exploited and distributed and the growing number of satellites used in constellation approaches.

In telecommunications applications the space segment is no longer the key item: important investments now are also associated to the multiple satellite ground stations and the terrestrial telecommunications networks that interlink them.

The ground segment now holds a large share of the whole space applications value added potential. The last decade has seen the growth of both consumer and professional segments, with some millions of user terminals now in service and the expansion of satellite data receiving stations.

Areas for development

Within this challenge, it is proposed to address developments for building blocks and technologies for ground segment innovation. With the focus on core and horizontal technologies and building blocks, the developments performed in this context will support implementation across many different services and applications. They shall also support implementation in professional stations and systems, as well as user terminals, in a scaled approach.

Recommended development strands

- Ground station and terminals, common building blocks, such as antennas, receivers, digital technologies, software defined radio chains...
- Control Centres and mission planning (technologies for multi-mission operations and constellations/mega-constellations)
- Cost effective and affordable data handling (storage, processing, distribution)
 - Massive and scalable processing, cloud processing, virtualisation
 - New concepts for data fusions, processing algorithms and processing chains
 - Innovation in data storage, management and access
- Infrastructure protection and security
 - Cyber-security
 - SST technologies
 - Signal threats protection (interference, jamming, spoofing)
- Optimisation of operations, addressing two main lines:
 - Automation (artificial intelligence, Data fusion, analytics & situation awareness...)
 - Human machine interfaces (augmented reality, voice/kinetic interfaces, cognitive assistance...)
- Simulation tools
- Test and integration equipment

Expected impacts

The objective is a cost effective, secure and affordable space segment for control and data dissemination.

The developments are expected to support overall system competitiveness and performance improvement in the following areas:

- Lower operations costs

- Increased service availability
- Quality controlled processes and continuity
- System responsiveness
- Openness to new services, flexibility and overall life time
- Reduction of latency (from user needs to product delivery)
- Increased security (data integrity, data protection...)
- Higher communication throughput

Indicative budget

A total budget in the order of 150-200 Meuro is expected to appropriately cover this challenge.