European Commission

Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe

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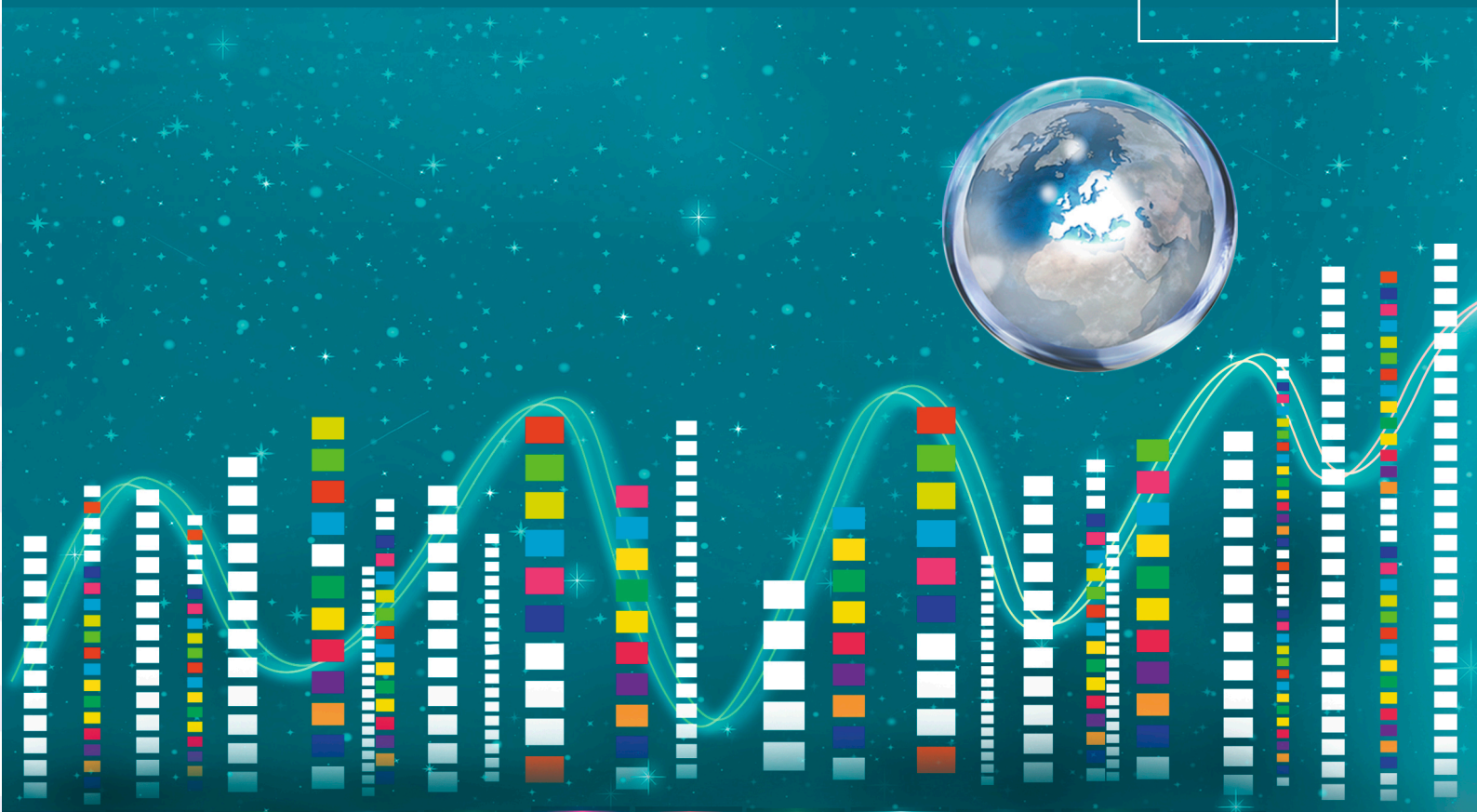
Report



Research and Innovation

Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe

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EUROPEAN COMMISSION

Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe

In collaboration with

2020 Directorate-General for Research and Innovation EN

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Introduction

This Impact Assessment Study had the primary objective to support and provide input to the impact assessments of the first set of 13 European Institutionalised Partnerships based on Articles 185 and 187 of the Treaty on the Functioning of the EU (TFEU) that are envisaged to be funded under the new Framework Programme for Research and Innovation, Horizon Europe.

In addition, the Impact Assessment Study team contributed to future European policymaking on the overall European Partnership landscape by means of a horizontal analysis of the coherence and efficiency in the implementation of European partnerships. The purpose of this analysis was to draw the lessons learned from the implementation of the impact assessment methodology developed for this study and to formulate recommendations for the refinement and operational design of the criteria for the selection, implementation, monitoring, evaluation and phasing-out for the three types of European Partnerships. Finally, an impact modelling exercise was conducted in order to estimate the potential for longer-term future impacts of the candidate Institutionalised European partnerships in the economic and environmental sustainability spheres.

Technopolis Group was responsible for the overall coordination of the 13 specific impact assessment studies, the development of the common methodological framework, and the delivery of the horizontal analysis. It also conducted specific analyses that were common to all studies, acting as a 'horizontal' team, in collaboration with CEPS, IPM, Nomisma, and Optimat Ltd. For the implementation of the individual impact assessment studies, Technopolis Group collaborated with organisations that are key experts in specific fields covered by the candidate Institutionalised European Partnerships. These partner organisations were Aecom, Idate, Steer, Think, and Trinomics. Cambridge Econometrics took charge of the impact modelling exercise.

The Impact Assessment Study was conducted between July 2019 and January 2020. The 13 Impact Assessment Studies were conducted simultaneously, based upon a common methodological framework in order to maximise consistency and efficiency. The meta-framework reflected the Better Regulation Guidelines and operationalised the selection criteria for European Partnerships set out in the Horizon Europe Regulation. The 'Horizontal analysis of efficiency and coherence of implementation' was conducted in the same time period, building upon the information available on the 44 envisaged European Partnerships landscape as in May 2019, complemented with information on five envisaged European Partnerships as decided by the European Commission in October and November 2019.

This final report contains the reports of all individual impact assessment studies and the 'horizontal' analyses. It is structured in two parts, reflecting the two strands of analysis:

PART I. Impact Assessment Studies for the Candidate Institutionalised European Partnerships

1. Overarching context to the impact assessment studies

This report sets out the overall policy context and methodological framework underlying the impact assessment studies for the candidate Institutionalised European Partnerships. It describes the changes in approach to the public-private and public-public partnerships under Horizon Europe compared to the previous EU Framework Programmes. An example is the requirement that all envisaged European Partnerships be implemented as either co-programmed, co-funded or institutionalised. The impact assessment studies will consider these three scenarios as the different options to be assessed, in compliance with the Better Regulation guidelines and against the functionalities that the candidate partnerships are expected to fulfil. The report describes the common methodological framework to assess the envisaged initiatives accordingly. The report also presents the landscape of European Partnerships at the level of Horizon Europe Pillar 2 clusters, which lay the grounds for all

of the impact assessment studies except the candidate Institutionalised European Partnership for Innovative SMEs.

2. EU-Africa Global Health Candidate Institutionalised European Partnership

This initiative focuses on research and innovation in the area of infectious diseases, with a particular focus on sub-Saharan Africa. It will address the challenges of a sustained high burden of infectious diseases in Africa, as well as the (re)emergence of infectious diseases worldwide. Its objectives will thus be to contribute to a reduction of the burden of infectious diseases in sub-Saharan Africa and to the control of (re)emerging infectious diseases globally. It will do so through investments in relevant research and innovation actions, as well as by supporting the further development of essential research capacity in Africa. The study concluded that an Institutionalised Partnership under Art. 187 of the TFEU is the preferred option for the implementation of this initiative.

3. Candidate Institutionalised European Partnership on Innovative Health

This initiative focuses on supporting innovation for health and care within the EU. It will address the EU-wide challenges raised by inefficient translation of scientific knowledge for use in health and care, insufficient innovative products reaching health and care services and threats to the competitiveness of the health industry. Its main objectives are to create an EU-wide health R&I ecosystem that facilitates translation of scientific knowledge into innovations; foster the development of safe, effective, patient-centred and cost-effective innovations that respond to strategic unmet public health needs currently not served by industry; and drive cross-sectoral health innovation for a globally competitive European health industry. The study concluded that an Institutionalised Partnership based on Article 187 of the Treaty on the Functioning of the EU (TFEU) is the preferred option for the implementation of this initiative.

4. Candidate Institutionalised European Partnership in High Performance Computing

The initiative focuses on coordinating efforts and resources in order to deploy a European HPC infrastructure together with a competitive innovation ecosystem in terms of technologies, applications, and skills. It will address the challenges raised by underinvestment, the lack of coordination between the EU and MS, fragmentation of instruments, technological dependency on non-EU suppliers, unmet scientific demand, and weaknesses in the endogenous HPC supply chain. The initiative has as its main objectives to enhance EU research in terms of HPC and related applications, continued support for the competitiveness EU HPC industry, and fostering digital autonomy in order to ensure long-term support for the European HPC ecosystem as a whole. The study concluded that an Institutionalised Partnership is the preferred option for the implementation of this initiative as it maximises benefits in comparison to the other available policy options.

5. Candidate Institutionalised European Partnership in Key Digital Technologies

This initiative focusses on enhancing the research, innovation and business value creation of European electronics value chains in key strategic market segments in a sustainable manner to achieve technological sovereignty and ultimately make European businesses and citizens best equipped for the digital age. It will address the risks of Europe losing the lead in critical industries and services and emerging KDTs. It will also tackle Europe's limited control over digital technologies that are critical for EU industry and citizens. It has as main objectives to strengthen KDTs which are critical for the competitive position of key European industries in the global markets, to establish European leadership in emerging technologies with high socioeconomic potential and to secure Europe's technological sovereignty to maintain a strong and globally competitive presence in KDTs. The study concluded that the Institutionalised Partnership is the preferred option for the implementation of this initiative.

6. Candidate Institutionalised European Partnership in Smart Networks and Services

This initiative focuses on the development of future networks infrastructure and the associated services. This includes bringing communication networks beyond 5G and toward 6G capabilities, but also the development of the Internet of Things and Edge Computing technologies. It will address the challenges raised by Europe delay in the deployment of network infrastructure and failure to fully benefit from the full potential of digitalisation. It has as main objective to ensure European technological sovereignty in future smart networks and digital services, to strengthen the uptake of digital solutions, and to foster the development of digital innovation that answers to European needs and that are well aligned with societal needs. The study concluded that an institutionalised partnership under article 187 is the preferred option for the implementation of this initiative.

7. Candidate Institutionalised European Partnership in Metrology

This initiative focuses on metrology - that is the science of measurement and the provision of the technical infrastructure that underpins accurate and robust measurements throughout society; measurements that underpin all domains of science and technology and enable fair and open trade and support innovations and the design and implementation of policy and regulations. It will address challenges in the fragmentation of national metrology systems across Europe and the need to meet ever-increasing demands on metrology infrastructure to support the measurement needs of emerging technologies and important policy domains in climate, environment, energy and health. The main objective of the initiative is to establish a sustainable coordinated world-class metrology system in Europe that will increase and accelerate the development and deployment of innovations and contribute to the design and implementation of policy, regulation and standards. The study concluded that an A185 Institutionalised Partnership is the preferred option for the implementation of this initiative.

8. Candidate Institutionalised European Partnership on Transforming Europe's Rail System

This initiative focuses on the development of a pan-European approach to research and innovation in the rail sector. It will address the challenges raised by the lack of alignment of research and innovation with the needs of a competitive rail transport industry and the consequent failure of the European rail network to make its full contribution to European societal objectives. It will also strengthen the competitiveness of the European rail supply industry in global markets. Accordingly, the objectives of the initiative are to ensure a more market-focused approach to research and innovation, improving the competitiveness and modal share of the rail industry and enhancing its contribution to environmental sustainability as well as economic and social development across the European Union. The study concluded that an institutionalised partnership under article 187 is the preferred option for the implementation of this initiative.

9. Candidate Institutionalised European Partnership for Integrated Air Traffic Management

This initiative focuses on the modernisation of the Air Traffic Management in Europe - an essential enabler of safe and efficient air transport and a cornerstone of the European Union's society and economy. The proposed initiative will address the challenges raised by an outdated Air Traffic Management system with a non-optimised performance. The current system needs to be transformed to enable exploitation of emerging digital technologies and to accommodate new forms of air vehicle including drones. The objective is therefore to harmonise European Air Traffic Management system based on high levels of digitalisation, automation and connectivity whilst strengthening air transport, drone and ATM markets competitiveness and achieving environmental, performance and mobility goals. This would create €1,800b benefits to the EU economy if the current initiative can

be built on and accelerated. The study concluded that an Institutionalised Partnership under Art. 187 TFEU is the preferred option for the implementation of this initiative.

10. Candidate Institutionalised European Partnership on Clean Aviation

This imitative focuses on further aeronautical research and innovation to improve technology leading to more environmentally efficient aviation equipment. It will address the challenges raised by the growing ecological footprint of aviation and the challenges and barriers faced by the aviation industry towards climate neutrality. It will also strengthen the competitiveness of the European aeronautical industry in global markets. Accordingly, the objectives of the initiative are to ensure that aviation reaches climate neutrality and that other environmental impacts are reduced significantly by 2050, maintain the leadership and competitiveness of the European aeronautics industry and ensure safe, secure and efficient air transport of passengers and goods. The Impact Assessment study assessed the options for implementation that would allow for an optimal attainment of these objectives. The study concluded that an institutionalised partnership under Art. 187 TFEU is the preferred option for the implementation of this initiative.

11. Candidate Institutionalised European Partnership on Clean Hydrogen

The report assesses the impact of potential initiatives to support, through research and innovation, the growth and development of clean hydrogen, among which an Institutionalised European Partnership is one of the options assessed. The existing challenges for clean hydrogen include the limited high-level scientific capacity and fragmented research activities, the insufficient deployment of hydrogen applications, and consequently weaker EU scientific and industrial value chains. Environmental, health and mobility pressures are also driving the need for cleaner hydrogen generation, deployment and use. An initiative for clean hydrogen must have as a main objective the strengthening and integration of EU scientific capacities, to support the creation, capitalisation and sharing of knowledge. This is necessary to accelerate the development and improvement of advanced clean hydrogen applications, the market entry of innovative competitive clean solutions, to strengthen the competitiveness of the EU clean hydrogen value chains (and notably the SMEs within them), and to develop the hydrogen-based solutions necessary to reach climate neutrality in the EU by 2050. The study concluded that an Institutionalised Partnership under Art. 187 TFEU is the preferred option for the implementation of this initiative.

12. Candidate Institutionalised European Partnership on Safe and Automated Road Transport

This initiative focuses on Connected, Cooperative and Automated Mobility: the use of connected and automated vehicles to create more user-centred, all-inclusive mobility, while also increasing safety, reducing congestion and contributing to decarbonisation. With current road traffic collisions and negative local and global environmental impacts not reducing quickly enough, it will address the challenges raised by the current fragmentation of research across the field, and the threat to European competitiveness if the research agenda does not advance quickly enough. The initiative will focus on strengthening EU scientific capacity and economic competitiveness in the field of CCAM, whilst contributing to wider societal benefits including improved road safety, less environmental impact, and improved accessibility to mobility. The study concluded that a co-programmed partnership is the preferred option for the implementation of this initiative.

13. Candidate Institutionalised European Partnership for a Circular Bio-based Europe

This initiative focuses on intensifying research and innovation allowing to replace, where possible, non-renewable fossil and mineral resources with biomass and waste for the production of renewable products and nutrients, in order to drive forward sustainable and climate-neutral solutions that accelerate the transition to a healthy planet and respect

planetary boundaries. It will address the challenges raised by the fact that the EU economy does not operate within planetary boundaries, is not sufficiently circular and is predominantly fossil based. It will also address the insufficient research and innovation (R&I) capacity and cross-sectoral transfer of knowledge and bio-based solutions, as well as risks posed to the European bio-based industry's global competitiveness. The study concluded that Institutionalised European Partnership based upon Article 187 TFEU is the preferred option for the implementation of this initiative.

14. Candidate Institutionalised European Partnership for Innovative SMEs

The initiative is envisaged as a continuation of the Eurostars 2 programme which is managed by the Eureka network. The initiative focuses on international collaborative R&D of innovative companies, facilitated through a network of national funding organisations as included in the Eureka network. The funded projects are bottom-up and involve small numbers of project partners. The candidate partnership addresses a niche issue namely limited opportunities for international bottom-up collaboration. The partnership provides thus an opportunity for SMEs for international R&D collaboration but does not address specific technological, social, or environmental challenges. Its main objective is to improve the competitiveness of European SMEs through collaborative funding. The study concluded that a co-funded partnership is the preferred option for the implementation of this initiative.

PART II. Horizontal studies

1. Horizontal Analysis of Efficiency and Coherence in Implementation

The focus of this report is on the coherence and efficiency in the current European Partnership landscape under Horizon Europe and the potential to enhance efficiency in the European Partnerships' implementation.

European Partnerships are geared towards playing a pivotal role in tackling the complex economic and societal challenges that constitute the R&I priorities of the Horizon Europe Pillar II and are in a unique position to address transformational failures. Multiple potential interconnections and synergies exist between the candidate European Partnerships within the clusters, but few are visible across the clusters.

As for the improvement of the efficiency in implementation of institutionalised partnerships under Art. 187, potential efficiency and effectiveness gains could be achieved with enhanced collaboration. An option for a common back-office sharing operational implementation activities is worth exploring further through a detailed feasibility study in order to assess whether efficiency gains can be made. Ideally this would be co-designed as a common Partnership approach, leading to a win-win situation for all partners.

2. Impact Modelling of the Candidate Institutionalised European Partnerships

This report presents the results of the use of a macroeconomic model to assess the economic and environmental impacts of the preferred options identified in the individual 13 impact assessment studies. The model used is E3ME. It includes explicit representation for each EU Member State with a detailed sectoral disaggregation.

The impact modelling estimated the impacts of the envisaged initiatives at an aggregated as well as individual level. In total, 14 macroeconomic models have been run, one per reviewed initiative with a time horizon of 2035 and one that combines all initiatives with a time horizon of 2050. The results of each of these models were compared with those of a baseline scenario, which corresponds to a situation where the initiatives would be funded through regular Horizon Europe calls rather than European Partnerships.

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Part I. Impact Assessment Studies for the Candidate Institutionalised European Partnerships

1. Overarching Context to the Impact Assessment Studies

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Introduction

This report sets out the overall policy context of the impact assessment studies for the candidate Institutionalised European Partnerships and the methodological framework that was developed for the impact assessment studies.

It describes the changes in approach to the public-private and public-public partnerships under Horizon Europe compared to the previous EU Framework Programmes. An example is the requirement that all envisaged European Partnerships be implemented as either co-programmed, co-funded or institutionalised. The impact assessment studies will consider these three scenarios as the different options to be assessed, in compliance with the Better Regulation guidelines and against the functionalities that the candidate partnerships are expected to fulfil. The report describes the common methodological framework to assess the envisaged initiatives accordingly.

The report also presents the landscape of European Partnerships at the level of Horizon Europe Pillar 2 clusters, which lay the grounds for all of the impact assessment studies except the candidate Institutionalised European Partnership for Innovative SMEs. This analysis is presented in more depth in the report on the 'Horizontal analysis of efficiency and coherence of implementation' in Part II of the Impact Assessment Study report.

The report is structured around two main headings:

- Chapter 1: Background and context to European Partnerships in Horizon Europe and focus of the impact assessment– What is decided
- Chapter 2: The Candidate European Partnerships under Horizon Europe – What needs to be decided

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1 Background and context to European Partnerships in Horizon Europe and focus of the impact assessment– What is decided

1.1 The political and legal context

1.1.1 Shift in EU priorities and Horizon Europe objectives

Horizon Europe is to be set in the broader context of the pronounced **systemic and holistic approach** taken to the design of the new Framework Programme and the overarching Multi-annual Financial Framework (MFF) 2021-27.

The future long-term budget will be a budget for the Union's priorities. In her Political Guidelines for the next European Commission 2019 – 2024, the new President of the European Commission put forward six overarching priorities for the next five years, which reach well beyond 2024 in scope: A European Green Deal; An economy that works for people; A Europe fit for the Digital Age; Protecting our European way of life; A stronger Europe in the world; and A new push for European democracy. These priorities build upon A New Strategic Agenda for 2019–2024, adopted by the European Council on 20 June 2019, which targets similar overarching objectives. Together with the United Nations Sustainable Development Goals (SDGs), they will shape future EU policy responses to the challenges Europe faces and will steer the ongoing transitions in the European economy and society,

The MFF 2021-27 strives to provide a framework that will ensure a more coherent, focused and transparent response to Europe's challenges. A stronger focus on European added value, a more streamlined and transparent budget, more flexibility in order to respond quickly and effectively to unforeseen demands, and above all, an effective and efficient implementation are among the key principles of the MFF. The objective is to strengthen the alignment with Union policies and priorities and to simplify and reform the system in order to "unlock the full potential of the EU budget" and "turn ambitions into reality". Investment from multiple programmes is intended to combine in order to address key crosscutting priorities such as the digital economy, sustainability, security, migration, human capital and skills, as well as support for small businesses and innovation.[1]

These principles underlying the MFF 2021-27 are translated in the intent for Horizon Europe "to play a vital role, in combination with other interventions, for creating new solutions and fostering innovation, both incremental and disruptive." [2] The new Framework Programme finds its rationale in the daunting challenges that Europe is facing, which call for "a radical new approach to developing and deploying new technologies and innovative solutions for citizens and the planet on a scale and at a speed never achieved before, and to adapting our policy and economic framework to turn global threats into new opportunities for our society and economy, citizens and businesses."

In the Orientations towards the first Strategic Plan for Horizon Europe, the need strategically to prioritise and "direct a substantial part of the funds towards the areas where we believe they will matter the most" is emphasised. The Orientations specify, "Actions under Pillar II of Horizon Europe will target only selected themes of especially high impact that significantly contribute to delivering on the political priorities of the Union."

Figure 1, below, which gives an indicative overview of how the EU political priorities are supported under Horizon Europe, shows the major emphasis placed on contributing to the priority 'A European Green Deal', aimed at making Europe the first climate-neutral

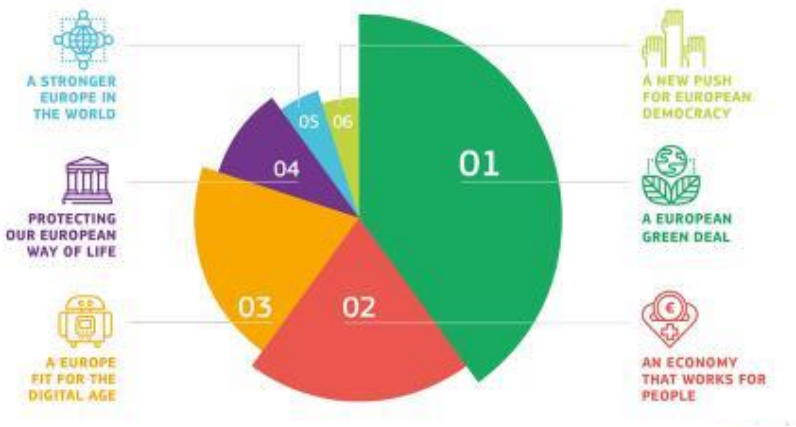
[1] EC (2018) *A Modern Budget for a Union that Protects, Empowers and Defends. The Multiannual Financial Framework for 2021-2027*. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2018) 321 final

[2] EC (2019), *Orientations towards the first Strategic Plan for Horizon Europe*.

continent in the world. At least 35 % of the expenditure from actions under the Horizon Europe Programme will address the Sustainable Development Goal 13: Climate Action.

Especially the R&I activities funded under Pillar II, including seven Partnership Areas (see below), are expected to contribute to the attainment of these objectives in an interconnected manner.

Figure 1: Targeted impacts under Horizon Europe by priority



Note: Preliminary, as described in the General orientations towards the first Strategic Plan implementing Horizon Europe.
Source: European Commission (2019) Orientations towards the first Strategic Plan for Horizon Europe, December 2019.

1.1.2 Renewed ambition for European Partnerships

Reflecting its pronounced systemic nature aimed at 'transformation' of the European R&I system, Horizon Europe intends to make a more effective use of these partnerships with an **ambitious approach** that is impact oriented and ensures complementarity with the Framework Programme. The **rationalisation** of the partnership landscape, both in terms of number of partnership forms and individual initiatives, constituted a first step in the direction of the strategic role that these policy initiatives are expected to play in the context of Horizon Europe. Future partnerships are expected to "provide mechanisms to consistently aggregate research and innovation efforts into more effective responses to the policy needs of the Union".[3] The expectation is that they will act as **dynamic change agents**, strengthening linkages within their respective ecosystems and with other related ecosystems as well as pooling resources and efforts towards the common objectives in the European, national and regional landscape. They are expected to develop *close synergies* with national and regional programmes, bring together a *broad range of actors* to work towards a common goal, translate *common priorities* into concrete roadmaps and coordinated activities, and turn research and innovation into *socio-economic results and impacts*.

The exact budget dedicated to European Partnerships under Horizon Europe will be agreed only upon decisions on the multiannual financial framework (MFF) 2021-2017 and the overall budget for Horizon Europe. In December 2017, the Council nevertheless introduced the principle of a "possible capping of partnership instruments in the FP budget".[4] Accordingly, it reached the common understanding, with the European Parliament, that "the majority of the budget in Pillar II [€52.7bn] shall be allocated to actions outside of

[3] European Commission (2019) *Orientations towards the first Strategic Plan implementing the research and innovation framework programme Horizon Europe*. Co-design via web open consultation. Summer 2019.

[4] Council of the European Union (2017) *From the Interim Evaluation of Horizon 2020 towards the ninth Framework Programme*. Council conclusions 15320/17.

European Partnerships" (Article 8.2(a) of the Common Understanding on the proposal for a regulation establishing Horizon Europe).[5]

1.1.3 Key evolutions as regards the partnership approach

The European R&I partnerships were initially conceived as a means to increase synergies between the European Union and the Member States (Article 181 of the Treaty on the Functioning of the European Union TFEU). Their objectives were to pool the forces of all the relevant actors of R&I systems to achieve breakthrough innovations; strengthen EU competitiveness; and, tackle major societal challenges. The core activities of the European partenrships consist therefore of building critical mass mainly through collaborative projects, jointly developing visions, and setting strategic agendas. They help accelerate the emergence of a programming approach in European R&I with the involvement of all relevant actors and provide flexible structures for partnerships that can be tailored to their goals.[6]

In the consecutive Framework Programmes up to the current Horizon 2020, the partnerships and their forms have mushroomed, leading to an increasing complexity of the partnership landscape. The Horizon 2020 interim evaluation highlighted that the overall landscape of EU R&I funding had become overly complex and fragmented, and a need to improve the partnerships' openness and transparency. The Lamy report suggested that the European Partnerships should focus on those areas with the greatest European Added Value, contribute to EU R&I missions and would need a simplified and flexible co-funding mechanism.

The Competitiveness Council conclusions of December 2017 called on the Commission and the Member States to jointly consider ways to rationalise the EU R&I partnership landscape. In 2018, the ERAC Ad-hoc Working Group on Partnerships concluded, "the rationalisation of the R&I partnership landscape is needed in order to ensure that the portfolio of R&I partnerships makes a significant contribution to improving the coherence, functioning and quality of Europe's R&I system and that the individual initiatives are able to fully achieve their potential in creating positive scientific and socio-economic impacts and/or in addressing societal challenges".

Horizon Europe has taken on board these concerns. The Impact Assessment of Horizon Europe gave a clear analysis of the achievements of Partnerships so far as well as the expectations for the new generation of Partnerships. Greater transparency and openness of the partnerships were considered as essential, as well a clear European added value and long-term commitments of the stakeholders involved.

A list of criteria to decide how European Partnerships will be selected, implemented, monitored, evaluated and phased-out was attached as an Annex III to the proposal to establish Horizon Europe (as revised by the partial political agreement). The rationalisation of the Partnership portfolio in Horizon Europe is expected to allow for a reduction from the current 120 to between 45 and 50 partnerships.

[5] Council of the European Union (2019) *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rule for participation and dissemination*. Common understanding 7942/19.

[6] European Commission (2011) Partnering in Research and Innovation. Communication from the Commission COM(2011) 572 final.

1.1.4 Overview of legal provisions

The Horizon Europe Regulation (common understanding) defines 'European Partnership' as "an initiative where the Union, prepared with early involvement of Member States and/or Associated Countries, together with private and/or public partners (such as industry, universities, research organisations, bodies with a public service mission at local, regional, national or international level or civil society organisations including foundations and NGOs), commit to jointly support the development and implementation of a programme of research and innovation activities, including those related to market, regulatory or policy uptake." It stipulates that "parts of Horizon Europe may be implemented through European Partnerships".

The Horizon Europe Regulation (common understanding) also stipulates that the European Partnerships are expected to adhere to the "principles of Union added value, transparency, openness, impact within and for Europe, strong leverage effect on sufficient scale, long-term commitments of all the involved parties, flexibility in implementation, coherence, coordination and complementarity with Union, local, regional, national and, where relevant, international initiatives or other partnerships and missions." The provisions and criteria set out for the selection and implementation of the European Partnerships reflect these principles.

1.1.5 Overview of the eight Partnership areas

The Horizon Europe Regulation also identifies the following "Areas for possible institutionalised European Partnerships on the basis of Article 185 TFEU or Article 187 TFEU":

- Partnership Area 1: Faster development and safer use of health innovations for European patients, and global health.
- Partnership Area 2: Advancing key digital and enabling technologies and their use, including but not limited to novel technologies such as Artificial Intelligence, photonics and quantum technologies.
- Partnership Area 3: European leadership in Metrology including an integrated Metrology system.
- Partnership Area 4: Accelerate competitiveness, safety and environmental performance of EU air traffic, aviation and rail.
- Partnership Area 5: Sustainable, inclusive and circular bio-based solutions.
- Partnership Area 6: Hydrogen and sustainable energy storage technologies with lower environmental footprint and less energy-intensive production.
- Partnership Area 7: Clean, connected, cooperative, autonomous and automated solutions for future mobility demands of people and goods.
- Partnership Area 8: Innovative and R&D intensive small and medium-sized enterprises.

Considering the realm of these partnership areas, potential synergies exist with the future **missions**. Horizon European introduced these cross-discipline and cross-sector policy instruments as part of its core objective of stimulating further excellence-based and impact-driven R&I. In contrast with the challenges targeted in Horizon 2020, the missions aim at the achievement of well-defined goals to provide solutions, within a specified timeframe, to scientific, technological, economical and/or societal problems. As part of the preparation of Horizon Europe, the European Commission set up five boards to formulate the future missions in the following areas:

- Adaptation to climate change including societal transformation

- Cancer
- Healthy oceans, seas, coastal and inland waters
- Climate-neutral and smart cities
- Soil health and food

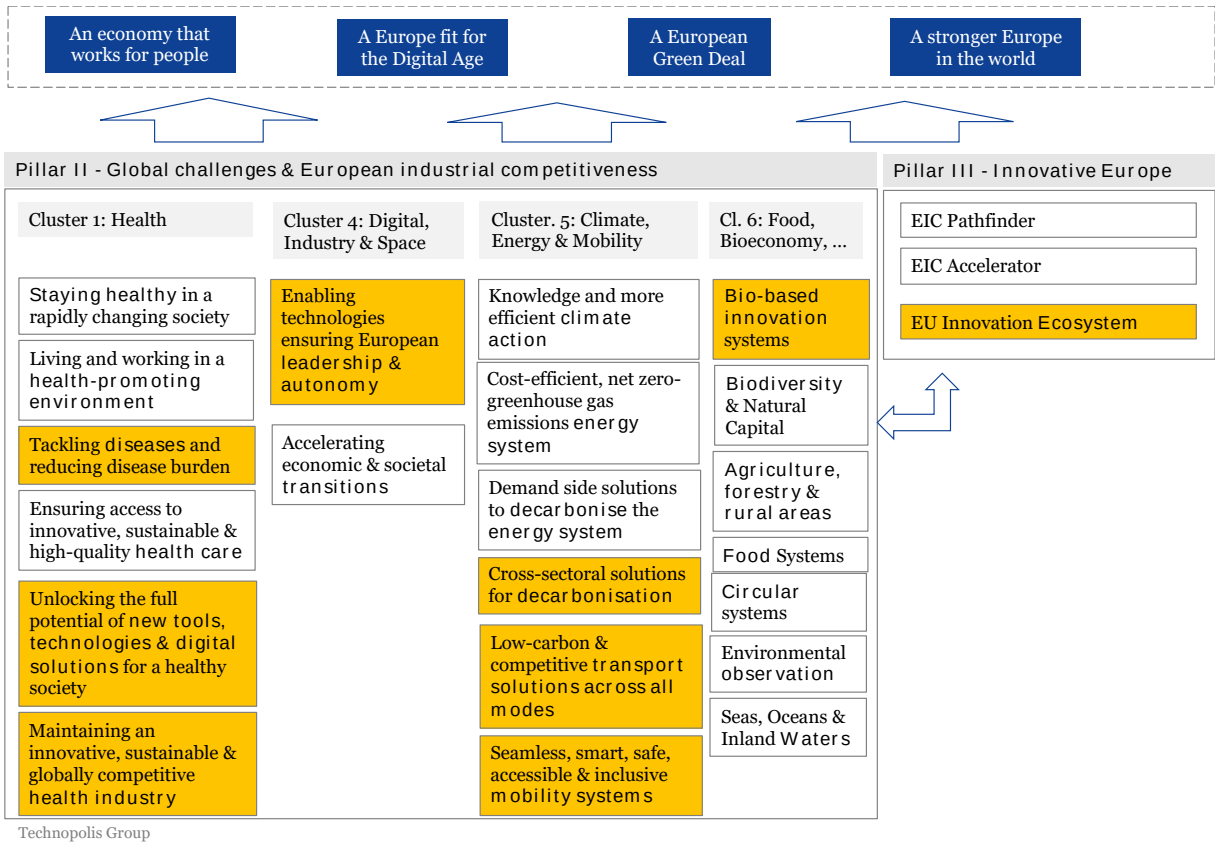
1.2 Typical problems and problem drivers

The European Partnerships are integral part of the framework programme and its three-pillar structure. They are predominantly funded under Pillar 2 "Global Challenges and European industrial competitiveness" and four of its thematic clusters. These clusters cover sectors and technologies, in which research and innovation activities are deemed of crucial importance in solving pressing scientific, societal or economic challenges and ensuring the scientific, technological and industrial leadership of Europe. Only one European Partnership, targeting innovative and R&D intensive SMEs, will instead act under Pillar 3 "Innovative Europe".

The European Partnerships are intended to contribute to the attainment of the pillars' and clusters' **challenges and R&I priorities**. Overarching EU policy priorities addressed are predominantly the European Green Deal, a people-centred economy, the fit for the Digital Age, and a stronger Europe in the world.

In Figure 2, below, the R&I priorities in the Pillars II and III to which the candidate *Institutionalised* Partnerships intend to contribute are highlighted in yellow.

Figure 2: Contribution of Candidate European Institutionalised Partnerships to the Horizon Europe priorities in Pillars II and III



The European Partnerships under Horizon Europe most often find their rationale in addressing **systemic failures**. Their primary function is to create a platform for a strengthened collaboration and knowledge exchange between various actors in the European R&I system and an enhanced coordination of strategic research agenda and/or R&I funding programmes.

The concentration of efforts and resources and pooling of knowledge, expertise and skills on common priorities in a view of solving complex and multi-faceted societal and economic challenges is at the core of these initiatives. Enhanced cross-disciplinary and cross-sectoral collaboration and an improved integration of value chains and ecosystems are among the key objectives of these policy instruments. In the light of Horizon Europe, the aim often is to drive system transitions and transformations.

Especially in fast-growing technologies and sectors such as ICT, the envisaged European Partnerships also react on emerging opportunities and address systemic failures such as shortage in skills or critical mass or cross-sectoral cooperation along the value chains that would hamper attainment of future European leadership and/or strategic autonomy.

Transformational failures addressed aim at reaching a better alignment of the strategic R&I agenda and policies of public and private R&I funders in order to pool available resources, create critical mass, avoid unnecessary duplication of research and innovation efforts, and leverage sufficiently large investments where needed but hardly achievable by single countries.

Market failures are less commonly addressed and relate predominantly to enhancing industry investments thanks to the sharing of risks.

1.3 Description of the options

The proposal for a regulation establishing Horizon Europe[7] stipulates that parts of the Horizon Europe Framework Programme may be implemented through European Partnerships and establishes three implementation modes: Co-programmed European Partnerships, Co-funded European Partnerships, and Institutionalised Partnerships in accordance with Article 185 TFEU or Article 187 TFEU.

1.3.1 Baseline option – Traditional calls under the Framework Programme

Under this option, strategic programming for research and innovation in the field will be done through the mainstream channels of Horizon Europe. The related priorities will be implemented through traditional calls under the Framework Programme covering a range of activities, but mainly calls for R&I and/or innovation actions. Most actions involve consortia of public and/or private actors in ad hoc combinations, some actions are single actor (mono-beneficiary). There will be no dedicated implementation structures and no further support other than the Horizon Europe actions foreseen in the related Horizon Europe programme or cluster.

Strategic planning mechanisms in the Framework Programmes allow for a high level of flexibility in their ability to respond to particular needs over time, building upon additional input in co-creation from stakeholders and programme committees involving MS. The broad scope of the stakeholders providing their input to the research agenda, however, implies a lower level of directionality than what can be achieved through the partnerships. Often, the long-term perspective of the stakeholder input is limited, which risks reducing strategic capacity in addressing priorities.

The Horizon Europe option also implies a lower level of EU budgetary long-term commitment for the priority. Without a formal EU partnership mechanism, it is also less likely that the stakeholders will develop a joint Strategic Research Agenda and commit to its implementation or agree on mutual financial commitments beyond the single project participation.

[7] Proposal for a Regulation of the European Parliament and of the Council stablishing Horizon Europe - the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination - Common understanding', March 2019

1.3.2 European Partnership

All European Partnerships will be designed in line with the new policy approach for more objective-driven and impactful partnerships. They are based on the common criteria in Annex III of the Horizon Europe Regulation, with few distinguishing elements for the different forms of implementation. All European Partnerships will be based on an agreed Strategic Research and Innovation Agenda / roadmap agreed among partners and with the Commission. For each of them the objectives, key performance and impact indicators, and outputs to be delivered, as well as the related commitments for financial and/or in-kind contributions of the partners will be defined ex-ante.

Option 1 - Co-programmed European Partnership

This form of European Partnership is based upon a *Memorandum of Understanding* or a *Contractual Arrangement* signed by the European Commission and the private and/or public partners. Private partners are typically represented by one or more industry association, which also functions as a back-office to the partnership. It allows for a *high flexibility* in the profile of organisation involved, objectives pursued, and/or activities implemented.

Co-programmed European Partnerships address *broader communities* across a diverse set of sectors and/or value chains and where the actors have *widely differing capacities and capabilities*. They may encompass one or more associations of organisations from industry, research, NGOs etc as well as foundations and national R&I funding bodies, with no restriction on the involvement of international partners from Associated and non-associated third countries. Different configurations are possible: private actors only, public entities only, or a combination of the two.

The basis, as for all European Partnerships, is the rationale is to create a *platform for 'concertation'*, i.e. in-depth and ongoing consultation of the relevant actors in the European R&I system for the co-development of a strategic research and Innovation agenda, typically covering the period of the next 10 years. The primary ambition is to generate *commitment to a common strategic research and innovation agenda* (SRIA). For the private actors involved, this would allow for a de-risking of their R&I investments and provide predictability of investment paths, for the public actors, it serves as a means to: inform national policy-makers on EU investments and allows for coordination and alignment of their efforts to support R&I in the field at the national level.

The *level of 'additionality is possibly lower than for other partnerships*. There is no expectation of a legally binding commitment from the partners to taking an integrated approach in their individual R&I implementation and it is based on 'best efforts'. However, the Union contribution to the partnership is defined for the full duration and has a comparable level of certainty for the partnerships than in the other forms of implementation. The priorities for the calls, proposed by the partnership members for integration in the Framework Programme Work Programmes, are subject to further input from Member States (comitology) and Commission Services. The full implementation of the Union contribution in the Framework Programme implies that the full array of Horizon Europe funding instruments in the related Pillar can be used, ranging from RIAs to CSAs and including grants, prizes, and procurement.

Option 2 – Co-funded European Partnership

The Co-funded Partnership is based on a Grant Agreement between the Commission and the consortium of partners, resulting from a call for a proposal for a programme co-fund action implementing the European Partnerships in the Horizon Europe Work Programme. Programme co-fund actions provide co-funding to a programme of activities established and/or implemented by entities managing and/or funding research and innovation programmes. Therefore, this form of implementation only allows to address public partners

at its core (comparable to the Article 185 initiatives below), while industry can nevertheless be addressed by the activities of the partnerships, but not make formal commitments and contributions to it. The expectation is that these entities would cover most if not all EU Member States (MS). Also 'international' funding bodies can participate as partners, which creates the potential for an efficient interaction with strategic international partners. Legal entities in countries that are not part of the programme co-fund consortium, are usually excluded from funding under the calls launched by the consortium.

The basic rationale for this partnership option is to bring MS together to invest at scale in key R&I issues of general and common interest. The joint programme of activities is agreed by the partners and with the EU and typically focuses on societal grand challenges and specifically, areas of high public good where EU action will add value while reflecting national priorities and/or policies. The ultimate intent is to create the greatest possible impact by pooling and/or coordinating national programmes and policies with EU policies and investments, helping to overcome fragmentation of the public research effort. Member States that are partners in this partnership become the 'owners' of the priority and take sole responsibility for its funding. Commitments of the partners and the European Union are ensured through the Grant Agreement.

Based on national programmes, this partnership option shows a particularly high level of flexibility in terms of activities to be implemented - directly by the national funding bodies (or governmental organisation "owning" institutional programmes), or by third parties receiving financial support (following calls for proposals launched by the consortium). The broad range of possible activities include support for networking and coordination, research, innovation, pilot actions, and innovation and market deployment actions, training and mobility actions, awareness raising and communication, dissemination and exploitation, any relevant financial support, such as grants, prizes, procurement, as well as Horizon Europe blended finance or a combination thereof.

Option 3 – Institutionalised European Partnership

This type of Partnership is the most complex and high-effort arrangement and will be based on a Council Regulation (Article 187) or a Decision by the European Parliament and Council (Art 185) and implemented by dedicated structures created for that purpose. The legal base for this type of partnership limits the flexibility for a change in core objectives, partners, and/or commitments as these would require amending legislation.

The basic rationale for this type of partnership is the need for a strong integration of R&I agenda's in the private and/or public sectors in Europe in order to address a strategic challenge or realise an opportunity. The focus is on major long-term strategic challenges and priorities beyond the framework of a single Framework Programme where collective action – by private and/or public sectors – is necessary to *achieve critical mass* and *address the full extent of the complexities* of the ecosystem concerned.

The long-term commitment expected from the European Union and its partners is therefore much larger than for any of the other options, given the considerably higher investment in the preparation and implementation of the Partnership. As a result, this type of partnership can be selected only if other parts of the Horizon Europe programme, including other forms of European Partnerships, would not achieve the objectives or would not generate the necessary expected impacts. The commitment for contributions by the partnership members is expected to be at least equal to 50% and may reach up to 75% of the aggregated European Partnership budgetary commitments.

The partnership members have a high degree of autonomy in developing the strategic research agenda and annual work programmes and call topics, based on a transparent and accessible process, and subject to the approval of the Commission Services. The choice of topics addressed in the (open) calls are therefore strongly aligned with the needs defined. Normally, the strategic priorities are fully covered by the annual work programmes in the

partnership, even though it is in principle possible to keep certain topics for calls in the FP thus complementing the activities in the partnership. The full integration in the Framework Programme implies that the full array of Horizon Europe funding instruments in the related Pillar can be used, ranging from RIAs to CSAs and including grants, prizes, and procurement.

Two forms of Institutionalised Partnerships are of direct relevance to this study, influencing the constellation of partners involved.

Institutionalised Partnerships based upon Art 185 TFEU

Article 185 of the TFEU allows the Union to participate in programmes jointly undertaken by Member States and limits therefore the scope of partners to Member States and Associated Third countries. This type of Institutionalised Partnership aims therefore at reaching the greatest possible impact through the integration of national and EU funding, aligning national strategies in order to optimise the use of public resources and overcome fragmentation of the public research effort.

It brings together R&I governance bodies of most if not all EU Member States (legal requirement: at least 40% of Member States) as well as Associated Third Countries that designate a dedicated legal entity (Dedicated Implementation Structure) for the implementation. By default, membership of non-associated Third Countries is not foreseen. Such membership is possible only if it is foreseen in the basic act and subject to conclusion of an international agreement. Eligibility for participation and funding follows by default the rules of the Framework programme, unless a derogation is introduced in the basic act.

Institutionalised Partnerships under Art. 187 TFEU

This type of Institutionalised Partnership aims at reaching the greatest possible impact by integrating the strategic R&I agendas of private and/or public actors and by leveraging the partners' investments in order to tackle R&I and societal challenges and/or contribute to Europe's wider competitiveness goals.

It brings together a stable set of partners with a strong commitment to taking a more integrated approach and requires the set-up of a dedicated legal entity (Union body, Joint Undertaking) that carries full responsibility for the management of the partnership and implementation of the calls.

Different configurations are possible: partnerships focused on creating strategic industrial partnerships where, most often, the partner organisations are represented by one or more industry associations, or in some cases individual private partners; partnerships coordinating national ministries, public funding agencies, and governmental research organisations in the Member States and Associated Countries; or a combination of the two (the so-called tripartite model). By default, membership of non-associated Third Countries is not foreseen. Such membership is possible only if it is foreseen in the basic act and subject to conclusion of an international agreement. Eligibility for participation and funding follows by default the rules of the Framework programme, unless a derogation is introduced in the basic act.

2 The Candidate European Partnerships under Horizon Europe – What needs to be decided

2.1 Portfolio of candidates for Institutionalised Partnerships under Horizon Europe

2.1.1 The process for identifying the priorities for Institutionalised Partnerships under Horizon Europe

In May 2019, the European Commission consulted the Member States on a list of 44 possible candidates for European Partnership which it had identified as part of the preparation of the first Strategic Planning of Horizon Europe. This list was also part of the

Orientations towards the first Strategic Plan implementing Horizon 2020[8] which served as a basis for an Open Public Consultation from July to October 2019. In October and November 2019, the European Commission and the Member States agreed on increasing the number of candidate European partnerships to 49. Subsequent discussions until the adoption of Horizon Europe will focus on ensuring the overall consistency of the EU partnership landscape and its alignment with the EU overarching priorities and on defining the precise implementation modalities.

In parallel, the European Commission completed inception impact assessments on the candidate institutionalised European partnerships. Stakeholders had the opportunity to provide their feedback on these inception impact assessments in August 2019. A web-based open public consultation to collect opinions on all candidate institutionalised partnerships (but the candidate EuroHPC partnership) was organised between September and October 2019.

2.1.2 Overview of the overall landscape of candidate European Partnerships subject to the impact assessment

Figure 3, below, gives an overview of all European Partnerships that are currently envisaged for funding under Horizon Europe. The candidate Institutionalised Partnerships that are the subject for this impact assessment study are coloured in dark orange.

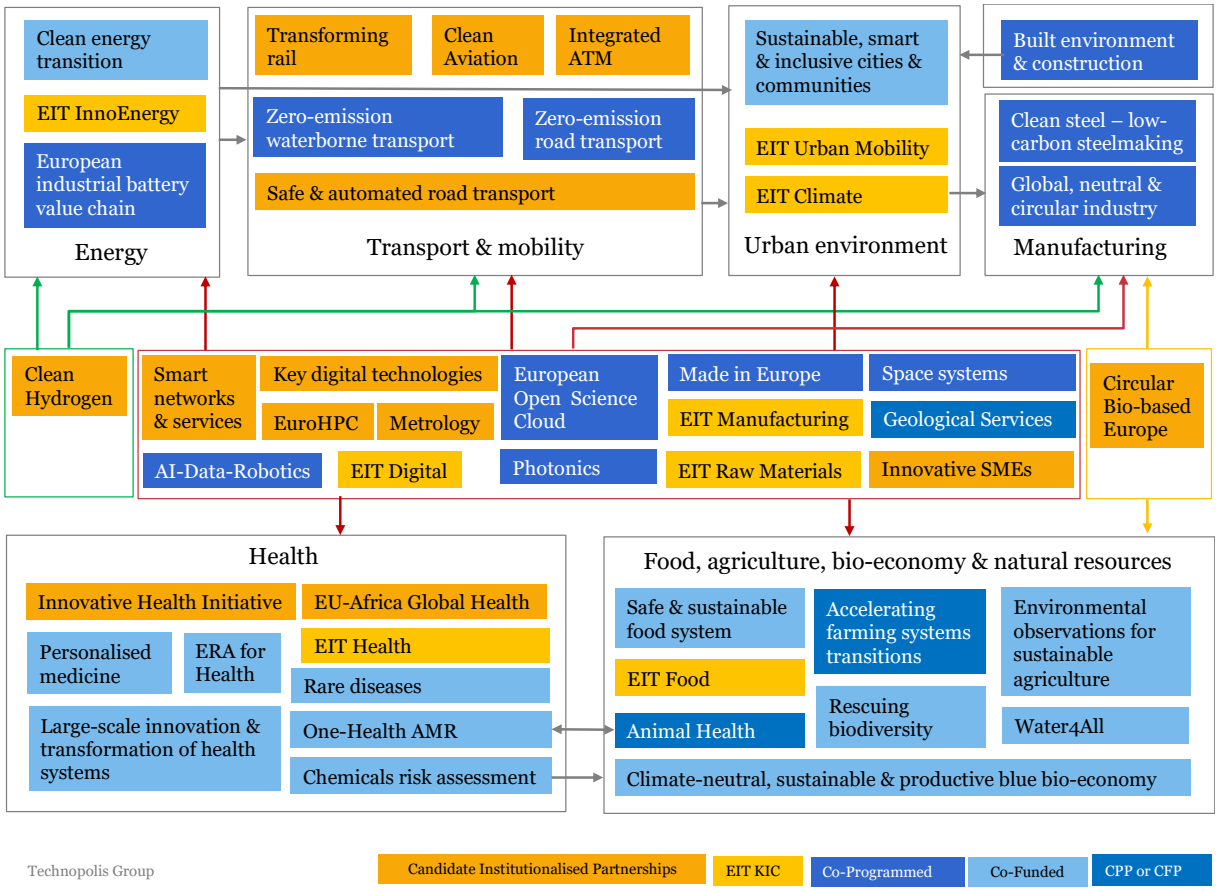
The European Partnerships can be categorised into two major groupings: *'horizontal' partnerships* focused on the development of technologies, methods, infrastructures and resources/materials, and *'vertical' partnerships* focused on the needs and development of a specific application area, be it industrial or societal.

The diagram below shows the central position of the **'horizontal' partnerships** in the overall landscape, developing methodologies, technologies or data management infrastructures for application in the other priority areas. These 'horizontal' partnerships are predominantly proposed as Institutionalised or Co-programmed Partnerships, in addition to a number of EIT KICs. The European Open Science Cloud (EOSC) partnership, for example, will support research partnerships by providing an infrastructure for the storage, management, analysis and re-use of research data.

The upper banner of the diagram groups the **industry-oriented 'vertical' partnerships**. Under Horizon Europe, they have in common a pronounced focus on enhancing sustainability. In this context, the banner includes also one of the most recent agreed-upon partnerships focused on the urban environment. This partnership illustrates the introduction under Horizon Europe of *challenge-oriented* cross-cluster partnerships. Multiple interconnections are envisaged among the 'vertical' partnerships in the different industry sectors covered. In the transport sector, the partnerships are predominantly proposed as Institutionalised Partnerships. In the other sectors, we see a mix of Co-Programmed Partnerships and EIT KICs. There are only two Co-Funded Partnerships.

[8] Orientations towards the first Strategic Plan implementing the research and innovation framework programme Horizon Europe, Co-design via Web Open Consultation (2019), see more here https://ec.europa.eu/research/pdf/horizon-europe/ec_rtd_orientations-towards-the-strategic-planning.pdf

Figure 3: Landscape of European Partnerships under Horizon Europe (2019)



The lower banner includes the '**vertical' partnerships in the societal application areas**. Striking is the dominance of the Co-Funded Partnerships (to be noted that in the Food/agriculture cluster, the partnership type still needs to be decided for several envisaged partnerships). We also note the limited interconnections that are envisaged between the two areas. An exception is the newly envisaged cross-cluster European Partnerships 'One Health AMR'.

2.2 Assessing the necessity of a European Partnership, possible options for implementation and their cost-effectiveness

In this section we set out the methodological framework that underpins the impact assessment studies. In line with the Better Regulation Guidelines, the impact assessment is intervention logic-based and impact-oriented.

The impact assessment allowed also for the conduct of the 'necessity test' for a European Partnership as set out in the Horizon Europe regulation. Pivotal in this context was the identification of the Horizon Europe calls as Option 0 as well as Baseline Option, allowing for a comparative analysis of the three partnership forms (Options 1-3) along all of the assessment dimensions – in relation to each other as well as to the Horizon Europe calls. The options assessment therefore incorporated the required 'necessity test'.

2.2.1 Assessment of the selection criteria

The common methodological framework that we defined for the 13 individual Impact Assessment studies reflects the approach defined in the Better Regulation guidelines. It also integrates the specific criteria for the use of the different types of European Partnerships as they are defined in the Horizon Europe Common Understanding (Article 8 and Annex III). Specifically this regards the **selection criteria** which have to be demonstrated as a minimum in order to justify the necessity of a European Partnership instead of regular Horizon Europe calls only and the implementation criteria in Article 8

1(a), (b) and (c) with certain elements distinguishing the use of the different partnership implementation modes (Table 1).

Table 1: Horizon Europe selection criteria for the European Partnerships

Common selection criteria and principles	Specifications
More effective (Union added value) clear impacts for the EU and its citizens	• delivering on global challenges and research and innovation objectives
	• securing EU competitiveness
	• securing sustainability
	• contributing to the strengthening of the European Research and Innovation Area
	• where relevant, contributing to international commitments
Coherence and synergies	• within the EU research and innovation landscape
	• coordination and complementarity with Union, local, regional, national and, where relevant, international initiatives or other partnerships and missions
Transparency and openness	• identification of priorities and objectives in terms of expected results and impacts
	• involvement of partners and stakeholders from across the entire value chain, from different sectors, backgrounds and disciplines, including international ones when relevant and not interfering with European competitiveness
	• clear modalities for promoting participation of SMEs and for disseminating and exploiting results, notably by SMEs, including through intermediary organisations
Additionality and directionality	• common strategic vision of the purpose of the European Partnership
	• approaches to ensure flexibility of implementation and to adjust to changing policy, societal and/or market needs, or scientific advances, to increase policy coherence between regional, national and EU level
	• demonstration of expected qualitative and significant quantitative leverage effects, including a method for the measurement of key performance indicators
	• exit-strategy and measures for phasing-out from the Programme
Long-term commitment of all the involved parties	• a minimum share of public and/or private investments
	• In the case of institutionalised European Partnerships, established in accordance with article 185 or 187 TFEU, the financial and/or in-kind, contributions from partners other than the Union, will at least be equal to 50% and may reach up to 75% of the aggregated European Partnership budgetary commitments

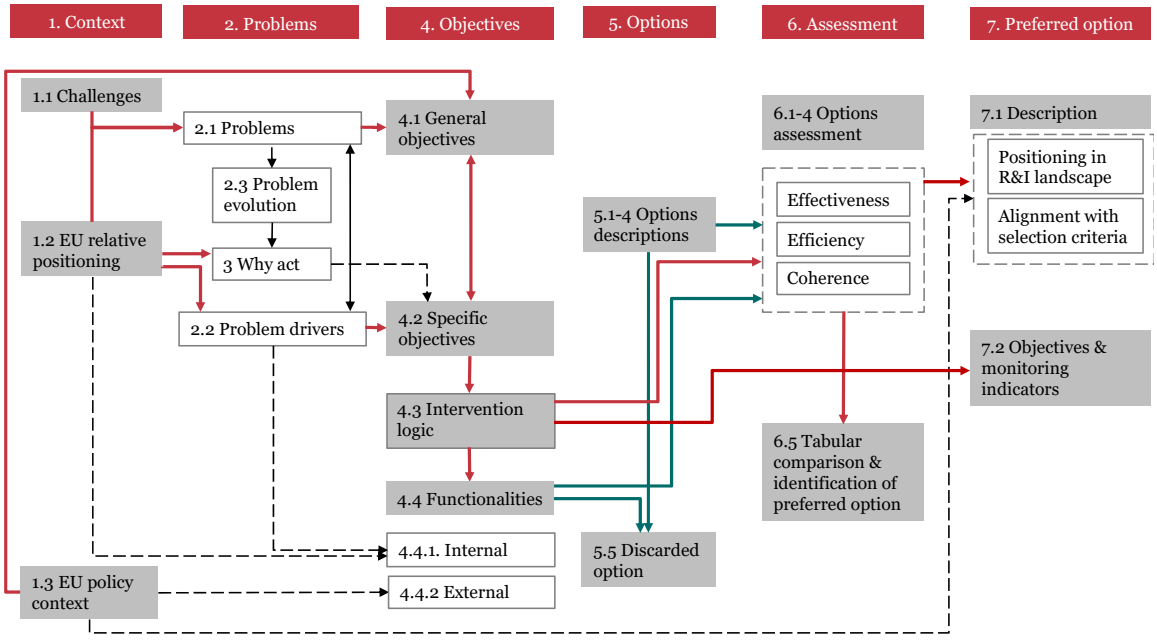
The **Better Regulation guidelines** remained the primary point of reference for the 13 individual Impact Assessment studies. The different steps of the IA process were carried out in a consistent manner in the 13 individual IA studies, supported by horizontal analyses (i.e. common to all studies) such as bibliometrics/patent analysis, social network analysis, the partnership portfolio mapping and analysis, as well as the analysis of the Open Public Consultation data.

The **selection criteria** for the European Partnerships related to effectiveness and coherence fit reasonably well in the Better Regulation impact assessment structure. More problematic was the coverage of the other three criteria groupings, i.e. the criteria of Openness and Transparency, Additionality and Directionality, and the Ex-ante demonstration of commitment.

The solution was the introduction of a section on the **'Functionalities of the initiative'**, in which set out our view on *how* the initiative should *concretely* respond to the selection criteria of 'coherence and synergies', 'openness and transparency' and 'additionality and directionality' in order to reach its objectives. We focused on those aspects that are not covered in other sections of this report, such as coherence and synergies, and covered those elements that from our analysis of the partnership options resulted being **key distinguishing features** of the partnership options, i.e. the composition of the partnership ('openness', including from a geographical perspective), the type of activities implemented ('flexibility'), and the level of directionality and integration of the stakeholders' R&I strategies needed ('directionality and additionality').

The logical process is summarised in Figure 4, below. The diagram shows how the 'functionality' sections constituted an important passage from the objectives and intervention logic sections to the options assessment. Building upon information collected in the previous sections (context, problem and objectives analysis) and in combination with the description of the available options, the description of the desirable 'functionalities' allowed for, on the one hand, the identification of the discarded option(s) and, on the other hand, the options assessment against coherence and against the selection criteria of 'Openness and Transparency' and 'Additionality and Directionality'. In the final chapter of the Impact Assessment report, the alignment of the preferred option with the criteria for the selection of European Partnerships was described, emphasising the outcomes of the 'necessity test'.

Figure 4: Flow of the analysis



Notes: the numbers indicate the related chapters or sections in the Impact Assessment reports

2.2.2 Methodological approach

Overview of the methodologies employed

The understanding of the overall context of the candidate institutionalised European Partnerships relies on a desk research partly covering the main impacts and lessons learned

from their predecessor partnerships (if any). This was complemented with a set of quantitative analyses of the Horizon 2020-funded partnerships, or in case these did not exist, the H2020-funded projects in the field. The analyses included a portfolio analysis, a stakeholder and social network analysis in order to profile the actors involved as well as their co-operation patterns, and an assessment of the partnerships' outputs (bibliometrics and patent analysis). A cost modelling exercise was performed in order to feed into the efficiency assessments of the partnership options (see below).

Public consultations (open and targeted) supported the comparative assessment of the policy options. Each study interviewed up to 50 relevant stakeholders (policymakers, business including SMEs and business associations, research institutes and universities, and civil organisations, among others). They also used the results from the Open Public Consultation organised by the European Commission (Sep – Nov 2019) and the feedback on the Inception Impact Assessments of the 13 candidate institutionalised European Partnerships that the European Commission received in September 2019.

The timing of the Impact Assessment studies, in parallel to the negotiations between the European Commission and the existing Joint Undertakings on the specific implementation of the rules for the future European Partnership, as well as the ongoing discussions within the existing partnership on their future research directions, has set potential limits to the validity of the input and feedback collected from the stakeholders during the consultations.

A more detailed description of the methodology is provided in the Annexes C of each impact assessment report.

Method for identifying the preferred choice

The four policy options were compared along a range of key parameters. The comparison along these parameters was carried out in an evidence-based manner. A range of quantitative and qualitative evidence was used, including ex-post evaluations; foresight studies; statistical analyses of Framework Programmes application and participation data and Community Innovation Survey data; analyses of science, technology and innovation indicators; econometric modelling exercises producing quantitative evidence in the form of monetised impacts; reviews of academic literature on market and systemic failures and the impact of research and innovation, and of public funding for research and innovation; sectoral competitiveness studies; expert hearings; etc.

Options assessment related to effectiveness and coherence

On the basis of the evidence collected and gathered, the Impact Assessment study teams assessed the effectiveness of the retained policy options along three dimensions corresponding to the different categories of likely impacts: scientific, economic and technologies, and societal (including environmental) impacts. The Impact Assessment study teams considered to which extent the retained policy options fulfilled the desirable 'functionalities' and were therefore likely to produce the targeted impacts. This analysis resulted in a scoring of the policy options along a three-point scale.[9] Instead of a compound score, the assessment of the effectiveness of the policy options concluded on as many scores as there are expected impacts.

Likewise, the impact assessment study teams attributed scores (using the same approach as above) reflecting the potential of each retained policy option for ensuring coherence with programmes and initiatives within (internal coherence) and beyond (external coherence) Horizon Europe.

[9] Scores vary from + to +++, where + refers to low potential for presenting a low potential for reaching the likely impacts, ++ to a good potential, and +++ to a high potential.

Scores were justified in a consistent and detailed manner in order to avoid arbitrariness and spurious accuracy. A qualitative or even quantitative explanation was provided of why certain scores were given to specific impacts.

When assessing the respective efficiency of the retained policy options, the Impact Assessment study teams considered the scores related to effectiveness and the identified costs to conduct a "value for money" (or cost-effectiveness) analysis. They accordingly attributed a comparative score to each of the options ranging from 1 (option with the highest costs) to 3 (options with the lowest costs).

Options assessment related to efficiency

A standard cost model

The 'horizontal' team has reviewed the cost categories and costs for each of the four policy options, at some length. Our first model used published data from past partnerships and Horizon 2020 calls working with the Commission's standard accounting codes (Title 1, Title 2, Title 3). The analysis revealed wide-ranging differences in costs across partnerships and functions, which was thought to be too complex to be helpful to the current exercise. As a result, we created a static, common model using average costs as a means by which to indicate the order of magnitude of effort and thereby reveal the principal differences between each of the policy options.

The model was developed jointly with the European Commission services and is presented in the study Data report (D1.2), along with an explanation of the data sources used and the assumptions made.

It is important to note that the costs identified are theoretical and do not reflect the actual costs of any existing individual partnership. In light of this fact, and to avoid any risk of misunderstanding, we have transposed the financial estimates into a qualitative presentation using + / - system in order to compare the various cost elements for each policy option with the equivalent costs for the baseline policy options (see Table 2).

The principal differences in costs as compared with regular Horizon Europe calls relate to the European Partnerships' one-off costs (e.g. developing the proposal and Strategic Research and Innovation Agenda), additional supervision by the European Commission and any additional programme management effort. The main difference between the three types of European Partnership are twofold: (i) the extent to which a partnership will need to run a limited or comprehensive programme management unit and (ii) the extent to which a new partnership may benefit from a pre-existing programme management unit that will greatly reduce or eliminate the set-up costs that would apply to a wholly new partnership.

Table 2: Intensity of additional costs compared with HEU Calls (for Partners, stakeholders, public and EC)

Cost items	Option 0	Option 1	Option 2	Option 3 -Art. 185	Option 3 -Art. 187
Preparation and set-up costs					
Preparation of a partnership proposal (partners and EC)	0	++	++	++	++
Set-up of a dedicated implementation structure	0	0	0	Existing: + New: ++	Existing: ++ New: +++
Preparation of the SRIA / roadmap	0	++	++	++	++

Cost items	Option 0	Option 1	Option 2	Option 3 -Art. 185	Option 3 -Art. 187
Ex-ante Impact Assessment for partnership	0	0	0	+++	+++
Preparation of EC proposal and negotiation	0	0	0	+++	+++
Running costs (Annual cycle of implementation)					
Annual Work Programme preparation	0	+	0	+	+
Call and project implementation	0	0 In case of MS contributions: +	+	+	+
Cost to applicants	Comparable, unless there are strong arguments of major differences in oversubscription				
Partners costs not covered by the above	0	+	0	+	+
Additional EC costs (e.g. supervision)	0	+	+	+	++
Winding down costs					
EC	0	0	0	0	+++
Partners	0	+	0	+	+

Notes: 0: no additional costs, as compared with the baseline; +: minor additional costs, as compared with the baseline; ++: medium additional costs, as compared with the baseline; +++: higher costs, as compared with the baseline

Rationale for the comparative scoring on 'overall costs' and 'cost-efficiency' in the scorecard

In the scorecard analysis, the scores related to the set-up and implementation costs will allow the study teams to consider the scale of the expected benefits and thereby allow a simple "value for money" analysis (cost-effectiveness).

Table 3 shows how we translated the cost analysis into a series of numerical scores.

Table 3: Cost-efficiency matrix

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 2: Co-funded	Option 3: Institutionalised
Overall cost	3	2	1	1
Cost-efficiency	3	3	2	2

For the 'overall cost' dimension, we assigned a score 1 to the option with the highest additional costs and a score 3 to the option with the lowest additional costs compared to the baseline. This was based on the following considerations:

- **Horizon Europe regular calls** will have the lowest overall cost among the policy options and have therefore been **scored 3** on this criterion, using a scale of 1-3 where 3 is best (lowest additional costs). This adjudged score is based on two facts: firstly, that Horizon Europe will not entail any additional one-off costs to set up or discontinue

the programme, where each of the other policy options will require at least some additional set-up costs; and secondly, that Horizon Europe will not require any additional running costs, where each of the other policy options will involve additional efforts by the Commission and partners in the carrying out of necessary additional tasks (e.g. preparing annual work programmes).

- A **co-programmed partnership** (Option 1 - CPP) will entail slightly higher overall costs as compared with the baseline policy option and has therefore been given a **score of 2**, using a scale of 1-3 where 3 is best (lowest additional costs). There will be some additional set-up costs linked for example with the creation of a strategic research and innovation agenda (SRIA) and additional running costs linked with the partners role in the creation of the annual work programmes and the Commission's additional supervisory responsibilities. A CPP will have lower overall costs than each of the other types of European Partnership, as it will function with a smaller governance and implementation structure than will be required for a Co-Funded Partnership or an Institutionalised Partnership and – related to this – its calls will be operated through the existing HEU agencies and RDI infrastructure and systems.
- The **Co-Funded Partnership (**Option 2 – CFP) has been **scored 1** on overall cost, using a scale of 1-3 where 3 is best (lowest additional costs). This reflects the additional set-up costs of this policy option and the substantial additional running costs for partners, and the Commission, of the distributed, multi-agency implementation model.
- The **Institutionalised Partnership** (Option 3 - IP) has been **scored 1** on overall cost, using a scale of 1-3 where 3 is best (lowest additional costs). This reflects the substantial additional set-up costs of this policy option – and in particular the high costs associated with preparing the Commission proposal and negotiating that through to a legal document – and the substantial additional running costs for the Commission associated with the supervision of this dedicated implementation model.

In relation to **cost-efficiency**, we considered that while there is a clear gradation in the overall costs of the policy options, the cost differentials are less marked when we take into account financial leverage (co-financing rates) and the total budget available for each of the policy options, assuming a common Union contribution. From this perspective, there are only one or two percentage points that split the most cost-efficient policy options – the baseline and CPP policy options – and the least cost-efficient – the CFP and IP. We have therefore assigned a score of 3 to the baseline Option 0 and CPP options for cost-efficiency (no or minor additional costs, as compared with the baseline) and a score of 2 for the CFP and IP policy options (medium additional costs, as compared with the baseline).

Scorecard analysis for the final options assessment

The scorecard analysis built a hierarchy of the options by individual criterion and overall. The scorecard exercise supported the systematic appraisal of alternative policy options across multiple types of monetary, non-monetary and qualitative dimensions. It also allowed for easy visualisation of the pros and cons of alternative options.

Each option was attributed a value of 1 to 3, scoring the adjudged performance against each criterion with the three broad appraisal dimensions of effectiveness, efficiency and coherence.

Scores were justified in a consistent and detailed manner in order to avoid arbitrariness and spurious accuracy. A qualitative or even quantitative explanation was provided of why certain scores were given to specific impacts, and why one option scores better or worse than others.

The scorecard analysis allowed for the identification of a single preferred policy option or in case of an inconclusive comparison of options, a number of 'retained' options or hybrid. The final selection is a policy decision.

2.3 Cross-partnership challenges in Horizon Europe clusters

In this section we set the envisaged and candidate partnerships in the context of the Horizon Europe clusters and the related higher-level EU policy objectives and priorities. We focus on the evolution of the policy context including the new European Green Deal/climate neutrality objectives, the Horizon Europe Framework relevant to this cluster, and the link to the relevant Sustainable Development Goals. Seeing the focus on the Pillar II clusters, this section excludes the candidate *Institutionalised Partnership for Innovative SMEs*.

2.3.1 Cluster 1 – Health

Research and innovation (R&I) actions under this cluster will aim at addressing the major socio-economic and societal burden that diseases and disabilities pose on citizens and health systems of the EU and worldwide.

The R&I activities funded under the Pillar II Cluster Health aim at contributing to the achievement of the Sustainable Development Goal 'Ensuring healthy lives and promoting well-being for all at all ages' resulting from investments in research and innovation focused on three overarching EU policy objectives: 'An economy that works for people', 'A Europe fit for the Digital Age', and 'A European Green Deal' (see Figure 5, below). The Horizon Europe proposal for a regulation defined the areas for possible institutionalised European partnerships on the basis of Article 185 TFEU or Article 187 TFEU as "*Partnership Area 1: Faster development and safer use of health innovations for European patients, and global health".*

At the core in this cluster are the R&I orientations that aim at ensuring that citizens *stay healthier throughout their lives* due to improved health promotion and disease prevention and the adoption of healthier behaviours and lifestyles, the development of *effective health services* to tackle diseases and reduce their burden, and an improved access to *innovative, sustainable and high-quality health care*. These objectives require an unlocking of the full potential of *new tools, technologies and digital solutions* and ensuring a *sustainable and globally competitive health-related industry* in the EU, allowing for the delivery of, e.g. personalised healthcare services. Last but not least, the citizens' health and well-being need to be *protected from environmental degradation and pollution*, addressing a.o. climate-related challenges to human health and health systems.

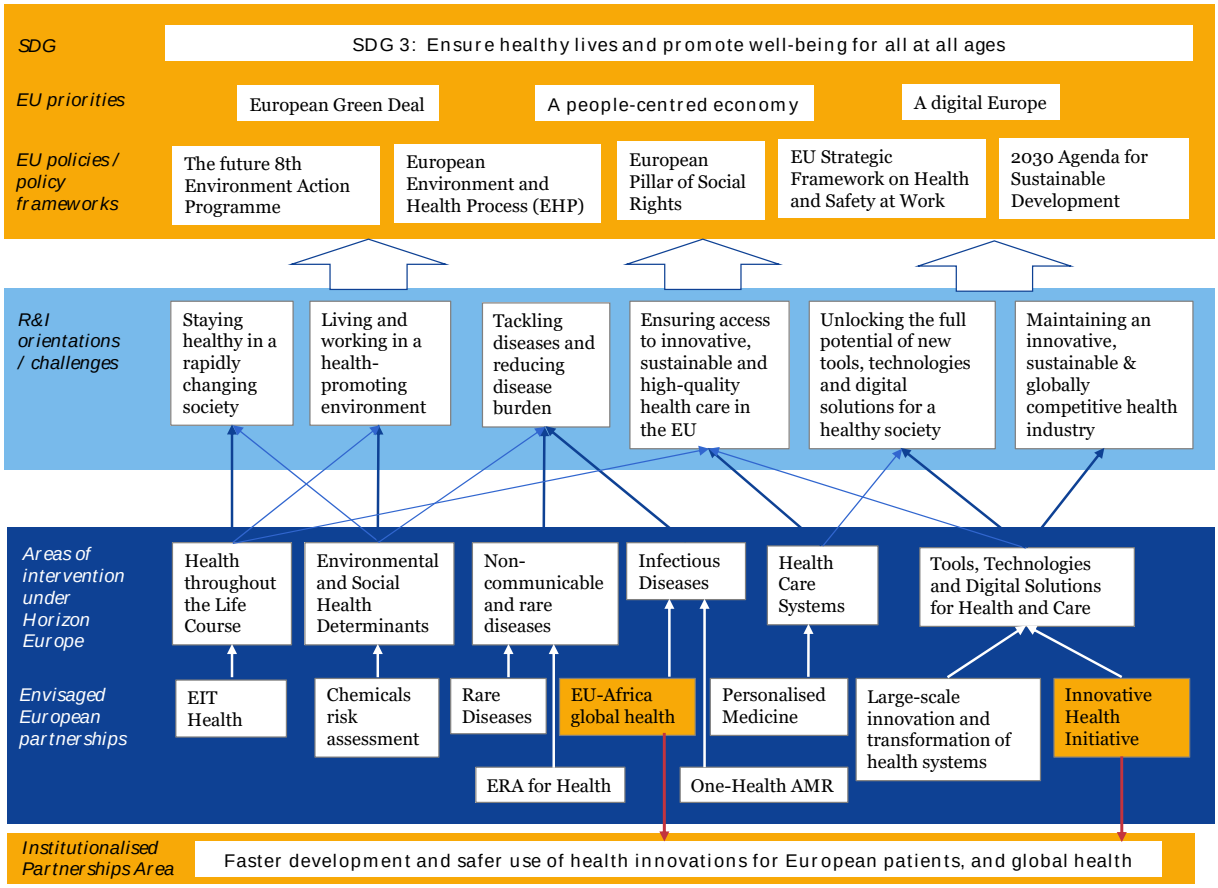
Figure 5, below, shows that the portfolio of envisaged European Partnerships in this cluster[10] aims to contribute to all of the R&I orientations in this cluster. However, there is a pronounced focus on the 'tackling diseases and reducing the disease burden' objective, addressed by five out of the ten partnerships (amongst which there is one candidate Institutionalised Partnership). The objectives focused on an improved exploitation of digital solutions and competitiveness of the EU health-related industry are addressed by two partnerships amongst which one is a candidate Institutionalised Partnership.

In this context, it should be noted that the portfolio of European Partnerships in this cluster predominantly encompasses Co-funded Partnerships, focused on joining the R&I programmes and investments at the national level. There is therefore overall a limited level of involvement of the private sector in the development of the SRIAs (i.e. as partners of the envisaged partnerships), be it from the supply or user side in the value chains. The only exceptions are the Innovative Health Initiative and the EIT KIC Health. European Partnerships also provide limited support for the assessment of environmental and social health determinants, uniquely addressed from a chemical risks perspective.

[10] As proposed in the Horizon Europe 'Orientations towards the first Strategic Plans', dd. December 2019

The description of the interconnections between the partnerships in this cluster and the ones funded in the context of other clusters, provided in the reports of the individual impact assessment studies, sheds more light on this topic.

Figure 5: R&I priorities and higher-level objectives of the Horizon Europe Cluster 1 – Health



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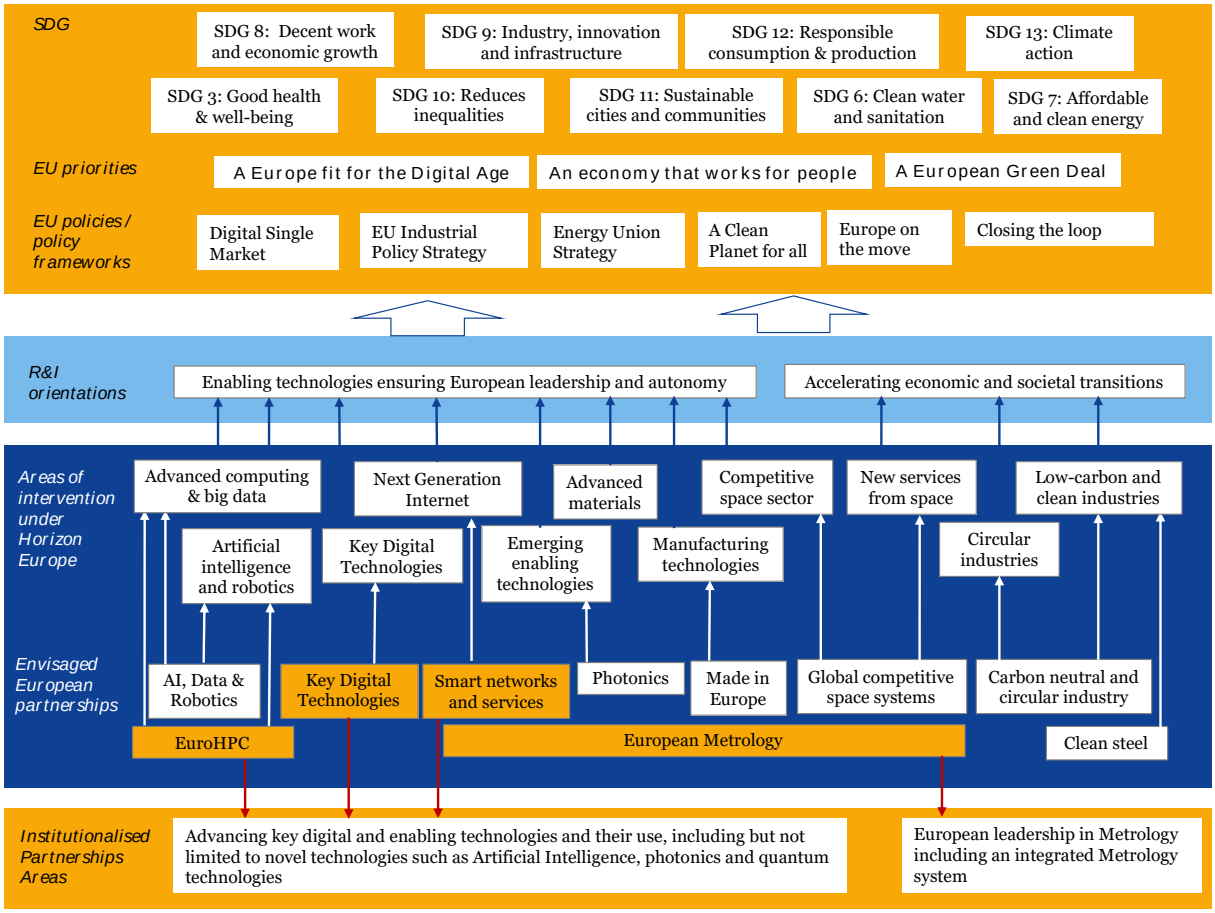
2.3.1 Cluster 4 – Digital, Industry and Space

In this cluster the focus is on the digitisation of European industry and on advancing key enabling, digital and space technologies which will underpin the transformation of our economy and society at large. The overarching vision for R&I investments in this cluster is "a European industry with global leadership in key areas, fully respecting planetary boundaries, and resonant with societal needs – in line with the renewed EU Industrial Policy Strategy." The expected effects on the European economy and society imply that the R&I activities under this cluster will contribute to various Sustainable Development Goals and respond to three key EU policy priorities: 'A European Green deal', 'A Europe fit for the digital age', and 'An economy that works for people' (Figure 6).

The cluster pursues three objectives: 1) ensuring the competitive edge and sovereignty of EU industry; 2) fostering climate-neutral, circular and clean industry respecting planetary boundaries; and 3) fostering social inclusiveness in the form of high-quality jobs and societal engagement in the use of technologies. A human-centred approach will be taken, i.e. technology development going hand in hand with European social and ethical values.

The key R&I priorities are grouped in two general categories: (I) Enabling technologies ensuring European leadership and autonomy; and (II) Accelerating economic and societal transitions (these will be complemented by priorities of other clusters). European Partnerships envisaged to support the R&I in the specific intervention areas are mainly co-programmed partnerships. Exceptions are the three candidate Institutionalised Partnerships in the digital field and the candidate Institutionalised Partnership in metrology, reflecting their related Partnership Areas.

Figure 6: R&I priorities and higher-level objectives of the Horizon Europe Cluster 4 – Digital, Industry and Space



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Multiple convergences exist between the technologies that are covered in the first strand of the priorities in this cluster, i.e. "enabling technologies ensuring European leadership and autonomy". In their function of 'enabling' technologies, they will also make critical contributions to the attainment of the desired 'transitions' in the 'vertical' industry sectors targeted in the second strand of priorities in this cluster as well as in the other clusters. A major contribution from this perspective can be expected from the four candidate Institutionalised Partnerships as well as from the 'Made in Europe' partnership, focused on manufacturing technologies.

2.3.2 Cluster 5 – Climate, Energy and Mobility

The main objectives of this cluster are to fight climate change, improve the competitiveness of the energy and transport industry as well as the quality of the services that these sectors bring to society. This is supportive of several Sustainable Development Goals including affordable and clean energy (SDG7); industry, innovation & infrastructure (SDG9); sustainable cities & communities (SDG11); sustainable consumption & production (SDG12); and climate action (SDG13). The cluster is most closely aligned to the EU priority for 'A European Green Deal' but also has synergy with two of the other five priorities; 'An economy that works for people' and 'A Europe fit for the Digital Age'. This extends across various policies including a Clean Planet for all, the Energy Union strategy, Single European Railway Area, European ATM Master Plan, Single European Sky, and Europe on the Move (Figure 7).

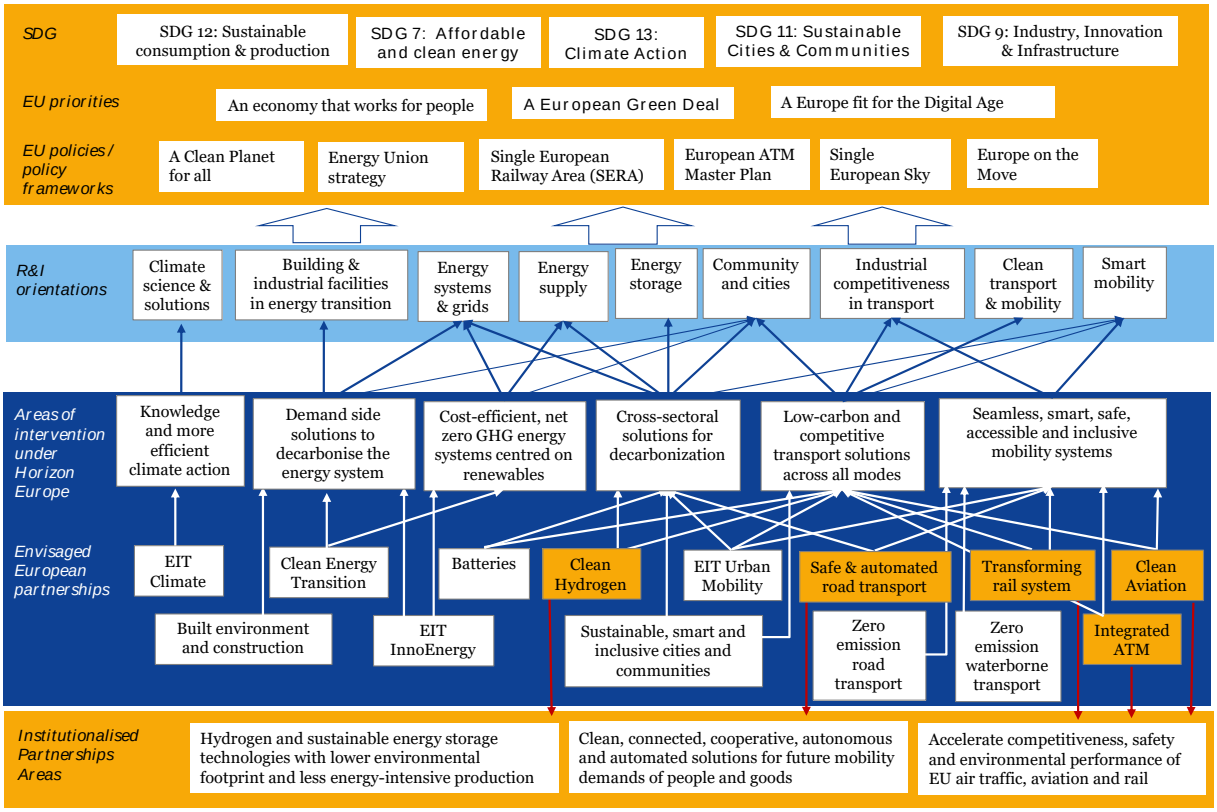
The cluster is directly relevant to several of the areas for possible institutionalised European partnerships on the basis of Article 185 TFEU or Article 187 TFEU, namely:

- Partnership Area 4: Accelerate competitiveness, safety and environmental performance of EU air traffic, aviation and rail

- Partnership Area 6: Hydrogen and sustainable energy storage technologies with lower environmental footprint and less energy-intensive production
- Partnership Area 7: Clean, connected, cooperative, autonomous and automated solutions for future mobility demands of people and goods

Cluster 5 is structured under six areas of intervention under Horizon Europe and nine R&I orientations. Figure 7, below, shows the portfolio of envisaged European Partnerships that are relevant to this cluster and their link to the areas of intervention.

Figure 7: R&I priorities and higher-level objectives of the Horizon Europe cluster Climate, Energy and Mobility



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There are 14 candidate Partnerships that align with this cluster of which eight are possible Institutionalised Partnerships, including five Article 187 initiatives and three EIT-KICs. There are no candidate Article 185 Partnerships in this cluster. The other partnerships are envisaged as either Co-programmed and/or Co-funded Partnerships.

The diagram above shows the strong orientation of the possible Institutional Partnerships towards the mobility area and more limited direct synergies between the envisaged Partnerships and the 'climate science & solutions' priority. Of course, the climate change challenge underpins the whole of this cluster, except where the focus is on industrial competitiveness, but this will also be at least partially dependent on innovation related to clean energy and mobility products and services.

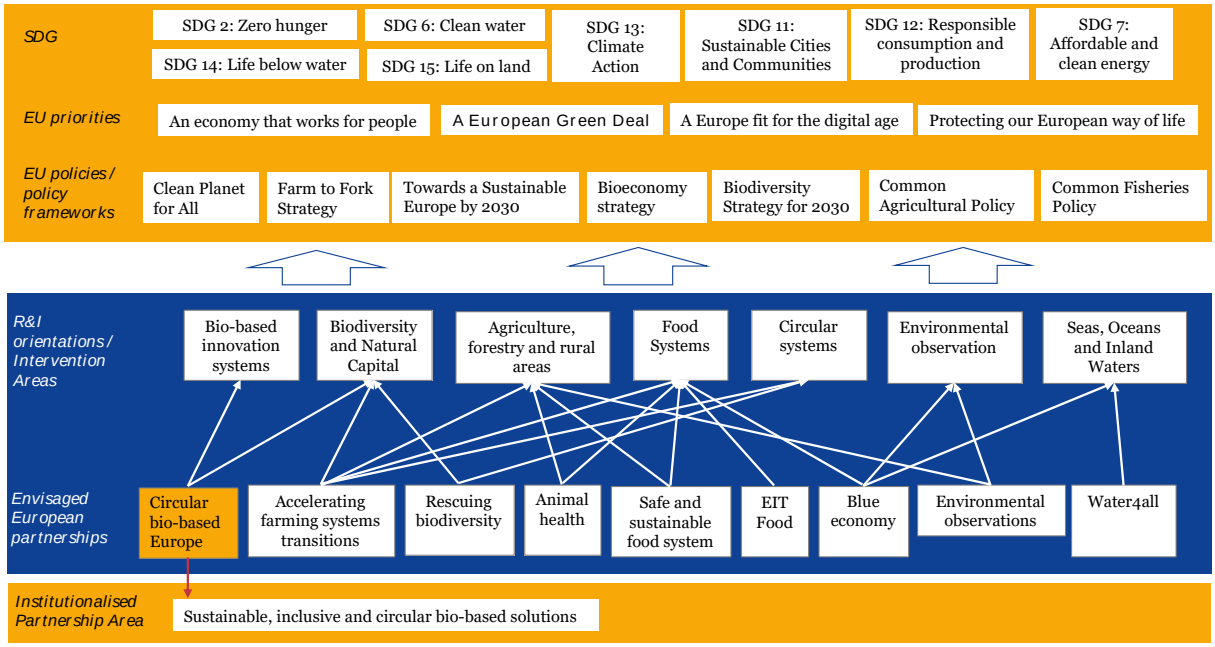
2.3.3 Cluster 6 – Food, Bioeconomy, Natural Resources, Agriculture and Environment

The key objective of Cluster 6, 'Food, Bioeconomy, Natural Resources, Agriculture and Environment' is to advance knowledge, expand capacities and deliver innovative solutions to accelerate the transition towards the sustainable management of natural resources (such as biodiversity, water and soils). The cluster has a large realm and aims to address a wide range of challenges relating to climate change, biodiversity and ecosystems, natural resources, and the production and consumption patterns that may affect them. It encompasses a single area for possible institutionalised European Partnerships aimed at the development of "sustainable, inclusive and circular, bio-based solutions".

The R&I activities funded under the Pillar II Cluster 6 contribute first and foremost to the 'European Green Deal'. More precisely, they will be instrumental to the announced climate change actions, the Biodiversity Strategy for 2030, the "Farm to Fork Strategy", the zero-pollution ambition, the New Circular Economy Action Plan, and the comprehensive strategy on Africa and trade agreements. However, through cooperation with the other clusters, Cluster 6 may make some contribution to the other EU overarching policy priorities. The R&I activities funded under this cluster therefore aim to contribute to the achievement of several United Nations SDGs including: SDG 2: Zero hunger; SDG 6: Clean water and sanitation; SDG 7: Affordable and clean energy; SDG 11: Sustainable cities and communities; SDG 12: Responsible consumption and production; SDG 13: Climate action; SDF 14: Life below water; and, SDG 15: Life on land.

Cluster 6 is structured around six targeted impacts and seven research and innovation orientations, as shown in Figure 8, below. The R&I activities funded under this cluster aim to (1) develop solutions for mitigation of, and adaptation to, *climate change*; (2) halt the *biodiversity* loss and foster the restoration of *ecosystems*; (3) encourage the sustainable (and circular) management and use of *natural resources*; (4) stimulate inclusive, safe and health *food and bio-based systems*; (5) a better understanding of the determinants of *behavioural, socio-economic and demographic changes* to accelerate system transformation; and, (6) improve solutions for *environmental observations and monitoring systems*.

Figure 8: R&I priorities and higher-level objectives of the Horizon Europe Cluster 6 – Food, Bioeconomy, Natural Resources, Agriculture and Environment



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The European Commission envisages nine partnerships under Cluster 6, two of which would be institutionalised (Circular bio-based Europe and EIT Food), four would be either co-programmed or co-funded (Animal Health; A climate-neutral, sustainable and productive Blue Economy; Safe and Sustainable Food Systems for People, Planet and Climate; Water4All), and three would be co-funded (Accelerating Farming System Transition; Agriculture for Data; Rescuing Biodiversity to safeguard life on Earth).

There is seemingly a good balance between the three types of partnerships. However, industry may have some interest in being involved in the design of the Strategic Research and Innovation Agendas regarding living labs and other research infrastructure ('Towards more sustainable Farming' envisaged partnership) to develop solutions for accelerating the transition of farming systems, and technologies to collect agriculture data.

The proposed portfolio of European Partnerships covers the full range of R&I orientations under Cluster 6.

All but one of the proposed partnerships contribute to orienting R&I activities towards the development of food systems that will ensure both sustainable and healthy diets and food and nutrition security for all. The food system has an impact on several challenges. It directly relates to nutrition and diets, access to food, food security, and has an influence on the use of natural resources, water and soil pollution, climate change. Food waste is a key component of circular systems and biomass has strong potential to offer bio-based energy solutions. Finally, the transformation of food systems should take into consideration demographic changes and the accelerating urbanisation (which reduces lands available for food production but offers opportunities for new types of agriculture such as urban farming).

Two R&I orientations are covered by less than half of the proposed partnerships: Environmental Observations (even though achievement in this area could make significant contribution to the other areas) and Bio-based innovation systems (which is nevertheless at the core of the candidate institutionalised partnership for a circular bio-based Europe).

EUROPEAN COMMISSION

Part I. Impact Assessment Studies for the Candidate Institutionalised European Partnerships

5. Candidate Institutionalised European Partnership in Key Digital Technologies

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Abstract

This document is the final report of the Impact Assessment Study for the candidate Institutionalised European Partnership on Key Digital Technologies (KDT) under Horizon Europe. The study was conducted by Technopolis Group from July to December 2019. The methodological framework reflects the Better Regulation Guidelines and operationalises the selection criteria for European Partnerships set out in the Horizon Europe Regulation.

This initiative focusses on enhancing the research, innovation and business value creation of European electronics value chains in key strategic market segments in a sustainable manner to achieve technological sovereignty and ultimately make European businesses and citizens best equipped for the digital age.

It will address the risks of Europe losing the lead in critical industries and services and emerging KDTs. It will also tackle Europe's limited control over digital technologies that are critical for EU industry and citizens. It has as main objectives to strengthen KDTs which are critical for the competitive position of key European industries in the global markets, to establish European leadership in emerging technologies with high socioeconomic potential and to secure Europe's technological sovereignty to maintain a strong and globally competitive presence in KDTs.

The study concluded that the Institutionalised Partnership is the preferred option for the implementation of this initiative.

Executive Summary

This document is the final report of the Impact Assessment Study for the candidate Institutionalised European Partnership on Key Digital Technologies (KDTs) under Horizon Europe. The study was conducted by Technopolis Group from July to December 2019. The methodological framework for this study reflects the Better Regulation Guidelines and operationalises the selection criteria for European Partnerships set out in the Horizon Europe Regulation. This report contains the findings of this specific study.

The **ambition** of the initiative is to enhance the research, innovation and business value creation of ***European electronics value chains*** in key strategic market segments in ***a sustainable manner***. To serve its ambition, it will build upon and expand the activities of H2020 and especially of ECSEL JU to include **silicon photonics** and **embedded software**, **software platforms, intelligent software** and **added value electronics components.**

Three main problems for the KDT industry and Europe that need to be addressed by European action have been identified: Europe risks losing its leading position in critical industries and services; Europe risks becoming a follower in emerging KDTs, and Europe's dependence on and limited control over digital technologies are critical for EU industry and citizens.

In order to tackle the identified problems, the following **general objectives** of EU action are required:

- KDTs to reinforce the strong and globally competitive position of Europe in key industries
- Establish European leadership in emerging technologies with high socioeconomic potential
- Secure Europe's technological sovereignty to maintain a strong and globally competitive presence in KDTs

For the initiative to deliver on the above objectives, it should be able to attract and mobilise the whole KDT ecosystem, including microelectronics and software companies, SMEs, developers in emerging KDT areas, RTOs and downstream industries. Also, the participation of the European Commission and MS is considered necessary. The initiative should support activities from the formulation of the technology concept (TRL2) to the completion and qualification of systems (TRL8). Besides, to achieve the objectives, the initiative needs to improve the KDT ecosystem and establish EU-level coordination that will facilitate the development of a shared vision and strategy, increase the alignment between the EC, MS and industry, and create critical mass in terms of funding, infrastructures and human resources. Finally, the coordination with other initiatives at all possible levels is vital to meet the KDT initiative's objectives.

The relevant policy options for this assessment were Horizon Europe calls (Option 0), Co-programmed Partnership, and Institutionalised Partnership. Our conclusion is that the Institutionalised Partnership is the preferred option. We considered that an Institutionalised Partnership would:

- Provide greater effectiveness by offering higher leverage and structuring effects in the KDT ecosystem by mobilising stakeholders, creating a critical mass of financial and human resources, and providing better coordination of the implementation
- Improve coherence through better coordination with other FP, non-FP, national or regional initiatives

Résumé exécutif

Ce document est le rapport final de l'étude de support à l'analyse d'impact de la proposition de partenariat européen institutionnalisé sur les technologies numériques clés (TNC) dans le cadre d'Horizon Europe. Cette étude a été menée par Technopolis Group entre juillet et décembre 2019. Le cadre méthodologique de cette étude tient compte des lignes directrices pour une meilleure réglementation et opérationnalise les critères de sélection des partenariats européens définis dans le règlement d'Horizon Europe. Le présent rapport contient les résultats spécifiques à cette étude.

L'ambition de l'initiative proposée est d'améliorer de manière durable la recherche, l'innovation et la création de valeur commerciale pour les chaînes de valeur électroniques sur les principaux segments de marchés stratégiques. Pour servir ses ambitions, l'initiative devra tirer parti et développer les activités de H2020, et en particulier de l'entreprise commune ECSEL, pour intégrer la photonique de silicium et les logiciels intégrés, les plate-formes logicielles, les logiciels intelligents et les composants électroniques à valeur ajoutée.

Trois problèmes majeurs pour le secteur des TNC et l'Europe qui doivent être réglés par l'action européenne ont été identifiés : l'Europe risque de perdre sa position dominante dans des secteurs et des services déterminants ; l'Europe risque de devenir un suiveur au niveau des TNC émergentes ; et la dépendance et le contrôle limité de l'Europe sur les technologies numériques sont critiques pour l'industrie et les citoyens européens.

Pour remédier aux problèmes identifiés, les objectifs généraux suivants de l'action de l'UE doivent être poursuivis :

- Les TNC doivent renforcer la position dominante et concurrentielle de l'Europe à l'échelle internationale dans des secteurs clés.
- L'Europe doit s'imposer en tant que leader des technologies émergentes ayant un potentiel socio-économique élevé.
- L'Europe doit assurer sa souveraineté technologique pour maintenir une présence dominante et concurrentielle à l'échelle internationale dans les TNC.

L'initiative derrière les objectifs précités doit pouvoir attirer et mobiliser tout l'écosystème des TNC, et notamment des entreprises de microélectronique et de logiciel, des PME, des développeurs dans les domaines TNC émergents, des organisations de recherche et de technologies, et les industries en aval. Par ailleurs, la participation de la Commission européenne et des États membres est considérée comme indispensable. Cette initiative doit soutenir les activités allant de la formulation du concept technologique (TRL 2) à l'achèvement et à la qualification des systèmes (TRL 8). En outre, pour atteindre ces objectifs, l'initiative doit améliorer l'écosystème des TNC et établir une coordination à l'échelle européenne qui permettra de faciliter la mise en place d'une vision et d'une stratégie partagées, d'améliorer l'alignement entre la CE, les États membres et l'industrie et de créer une masse critique en termes de financement, d'infrastructures et de ressources humaines. Enfin, la coordination avec d'autres initiatives à tous les niveaux possibles est vitale pour atteindre les objectifs de l'initiative TNC.

Les options stratégiques pertinentes pour cette analyse étaient les appels à projets d'Horizon Europe (option 0), les partenariats co-programmés et les partenariats institutionnalisés. Nous en avons conclu que le partenariat institutionnalisé était la meilleure option. Nous avons estimé qu'un partenariat institutionnalisé permettrait de :

- Garantir une meilleure efficacité grâce à des effets de levier et structurant supérieurs dans l'écosystème des TNC en mobilisant les intervenants, en créant une masse critique

de ressources financières et humaines et en assurant une meilleure coordination de la mise en œuvre.

- Améliorer la cohérence en assurant une meilleure coordination avec d'autres initiatives dans ou hors l'accord cadre de l'UE pour la recherche et l'innovation, nationales ou régionales.

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Glossary

AI	Artificial intelligence
CAGR	Compound annual growth rate
CEF	Connecting European Facility
CF	Co-funded partnership
CMOS	Complementary metal–oxide–semiconductor
CP	Co-programmed partnership
CPS	Cyber-physical system
DAE	Digital Agenda for Europe
DEP	Digital Europe Programme
DSM	Digital Single Market
ECS	Electronic components and systems
ECSEL JU	Electronic Components and Systems for European Leadership Joint Undertaking
EDA	Electronic design automation
ELG	Electronics Leaders Group
EMS	Electronics manufacturing services
ES	Embedded software
FDSOI	Fully depleted silicon on insulator
FPGA	Field-programmable gate array
GaN	Generative Adversarial Network
HPC	High performance computing
IC	Integrated circuits
IIoT	Industrial Internet of Things
IoT	Internet of Things
IPCEI	Important projects of common European interest
IS	Intelligent Software
JTI	Joint Technology Initiative
KDT	Key Digital Technologies
MFF	Multi-annual Financial Framework
MS	Member States of the European Union
NITRD	Networking and Information Technology Research and Development programme
PS	Platform software

R&D&I	Research, development and innovation
RTO	Research and technology organisation
SDGs	Sustainable Development Goals
SiC	Silicon carbide
SOI	Silicon on insulator
SoS	System of systems
TRL	Technology readiness level

1 Introduction: Political and legal context

This document presents the impact assessment of the candidate institutionalised partnership **Key Digital Technologies** (KDT), which is one of the initiatives that will implement the Commission's vision for the period beyond 2020 under the Horizon Europe Pillar II, specifically Cluster 4 – Digital, Industry and Space. It is one of the envisaged European Partnerships in the Partnership Area 'Advancing key digital and enabling technologies and their use, including but not limited to novel technologies such as artificial intelligence, photonics and quantum technologies'.

The **ambition** of the candidate initiative on Key Digital Technologies is to enhance the research, innovation and business value creation of **European electronics value chains** in key strategic market segments in **a sustainable manner** to achieve technological sovereignty and ultimately make European business and citizens best equipped for the digital age.

To serve its ambition, **the scope** of the candidate imitative for key digital technologies is threefold:

- *Widening European electronics value chains at hardware level* to **silicon photonics** and **embedded software** (ES) that together with **electronic components** provide the basis for **systems** that are secure, energy efficient and high performing
- *Integrating seamlessly European electronics value chains at middleware level* through **software platforms** (SP) that enable interoperability of **electronics and photonics components** and **systems,** and facilitate **interaction** between the supply and demand sides of the chains
- *Expanding European electronics value chains at function level* to **intelligent software** (IS), **added value electronics components and photonics** for enhancing product and service functionalities to address the diverse needs in key industries and respond to crucial societal challenges

1.1 Emerging challenges in the field

The following section outlines the key emerging trends and challenges in the field of KDT. A more detailed analysis can be found in Appendix D.

Social trends and challenges

The ageing of the European population increases the stress on **health budgets** and **health service** infrastructures, thereby changing the needs for digital services and impacting the production infrastructure. In order to maintain high living standards, new approaches in electronics components, software and systems are needed for developing new solutions and services contributing to increases in the productivity, efficiency and quality of **health services**.

Increased urbanisation introduces challenges for **pollution** and **traffic management,** among others, requiring reliable, highly secure, energy efficient, seamless and intelligent new approaches for energy, transport and mobility as well as energy management.[1]

[1] ERTRAC. (2017). *Integrated Urban Mobility Roadmap*, Joint ERTRAC-ERRAC-ALICE Working Group on Urban Mobility, available at https://www.ertrac.org/uploads/documentsearch/id45/2017%20ERTRAC%20Urban%20Mobility%20Roadmap%20-%20web.pdf, and Picasso. (2016). *Public Report – Revised Panorama of ICT Landscape in EU and US: ICT, policies, regulations, programmes and networks in the EU and US*, available at http://www.picasso-

Technological trends and challenges

Digital transformation of the economy and society generates an exponential demand for data exchange, which existing infrastructures in several cases are unable to manage in a trusted and energy efficient manner. **Artificial intelligence** (AI) affects all industrial sectors and several application areas, and together with the **Internet of Things** (IoT), it necessitates new **computing architectures**, software and advanced semiconductor technologies addressing the insatiable need to transfer, store and analyse vast amounts of data locally. AI-related semiconductors could reach a growth of 18% annually over the next few years, five times greater than the rate for semiconductors used in non-AI applications, while accounting for almost 20% of all demand by 2025, raising revenues of around €60 billion.[2] Driven by the need for new-generation distributed/edge computing serving AI, new computing paradigms (**neuromorphic/quantum computing** accelerators and complex integration) emerge.

Photonics and software are increasingly co-integrated with chip-level electronic components and systems (ECS) to build complex systems and integrated platforms as well as open up new application areas. **Silicon photonics** is closely related to ECS; photonics is increasingly used in several sectors, such as healthcare, 5G communications, self-driving vehicles, food-safety tests and environmental monitoring, and also in data centres.[3]

Mastering complex European electronic value chains increasingly requires pairing **software** with microelectronics. While hardware and software parts are becoming increasingly hard to dissociate, there is a need for different software layers to be integrated across electronic value chains.

Economic trends and challenges

The ECS value chain has become a strategic technology market with significant impact on the economy and, therefore, the **latter is increasingly dependent on the former to support its growth**. The size of the worldwide **electronics value chain,** including downstream industries, is enormous, estimated at around €52.6 trillion in 2018. The microelectronics segments were estimated at €4.1 trillion in 2018 and are expected to reach €5.7 trillion by 2025, experiencing a compound annual growth rate (CAGR) of 5%.[4] Already by 2020, more than 50% of Europe's GDP will be driven by the ECS industry.[5] Furthermore, the market for AI-related semiconductors is expected to grow from €5.5

project.eu/wp-content/uploads/2017/03/PICASSO-Panorama-of-ICT-landscape-in-EU-and-US-public-version.pdf.

[2] McKinsey & Company. (2019). *Artificial Intelligence Hardware: New opportunities for semiconductors companies*, available at https://www.mckinsey.com/industries/semiconductors/our-insights/artificial-intelligence-hardware-new-opportunities-for-semiconductor-companies; European Commission. (2018). *Boosting Electronics Value Chains in Europe, A report to Commissioner Gabriel*, available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53119.

[3] SciTech Europa. (2019). *Photonics PPP: Positive outlook with 5-fold leverage on EU investment*, available at https://www.scitecheuropa.eu/photonics-ppp-5-fold-leverage-on-eu-investment/96454.

[4] European Commission. (2019). *Study on the Electronics Ecosystem: Overview, developments and Europe's position in the world*. Final Report. SMART 2016/0007; Advancy. (2019). *Embedded Intelligence: Trends and challenges*. Commissioned by ARTEMIS-IA, available at https://artemis-ia.eu/news/embedded-intelligence-trends-challenges-book-release.html.

[5] ECSEL JU. (2018). *A vision for electronics*, available at https://www.ecsel.eu/sites/default/files/2018-10/Binspired%20-%20A%20vision%20for%20electronics.pdf.

billion in 2018 to €27 billion in 2020 while the market forecast for IoT semiconductor spending amounts to €30 billion in 2020.[6]

Software and solutions are further expected to outgrow hardware and electronic parts in several application areas. In the automotive sector's demand for software is projected to grow by 9% CAGR for the period 2020 to 2030.[7] In the healthcare segment, the growth forecast for global mobile health services and devices markets, with strong software underpinnings, is 30-40% per annum over the next five years. The European smart grid market is also foreseen to grow by 9% on a yearly basis until 2025.[8]

Sectors with high intensity of and therefore dependency on microelectronics are the automotive and industrial manufacturing equipment-makers, including industrial robotics and electronics. Microelectronics components are expected to grow annually (CAGR) between 2017 and 2022 by 7.7% and 7.1% respectively.[9] Other sectors with projected growth are logistics, energy, communications, aerospace, defence and security as well as the smart city, healthcare and consumer markets, with major applications for IoT at home and wearables.

The semiconductor industry ranks among the highest of all industry sectors in terms of **investment levels** on production equipment and R&D&I, and it is **increasingly challenging for companies and countries to compete**. R&D investments could be as high as 15% of revenues, on average, while reaching 20-25% in some ECS segments. New production technologies to maintain Moore's Law and to increase the wafer size significantly increases the required investments with the cost of a new foundry reaching approximately €12.5 billion in 2015.[10]

The **fragmentation and internationalisation** of semiconductor value chains, which **pulls the production from US and Europe towards Asia**, are expected to continue.[11]

The consolidation of the semiconductor industry continues with **mergers and acquisitions** at an increased pace, generating **significant market failures**. Due to this trend, roughly 43% of all global chip sales in 2017 were generated by

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[6] Tractica. (2017). *Artificial Intelligence Market Forecasts*, available at https://www.tractica.com/wp-content/uploads/2017/04/MD-AIMF-2Q17-Executive-Summary.pdf; PwC. (2019). *Opportunities for the global semiconductor market*, available at https://www.pwc.com/gx/en/industries/tmt/publications/global-tmt-semiconductor-report-2019.html. and Deloitte. (2018). *IoT Opportunity in the World of Semiconductor Companies*, available at https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology/us-semiconductor-internet-of-things.pdf.

[7] McKinsey & Company. (2019). *Automotive Software and Electronics 2030: Mapping the sector's future landscape*, available at https://www.mckinsey.com/~/media/McKinsey/Industries/Automotive%20and%20Assembly/Our%20Insights/Mapping%20the%20automotive%20software%20and%20electronics%20landscape%20through%202030/Automotive-software-and-electronics-2030-vF.ashx.

[8] Advancy. (2019). *Embedded Intelligence: Trends and challenges*. Commissioned by ARTEMIS-IA, available at https://artemis-ia.eu/news/embedded-intelligence-trends-challenges-book-release.html.

[9] European Commission. (2018). *Boosting Electronics Value Chains in Europe* (2018), available at https://ec.europa.eu/digital-single-market/en/news/boosting-electronics-value-chains-europe.

[10] Fraunhofer IMW. (2018). *Global Competition in Microelectronics Industry from A European Perspective: Technology, markets and implications for industrial policy* and Armasu, L. (2015). *Samsung's New 14 Billion Chip Plant To Manufacture DRAM, Processors in 2017*, available at https://www.tomshardware.com/news/samsung-14-billion-chip-plant,29058.html.

[11] DTI. (2012). *Study on Internationalisation and Fragmentation of Value Chains and Security of Supply: Case study on semiconductors*. European Commission, DG Enterprise and Industry, available at https://ec.europa.eu/docsroom/documents/394/attachments/1/translations/en/renditions/native.

five companies.[12] Electronic and electric equipment and machinery are among the sectors with the most acquisitions in 2019. There are cases where more than 50% of EU assets are controlled by companies from outside Europe; for the manufacture of computer, electronic and optical products, the share of foreign assets was 54% in 2016.[13]

Environmental and other societal challenges

Climate change and the need to safeguard the environment are pressing challenges that cannot be solved without digital technologies. While the KDT industry contributes to improving energy efficiency levels (by 14% on average between 2000 and 2015), it also has an increasingly negative impact due to the use of non-environmentally friendly materials (i.e. rare earth and the waste it creates).[14]

KDTs are perceived as having the potential to deliver **transformative solutions**, including autonomous and connected vehicles transforming mobility while reducing greenhouse gas emissions, distributed energy grids decarbonising power grids and increasing energy efficiency, intelligent, connected and liveable cities with minimal air pollution and environmental impact, and a combined use of sensors and IoT registering natural products and processes.[15]

Energy consumption is an important aspect as supercomputers and data centres consume massive amounts of power and mobile and IoT devices require a reduction in energy consumption to maximise usage of increasingly smaller and lighter batteries.

As digitalisation affects a growing spectrum of activities, the need for **security and safety** increases. These issues, which are of immediate concern for all cyber-physical and network-connected devices, need to be addressed both at software and hardware levels, including in the design (security by design) and manufacturing of digital technologies.[16]

Political, policy and regulatory framework

The **influence of politics** is increasing in digital technologies. The US uses its position in the production of semiconductors and microelectronics to serve its foreign policy agenda, which can be exemplified through the involvement of microelectronic products in the US-China trade war and the US export ban on critical electronic components for security reasons.[17]

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[12] EE Times. (2018). *The Concentration of Semiconductor Market Share*, available at https://www.eetimes.com/author.asp?section_id=40&doc_id=1333179#.

[13] Ibid

[14] ECSEL JU. (2019). *Multi-Annual Strategic Plan (MASP) 2019*, available at https://ec.europa.eu/research/participants/data/ref/h2020/other/legal/jtis/ecsel-multi-stratplan-2019_en.pdf.

[15] World Economic Forum. (2018). *Harnessing Artificial Intelligence for the Earth*, available at http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf and European Commission. (2018). *Electronics Value Chains: Workshop on Energy Management, including Electrification of Cars and Smart Grids*, Brussels, 22 March 2018, available at http://ec.europa.eu/information_society/newsroom/image/document/2018-13/report-digitisingenergyvaluechain-workshop_0209BF3E-0D40-52CF-48B579B49BE24D96_50739.pdf

[16] HiPEAC. (2019). *HiPEAC Vision 2019*, available at https://www.hipeac.net/vision/2019.

[17] E&T. (2018). *Boeing and Airbus set to lose USD39bn following Iran nuclear deal blow*, available at https://eandt.theiet.org/content/articles/2018/05/boeing-and-airbus-set-to-lose-39bn-following-iran-nuclear-deal-blow.

In the **open public consultation** all stakeholders (in particular all public authorities and the overall majority[18] of business associations and large companies, but also SMEs, universities and RTOs) recognised that rapid change, including big data and the emergence of new computing paradigms, are relevant challenges which need to be addressed. Also, the sky-rocketing costs of equipment were perceived as a topic of relevance, especially according to the opinion of an overall majority of public authorities and more than half of universities and RTOs, large companies and SMEs. While about a third of business associations still found it important, about half of them was of a neutral opinion on the importance of the sky-rocketing costs.

According to **feedback on the inception impact assessment**, several respondents asked for a broadening of the scope; the need to integrate semiconductor-based integrated photonics, selected software technologies (beyond embedded software) and their applications to cover full value chains and networks was highlighted by industry associations. A majority of **interviewees**, including from large companies, industry associations, SMEs, RTOs and universities, equally stressed the importance of AI, computer architectures, software engineering and silicon-based photonics for the KDT initiative.

The main trends are summarised in Table 1.

Table 1: Overview of the challenges emerging in the area of KDT

Social	• Ageing society and increased pressure on the health system • Increased urbanisation leads to pollution, traffic management and energy management challenges
Technical and technological	• Digital transformation generates an exponential demand for data exchange, which existing infrastructures often cannot manage adequately in adherence with EU data protection, security, porting and energy efficiency values • Risk of failure associated with new technological trends is high and the level of critical mass is increasing for financial and human resources • AI needs new computer architectures (such as neuromorphic and quantum computing accelerators and complex integration), advanced semiconductor technology and intelligent software that demand intensive R&D efforts • Software is increasingly required by European electronics value chains as a 'pairing' KDT for microelectronics
Economic	• The economy is increasingly dependent on digital technologies for innovations and growth • Continuation of existing fragmentation trends in the semiconductor value chain which reduce the presence of certain segments in Europe • Global competition requires high investments on R&D and production capacity • Shortening of the innovation cycle and the fast uptake of innovations by markets demand closer and more effective links among stakeholders and increased involvement of industry in early stages of research • The horizontal expansion of the value chain to include more partners and technologies, transforming them into value networks with increased complexity and coordination needs • The increasing consolidation of the semiconductor and software industries with mergers and acquisitions intensifies the competition and increases pressure on the European ecosystem

[18] The study's analysis of the open public consultation applies the following categories: overall majority (+80%), more than half (+50%), about half (40-50%), about a third (30-40%) and few (-30%).

Environmental and other societal	• Supercomputers, data centres and IoT increase demand for energy to perform computational, storage and communications activities • The digital technologies industry has an increasingly negative impact due to non-environmentally friendly materials and waste created • The need for security and safety increases as digitalisation affects all aspects of life; the development of new design and manufacturing approaches in microelectronic components, systems and software are necessary to address the problem
Political, policy and regulatory framework	• Increased protectionism (e.g. in the US) • Involvement of microelectronic products in the trade war • Concerns are raised with security of imported microelectronics and electronic applications in the international political discourse

1.2 EU relative positioning

1.2.1 Competitive positioning of Europe in the field

Position of Europe in the fields of microelectronics and software

Europe's share of the entire ECS value chain, including related user industries and services, was estimated at €12.5 trillion in 2018, representing 24% of the world value (Figure 1).[19] If only ECS segments are considered, represented by the first four value chain levels – materials and tools, components, electronic boards and electronic equipment – Europe's value grew from €357 billion in 2012 to €469 billion in 2017,[20] experiencing a CAGR of 5%. Given a slower growth relative to the global level, Europe's share dropped from 14% in 2012 to 12% in 2018. If Europe retains its share in global markets, then the value of Europe's ECS could reach €691 billion by 2025.[21]

Europe holds a **strong position** in embedded/professional electronics for automotive, industrial equipment, aerospace/defence/security, and the health and care sectors with a share of 22% of world sales. This segment is among the most dynamic and it grows faster than the consumer electronics where Europe is weaker (Figure 1). Europe is also well positioned in materials and tools for the production of electronic equipment (17%).[22] Europe also has a leading position in the areas of lithography, SOI wafers, use of deposition technologies, and in robotic wafer handling. However, Europe's position is rather weak in the production of stand-alone electronics, electronics boards, semiconductors and other electronic components.

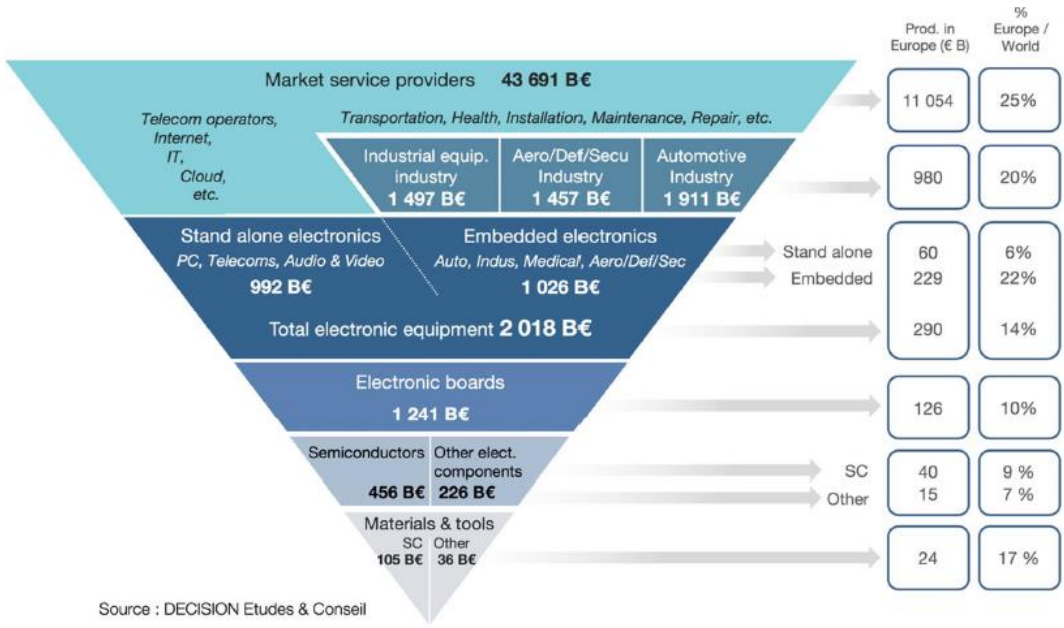
[19] European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems (ECS): Opportunities ahead*. SMART 2018-0005.

[20] Fraunhofer IMW. (2018). *Global Competition in Microelectronics Industry from a European Perspective: Technology, markets and implications for industrial policy*.

[21] For more information see Appendix D.

[22] European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems (ECS): Opportunities ahead*. SMART 2018-0005.

Figure 1: Worldwide electronics value chain and the position of Europe in 2018 – production values in euros



Source: European Commission. (2019). *Study on Emerging Technologies in Electronic Components and* Systems (ECS): Opportunities ahead. SMART 2018-0005.

Europe's position in the **semiconductor** segment has declined from 22% in 1998 to 9% in 2017.[23] Only three European companies are represented among the 15 largest semiconductor companies worldwide in 2019. Despite the decline in shares in absolute terms, European sales grew with a CAGR of 3.8%, jumping from €28 billion in 2010 to €35 billion in 2017; the growth was driven primarily by demand for embedded electronics systems.

In **electronic equipment for consumer mass markets,** such as mobile phones and PCs, Asian countries and the US are leaders, while Europe is leading in **downstream industry segments,** such as **industrial electronics, automotive, aerospace, defence and security, and health and care electronics**. The driver for Europe's success is its strong position in relevant sectors and the pivotal role of electronics in product innovation. The availability of leading-edge ECS – both hardware and software – is a key determiner behind the competitiveness of Europe's industrial domains. Approximately 80-90% of key differentiating competitive features rely on built-in ECS, which increasingly includes sensors and software.[24]

The EU's **automotive electronics** sector is strong not only in production capacity but also in engineering and R&D. In terms of production, Europe is leading with 27% of global production followed by China (20%) and North America (18%). Europe is second in **industrial electronics** with 20% after China (24%) and ahead of North America (19%). In **aeronautics, defence and security electronics,** Europe comes second after US (41%) with a strong industrial base, representing 22% of global production. Europe is third

[23] Ibid

[24] ECSEL JU. (2018). *Decision of the Governing Board of the ECSEL Joint Undertaking: ECSEL multi-annual strategic plan 2019*, ECSEL GB 2018.114, available at https://www.ecsel.eu/sites/default/files/2019-01/ECSEL%20GB%202018.114%20-%20MASP%202019%20and%20Annex%20V1.1.pdf

in the **health and care** segment with a share of 19% of global production; the shares of the US and China are 40% and 20% respectively.[25]

Demand from downstream industries pull the whole European supply chain. The **ECS segments where Europe has its strongest position, and with the highest spillover effects on downstream industries,** are semiconductors, electronic boards and embedded electronic equipment in such sectors as automotive, industrial equipment, aerospace, defence and security, and health and care. However, the diversity of applications and markets served, each with specialised characteristics, raise barriers for SMEs, especially in the area of design, packaging and testing, which have become unaffordable for European SMEs.[26]

In terms of **R&D in micro- and nanoelectronics**, Europe's position is strongly powered by high investments in R&D by companies where Europe's semiconductor companies invest, on average, 15% to 20% of revenues in R&D and the existence of world-renowned research organisations.[27]

The US has a dominant position at global level in the development of **associated software and digital services** (i.e. the fifth level of the value chain) in support of the entire electronics value chain. Beyond legacy telecom operators, Europe is weakly positioned in terms of digital services players.[28] Furthermore, there is a significant gap between European and US companies in R&D investments in software: European-based companies invests approximately €4.9 billion in R&D compared to €28.3 billion by US counterparts. The investment in internet and computer science was around €1.6 billion and €20.2 billion by European and US companies respectively. Also, the distribution of company sizes in the software industry is highly uneven with a strong market dominance by US providers in terms of worldwide revenues: most top 10 software providers are US companies.[29]

An analysis[30] of scientific publications indicates that Europe retains a strong position in **microelectronics research**,[31] producing 31% of publications in the period from 2009 to 2018. China (25%) comes second followed by the US (24%). Europe is the leading research player in the **embedded electronics field, computer architectures, software related to microelectronics, power electronics and** the emerging area of **AI related to microelectronics** while in the emerging area of **edge computing** Europe follows closely the leading China. Despite the leading position of Europe, China is caching-up in all fields driven by significant investments made by the Chinese government. Comparing the performances of individual EU Member States against other countries, China is the leader followed by the US, while the two top European countries, Germany and France, remain

[25] European Commission. (2019). Study on the Electronics Ecosystem: Overview, developments and Europe's position in the world. Final Report. SMART 2016/0007.

[26] European Commission. (2018). Boosting Electronics Value Chains in Europe, A report to Commissioner Gabriel, available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53119.

[27] European Commission. (2019). Study on the Electronics Ecosystem: Overview, developments and Europe's position in the world. Final Report. SMART 2016/0007.

[28] Ibid

[29] PAC, CXP & Fraunhofer ISI. (2017). The Economic and Social Impact of Software & Services on Competitiveness and Innovation (SMART 2015/0015). Final Report, available at https://op.europa.eu/en/publication-detail/-/publication/480eff53-0495-11e7-8a35-01aa75ed71a1.

[30] The analysis of the performance in scientific publications is based on Scopus data. Please refer Appendix D and Figure 45 to Figure 23.

[31] The area of microelectronics was defined by a cloud of keywords suggested by the study's expert panel. Other technological areas included in the analysis were defined in a similar way.

far behind. The contrast between the strong position of Europe as a whole and the relatively weak position of individual countries illustrates, on the one hand, the limitations of thinking national, while on the other hand, it underlines the possibilities and **added value of pooling together resources at the European level**.

1.2.2 Support for the field in the previous Framework Programme

The main instrument of Horizon 2020 for supporting ECS was **the Electronic Components and Systems for European Leadership Joint Undertaking** (ECSEL JU).[32] The total amount invested up to 2018 was approximately €3.4 billion and it is expected by 2020 to reach approximately €5 billion, with €1 billion from the European Commission expected to mobilise a further €1 billion from MS, and at least €2 billion from industry.[33]

From a scientific impact perspective, 66% of publications from ECSEL JU participants were in the top 25% ranked journals in their respective fields. When it comes to patents, ECSEL JU has a total of 46 patents[34] registered based on projects from 2014 to 2018, out of which 12 have been cited. ECSEL JU's partners are the EU, 30 ECSEL JU Participating States[35] and three private associations, respectively AENEAS, EPoSS and ARTEMIS-IA representing companies and RTOs from the fields of micro- and nanoelectronics, smart integrated systems and embedded/cyber-physical systems (CPS).

In addition to ECSEL, EU investment (2014 to 2018) in the field of ECS through traditional calls under Horizon 2020 was in the region of €250-350 million.[36]

Based on experiences from ECSEL JU, and given the interactions among various elements of the ECS value chain in the design and development of new technologies and innovations, it is key to provide a broad **coverage of the ecosystem** including embedded and intelligent systems and downstream industries (automotive, MedTech, manufacturing, energy, etc).

As evident from the interim evaluation of ECSEL JU and interviews conducted with industry associations and companies, the **interactions and coordination among the various elements of the value chain** in the design and development of new technologies and innovations are increasingly important. Prior to the launch of ENIAC and ECSEL JU, there was no overriding strategy in the microelectronics area, and a lack of communication and collective vision among actors, in particular regarding research and technology organisations. Continued policy intervention is a precondition to sustaining better interaction and cooperation among the players.

ECSEL JU has been able to support **large-scale projects** (up to €60-100 million) that no single MS would otherwise have been able to support by itself, including to address the

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[32] Council of the European Union. (2014). *Council Regulation (EU) No 561/2014 establishing the ECSEL Joint Undertaking*, available at https://www.ecsel.eu/sites/default/files/2017-09/Council_Regulation_Establishing_ECSEL_JU.pdf.

[33] ECSEL JU was established in 2014 as a Joint Undertaking and tripartite PPP. It replaced the previous ENIAC JU focussing on nanoelectronics and ARTEMIS JU concentrating on embedded systems.

[34] Due to competition, business practices and the pre-competitive nature of collaborative R&D projects, it is anticipated that most industrial partners are likely to apply for IPR outside the context of the treatment. Thus, the number of IP recorded in the database may highly underestimate the real effects.

[35] The Participating States comprise 26 MS (Cyprus and Croatia excluded) and four Associated States within the Horizon 2020 programme (Switzerland, Norway, Israel and Turkey).

[36] Rough estimation based on Corda data for 2014 to 2018. The estimation takes into account projects that indicates 'electronics' in the project abstract.

need for harmonisation with testbeds, standards and platforms, respectively. As the experience from ECSEL JU shows, the tripartite model with sourcing of investments from the Commission, MS and industry helps to streamline priorities and strategies, while mobilising resources and making synchronised funding decisions otherwise not achievable.[37]

1.3 EU policy context beyond 2021

As set out in report on the overarching context to the impact assessment studies, the R&I activities funded under the Pillar II Cluster Digital, Industry, Space aim at contributing to the attainment of three overarching EU policy objectives: 'A Europe fit for the Digital Age', 'An economy that works for people', and 'A European Green Deal'. Their critical role in facilitating transitions in multiple 'vertical' sectors in our economy and society imply that the R&I actions under this cluster will contribute to addressing several SDGs.

Specifically, advancements in the field of KDT are expected directly to contribute to *SDG 9 – Industry Innovation and Infrastructure* by providing direct support to the improvement of the competitive position of the ECS as well as the software and system integration European industry, in line with the Electronics Industrial Strategy for Europe. They will also strengthen the innovation performance of companies in downstream sectors using electronic components/systems and software such as the automotive, defence, aerospace, security, health and smart cities sectors. It is further expected to contribute to resource efficiency, transformation of production and consumption patterns and e-work (*SDG 8, Decent Work and Economic Growth*). Thanks to the emphasis on lower power electronics and the support for applications in the field of energy efficiency and renewable energy, this initiative can also be expected to contribute to sustainability and environmental protection (*SDG 7, Affordable and Clean Energy* and *SDG 13, Climate Action*), while it will contribute to an improvement of water-use efficiency and the protection of oceans and water quality through, for instance, IoT/smart systems that reduce the usage of water resources (*SDG 6, Clean Water and Sanitation* and *SDG 14, Life below Water*). While connected infrastructure/IoT can help to promote energy efficiency and resource efficiency, CPS and embedded system production technology improves production and consumption patterns and facilitates the transition towards a circular economy (*SDG 11, Sustainable Cities and Communities* and *SDG 12, Responsible Consumption and Production*). Microelectronics and related software can guarantee data integrity, privacy and security. An indirect impact on the SDGs is also expected through the contribution of KDT to the development of the necessary technological elements for AI applications that increase productivity in a secure and energy efficient manner in areas such as healthcare (*SDG 3, Good Health and Well-being*), agriculture (*SDG 2, Zero Hunger*) and education (*SDG 4, Quality of Education*). Precision agriculture and food monitoring are further envisaged to help increase agricultural productivity and reduce the need for scarce resources. Lastly, microelectronics and related software can also guarantee data integrity, privacy and security (*SDG 10, Reduces Inequalities* and *SDG 16, Peace Justice and Strong Institutions).*

Figure 2, below, maps out the positioning of the candidate Institutionalised Partnership in this field in the landscape of the envisaged partnerships in Cluster 4, with a specific focus on the digital field. The three candidate Institutionalised Partnerships covering enabling technologies are all related to digital technologies, i.e. ECS, 5G infrastructure and high-performance computing. Together with photonics, AI, data technologies and robotics, these partnerships are intended to enable digitalisation of vertical industries such as transport, automotive, manufacturing, energy and health, enable new services and ensure

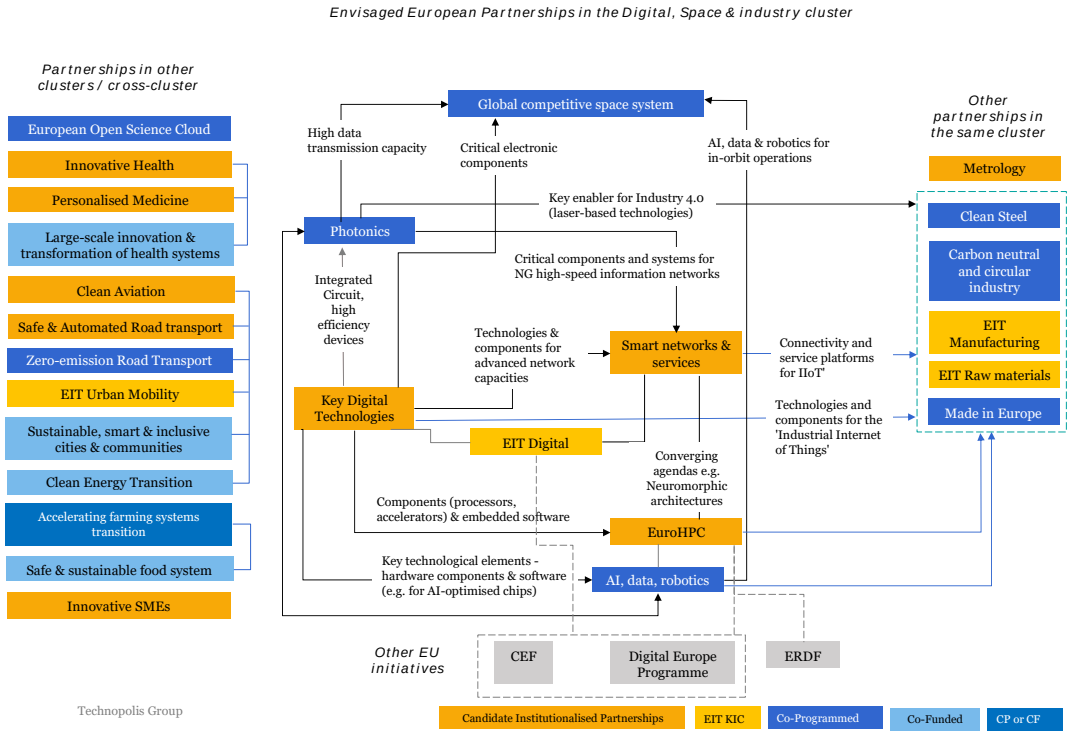
[37] European Commission. (2018). *Interim Evaluation of the ECSEL Joint Undertaking (2014-2016) Operating under Horizon 2020*. Final report, available at https://ec.europa.eu/research/evaluations/pdf/ecsel.pdf.

the development and deployment of the 'Industrial Internet of Things' (IIoT). The move towards Industry 4.0 (supported by IIoT) is crucial to maintain industrial production in Europe by developing more intelligent systems and machines, to increase value and remain competitive especially in high-end markets.

Figure 2 shows that developments in the field of IIoT will in the first instance be to the benefit of the other envisaged partnerships in this cluster. It also lists the most important initiatives related to the 'vertical' industries in the other Pillar II clusters that can be expected to draw benefits from these developments in the digital sphere, allowing for the development of 'smart health', 'smart mobility', 'smart grids', 'smart cities', precision farming, etc. Metrology research will support initiatives in the digital sphere by providing accurate, state-of-the-art measurement capabilities that are necessary for the materials, and equipment to produce integrated circuits (IC).

The mapping of the partnerships landscape in Figure 2 shows a close interconnection between the various initiatives in the digital field, taking a full value chain approach and building upon each other for the attainment of future technological advancements. Technologies like 5G connectivity, cloud computing, and IoT, which find a point of convergence in the Smart Networks and Services initiative, are key elements leading the technological evolution of digital infrastructures towards 'beyond 5G' and later 6G networks. In order to develop a strong industrial and technological base, it will be necessary to guarantee cybersecurity for these critical infrastructures as well. While the Smart Networks and Services initiative is expected to set in place the overall architecture of future networks and services (from component to application level), close collaboration with the KDT initiative that complements the value chain at the device level, creating technological breakthroughs on the individual components, will allow for the creation of the service platforms required for the likes of IIoT, smart cities and 5G corridors for Connected and Automated Mobility.

Figure 2: The envisaged partnerships in the Digital, Industry, Space cluster



The High-Performance Computing (HPC) initiative, in close interaction with the AI-data-robotics envisaged partnership, will be pivotal in addressing the need to integrate and analyse information for building smarter applications in emerging smart cities and the IoT. Addressing future challenges requires scaling to extreme performance levels by means of HPC solutions, as well as bringing computing closer to data sources, i.e. enabling computing at the edge. Connected sensors and IoT devices, smart grid, smart cities, software-defined networks, network function virtualisation, data-driven cognitive networking, and cyber security utilise edge computing networks to support data transmission over significant distances via distributed and connected communication devices.

The Cluster 4 envisaged European Partnerships and, especially, those related to digital technologies will benefit from the infrastructure developed in the European Open Science Cloud partnership for the storage, management, analysis and re-use of data. In turn, the technological advancement allowed by the research and innovation activities in Cluster 4 could help further improve the infrastructures and related serviced offered by the European Open Science Cloud.

The Innovative SMEs partnership may also interact closely with the Cluster 4 candidate European Partnerships, as its main beneficiaries (SMEs) compose a large share of the digital companies.

The political guidelines of the Commission President, Ursula von der Leyen, presented 'A Europe fit for the digital age' among the six headline ambitions for Europe.[38] This headline ambition covers a focus on grasping the potential of the digital age, strengthening related industry and innovation capacities, achieving **technological sovereignty in critical technology areas,** and leading the way on the **next-generation hyperscalers**. A mission letter[39] to Thierry Breton, now Commissioner for Internal Market, further underlines the need to enhance Europe's technological sovereignty, which comprises **investments in next frontier of technologies** such as "blockchain, HPC, algorithms, and data-sharing and data-usage tools." As part of the mission is also the jointly definition of standards for 5G networks and new-generation technologies.

The value chain of KDT is also addressed through the **IPCEI framework's support for microelectronics**, a €7.75 billion investment project mobilising €6 billion private investments and €1.75 billion from 4 MS, focusing on **downstream applications, research and innovations**, which are complementary to upstream R&I activities.[40] The IPCEI involves around 30 direct participants that will carry out sub-projects focusing on energy efficient chips, power semiconductors, smart sensors, advanced optical equipment and compound materials.

[38] von der Leyen, U. (2019). *Political Guidelines for the Next European Commission 2019-2024: A Union that strives for more. My agenda for Europe*, available at https://ec.europa.eu/commission/sites/beta-political/files/political-guidelines-next-commission_en.pdf.

[39] European Commission. (2019). *Thierry Breton: Commission-designate for Internal Market. Mission Letter*, available at https://ec.europa.eu/commission/sites/beta-political/files/president-elect_von_der_leyens_mission_letter_to_thierry_breton.pdf.

[40] European Commission. (2018). *State aid: Commission approved plan by France, Germany, Italy and the UK to give €1.75 billion public support to joint research and innovation project in microelectronics*. Press release, 18 December 2018, available at https://ec.europa.eu/commission/presscorner/detail/en/IP_18_6862.

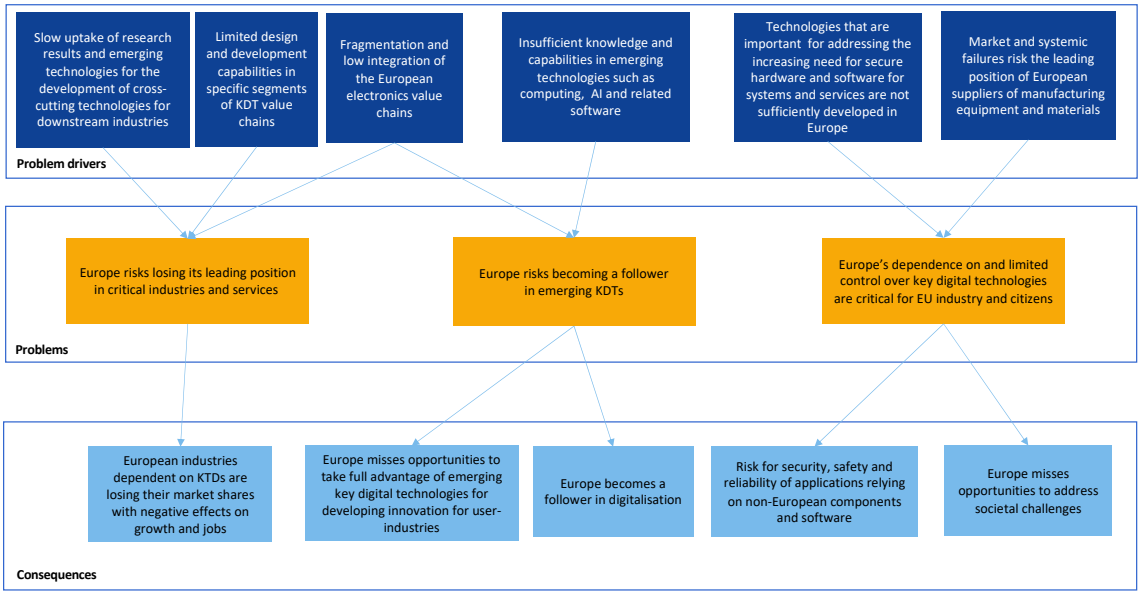
It is further foreseen that the framework for partnerships under the next MFF (2021-2027) has a systemic effect beyond research and innovation projects strengthening strategic value chains.[41]

2 Problem definition

This section provides a discussion of the problems to be addressed in relation to the emerging challenges presented in Section 1.1 and the position of Europe presented in Section 1.2, drawing on evidence from desk research and the findings of the stakeholder consultation undertaken as part of this study.

A problem tree portraying related problems, their drivers and consequences is presented in Figure 3 and described in detail in the following sections.

Figure 3: Problem tree for the initiative on Key Digital Technologies



2.1 What are the problems?

2.1.1 Europe risks losing its leading position in critical industries and services

KDT has become a critical factor for the competitiveness of downstream industries, such as automotive, industrial equipment, aerospace, security and health electronics, and related services (telecommunications, energy, etc). Therefore, for Europe to remain a world leader in these sectors, or to increase its current world share (20%), it should also retain a leadership position in KDT.

Demand from downstream industries pull the whole European supply chain as can be observed in Table 2, below. The area highlighted in blue presents **EC segments where Europe has its strongest position and with the highest spillover effects on downstream industries such as the automotive, aerospace, health electronics telecommunications, and energy.**

The EU produces 22% of embedded microelectronics, 19% of electronics boards and 18% of semiconductors used in the above-mentioned sectors. All three segments of the KDT

[41] European Commission. (2019). *Strengthening Strategic Value Chains for a Future-ready EU Industry*. Report of the Strategic Forum for Important Projects of Common European Interest, available at https://ec.europa.eu/docsroom/documents/37824.

value chain amounted to €344 billion in 2018 and are estimated to reach €500 billion by 2025.[42] When considering other segments of the broader KDT value chain (e.g. silicon photonics, ES, PS and IS) KDT's economic significance and spillover effects is even higher.

Table 2: EU28 share of the world production of electronics for downstream industries and mass-market consumer devices – shares in 2018

Sector	Semiconductors	Electronic boards	Electronic equipment (embedded and stand-alone)	Downstream industries (auto, aerospace, etc)	Services related to end user equipment
Automotive	22%	22%	27%	20%	22%
Industrial equipment	14%	17%	20%	18%	13%
Aerospace, defence and security	15%	15%	22%	22%	19%
Health and care	20%	20%	19%		20%
Home appliances	4%	8%	17%		
Audio and video	5%	7%	11%		
Computers and data processing	4%	5%	5%		5%
Telecommunications	5%	4%	4%		18%

Source: European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems (ECS): Opportunities ahead*. SMART 2018-0005.

Although the current position of Europe in these KDT segments is strong, the main competitors (US and China) threaten this position not only in terms of market share but also in R&D. In the **automotive electronics** sector Europe is leading with 27% of global production, followed closely by China (20%) and North America (18%). Europe is second in **industrial electronics** with 20% after China (24%) and ahead of North America (19%). In **aeronautics, defence and security electronics,** Europe comes second with 22%, after the US 41%. Europe holds third position in the **health and care** segment, with a share of 19% of global production; the US and China have shares of 40% and 20% respectively.[43]

For Europe to compete, significant R&D investments are necessary. Already China overtook Europe as the leading publisher – a proxy for measuring research output – in microelectronics in 2017 (for more details see the Appendix D and Figure 47). This fast growth has been supported by significant investment by the Chinese government.

2.1.2 Europe risks becoming a follower in emerging Key Digital Technologies

The digital transformation of the economy and society and AI applications' need for new computer architectures, such as neuromorphic/quantum computing accelerators, demands

[42] The estimation is based on data from European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems (ECS): Opportunities ahead*. SMART 2018-0005.

[43] European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems (ECS): Opportunities ahead*. SMART 2018-0005.

persistent research efforts and significant investments in R&D and innovation. Intense global competition and a steep **increase in R&D investments and research production capacity** within competing regions, threaten the position of Europe in KDTs, including AI edge computing, software and algorithms for AI, semiconductor-based neuromorphic components and quantum computing.

As it is evident from the evolution in the production of publications, Europe has fallen behind in some segments, while in others, it is very closely followed by China and the US. The production of publications in the emerging area of **edge computing** has experienced exponential growth after 2016 (see Figure 49 in Appendix D) with China leading the race with a 40% share in 2018, while the EU is following with a share of 33% of total publications. In the area of **computer architectures**, the EU leads the race, followed very closely by China and the US, (see Figure 50 in Appendix D). The EU (36% share in 2018) has a leading position in the emerging area of **AI related to microelectronics**, with the US (27% share) and China (16% share) ranked second and third respectively (see Figure 51 in Appendix D).

The **risk of failure** associated with these investments is high, and the required critical mass of financial and human resources exceeds the capacity of individual companies or countries. What is more, the **speed of reaction and time** are of the essence due to the **shortening of the innovation cycle.** The combination of high risks and the European funding system's lack of focus and technological expertise to properly assess the opportunities result in insufficient private financing (i.e. information asymmetry).[44] To achieve the necessary critical mass of resources, European, national and private priorities need to be better coordinated and more resources need to be mobilised, avoiding overlaps wherever possible.

2.1.3 Europe's dependence on and limited control over digital technologies are critical for EU industry and citizens

As safety and security considerations are increasing, the need for European companies to have access to secure and reliable electronic components and software, which are produced by reliable producers, increases. Even more, security and safety are critical for cyber-physical and network-connected devices, AI applications, power and energy infrastructures, mobility and autonomous or assisted driving. It was also highlighted by industry interviewees that the importance of relying on European suppliers is more critical in periods of increasing tariffs and uncertainties in the geopolitical environment.

Although Europe has leading competences, there are areas where it is losing its technological sovereignty, which affects its technological and economic leadership, and its ability to keep EU citizens safe and secure. Europe has already lost technological sovereignty in general purpose microprocessors and memory devices in the consumer domain. This has affected its position in relevant markets (see Table 2 and the discussion on the relevant problem drivers). Europe has also lost the capability to manufacture FPGA devices that are critical for a broad range of applications, such as digital signal processing, bioinformatics, device controllers or ASIC prototyping.

Almost all responding stakeholders in the **open public consultation** recognised both the lack of research and innovation expertise and the problem of an innovation gap in KDT at the European level. Both the innovation gap in KDT and the lack of research and innovation expertise was noted by an overall

[44] European Commission. (2018). *Financing the Digital Transformation: Unlocking the value of photonics and microelectronics – study*, available at https://op.europa.eu/en/publication-detail/-/publication/5c9c8044-7500-11e8-9483-01aa75ed71a1.

majority of all stakeholder types; however, among SMEs only more than half acknowledged the lack of R&I expertise in KDT. An overall majority under each stakeholder type remarked that there is a need to make a significant contribution to the global competitiveness of Europe's KDT industries. The need for a stronger focus on the development and effective deployment of technology was equally noted by an overall majority of consulted stakeholder categories, apart from large companies where more than half of respondents agreed with the view.

Most **interviewed stakeholder categories** perceived technological sovereignty as important, especially when considering recent global trade wars. While interviewed industry stakeholders commented that the importance of relying on European suppliers becomes more critical when the geopolitical environment is facing increasing tariffs and uncertainties, MS commented that although lost production and design capacity in Europe is a significant issue requiring intervention, the focus should also be on emerging technologies relevant for future value chains. The **feedback on the inception impact assessment** also noted the relevance of sovereignty and autonomy in Europe's KDT industry, which was highlighted by industry associations. According to the **open public consultation**, an overall majority of all stakeholder types (although only more than half of SMEs) agreed that the KDT initiative has high relevance for the provision of trusted electronics components and systems to businesses and the public.

2.2 What are the problem drivers?

The key problem drivers affecting research and innovation performance in the area of key digital technologies in Europe are discussed in more detail in the following paragraphs.

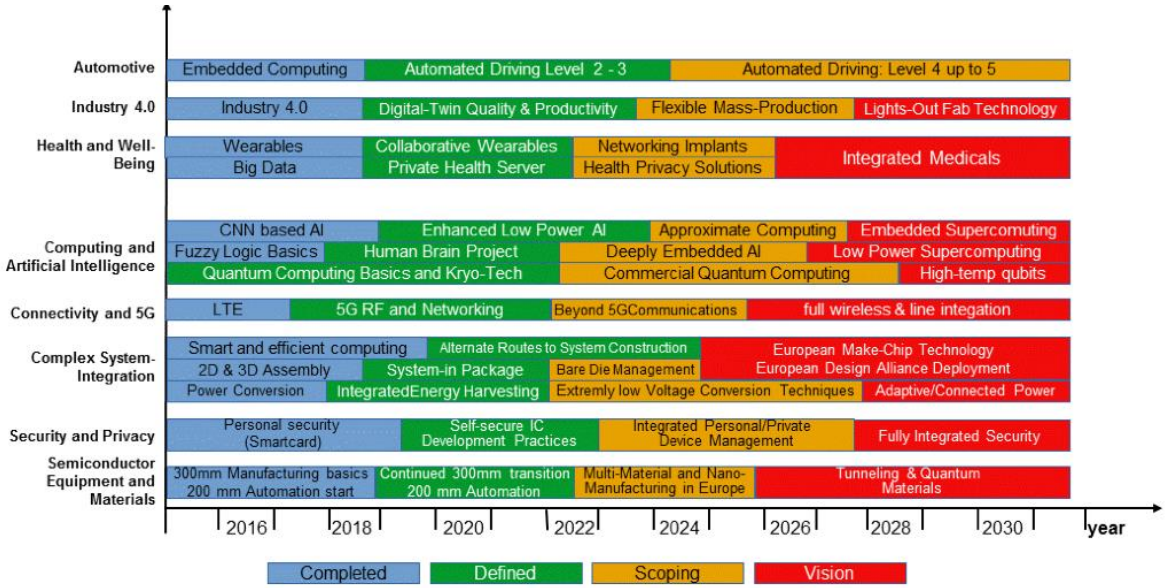
2.2.1 Slow uptake of research results and emerging technologies for the development of cross-cutting technologies for downstream industries

Technological developments in the area of AI, edge computing, silicon photonics and software transform the traditional value chains of microelectronics and bring new possibilities and potential for improving performance, increasing safety and energy-saving, and for reducing the environmental footprint of final products in key European industries. Research results in these areas should be transformed into new technologies and components for downstream European industries ahead of the competition.

Although the EU achieves strong performance in several scientific areas of KDT, Europe still lacks sufficient expertise and capacity in bringing research to market.

Figure 4 summarises the challenges for R&D and the development of capabilities in the KDT areas over the next decade for several segments of KDTs and related downstream industries.

Figure 4: Technological challenges in key digital technologies



Source: Electronics Leaders Group. (2019). *Boosting Electronics Value Chains: An industrial strategy for Europe – Implementation plan*. Not yet published.

As illustrated above and according to the opinions of semiconductor manufacturers, downstream equipment manufacturers, system designers, RTOs and relevant clusters expressed in the Electronics Value Chains workshops organised by the European Commission, the priority areas for strengthening EU leadership in KDTs in key sectors are the following:

- Automotive sector: Automated driving to reach level 5;
- Industry automation: Flexible mass production and lights-out fab technology;
- Health: Technologies and capabilities that improve patient outcomes, develop patient and staff experience and lower the cost of care;
- Telecoms: Enhance position of Europe in 5G and beyond, from mastering 5G RF and networking to full wireless and line integration;
- Security: Business cybersecurity and novel AI-based products and services.

In order to address the technological challenges in the above areas, close collaboration of microelectronics and software companies with developers in emerging KDT areas, RTOs and downstream industries is necessary for accelerating the uptake of the research results and developing edge-technology components and applications for downstream industry.

According to the **open public consultation,** an overall majority under each stakeholder type recognised that the innovation gap hinders the transition of research results into innovative digital solutions. Most respondents, covering an overall majority of respondents from large companies, public authorities, RTOs and universities and more than half of business associations and SMEs, further noted that Europe still lacks sufficient expertise in KDT.

Several **interviewees** from MS, industry associations and large companies commented that Europe has strengths in research but needs more emphasis on transforming research results into production and uptake, and in addressing the missing steps (i.e. 'valley of death') to deployment and market uptake. In this context, interviewees also remarked that problems with market size and business models also limit the uptake of innovations – this

view was highlighted especially by business associations, large companies, SMEs and public authorities, while universities and RTOs perceived it as important to a lesser extent.

More than half of consulted SMEs, universities and RTOs and about half of large companies, public authorities and business associations in the **open public consultation** also highlighted user needs and applications as important in KDT-oriented research and innovation. An overall majority of consulted SMEs, universities, RTOs, industry associations and public authorities and more than half of large companies commented that a stronger focus is needed on the development and effective deployment of technology in KDT.

2.2.2 Limited design and development capabilities and capacity in specific segments in KDT value chains

The design landscape is characterised by significant market and systemic failures related to high barriers to entry, the dominant position of 'big players' and the lack of sufficient capabilities.

Among the 10 largest, in terms of revenue, IC designers in 2019 only one is from Europe (UK).[45] Besides there is a significant increase in complexity and development costs for advanced technologies in digital, analogue, mixed-signal and power. In addition, the cost of prototyping, IP designed blocks and commercial electronic design automation (EDA) tools are very expensive, especially for SMEs. The development of the first full mask-set often costs several million euros, which is only half of the total design cost. The design cost of a planar 28nm chip could amount to €27 ($30) million while the cost of the latest 16nm/14nm and 7nm chips blows out to €72 ($80) million and €245 ($271) million respectively.[46]

The above trends set high entry barriers, especially for SMEs, and push for a consolidation of the ecosystem into fewer players. At the same time, advanced chips are becoming increasingly proprietary, concentrating power among a few suppliers. As it can be seen in Table 3, prominent players on the design side are mostly located in the US and Taiwan; only one European company is represented among the top ten.

Europe clearly needs to secure its own chip development capabilities. In doing so, a robust design ecosystem is necessary that can create ICs and electronic systems faster, with new features, higher functional integration and reduced power needs. The ecosystem needs to bring together design houses, integrated device manufacturers, IC producers, RTOs and downstream companies.

In the **open public consultation** an overall majority of public authorities, more than half of respondents from respectively large companies, SMEs, universities and RTOs and about a third of business associations recognised the high cost associated with design and product development in equipment. Further to this, several **interviewees** from industry associations, large companies and SMEs commented that the high design and product development-related costs impose barriers also for SMEs, which often lack the required time, skills, technologies and infrastructure.

[45] TrendForce. (2019). Press Release. Global top ten IC design companies (2019), ranked by revenue released available at https://press.trendforce.com/press/20190829-3290.html.

[46] Semiconductor Engineering. (2017). *The Race to 10/7nm*. May 22, 2017, available at https://semiengineering.com/racing-to-107nm.

The **interviews** also highlighted the importance of keeping design capabilities combined with a current lack of production and design capabilities (e.g. for ICs, memory devices, FPGAs) in Europe – this was stressed by different MS, industry and industry associations.

2.2.3 Fragmentation and low integration of the European electronics value networks

Intense competition and technological trends transform former linear microelectronics value chains into more complex value networks by integrating an increasing number of technologies and actors into the various stages. This can mean higher barriers to entry for SMEs. Yet technological developments in the area of AI, edge computing, neuromorphic components and quantum computing, silicon photonics and software bring new possibilities and potential, expanding horizontally the value chains covering new technological areas and stakeholders.

Research results produced in RTOs needs to be absorbed fast by companies and **microelectronics and software developers from various levels of the value networks need to interact directly and cooperate with end-product producers** in order to define, develop and test new solutions. At the same time, a wide number of technologies must be considered for integration at various stages of the design and manufacturing process.

Due to their complexity, the evolving value networks require better **integration of technology providers and users** through collaboration and **coordination of research agendas and roadmaps** across different sectors and countries. It also requires **better cooperative behaviour between stakeholders,** hardware and software players, and between industry and academia. In addition, **access mechanisms to emerging integration technologies** are needed, for systems houses and SMEs. SMEs play a key role in emerging areas like plastic and organic electronics, smart integrated systems and, more generally, in the field of design. However, they are facing increasing entry barriers to IP, design, manufacturing and access, due to the high level of the investment required.

According to the **open public consultation**, an overall majority of business associations and SMEs and more than half of universities, RTOs, large companies and public authorities recognised the problem of limited collaboration between MS, industry, research organisations and the EU.

Moreover, the need for better alignment of European and national R&I efforts were highlighted by an overall majority of consulted public authorities, universities, RTOs and large companies and more than half of SMEs and business associations. This need for aligning European and national R&I efforts on KDT was also stressed in the **feedback on the inception impact assessment** by industry associations. Also, in the **interviews** it was commonly remarked by all stakeholder types that coordination between EU, MS and industry is key in addressing the problems in the field.

A few **interviewees**, especially from large companies and industry associations, highlighted the transition towards more complex value networks with several actors interacting, and the fast-evolving nature of KDT technologies and sectors. The need to reinforce interconnections between RTOs and industry, as well as between R&D activities and production, was stressed by several interviewees from large companies, business associations, RTOs, universities and MS. Beyond the contribution of research results and RTOs, the role of SMEs in the ecosystem was highlighted by all interviewed stakeholder types; SMEs often work in supplier/buyer relationships with large companies and also have a role in bringing innovations to markets, according to large companies and industry associations. However, SMEs were found to face several constraints, including the significant entry costs linked to advanced technologies, high design and R&D costs, and

lack of skills and infrastructure – this view was highlighted by interviewed industry associations, large companies, SMEs, universities and RTOs.

According to the **open public consultation**, more than half of consulted SMEs, universities and RTOs and about a half of public authorities, large companies and business associations, considered that co-creation of solutions with downstream potential has high relevance.

2.2.4 Insufficient knowledge and capabilities in emerging technologies such as computing, AI and related software

Although the EU is performing well in several of the emerging technologies, there are still systemic failures related to the necessary knowledge and technology capabilities that Europe needs to build in its RTOs and industry in order to remain at the technological forefront.

To keep up with future production needs, technological capabilities in emerging technologies and AI solutions for autonomous machines and devices, the development of a critical mass of competences in the design of software and algorithms for AI, semiconductor-based neuromorphic components and quantum computing are necessary.

Despite Europe's prominence in some of these segments, it is threatened by significant competition fuelled by large-scale investments in China and the US aimed at building knowledge and capabilities in computing and AI. The "Made in China 2025" initiative has invested $1 billion since 2009 in HPC, while $7.7 billion was made available for cloud computing and $150 billion is to be invested in AI. In the US, NITRD has made a total of $4 billion available, for example for high capability computing systems, data management, software design, etc. [47]

While there is increasing pressure to be strong in software development, there is a significant gap between European and US-based companies as regards the level of R&D investment in software, internet and computer science. Despite the expected growth rates for embedded systems, platform software and intelligence software, Europe is well below the US and South Korea in private-sector spending on software technologies relevant for embedded systems, CPS and systems software.[48] The US requirements on American ownership and headquartering of equipment have further contributed to its dominant position (knowledge and capabilities) in associated software and services (i.e. the fifth level of the value chain).[49]

Investments in R&D and innovation at the forefront of KDT are highly risky and costly, discouraging private funding. Information asymmetries between ECS companies and potential investors (i.e. venture capitalists) discourage the latter, resulting in sub-optimal funding levels. The size of the required investment and the lack of funding generate significant barriers to entry, especially for start-ups and SMEs.[50]

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[47] Advancy. (2019). *Embedded Intelligence: Trends and challenges*. Commissioned by ARTEMIS-IA, from ARTEMIS-IA, available at https://artemis-ia.eu/news/embedded-intelligence-trends-challenges-book-release.html.

[48] Ibid

[49] European Commission. (2019). *Study on the Electronics Ecosystem: Overview, developments and Europe's position in the world*. Final Report. SMART 2016/0007.

[50] European Commission. (2018). *Financing the digital transformation: Unlocking the value of photonics and microelectronics*, available at https://www.eib.org/attachments/pj/financing_the_digital_transformation_en.pdf.

Due to the size of the investments, transformative failures related to the lack of directionality and policy coordination at European, national and industry levels are necessary for maximising available resources.

An overall majority of consulted stakeholders (especially large companies, public authorities, RTOs, universities and business associations, although only more than half of SMEs) in the **open public consultation** found that Europe still lacks sufficient R&I expertise in KDT. An overall majority for each stakeholder type perceived the innovation gap as the main hindrance for turning research results into innovative digital solutions with strong market take-up; for each stakeholder category this problem was deemed as 'very relevant'. The uptake of innovations was considered to be hindered by barriers to exploitation, such as access to capital, data or IP; this view was expressed by all business associations, an overall majority of public authorities and SMEs and more than half of large companies, universities and RTOs.

The need to build up know-how and technological capabilities in emerging technologies, AI, software and neuromorphic computing was stressed by several **interviewees**, including from MS, large companies, SMEs, business associations, universities and RTOs. One university also commented that the microelectronics industry is too focused on urgent and pressing needs, while it neglects new technologies or domains that could benefit industry in the future. The strengths of China (e.g. quantum computing and AI) and the US (e.g. software) in investment, knowledge and capabilities relevant to emerging technologies were stressed by several interviewees, including especially MS, industry associations and large companies, although also recognised by RTOs, universities and SMEs. Interviewees repeated that no single European country on its own could adequately compete with the likes of the US and China on emerging technologies.

2.2.5 Technologies that are important for addressing the increasing need for secure hardware and software for systems and services are not sufficiently developed in Europe

Significant market failures hinder the access of European companies to specific technologies, components or production facilities that are critical for Europe's technological sovereignty. Current supply cannot meet the demand for specific components or production services. For example, according to opinions of semiconductor manufacturers, system designers, AI application developers, user industries and RTOs,[51] access to electronic components is challenging for AI companies. Existing constraints in packaging are also an inhibiting factor. While industry is heading towards 3D configurations and more advanced nodes, access to 3D packaging is difficult in Europe. Geographical proximity for companies applying quick-response strategies (e.g. in the automotive sector) are critical for their success. Streamlined access to specific components is key to maintaining a competitive position.

There are also several examples of the US and other countries using their dominant position in the production of microelectronics for political leverage, risking the availability of components that are critical for European industry.

Although Europe has no interest in investing in general-purpose semiconductors and components for consumer markets, securing a supply of secure, certified, reliable low-power components for downstream industries is of paramount importance. This can only be achieved if European industry develops its own ICs, FPGAs, electronic systems and

[51] European Commission. (2018). *Electronics Value Chains: Workshop on artificial intelligence, low power processors and accelerators*, Brussels, 18 April 2018.

software. However, developing and producing the missing components in Europe demands heavy R&D and capacity investments. To remain competitive, semiconductor companies (both fabless and integrated device manufacturers) should continue to invest in R&D. The R&D expenditure of the top ten semiconductors companies ranges from 5% to 24% of their sales, with an average of 13% in 2017.[52]

There is also a systemic lack of capabilities; migration of semiconductor production out of Europe has drained it of related technical and production expertise and skills.

For the future, European integrated device manufacturers, IC producers, design houses, software companies, RTOs and downstream companies should work together to develop European value chains to support:

- Embedded, platform and intelligent software developments and rollout across European sectors of the economy, to serve the newest, targeted and diverse industrial needs and societal expectations;
- Lower power graphics processing and accelerators for future autonomous cars;
- Devices to support future connectivity, such as 5G interfaces;
- Power electronics for electric cars and charging; here there is a need for capability in SiC;
- Low-power, mixed signal devices to support biomedical, bio-sensing, bioenergy harvesting as well as secure communications for privacy in health applications;
- FPGA and GaN devices for the aerospace, defence and security industries.

According to the **open public consultation**, most stakeholders considered that the initiative can impact the provision of trusted electronics components and systems to the public and businesses. This view was shared by an overall majority of all stakeholders with exception of SMEs where more than half of respondents found it relevant (the remaining SMEs were of a neutral opinion).

Almost all **interviews** stressed that Europe should achieve technological sovereignty in specific segments. The need for technological sovereignty was, for example, explained due to the need for security and trusted hardware and software (MS, business associations, large companies, SMEs), quality and reliability of products (MS, large companies) and due to global trade wars (MS, business associations, large companies).

2.2.6 Market and systemic failures risk the leading position of European suppliers of manufacturing equipment and materials

Progress in production equipment is essential for advances in miniaturisation and increased chip functionality. Progress in both directions is critical for the applications in key European downstream industries and the sustainable manufacturing of semiconductors, essential for European technological sovereignty in KDTs. New materials are also necessary for improving performance (e.g. for alternative memory sources/technologies or power electronics) and reducing environmental impact. The market for materials is highly concentrated, and there are often shortages of specific materials.

[52] Electronic Specifier. (2016). *The Top 10 semiconductor R&D Spenders in 2015*, February 2, 2016, based on data from the IC Insights. Strategic Reviews database, available at https://www.electronicspecifier.com/around-the-industry/the-top-10-semiconductor-r-d-spenders-in-2015.

The manufacturing equipment industry is affected by significant market failures as it has been highly concentrated during the last 20 years, with the number of suppliers reduced to 1 or 2 per process technology/step. Concentration of power within a few players, several of them outside Europe, poses a high risk for Europe. Despite unfavourable trends, Europe remains a significant player in the equipment and materials sector, holding 17% of the world market, and it is the leader in photolithography for advanced CMOS processes. Other areas of European strength are metrology, silicon substrates (FDSOI), thermal processing, deposition, cleaning, wafer handling as well as wafer assembly, packaging and reliability.

To support and further extend Europe's position in semiconductor equipment and materials, leading-edge research by RTOs and equipment and materials suppliers is necessary to increase the functionality and performance for integrated electronics and photonics components. In addition, the tools and materials need to be aligned with the needs of European and world-leading semiconductor and photonics components manufacturers. For this alignment, the existing network failures need to be addressed by facilitating collaboration between RTOs, manufacturing equipment suppliers and semiconductor producers.

The power concentration in the manufacturing equipment industry and the dependency on the US, Japan, etc. was stressed by **interviewees** from large companies.

The link between semiconductor producers, equipment manufacturers and RTOs were stressed by **interviewee**s from MS. The link between R&D and production is perceived as strong, implying that R&D efforts in Europe are strengthened with the presence of European production capabilities and vice-versa.

2.3 How will the problem(s) evolve?

Without policy action, it is expected that the identified problems will continue to exist and worsen over time. The next 7 to 10 years are critical for developing the conditions for the European KDT ecosystem to be able to respond.

The risk for Europe of losing its leading position in critical industries and services (automotive, industry technologies, health, security, telecoms) will continue and become more significant as emerging technologies increasingly penetrate their sectors. The R&D and technological challenges of the key European sectors have been identified and presented in Figure 4. The goals for the well-defined technological areas will have been achieved before 2024 while those for the next phase are expected to be met by 2027. Among them, only autonomous driving might need more time until 2030 to reach level 5.

Europe's position in emerging KDTs will continue to face threats as long as new technological areas emerge, demanding a rapid response. However, the current technological goals for the emerging and fast-growing areas of computing and AI (green) (Figure 4) are expected to be achieved by 2025, while the targets for the next phase are extended to 2027.

The factors affecting Europe's technological sovereignty will continue to gain pace as markets continue their consolidation. However, development of the necessary technological capabilities, together with the expected investments of industry on production capacity for microelectronics and related software in Europe within the next five to ten years, will provide the necessary base for European companies to respond to the technological challenges. The current research and technological goals for semiconductor equipment and materials, which are important to the production base, are expected to be achieved by 2023, while the target for the next phase is set for 2025 (see Figure 4).

The fast-evolving nature of emerging KDTs, including their influence on industries and technological areas, was stressed by several **interviewees** from industry associations, large companies and SMEs. While one large company interviewed highlighted the sectors' appetite and quickly evolving needs for technological innovations, another large company noted that, although technologies develop rapidly, there is a lack of knowledge on how to operate novel digital technologies in Europe.

The need for 'policy action', and the implications of 'no-policy action' for critical industries, was underlined by all **interviewed** stakeholder types.

3 Why should the EU act?

3.1 Subsidiarity: Necessity of EU action

With a combined market value of €10.4 trillion in 2017, the role of micro/nanoelectronics, embedded/cyber-physical systems, software (platforms) and smart/microsystems is increasingly important for the competitiveness of downstream industries in Europe (see Figure 1). Sectors of major importance for Europe, such as automotive, industry 4.0, IoT devices and systems, 5G, energy, healthcare, aeronautics and space, are heavily dependent on reliable, secure and energy-saving ECS to be competitive. These technologies drive a value chain in Europe that employs 9 million people – over 1 million of which are in the semiconductor industry – and gives European ECS companies access to a global market of more than €3.8 trillion.

Rapid technological changes due to emerging technologies that affect ECS, the changes in international industry structure and massive on-going investments in know-how and production capacity in competitive countries, all require a rapid and coordinated response for the EU to keep and further improve its competitive position both in ECS and related industries. ECS value chains are expanding across countries and sectors, making it difficult to align national and business funding as well as research agendas under a European strategy without central coordination. The positive experience from ECSEL JU confirms that such coordination is necessary and feasible. Moreover, the EU can help shape related technological developments so that they become essential cogs in its green transition, in line with stated climate and environmental goals. This will shape a European model which can create a competitive advantage in a global context, increasingly dominated by the need to address the climate crisis.

3.2 Subsidiarity: Added value of EU action

The major changes in technology and speed of innovation creates changes in the value chain that improve links between supply and demand, and involve all upstream and downstream levels of the value chains, including a wide range of applications. These changes require large initiatives that combine both hardware and software, as well as design and manufacturing. Such an initiative requires strong coordination involving several MS and the alignment of national and EU strategies.

Companies alone or single countries cannot meet the significant scale and increasing intensity of investments in ECS by major competitors (US, China, South Korea, Taiwan and Japan). Only a European mobilisation and coordination of investments could ensure the necessary critical mass. In terms of research production, China and the US retain the first and second positions with 25% and 24% of the world publications in the area of microelectronics for the period 2008-2018, while the main European players (Germany and France) produce only 8% each, followed by the UK (4%) and Italy (3%). Yet, pooling together all EU28 countries, it is the biggest producer of research results, representing

31% of the world production of research publications (see the discussion in section 1.2.1 and related figures).

Interviewees representing large companies, industry associations and MS recognised the importance of emerging technologies for growth and job creation in Europe. An overall majority (for each stakeholder type) in the **open public consultation** underlined the link between, on one hand, micro/nanoelectronics, embedded/cyber-physical systems, software (platforms) and smart/microsystems and, on the other hand, the EU's global competitiveness.

All **interviewed** stakeholder groups noted the need for alignment and central policy coordination on research agendas; one MS and one RTO commented that the level of investment by the US and China in KDT technologies cannot be matched by any individual European country and, as a result, central coordination and critical mass are required

4 Objectives: What is to be achieved?

4.1 General objectives

In order to tackle the problems identified in Section 2, it is important to clarify the objectives of EU action in the field of research and innovation. We have identified three general objectives corresponding to the main problems discussed in Section 2.1.

These objectives contribute to Horizon Europe's general objective to deliver scientific, technological, economic and societal impact from the Union's investments in research and innovation in order to strengthen its scientific and technological base, and foster industrial competitiveness in all MS.

KDTs to reinforce the strong and globally competitive position of Europe in key industries

For the leading EU sectors, such as automotive, industrial equipment, aerospace/defence/security, health equipment and related services to retain their leading position in the international markets, Europe needs to remain at the forefront of KDTs that drive innovation in those sectors. Emerging technologies bring new opportunities for improving the functionality, performance and environmental friendliness of the applications, which makes the acceleration of the market uptake of research results in this area is essential. The integration of emerging technologies and development of cross-cutting technologies will be supported by the improvement of European design capabilities and the building of dynamic ecosystems that bring together all actors and technologies in the supported value networks.

Direct support to the improvement of the competitive position of KDT sectors and the strengthening of the innovation performance of companies in downstream industries using electronic components, systems and software – e.g. automotive, defence, aerospace, security, health and smart city sectors – is in line with the SDG 9 Industry Innovation and Infrastructure. In addition, the objective contributes to resource efficiency and energy saving. Through the use of KDT in downstream industries and being at the core of a broad spectrum of applications, it also contributes to SDG 8, SDG 7, SDG 13, SDG 11, SDG 3, SDG 12, SDG 6, SDG 14, SDG 2, SDG 10 and SDG 4.

Establish European leadership in emerging technologies with high socioeconomic potential

AI and new computing paradigms are at the heart of a pervasive digital transformation affecting most sectors and societal issues. Therefore, mastering these emerging technologies is essential for Europe to remain at the forefront of KDTs and maximise the

economic and societal impact. Due to the pervasive character of the technologies, they contribute to several SDGs: SDG 9, SDG 8, SDG 7, SDG 13, SDG 11, SDG 3, SDG 12, SDG 6, SDG 14, SDG 2, SDG 10 and SDG 4.

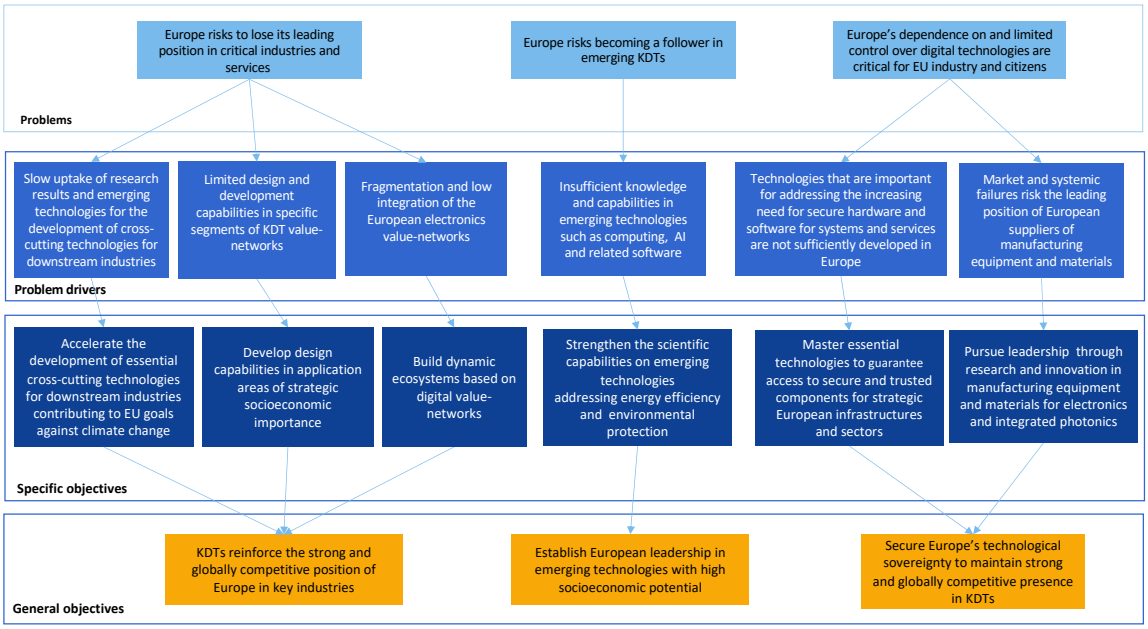
Secure Europe's technological sovereignty to maintain a strong and globally competitive presence in KDTs

For the EU to be able to maintain, or even to improve, its leading technological and economic position and ensure the security and safety of EU citizens, pursuing technological sovereignty in KDTs is necessary. The EU needs to pool resources for building the necessary capabilities in segments that are currently missing, or not sufficiently developed, and are essential for producing in Europe reliable, trusted and low-energy microelectronics components, systems and software for user-industries. Furthermore, Europe needs to remain a leader in production equipment and materials to meet new needs and secure the sustainable supply of materials. The objective mainly contributes to data integrity, privacy and security, and therefore to SDG 10 and SDG 16. Due to the effect on industry and innovation, and to economic growth, it also contributes to SDG 9 and SDG 8.

4.2 Specific objectives

In order to achieve the general objectives, we defined six specific objectives responding to each of the problem drivers discussed in Section 2.2. The relationship between the general and specific objectives is shown in Figure 5.

Figure 5: Objectives tree for the initiative on Key Digital Technologies



Accelerate the development of essential cross-cutting technologies for downstream industries contributing to EU goals against climate change

Europe develops technologies, components and applications that are important for the competitiveness of downstream industries, such as automotive, health, industry automation, telecoms and energy grids. The initiative will address the need for increased technological capabilities in software, and it will seek to integrate emerging technologies (e.g. AI edge), embedded software and silicon photonics with electronic components, delivering enhanced performance and functionality as well as improved impact on the environment.

Develop design capabilities in application areas of strategic socioeconomic importance

The EU will develop the technological capabilities and strengthen the design ecosystem to maximise its ability to develop new products that rely on complex semiconductor-based devices that are faster, more power-efficient and with new advanced features as well as higher functional integration.

Build dynamic ecosystems based on digital value-chains

The ecosystems around value networks of key European downstream industries will be developed and strengthened. The initiative will facilitate the interaction between key players in the value networks, from semiconductor and software companies to RTOs and downstream manufacturers and their suppliers, to set common agendas and roadmaps for the development and integration of technologies. Further coordination with the MS and the Commission will contribute to the alignment of strategies towards common goals and the pooling of resources that will create the necessary critical mass.

Strengthen the scientific capabilities on emerging technologies addressing energy efficiency and environmental protection

The EU is developing new knowledge and technological capabilities for next-generation circuits needed for novel computing paradigms and AI, and related software that will allow Europe to remain at the forefront of KDT. Research in the area will also contribute to the improvement of the energy efficiency of the components and applications. Also, the research results will contribute to the development of breakthrough innovations for downstream industries and services supported by other objectives.

Master essential technologies to guarantee access to secure and trusted components for strategic European infrastructure and systems

Europe develops critical missing segments in its KDT value chains, to ensure the supply of secure, safe, and high-quality components for its downstream industries. Coordination with European manufactures is also required to ensure that the necessary production capacity will also be available in Europe.

Pursue leadership through research and innovation in manufacturing equipment and materials for electronics and integrated photonics

For the EU to further extend its leadership in semiconductor equipment and materials and strive for sovereignty in the manufacturing of components and systems, the initiative will address significant challenges in next-generation equipment and materials.

The **open public consultation**'s stakeholders are very clear on the objectives: there is a broad consensus about the key need, which is to 'make a significant contribution to EU global competitiveness', thus underlining the link between KDTs and the globally competitive position of key European industries. This was perceived as fully needed by an overall majority (nearly four out of five) of respondents from all stakeholder types alike. The deployment of technology was equally seen as important, with the need to 'focus more on the development and effective deployment of technology' stressed by an overall majority of all key stakeholder categories, although only more than half of large companies.

Also, all **interviewed** stakeholder groups, stressed the need for the initiative to contribute to the competitiveness of key European industries, to promote leadership in emerging technologies and secure technological sovereignty and a globally competitive presence in KDTs.

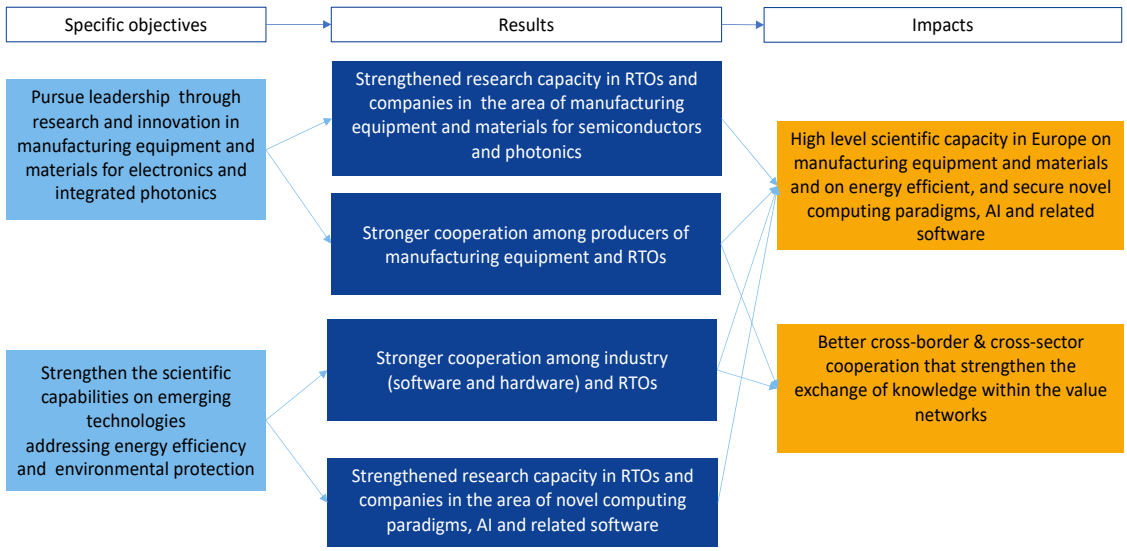
Climate and societal needs were also considered highly relevant in the **open public consultation**. The need to 'focus more on bringing about transformative change towards sustainability' was recognised by an overall majority of all consulted stakeholder types except large companies where more than half of respondents agreed to the statement. All consulted stakeholder types (although only more than half of public authorities) noted the need to make a 'significant contribution to the EU efforts to achieve climate-related goals'. Also 'responsive towards societal needs" was found to be fully needed by an overall majority of consulted stakeholders, while more than half of respondents from public authorities and large companies agreed with the statement.

4.3 Intervention logic and targeted impacts of the initiative

4.3.1 Likely scientific impacts

The initiative is likely to lead to two key scientific impacts, as illustrated in Figure 6 and further described below.

Figure 6: Impact pathway leading to scientific impacts



It is expected that both objectives will strengthen knowledge creation in Europe in the fields of manufacturing equipment and raw materials, in emerging fields of new computing architectures, IA, and related software, and in strengthening cross-border, cross-discipline and RTO-industry scientific collaboration.

Europe is already strong in the areas of photolithography for advanced CMOS processes, metrology, silicon substrates (FDSOI), thermal processing, deposition, cleaning, wafer handling as well as wafer assembly, packaging and reliability. R&D on next-generation manufacturing equipment and materials will strengthen the scientific and technological capacity of both RTOs and industry in the area, and it will deliver a ground-breaking increase in the production performance of integrated electronics and photonics components. In the longer term it will also strengthen the scientific and technological leadership of Europe in the next generation of manufacturing methods and equipment, and in the materials for semiconductors and photonics.

Also, the manufacturing equipment and materials need to be aligned with the needs of European and world-leading semiconductor and photonics components manufacturers. Therefore, collaboration between RTOs, manufacturing equipment suppliers and semiconductor producers (European and from third countries) at various stages of the research process is necessary.

Leading-edge collaborative research between semiconductor companies, system houses and RTOs on software and algorithms for AI, semiconductor-based neuromorphic components and quantum computing will lead to the creation of new knowledge in the area and strengthen the scientific capacity of participating companies and RTOs. In the longer-term, Europe will lead the research in emerging technology areas.

The research will focus on improving the performance, functionality, energy efficiency and security of the technologies. The research will bring together companies and research organisations of various disciplines and from different KDT value chains, strengthening their collaboration and enhancing their capabilities to absorb and internalise knowledge through collaboration. Thus, the results will improve the scientific capacity in the specific fields of both European industry and the RTOs, while at the same time it will lead to more effective exchange of knowledge within the value networks.

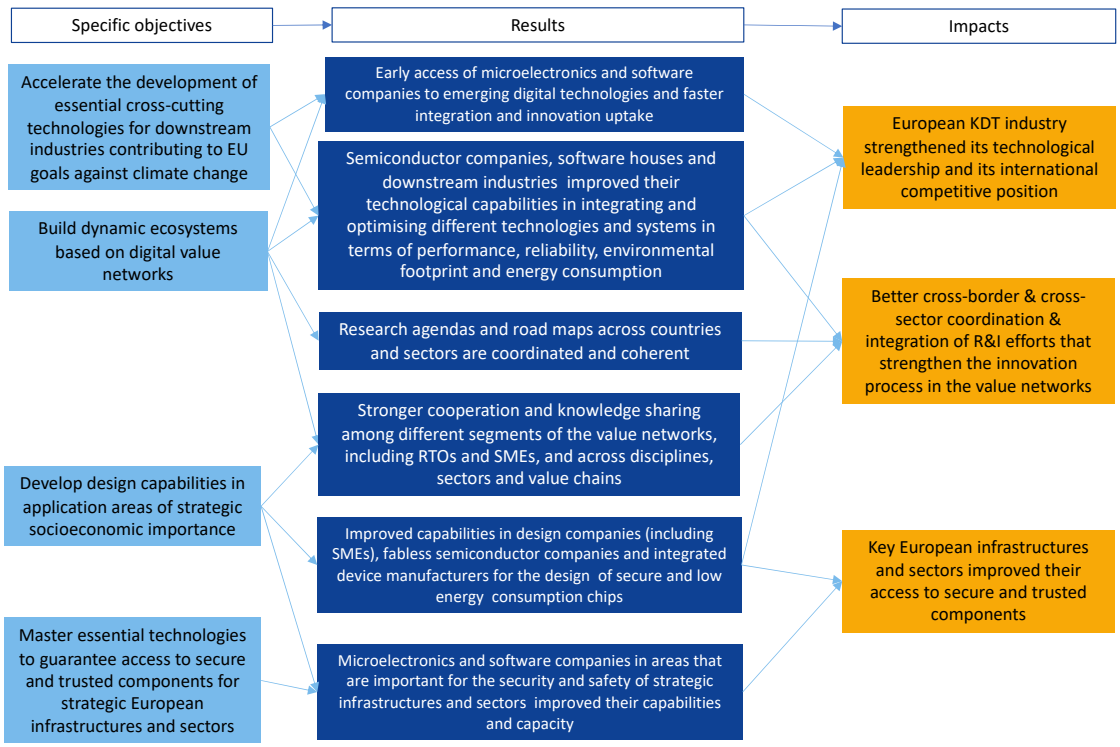
All impacts are expected to be materialised within the time framework of the new initiative.

In the **open public consultation** the delivery of scientific impact through scientific knowledge and R&I capabilities in Europe was deemed to be among the most relevant for the KDT initiative, according to the key stakeholders consulted (an overall majority of business associations, universities, RTOs, large companies and SMEs and more than half of public authorities). Of the universities and RTOs consulted, more than three-quarters found it 'very relevant'.

4.3.2 Likely economic/technological impacts

The likely key economic/technological impacts of the initiative are mapped in Figure 7.

Figure 7: Impact pathway leading to economic/technological impacts



Early-stage R&D on emerging technologies supported by the scientific objectives of this initiative will produce research results with exploitation potential. Due to pressure from international competition, their rapid uptake by downstream industries is vital for the competitive position of both the KDT and downstream industries. The R&D and innovation activities supported by the objective **accelerate the development of essential cross-**

cutting technologies for downstream industries and will result in the fast transfer of results from the laboratory to the market, and to the integration of different technologies into new components and systems with improved performance, reliability and environmental characteristics. Both outcomes will contribute to the further strengthening of the technological leadership and competitive position of the KDT industry.

Early access to research results and the effective integration of technologies require **a dynamic ecosystem based on digital value networks** being in place, which will facilitate the collaboration of different actors from various segments of the value networks including microelectronics companies, software houses, SMEs, RTOs and downstream companies. Furthermore, the mobilisation of resources for building capabilities in emerging technologies and developing the missing segments that are necessary for ensuring Europe's technological sovereignty requires the coordination of the strategies and pooling of resources of all actors including at the MS and EU- level. Thus, the building of the ecosystem is expected to contribute to the acceleration of the market readiness of edge AI and other emerging technologies, and to the development of capabilities for integrating technologies, stronger cooperation and knowledge-sharing among the different segments of the ecosystem, as well as the coordination of research agendas and priorities across countries and sectors.

The development of **design capabilities** of companies providing such services, including SMEs, fabless semiconductor companies and integrated device manufacturers, will improve the capabilities to design reliable and secure chips with low energy consumption. The activities will expand and strengthen the whole design ecosystem, and will contribute to a stronger European KDT industry, in terms of technological leadership and competitive position.

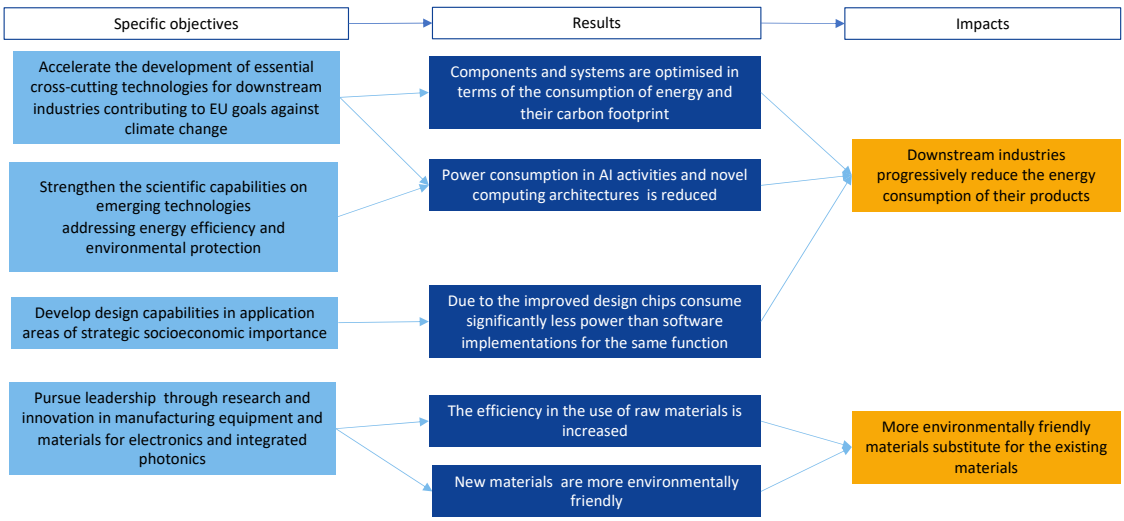
Mastering of essential technologies to guarantee access to secure and trusted components for strategic European infrastructures and sectors will strengthen the capabilities of companies in the target segments and will increase existing capacity by expanding or diversifying current companies or the arrival of companies from abroad. As a result, European infrastructures and key sectors will improve their access to secure, reliable and low energy consumption components, while in the long-run, and probably beyond the horizon of the initiative, Europe will achieve its technological sovereignty in KDT.

According to the **open public consultation**, to ensure economic impact and 'more innovative, sustainable and competitive electronics and systems industries' was deemed as the most important impact overall by key stakeholders; an overall majority of universities, RTOs, companies, business associations and public authorities found it relevant or highly relevant. To facilitate economic impact through the 'development and exploitation of innovative technology paradigms' was also considered to be of high relevance, although to a slightly lower extent overall than the above-mentioned economic impact. It was underlined as relevant or highly relevant by an overall majority of business associations, large companies, universities, RTOs and SMEs, while more than half of public authorities found it relevant or very relevant (the remaining were of a neutral opinion).

4.3.3 Likely societal impacts

The scientific and economic/technological impacts discussed above will also influence the societal impacts as shown in Figure 8.

Figure 8: Impact pathway leading to societal impacts



Likely environmental impacts

Although the general and specific objectives of the initiative do not focus on the generation of positive environmental impact, several of the objectives directly or indirectly contribute in this direction (see Figure 8).

Due to new research findings, the improved design of chips, optimised system integration and more efficient production methods, the initiative will contribute to the optimisation of the environmental characteristics of KDT components, systems and applications. In the medium-to-long run, the uptake of new environmentally friendlier KDT products will contribute to the reduction of energy in downstream industries such as automotive, industry 4.0 applications, transport, and health electronics. The following expected results will contribute to the impact:

- The strengthening of the scientific capabilities on emerging technologies and the development of cross-cutting technologies for downstream industries will reduce power consumption in AI activities and novel computing architectures and related software, and it will optimise the consumption of energy and carbon footprint of components and systems.
- The development of design capabilities in application areas of strategic socioeconomic importance will improve the design of chips that consume five times less power than software implementations for the same function.

Also, the research and innovation activities in manufacturing equipment and materials for electronics and integrated photonics will increase the efficiency of production methods in the use of materials. In the medium-to-long run, IC manufacturers will replace existing materials with more environmentally friendly ones.

Finally, it is expected that in the long-run, KDT will contribute to the reduction of the carbon footprint and emissions due to the improved automotive technology and mobility. Other positive impacts on the environment will be produced by the improvement of water management in industry and more efficient management of energy and energy distribution.

Likely social impacts

Several of the objectives indirectly contribute to the generation of social impacts:

- R&D on electronic components (e.g. wearables, sensors), software and systems for health applications could result in new solutions and services contributing to increases in productivity, efficiency and the quality of health services.
- The objective to master essential technologies that guarantee access to secure and trusted components for strategic European infrastructures and sectors will increase the security and safety of components and applications in downstream products such as vehicles and health equipment.
- R&D and innovation on emerging technologies, electronics components, software and systems could lead to the development of new solutions and services contributing to increases in the productivity, efficiency and quality of health services, and thereby maintaining high living standards in Europe.
- Development of KDT applications for intelligent traffic management and multimodality in transportation improve traffic conditions and increase the reliability, security and energy efficiency of transport, and eventually reduce pollution and increase quality of life.
- Development of KDT applications that enhance the autonomy of cars improve transport safety and reduce injuries and deaths.

4.3.4 Likely impacts on simplification and/or administrative burden

The initiative is unlikely to create impacts in terms of the simplification or administrative burden of the R&I activities supported under Horizon Europe.

4.3.5 Likely impacts on fundamental rights

It is expected that R&D and innovation activities aiming at improving the security of components, systems and software, and related applications will contribute to the protection of sensitive personal information.

According to the **open public consultation** to deliver 'enabled safety and security' was recognised among the most important impacts of key stakeholders, followed by the need to ensure the 'provision of trusted electronics components and systems to the public and businesses' and 'contribution to more functional, efficient and economical electronics systems accessible to a larger part of the population'. An overall majority of consulted stakeholders found the need for enabled safety and security to be 'relevant' or 'very relevant'. Impact on the provision of trusted electronics components and systems to the public and businesses was noted by an overall majority of consulted stakeholders although only more than half of SMEs found it to be 'relevant' or 'highly relevant'. Lastly, an overall majority of SMEs, universities, RTOs and large companies and more than half of business associations and public authorities found the 'contribution to more functional, efficient and economical electronics systems accessible to a larger part of the population' to be 'relevant' or 'very relevant'.

4.4 Functionalities of the initiative

This section outlines the functionalities that need to be considered when assessing the policy options in Section 6, reflecting the selection criteria for European Partnerships

defined in the Commission proposal for the Horizon Europe Regulation.[53] In the following paragraphs, we discuss the implications of the criteria relating to the type and composition of the actors involved, the range of activities to be undertaken and the directions required if the initiative is to deliver the objectives discussed above. We also consider the complementarities and synergies with other, related initiatives under Horizon Europe and beyond.

4.4.1 Internal factors

Type and composition of the actors involved

This functionality relates to the criterion 'Involvement of partners and stakeholders from across the entire value chain, from different sectors, backgrounds and disciplines, including international ones when relevant and not interfering with European competitiveness'. It concerns the need to involve the full range of stakeholders that can usefully contribute to delivering the future R&I agenda.

As it is argued in the evaluation of the ECSEL JU,[54] collaboration among the actors in the ecosystem, including players in all segments of the value networks, was essential for the design and development of new technologies and the fast uptake of innovation by the market. The scope of the current initiative in terms of technology coverage is even broader than ECSEL JU, and therefore the need to integrate various stakeholders is even more relevant. According to the report prepared by the Electronics Leader Group,[55] the shortening of the innovation cycle in KDTs and the need for the fast uptake of innovation by the market requires close collaboration among technology developers and downstream links in the chain, as well as their involvement in lower TRLs in collaborations with RTOs. Furthermore, the report argues that an increased number of technologies must be assessed and considered for integration at various stages of the design and manufacturing process and, thus, direct connections among various players are necessary. The above needs have also been stressed in the analysis of problems and drivers and especially in the discussion about the fragmentation and poor integration of the European electronics value networks (Section 2.2.3).

The need for being open and flexible to integrate players from emerging technologies in the existing value networks was also stressed. The role of SMEs is also essential, especially in emerging areas. Cross-border participation is also vital due to the international character of the value networks. To address the slow uptake of research results and emerging technologies for the development of cross-cutting technologies for downstream industries (Section 2.2.1), the close collaboration of microelectronics and software companies with developers in emerging KDT areas, RTOs and downstream industries is necessary. For addressing the limited design and development capabilities and capacity in specific segments of the value chain (Section 2.2.2), the development of a European design ecosystem that brings together design houses, integrated device manufacturers, renowned IC producers, RTOs and downstream companies is essential. The need for collaboration between European equipment manufacturers and IC manufacturers, European and

[53] European Commission. (2018). *Proposal for a Regulation of the European Parliament and of the Council establishing Horizon Europe: The Framework Programme for Research and Innovation, laying down its rules for participation and dissemination*, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018PC0435&from=EN.

[54] European Commission. (2018). *Interim Evaluation of the ECSEL Joint Undertaking (2014-2016) Operating under Horizon 2020*. Final report, available at https://ec.europa.eu/research/evaluations/pdf/ecsel.pdf.

[55] Electronics Leaders Group. (2018). *Boosting Electronics Value Chains in Europe: A report to Commissioner Gabriel*.

international in order to set the requirements for the production and materials was stressed in Section 2.2.6, where the market and system failures related to the manufacturing equipment and materials was discussed.

The importance of the coordination of research agendas and the pooling of resources at the sectoral, national and European level was also analysed in sections 2.2.4 and 2.2.3. The need to master emerging technologies and build a robust and dynamic ecosystem was discussed. For this, the participation of the European Commission and MS in setting the research agenda is considered necessary.

Type and range of activities

This functionality relates to the criterion 'Approaches to ensure flexibility of implementation and to adjust to changing policy, societal and/or market needs, or scientific advances. It concerns the types of activity that the initiative is intended to encourage, responding effectively to the challenges and problems described in Section 2.

The initiative should support activities from the formulation of the technology concept (TRL2) to the completion and qualification of systems (TRL8).

- For the objective supporting **manufacturing equipment and materials,** the required actions include:
  - Research for the formulation of technology concepts, the experimental proof of concept and validation in the lab of production methods and materials that generate ground-breaking increases in functionality and performance of integrated electronics and photonics components.
  - Manufacturing pilot lines for the collaboration of RTOs and manufacturing companies for the technical validation and demonstration of semiconductor equipment and materials technologies.
- To **strengthen the scientific capabilities on emerging technologies**: Collaborative and multidisciplinary research on software and algorithms for AI, semiconductor-based neuromorphic components and quantum computing.
- To **accelerate the development of essential cross-cutting technologies** for automotive systems, industry 4.0, medical technologies, connectivity and 5G and cybersecurity:
  - Activities accelerating the market readiness of edge AI semiconductor-based neuromorphic components and quantum computing technologies for the development of more secure and energy efficient autonomous machines and devices, by supporting collaboration between TROs and semiconductor companies, software houses and downstream industries on demonstration projects and pilot lines.
  - Large-scale pilot lines for the validation and demonstration of applications covering value networks for downstream industries.
  - Organisation of a technology platform in the form of the Digital Innovation Hubs involving RTOs, integrated device manufacturers and foundries for the development and testing of new integration concepts and the development of the necessary design capabilities.
- To **build a dynamic ecosystem** based on coordination and support actions for digital value networks that support coordination among research agendas, build networks of stakeholders, mobilise the KTD ecosystem; coordinate and network with other European

and national initiatives, and contribute to standardisation regarding the security and quality of components.

- To **develop design capabilities in application areas of strategic socioeconomic importance,** strategic initiatives for the design of ICs will be supported over the next decade:
  - Initiatives for base designs of strategic importance for a range of products including AI accelerators, edge computing, RF IP blocks, ultra-low power, smart and power-efficient computing, and embedded memory.
  - Collaboration platforms for application-specific designs.
- To master essential technologies to guarantee access to secure and trusted components for strategic European infrastructures and sectors:
  - Coordination activities between MS, the Commission, industry and RTOs to develop a roadmap of the weak or missing segments in the KDT value networks.
  - Coordination with other European initiatives and IPCEI for complementary investments on production capacity and human resource development.
  - Support pilot and demonstration projects.

Directionality and additionality required

This functionality relates to the criteria 'Common strategic vision of the purpose of the European Partnership' and 'Creation of qualitative and significant quantitative leverage effects'. The former highlights the importance of ensuring that all participating stakeholders have a common understanding of the purpose of the policy intervention and the direction of the R&I activity it is intended to encourage. The leveraging relates to the spillover effects of the knowledge gained in the broader community as well as the crowding-in effects on private investments in R&I – both among participating stakeholders and in the broader community, and/or the pooling of resources from MS.

It has been argued in the problem analysis in section 2.1.2 and the analysis of drivers in section 2.2.4 that for Europe to compete with China and US in the area of KDT, and especially in the emerging technologies segments, significant investments and resources need to be mobilised. What's more, meeting the objective of technological sovereignty and addressing the problem of Europe's dependence on critical technologies (see section 2.1.3) and the related drivers (section 2.2.5), a broad agreement over a roadmap of activities is necessary. The higher the ambitions for technological sovereignty and technological and economic leadership, the more significant is the need for developing a shared **European vision** with **coordinated research agendas** and **strategies** – aligned with national and industry priorities – and the **pooling of resources** (financial, infrastructures and human). Thus, the highest possible **leverage of resources from industry and MS** under the shared vision is critical.

In addition, the building of the KDT ecosystem is of paramount importance. As it has been argued in section 2.2.3, the traditional linear value chains of ECS are becoming more complex as they form value-creation networks with an increasing number of technologies and actors integrated into the various stages. Therefore, there is a growing need for coordination, at least at the early stages of the new ecosystem formation.

To achieve all the above requirements, and also increase the effectiveness of the ecosystem's response to the current and emerging R&I challenges, EU-level coordination is necessary. Better coordinated action will facilitate the development of a shared vision and strategy, increase the alignment between the European Commission, MS and industry,

and create critical mass in terms of funding, infrastructures and human resources. The significance of coordination, common vision and research agendas was also recognised in the interim evaluation of ECSEL JU.[56] The experience from ECSEL JU also shows that the crowding-in effect could even reach a ratio 1:3, meaning that for every euro of EU funding, MS and industry could contribute 3 euros.

The above conclusions are also supported by the interviews with the ECSEL JU industry associations and downstream associations. The consensual view is that coordination of research agendas among EU, MS and industry actors allows for a more effective R&I response in a fast-moving market and to achieve more impact.

4.4.2 External factors

The proposed Regulation for Horizon Europe also identifies the need to consider 'Coordination and complementarity with Union, local, regional, national and, where relevant, international initiatives or other partnerships and missions' when assessing the case for a partnership. It concerns the potential for linkages with other relevant R&I initiatives proposed or planned for the forthcoming Framework Programme, at the EU level in the context of the MFF 2021-27, and beyond.

Coordination with other initiatives at all possible levels is vital to meet the KDT initiative's objectives. The interim evaluation of ECSEL JU stressed the importance of, and potential for, coordination with local, regional national and European initiatives.[57] Coordination with cluster initiatives, such as Silicon Europe, Silicon Saxony, Minalogic, DSP Valley, could contribute to the **mobilisation of significant resources,** and especially SMEs, and to the **better integration of the ecosystem**.

Coordination with the Digital Single Market and its efforts in digitising industry can ensure awareness of the platforms and solutions being developed and promoted by both the DSM and the KDT to avoid duplication and fragmentation of efforts. Also, the objective to guarantee **access to secure and trusted components for strategic European infrastructure and systems** is closely related with those of the DSM to set up security and safety standards for components, software and applications. Coordination with DSM in the area of **standards** is critical in two ways. Firstly, the research results and the knowledge produced by the initiative can feed efforts to generate standards, and, secondly, the standards should be adopted and applied to all technologies and applications developed by the initiative.

Furthermore, the achievement of **technological sovereignty** would be facilitated by the coordination of activities with future KDT IPCEI initiatives. Although there are no decisions yet regarding the objectives, scope and size of such an initiative, there are indications[58] that efforts will be made towards supporting investments for the development of manufacturing capabilities and building the required capacity for the manufacturing of ICs in Europe.

Due to their enabling character, KDTs are embedded in an increasing number of products from almost all sectors. Therefore, the KDT initiative can benefit from, and contribute to, other initiatives targeting the user sectors. Among them, **priority** is coordination with

[56] European Commission. (2018). *Interim Evaluation of the ECSEL Joint Undertaking (2014-2016) Operating under Horizon 2020*. Final report, available at https://ec.europa.eu/research/evaluations/pdf/ecsel.pdf.

[57] Ibid

[58] Electronics Leaders Group. (2018). *Boosting Electronics Value Chains in Europe: A report to Commissioner Gabriel*.

other envisaged **partnerships targeting enabling technologies, i.e. the Digital cluster (EuroHPC, and Smart Networks and Services), Photonics, AI, data, robotics, Global competitive space system and Made in Europe, together with the EIT Digital which will contribute to the development of skills and the boosting of the digital entrepreneurship.** In addition, synergies with partnerships targeting application areas and other EIT KICs needs to be explored and cultivated. Priority needs to be given on the Horizon Europe initiatives presented in Table 3. A complete list of Horizon Europe initiatives with their **the synergies and needs for coordination** with the KDT initiative is presented in Appendix E.

Table 3: Mapping of the priority Horizon Europe initiatives for collaboration with the KDT initiative and the envisaged inputs and type of collaboration

Initiatives	Input from KDT	Input to KDT	Type of collaboration
EuroHPC	• Components (processors, accelerators) and ES • Requirements from application domains, e.g. automotive (i.e. video processing, simulation), aerospace, space, etc.	• Processing of (big) data, computing capabilities and new algorithms to address complex 'Systems of Systems' applications • Requirements for microprocessors and components	• Coordination of research agendas • Exchange of algorithmic knowledge and requirements for HPC in application domains (e.g. automotive, aerospace)
Smart Networks and Services	• Technologies and components for advanced networks, 5G and 6G • Requirements for new services (real-time networks for autonomous cars, etc.)	• Connectivity to enable software, CPS, Systems of Systems, IIoT, etc. • Networking requirements	• Coordination of research agendas • Exchange of knowledge on capabilities and requirements
AI, data and robotics	• Hardware components and software (e.g. for AI-optimised chips, neuromorphic computers, image processing, sensors) • Application data to test new algorithms and requirements for new applications	• AI techniques/ algorithms • Requirements for microprocessors and components	• Coordination of research agendas • Exchange of data and requirements as well as AI know-how • Contribution to the European ethical debate on AI to support European values
Photonics	• Integrated circuits (PICs), low-cost manufacturing techniques and high-efficiency devices	• Photonics technologies within application fields and roadmap for the future • Requirements for microprocessors and components	• Coordination of research agendas • Exchange of requirements information and strategic business needs

Initiatives	Input from KDT	Input to KDT	Type of collaboration
Made in Europe	• Technologies and components for IIoT to support factory automation and maintenance monitoring, including sensors, power electronics for efficient drives and processing for process optimisation	• Requirements for factory automation and monitoring	• Coordination of research agenda • Exchange of requirements from both large and SME manufacturers • Strategic actions to support standardisation
Global competitive space systems	• Critical electronic components for space platforms and communications, e.g. FPGAs, GaN and Rad Hard Components	• Requirements for space platforms and testing facilities	• Coordination of research agenda • Visibility of future space requirements
EIT Digital	• Technologies and components for IoT to support factory automation and maintenance monitoring	• Requirements for new technologies and development of new skills	• Collaboration on technology adoption and skills development

5 What are the available policy options?

In this section, we provide an overview of the key characteristics of the policy options for this initiative. The Horizon Europe regulations put forward three forms of European Partnerships that constitute the policy options for this initiative; standard Horizon Europe calls are a fourth option while acting also as a baseline against which the three partnership options will be compared.

To ensure a correct assessment of the different options and their effectiveness, it is crucial to take into consideration both the objectives and the functional requirements outlined in Section 4.4. The descriptions of the options in the sections below therefore focus on the implications of the options' characteristics related to these functionalities. They are based on the options' characteristics specifically related to the functionalities listed in Appendix E. A full description of the options is provided in the report on the overarching context to the impact assessment studies.

5.1 Option 0: Horizon Europe calls (baseline)

Under this option, the strategic programming for research and innovation in the field of KDT will be done through the mainstream channels of Horizon Europe. The related priorities will be implemented through traditional calls under the Framework Programme.

Table 4 presents the key characteristics of the option.

Table 4: Effects of the key characteristics of Option 0 for the functionalities desired

Functionalities	Implications of the option's characteristics
Enabling appropriate profile of participation (*actors involved*)	• Consortia of public and/or private actors in ad hoc combinations are eligible. Some actions are a single actor (mono-beneficiary). • Calls are open for participation across Europe and the world, although not all third countries are eligible for funding. • Systematic and structured engagement of MS is limited to participation in the programme committees.
Supporting implementation of R&I agenda (*activities*)	• Supported activities include Horizon Europe standard actions that allow a broad range of **individual** activities covering the whole spectrum of activities required for KDT to achieve the objectives (RTL2 to TRL 7 or higher). • Combination of activities into a portfolio of actions for achieving a common objective is not possible. • Leverage of additional activities or investments beyond the direct scope of the funded actions is not possible.
Ensuring alignment with R&I agenda (*directionality*)	• The strategic programming through the programme committees of Horizon Europe involving a wide range of stakeholders (who are not necessarily aware of, relevant to, or interested in the objectives of the KDT initiative) implies a lower level of directionality and a lower weight of industry's voice in shaping the priorities compared to other options. • There is a possibility to develop an SRIA or roadmaps. However, without a formal EU partnership mechanism, it is less likely that the stakeholders will develop a joint Strategic Research Agenda and commit to its implementation or agree on mutual financial commitments beyond the single project participation. • The strategic planning mechanisms of Horizon allow for a high level of flexibility and responsiveness to changing needs. • Support of priorities cannot continue over the four years of the strategic plan and budget, and therefore it is less likely that the funding will be used for supporting long-term objectives. • The coherence of funded activities in the area of KDT with other parties of the Annual Work programme is ensured by the Commission. • Coordination and exploitation of synergies with other programmes beyond the FP and industrial strategies is limited as it requires more structured approaches which are not available in Horizon. • Coordination with national or regional initiatives is not possible. • Coordinated implementation and funding linked to concrete objectives and roadmap is not possible as the funded projects are part of a much broader project portfolio managed by an agency.
Securing leveraging effects (*additionality*)	• MS do not contribute to the budget. Thus, the resources that could be mobilised are lower compared with other options.

5.2 Option 1: Co-programmed European Partnership

This form of European Partnership is based upon a *Memorandum of Understanding* or a *Contractual Arrangement* signed by the European Commission and the private and public partners. Table 5 presents the key characteristics of the option.

Table 5: Effects of the key characteristics of Option 1 (Co-Programmed Partnership) for the functionalities desired

Functionalities	Implications of the option's characteristics
Enabling appropriate profile of participation (*actors involved*)	• Suitable for all type of partners, including MS and associations with members industry and RTOs. • Open to Associated Countries and to third countries. • Can cover a large and changing community. • The calls are included in the FP Work programme and Horizon Europe rules apply to calls. Therefore, any legal entity can apply. • If MS launch calls under their responsibility, usually only legal entities from countries that are part of the consortia can apply to these, under national rules.
Supporting implementation of R&I agenda (*activities)*	• A broad range of coordinated activities from low TRL to uptake are possible under the standard actions of Horizon Europe. • The associations representing private partners allows the continuous building on the results of previous projects, including activities related to regulations and standardisation, and developing synergies with other funds. • Union contribution is implemented via calls for proposals published in the Work Programmes of Horizon Europe based on input from partners (adopted via comitology). • The control of the precise call definition, resulting projects and outcomes by the partners, is limited as they are implemented by EU agencies.
Ensuring alignment with R&I agenda (*directionality*)	• The strategic R&I agenda/roadmap is agreed between partners and the Commission. • The objectives and commitments are set in the contractual arrangement. • The input to FP annual work programme is drafted by partners and finalised by the Commission (comitology). • The commitments are political/best effort, but they are usually fulfilled. • Coherence among partnerships and with different parts of the Annual Work programme of the FP can be ensured by partners and the Commission, however exploitation of synergies with non-FP programmes is limited. • If MS participate then synergies with national and regional programmes and activities can be explored. • Synergies with industrial strategies is ensured through the industrial partners.
Securing leveraging effects (*additionality*)	• Under the new regulation for this type of partnership financial, contributions from MS and industry are possible and the agreed contribution can be part of the Contractual Agreement. In the case of the KDT initiative, where a tripartite model is envisaged, the commitment for contributions by the partnership may reach up to 75% of the aggregated European Partnership budgetary commitments, with a contribution from industry of 50%. There is no prior experience of how the overall dynamics of this type of partnership will affect leverage.

5.3 Option 2: Co-funded European Partnership

The Co-funded Partnership is based on a *Grant Agreement* between the Commission and the consortium of partners, resulting from a call for a proposal for a co-funded action implementing the European Partnerships in the Horizon Europe Work Programme.

Table 6: Effects of the key characteristics of Option 2 (Co-Funded Partnership) for the functionalities desired

Functionalities	Implications of the option's characteristics
Enabling appropriate profile of participation (*actors involved*)	• Partners can include any national funding body or governmental research organisation, Possible to include also other type of actors, including foundations. • It is not possible to have the KDT industry associations as partners. • Requires substantial national R&I programmes (competitive or institutional) in the field and therefore limits the participation to a few MS with existing national KDT programmes. • Usually only legal entities from countries that are part of the consortia can apply to calls launched by the partnership, under national rules.
Supporting implementation of R&I agenda (*activities)*	• Activities may range from R&I, pilot, deployment actions to training and mobility, dissemination and exploitation, but according to national programmes and rules. • The decision and implementation are the responsibility of the partners through institutional funding KDT programmes, or by 'third parties' receiving financial support, following calls for proposals launched by the consortium. • The scale and scope of the initiative is limited and depends on the participating programmes. The resulting funded R&I actions are typically smaller in scale than FP projects.
Ensuring alignment with R&I agenda (*directionality*)	• The strategic R&I agenda/roadmap is agreed between the MS and Commission without the participation of industry. • The annual work programme drafted by partners, approved by Commission. • Objectives and commitments are set in the Grant Agreement. • The coherence of the partnership with other actions of the can be ensured by partners and Commission. • There are strong synergies with national/regional programmes and activities, and they can be ensured by the MS. • Synergies with other European programmes or industrial strategies are limited.
Securing leveraging effects (*additionality*)	• Low possibilities for leverage of industry contribution as industry does not participate in the decision making.

5.4 Option 3: Institutionalised European Partnership

5.4.1 Institutionalised Partnerships under Art 185 TFEU

Article 185 of the TFEU is a complex and high-effort arrangement and is based on a Decision by the European Parliament and Council and implemented by dedicated structures created for that purpose. It allows the Union to participate in programmes jointly undertaken by MS and Associated Countries.

Table 7: Effects of the key characteristics of Option 3: Institutionalised Partnership Art 185 for the functionalities desired

Functionalities	Implications of the option's characteristics
Enabling appropriate profile of participation (*actors involved*)	• Partners can include MS and Associated Countries. • Non-associated third countries can only be included as partners if foreseen in the basic act and subject to conclusion of dedicated international agreements. • Good geographical coverage is required with participation of at least 40% of MS. • The existence of substantial national R&I programmes (competitive or institutional) in the field is required. • While by default the FP rules apply to eligibility for funding/participation, in practice (subject to derogation) often only legal entities from countries that are Participating States can apply to calls launched by the partnership, under national rules.
Supporting implementation of R&I agenda (*activities)*	• Horizon Europe's standard actions that allow a broad range of coordinated activities from R&I to uptake apply. • In case of implementation based on national rules (subject to derogation) the activities follow the national programmes and rules. • The option allows the integration of national funding and Union funding into the joint funding of projects.
Ensuring alignment with R&I agenda (*directionality*)	• The strategic R&I agenda/roadmap is agreed between partners and the Commission. • The objectives and commitments are set in the legal base. • The annual Work Programme is drafted by partners and approved by the Commission. • The commitments include the obligation for financial contributions (e.g. to administrative costs, from national R&I programmes).
Securing leveraging effects (*additionality*)	• National R&I activities can be integrated into the programme, which can then be matched from the EU budget to increase scope and promote transnational cooperation.

5.4.2 Institutionalised Partnerships under Art. 187 TFEU

The Art 187 TFEU is a complex and high-effort arrangement and is based on a Council Regulation and implemented by dedicated structures created for that purpose. It can be implemented only where other parts of the Horizon Europe programme, including other forms of European Partnerships would not achieve the objectives or would not generate the necessary expected impacts, and if justified by a long-term perspective and high degree of integration.

Table 8: Effects of the key characteristics of Option 3: Institutionalised Partnership Art 187 for the functionalities desired

	Implications of option
Enabling appropriate profile of participation (*actors involved*)	• This option is suitable for all types of partner and therefore MS and private partners such as industry and RTOs operating under private law can participate. • Non-associated third countries can only be included as partners if foreseen in the basic act and subjected to conclusion of dedicated international agreements. • In addition to MS, companies and research organisations from all countries that are major players in KDT can participate, but subject to policy considerations. • Horizon Europe rules apply by default, so any legal entity can apply to partnership calls. • The option requires a rather stable set of partners. • The basic act can foresee exceptions for participation in calls/eligibility for funding.
Supporting implementation of R&I agenda (*activities)*	• The standard action of Horizon Europe that allows the building of a portfolio with broad range of activities, from research to market uptake, can be supported. • The back-office allows dedicated staff to implement an integrated portfolio of projects and build a 'system' via a pipeline of support to accelerate and scale up the take-up of partnership results, including those related to regulations and standardisation, and to develop synergies with other initiatives. For instance, setting up industry 4.0 pilot production line semiconductors or distributed semiconductors manufacturing pilot lines that can be replicated with additional investments from MS or the private sector through, for example, an IPCEI. • It allows the integration of national and Union funding into the joint funding of projects. • There is limited flexibility in changing the objectives, range of activities and partners as such changes need changes in the Regulation of the partnership, and negotiation in the Council.
Ensuring alignment with R&I agenda (*directionality*)	• The strategic R&I roadmap is agreed between MS, the KDT associations and the Commission. • The objectives and commitments are set in the legal base. • The annual Work Programme is drafted by the partners and approved by Commission, which has veto right. • Commitments include the obligation for financial contributions, including those to the administrative costs.
Securing leveraging effects (*additionality*)	• The commitment for contributions by the partnership members is expected to be at least equal to 50% and may reach up to 75% of the aggregated European Partnership budgetary commitments. In the case of KDT, where a tripartite model is envisaged, the maximum 75% can be achieved. In all scenarios, contributions from industry could be 50% or more.

5.5 Options discarded at an early stage

The Co-Funded Partnership and the Institutionalised Partnership created under Article 185 of the TFEU are not considered relevant for the impact assessment of the candidate Institutionalised Partnership on KDT

Based on the objectives of the KDT initiative, the direct beneficiary is industry. Therefore, the objectives can be only achieved if industry plays a pivotal role in the setting of the agenda, implementation and mobilisation of resources. This precondition is not satisfied by the afore-mentioned partnerships:

- The Co-Funded Partnership allows only public partners at its core, and industry cannot make formal commitments and contributions to it, nor participate in the setting of the research agenda.
- The participation in Art 185 TFEU is limited to MS.

6 Comparative assessment of the policy options

6.1 Assessment of effectiveness

Based on the intervention logic, the initiative aims to deliver scientific, economic/technological and societal (including environmental) impacts through a set of pathways (Section 4.3), which require a set of critical factors in place to be achieved in the best possible way (Section 4.4).

This section assesses the extent to which each retained policy option has the potential to achieve the likely impacts in the scientific, economic/technological and societal sphere, based upon its characteristics (Section 5). At the end of each section we summarise the outcomes of the assessment by assigning a non-numerical score to each option for each impact desired. The analysis in this section sets the basis for the comprehensive *comparative assessment* of all retained options against all dimensions in Section 6.4.

Table 9 lists the desired impacts in the three impact areas.

Table 9: Likely impacts of the initiative

Impact area	Likely impacts
Scientific impact	• High-level scientific capacity in Europe in manufacturing equipment and materials, energy efficiency, and secure novel computing paradigms, AI and related software. • Better cross-border and cross-sector cooperation that strengthens the exchange of knowledge within the value networks.
Economic/ technological impact	• European KDT industry strengthened its technological leadership and its international competitive position. • Key European infrastructures and sectors improved their access to secure and trusted components. • Better cross-border and cross-sector coordination and integration of R&I efforts that strengthen the innovation process in the value networks.
Societal impact	• Downstream industries progressively reduce the energy consumption of their products. • More environmentally friendly materials substitute for existing materials .

6.1.1 Scientific impacts

Option 0: Horizon Europe calls (baseline)

Impact: High-level scientific capacity in Europe in novel computer paradigms, AI and related software and in manufacturing equipment and materials.

To generate the impact, collaborative research at low TRLs with the participation of interdisciplinary teams from RTOs and industry is necessary. The traditional calls under the Framework Programme can effectively attract such groups, especially for activities at the lower TRLs. It is expected that Horizon Europe calls could attract the best research teams and thus deliver high-quality research results. Although the manufacturing equipment sector is dominated by large companies, in the emerging and less-established technologies, SMEs have an important role to play. However, due to intense competition, SMEs are in an inferior position compared to large and more experienced companies, and it will be more difficult for them to attract funding. Therefore, this option does not ensure the participation of all necessary actors to the highest possible extent.

In order to achieve the expected impact, scientific capacity needs to be generated in areas aligned with industry needs. The mechanism used by the HE for setting priorities does not guarantee such alignment. Although it is possible to develop an SRIA or a roadmap with the participation of industry that would reflect common priorities, it is less likely to ensure industry commitment beyond the single project participation in the absence of a formal mechanism of commitment. Also, there is a high risk of duplication of effort with different projects addressing similar issues while other important areas might be underdeveloped. At the same time, there is the risk of fragmentation of effort as effective communication between projects, or the continuation of the work to the next level by follow-up projects, is not guaranteed.

Due to uncertainty regarding the level of financial contribution by industry and the absence of financial participation by the MS, it is unlikely that this option will secure a level of investment equivalent to the other options.

Therefore, the potential of the option to generate the expected impact is low (+).

Impact: Better cross-border and cross-sector cooperation that strengthens the exchange of knowledge within the value networks.

The generation of the impact depends, among other factors, on the ability of the option to systematically mobilise and engage a broad population of actors from the various segments of the value networks. Also, effective knowledge exchange is built on trust, and it is galvanised through repetitive collaborations. The HE calls can effectively attract several actors in the area of KDTs, however with two limitations:

- As it was argued earlier, they are less effective in engaging SMEs.
- In the absence of a type of partnership or coordination, it is more likely that the joint participation of actors in research activities would be limited to the participation in a single project with low possibilities for continuation of the collaboration in later rounds of calls.

Therefore, the potential of the option to generate the expected impact is low (+).

Option 1: Co-Programmed

Impact: High-level scientific capacity in Europe in novel computer paradigms, AI and related software and in manufacturing equipment and materials.

A Co-programmed Partnership allows for high flexibility in the profile of the organisation involved. The industry is represented by the KDT associations, which function as back-office to the partnership. The associations could effectively steer the participation of their members. However, the openness and flexibility of the option could attract actors beyond the existing networks, bringing in new knowledge and ideas. Also, there are no significant barriers to entry for SMEs.

A Co-programmed Partnership can generate the commitment of industry and MS around a strategic agenda, which can be translated into an SRIA. Thus, the required alignment of the calls with the strategy of the industry can be achieved. However, control over the precise content of the calls and the selection of projects is limited, as the calls are implemented by EU agencies. Therefore, despite coordination at the level of the research agenda, there is still a high risk of duplication of efforts and fragmentation similar to Option 0. In addition, there is some risk of a disparity between the industry expectations and the final focus of the calls and selection of projects which might discourage the participation of industry.

The magnitude of the impact also depends on the total investment by all possible actors. It is expected that the Commission contribution would be similar to all options. In the current option, the MS will also contribute to the budget. Due to the formal commitment of all partners regarding their contribution, the 'leverage effect' for the whole partnership is likely to be high. However, the industry participation in specific activities could vary depending on their attractiveness. Thus, depending on the alignment of the calls with industry's priorities, it might be inclined to invest in projects of higher TRL, and therefore the financial contribution to activities generating scientific impact could be less than expected.

Considering all the elements, the potential of the option to generate the expected impact is good (++).

Impact: Better cross-border and cross-sector cooperation that strengthens the exchange of knowledge within the value networks.

Option 1 can mobilise and engage a broad population of actors from various segments of the value networks, including SMEs. The KDT associations participating as partners can mobilise actors and ensure better coverage of the value networks in the proposals. Also, they can contribute more systematically in the building of collaborations with a horizon exceeding the life of a project. However, this potential might be hindered by the limited control of the partnership over the final selection of projects.

Therefore, the potential of the option to generate the expected impact is good (++).

Option 3: Institutionalised Art 187

Impact: High-level scientific capacity in Europe in novel computer paradigms, AI and related software and in manufacturing equipment and materials.

The Institutionalised Partnership Art 187 is subject to a legal framework set out in a Council Regulation, which defines the objectives and the resources contributed by partners in relation to the proportion of EU funding. The partnership is governed by a body representing all partners, i.e. the private sector, represented by industry associations, representatives of all participating MS and the Commission. The operation is managed by

a central structure supporting, among other things, the development of a long-term strategy and the specification of annual work programmes delivered through projects undertaken either by specific partners or through open calls.

As it was unanimously agreed by industry representatives interviewed during the consultation, Option 3 can ensure the highest possible commitment of industry and MS around a strategic agenda. At the same time, alignment with EU policy is ensured by the participation of the Commission in the management of the partnership. The calls are designed by the management of the partnership according to the Work Programme with the highest possible alignment with the industry's strategy. The central coordination of the project selection will result in a stronger and more coherent research portfolio. Therefore, the potential to achieve the required directionality is high.

Option 3 can attract and engage all necessary types of actors. The possibility of launching public calls also provides opportunities to new actors beyond existing members of the partnership to participate. Therefore, the leverage effect could be comparable to other options providing that the communication and the visibility of the calls would be similar to other options. Furthermore, industry participation is expected to be high as this option provides the highest possible commitment. Therefore, it is considered that the overall potential to attract the necessary mix of actors is high.

The EU's financial contribution to the partnership would be similar to other options. The tripartite model, where the partnership brings together the private sector, national ministries and the European Commission combined with a high level of commitment by the partners, ensures the highest mobilisation of investments which can reach a high rate of 1:3.

Therefore, the overall potential of the option to generate the expected impact is high (+++).

Impact: Better cross-border and cross-sector cooperation that strengthens the exchange of knowledge within the value networks.

The existence of a central coordination mechanism which can proactively and systematically address and mobilise actors in the various segments of the value networks can provide the highest possible coverage of the value networks. Also, the coordination mechanism can design and implement follow-up activities that can sustain and reinforce the collaboration among the actors and provide a long-term perspective. There is also enough flexibility to design activities that address specific collaboration barriers.

Therefore, the potential of the option to generate the expected impact is high (+++).

Interviews with MS, business associations and RTOs supported the conclusion that HE calls are effective in generating scientific impact and in targeting lower TRLs. It was, however, also pointed out by MS and industry associations that HE calls are less suited for aligning with the industrial demand/user side or in generating scientific impact in areas aligned with industry needs. Furthermore, interviewed RTOs raised an issue – based on past experience with Horizon 2020 – with HE calls' capacity to align research agendas. Different interviewees (from MS, industry associations, large companies) also highlighted that HE calls are unlikely to mobilise a level of investment equivalent to other options, for example given the absence of national funding. In this context, the lack of formal commitment mechanism and uncertainty concerning the level of financial contribution by industry was highlighted by large companies and RTOs.

The Co-programmed Partnership was found to allow the highest level of flexibility and agility in the organisation and involvement, while also having the capacity to facilitate

commitment from both public and private partners as well as mobilise funding, according to several **interviewed** universities, RTOs, MS, industry associations and large companies.

Among **interviewed** stakeholders, a majority, especially from MS, business associations and large companies but also SMEs, RTOs and universities, preferred overall the Institutional Partnership model – given its ability to ensure the commitment of industry and MS around a strategic agenda, alignment with industry strategies, coordination of research agendas, and mobilisation of funding. It was pointed out by business associations, large companies, universities and RTOs that the Institutional Partnership has a long-term perspective on collaboration and, accordingly, is more effective in strengthening the exchange of knowledge within the value networks, given that HE calls limit participation in a single project, lowering the chances of continued collaboration in ensuing rounds of calls.

Summary

Table 10, below, lists the scores we assigned for each of the policy options, based upon the assessments above, as well as taking into account the support expressed by the different stakeholders.

Table 10: Overview of the options' potential for reaching the scientific impacts

Impacts	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Art 187
High-level scientific capacity in Europe on manufacturing equipment and materials, energy efficiency, secure novel computing paradigms, AI and related software	+	++	+++
Better cross-border and cross-sector cooperation that strengthens the exchange of knowledge within the value networks	++	++	+++

Notes: Score +++: Option presenting a *high* potential; Score ++: Option presenting a *good* potential; Score +: Option presenting a *low* potential.

6.1.2 Economic/technological impacts

Directionality and additionality required

As mentioned in the problem and drivers sections (Sections 2.1 and 2.2, respectively), the main challenge for both the European KDT ecosystem and the downstream industries that are depending on KDT for their competitiveness, is to face the severe competition from China and US and retain leadership and technological sovereignty.

The KDT initiative is expected to play a pivotal role in tackling the challenge by strengthening the technological leadership of Europe in KDTs, guaranteeing the supply of secure and trusted components and applications for key infrastructure and sectors, and improving the coordination and integration of R&I efforts in KDT value networks. In section 4.4.1, it was pointed out that to achieve the above impacts, financial and human resources and infrastructures comparable to those in the US and China should be mobilised. Therefore, the development of a shared European vision with a coordinated research agenda aligned with the national and industry priorities and strategies is necessary for reducing duplication and overlapping efforts, and pooling together the resources. Thus, the

option that offers the highest level of directionality and additionality will maximise the economic and technological impacts of the initiative.

Horizon Europe calls do not allow the selection of projects that continuously build on the results

Option 0: Horizon Europe calls (baseline)

Impact: European KDT industry strengthened its technological leadership and its international competitive position.

A critical element for achieving the expected impact is the rapid uptake by the downstream industry of early-stage R&D results, especially in emerging technologies. Also, the ability to create a critical mass of resources invested in R&I is essential.

The shortening of the innovation cycle and the transformation of values chains into value networks with several technologies involved require the fast transfer of results from the laboratory to the market, and the integration of different technologies into new components and systems with improved performance and reliability and enhanced environmental characteristics. To move fast from lower to higher TRLs and achieve the required high level of integration, a close and coordinated collaboration of actors across all segments of the value networks is necessary. SMEs and especially start-ups have a significant role to play as providers of new ideas for innovations.

The alignment of the calls with industry priorities is even more critical here than in the case of the scientific impacts. The current stage of R&I is closely related to the needs of the market, and therefore industry understands the needs better than the Programming Committees of Horizon Europe. Although the development of a SRIA with the participation of industry is possible, it is less likely to reflect the needs of industry compared to the strategies and Work Programmes developed in partnerships.

Horizon Europe calls do not allow the selection of projects that continuously build on the results of previous projects, effectively taking them from lower to higher TRLs. It is more likely that efforts will remain fragmented with the consortia looking for alternative funding outside Horizon Europe, to take the results to the next level after the completion of their project. The lack of continuation and, without a formal mechanism of commitment, the baseline option cannot provide the necessary certainty that is required for a long-term commitment by industry.

Overall, the lack of the required directionality will prevent industry from committing the necessary resources and, due to the absence of a contribution from the MS, the potential of the baseline option to achieve the required leverage of resources is low.

Therefore, the potential of the option to generate the expected impact is low (+).

Impact: Key European infrastructures and sectors improved their access to secure and trusted components.

In order to generate the expected impact, the alignment of the strategies of the Commission, MS and industry (mainly integrated device manufacturers, IC design companies, fabless companies and IC founders and software houses) for the selection of priority areas and development of a roadmap for the strengthening of weak or sourcing of missing segments is necessary. The roadmap will be followed by pilot and demonstration projects.

Traditional Horizon Europe calls cannot provide the necessary coordination to bring together specific actors and generate a portfolio of projects that will be implemented in a coordinated manner in terms of location and time. It is also less likely to ensure the long-

term commitment that is necessary for the implementation of the projects and the mobilisation of the investments that need to be implemented with the support of other initiatives (e.g. IPCEI).

Therefore, the potential of the option to generate the expected impact is low (+).

Impact: Better cross-border and cross-sector coordination and integration of R&I efforts that strengthen the innovation process in the value networks.

To generate the impact, a dynamic ecosystem needs to be in place which will facilitate collaboration among different actors from various segments of the value networks, including microelectronics companies, software houses, SMEs, and RTO downstream companies.

The necessary activities include the coordination of research agendas, building of networks of stakeholders and mobilisation of ecosystem stakeholders, and coordination with other European and national initiatives.

The coordination offered by the Programming Committees and the implementation through the Horizon calls cannot combine the necessary activity into a portfolio of support actions implemented in the required sequence and locations.

Therefore, the potential of the option to generate the expected impact is low (+).

Option 1: Co-Programmed

Impact: European KDT industry strengthened its technological leadership and its international competitive position.

Under Option 1, the KDT industry associations could coordinate their members and mobilise the necessary mix of actors.

The development of a SRIA contributes to the alignment of the strategies of industries, the MS and the Commission. KDT associations can provide a coordination service or function to consortia in order to further build on the research results of previous projects and transfer them from low to high TRLs. However, the implementation of the calls by an EU agency limits the control of the stakeholders over the precise content of the calls and the selection of the projects. The limited control could create uncertainty that might discourage industry from participating. It will also increase the risk of duplication and fragmentation of effort.

The leverage of investments is expected to be much higher than the baseline option due to the MS contributions. However, the leverage of industry investments depends on the degree of certainty provided that the content of the calls and the selection of projects will allow long-term planning, continuity of activities, and maximisation of synergies among the projects.

Therefore, the potential of the option to generate the expected impact is good (++).

Impact: Key European infrastructures and sectors improved their access to secure and trusted components.

Option 1 offers the possibility of aligning the strategies between the Commission, MS and industry, and the development of a roadmap of activities and areas for intervention. The KDT associations can organise the dialogue between their members and prepare coordinated proposals with the participation of the required actors.

The pilot and demonstration projects will be implemented through the mechanism of open calls. The smaller number of projects that need to be financed compared to other areas of

the initiative will allow for better coordination between the Commission, MS and industry in the launching of the calls and selection of projects.

The leverage of investments is expected to be high due to the contribution of MS and industry participation.

Therefore, the potential of the option to generate the expected impact is high (+++).

Impact: Better cross-border and cross-sector coordination and integration of R&I efforts that strengthen the innovation process in the value networks.

Option 1 can mobilise and engage a broad population of actors from the various segments of the value networks, including SMEs, and are open to newcomers according to the needs. The KDT associations will facilitate collaboration among their members from the segments of the value networks they represent.

Although the Option offers better coordination compared to the baseline, the building of the ecosystem requires more coordination effort, flexibility and feedback mechanisms. It entails coordination across the participating associations, flexibility to design and implement calls according to the needs, feedback loops that facilitate learning and adaptation of the activities to fit the changing needs best. These possibilities are only partially covered due to the absence of a central management and coordination mechanism.

Therefore, the potential of the Option to generate the expected impact is good (++).

Option 3: Institutionalised Art 187

Impact: European KDT industry strengthened its technological leadership and its international competitive position.

The Institutionalised Partnership Art 187 is subject to a legal framework set out in a Council Regulation. Despite its rigidness in terms of partners, the Option provides the opportunity to any actor, member of the partnership/consortium or not, to participate through open calls. Participation is even open (as in the other options) to partners from third countries. The participation of SMEs can be quite high according to the experience of ECSEL JU, where participation rates were 38% higher than in Horizon 2020. If needed, the Institutionalised Art 187 offers flexibility to design specific activities for SMEs. Therefore, in terms of the participation of the necessary mix of actors, the potential is high.

As mentioned earlier, to generate the expected impact, the speed of transferring early-stage R&D results to market, and the ability to integrate new technologies and expand the value networks with new actors, is critical. Therefore, transferring results from low TRL projects to projects combining high TRL activities (up to 7 or 9) is important. Option 3 offers the ability to generate integrated portfolios of projects by building a system via a pipeline of support to validate, accelerate and scale up the uptake of results.

Option 3 offers the highest directionality among the Options. The partnership is built around a common European strategy agreed among the Commission, MS and the private sector, represented by the KDT associations, and is implemented by Work Programmes that can be updated annually. The fact that the change of objectives requires the change of legislation offers a far more stable framework for long-term planning and implementation compared to other Options. The existence of the central management structure increases the already high directionality. The high level of directionality, the stability and the legally binding financial commitments for all partners create a far less-risky environment for companies to commit themselves and, therefore, offers the highest possible leverage of investments.

Therefore, the overall potential of the option to generate the expected impact is high (+++).

Impact: Key European infrastructures and sectors improved their access to secure and trusted components.

Option 3 provides the highest possible directionality which is necessary for setting priorities regarding the segments that need to be supported and organise the required interventions. Similarly, the leverage is high due to stability and long-term commitment of the partners.

Therefore, the overall potential of the option to generate the expected impact is high (+++).

Impact: Better cross-border and cross-sector coordination and integration of R&I efforts that strengthen the innovation process in the value networks.

In order to generate the desired impact, a high level of coordination of resources and commitment of the partners around a common strategy is required. Option 3 provides the highest possible directionality and leverage, and the ability to design and implement a portfolio of activities that can support the building of the ecosystem in a structured way.

Therefore, the overall potential of the option to generate the expected impact is high (+++).

According to **interviewees** from MS, industry associations and large companies, HE calls have a relatively low capacity to ensure long-term commitment, leverage resources and build upon the results of previous projects, thereby holding it back from strengthening the technological leadership and competitiveness of Europe's KDT industry. The Co-programmed option was found to have a more aligned format to industry needs, combined with a high level of flexibility and openness – both perceived to be conducive to achieving technological and industrial impact, according to MS, business associations and large companies. Several MS, industry associations and large companies highlighted that an Institutionalised Partnership Art 187 has the highest relevance for achieving industrial impact and competitiveness and for developing strategic technologies because it provides the strongest type of commitment, long-term stability and critical mass.

Strengthening weak or developing missing segments requires an alignment of strategies and coordination; traditional H2020 calls struggled to deliver that, according to several **interviewed** MS, business associations and large companies. The Institutionalised Partnership Art 187 offers a complementary format for agreeing on priorities of technological importance and for achieving technological sovereignty.

All **interviewed** stakeholder categories agreed that the Institutionalised Partnership Art 187 is the most capable of addressing and building the KDT ecosystem and value chains. The Institutionalised Partnership Art 187's long-term perspective on coordination and collaboration was further deemed to be supportive in addressing fragmentation and strengthening integration and cooperation in European value chains, according to MS, RTOs, business associations, large companies. Moreover, one RTO commented – based on past ECSEL JU experience – that an Institutional Partnership is likely to provide a broad coverage of TRLs and, thus, the value chain.

Summary

Table 11, below, lists the scores we assigned for each of the policy options, based upon the assessments above, as well as taking into account the support expressed by the different stakeholders.

Table 11: Overview of the options' potential for reaching the likely economic/technological impacts

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Art 187
European KDT industry strengthened its technological leadership and its international competitive position	+	++	+++
Key European infrastructures and sectors improved their access to secure and trusted components	+	+++	+++
Better cross-border and cross-sector coordination and integration of R&I efforts that strengthen the innovation process in the value networks	+	++	+++

Notes: Score +++ : Option presenting a *high* potential; Score ++: Option presenting a *good* potential; Score +: Option presenting a *low* potential.

6.1.3 Societal impacts

Option 0: Horizon Europe calls (baseline)

Under Horizon Europe, it is more likely that the prioritisation and the Work Programmes developed by the Programming Committees will place more emphasis on societal impact. This should lead to high-quality research results regarding the optimisation of the environmental characteristics of KDT components, systems and applications, the efficiency of the production methods in the use of the material, and the development of more environmentally friendly materials. However, the generation of the expected impacts depend on the final uptake by downstream industries of the new environmentally friendlier KDT products. Although Horizon Europe is expected to be very effective in the generating research results, it is more likely that it will be less effective at the later stages of the validation of the technology and the development of applications. The underlined reasons have been discussed in the assessments of the potential of Horizon Europe to create the expected technological and economic impact.

Therefore, the overall potential of the option to generate the expected impact is low (+).

Option 1: Co-Programmed

Under the Co-programmed Partnership, more emphasis will be placed on later stages of the research process compared to Horizon Europe. Still, the effectiveness of this Option to generate research results is expected to remain high.

The environmental impact of the initiative is related to its potential to reduce the energy consumption of the applications either by optimising the design and the system integration or by improving the software. As the use of the KDT applications increases and the competitiveness of downstream industries relies more and more on them, the demand for energy-saving applications also increases. Therefore, under market pressure, the KDT

industries will also prioritise improving the energy efficiency of their products. However, the reaction of the market might be less favourable to the development of new, more environmentally friendly materials if the new materials are not sufficiently cost-efficient.

It is expected that under the influence of the MS and the Commission in the development of the SRIA, attention will be given to improving the environmental impacts of the initiative. Therefore, the improvement of the energy efficiency of the technologies and the development of new, environmentally friendly materials will be of high priority.

Therefore, the overall potential of the Option to generate both societal impacts is expected to be high (+++).

Option 3: Institutionalised Art 187

For reasons similar to Option 2, the Institutionalised Art 187 partnership will give priority to developing technologies and applications of high energy efficiency.

However, due to the stronger influence of industry in the development of the priorities and the Work Programme, the support of the environmentally friendly materials might take more time to become a priority if they are less cost-efficient than currently materials used.

Therefore, the overall potential of the Option to generate the first societal impacts is expected to be high (+++) while for the second it is expected to be good (++).

Summary

Table 12, below, lists the scores we assigned for each of the policy options, based upon the assessments above, as well as taking into account the support expressed by the different stakeholders.

Table 12: Overview of the options' potential for reaching the likely societal impacts

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Art 187
Downstream industries progressively reduce the energy consumption of their products	+	+++	+++
More environmentally friendly materials substitute for the existing materials	+	+++	++

Notes: Score +++ : Option presenting a *high* potential; Score ++: Option presenting a *good* potential; Score +: Option presenting a *low* potential.

6.2 Assessment of coherence

6.2.1 Internal coherence

In this section we assess the extent to which the policy options show the potential of ensuring and maximising coherence with other programmes and initiatives under Horizon Europe, in particular European Partnerships.

Option 0: Horizon Europe calls (baseline)

Under this option, coherence between activities in the area of KDT with activities under Cluster 4 of the Horizon Europe, and the other initiatives presented in Table 3, are ensured by the European Commission. However, exploitation of synergies between the KDT and other initiatives, such as exchange of knowledge and experience at the level of projects and stakeholders, requires an extra layer of coordination beyond the Programme Committees.

Option 1: Co-Programmed

Under the Co-programmed option, the exploitation of synergies can go beyond the possibilities offered by the baseline option. The European Commission can ensure coordination at the level of the research agendas, while the KDT associations can proactively bring together projects and stakeholders from various initiatives to work together on common problems or explore common challenges together.

Option 3: Institutionalised Art 187

The Institutionalised Art 187 partnership can provide the highest level of coordination, as in addition to the role of the Commission and the KDT associations, there is a central coordination layer which can increase the effectiveness of the effort. Since the management group of the partnership organises the funding and implementation of projects, the KDT can set, together with other institutionalised partnerships, concrete objectives and a roadmap of activities and projects that can be implemented.

Through centralised coordination and management, the Institutionalised Partnership Art 187 model is expected to provide a higher level of internal coherence according to the **open public consultation**. Respondents to the open public consultation noted that establishing a specific legal structure was relevant or very relevant for facilitating collaboration with other partnerships. This view was especially held by universities and RTOs (an overall majority) and more than half of large companies, SMEs, public authorities and business associations.

6.2.2 External coherence

In this section we assess the extent to which the policy options show potential for ensuring and maximising coherence with EU-level programmes and initiatives beyond the Framework Programme and/or national and international programmes and initiatives.

Option 0: Horizon Europe calls (baseline)

In section 4.4.2 several opportunities for collaboration and developing synergies with non-FP initiatives have been identified. Under this option, some coordination with other European Commission activities is possible at the level of priorities. However, coordination at the level of implementation is somewhat limited or even not feasible.

Collaboration with national or regional initiatives, such as national programmes for the support of KDT or the coordination with regional clusters, is not feasible under this option.

Option 1: Co-Programmed

Under this option, the European Commission can contribute to some extent to the coordination with European non-FP initiatives at the level of the strategy. The participation of MS provides the opportunity for coordination with the national programmes and initiatives and the regional clusters. MS and KDT associations could coordinate with the national and industry efforts to set up a new KDT IPCEI which could contribute to the efforts towards technological sovereignty.

Option 3: Institutionalised Art 187

Under this option, the possibilities of coordination and exploitation of synergies offered by the Co-programmed option are expanded by the existence of a central coordination level which can improve and extend collaboration at the level of projects.

According to the **open public consultation**, most stakeholders perceived that an Institutionalised Partnership Art 187 would offer a central point of contact for coordinating engagement in the field of KDT. An overall majority of public authorities, universities, RTOs and large companies and more than half of business associations and SMEs, recognised that establishing a specific legal structure was 'relevant' or 'very relevant' for facilitating synergies with EU/National programmes.

As mentioned by one of the **interviewed** MS, the Institutionalised Partnership Art 187 has a relatively high capacity to ensure coordination and alignment with other national and European policies in the field. Another MS noted that the tripartite nature and centralised structure of an Institutionalised Partnership Art 187 offers a strong incentive for making synchronised funding decisions taking into account national and industry developments.

Several **interviewees** indicated potential links in relation to key application areas, e.g. automotive, energy, health, manufacturing and mobility/transport. In this context, one large company noted that all areas (e.g. food, agriculture, medicine, etc.) need KDT solutions.

Summary

Table 13, below, lists the scores we assigned for each of the policy options, based upon the assessments above, as well as taking into account the support expressed by the different stakeholders.

Table 13: Overview of the options' potential for ensuring and maximizing coherence

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Art 185/187
Internal coherence	+	++	+++
External coherence	+	++	+++

Notes: Score +++ : Option presenting a *high* potential; Score ++: Option presenting a *good* potential; Score +: Option presenting a *low* potential.

6.3 Comparative assessment of efficiency

In order to compare the policy options under common standards, we developed a standard cost model for all 13 candidate Institutionalised Partnership studies. The model and the underlying assumptions and analyses are set out in the report on the overarching context to the impact assessment studies.

Table 14 below, shows the intensity of additional costs against specific cost items for the various options as compared to the baseline, i.e. Option 0 (Horizon Europe calls). In this table we have taken into account that for Option 3 (Institutionalised Partnership) there would be a moderate additional cost for the set-up of a dedicated implementation structure seeing that such a structure is already existing. For Option 1 (Co-programmed), we

considered an additional cost for the call and project implementation as, ideally, MS would be providing contributions.

Table 14: Intensity of additional costs compared with HEU Calls (for partners, stakeholders, public and the Commission)

Cost items	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Art. 187
Preparation and set-up costs			
Preparation of a partnership proposal (partners and Commission)	0	++	++
Set-up of a dedicated implementation structure	0	0	++
Preparation of the SRIA/roadmap	0	++	
Ex-ante Impact Assessment for partnership	0	0	+++
Preparation of Commission proposal and negotiation	0	0	+++
Running costs (annual cycle of implementation)			
Annual Work Programme (AWP) preparation	0	+	+
Call and project implementation	0	+	+
Cost to applicants	0	0	0
Partners costs not covered by the above	0	+	+
Additional Commission costs (e.g. supervision)	0	+	++
Winding down costs			
European Commission	0	0	+++
Partners	0	+	+

Notes: 0: no additional costs, as compared with the baseline; +: minor additional costs, as compared with the baseline; ++: high additional costs, as compared with the baseline; +++: very high additional costs, as compared with the baseline

The scores related to the costs set out above will allow for a 'value for money' analysis (cost-effectiveness) in the final scorecard analysis in Section 6.4. For this purpose, in Table 16 where we provide the scores for the scorecard analysis, based on our insights and findings and based on the scores above, we assign a score 1 to the option with the highest costs and a score 3 to the lowest.

Table 15: Matrix on 'overall costs' and 'cost-efficiency'

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised
Overall cost	3	2	1
Cost-efficiency	3	3	2

Notes: Score 1 = Substantial additional costs, as compared with the baseline; score 2 = Medium additional costs, as compared with the baseline; score 3 = No or minor additional costs, as compared with the baseline.

We considered that, while there is a clear gradation in the overall costs of the policy options, the cost differentials are less marked when we take into account financial leverage (co-financing rates) and the total budget available for each of the policy options, assuming a common Union contribution. From this perspective, there are only one or two percentage points that split the most cost-efficient policy options – the baseline Option 0 and the Co-programmed policy options – and the least cost-efficient – the Institutionalised Partnership

options. We have therefore assigned a score of 3 to the Option 0 and the Co-programmed policy options for **cost-efficiency** and a score of 2 for the Institutionalised Partnership policy option.

It should be noted that the potential for the creation of crowding-in effects for industry has been taken into account when assessing the effectiveness of the policy options, above.

6.4 Comprehensive comparison of the options and identification of the preferred option

Building upon the outcomes of the previous sections, this section presents a comparison of the options' 'performance' against the three dimensions of effectiveness, efficiency and coherence.

In Section 6.4.1, we first compare the policy options against each other for each criterion in the effectiveness and coherence dimensions, resulting in a scorecard with scores from 1 to 3 where 3 stands for a substantially higher performance. Combined with the results from the comparative assessment for efficiency in Section 6.3, above, the final scorecard will allow for the identification of the preferred option in Section 6.4.2, taking all dimensions and criteria into account.

6.4.1 Comparative assessment

Effectiveness

Scientific impacts

The baseline Option has the potential to generate high scientific capacity in the area of emerging technologies, manufacturing equipment and materials. However, Option 1 can provide better alignment of the objectives with lower barriers to entry for SMEs and can achieve higher additionality. While Option 3 can offer an even higher alignment of objectives and a more coherent research portfolio.

Regarding the strengthening of collaborations, the baseline option allows for a broad participation of actors, although with higher barriers to SMEs. However, the ability to strengthen long-term collaborations is limited compared to other options. Option 1 can steer and better organise and retain collaboration among actors compared to the baseline. Option 3 provides greater integration and a long-term perspective in the collaborations. Therefore, the baseline option scores 1 on both scientific impacts, Option 1 scores 2 and Option 3 scores 3 (Table 16).

Economic/technological impacts

The baseline option is less effective compared to the other options in supporting the fast transformation of research results into validated technologies and demonstration projects that can be quickly taken up by the market. Option 1 allows for better alignment of objectives and for projects to build on previous results. However, Option 3 provides the highest directionality, and integrated portfolios of projects that can more effectively, compared to the other options, integrate technologies and transfer results from the laboratory closer to market.

Option 1 is more effective compared to the baseline in setting priorities and mobilising actors for strengthening the segments of the European value networks that are critical for the security and safety of the KTD applications. Although Option 3 provides a more integrated approach, both options are similarly effective.

For the coordination and integration of the R&I efforts, Option 3 provides the most integrated approach with the highest directionality and additionality compared to Option 1 and the baseline.

Therefore, the Baseline option scores 1 on all three economic impacts, Option 1 scores 2 on all but the second impact where it scores 3, and Option 3 scores 3 on all impacts (Table 16).

Environmental/societal impact

The baseline and Option 1 are expected to direct efforts towards activities with societal impact. However, Option 1 is more effective in bringing the result towards the market. Option 3 is expected to be responsive to the need for increasing the energy efficiency of the applications and therefore, it is expected to be equally effective as Option 1. However, it might be less responsive to the need to use more environmentally friendly materials. Therefore, Option 1 scores 1 on both societal impacts, Option 1 scores 3 on both impacts and Option 3 scores 3 and 2 on the first and second impact respectively (Table 16).

Coherence

The baseline option provides sufficient coherence between KDT and other activities within the Horizon Europe Work Programmes. Option 1 offers more opportunities for exploitation of synergies, as it can bring together projects and stakeholders from various initiatives and coordinate their activities. However, Option 3 provides the highest level of coordination and coherence at the strategy and implementation level. In addition to possibilities offered by Option 1, Option 3 can cluster projects together with other institutionalised partnerships under common objectives and a roadmap of implementation. Therefore, the scores we give for the internal coherence is 1 for the baseline option, 2 for Option 1, and 3 for Option 3 (Table 16).

Regarding the external coherence, the opportunities offered by the baseline option are limited to coordination with other European initiatives. In addition to that, Option 1 provides coordination with national and regional initiatives and industry strategies. Option 3 can go farther by coordinating implementation at the level of projects. Therefore, the scores we give for external coherence is 1 for the baseline option, 2 for Option 1, and 3 for Option 3 (Table 16).

Summary

Table 16: Scorecard of the policy options

	Impacts	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 3: Institutionalised Art 187
Effectiveness	**Scientific impacts**			
	High-level scientific capacity in Europe on manufacturing equipment and materials and on energy efficiency, and secure novel computing paradigms, AI and related software	1	2	3
	Better cross-border and cross-sector cooperation that strengthens the exchange of knowledge within the value networks	1	2	3
	Economic/technological impacts			
	European KDT industry strengthened its technological leadership and its international competitive position	1	2	3
	Key European infrastructures and sectors improved their access to secure and trusted components	1	3	3
	Better cross-border and cross-sector coordination and integration of R&I efforts that strengthen the innovation process in the value networks	1	2	3
	Societal impacts			
	Downstream industries progressively reduce the energy consumption of their products	1	3	3
	More environmentally friendly materials substitute for the existing materials	1	3	2
Coherence	**Internal coherence**	**1**	**2**	**3**
	External coherence	**1**	**2**	**3**
Efficiency	**Overall cost**	**3**	**2**	**1**
	Cost-efficiency	**3**	**3**	**2**

Notes: Scores for effectiveness and coherence: 3 = *substantially higher performance*; 2 = *higher performance*; 1 = *lower performance*. Scores for efficiency: 1 = *substantial additional costs*, as compared with the baseline; 2 = *medium additional costs*, as compared with the baseline; 3 = *No or minor additional costs*, as compared with the baseline.

6.4.2 Identification of the preferred option

According to the scorecard in Table 16, the baseline option performs less well against the criteria of effectiveness and coherence compared to Options 1 and Option 3. Its high score in the criterion of cost-efficiency does not weigh up against its low scores in the other dimensions.

Option 3 received the highest scores in almost all but one effectiveness and coherence criteria, and therefore it maximises the benefits compared to the other two options. Option 3 received the lowest score in terms of cost-efficiency. However, the difference with the other two options is not significant (one to two percentage points) and does not compare with the high performance on benefits.

Compared to the other options, Option 3 would:

- Provide greater effectiveness by offering higher leverage and structuring effects in the KDT ecosystem by mobilising stakeholders, creating a critical mass of financial and human resources, and providing better coordination of the implementation.
- Improve coherence through better coordination with other FP, non-FP, national or regional initiatives at the level of priorities and implementation, as well at the level of individual projects or stakeholders.

Our assessment concludes that Option 3 is the preferred option, showing a higher level of cost-effectiveness than the other options.

7 The preferred option - Description of the implementation and monitoring system

7.1 Description of the preferred option

Based on the assessment in Section 6, we conclude that Article 187 TFEU is the preferred option. This option ensures that the KDT industry, including all segments of the European ecosystem, is taking a leading role and fully engaged in the implementation. This option also ensures the highest possible coordination of research agendas and mobilisation of resources that are necessary for generating the critical mass that is necessary for meeting the objectives.

This option also offers the highest possible coordination and coherence with other initiatives of Horizon Europe, as well as external initiatives.

In Table 17, below, we indicate the alignment of the preferred option with the selection criteria for European Partnerships defined in Annex III of the Horizon Europe Regulation. Seeing that the design process of the candidate Institutionalised Partnerships is not yet concluded and several of the related topics are still under discussion at the time of writing, the criteria of additionality/directionality and long-term commitment are covered in terms of *expectations* rather than ex-ante demonstration.

Table 17: Alignment with the selection criteria for European Partnerships

Criterion	Alignment of the preferred option
Higher level of effectiveness	According to the assessment in Section 6, an Article 187 TFEU partnership will be more effective in increasing the competitive position of the KDT and downstream industries, establishing European leadership in emerging technologies and securing its technological sovereignty.

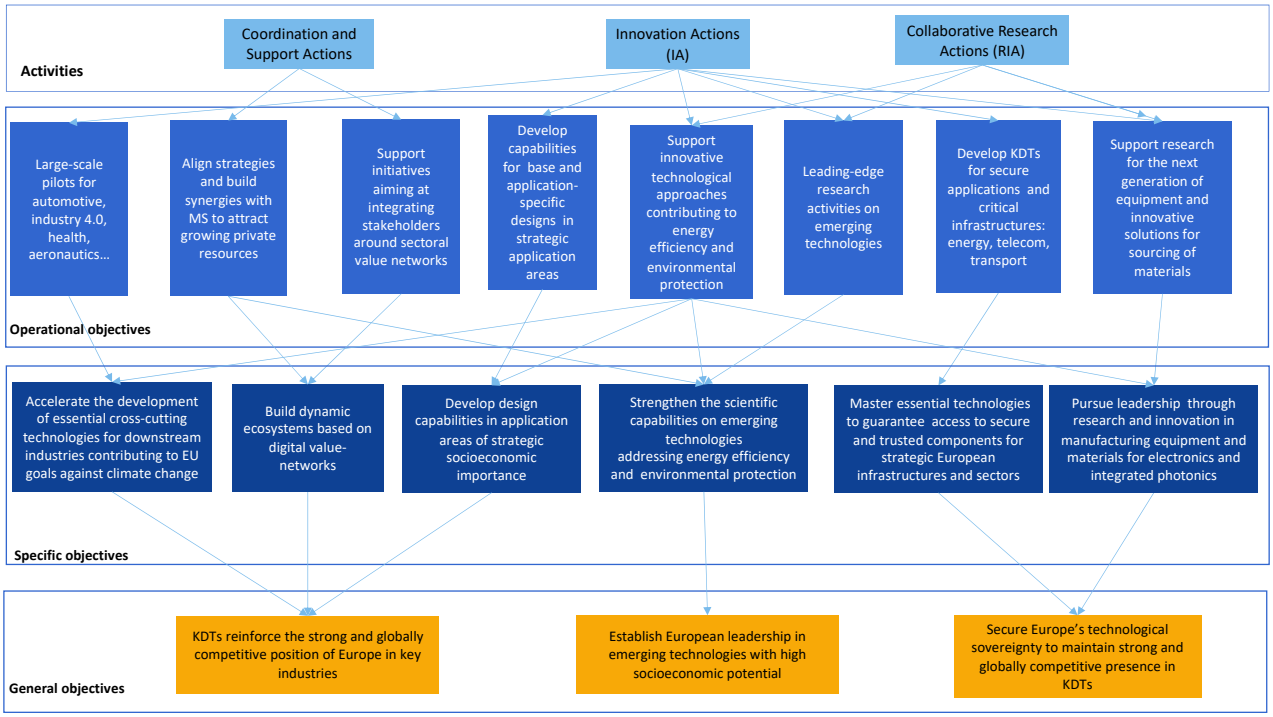
Criterion	Alignment of the preferred option
Coherence and synergies	The Article 187 TFEU partnership provides the necessary conditions for coordinating, creating synergies with other internal or external initiatives, and also for developing the KDT ecosystem. The participation of the Commission in the governance structure of the partnership ensures the alignment of the objectives with those of Horizon Europe and EU priorities, while the central management structure can effectively coordinate with other partnerships and European initiatives.
Transparency and openness	The management framework and the tripartite character of the partnership ensure transparency and openness in terms of decisions and participation based on commonly agreed criteria.
Additionality and directionality	The partnership would be able to develop a coherent long-term strategy for the development of the KDT ecosystem and its technological capabilities that will establish Europe's leadership in emerging technologies, secure the sovereignty in KDT and further strengthen its competitive position in key sectors that rely on KDTs.
Long-term commitment	The partnership would encourage the long-term commitment of financial and in-kind resources from MS and KDT companies. Hence, we would expect the partnership to ensure a financial contribution from MS up to 25% and a contribution from the private sector at least equal to 50% of the aggregated European Partnership budgetary commitments.

7.2 Objectives and corresponding monitoring indicators

7.2.1 Operational objectives

Figure 9, below, shows the broad range of actions and activities, beyond the R&I activities that can be implemented under Horizon Europe. This reflects the definition of European Partnerships in the Horizon Europe Regulation as initiatives for which the Union and its partners "commit to jointly support the development and implementation of a programme of research and innovation activities, including those related to market, regulatory or policy uptake."

Figure 9: Operational objectives of the initiative



We have identified a number of short, medium and long-term monitoring indicators to enable the progress of the partnership towards meeting its objectives to be tracked. These are shown in Table 18.

Table 18: Monitoring indicators in addition to the Horizon Europe key impact pathway indicators

Impacts	Short-term (typically as of year 1+)	Medium-term (typically as of year 3+)	Long-term (typically as of year 5+)
Scientific impact – High level of scientific capacity in Europe in novel computer paradigms, AI and related software and in the manufacturing equipment and materials	• Number of projects with one or more publications • Number of peer reviewed publications produced by the partnership	• Share of publications produced by the partnership in journals within the upper 25% based on Field-weighted Citation index	• Number and share of peer-reviewed publications from the partnership projects that are core contribution to the scientific filed
Scientific impact – Cross-sector cooperation that strengthens the exchange of knowledge within the value networks	• Number of peer-reviewed publications with co-authoring from industry and RTOs	• Field-weighted citation index of peer-reviewed publication with co-authoring from industry and RTOs	• Number and share of peer-reviewed publications from projects that are core contributions to scientific field with co-authoring from industry and RTOs

Impacts	Short-term (typically as of year 1+)	Medium-term (typically as of year 3+)	Long-term (typically as of year 5+)
Technological/economic impact – Key European infrastructures and sectors improved their access to secure and trusted components	• Number of IPRs, new products or services developed in the segments selected for support	• Number/Share of supported companies successfully launching new products	• World market share of Europe in the supported segments
Technological / economic impact – European KDT industry strengthened its technological leadership and its international competitive position	• Number of IPRs, new products or services developed by the supported projects	• Number of innovations from supported projects	• World market share of Europe in KDT segments related to key downstream industries
Technological/economic impact – Better cross-border and cross-sector coordination and integration of R&I efforts that strengthen the innovation process in the value networks	• Number of supported projects at TRLs 1 – 4 with a documented strategy for progressing to TRLs 5 - 8	• Number of supported projects moved from TRLs 1 – 4 to TRLs 5 - 8	• Strength of networking as it is measured by SNA
Environmental impact – Downstream industries progressively reduce the energy consumption of their products	• Number of KDT products (chips, components, systems, applications) with reduced consumption of energy developed by supported projects	• Number of products (chips, components, systems, applications) with reduced consumption of energy developed by supported projects reached the market	• Market share of new products with reduced consumption of energy
Environmental impact – More environmentally friendly materials substitute for the existing materials	• Number of projects which improved the environmental characteristics of materials used in the production of ICs	• Number of materials with improved environmental characteristics are used in the production of ICs	• Share of production using the new environmentally friendly materials

Appendix A Bibliography

Advancy. (2019). Embedded Intelligence: Trends and Challenges. Commissioned by ARTEMIS-IA. Retrieved November 2019, from https://artemis-ia.eu: https://artemis-ia.eu/news/embedded-intelligence-trends-challenges-book-release.html.

Armasu, L. (2015). Samsung's New 14 Billion Chip Plant To Manufacture DRAM, Processors in 2017, Retrieved December 2019, from tomshardware.com: https://www.tomshardware.com/news/samsung-14-billion-chip-plant,29058.html.

Council of the European Union. (2019). Proposal for a Regulation of the European Parliament and of the Council establishing Horizon Europe - the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination. Retrieved August, 2019 from Consilium: https://www.consilium.europa.eu/media/38902/st07942-en19.pdf

European Commission. (2015). A Digital Single Market Strategy for Europe COM(2015) 192 final . Retrieved August, 2019 from ec.europa.eu: https://ec.europa.eu/digital-single-market/en

European Commission. (2014). Electronics Leaders Group (2014). A European Industrial Strategic Roadmap for Micro- and Nano-Electronic Components and Systems. Retrieved August, 2019 from ec.europa.eu: https://ec.europa.eu/digital-single-market/en/news/european-industrial-strategic-roadmap-micro-and-nano-electronic-components-and-systems

European Commission. (2018). Boosting Electronics Value Chains in Europe, A report to Commissioner Gabriel . Retrieved August, 2019 from ec.europa.eu: https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53119

European Commission. (2019). European Partnerships under Horizon Europe: results of the structured consultation of Member States. Draft Report for the meeting of the Shadow Configuration of the Strategic Programme Committee on 27 June 2019. Retrieved August, 2019 from Era-learn.eu: www.era-learn.eu%2Fdocuments%2Fresults_structured_consultation_ms&usg=AOvVaw2iYBFRV7XCCV3tY3TLa0oP

European Commission. (2019). Towards a Sustainable Europe by 2030. Retrieved August, 2019 from ec.europa.eu: https://ec.europa.eu/commission/sites/beta-political/files/rp_sustainable_europe_30-01_en_web.pdf https://ec.europa.eu/digital-single-market/en/news/digital-europe-programme-proposed-eu92-billion-funding-2021-2027

Council of the European Union. (2014). Council Regulation (EU) No 561/2014 establising the ECSEL Joint Undertaking. Retrieved August, 2019 from ecsel.eu: https://www.ecsel.eu/sites/default/files/2017-09/Council_Regulation_Establishing_ECSEL_JU.pdf

ECSEL. (2019). Lighthouse Initiatives. Retrieved August, 2019 from ecsel.eu: https://www.ecsel.eu/lighthouse-initiatives

ECSEL. (2018). Annual Activity Report 2018. Retrieved August, 2019 from ecsel.eu: https://www.ecsel.eu/sites/default/files/2019-06/ECSEL%20Annual%20Report%202018%20%E2%80%93%20pubished.pdf

ECSEL. (2018). Decision of the governing board of the ECSEL joint undertaking – ECSEL multi-annual strategic plan 2019, ECSEL GB 2018.114. Retrieved August, 2019 from

ecsel.eu: https://www.ecsel.eu/sites/default/files/2019-01/ECSEL%20GB%202018.114%20-%20MASP%202019%20and%20Annex%20V1.1.pdf

European Commission. (2017). Mid-term review of the contractual Public Private Partnerships (cPPPs) under Horizon 2020 – Report of the Independent Expert Group. Retrieved August, 2019 from ec.europa.eu: https://publications.europa.eu/en/publication-detail/-/publication/6de81abe-a71c-11e7-837e-01aa75ed71a1

ERA LEARN. (2019). & ERA LEARN (2019) H2020 Partnership Landscape and its relevance for Horizon Europe – Cluster 'Digital and Industry' – Description and Analysis. Retrieved August, 2019 from ERA LEARN: https://www.era-learn.eu/documents/thematic_analysis_digital_and_industry.pdf

ECSEL. (2019). ECSEL Joint Undertaking Coordinators' Day 2019. Retrieved August, 2019 from ECSEL: https://www.ecsel.eu/sites/default/files/2019-05/1%20ECSEL%20in%20a%20nutshell.pdf

European Court of Auditors. (2017). Summary of results from the ECA's 2017 annual auditof the European research Joint Undertakings. Retrieved August, 2019 from ECA: https://www.eca.europa.eu/Lists/ECADocuments/SUMMARY_JUS_2017/Summary_report_JUs_EN.pdf

McKinsey & Company. (2019). Artifical-Intelligence hardware:New opportunities for semiconductros companies. Retrieved August, 2019 from mckinsey.com: https://www.mckinsey.com/industries/semiconductors/our-insights/artificial-intelligence-hardware-new-opportunities-for-semiconductor-companies

European Commission. (2019). Boosting Electronics Value Chains in Europe. Retrieved August, 2019 from ec.europa.eu: https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53119

ScitechEuropa. (2019). Photonics PPP: positive outlook with 5-fold leverage on EU investment. Retrieved August, 2019 from Scitecheuropa.eu: https://www.scitecheuropa.eu/photonics-ppp-5-fold-leverage-on-eu-investment/96454/

EPS News. (2019). Global EMS Market Grew 15% in 2018 to Nearly $542 Billion. Retrieved August, 2019 from epsnews.com: https://epsnews.com/2019/07/24/global-ems-market-grew-15-in-2018-to-nearly-542-billion/

ECSEL. (2018). Vision for Electronics. Retrieved August, 2019 from ecsel.eu: https://www.ecsel.eu/sites/default/files/2018-10/Binspired%20-%20A%20vision%20for%20electronics.pdf

SEMI. (2018). Turbulent Times Ahead for Trade. Retrieved August, 2019 from semi.org: http://www1.semi.org/en/turbulent-times-ahead-trade

PWC. (2019). Opportunities for the global semiconductor market. Retrieved August, 2019 from pwc.com: https://www.pwc.com/gx/en/industries/tmt/publications/global-tmt-semiconductor-report-2019.html

Deloitte. (2018). IoT opportunity in the world of semiconductor companies. Retrieved August, 2019 from deloitte.com: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology/us-semiconductor-internet-of-things.pdf

European Commission. (2018). Interim Evaluation of the ECSEL Joint Undertaking (2014-2016). Retrieved August, 2019 from ec.europa.eu: https://ec.europa.eu/research/evaluations/pdf/ecsel.pdf

EE Times. (2018). The Concentration of Semiconductor Market Share. Retrieved August, 2019 from EETIMES: https://www.eetimes.com/author.asp?section_id=40&doc_id=1333179#

World Economic Forum. (2018). Harnessing Artificial Intelligence for the Earth. Retrieved August, 2019 from weforum.org: http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf

Photonics 21. (2019). Europe's age of light!How photonics will power growth and innovation. Retrieved August, 2019 from photonics21.org: https://www.photonics21.org/download/ppp-services/photonics-downloads/Europes-age-of-light-Photonics-Roadmap-C1.pdf

ARTEMIS . (2013). ITEA ARTEMIS-IA High-Level Vision 2030 – Opportunities for Europe – the impact of software innovation on revenue and jobs. Retrieved August, 2019 from artemis-ia.eu: https://artemis-ia.eu/documents.html

eeNews. (2014). Innovation in the car: 90% comes from electronics and software. Retrieved August, 2019 from eenewseurope.com: https://www.eenewseurope.com/news/innovation-car-90-comes-electronics-and-software

European Commission. (2019). Biannual Work Programme 2018-2020 Horizon 2020. Retrieved August, 2019 from ec.europa.eu: https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-swfs_en.pdf

European Parliament. (2019). Connecting Europe Facility 2021-2027: Financing key EU infrastructure networks. Retrieved August, 2019 from europarl.europa.eu: http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2018)628247

European Commission. (2019). Digital Europe Programme: a proposed EUR 9. Billion of Funding for 2021-2027. Retrieved August, 2019 from ec.europe.eu: https://ec.europa.eu/digital-single-market/en/news/digital-europe-programme-proposed-eu92-billion-funding-2021-2027

ECSEL. (2019). Multi-annual strategic plan ("MASP") 2019. Retrieved August, 2019 from https://ec.europa.eu/research/participants/data/ref/h2020/other/legal/jtis/ecsel-multi-stratplan-2019_en.pdf

ARTEMIS. (2018). Electronic Components and Systems Strategic Research Agenda-Strategic Research Agenda 2018. Retrieved August, 2019 from artemis-ia.eu: https://artemis-ia.eu/documents.html

European Commission. (2018). First ever joint Electronic Components and Systems (ECS) Strategic Research Agenda (SRA). Retrieved August, 2019 from ec.europa.eu: https://ec.europa.eu/digital-single-market/en/news/first-ever-joint-electronic-components-and-systems-ecs-strategic-research-agenda-sra

European Commission. (2016). Communication from the Commission to the Parliament, the Council and Committee of the Region. Digitising European Inudstry. Retrieved August, 2019 from https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-180-EN-F1-1.PDF

ASPECT. (2017). ECSEL JU Impact analysis study. Retrieved August, 2019 from ecsel.eu: https://www.ecsel.eu/sites/default/files/2017-09/Ecsel_Impact_Analysis_study_website.pdf

IMI. (2017). Public Pirvate Partnerships Strengthening Innovation and Research in Europe. Retrieved August, 2019 from europeanfiles.eu: https://www.europeanfiles.eu/wp-content/uploads/2017/12/Strengthening-Innovation-and-Research-in-europe-December-2017-Issue-49.pdf

European Commission. (2017). Results of stakeholder consultation. interim evaluation of the Joint Undertakings operating under Horizon 2020. Retrieved August, 2019 from ec.europe.eu: https://ec.europa.eu/research/consultations/interim_joint-undertakings_h2020/ju_interim_stakeholder_consultation_web.pdf

Idea Consult. (2018). Impact Assesment: Strategic pre-study and Feasibility. Final Report. Retrieved August, 2019 from ecsel.eu: https://www.ecsel.eu/sites/default/files/users/Anna-zuzanna/ECSEL%20prestudy%20FINAL%20REPORT%202018%2009%2011.pdf

ECSEL. (2018). Decision of the public authorities board of ECSEL U. Retrieved August, 2019 from ecsel.eu: https://www.ecsel.eu/sites/default/files/2018-02/ECSEL%20PAB%202018.32.pdf

SEMI. (2015). Whitepaper: Semiconductor Industry from 2015 to 2025. Retrieved August, 2019 from semi.org: https://www.semi.org/en/semiconductor-industry-2015-2025

Tractica. (2017). Research Report. Executive Summary: Aritifical Intelligence Market Forecasts. Retrieved August, 2019 from https://www.tractica.com/wp-content/uploads/2017/04/MD-AIMF-2Q17-Executive-Summary.pdf

E&T. (2018). Boeing and Airbus set to lose USD 39bn following Iran nuclear deal blow. Retrieved August, 2019 from eandt.theit.org: https://eandt.theiet.org/content/articles/2018/05/boeing-and-airbus-set-to-lose-39bn-following-iran-nuclear-deal-blow/?utm_source=Adestra&utm_campaign=New%20EandT%20News%20-%20Automation%20FINAL%20-%20MEMBER&utm_medium=Newsletters%20-%20E%26T%20News&utm_c

European Commission. (2018). Workshop on Digitising the energy value chain. Retrieved August, 2019 from ec.europa.eu: http://ec.europa.eu/information_society/newsroom/image/document/2018-13/report-digitisingenergyvaluechain-workshop_0209BF3E-0D40-52CF-48B579B49BE24D96_50739.pdf

European Commission. (2018). Electronics Value Chains: Workshop on Automotive focusing on Connected and Autonomous Driving Brussels, 11 April2018. Retrieved August, 2018 from ec.europa.eu: https://ec.europa.eu/digital-single-market/sites/digital-agenda/files/electronics_value_chains_-_automotive_workshop_report.pdf

European Commission. (2019). Orientations towards the first Strategic Plan implementing the research and innovationframework programme Horizon Europe. Retrieved August, 2019 from ec.europa.eu: https://ec.europa.eu/research/pdf/horizon-europe/ec_rtd_orientations-towards-the-strategic-planning.pdf

European Commission. (2019). Study on the electronics ecosystem: overview, developments and Europe's position in the world. From ec.europa.eu.

Electronics Leaders Group. (2019). Boosting Electronics Value Chains: An Industrial Strategy for Europe - Implementation Plan.

Electronics Leaders Group. (2018). Boosting Electronics Value Chainsin Europe: A report to Commissioner Gabriel.

Appendix B Synopsis report on the stakeholder consultation – Focus on the candidate European Partnership for EU-AFRICA Global Health

Disclaimer: the views expressed in the contributions received are those of the respondents and cannot under any circumstances be regarded as the official position of the Commission or its services.

B.1 Introduction

Following the European Commission's proposal for Horizon Europe in June 2018,[59] 12 candidates for institutionalised partnerships within 8 partnership areas have been proposed, based on the political agreement with the European Parliament and Council on Horizon Europe reached in April 2019.[60] Whether these proposed institutionalised partnerships will go ahead in this form under the next research and innovation programme is subject to an impact assessment.

In line with the Better Regulation Guidelines,[61] the stakeholders were widely consulted as part of the impact assessment process, including national authorities, the EU research community, industry, EU institutions and bodies, and others. These inputs were collected through different channels:

- A feedback phase on the inception impact assessments of the candidate initiatives in August 2019,[62] gathering 350 replies for all 12 initiatives;
- A structured consultation of Member States performed by the EC services over 2019;
- An online public stakeholder consultation administered by the EC, based on a structured questionnaire, open between September and November 2019, gathering 1635 replies for all 12 initiatives;
- A total of 608 Interviews performed as part of the thematic studies by the different study teams between August 2019 and January 2020.

This document is the synopsis report for the initiative "Key Digital Technologies". It provides an overview of the responses to the different consultation activities. A full analysis of the results is provided in the study Data Report.

[59] https://ec.europa.eu/commission/presscorner/detail/en/IP_18_4041

[60] https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_19_2163

[61] https://ec.europa.eu/info/files/better-regulation-guidelines-stakeholder-consultation_en

[62] The full list of inception impact assessments is available here. They were open for public feedback until 27 August 2019.

B.2 Feedback to the inception impact assessment on candidate initiatives for institutionalised partnerships

Following the publication of the inception impact assessment, a feedback phase of 3 weeks allowed any citizen to provide feedback on the proposed initiatives on the "Have your say" web portal. In total 350 feedbacks were collected for all initiatives.

For the initiative "Key Digital Technologies" 17 individual feedbacks were collected, mainly from business associations, academic/research institutions, company/business organisations, public authorities and EU citizens.[63] Among the elements mentioned were:

- Two Member States noted the need for ensuring strong synergies with other initiatives; while one Member State noted the relevance of linking with partnerships on AI and robotics, another Member State suggested a focus on Smart networks and services, EuroHPC and Innovative Health. One Member State further recognised the need for clearer and harmonised procedure on reporting, with an eye to limit the administrative burden on participants.
- One academic/research institution expressed a strong support for broadening the scope of ECSEL to cover key digital technologies, while also stressing that a collaborative ecosystem involving academia and enterprise serves to boost the quality of interdisciplinary research. Another academic/research institution called for the broadening to include such critical underlying technologies as high frequency, low power, antenna, photonics, and embedded software. A third academic/research institution noted that the new KDT initiative should seek to improve on how MS funding may negatively influence future project definition, geographical balance and administrative requirements.
- Two large companies emphasised the high relevance of the KDT initiative and the Institutional Partnership framework. Current rules were found by one SME to induce large projects with a large number of partners, which only could be led by a big company; accordingly, the respondent called for an improvement to the participation rules in order to foster more open calls for all types of companies.
- A few industry associations commented that the new KDT initiative will strengthen European leadership in KDT and be key in driving the digital transformation of Europe's economy and society. Applications of KDT are further anticipated to have a high level of importance in addressing global challenges, including transport and smart mobility, health and wellbeing, energy, digital industry and digital life. According to industry associations, it was further expected that the KDT initiative aligns European and national R&I efforts on KDT, strengthens global competitiveness of Europe's KDT industry and ensure sovereignty and autonomy. It is further supportive in building a vibrant ecosystem involving a broad set of stakeholders and assembles the critical mass necessary.
- One business association underlined the need for focussing on cybersecurity and digital security, to support EU in becoming a global leader in key areas of cybersecurity.
- It was commented by one consumer organisation that the extension of the involvement of European software suppliers in KDT could improve competitive parameters of Europe's software and system suppliers and result in new software-enabled and hardware/technology secured new applications and services.

[63] Feedback on inception impact assessment to be found on https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2019-4972315/feedback_en?p_id=5722216

B.3 Structured consultation of the member states on European partnerships

A structured consultation of Member States through the Shadow Strategic Configuration of the Programme Committee Horizon Europe in May/ June 2019 provided early input into the preparatory work for the candidate initiatives (in line with the Article 4a of the Specific Programme of Horizon Europe). This resulted in 44 possible candidates for European Partnerships identified as part of the first draft Orientations Document towards the Strategic Plan for Horizon Europe (2021-2024), taking into account the areas for possible institutionalised partnerships defined in the Regulation.

B.3.1 Key messages overall for all candidate Institutionalised Partnerships are the following:

Overall positive feedback on the proposed portfolio, but thematic coverage could be improved

The results indicate a high level of satisfaction with the overall portfolio, the level of rationalisation achieved, and policy relevance. While delegations are in general satisfied with the thematic coverage, the feedback suggests the coverage could be improved in cluster 2 "Culture, creativity and inclusive society" and cluster 3 "Civil Security for Society".

Large number (25) of additional priorities proposed for partnerships by delegations

Despite high satisfaction with the portfolio and candidates put forward by the Commission, countries put forward a high number of additional priorities to be considered as European Partnerships. A closer examination suggests that these additional proposals are motivated by very different reasons. Whilst some proposals are indeed trying to address gaps in the portfolio and reach a critical mass, then, others are driven by the wish to maintain existing networks, currently not reflected in the Commission proposal (e.g. those based on JPIs, ERA-NETs). In addition, some proposals reflect worries over some topics not being sufficiently covered in the existing proposals, but could be possibly well covered within the scope of existing partnerships, or by traditional calls under the Framework Programme.

Critical view on the high number and openness of Joint Undertakings

Country feedback suggests dissatisfaction with the high number of proposed Article 187 TFEU partnerships. Notably smaller as well as EU-13 countries raise concerns with regards to the potential insufficient transparency and openness of the partnership model. In the feedback, countries either directly support or ask to carefully analyse whether the objectives of this proposal could be reached with the co-programmed model.

For those partnerships that will be set up on the basis of Article 187, the country feedback stresses the need to ensure a clear shift towards openness in the governance, membership policy and allocation of funding of these partnerships. Notably, it is emphasised that the JU rules should not have any limitations or entry barriers to the participation of SMEs and other partners, including from academia.

Although the feedback suggests a general criticism, there are few concrete and broadly supported proposals, including to reduce the number of institutionalised partnerships mergers or by alternative implementation modes.

Lack of cross-modal perspective and systematic approach to mobility

The current proposal foresees 5 partnerships in the area of transport (for rail, air traffic management, aviation, connected and automated driving, zero-emission road transport), and 2 that in closely related technologies for radically reducing carbon emissions (hydrogen, batteries). Several delegations would wish to see a systemic approach to

developing mobility and addressing related challenges (optimisation of overall traffic, sustainable mobility solutions for urbanisation), and do not support a mode-dependent view only. This suggests the need to discuss how to ensure greater cooperation between transport modes and cross-modal approaches in establishing partnerships in the area of mobility.

Partnership composition: the role of Member States in industry partnerships

The composition and types of partners is an important element for the success of a partnership, e.g. to ensure the right expertise and take-up of results. Ensuring broad involvement without overly complicating the governance of the partnership remains an important an important challenge in the design of future partnerships.

In the feedback, several Member States express their interest to join as a partner in partnerships that have traditionally been industry-led. However, individual comments suggest there are different views on what their involvement means in practice, with some countries expressing readiness to commit funding, while others support limiting their involvement to alignment of policies and exploiting synergies. This suggests the need to discuss further what the involvement of Member States means in practice (notably in terms of contributions, in the governance), and what would be possible scenarios/options in Horizon Europe. There is special interest in testing and deployment activities, in synergies with Cohesion Funds and CEF priorities and investments.

Although it is too early to determine the interest of industry/ businesses in the topics proposed for partnerships where the main partners are public authorities, their involvement in in public centric partnerships will also be an important question in the design and preparation of future proposals.

Some proposals are more mature than others

The analysis of feedback per partnership candidates suggests that some proposals are more mature, while others would need more time to determine the scope, objectives, partner composition and contribution and appropriate mode of implementation. This relates to in particular to partnerships with no predecessors and those where the main partners are public. It suggests that the proposals would need to be developed at different paces in order to achieve good quality, and thus, not all partnership proposals may be ready for implementation at the start of Horizon Europe.

The feedback provided by 30 countries (all Member States, Iceland and Norway) has been analysed and summarised in a report, with critical issues being discussed at the Shadow Strategic Programme Committee meetings.

The feedback provided by 30 countries (all Member States, Iceland and Norway) has been analysed and summarised in a report, with critical issues being discussed at the Shadow Strategic Programme Committee meetings.

Countries strongly support the proposed Key Digital Technologies partnership, with high relevance in the national context. Key issues raised by delegations include the careful assessment of the scope of partners and relevant stakeholders, the need to provide strong support to and impact on SMEs and the limitation of activities related to photonics to those that require a very strong integration with electronic devices. Synergies with other partnerships within and outside the cluster need to be ensured, and issues related to central management of all financial contributions need to be clarified.

B.3.2 Overall feedback for the initiative "Key Digital Technologies"

Relevance and positioning in a national context

The results of the Member State consultation confirm strongly the overall relevance of the proposed Key Digital Technologies (KDT) partnership. 96% of member states consider it relevant for their national policies and priorities, as well as for their industry, research organisation and universities.

On the question of existing national/regional R&I strategies, plans and / or programmes in support of the proposed Key Digital Technologies partnership, 27 countries report to have relevant elements in place. National R&I strategies or plans were identified most frequently (82%, AT, CY, CZ, DE, DK, EE, ES, FI, FR, HR, HU, IE, LV, MT, NL, PL, PT, RO, SE, SI, SK, UK, NO), followed by national economic, sectoral strategy and/or plan with a strong emphasis on research and/or innovation (81%, AT, BE, CZ, DK, EE, GR, ES, FI, FR, HR, HU, IE, IT, LV, PL, PT, RO, SE, SI, UK, NO) and regional R&I and/or smart specialisation strategies (75%, AT, BE, CY, CZ, DE, DK, GR, ES, FR, HR, HU, IE, LV, MT, PL, PT, RO, SE, SI, SK, UK).

Delegations identified a number of aspects that could be reinforced in the proposal for this partnership that would increase its relevance for national priorities, e.g.:[64]

- Ensure high level of participation of impact on SMEs;
- Include relevance of KDT to the innovative high-tech products and services that are being increasingly introduced by EU start-ups;
- Clarify synergies and boundaries with related initiatives and partnerships (e.g. on AI, mobility, photonics, smart transportation and measurements, HPC, Cybersecurity, 5G and Made in Europe);
- Clarify the scope: whether the focus is digital systems and their manufacturing processes or the electronics sector, including end users;
- Consider extending the scope by including a broader range of key digital technologies and software;
- Ensure attractive conditions for the participation of academia and Research Technology Organisations.

The majority of countries (68%) are at this stage interested to participate, with 8 countries undecided (CY, DK, EE, EL, HR, LU, SI, UK) and only IS excluding participation. Existing national R&I programmes and governmental research organisations (both at 78%) are identified as main potential partners or contributors. A number of countries (CY, DK, PL) state that their final decision to participate will be taken at a later stage. Two delegations stress the importance of representation of Member States in the partnership.

Most countries (96%) expressed interest in having access to results produced in the context of the partnership.

Feedback on objectives and impacts

Overall there is a strong agreement (96%) on the use of a partnership approach in addressing this specific priority. There is broad agreement (82%) that the partnership is more effective in achieving the objectives and delivering clear impacts for the EU and its

[64] Comments on scope and content have to be assessed in the context of the overall priority setting to ensure coherence.

citizens, and to lesser degree (59%) that it would contribute to improving the coherence and synergies within the EU R&I landscape.

Countries indicate good agreement with the proposed objectives at short, medium and long term (96%) and the expected scientific, economic and societal impacts at European level (96%), with the remaining ones being neutral. Slightly less (89%) consider the impacts relevant in the national context. There is also good agreement (74%) with the envisaged duration of the proposed partnership. Some additional comments made by individual delegations reiterate points made previously under elements to be reinforced. Additional comments address the following aspects:

- Ensure strong expected impact also beyond automotive on the rapidly developing domain of various mobile unmanned and autonomous systems;
- Need to keep the partnership open and provide incentives to industry for trying new solutions, methods and technologies (instead of incrementally improved solutions);
- Important to allocate sufficient budget for embedded software and Innovation Actions;
- A number of delegation comment critical on the proposed integration of certain photonics activities, and request to limit this to those that require a very strong integration with electronic devices to avoid duplication;
- Need to ensure feasibility of the proposed blending of various funding streams.

Views on partners, contributions and implementation

There is broad agreement (88%) between countries on the type and composition of partners, with comments (DE, UK) on the need to adapt the governance to the new type of partners, and the need to include academic partners. Pilot projects with industries are important, and there is a need to focus budgets on calls that are relevant for national strategies.

At this stage most countries (59%) would need more information on contributions and level of commitments expected from partners, while 29% agree with the proposal. The feedback suggests that more clarity is needed on the central management of financial contributions, and its implications (e.g. to country's decision-making ability). A number of countries are not convinced that the tri-partite funding model is ideal for this partnership. Some delegations consider that low TRL projects should be funded under Horizon Europe and should not require national funding as the scale of those projects does not justify the additional "red-tape" for national participants. Conversely, one country suggests the partnership should offer support to smaller, concretely focused projects in addition to larger, broad-based projects with many partners. It is important to set up a clearer methodology to calculate the contributions from industrial partners, both for the funded proposals and for the administrative costs.

The majority of countries (59%) agree with the proposed implementation mode as Article 187, with 41% expecting more details in order to be able to make an informed decision. Two delegations propose (with another one being supportive if it facilitates implementation) co-programmed as implementation mode. Two delegations propose to continue this partnership without Member State funding, while others underline that involvement of Member States is important.

B.4 Targeted consultation of stakeholders related to the initiative "Key Digital Technologies"

In addition to the consultation exercises coordinated by EC services, the external study thematic teams performed targeted consultations with businesses, research organisations and other partners on different aspects of potential European Partnerships.

This annex complements the description of the common methodological framework for all 13 Impact Assessment studies, described in the report on the overarching context to the impact assessment studies.

It sets out the interview strategy that was developed specifically for the Impact Assessment study of the candidate Institutionalised Partnership on Key Digital Technologies and its implementation.

The study-specific methodology regarded the interview strategy only.

B.4.1 Approach to the targeted consultation

The lists of topics and sub-topics – as outlined in Table 19 – that need to be covered to collect stakeholders' opinions and to contribute to the Impact Assessment study entails several requirements for the selection of targeted interviewees, including the need to:

- provide a broad coverage of the value chain, including a comprehensive set of stakeholder types depending on their positioning along the value chain;
- involve key actors (according to S&T fields, industry sectors and specific Member States) to scope viewpoints and the needs for reaching the stated objectives;
- cover members of the current JU (or future initiative), i.e. representatives from the executive and board level, with an eye to obtaining information on the envisaged set up and measures to respond to the requirements in terms of scope, openness, transparency, flexibility, etc.;
- achieve a balance between interviews focused on the options/measures for the initiative as well as on the problems/objectives of the needed 'initiative' that brings in both current actors with a good knowledge of the initiative as well as new actors.

The interviews are expected to provide input and contribute to the Impact Assessment study by addressing the topics and sub-topics outlined in Table 19.

Table 19: Topics for interviews versus report chapters/sections

Topics	Sub-topics
Problems and objectives	• Severity/relevance of the barriers/problems associated with KDT
	• Importance of objectives to be attained through KDT
Activities	• Envisaged activities foreseen to address the identified problems/barriers
	• Importance of flexibility to adapt the R&I actions over time
Segments and technological areas	• Identified missing segments of the value chain in ECS for Europe and implications of gaps
	• Relevance of technological sovereignty

Topics	Sub-topics
	• Important technological areas to be included in the initiative
Key players to involve	• Importance of RTO participation to achieve the objectives
	• Importance of SME participation to achieve the objectives
	• Importance of end-user industry participation to achieve the objectives
	• Importance of openness towards international partners
	• Importance of openness towards new actors and Member States
	• Importance of industry participation to achieve the objectives
Organisation and governance	• Efficiency, effectiveness and flexibility of current JU governance
	• Extent to which changes are needed to the current JU governance
	• The extent to which central management of all financial contributions is needed
Added value and coherence of EU action	• Extent to which action at EU level is needed to seize the benefits/opportunities
	• Benefits from coordination with other European Partnerships
	• Relevant national initiatives
Comparison of options	• Added value of a European Partnership compared to calls under Horizon Europe
	• The extent to which industry should actively be setting priorities and research agendas
	• Most appropriate type of commitment to achieve the objectives
	• The extent to which the coordination of research agendas among EU, Member States and industry are important to address the objectives
	• Most appropriate type of policy option to address the fragmentation of the European landscape and on technological sovereignty
	• Most appropriate type of policy option to ensure the necessary openness and flexibility
	• Most appropriate type of policy option to support the development of a European ecosystem in KDT
	• Most appropriate type of policy option in pooling the necessary resources for achieving the objectives

Strategy behind the selection of interviews

A long list of interviewees was formulated to address the above-mentioned need for input. In order to cover the listed topics and sub-topics, the interviews were required to include,

among others, research, development, supply and end-user organisations as well as representatives from the KDT value chain, from equipment, design and production to systems integration and end-product. As a consequence, interviews had to be conducted with academic and research organisations, industry associations, businesses and industries (including SMEs), and public authorities (European Commission/EU actors and Member States). The segments covered were, for example, electronics, semiconductors, foundries, systems, software, application areas (automotive, MedTech, energy, manufacturing, etc.), engineering and photonics.

To obtain information about the envisaged set up and measures, the list of interviewees also covers the executive level, board members, programme officers of ECSEL JU. It was equally sought to carry out interviews with Member State representatives (e.g. members of the Governing Board or Public Authorities Board in ECSEL JU) to scope the opinions and interest of Member States.

Operationalisation of the strategy

The identification of interviewees relied on several approaches:

- identification of key actors in the field, such as active organisations, companies and Member States in ECSEL JU, or companies with a significant market share in value chains relevant to the KDT initiative;
- study team's expert panel proposing interviewees;
- recommendation for interviewees by Commission services (DGs).

Accordingly, a long list of 184 interviewees were compiled. The list of identified interviewees evolved over the course of the study, according to the identified data needs and gaps. Based on the long list of interviewed interviewees, around 65 interviews were prioritised according to feedback from the involved expert panel and Commission services. Some 65 interviewees were prioritised initially, as not all were expected to be available for the interviews, while the remaining non-prioritised interviewees acted as backup in case members of prioritised group were unavailable or unwilling to participate (additional interviewees were added to the priority list accordingly). Ultimately 51 interviews were carried out.

In order to ensure both coverage of the identified topics/sub-topics and balance among various stakeholder categories, the interview invitations were sent out in batches from the beginning of October and until mid-December (2019).

Topic guides for the interviews

The questions and themes were developed for discussion during the semi-structured interviews per category of interviewees. The interview questions were developed on the basis of the topics/sub-topics to be covered as listed in Table 19. It implies a structure around objectives and activities, key players (partners) to involve, organisation and governance, coherence, EU added value, and comparison of options. The interview questions were tailored according to type of interviewee (such as research organisations, large companies, SMEs, industry associations, ECSEL JU, Member States and the Commission and its Agencies).

B.4.2 Overview of respondents to the targeted consultation

A total of 51 stakeholders have been interviewed in the framework of this partnership, covering five different stakeholder categories. The table below provides an overview of the number of interviews provided per category of stakeholder. As it can be seen, around one third of interviews were conducted with large companies (31%), followed by industry

associations (25%), RTOs and universities (14%), Member States (14%), SMEs (12%) and European Commission services (4%).

Geography of interviewees: Western Europe (49%); Eastern Europe (10%); Southern Europe (8%); Nordics (4%); and international (6%).

Gender: 76.5% male and 23.5% female

Table 20: Number of interviews per stakeholder category

Stakeholder category	Number	Share (%)
European Commission #1	2	4%
Member States #2	7	14%
Industry Associations #3	13	25%
Large Companies #4	16	31%
RTOs and Universities #5	7	14%
SMEs #6	6	12%
TOTAL	**51**	**100%**

B.4.3 Key results/messages from the targeted consultation

This section provides an overview of the main findings structured according to the following topics: problems and objectives; activities; segments and technological areas; key players to involve; organisation and governance; added value and coherence of EU action; and comparative assessment of the policy options. Each of the before mentioned topics are divided into several sub-topics presenting a synthesis of interview responses at the level of each interview stakeholder category.

While 51 interviews were carried out, the interview guide and questions were tailored to the concerned stakeholder category, implying that not all stakeholders faced similar interview questions. Accordingly, the presentation of the synthesised interview responses does not always comprise a response from each stakeholder category.

In the remaining of this section we focus on the input from interviewees related to the added value and benefits of the different options presented for this impact assessment. A full reporting on the input from the interviews is provided in a separate deliverable (Data Report).

Most appropriate type of policy option to address the fragmentation of the European landscape and on technological sovereignty

Stakeholder category	Opinions
EC	• The European Commission DGs expressed a preference for an institutionalised partnership, as this would both ensure the necessary mobilisation and aggregation of resources from stakeholders and for facilitating a unified European strategy in the area of technological sovereignty.
Member States	• The institutional partnership option was recommended by four Member States, in particular if the objectives are to induce technological sovereignty, build a European-wide ecosystem, ensure alignment and achieve a balance of what is good for industry and Member States. The institutional partnership option was framed as a partnership framework where focus and mass are key ingredients which are perceived as necessary for addressing fragmentation. One Member State equally stressed that with strong ambitions around technological sovereignty, the need for coordinating research agendas becomes more significant. • Two Member States expressed uncertainty with regards to which partnership has more relevance for addressing the fragmentation of the European landscape and achieving technology sovereignty.
Industry associations	• Two Interviewed ECSEL JU industry associations found that all partnership models could serve to address fragmentation of the European landscape and technological sovereignty; rather than speaking about partnership framework, the decisive factor is the content/scope and size of the investment to address fragmentation – more resources allow for a more impactful response to fragmentation. A third ECSEL JU industry association preferred an institutional partnership model given its ability to mobilise a critical mass of resources from both public and private sources. • Among interviewed end-user associations, diverging views emerged: an institutional partnership model strength was involvement of both Member States and industry with more emphasis on technological development, a co-programmed was perceived to better induce steering from national authorities while a co-funded would enhance flexibility and have less bureaucracy as other partnership types.
Large companies	• The majority of the large companies feels that the most suitable partnership to address fragmentation and to support technological sovereignty of Europe is the Institutionalised Partnership as it allows to pool resources from different Member States and private organisations therefore ensuring commitment, a common vision and avoiding fragmentation and duplication. • One large company commented that fragmentation should not be the goal or the aim of the partnership, the focus should be on the most effective way to achieve goals and to stimulate development.
SMEs	• Most SMEs perceived the institutional partnership model as most effective in addressing fragmentation of the European landscape and support technological sovereignty.
RTOs & Universities	• Most RTOs agreed that the institutional partnership is most effective in addressing fragmentation and achieving technological sovereignty as it has legally binding agreements and as it combines the EC, national and industry

Stakeholder category	Opinions
	levels, thereby being more supportive in getting stakeholders to be on the same line. One RTO preferred the co-programmed model, to avoid involvement of Member States. One RTO did not know what partnership to choose. • Technological sovereignty was perceived as important, but hard to achieve as a strong commitment, also financially, is needed.

Most appropriate type of policy option to ensure the necessary openness and flexibility

Stakeholder category	Opinions
EC	• Openness and accessibility were also highlighted as critical for KDT. As far as non-EU countries are concerned, on DG stressed that the principle of reciprocity should be followed, while also taken into account the EU foreign investment legislation.
Member States	• Two Member States perceived that the co-funded was more suited for achieving openness and flexibility, as Member States are the key drivers and can introduce changes more rapidly, while another Member State found the co-programmed model equally open and flexible. • One Member States expressed that the institutional partnership model offers openness and flexibility as required; it may be less flexible relative to other policy models, which on the contrary are looser and less coherent, but it has the advantage of bringing Member States, EC and industry closer together and allows for a more long-term view. • According to three Member States, it was argued that ECSEL JU – as a predecessor initiative to KDT – was no closed shop and already provided for a high level of flexibility and openness as EU Member States and associated countries (countries from outside Europe faces more restricted access), including their domestic stakeholders, have relatively easy access. Of course, if the intention is to moderately enlarge the scope of the new partnership, new user groups may not be fully covered, but adding them should not be problematic according to the before mentioned Member States. As for flexibility, while broad strategic lines are anchored in a council regulation, which is hard to change and can be perceived as inflexible, given its validity of seven years, flexibility is ensured by having sufficiently broad research agendas and strategic lines to cover multiple areas of ECS. • One Member State expressed uncertainty about the most fitting partnership model for achieving openness and flexibility.
Industry associations	• One ECSEL JU industry association recommended the institutional partnership while another ECSEL JU industry association remarked that the institutional partnership model could be inspired from the flexibility of the co-programmed where there is less need for bureaucratic agreement from ministries in order to make decisions (it can be handled by a task force. According to ECSEL JU industry associations, the current ECSEL JU was still perceived to already be highly open for members or countries to join. As for flexibility, the current JU ensures this for example by having a yearly updating of the strategic research agenda, allowing for flexibility in call topics and focus. • One ECSEL JU industry association stressed the need for a better coverage of the full spectrum of the value chain, in particular for downstream industries.

Stakeholder category	Opinions
	More efforts should also be made to make it more open, for example by facilitating access for SMEs that have less resources and face more challenges with project overhead, while also the one-to-one ratio was found to be inflexible. • Among the 7 interviewed end-user associations there were no clear preferences expressed. Two associations stated a preference for the institutional partnership but remarked that more flexibility should be delivered, for example by giving a stronger base for making more solid shifts in direction from time to time (rather than only after 7 years).
Large companies	• When asking large companies what policy options would offer the necessary openness and flexibility the majority was unsure what would be the best one. Four companies suggested co-programmed might be more flexible. Comments were: • The more participating states you involve, the more complicated discussions get. • Art. 187 PPPs are better at preventing leaking of knowledge to non-involved players or non-European parties. • Openness should come from all partners to ensure effective collaboration. Flexibility decreases with the size of the programme. • Too much flexibility is also bad, because you need time to change things.
SMEs	• Both the institutional partnership and the co-programmed partnership were was considered as offering the necessary openness and flexibility according to different SMEs.
RTOs & Universities	• While the co-programmed partnership was preferred by two RTOs in terms of offering the necessary openness and flexibility, with one of those RTOs highlighting this in particular with regard to having a strong focus on lower TRLs, another RTO favoured the co-funded partnership as the best tool for providing openness and flexibility, but subject to the openness of national authorities as it is publicly driven. According to one RTO, the institutional partnership model was found, when compared to ECSEL JU, to not offer a sufficiently high reimbursement rate for RTOs that struggle with finding funds externally – Horizon 2020 was found to provide more equal rules for participants from different stakeholder categories. One RTO considered that the Institutionalised Partnership would need some more flexibility in its governance. Two RTOs did not know what type of partnership was best.

Most appropriate type of policy option to support the development of a European ecosystem in KDT

Stakeholder category	Opinions
Member States	• Four Member States considered the institutional partnership model as mostly conducive to supporting the development of the European ECS ecosystem. Reasons for considering the institutional policy model as mostly promising for ecosystem building related e.g. to that it is centred on industry which is perceived as crucial and needs to be involved for ecosystem-building. • The co-funded and co-programmed partnership models were also articulated as to have an impact to boost the ECS ecosystem by a couple of Member States, with one Member State favouring the co-funded programme as its public authorities are key drivers and can introduce changes more rapidly.

Stakeholder category	Opinions
	• One Member State commented that it was not able to single out one partnership model as more suited for developing the ecosystem; rather than reflecting upon the best partnership model, the key emphasis should be to achieve synergy effects, avoid duplication or double funding. • Eureka was found to be more effective than ECSEL JU in allowing for a few selected Member States to initiative some work in a top-down manner and go ahead without participation from all Member States; ECSEL JU was perceived as more suited for long-term effort that involves multiple countries.
Industry associations	• According to ECSEL JU industry associations the majority (2 out of 3) favoured an institutional partnership model as most effective to develop a European ECS ecosystem. The institutional partnership model was found to be mostly conducive to achieve alignment, coordination, critical mass and provide full coverage of ECS value chain. The reason relates to that it mobilises more funding, allows for larger projects, has legally binding agreements and with Member States and industry onboard one creates more connections with stakeholders, all supportive of ecosystem building. A third ECSEL JU industry association perceived that all partnership model could be impactful with regards to building an ECS ecosystem. • Among the 7 interviewed end-user associations there were no clear preferences expressed.
Large companies	• Large companies find it difficult to answer what is the best type of Partnership to support the development of the European ecosystem in ECS. Five companies consider the Institutionalised Partnership most suitable. Arguments were that the added value of an Institutionalised Partnership is the strategic approach and that the ECSEL JU has proven to be a well-adapted model for ECS and industry, although somewhat more flexibility would be welcome.
SMEs	• SMEs found it difficult to determine what partnership model would be the best to support the development of the European ecosystem in ECS. Two SMEs favoured the partnership model, another favoured the co-programmed model. The rest of the SMEs was unable to answer the question or did not have a preference.
RTOs & Universities	• To support the development of a European ecosystem in ECS, two RTOs favoured the institutional partnership model so as to have a more streamlined structure with clear decisions and rules and more long-term up-front commitment. One university found that both the co-programmed and institutional model could be effective in this regard. One RTO favoured the co-programmed model. Two RTOs was not able to favour one specific partnership model over another. • One RTO stressed overall the need for both small and large projects, broad coverage of TRLs, synergies between partnerships and a comprehensive focus for developing the ecosystem. The need for KDT to get support from Horizon Europe and other programmes on the lower TRLs was stressed by another RTO; should KDT focus increasingly on the lower TRLs it should provide a more attractive reimbursement rate.

Most appropriate type of policy option in pooling the necessary resources for achieving the objectives

Stakeholder category	Opinions
EC	• The European Commission DGs expressed a preference for an institutionalised partnership, as this would both ensure the necessary mobilisation and aggregation of resources from stakeholders and for facilitating a unified European strategy in the area of technological sovereignty. It was perceived that the other partnership modes would not bring the same investment (€5b or above) nor be suited when EC, as opposed to Member States, is in the driving seat, allowing for EC and Members to go together in an aligned manner to give direction. Along these lines it was mentioned that the institutional partnership provides a more formal structure for final commitments on investments. It was stressed that stakes are very high for the EC as it is a big investment; however, while the EC has 50% of voting rights it is very rarely blocking situations given a good and constant dialogue with Member States.
Member States	• Five out of seven Member States found the institutional partnership model as most effective in pooling the necessary resources for achieving the partnership objectives, due to the multi leverage of funding and the need for joint funding decisions during budget year. • One Member State also found the co-funded and co-programmed as promising ones given complex national procedure vis-à-vis aligning with the one-to-one ratio requirement. Another Member State perceived that either the co-programmed or institutional partnership was most effective given that resources are pooled through different channels.
Industry associations	• The interviewed ECSEL JU industry associations and end-user industries generally favoured the institutional partnership framework as mostly effective to pool necessary resources primarily according to its tripartite model sourcing contributions from both Member States, EC and industry.
Large companies	• Answers from large companies on the type of partnership that would be most effective in pooling resources differ. Most are unsure about the correct type. Five large companies make the argument for an Institutionalised Partnership, because: • The willingness of Public Authorities to agree/align on objectives and priorities is essential to pool investment funds and reach critical mass. • This way all participants across the value chains and all available resources can be integrated. • It has a clear vision/commitment and involves industry and can offer more resources than in other types of partnerships or programmes under H2020.
SMEs	• The importance of a broad involvement of multiple partners and dialogue were stressed as important. SME responses were mixed as to what type of partnership would be best to facilitate this.
RTOs & Universities	• One RTO and one university interviewed suggested that both the co-programmed and institutional model could be effective; while the co-programmed model was found to potentially have a wider audience involving both public and private actors, the institutional model would ensure more commitment from industry. Two RTOs favoured the institutional model in light of the identified objectives. Another RTO stressed the importance of keeping a strong focus on lower TRLs, either through H2020, ECSEL or other programmes; the impression was that budget were diminishing for basic research and that small projects were not suited for ECSEL due to large overhead and coordination needs. It was underlined that Horizon Europe should have focus also on smaller projects as the larger ones are not

Stakeholder category	Opinions
	necessarily effective. One RTO and one university could not answer the question.

B.5 Open public consultation on the Candidate institutionalised European Partnerships

B.5.1 Approach to the open public consultation

The consultation was open to everyone via the EU Survey online system.[65] The survey contained two main parts and an introductory identification section. The two main parts collected responses on general issues related to European partnerships (in Part 1) and specific responses related to 1 or more of the 12 candidate initiatives (as selected by a participant).

The survey contained open and closed questions. Closed questions were either multiple choice questions or matrix questions that offered a single choice per line, on a Likert-scale. Open questions were asked to clarify individual choices.

The survey was open from 11 September till 12 November 2019. The consultation was available in English, German and French. It was advertised widely through the European Commission's online channels as well as via various stakeholder organisations.

The analysis of the responses was conducted by applying descriptive statistic methods to the answers of the closed questions and text analysis techniques to the analysis of the answers of the open questions. The keyword diagrams in this report have been created by applying the following methodology: First, the open answer questions were translated into English. This was followed by cleaning of answers that did not contain relevant information, such as "NA", "None", "no comment", "not applicable", "nothing specific", "cannot think of any", etc. In a third step, common misspellings were corrected, such as "excellence" instead of "excellence", or "partnership" instead of "partnership". Then, then raw open answers were tokenised (i.e. split into words), tagged into parts of speech (i.e. categorised as a noun, adjective, preposition, etc) and lemmatised (i.e. extraction of the root of each word) with a pre-trained annotation model in the English language. At this point, the second phase of manual data cleaning and correction of the automatic categorisation of words into parts of speech was performed. Finally, the frequency of appearance and co-occurrences of words and phrases were computed across the dataset and the different sub-sets (e.g. partnerships, stakeholder groups). Data visualisations were created based on that output.

The keyword graphs in the following sections have been built based on the relationships between words in the open responses of the survey participants. It features words that appear in the same answer either one after the other or with a maximum distance of two words between them. Each keyword is represented as a node and each co-occurrence of a pair of words is represented as a link. The size of the nodes and the thickness of the links vary according to the number of times that keywords are mentioned and their co-occurrence, respectively. In order to facilitate the visualisation of the network, the keyword graphs have been filtered to show the 50 most common co-occurrences. Although the keywords do not aim to substitute a qualitative analysis, they assist the identification of

[65] https://ec.europa.eu/eusurvey/runner/ConsultationPartnershipsHorizonEurope

the most important topics covered in the answers and their most important connections with other topics, for later inspection in the set of raw qualitative answers.

B.5.2 Overview of respondents to the open public consultation

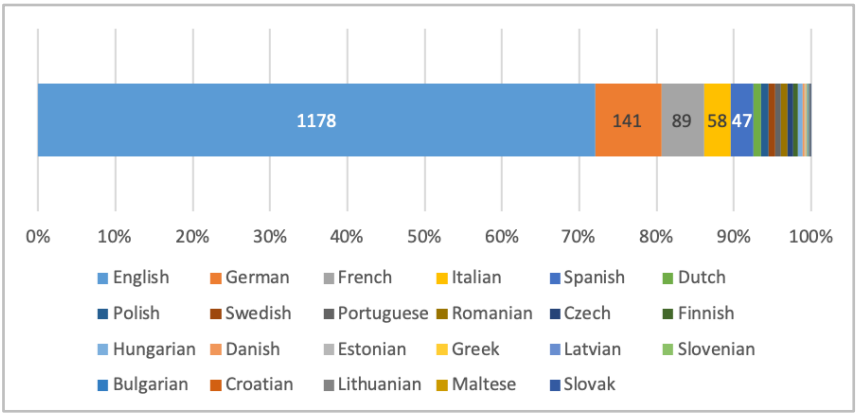
Profile of respondents

In total, 1635 respondents filled in the questionnaire of the open public consultation. Among them, 272 respondents (16.64%) were identified to have responded to the consultation as part of a campaign (coordinated responses). Based on the Better Regulation Guidelines, the groups of respondents where at least 10 respondents provided coordinated answers were labelled as *'campaigns',* segregated and analysed separately and from other responses. In total 11 campaigns were identified. In addition, 162 respondents in the consultation also display similarities in responses but in groups smaller than 10 respondents. Hence, these respondents were not labelled as campaigns and therefore were not analysed separately from the general analysis.

Among the 1635 respondents, 1178 (72.05%) completed the online consultation in English, 141 (8.62%) in German, 89 (5.44%) in French, 58 (3.55%) in Italian and 47 (2.87%) in Spanish, see Figure 10. Respondents that belong to the 11 campaigns follow the same pattern of language distribution, with English being the dominant language of respondents in that group. Table 21 shows that over 50% of respondents come from 4 Western and Southern European countries – Germany, Italy, France and Spain. Overall, the number of respondents from Eastern and Northern Europe is lower, while among non-EU countries the greater number of respondents come from Switzerland, Norway and Turkey, which are countries associated to the Framework Programme. In the group of respondents labelled as campaigns, most respondents are from Germany (48 respondents or 17.65%), France (39 respondents or 14.34%), Italy (37 respondents or 13.6%), Belgium (23 respondents or 8.46%), the Netherlands (21 respondents or 7.72%) and Spain (17 respondents or 6.25%). Hence, a similar pattern of country of origin is observed in the entire sample of respondents and for the campaigns.

Across all respondents 40.80% indicated to answer to the open public consultation in a public way (non-anonymous) and 20.67% of all respondents indicated their Transparency Register number.

Figure 10: Language of the consultation (N=1635)



Notes: Non-campaign replies; Aggregation of responses of all candidate initiatives

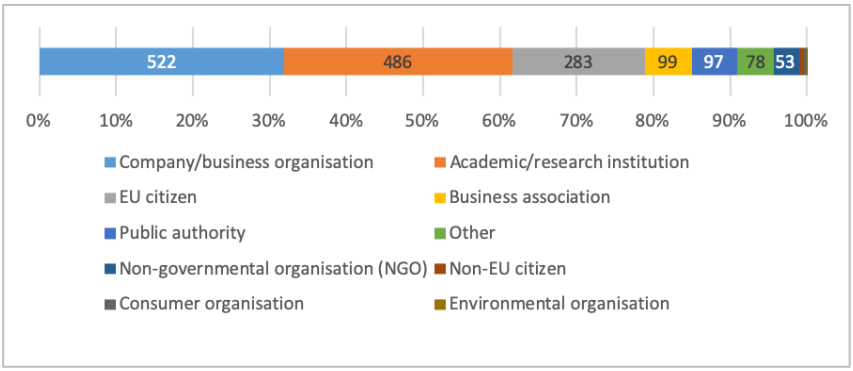
Table 21: Country of origin of respondents (N=1635)

Country	Number of respondents	Percentage of respondents
Germany	254	15.54%
Italy	221	13.52%
France	175	10.70%
Spain	173	10.58%
Belgium	140	8.56%
The Netherlands	86	5.26%
Austria; United Kingdom	61	3.73%
Finland	49	3.00%
Sweden	48	2.94%
Poland	45	2.75%
Portugal	32	1.96%
Switzerland	28	1.71%
Czechia	24	1.47%
Greece	23	1.41%
Norway; Romania	22	1.35%
Denmark	20	1.22%
Turkey	19	1.16%
Hungary	14	0.86%
Ireland	12	0.73%
United States	11	0.67%
Estonia; Slovakia; Slovenia	10	0.61%
Bulgaria; Latvia	9	0.55%
Bosnia and Herzegovina	7	0.43%
Lithuania	4	0.24%
Canada; Croatia; Israel	3	0.18%
China; Ghana; Iceland; Japan; Luxembourg; Morocco	2	0.12%
Bhutan; Botswana; Cyprus; Iran; Malta; Mexico; Moldova; Mongolia; Palestine; Russia; Serbia; South Africa; Tunisia; Ukraine; Uruguay	1	0.06%

According to Figure 11, the three biggest groups of respondents are companies and business organisations (522 respondents or 31.93%), academic and research institutions (486 respondents or 29.72%) and EU citizens (283 respondents or 17.31%). Business associations, representing multiple businesses, were the fourth largest responding group (99 respondents or 6.05%), no other types of associations were presented amongst the

selectable options for respondents. Among the group of respondents that are part of campaigns, most respondents are provided by the same groups of stakeholders, namely companies and business organisations (121 respondents or 44.49%), academic and research institutions (54 respondents or 19.85%) and EU citizens (42 respondents or 15.44%).

Figure 11: Type of respondents (N=1635)



Notes: Non-campaign replies; Aggregation of responses of all candidate initiatives

Respondents were asked to indicate the organisational size of the companies, organisations and institutions they work for. Based on Table 22, a greater number of respondents work in large companies and business organisations (295 respondents out of 522 or 56.51%) and large academic and research institutions (348 respondents out of 486 or 71.60%). A greater number of respondents that are employed by business associations and NGOs indicated an organisation size of 1 to 9 employees. Among the group of respondents that are marked as campaigns, a greater number of respondents work in large companies and business organisations (82 respondents out of 121 or 67.77%) and academic and research institutions (39 out of 54 respondents or 72.22%).

Table 22: Size of organisations that represent consultation respondents (N=1635)

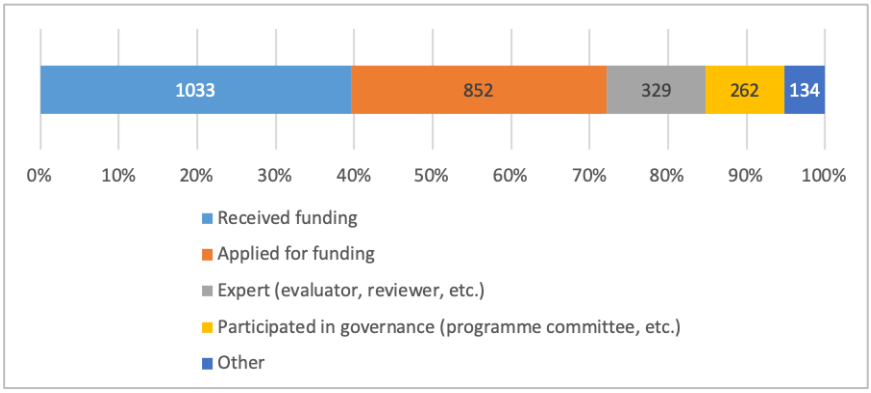
	Organisation size			
Type of respondents' organisations	**Large (250 employees or more)**	**Medium (50 to 249 employees)**	**Small (10 to 49 employees)**	**Micro (1 to 9 employees)**
Company/business organisation	295	66	90	71
Academic/research institution	348	95	31	12
Business association	15	6	34	44
Public authority	58	33	6	0
Non-governmental organisation (NGO)	7	9	11	26
Consumer organisation	1	0	2	1
Environmental organisation	0	0	1	0
Trade union	0	0	1	0

	Organisation size			
Type of respondents' organisations	**Large (250 employees or more)**	**Medium (50 to 249 employees)**	**Small (10 to 49 employees)**	**Micro (1 to 9 employees)**
Other	24	16	19	19

Among all consultation respondents, 1303 (79.69%) have been involved in the on-going research and innovation framework programme Horizon 2020 or the preceding Framework Programme 7, while 332 respondents (20.31%) were not. In the group of campaign respondents, the share of those who were involved in these programmes is higher (245 respondents out of 272 or 90.07%) than in the group of non-campaign respondents (1058 out of 1363 or 77.62%). When respondents that participated in the Horizon2020 or in the preceding Framework Programme 7 were asked to indicate in which capacity they were involved in these programmes, the majority stated that they were a beneficiary (1033 respondents or 39.58%) or applicant (852 respondents or 32.64%).

The main stakeholder categories, e.g. companies/business organisation, academic/research institutions, etc., show a similar distribution across the capacities in which they 'have been involved in Horizon 2020 or in the Framework Programme 7' as the overall population of consultation respondents (see distribution in Figure 12). However, a few stakeholder categories have mainly been involved in the capacity of "Received funding" and/or "Applied for funding", this applies to business associations, NGOs and public authorities.

Figure 12: Capacity in which respondents were involved in Horizon 2020 or in the Framework Programme 7 (N=1303)



Notes: Non-campaign replies; Aggregation of responses of all candidate initiatives

Among those who have been involved in the on-going research and innovation framework programme Horizon 2020 or the preceding Framework Programme 7, 1035 respondents (79.43%) are/were involved in a partnership. The share of respondents from campaigns that are/were involved in a partnership is higher than for non-campaign respondents, 89.80% versus 77.03% respectively. The list of partnerships under Horizon 2020 or its predecessor Framework Programme 7 together with the numbers, percentages of participants is presented in Table 23, the table also show the key stakeholder categories for each partnership.

Most consultation respondents participated in the following partnerships: Fuel Cells and Hydrogen 2 (FCH2) Joint Undertaking, Clean Sky 2 Joint Undertaking, European Metrology Programme for Innovation and Research (EMPIR) and in Bio-Based Industries Joint Undertaking. The comparison between the non-campaign and campaign groups of respondents shows that the overall distribution is quite similar. However, there are some

differences. For the campaign group almost a half of respondents is/was involved in the Fuel Cells and Hydrogen 2 (FCH2) Joint Undertaking, a higher share of campaign respondents is/was participating in Clean Sky 2 Joint Undertaking and in Single European Sky Air Traffic Management Research (SESAR) Joint Undertaking.

Table 23: Partnerships in which consultation respondents participated (N=1035)

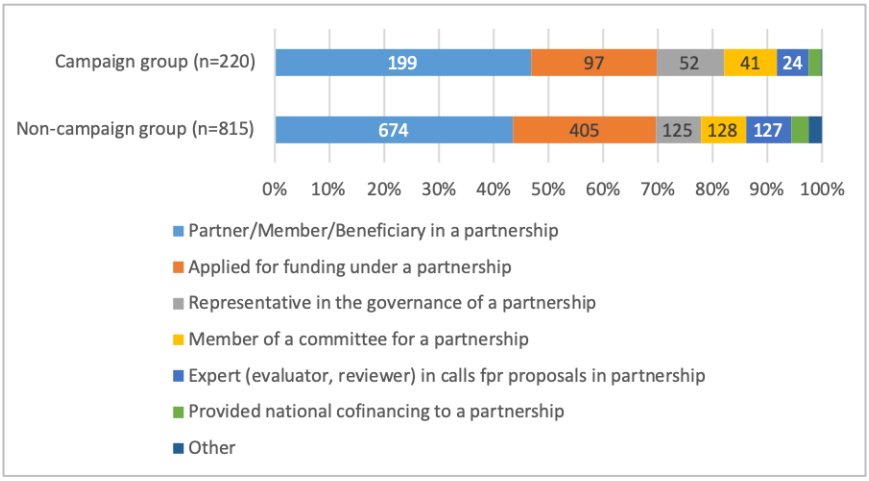
Name of the partnership	Number and % of respondents from both groups (n=1035)	Number and % of respondents from a non-campaign group (n=815)	Academic/research institutions	Business associations	Company/business organisations (<250)	Company/business organisations (250+)	EU citizens	NGOs	Public authority
Fuel Cells and Hydrogen 2 (FCH2) Joint Undertaking	354 (33.33%)	247 (30.31%)	97	9	37	43	41	8	5
Clean Sky 2 Joint Undertaking	195 (18.84%)	145 (17.79%)	57	2	10	27	37	1	7
European Metrology Programme for Innovation and Research (EMPIR)	150 (14.49%)	124 (15.21%)	64	0	13	9	14	2	19
Bio-Based Industries Joint Undertaking	142 (13.72%)	122 (14.97%)	39	8	20	27	14	1	6
Shift2Rail Joint Undertaking	124 (11.98%)	101 (12.40%)	31	7	5	31	14	3	7
Electronic Components and Systems for European Leadership (ECSEL) Joint Undertaking	111 (10.72%)	88 (10.80%)	42	2	7	20	12	0	5
Single European Sky Air Traffic Management Research (SESAR) Joint Undertaking	66 (6.38%)	46 (5.64%)	10	3	3	20	3	2	3
5G (5G PPP)	53 (5.12%)	47 (5.77%)	20	1	6	14	5	0	1
Eurostrars-2 (supporting research-performing small and medium-sized enterprises)	44 (4.25%)	40 (4.91%)	17	0	6	1	7	0	6

Name of the partnership	Number and % of respondents from both groups (n=1035)	Number and % of respondents from a non-campaign group (n=815)	Academic/research institutions	Business associations	Company/business organisations (<250)	Company/business organisations (250+)	EU citizens	NGOs	Public authority
Innovative Medicines Initiative 2 (IMI2) Joint Undertaking	37 (3.57%)	35 (4.29%)	18	2	3	3	2	4	3
Partnership for Research and Innovation in the Mediterranean Area (PRIMA)	28 (2.71%)	26 (3.19%)	15	0	3	1	2	0	2
European and Developing Countries Clinical Trials Partnership	25 (2.42%)	24 (2.94%)	12	0	1	2	3	3	2
Ambient Assisted Living (AAL 2)	22 (2.13%)	21 (2.58%)	11	2	1	1	3	0	3
European High-Performance Computing Joint Undertaking (EuroHPC)	22 (2.13%)	18 (2.21%)	6	0	2	3	5	0	2

When respondents were asked in which role(s) they participate(d) in a partnership(s), over 40% indicated that they act(ed) as partner/member/beneficiary in a partnership (see,Figure 13). The second largest group of respondents stated that they applied for funding under a partnership. The roles selected by non-campaign and campaign respondents are similar.

The few respondents that selected "Other" as their role were provided with the opportunity to outline their role. A total of 25 people did provided description. The answers provided were very varied and could not be clustered in sub-groups, a few examples are: former communication and stakeholder relationship officer, chair of steering board, system engineer, grant manager, Joint Programming Initiative (JPI), or a role in advocacy of the partnership.

Figure 13: Role of respondents in a partnership (N=1035)



Notes: Non-campaign replies; Aggregation of responses of all candidate initiatives

In the open public consultation respondents could provide their views on each of the candidate Institutionalised European Partnerships, and each respondent could select multiple partnerships to provide their views on. The table below presents the number and percentage of respondents for each partnership. It is visible that the majority of respondents (31.37%) provided their views on the Clean Hydrogen candidate partnership. More than 45% of respondents from the campaigns selected this partnership. Around 15% of all respondents provided their views for the candidate partnerships European Metrology, Clean Aviation and Circular bio-based Europe. The share of respondents in the campaign group that chose to provide views on the Clean Aviation candidate partnership is of 20%. The smallest number of respondents provided opinions on the candidate initiative 'EU-Africa research partnership on health security to tackle infectious diseases – Global Health'.

Table 24: Future partnerships for which consultation respondents provide responses (N=1613)

Name of the candidate Institutionalised European partnership	Number and % of respondents from both groups (n=1613)	Number and % of respondents from a non-campaign group (n=1341)	Academic/research institutions	Business associations	Company/business organisations (<250)	Company/business organisations (250+)	EU citizens	NGOs	Public authority
Clean Hydrogen	506 (31.37%)	382 (28.49%)	123	21		55	74	8	13
European Metrology	265 (16.43%)	225 (16.78%)	112	3	21	11	34	3	28
Clean Aviation	246 (15.25%)	191 (14.24%)	57	5	21	34	54	3	8
Circular bio-based Europe: sustainable Innovation for new local value	242 (15%)	215 (16.03%)	63	19	36	35	31	7	13

Name of the candidate Institutionalised European partnership	Number and % of respondents from both groups (n=1613)	Number and % of respondents from a non-campaign group (n=1341)	Academic/research institutions	Business associations	Company/business organisations (<250)	Company/business organisations (250+)	EU citizens	NGOs	Public authority
from waste and biomass									
Transforming Europe's rail system	184 (11.41%)	151 (11.26%)	29	14	23	39	31	2	7
Key Digital Technologies	182 (11.28%)	162 (12.08%)	55	13	20	22	35	5	7
Innovative SMEs	111 (6.88%)	110 (8.20%)	19	12	39	4	14	4	10
Innovative Health Initiative	110 (6.82%)	108 (8.05%)	35	6	9	12	16	16	5
Smart Networks and Services	109 (6.76%)	107 (7.98%)	34	9	12	17	21	2	6
Safe and Automated Road Transport	108 (6.70%)	102 (7.61%)	25	12	11	19	10	3	9
Integrated Air Traffic Management	93 (5.77%)	66 (4.92%)	8	7	4	24	9	2	7
EU-Africa research partnership on health security to tackle infectious diseases – Global Health	49 (3.04%)	47 (3.50%)	15	2	4	3	12	6	4

Campaigns per candidate Institutionalised European Partnership

As was mentioned above, 11 campaigns were identified, the largest of them includes 57 respondents. The table below presents the campaigns that replied for each candidate partnership. As presented, the candidate Institutionalised Partnership Clean Hydrogen has the highest number of campaigns, namely 5. A few partnerships, such as Innovative SMEs, Smart Networks and Systems, were not targeted by campaigns. Some campaign respondents decided to provide opinions about several partnerships, therefore, campaign #2 and #6 feature in several partnerships.

Table 25: Overview of campaigns across partnerships

Name of the candidate Institutionalised European partnership	Number of a campaign group (total number of respondents in a campaign)	Number of respondents that provided views about a partnership
Clean Hydrogen	Campaign #1 (57 respondents)	57 respondents
	Campaign #2 (41 respondents)	25 respondents
	Campaign #7 (18 respondents)	18 respondents
	Campaign #9 (14 respondents)	13 respondents
	Campaign #11 (10 respondents)	9 respondents
Clean Aviation	Campaign #2 (41 respondents)	17 respondents
	Campaign #6 (19 respondents)	19 respondents
	Campaign #8 (14 respondents)	13 respondents
Integrated Air Traffic Management	Campaign #2 (41 respondents)	10 respondents
	Campaign #6 (19 respondents)	12 respondents
European Metrology	Campaign #3 (36 respondents)	35 respondents
Circular bio-based Europe: sustainable Innovation for new local value from waste and biomass	Campaign #5 (20 respondents)	20 respondents
Transforming Europe's rail system	Campaign #4 (31 respondents)	29 respondents
Key Digital Technologies	Campaign #10 (12 respondents)	12 respondents
Innovative SMEs	-	-
Innovative Health Initiative	-	-
Smart Networks and Services	-	-
Safe and Automated Road Transport	-	-
EU-Africa research partnership on health security to tackle infectious diseases – Global Health	-	-

B.5.3 Responses to the open public consultation at programme level

The following section of the report presents the analysis of responses at programme level, meaning all respondents (excluding campaigns) were included, independent of which candidate European Partnerships respondents selected to provide their views upon. The results for responses as part of campaigns are presented separately.

Characteristics of future candidate European Partnerships

Respondents were asked to assess what areas, objectives, aspects need to be in the focus of the future European Partnerships under Horizon Europe and to what extent. According to Figure 14, a great number of respondents consider that a significant contribution by the future European Partnerships is 'fully needed' to achieve climate-related goals, to the development and effective deployment of technology and to EU global competitiveness in specific sectors/domains. Overall, respondents' views reflect that many aspects require attention of the Partnerships. The least attention should be paid to responding towards priorities of national, regional R&D strategies, including smart specialisation strategies, according to respondents.

Overall, only minor differences can be found between the main stakeholder categories. Academic/research institutions value the responsiveness towards EU policy objectives and focus on development and effective deployment of technology a little less than other respondents. Business associations, however, find that the future European Partnerships under Horizon Europe should focus a little bit more on the development and effective deployment of technology than other respondents. Furthermore, business associations, large companies as well as SMEs (companies with less than 250 employees) value role of the future European Partnerships for significant contributions to EU global competitiveness in specific sectors domains a little higher than other respondents. Finally, both NGOs and Public authorities put a little more emphasis on the role of the future European Partnerships for significant contributions to achieving the UN SDGs.

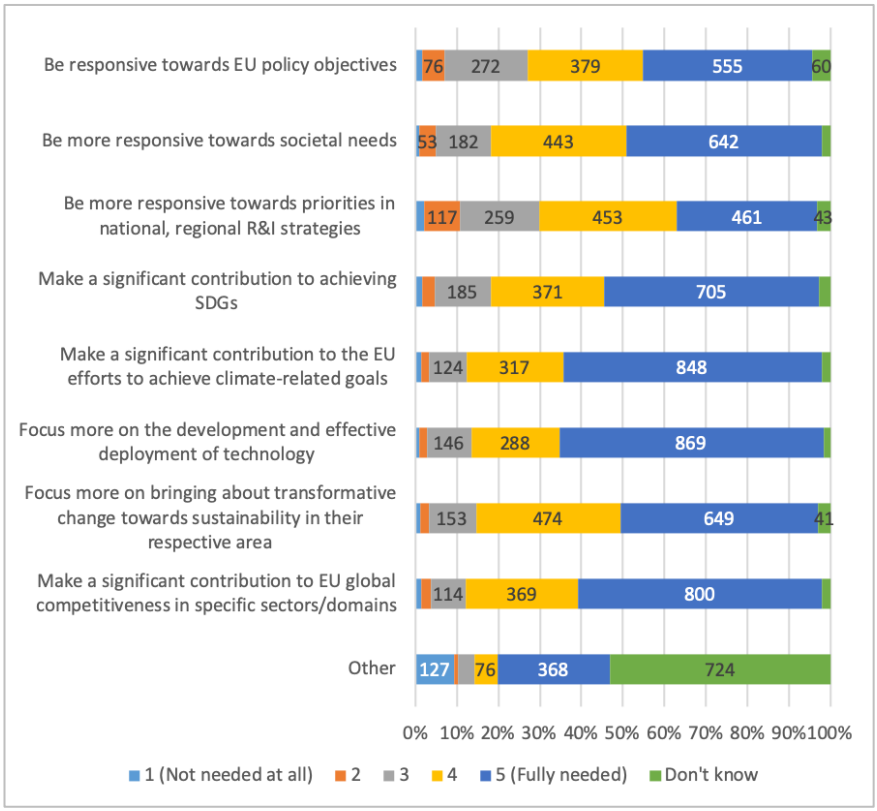
The views of citizens (249, or 18.27%), both EU and non-EU citizens, that participated in the open public consultation do not reflect significant differences with other types of respondents. However, respondents that are/were directly involved in a partnership under Horizon 2020 or its predecessor Framework Programme 7 assign a higher importance of the future European Partnerships to be more responsive towards EU policy objectives and to make a significant contribution to achieving the UN's Sustainable Development Goals.

Among 272 respondents that are classified as **campaigns,** the majority (86.76%) indicated that the future European Partnerships should focus more on the development and effective deployment of technology. Other categories of presented needs that received a high score among many campaign respondents are the need to make a significant contribution to the EU efforts to achieve climate-related goals, Sustainable Development Goals and to EU global competitiveness in specific sectors/domains. The least number of campaign respondents valued the need to be more responsive towards priorities in national, regional R&I strategies (54 respondents gave a score "5 Fully needed", or 19.85%) and to be more responsive towards societal needs (71 respondents gave a score "5 Fully needed", or 26.10%).

Similarly as for non-campaign respondents, we find only minor differences between the main stakeholder categories amongst campaign respondents. Academic/research institutions indicated that the future European Partnerships need to focus a little less on development and effective deployment of technology than other respondents. On the contrary, large companies find the focus on the development and effective deployment of technology a little more needed than other respondents, as do public authorities. Furthermore, large companies feel responsiveness towards priorities in national, regional

R&I strategies is a little less needed than other respondents. Public authorities, however, value the responsiveness towards societal needs and priorities in national, regional R&I strategies more than others.

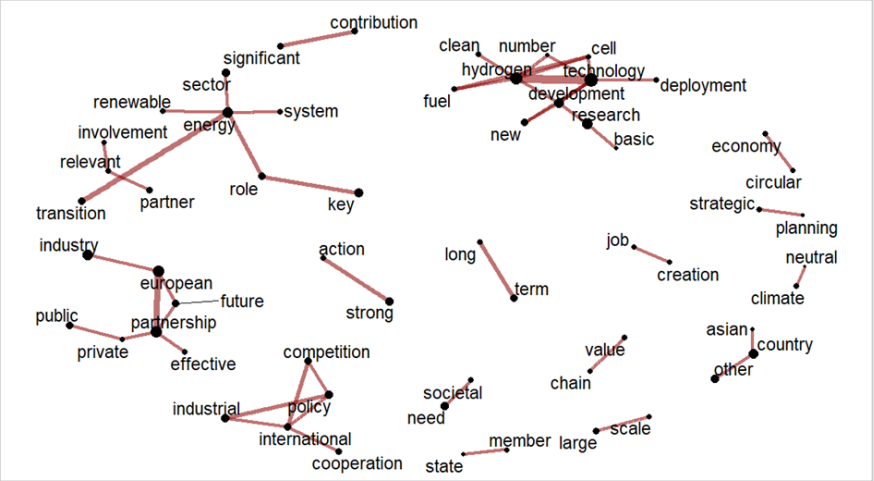
Figure 14: Needs assessment (N=1363)



Notes: Question: " To what extent do you think that the future European Partnerships under Horizon Europe need to …"; Non-campaign replies; Aggregation of responses of all candidate initiatives

The analysis of the open answers provided to explain the "Other" field show that many respondents included the set-up of public-private European partnerships and the link between industrial policy and international competition and cooperation (see Figure 15). This is confirmed through qualitative analysis of answers, many of which mention the importance of collaboration and integration of relevant stakeholders to tackle main societal challenges and to contribute to policy goals. Against this backdrop, fragmentation of funding and research efforts across Europe should be avoided. Additionally, several respondents suggested that faster development and testing of technologies, acceleration of industrial innovation projects, science transfer and market uptake are deemed as priorities. Next to that, many respondents provided answers related to the fields of hydrogen and the energy transition, which corresponds to the high number of respondents that provided answers to the candidate European Partnership specific questions related to these topics.

Figure 15: Needs assessment, open answers to "Other" field (N=734)



Notes: Question: " To what extent do you think that the future European Partnerships under Horizon Europe need to …"; 50 most common co-occurring keywords; Non-campaign replies; Aggregation of responses of all candidate initiatives

Many of the respondents that are classified as campaigns took the opportunity of the "Other" field to underline their key messages. The main aspects mentioned were:

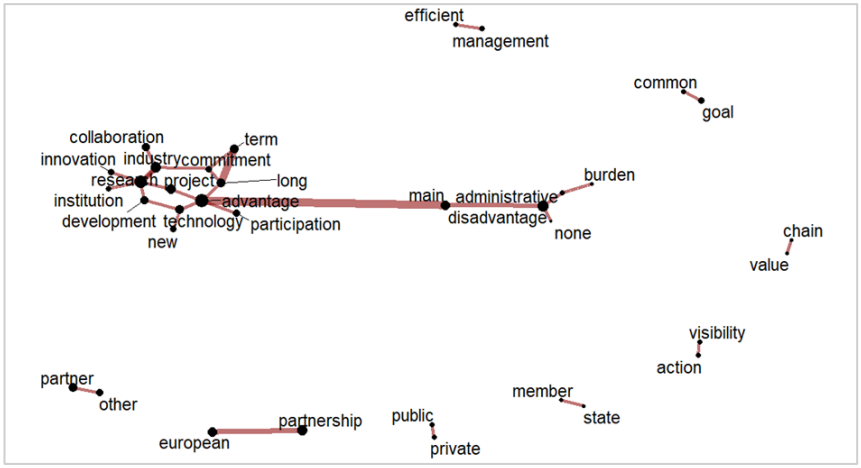
- The global positioning of Europe: outlining the role of global competition (including the role of technology), the importance of autonomy for Europe and the ability of Europe to act as a key player at the global level.
- The balance between policy objectives and private sector interests: Partnerships are regarded as an instrument to secure industry commitments due to the stability required for investments that serve policy goals.
- The importance of the transition between research and innovation (implementing research results in the market).
- The importance of multidisciplinary, and specifically cross-sectoral/cross-partnership collaboration.
- The importance of the long term commitment of a wide range of relevant stakeholders.

Next to that many respondents as part of campaigns stressed the importance of the energy transition, hydrogen and the environment, which corresponds to the high number of respondents that provided answers to the candidate European Partnership specific questions related to these topics.

Main advantages and disadvantages of Institutionalised European Partnerships

In the next question, respondents were asked to outline the main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe. This was an open question for which a keyword analysis was used (see the main results in Figure 16). As can be observed, the advantages mentioned focus on the development of technology, overall collaboration between industry and research institutions, and the long-term commitment. Disadvantages mentioned are mainly administrative burdens.

Figure 16: Main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) (N=1551)



Notes: Question: " What would you see as main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe?"; 30 most common co-occurring keywords; Non-campaign replies; Aggregation of responses of all candidate initiatives

When asked about the main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe, the following points were mentioned by respondents that are classified as campaigns:

Advantages:

- Long term commitment, stability, and visibility in financial, legal, and strategic terms
- Participation of wide range of relevant stakeholders in an ecosystem (large/small business, academics, researchers, experts, etc.)
- Complementarity with other (policy) initiatives at all levels EU, national, regional
- Efficient and effective coordination and management
- High leverage of (public) funds
- Some innovative field require high levels of international coordination/standardisation (at EU/global level)
- Ability to scale up technology (in terms of TRL) through collaboration
- Networking between members
- Direct communication with EU and national authorities

Disadvantages:

- Slow processes
- System complexity
- Continuous openness to new players should be better supported as new participants often bring in new ideas/technologies that are important for innovation
- Lower funding percentage compared to regular Horizon Europe projects
- Cash contributions
- Administrative burdens

- Potential for IPR constraints

Relevance of EU level efforts to address problems in selected areas of Partnerships

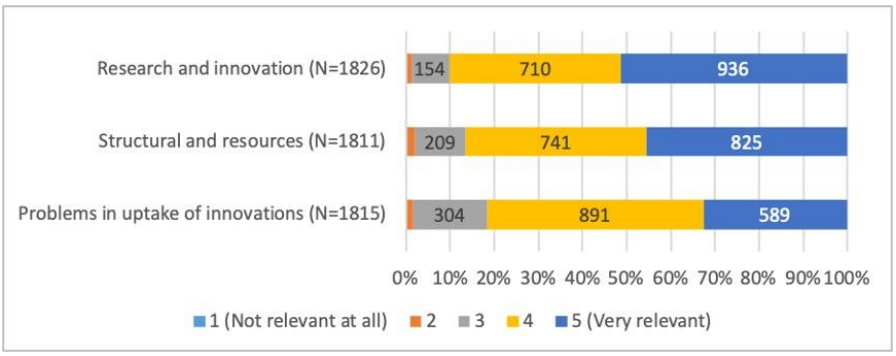
Per candidate European Partnership respondents were asked to rate the relevance of partnership specific problems in three main areas: Research and innovation problems, Structural and resource problems and Problems in the uptake of innovations. To aggregate results the average of the responses on partnership specific problems were calculated.

As presented in Figure 17, research and innovation related problems were rated as most relevant by the respondents across all candidate initiatives, followed by structural and resources problems and problems in the uptake of innovations. Overall, all three areas were deemed (very) relevant across the partnerships, as more than 80% of respondents found these challenges (very) relevant.

Only minor differences were found between the main stakeholder categories of respondents. Research and innovation problems were found slightly more relevant by academic/research institutions, yet slight less relevant by large companies and SMEs. Structural and resource problems were indicated as slightly more relevant by NGOs, but slightly less by academic/research institutions. While both NGOs and public authorities find it slightly more relevant to address problems in uptake of innovation than other respondents.

The views of citizens, both EU and non-EU citizens, are the same as other respondents (no significant differences). Respondents that are/were directly involved in a current/preceding partnership (Horizon 2020 or Framework Programme 7) find, however, the uptake of innovation problems slightly more relevant than other respondents.

Figure 17: Relevant problems to address



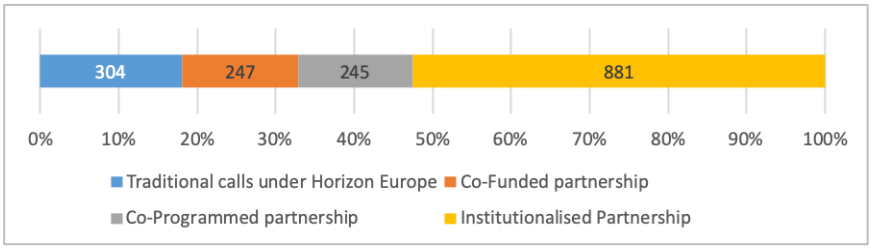
Notes: Question: "To what extent do you think it is relevant for research and innovation efforts at EU level to address the following problems in relation to the candidate partnership in question?"; Non-campaign replies; Aggregation of responses of all candidate initiatives

Horizon Europe mode of intervention to address problems

After providing their views on the relevance of problems, respondents were asked to indicate how these challenges could be addressed through Horizon Europe intervention. As shown in Figure 18, just over 50% of all respondents indicated that institutionalised partnerships were the best fitting intervention, however, relatively strong differences between stakeholder categories were found. The intervention of institutionalised partnerships was indicated more by business associations and large companies, but less by academic/research institutions and SMEs. While academic/research institutions valued traditional calls more often, this was not the case for business associations, large companies and public authorities. Public authorities indicated a co-programmed

intervention more often than other respondents. Citizens, compared to other respondents, indicated slightly less often that institutionalised partnerships were the best fitting intervention. Respondents that are/were directly involved in a current/preceding partnership, however, selected the institutionalised partnership intervention in far higher numbers (nearly 70%).

Figure 18: Options to address challenges



Notes: Question: "In your view, how should the specific challenges described above be addressed through Horizon Europe intervention?"; Non-campaign replies; Aggregation of responses of all candidate initiatives

When asked to reflect on their answers, respondents that pointed to the need for using the "institutionalised partnership" intervention mentioned the long-term commitment of collaboration, a common and ambitious R&I strategy as well as the overall collaboration between industry and research institutions. Respondents that referred to possible approaches, sometimes gave examples of good experiences in with other interventions:

- Traditional calls because of their flexibility and integration of a wide range of actors, as long as the evaluation panels do not deviate from the policy premier. This was mentioned by 94 participants, evenly distributed across companies (25 of them), academics (26) and EU citizens (25).
- Co-funded partnership, as a mechanism to ensure that all participants take the effort seriously, while allowing business partnerships to develop. This approach was deemed suitable based on previous experiences with ERANETs. This was raised by 84 participants, 36 of them academic respondents, 18 companies and 16 EU citizens.
- Co-programmed partnerships to tackle the need to promote and engage more intensively with the private sector. This was mentioned by 97 participants, most of them companies (34), followed by academics (22), business associations (15) and EU citizens (11).

Relevance of a set of elements and activities to ensure that the proposed European Partnership would meet its objectives

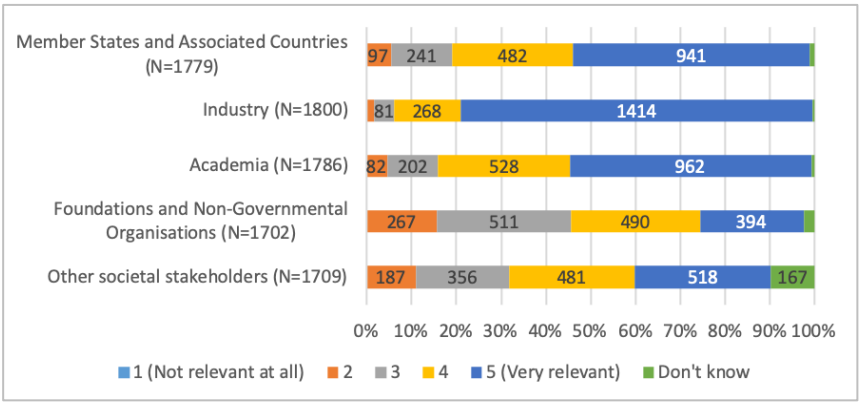
Setting joint long-term agendas

Respondents were asked how relevant it is for the proposed European Partnerships to meet their objectives to have a strong involvement of specific stakeholder groups in setting joint long-term agenda. As presented in Figure 19, collectively all respondents see stakeholders from industry as the most relevant, followed by academia and governments (Member States and Associated Countries). The involvement of foundations and NGOs as well as other societal stakeholders were, however, still found to be (very) relevant by more than 50% of the respondents.

When looking at the differences between the answers of the main stakeholder categories only minor differences could be found. Overall, it could be observed that most respondents indicated the stakeholder group they belong to themselves or that represent them as relevant to involve. Academic/research institutions find it more relevant to involve

academia and less relevant to involve industry when compared to other respondents. The other way around large companies, SMEs and business associations find it more relevant to involve industry and less relevant to involve academia, Member States and Associated Countries and NGOs. The involvement of Member States and Associated Countries was found more relevant by academic/research institutions and public authorities. NGOs also values their own involvement and those of other societal stakeholders more than other respondents. The views of citizens also show a slightly higher relevance for foundations and NGOs. This is less so the case for respondents that are/were directly involved in a current/preceding partnership (most predominantly companies and academia).

Figure 19: Stakeholders to involve in setting joint long-term agenda's



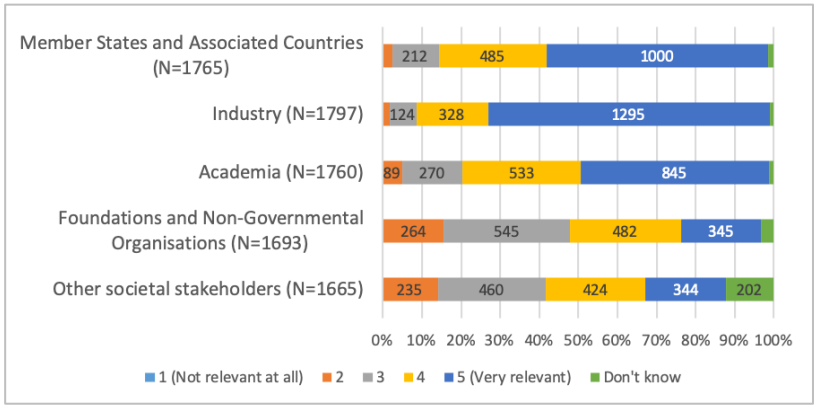
Notes: Question: "In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives - Setting joint long-term agenda with strong involvement of:"; Non-campaign replies; Aggregation of responses of all candidate initiatives

Pooling and leveraging resources through coordination, alignment and integration with stakeholders

Respondents were also asked how relevant it is for the proposed European Partnership to meet its objectives to pool and leverage resources (financial, infrastructure, in-kind expertise, etc.) through coordination, alignment and integration with specific groups of stakeholders. As shown in Figure 20 - similarly as for the previous questions, respondents also see stakeholders from industry as the most relevant, followed by academia and governments (Member States and Associated Countries). The involvement of foundations and NGOs as well as other societal stakeholders are also still found to be (very) relevant for more than 50% of the respondents.

Similarly as described for the question on setting joint long-term agendas, most stakeholder categories valued their own involvement higher than other respondents – although also here differences between stakeholder categories were minor. As such, academic/research institutions see the relevance of academia higher, while large companies, SMEs and business association indicated a lower relevance of academia than other respondents. Similarly, these private sector stakeholders valued the relevance of industry higher than others while valuing the relevance of NGOs and other societal stakeholders less. NGOs value themselves and other societal stakeholders however higher than other respondents, and also public authorities indicated a higher relevance for Member States and Associated Countries then other respondents. Citizens mainly put more emphasis on the role of NGOs and other societal stakeholders then other respondents.

Figure 20: Relevance of actors for pooling and leveraging resources



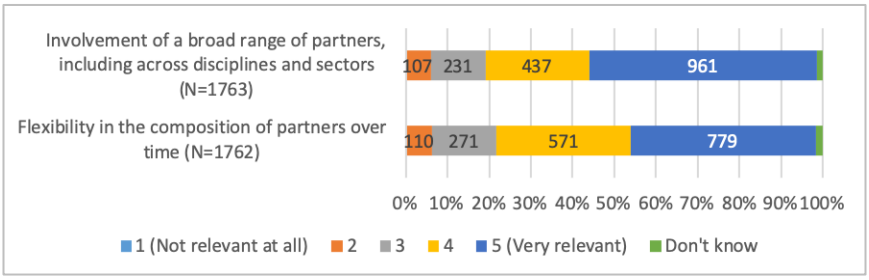
Notes: Question: "In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives – Pooling and leveraging resources (financial, infrastructure, in-kind expertise, etc.) through coordination, alignment and integration with:"; Non-campaign replies; Aggregation of responses of all candidate initiatives

Composition of the partnerships

Regarding the composition of the partnership most respondents indicated that for the proposed European Partnership to meet its objectives the composition of partners needs to be flexible over time and that a broad range of partners, including across disciplines and sectors, should be involved (see Figure 21).

When comparing stakeholder groups only minor differences were found. Academic/research institutions and public authorities found the involvement of a broad range of partners and flexibility in the composition of partners over time slightly more relevant than other respondents, while large companies found both less relevant. SMEs mainly found the flexibility in the composition of partners over time less relevant than other respondents, while no significant differences were found regarding the involvement of a broad range of partners. Citizens provided a similar response to non-citizens. Respondents that are/were directly involved in a current/preceding partnership, when compared to respondents not involved in a current/preceding partnership, indicated a slightly lower relevance of the involvement of a broad range of partners and flexibility in the composition of partners over time.

Figure 21: Assessment of the partnership composition



Notes: Question: "In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives – Partnership composition"; Non-campaign replies; Aggregation of responses of all candidate initiatives

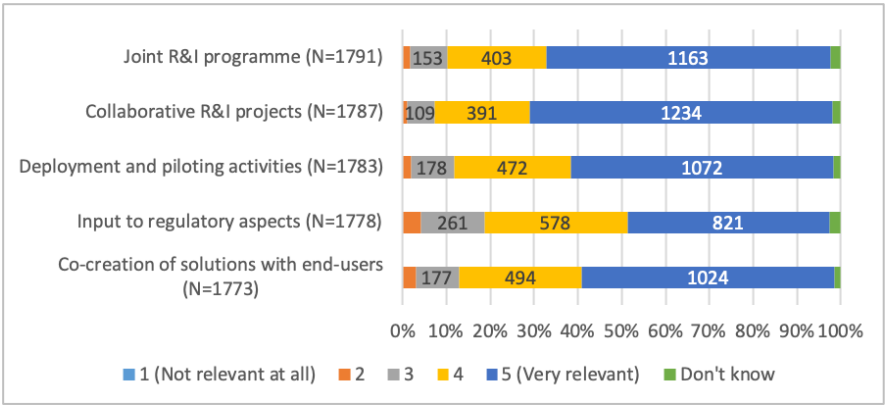
Implementation of activities

Most respondents indicated that implementing activities like a joint R&I programme, collaborative R&I projects, deployment and piloting activities, providing input to regulatory

aspects and the co-creation of solutions with end-users are all (very) relevant for the partnerships to be able to meet its objectives (see Figure 22).

Minor differences were found between the main stakeholder categories, the differences found were in line with their profile. As such, academic/research institutions found joint R&I programme & collaborative R&I projects slightly more relevant and deployment and piloting activities, input to regulatory aspects and co-creation with end-users slightly less relevant than other respondents. For SMEs an opposite pattern is shown. Large companies, however, also found collaborative R&I projects slightly more relevant than other respondents, as well as input to regulatory aspects. The views of citizens are similar to non-citizens. Respondents that are/were directly involved in a current/preceding partnership, when compared to respondents not involved in a current/preceding partnership, show a slightly higher relevance across all activities shown in Figure 22.

Figure 22: Relevance of activities to implement



Notes: Question: "In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives – Implementing the following activities"; Non-campaign replies; Aggregation of responses of all candidate initiatives

Relevance of setting up a legal structure (funding body) for the candidate European Partnerships to achieve improvements

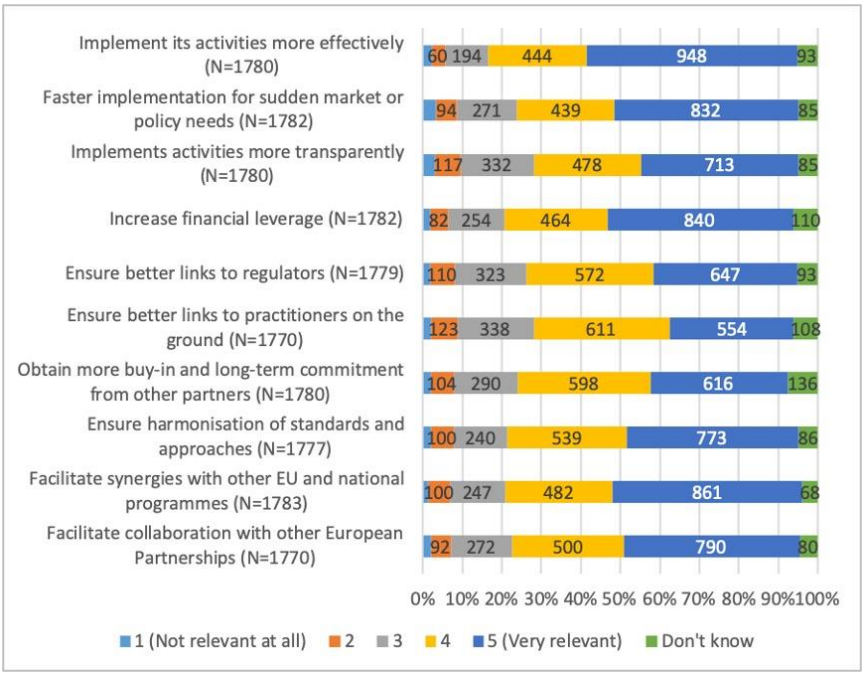
Respondents were then asked to reflect on the relevance of setting up a legal structure (funding body) for achieving a set of improvements, as presented in Figure 23. In general, 70%-80% of respondents find a legal structure (very) relevant for these activities. The legal structure was found most relevant for implementing activities in a more effective way and least relevant for ensuring a better link to practitioners on the ground, however differences are small.

When comparing the main stakeholder categories we found minor differences. Academic/research institutions indicated a slightly lower relevance for transparency, better links to regulators as well as obtaining the buy-in and long-term commitment of other partners. SMEs also indicated a lower relevance regarding obtaining the buy-in and long-term commitment of other partners. Large companies showed a slightly higher relevance for implementing activities effectively, ensure better links to regulators, obtaining the buy-in and long-term commitment of other partners, synergies with other EU/MS programmes and collaboration with other EU partnerships than other open consultation respondents. NGOs find it slightly more relevant to implement activities faster for sudden market or policy needs. Public authorities, however, find it slightly less relevant to facilitate collaboration with other European Partnerships than other respondents.

The views of citizens show a slightly lower relevance for a legal structure in relation to implementing activities in an effective way. Quite different results are shown for

respondents that are/were directly involved in a current/preceding partnership when compared to respondents not involved in a current/preceding partnership, they indicated a higher relevance across all elements presented in Figure 23.

Figure 23: Relevance of setting up a legal structure (funding body)



Notes: Question: "In your view, how relevant is to set up a specific legal structure (funding body) for the candidate European Partnership to achieve the following?"; Non-campaign replies; Aggregation of responses of all candidate initiatives

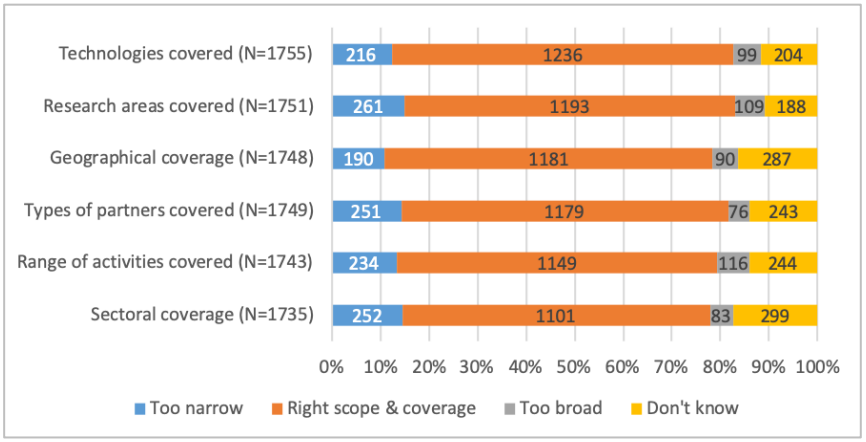
Scope and coverage of the candidate European Partnerships based on their inception impact assessments

The response regarding the scope and coverage for the partnerships, based on inception impact assessments, shows that the large majority feels like the scope and coverage initially proposed in the inception impact assessments is correct. Figure 24 shows the results. However, about 11% to 15% of the respondents indicated the scope and coverage to be too narrow. About 11%-17% of respondents answered "Don't know". In the open answers respondents mostly reflected on specific aspects of the geographical and sectoral scope and coverage of the specific candidate European Partnerships, no overall lessons could be extracted.

Overall, differences between the main stakeholder categories were found to be minor. Academic/research institutions indicated slightly more often that the research area was "too narrow" then other respondents. SMEs on the other hand indicated slightly more often that the research area and the geographical coverage were "too broad". NGOs and public authorities, however, found the geographical coverage slightly more often "too narrow" when compared to other respondents. Large companies found the range of activities slightly more often "too broad" and the sectoral focus slightly more often "too narrow" when compared to other respondents.

The views of citizens are the same as for other respondents. Most notably, respondents that are/were directly involved in a current/preceding partnership, when compared to respondents not involved in a current/preceding partnership, more often indicated that the candidate institutionalised European Partnership have the "right scope & coverage".

Figure 24: Assessment of the proposed scope and coverage of the candidate European Partnerships



Notes: Question: "What is your view on the scope and coverage proposed for this candidate institutionalised European Partnership, based on its inception impact assessment?"; Non-campaign replies; Aggregation of responses of all candidate initiatives

Scope for rationalisation and alignment of candidate European Partnerships with other initiatives

When asked whether it would be possible to rationalise a specific candidate European Institutionalised Partnership and its activities, and/or to better link with other comparable initiatives, nearly two thirds of respondents answered "Yes" (1000, or 62.15%), while over one third answered "No" (609, or 37.85%). Nearly no differences were found between the main stakeholder categories, only large companies and SMEs indicated slightly more often "Yes" in comparison to other respondents.

The views of citizens are the same as for other respondents. Respondents that are/were directly involved in a current/preceding partnership, indicated "No" more often, the balance is about 50/50 between "Yes" and "No" for this group.

In the open responses respondents often referred to specific similar/comparable and complementary initiatives discussing the link with a specific candidate European Partnership, no overall lessons could be extracted, but more detailed results can be found in the partnership specific result sections.

Relevance of European Partnerships to deliver targeted scientific, economic/technological and societal impacts

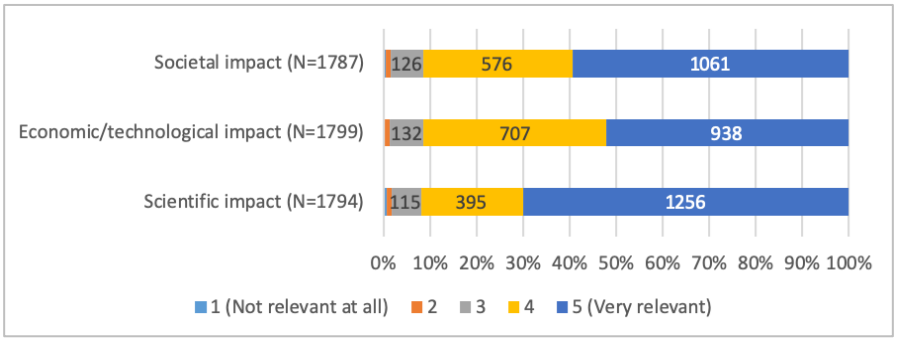
Finally, respondents were asked to rate the relevance of partnership specific impacts in three main areas: Societal impacts, Economic/technological impacts and Scientific impacts. To aggregate results the average of the responses on partnership specific impacts were calculated.

As presented in Figure 25, overall, all three areas were deemed (very) relevant across the candidate partnerships. Scientific impact was indicated as the most relevant impact, more than 90% of respondents indicated that these impacts were (very) relevant.

Only minor difference between stakeholder groups were found. Academic/research institutions found scientific impacts slightly more relevant, while large companies found economic and technological impacts slightly more relevant than other respondents. NGOs found societal impact slightly more relevant, while SMEs found this slightly less important.

Citizens, both EU and non-EU citizens, did not a significantly different view when compared to other respondents. Respondents that are/were directly involved in a current/preceding partnership find all impacts slightly more relevant than other respondents.

Figure 25: Relevant impacts of future European Partnerships



Notes: Question: "In your view, how relevant is it for the candidate European Institutionalised Partnership to deliver on the following impacts?"; Non-campaign replies; Aggregation of responses of all candidate initiatives

B.6 Responses to the open public consultation for the candidate partnership "key enabling and digital technologies"

B.6.1 Introduction

This section outlines the results of the Open Public Consultation for the candidate European Partnership on Key Enabling and Digital Technologies. The section outlines the following:

- Results on general questions, segregated for this candidate European Partnership:
  - Views on the needs of the future European Partnerships under Horizon Europe
  - Views on the advantages and disadvantages of participation in an Institutionalised European Partnership
- Results on specific questions for this candidate European Partnership:
  - Relevance of research and innovation efforts at the EU level to address problems
  - Views on Horizon Europe interventions to address these problems
  - Views on the relevance of elements and activities in:
    - setting a joint long-term agenda;
    - pooling and leveraging resources;
    - partnership composition;
    - implementation of activities.
  - Views on setting up a specific legal structure (funding body)
  - Views on the proposed scope and coverage of this candidate European Partnership
  - Views on the alignment of the European Partnership with other initiatives
  - Relevance of this candidate European Partnership to deliver impacts

B.6.2 Characteristics of respondents

For the Key Digital Technologies Partnership, 162 respondents provided their views. Among them, 55 respondents (33.95%) are representatives of academic and research institutions, 42 (25.93%) work in company/business organisations and 35 respondents (21.60%) are citizens. The majority of respondents, namely 124 (76.54%), have been involved in the

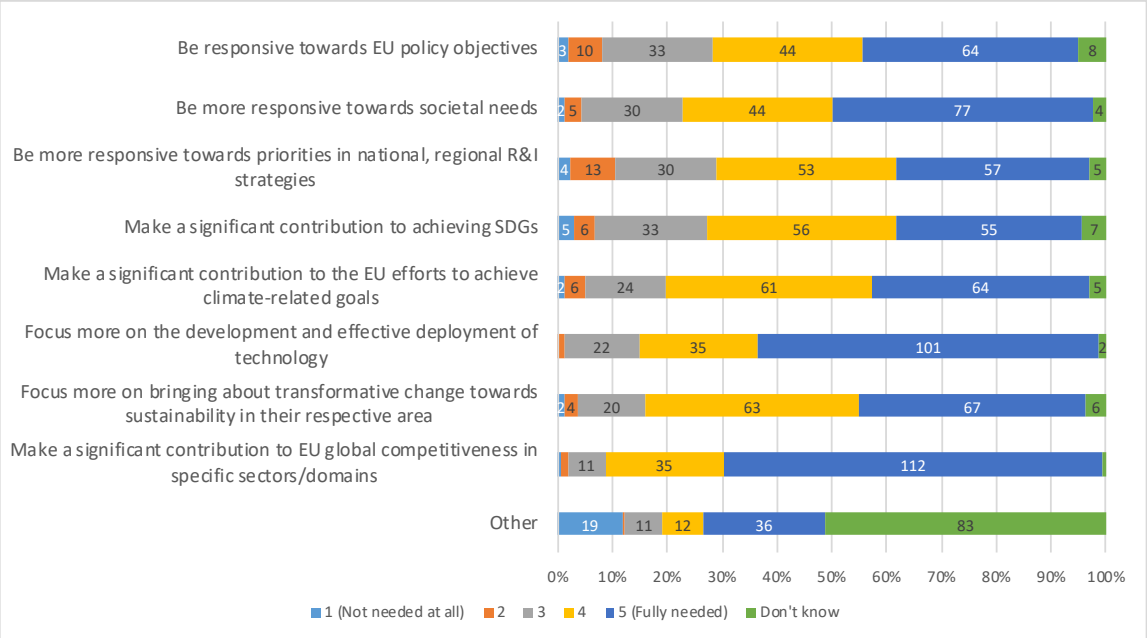
on-going research and innovation framework programme, while 84 respondents (67.74%) were directly involved in a partnership under Horizon 2020 or its predecessor Framework Programme 7.

B.6.3 Characteristics of future candidate European Partnerships – as viewed by respondents to the Key Enabling and Digital Technologies initiative

At the beginning of the consultation, the respondents of this partnership indicated their views of the needs of the future European Partnerships under Horizon Europe. Overall, respondent indicated that many of these needs were fully needed. The needs where most respondents indicated this, was making a significant contribution to EU global competitiveness in specific sectors and/or domains (112, 69.14%) and focusing more on the development and effective deployment of technology (101, 62.35%). Aside from 'other', the needs where the least respondents indicated that improvements were fully needed, was making a significant contribution to achieving SDG's (55, 33.95%) and being more responsive towards priorities in national and/or regional R&I strategies (57, 35.19%).

No statistical differences were found between the views of citizens and other respondents for most needs. However, citizens found the need of making significant contribution to the EU efforts to achieve climate-related goals slightly less relevant.

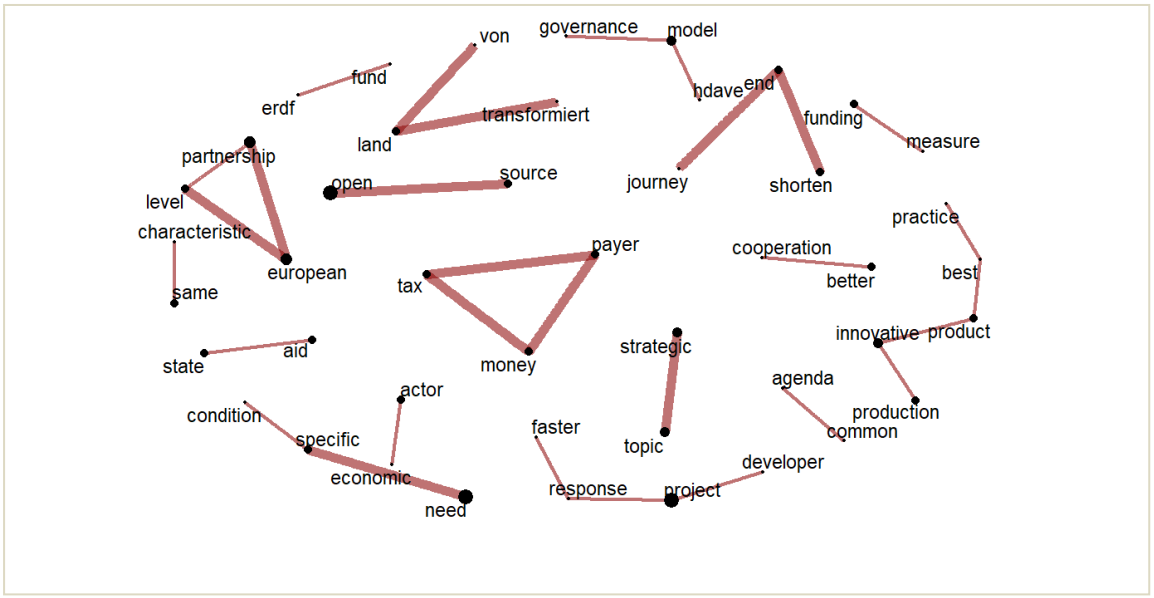
Figure 26: Needs assessment (N=162)



Notes: Question: " To what extent do you think that the future European Partnerships under Horizon Europe need to …"

The respondents also had the option to indicate other needs. The results of the analysis resulted in the chart shown in Figure 27 showing the co-occurrences of keywords. The results show that respondents have indicated needs around tax payer money, specific economic needs and open source.

Figure 27: Needs assessment, open answers to "Other" field (N=58)



Notes: Question: " To what extent do you think that the future European Partnerships under Horizon Europe need to …"; 50 most common co-occurring keywords

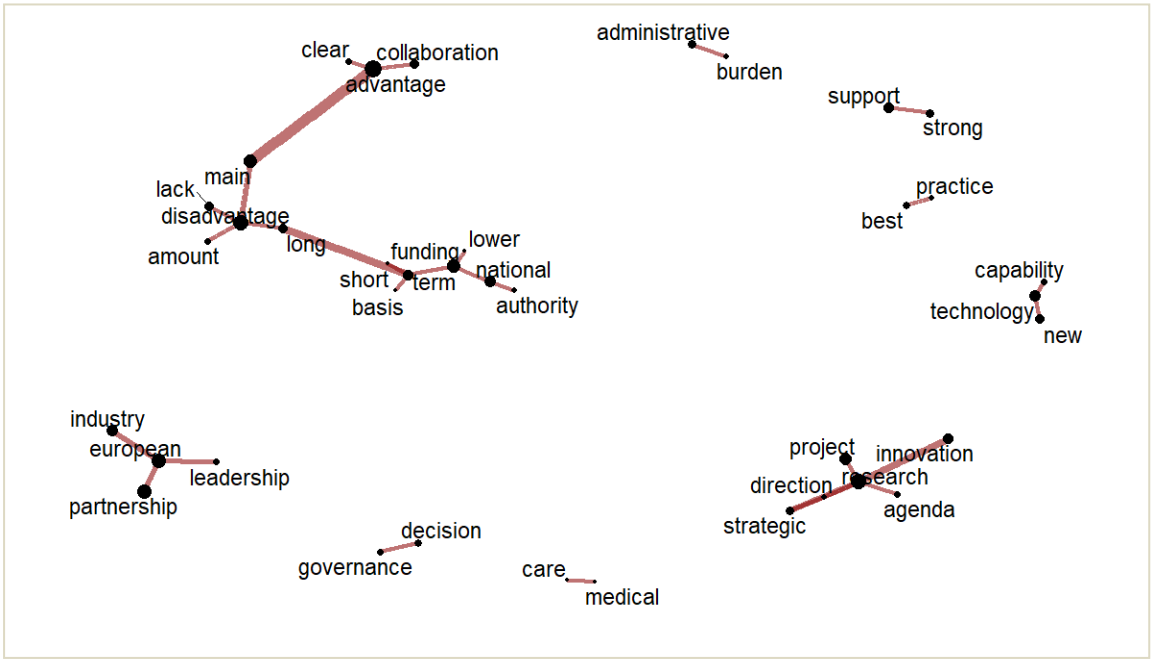
The identified needs were quite recurrent among respondents. The sovereignty of the EU in critical sectors (i.e. digital and energetic security) was put forward by participants from all the different stakeholder categories. Ensuring the EU's leadership in flagship KDT sectors is perceived as the only way to be competitive in the global market. For the majority of respondents, this quest for proficiency must be accompanied by a high level of transparency and the avoidance of any opacity. Indeed, companies (both large corporations and SMEs), members from academia and NGOs argue that awareness should be raised on what is being achieved and how the financing is being transformed into concrete actions.

While the necessity of collaboration in the sector of KDT is acknowledged, many respondents commented on the need for inclusive platforms, covering societal needs, and the need for capacity to integrate all the different actors. For example, one of the answers, from the owner of an SME, called for "more agility to listen to the societal needs in the EU". The topic of environment and climate change is also at the heart of the identified concerns. Many respondents argue that a delicate balance should be found between a short-term approach, adapted to the current and most immediate needs, and a long-term vision, seeking sustainable solutions for the future.

B.6.4 Main advantages and disadvantages of Institutionalised European Partnerships

The respondents were asked what they perceived to be the main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe. The keyword analysis used for open questions resulted in the graph shown in Figure 28. This analysis showed the respondents viewed collaboration as the main advantage.

Figure 28 Main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) (N=139)



Notes: Question: " What would you see as main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe?"; 30 most common co-occurring keywords

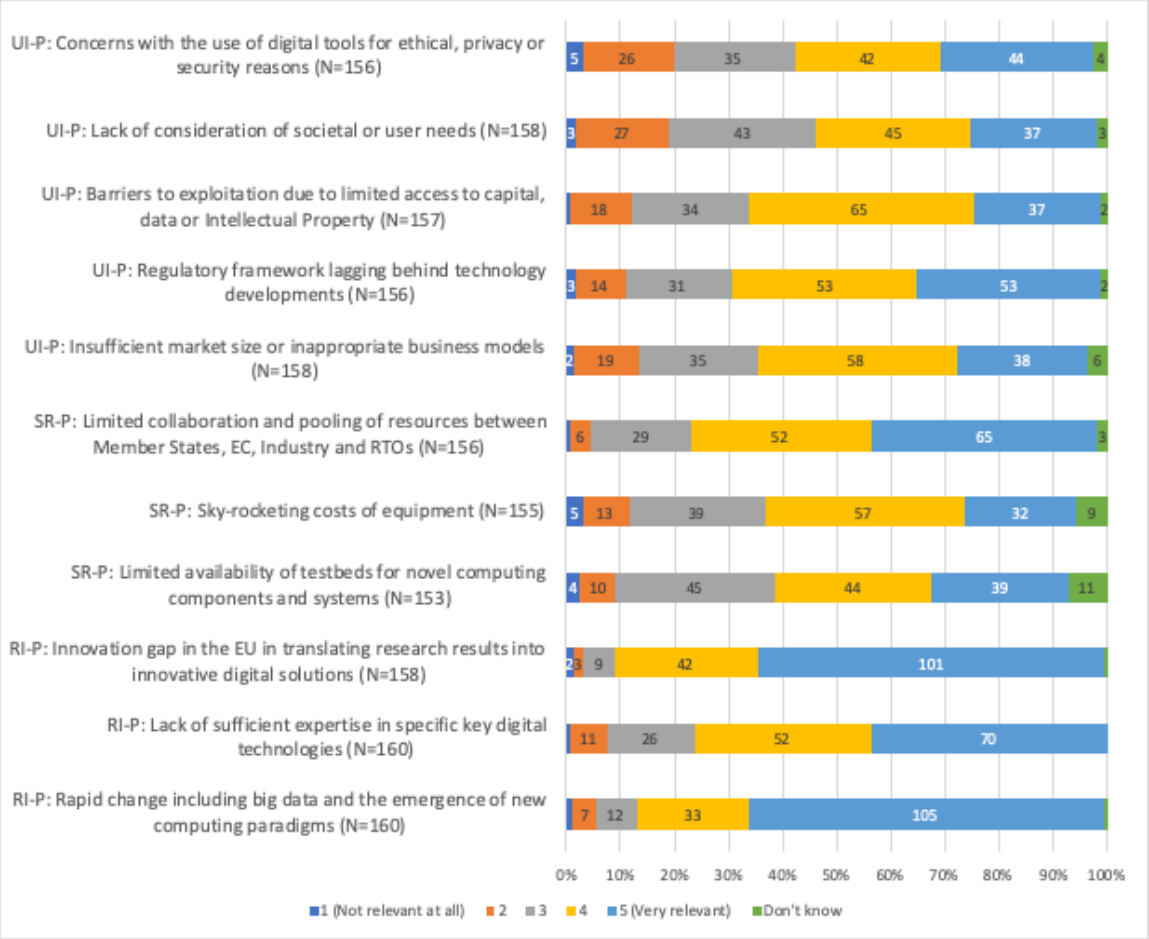
Respondents identified clear advantages with an Institutionalised Partnership; the answers were consistent among the different types of stakeholder categories (public authorities, business associations, academic/research institutions, large companies and SMEs). Representatives from large business organisations identified the larger scale of cooperation at the EU-level and the integration of different actors among the main advantages of an Institutionalized Partnership. This opinion is shared by a majority of SME representatives who underline the importance of having common guidelines and strategies in order to achieve enhanced leverage. In the case of academic/research institutions, increased technology and knowledge transfer is perceived as a key factor to achieve competitiveness at the international level and the possibility of an increased role of the EU institutions is seen as a guarantee for higher transparency.

The main concerns regarding the Institutionalised Partnership is that it was perceived to involve more administration complexity, which can slow down the decision- making process, and scepticism towards the complexity of the governance in such a comprehensive framework. One large business organization also noted that in an Institutionalised Partnership framework there could be a "lower funding rate than in regular Horizon projects".

B.6.5 Relevance of EU level efforts to address problems in relation to the Key Enabling and Digital Technologies initiative

In the consultation, respondents were asked to provide their view on the relevancy of research and innovation efforts at EU level to address the following problems in relation to key digital technologies, specifically on three types of problems: problems in uptake of digital innovations (UI-P), structural and resource problems (SR-P)and research and innovations problems (RI-P). In Figure 29 the responses to these answers are presented.

Figure 29: Relevant problems to address



Notes: Question: "To what extent do you think it is relevant for research and innovation efforts at EU level to address the following problems in relation to the candidate partnership in question?"

With regard to the uptake in innovation problems, the majority of respondents have picked either a 4 or a 5 on the 5-point relevancy scale. The regulatory framework lagging behind technology developments has received the most 5 (very relevant) answers (53, 33.97%) and the most 4 and 5 answers (106, 67.95%). The option that has received the least 5 (very relevant) answers is the lack of consideration of societal or user needs (37, 23.42%) followed by the barriers to exploitation due to limited access to capital data or intellectual property (37, 23.57%).

With regard to structural and resource problems, the limited collaboration and pooling of resources between Member States, European Commission, Industry and Research organisations (Universities, RTO's) is clearly considered the most relevant for research and innovation efforts at EU level to address, with 65 respondents indicating it is very relevant (41.67%).

Finally, respondents have indicated that research and innovation problems are considered the most relevant, as all of the problems presented in this category have received more 5 (very relevant) answers than any of the other problems. The rapid change including big data and the emergence of new computing paradigms is considered the most relevant, with 105 respondents selecting this answer (65.63%).

No statistical differences were found between the views of citizens and other respondents. The research and innovation problem regarding the lack of sufficient expertise in specific

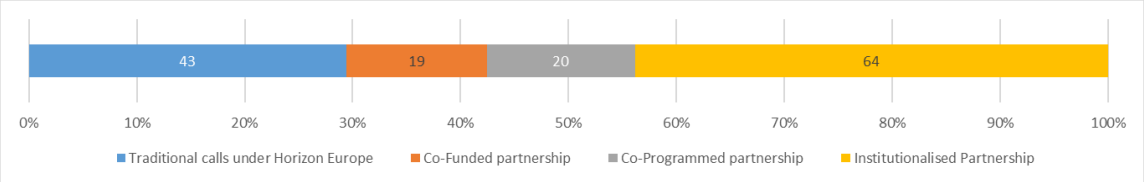
key digital technologies was found more relevant by respondents that are/were involved in a current/preceding partnership (Horizon 2020 or Framework Programme 7).

B.6.6 Horizon Europe mode of intervention to address problems

After providing their views on the relevance of problems, respondents were asked to indicate how these challenges could be addressed through Horizon Europe intervention. As shown in Figure 30, just over 40% of respondents indicated that institutionalised partnerships were the best fitting intervention.

No statistical differences were found between the views of citizens and other respondents.

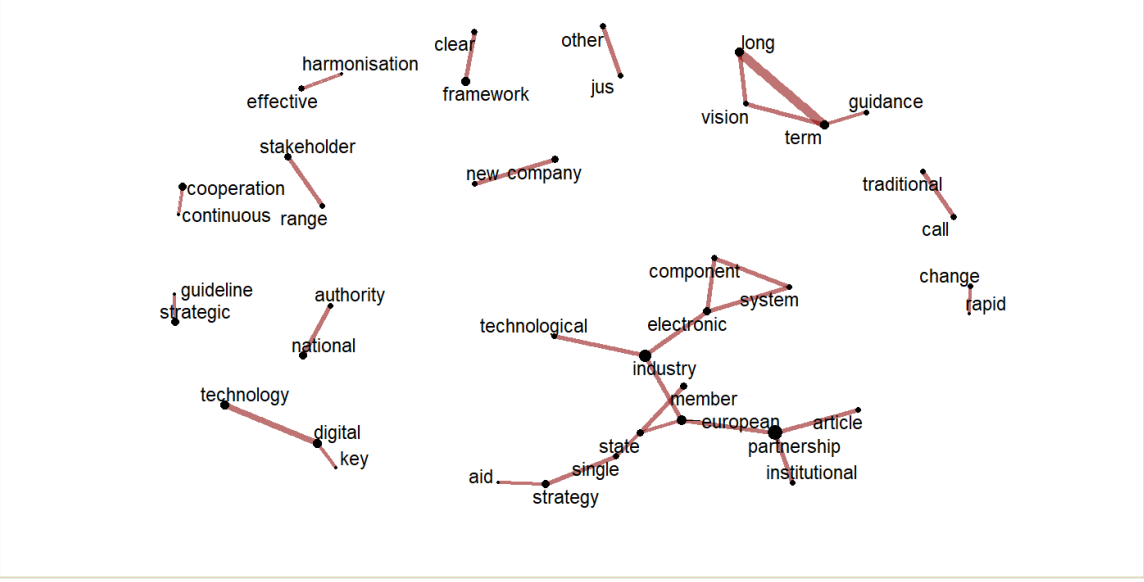
Figure 30: Options to address the challenges



Notes: Question: "In your view, how should the specific challenges described above be addressed through Horizon Europe intervention?"

The respondents were asked to briefly explain their answers to the question above. People who stated that an institutionalised partnerships was the best fitting answer mentioned long term vision and guidance, traditional calls, range of stakeholders and single state strategy (Figure 31). Respondents who did not select institutionalised partnership as their preferred intervention (N=76) mentioned traditional calls, public private sector and the development of new technology (not pictured).

Figure 31: Open answers to explain the choice institutionalised partnership in the assessment of the Horizon Europe intervention (N=49)



Notes: Question: "In your view, how should the specific challenges described above be addressed through Horizon Europe intervention?

The main challenges identified in respondents' answers were competitiveness at the international level, especially regarding global leaders China and USA, the complex coordination between the different stakeholders and an equal and effective access to funding. The majority of respondents across sectors and categories pointed out

Institutional Partnerships as the best model to face such challenges. In the specific sector of KDT, one respondent stated that it is the only way to "achieve critical mass to keep up with the global competition for leadership in these technologies". Company representatives stressed the need for better harmonisation to facilitate communication in these multi-layered structures. Ensuring collaboration and effective communication between industry and research institutions is seen as a key factor of success among members of research and academic institutions. On the other hand, while the model of Joint Undertakings and the functioning of the tripartite model are widely acknowledged, some respondents also indicated a co-programmed and co-funded partnership as the more suitable structures.

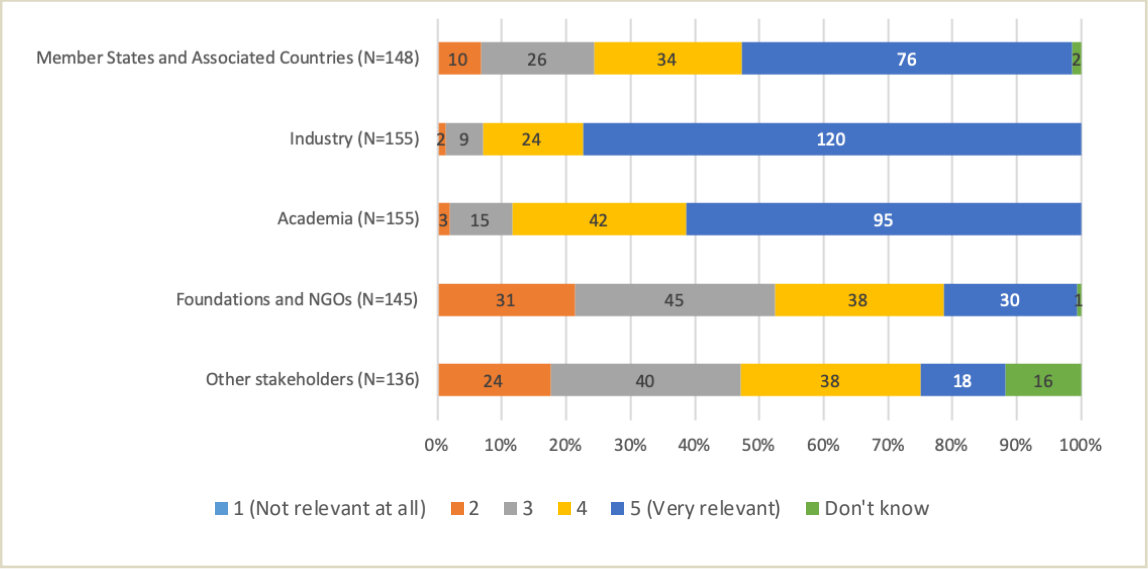
B.6.7 Relevance of a set of elements and activities to ensure that the proposed European Partnership would meet its objectives

Setting joint long-term agendas

Respondents were asked how relevant the involvement of actors is in setting a joint long-term agenda to ensure that the proposed European Partnership would meet its objectives. Based on Figure 32, industry is considered to be a most relevant actor in setting the long-term agenda, as 120 respondents (77.42%) gave it the highest score (namely, 5) on the proposed scale. The role of academic and Member States, Associated Countries is also considered important by many respondents, while involvement of foundations, NGOs and other stakeholders is not seen considered crucial for setting joint long-term agenda.

No statistical differences were found between the views of citizens and other respondents. Respondents that are/were involved in a current/preceding partnership indicate that industry and government (Member States and Associated Countries) are more relevant that other respondents.

Figure 32: Stakeholders to involve in setting joint long-term agenda's



Notes: Question: "In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives - Setting joint long-term agenda with strong involvement of:"

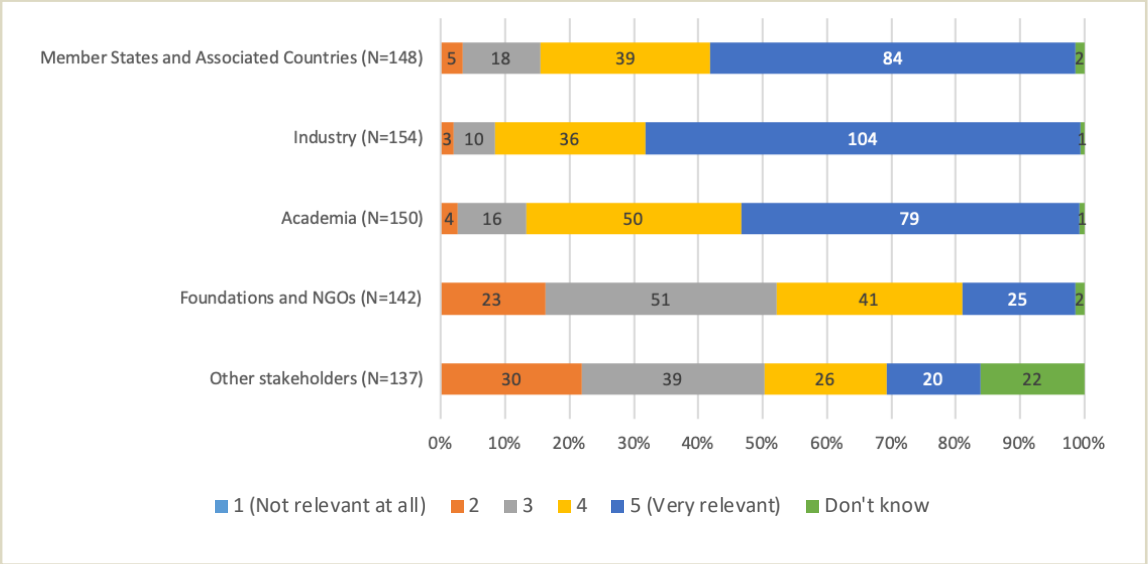
Relevance of elements and activities in pooling and leveraging resources

Respondents were asked to assess the relevance of different actors in pooling and leveraging resources, such as financial, infrastructure, in-kind expertise etc.), to meet Partnership objectives. The pattern of responses on this question is similar to the above-listed question. The role of industry is considered high, as 104 respondents out of 154

(67.53%) indicated that their involvement is very relevant for above-listed purpose, while involvement of foundations, NGOs and other stakeholders is seen as less important by respondents. See Figure 33.

A slight statistical differences were found between the views of citizens and other respondents., citizens indicate that academia are slightly less relevant. Similarly, Respondents that are/were involved in a current/preceding partnership indicate a slightly higher relevance of industry.

Figure 33: Relevance of actors for pooling and leveraging resources



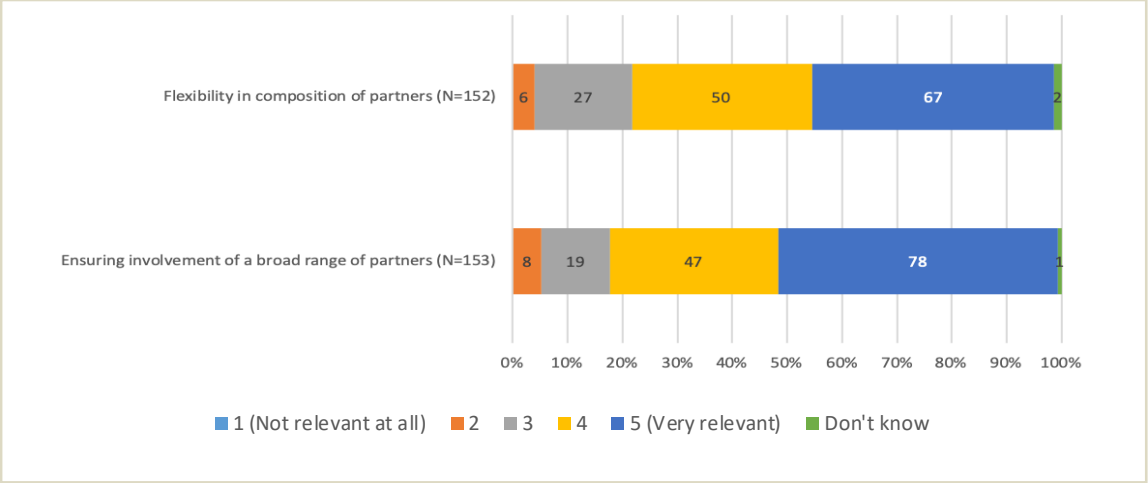
Notes: Question: "In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives – Pooling and leveraging resources (financial, infrastructure, in-kind expertise, etc.) through coordination, alignment and integration with:"

Relevance of elements and activities for the partnership composition

Respondents were asked about the relevance of Partnership composition, such as flexibility in the composition of partners over time and involvement of a broad range of partners (including across disciplines and sectors), to reach objectives of the Key Digital Technologies Partnership. As illustrated in Figure 34, the distribution of responses is similar across two answer categories. Over 77% of respondents view that flexibility in the composition of partners over time and involvement of a broad range of partners is relevant by giving a score 4 and 5 on the indicated scale. However, the involvement of a broad range of partners is considered relevant by a slightly higher number of respondents.

No statistical differences were found between the views of citizens and other respondents.

Figure 34: Relevant principles for the partnership composition

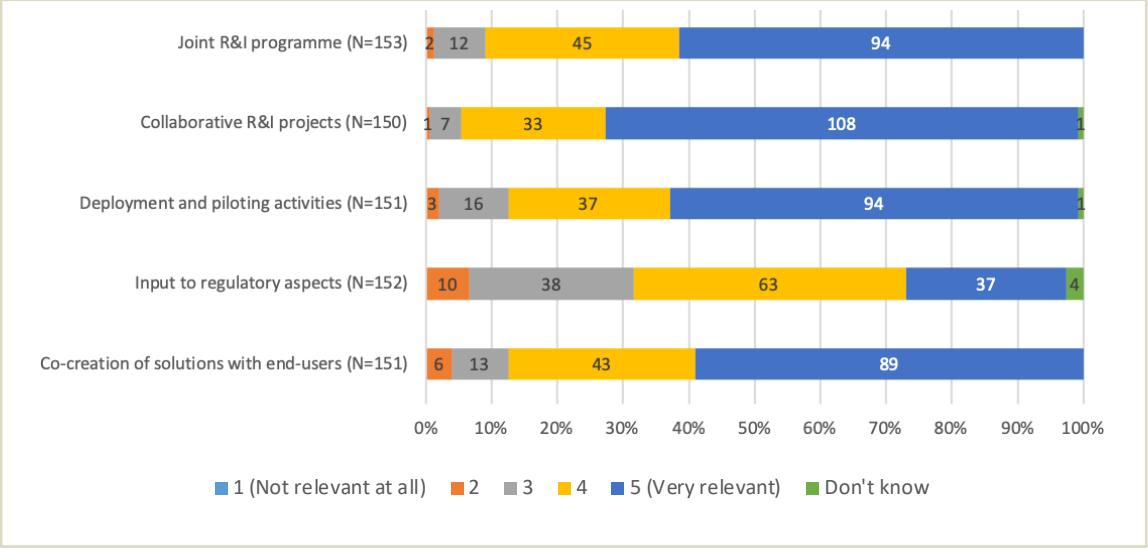


Relevance of implementation of activities

Respondents were asked to provide opinions on relevance of implementation of several activities for meeting objectives of the Key Digital Technologies Partnership. According to Figure 35, there are small differences in the distribution of responses across activities. Over 85% of respondents assessed listed activities as relevant, giving a score of 4 and 5 on the proposed scale. However, the least number of respondents, namely 37 out 152 (24.34%) consider the input to regulatory aspects very relevant for meeting objectives of the Key Digital Technologies Partnership.

No statistical differences were found between the views of citizens and other respondents. Respondents that are/were involved in a current/preceding partnership indicate a slightly higher relevance of collaborative R&I projects.

Figure 35: Relevance of activities to implement



Notes: Question: "In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives – Implementing the following activities"

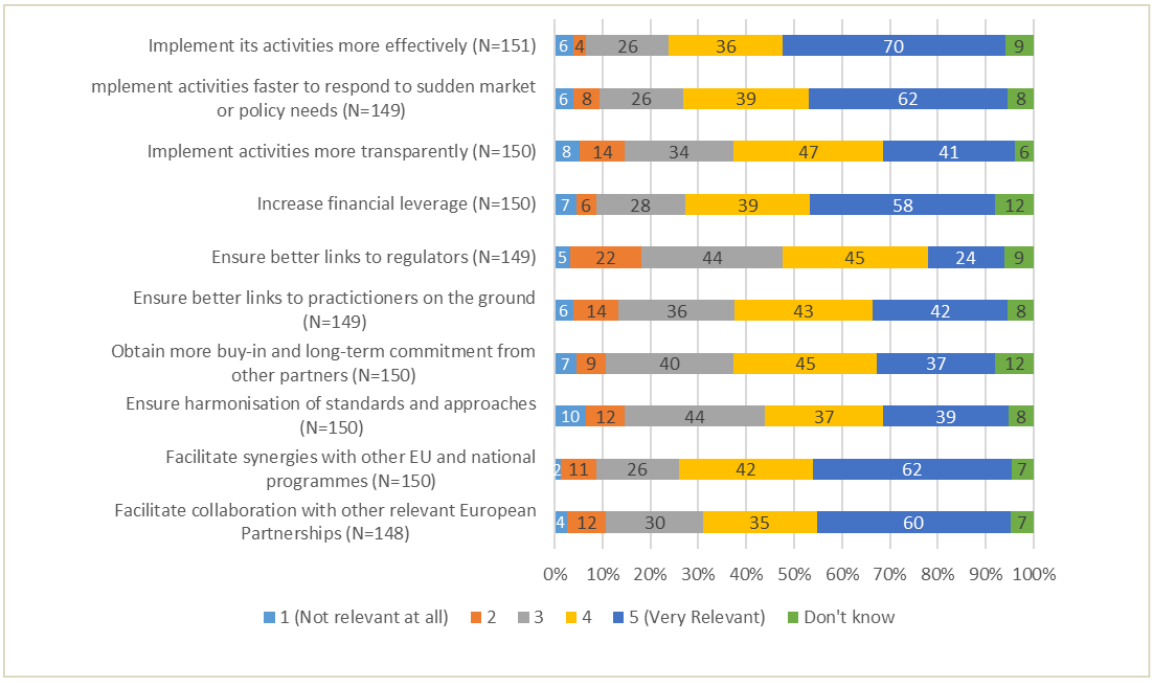
B.6.8 Relevance of setting up a legal structure (funding body) for the candidate European Partnerships to achieve improvements

Respondents were asked to assess the relevance of a specific legal structure (funding body) for the candidate European Partnership to achieve several objectives. According to

Figure 36, a higher number of respondents (70 out of 151 or 46.36%) suggest that the legal structure would be very relevant for implementing activities more effectively. Other objectives, such as implement activities faster to respond to sudden market or policy needs, facilitate synergies with other EU and national programmes and facilitate collaboration with other relevant European Partnership, also can benefit from the legal structure, according to a higher number of respondents. The least number of respondents, namely 24 (16.11%), indicated that the legal structure would be very relevant to ensure better links to regulators.

No statistical differences were found between the views of citizens and other respondents. Respondents that are/were involved in a current/preceding partnership indicate a slightly higher relevance of legal structure to facilitate collaboration with other relevant European Partnerships.

Figure 36: Relevance of setting up a legal structure (funding body)



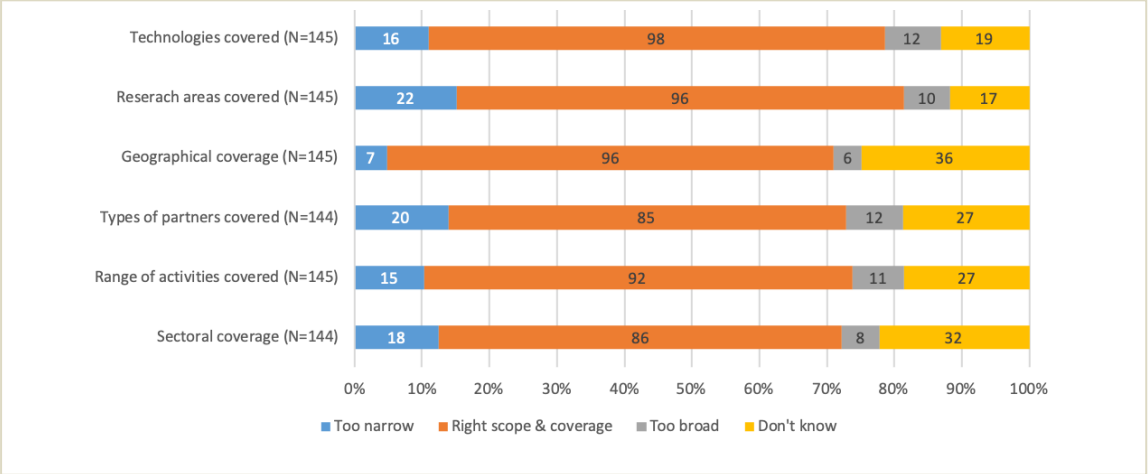
Notes: Question: "In your view, how relevant is to set up a specific legal structure (funding body) for the candidate European Partnership to achieve the following?"

B.6.9 Scope and coverage of the candidate European Partnerships based on their inception impact assessments

Respondents were asked to assess the scope and coverage of the proposed Key Digital Technology Partnership, based on its inception impact assessment. Overall, the majority of respondents consider that the scope and coverage are right in terms of technologies, research areas, geographical coverage, types of partners, range of activities and sectors. However, the number of respondents that consider it too narrow is slightly higher for the categories – research areas covered and type of partners covered, 22 (15.17%) and 20 (13.89%) respectively.

No statistical differences were found between the views of citizens and other respondents.

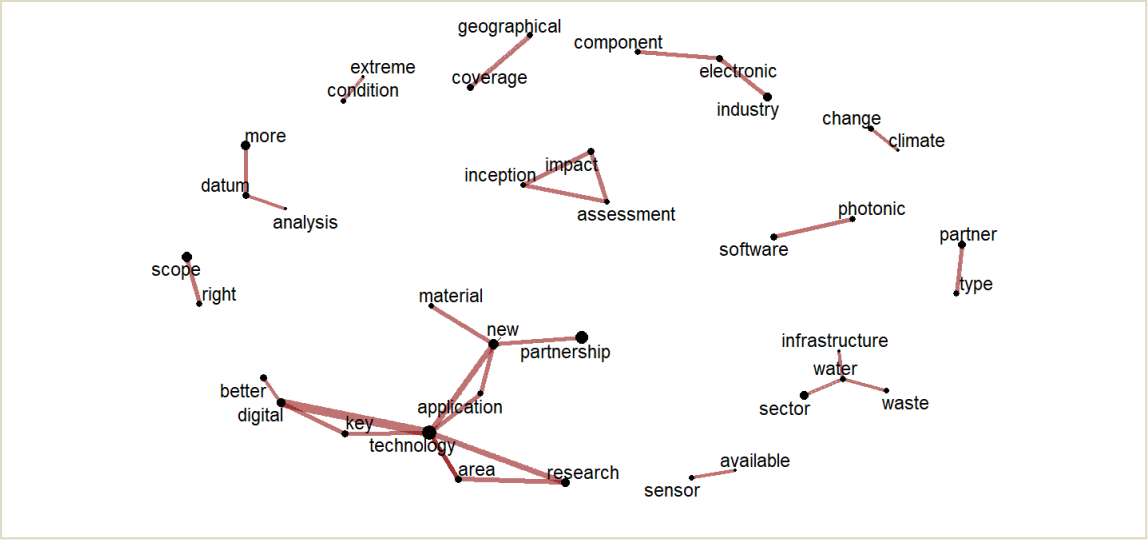
Figure 37: Scope and coverage proposed for the institutionalised Partnership



Notes: Question: "What is your view on the scope and coverage proposed for this candidate institutionalised European Partnership, based on its inception impact assessment?"

Aside from this multiple choice question, the respondents were also asked to provide any comment that they may have on the proposed scope and coverage for this candidate Institutionalised Partnership. The keyword analysis used for open questions resulted in the graph shown in Figure 38. This analysis showed the respondents used this question to talk about inception impact assessments, new technology and research and technology.

Figure 38: Scope and coverage proposed for the institutionalised Partnership – open question (N=40)



Notes: 30 most common co-occurring keywords

Not all participants were familiar with the anticipated scope of the proposed initiative. Some interviewees admitted to not being fully aware of the geographical coverage of the Partnership, and respondents from Norway and Switzerland advocated for the inclusion of the EFTA countries. In terms of content, the majority of respondents argued for a KTD partnership based on the ECSEL model with the addition of some features, especially in the fields of photonics and AI. It was for example highlighted by an SME representative that "experience from ECSEL has illustrated a need to extend R&I efforts to related aspects of photonics and software, advanced computing technologies". This opinion was shared by

several research and academic institutions who recommended an inclusion of software technology as a core area in the KDT portfolio. In fact, one respondent from a large company found the initiative to be "too focused on the interests of the electronics industry" and too narrow to "embrace the wide spectrum of Key Digital Technologies (i.e. Big Data, AI, Software, etc)". Among the observations by public authorities and NGO's was the need to include transport automatization in the scope of the KTD partnership especially regarding the automatization and transformation of transport.

B.6.10 Scope for rationalisation and alignment of candidate European Partnerships with other initiatives

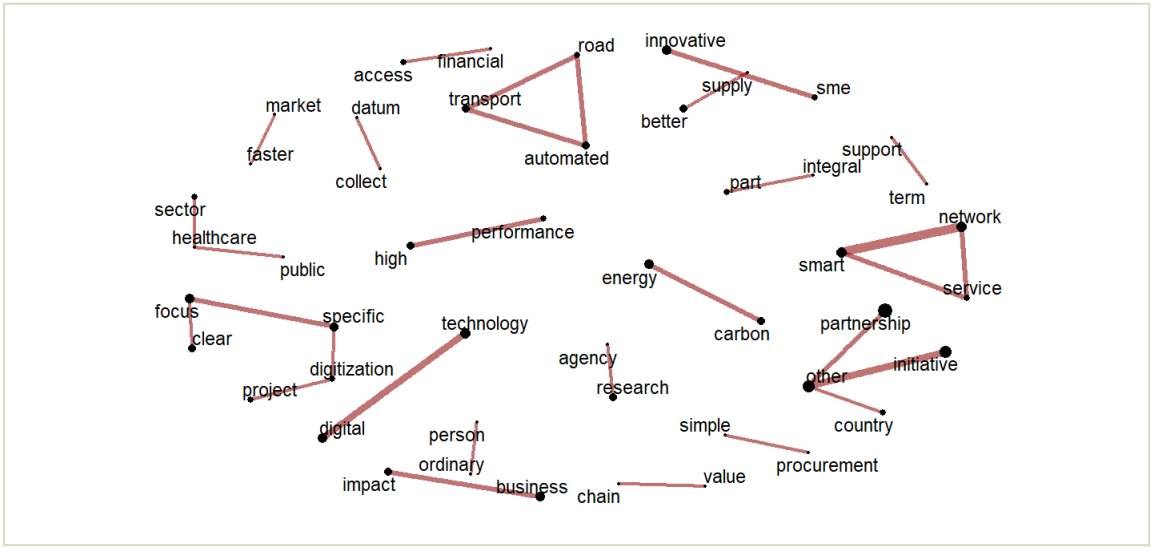
Respondents were asked a question - "would it be possible to rationalise the candidate European Institutionalised Partnership and its activities, and/or to better link it with other comparable initiatives?". According to majority of respondents (100 respondents or 76.34%), it would be possible to rationalise the Key Digital Technologies and its activities and to link it to other initiatives.

No statistical differences were found between the views of citizens and other respondents.

The respondents who answered affirmative, where asked which other comparable initiatives it could be linked with. The results of the analysis resulted in the chart shown in

Figure 39 showing the co-occurrences of keywords. The results show that respondents mention digital technology, automated road transport and smart service networks as well as other initiatives.

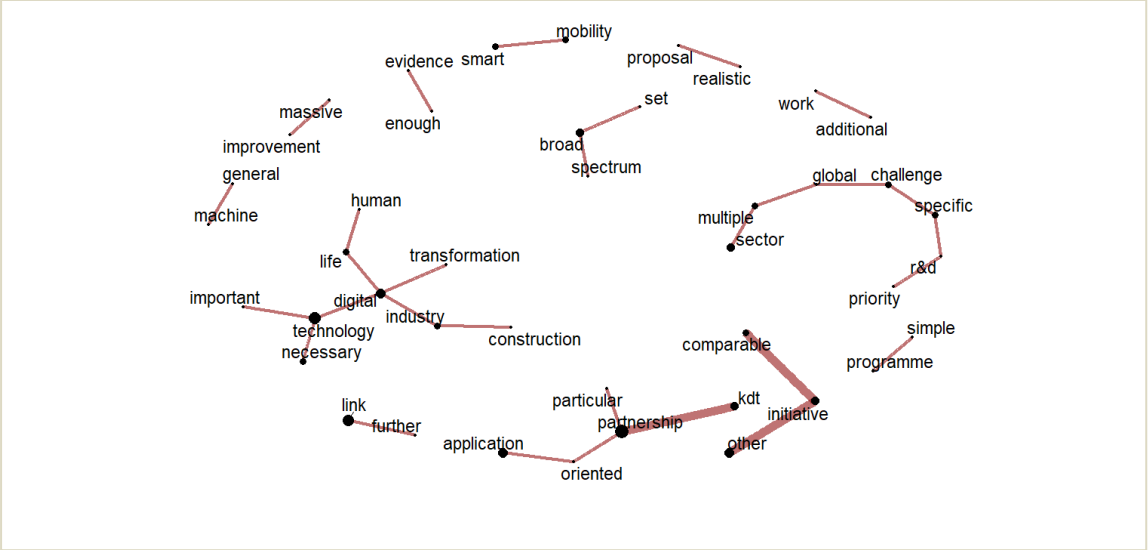
Figure 39: Comparable initiatives to link with the partnership (N=55)



Notes: Open question: "Which other comparable initiatives could the partnership be linked with?"; 30 most common co-occurring keywords

For the respondents who answered negatively on the previous question, the results of the analysis resulted in the chart shown in Figure 40showing the co-occurrences of keywords. The results show that respondents mention other comparable initiatives, transformation of digital technology and smart mobility.

Figure 40: Other comparable initiatives – open question (N=16)



Notes: Open question: "why other comparable initiatives are not suitable to be linked"; 30 most common co-occurring keywords

The majority of respondents answered that it would be in the initiative's best interest to rationalize and be as complementary as possible with other initiatives. It was commented among company members, that linking with other sectors such as health (Innovative Health Initiative) and transport (SESAR, Shift2Rail, etc) would increase business impact. One large company argued that "there must be strong coordination with other domains such as HPC and Smart Networks, while remaining permeable to requirements of vertical sectors". Some respondents see the inception of this new KDT initiative also as a possibility to enhance the link to other initiatives outside of the digital field; this is for example the case of one large corporation, who pointed out that several initiatives, such as the Innovative Health Initiative or the Automated Road Transport, will benefit from this by getting access to advanced European digital technologies". In the public sphere, two national authorities suggested further coordination with Eureka clusters in the likes of ITEA, PENTA and other photonics initiatives.

There were, however, many arguments raised against the rationalisation of the KDT initiative. For some respondents, the already broad nature of Key Digital Technologies is a guarantee of a large portfolio involving actors from different sectors. One large company feared that "rationalizing would create overlaps and complexities in defining specific R&D priorities". Indeed, an excessive range of competencies is seen by many as contradictory with the objective of increasing efficiency. For academia members, there must be a delicate balance between focus in specific areas and a broad approach, which could be undermined due to linkages with other initiatives. An individual EU citizen stated pointed out that "the Institutionalised Partnership is already being rationalised by the extension of coverage beyond ECSEL. Further rationalisation would result in significant dilution of an action which is essential for the future digital autonomy of Europe".

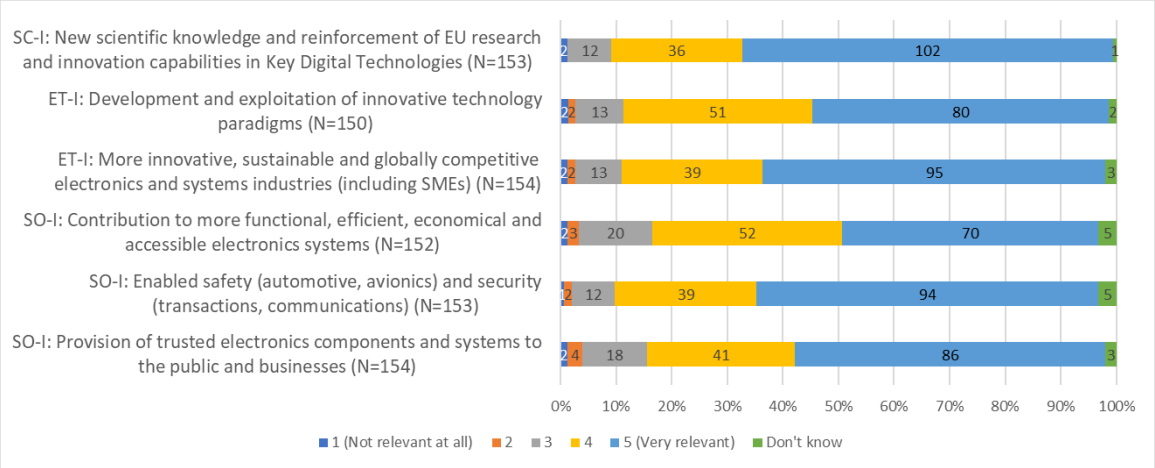
B.6.11 Relevance of European Partnerships to deliver targeted scientific, economic/technological and societal impacts

Respondents were asked to assess the relevance of the candidate European Institutionalised Partnership to deliver on listed impacts. Based on Figure 41, there are many similarities among responses of open public consultation participants. With exception of the category "contribution to more functional, efficient, economical and accessible electronics systems", at least a half of respondents indicated that the candidate Partnership

would be 'very relevant' for delivering on presented societal, economic/technological and scientific impacts. A slightly higher number of respondents, namely 102 out of 153 (66.66%), indicated that the Partnership would be 'very relevant' for generating new scientific knowledge and reinforcing EU research and innovative capabilities in Key Digital Technologies.

No statistical differences were found between the views of citizens and other respondents.

Figure 41: Relevance of the candidate European Institutionalised Partnership to various impacts



Notes: Question: "In your view, how relevant is it for the candidate European Institutionalised Partnership to deliver on the following impacts?"

B.6.12 Summary of campaigns results for this specific initiative

The current candidate Partnership received 12 similar responses, which are treated as a campaign (campaign #10).

Table 26: Overview of responses of campaign participants (N=12)

Question category	Summary of responses
Research and innovation problems	All categories are considered mostly 'very relevant' (score 5).
Structural and resource problems	The categories "Limited availability of testbeds for novel computing components and systems" and "Sky-rocketing costs of equipment" are considered 'relevant' (score 4) and 'very relevant' (score 5). In contrast, "Limited collaboration and pooling of resources between Member States, European Commission, Industry and Research organisations (Universities, RTOs)" received an average score.
Problems in uptake of digital innovations	The category "Insufficient market size or inappropriate business models" is considered 'relevant', while other categories in this group of questions received a low score (namely, 2 and 3).

Question category	Summary of responses
Preferred Horizon Europe intervention	Institutionalised Partnership was selected by all respondents. When respondents were asked to explain their choice, all of them used the following quote: *"Only an institutionalised European Partnership based on Article 187 TFEU will bring together the critical mass of public and private resources needed to ensure Europe's competitiveness, sovereignty and autonomy in the strategic domain of KDT and act on the basis of an industry-driven, truly pan-European common strategy. A JU will create a long-term dedicated implementing structure representing the deepest level of integration, engagement and up-front commitment from public and private partners".*
Relevance of actors for setting join long-term agenda	Involvement of Member States and Associated Countries, Industry and Academic is considered 'very relevant' by all respondents, while other categories received a low score (namely, 2 or 3).
Relevance of actors for pooling and leveraging resources	Involvement of Member States and Associated Countries, Industry and Academic is considered 'very relevant' by almost all respondents, while other categories received a low score (namely, 2 or 3).
Partnership composition	Mostly low score (on average, 3) on both answer categories ("Flexibility in the composition of partners over time" and "Involvement of a broad range of partners, including across disciplines and sectors").
Implementation of activities	Joint R&I programme, collaboration R&D projects and deployment, piloting activities, and co-creation of solutions with end-users are considered 'very relevant' and 'relevant' by most respondents. In contrast, "input to regulatory aspects" received a low score.
Relevance of the legal structure	Most answer categories received a high score with exception of "ensure better links to regulators", "ensure better links to practitioners on the ground" and "ensure harmonisation of standards and approaches".
Scope and coverage of the candidate Partnership	Almost all respondents considered that listed components of the candidate Partnership have right scope and coverage. Respondents were offered an opportunity to provide comments on the proposed scope and coverage of the Institutionalised Partnership. Several of them included the following quote: *"Experience from ECSEL has illustrated a need to extend R&I efforts to related aspects of photonics and software, advanced computing technologies (such as neuromorphic computing and edge computing), biosensors and flexible electronics, all of which are featuring increasingly in the digital transformation of the economy and society and now need to be co-integrated to build complex systems and open up new avenues of application".*

Question category	Summary of responses
Rationalisation of the candidate Partnership and linking to other initiatives	Respondents consider that it would not be possible to rationalise the candidate Partnership and its activities, and/or to better link it with other comparable initiatives. Respondents were asked to explain their answer, most of them inserted a following quote: *"The technologies of the KDT partnership and their applications will be key in addressing multiple global challenges such as transport & smart mobility, health & wellbeing, energy, digital industry and digital life, as well as driving the digital transformation of multiple sectors of Europe's economy and society. Whereas the KDT partnership will collaborate closely with comparable initiatives focusing on one specific challenge or sector, it cannot be linked or merged with only one of them".*
Societal impact	Almost all respondents considered that the candidate Partnership would be 'very relevant' to deliver on listed impacts.
Economic/technological impact	Almost all respondents considered that the candidate Partnership would be 'very relevant' to deliver on listed impacts.
Scientific impact	All respondents considered that the candidate Partnership would be 'very relevant' to deliver on listed impacts.

Appendix C Methodological Annex

The Impact Assessment studies for all 13 candidate institutionalised European Partnerships mobilised a mix of qualitative and quantitative data collection and analysis methods. These methods range from desk research and interviews to the analysis of the responses to the Open Consultation, stakeholder analysis and composition/portfolio analysis, bibliometrics/patent analysis and social network analysis, and a cost-effectiveness analysis.

The first step in the impact assessment studies consisted in the definition of the context and the problems that the candidate partnerships are expected to solve in the medium term or long run. The main data source in this respect was desk research. The Impact Assessment Study Teams went through grey and academic literature to identify the main challenges in the scientific and technologic fields and in the economic sectors relevant for their candidate partnerships. The review of official documentations, especially from the European Commission, additionally helped understand the main EU policy proprieties that the initiatives under assessment could contribute to achieve.

Almost no candidate institutionalised European Partnership is intended to emerge ex nihilo. Partnerships already existed under Horizon 2020 and will precede those proposed by the European Commission. In the assessment of the problems to address, the Impact Assessment Study Teams therefore considered the achievements of these ongoing partnerships, their challenges and the lessons that should be drawn for the future ones. For that purpose, they reviewed carefully the documents in relation to the preceding partnerships, especially their (midterm) evaluations conducted. The bibliography in Appendix A gives a comprehensive overview of the documents and literature reviewed for the present impact assessment study.

Finally, the description of the context of the candidate institutionalised European Partnerships required a good understanding of the corresponding research and innovation systems and their outputs already measured. The European Commission services and, where needed the ongoing Joint Undertakings or implementation bodies of the partnerships under Article 185 of the TFEU, provided data on the projects that they funded and their participants. These data served as basis for descriptive statistic of the numbers of projects and their respective levels of funding, the type of organisations participating (e.g. universities, RTOs, large enterprises, SMEs, public administrations, NGOs, etc.) and how the funding was distributed across them. Special attention was given to the countries (and groups of countries, such as EU, Associated Countries, EU13 or EU15) and to the industrial sectors, where relevant. The sectoral analysis required enriching the eCORDA data received from the European Commission services with sector information extracted from ORBIS. We used the NACE codification up to level 2. These data enabled identified the main and, where possible, emerging actors in the relevant systems, i.e. the organisations, countries and sectors that will need to be involved (further) in the future partnerships.

The horizontal teams also conducted a Social Network Analysis using the same data. It consisted in mapping the collaboration between the participants in the projects funded under the ongoing European partnerships. This analysis revealed which actors – broken down per type of stakeholders or per industrial sector – collaborate the most often together, and those that are therefore the most central to the relevant research and innovation systems.

The data provided by the European Commission finally served a bibliometric analysis aimed at measuring the outputs (patents and scientific publications) of the currently EU-funded research and innovation projects. A complementary analysis of the Scopus data enabled to determine the position and excellence of the European Union on the international scene,

and identify who its main competitors are, and whether the European research and innovation is leading, following or lagging behind.

All together, these statistical analyses will complement the desk research for a comprehensive definition of the context in which the candidate institutionalised European Partnerships are intended to be implemented. The conclusions drawn on their basis will be confronted to the views of experts and stakeholders collected via three means:

- The comments to the inception impact assessments of the individual candidate institutionalised European partnerships received in August 2019
- The open public consultation organised by the European Commission from September to November 2019
- The interviews (up to 50) conducted by each impact assessment study team conducted between August 2019 and January 2020.

For instance, in all three exercises, the respondents were asked to reflect on the main challenges that the candidate institutionalised European Partnerships should address. In the open public consultations, they mainly reacted to proposals from the European Commission like when they were given to opportunity to give feedback to the inception impact assessment.

The views of stakeholders (and experts) were particularly important for determining the basic functionalities that the future partnerships need to demonstrate to achieve their objectives as well as their most anticipated scientific, economic and technological, and societal impacts. The interviews allowed more flexibility to ask the respondents to reflect about the different types of European Partnerships. Furthermore, as a method for targeted consultation, it was used to get insights from the actors that both the Study Teams and the European Commission were deemed the most relevant. For the comparative assessment of impacts, the Study Teams confronted the outcomes of the different stakeholder consultation exercises to each other with a view of increasing the validity of their conclusions, in line with the principles of triangulation. Appendix B includes also the main outcomes of these three stakeholder consultation exercises.

The comparison of different options for European partnerships additionally relied on a cost-effectiveness analysis. When it comes to research and innovation programmes, the identification of costs and benefits should primarily be aimed at identifying the "value for money" of devoting resources from the EU (and Member States) budget to specific initiatives. Based on desk research and consultation with the European Commission services, the horizontal study team produced financial estimates for different types of costs (preparation and setup costs, running costs and winding down costs) and per partnership option. The costs were common to all candidate European Partnerships. The results of the cost model were displayed in a table, where each cost was translated on a scale using "+" in order to ease the comparison between the partnership options.

A scorecard analysis, which allocated each option a score between 1 and 3 against selected variables, was used to highlight those options that stand out as not being dominated by any of the other options in the group: such options are then retained as the preferential ones in the remainder of our analysis. It also allowed for easy visualisation of the pros and cons of alternative options.

Appendix D Additional information on the trends challenges and policy context

D.1 Emerging challenges in the field

This section analyses the challenges, problems and opportunities in the area of KDT up to 2030 based on desk research and input received from interviews and the public consultation.

Social trends and challenges

The ageing of the European population increases stress on already stretched health budgets, services and infrastructures, thereby changing the needs for digital services and impacting the production infrastructure. New approaches in electronics components, software and systems could be the base for developing new solutions and services contributing to increases in the productivity, efficiency and quality of health services, thereby helping to maintain high living standards in Europe. Furthermore, developing solutions for dealing with the challenge now also gives Europe an advantage over other regions that are expected to face similar challenges in the future.

Due to increased urbanisation, challenges such as pollution and traffic management are on the rise, which calls for new approaches to energy transport, mobility and energy management.[66] Urban environments and smart cities will require reliable, highly secure, energy efficient and seamless transportation modes. As a consequence of urbanisation and increased instrumentation and interconnection, cities will gain 'intelligence' and become more in control.[67] Shifts towards multimodality in transportation and autonomous driving, mobility and logistics require physical infrastructures to provide digital services to facilitate everyday mobility, traffic management and safety, which in turn puts pressure on the availability of components, ES and system integration.

Technological trends and challenges

Digital transformation of the economy and society generates an exponential demand for data exchange, which the existing infrastructures in several cases are unable to manage in a trusted and energy efficient manner. **AI**, a driver in digital transformation, affects all industrial sectors and several application areas (e.g. autonomous driving, applications, next-generation robotics, personalised healthcare, cybersecurity, energy). AI and IoT necessitates new **computing architectures**, software and advanced semiconductor technologies addressing the insatiable need to transfer, store and analyse vast amounts of data locally and with very low energy consumption. More specifically, AI-related semiconductors could reach a growth of around 18% annually over the next few years, five times greater than the rate for semiconductors used in non-AI applications. AI-related semiconductors could account for almost 20% of all demand by 2025, raising revenues of around €60 billion.[68]

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[66] ERTRAC. (2017). *Integrated Urban Mobility Roadmap*, Joint ERTRAC-ERRAC-ALICE Working Group on Urban Mobility, available at https://www.ertrac.org/uploads/documentsearch/id45/2017%20ERTRAC%20Urban%20Mobility%20Roadmap%20-%20web.pdf.

[67] Picasso. (2016). *Public Report – Revised Panorama of ICT landscape in EU and US: ICT, policies, regulations, programmes and networks in the EU and US*, available at http://www.picasso-project.eu/wp-content/uploads/2017/03/PICASSO-Panorama-of-ICT-landscape-in-EU-and-US-public-version.pdf.

[68] McKinsey & Company. (2019). *Artificial Intelligence Hardware: New opportunities for semiconductors companies*, available at https://www.mckinsey.com/industries/semiconductors/our-insights/artificial-intelligence-hardware-new-opportunities-for-semiconductor-companies; European Commission. (2018).

The KDT area's relevance to developments in the area of big data and **new computing paradigms** was stressed by 78% of respondents in the public consultation. Driven by the need for a new generation of distributed/edge computing serving AI, new computing paradigms emerge such as **neuromorphic/quantum computing** accelerators and complex integration. Neuromorphic engineering brings together biology, physics, mathematics, computer science and electronic engineering to design artificial neural systems, such as vision system, auditory processors and autonomous robots. The same technology trend also serves centralised computing for the cloud (HPC). Quantum computing offers a steep change in processing capability and especially in addressing 'exponential' problems and searching through gigantic databases. The ECS industry needs to explore the quantum effects in electronic components, such as sensors, and make quantum technologies manufacturable.

Photonics and **software** are increasingly co-integrated with chip-level ECS to build complex systems and integrated platforms as well as to open up new areas of applications. Photonics, and especially light-based technologies, have the capacity to create smaller, cheaper and faster devices, and are increasingly used in several sectors, spanning healthcare (needle-free testing for diseases), secure 5G communications, self-driving vehicles, food safety tests for pathogens and environment monitoring on earth and from space.[69]Among the various areas of photonics, **silicon photonics**, in which the optical and electronic components are integrated onto a single microchip, has the closest relation with ECS.

Mastering complex European electronic value chains increasingly requires the pairing of **software** as a KDT along the microelectronics chain. While hardware and software parts are becoming increasingly hard to dissociate, there is a need for different software layers to be integrated across electronic value chains: at the hardware-level, ES will be needed to ensure that systems integrating various electronics components have high levels of security, energy efficiency and performance. The middleware-level necessitates **PS**[70] to facilitate the interoperability of systems integration, for instance for IoT systems such as smart city, smart mobility and e-health. In order to address the needs for seamless human/machine interaction, **IS** will be increasingly required at the functional level, e.g. for pattern recognition and digital representations.

The risk of failure associated with new technologies is high and the necessary critical mass for financial and human resources exceeds the capacity of individual companies or countries. The speed of reaction and time are also of the essence.

Economic trends and challenges

The ECS value chain, including micro- and nanoelectronics, semiconductors, IoT, software, photonics and AI, has become a strategic technology market with significant impact on the economy. The size of the worldwide **electronics value chain,** including downstream industries, is enormous, estimated at around €52.6 trillion in 2018. The microelectronics segments were estimated at €4.1 trillion in 2018 and are expected to reach €5.7 trillion by

Boosting Electronics Value Chains in Europe, A report to Commissioner Gabriel, available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53119.

[69] SciTech Europa. (2019). *Photonics PPP: Positive outlook with 5-fold leverage on EU investment*, available at https://www.scitecheuropa.eu/photonics-ppp-5-fold-leverage-on-eu-investment/96454.

[70] NESSI. (2017). *Strategic Research and Innovation Agenda*, available at http://www.nessi-europe.com/files/NESSI_SRIA_2017_issue_1.pdf.

2025, experiencing a CAGR of 5%.[71] Already by 2020, more than 50% of European GDP will be driven by the ECS industry.[72] Furthermore, the market for AI-related semiconductors is expected to grow from €5.5 billion in 2018, to €27 billion by 2022.[73,74] IoT provides further opportunities, with a market forecast for IoT semiconductor spending of €30 billion in 2020.[75]

Software and solutions will outgrow hardware and electronic parts in such application areas as mobility, healthcare, energy, industry and digital life. The market related to SoS and solutions, which is driven largely by software content, is foreseen to experience a tenfold growth from 2016 to 2025 reaching between €3.9 and €11.1 billion.[76] The automotive market's demand for software and electrical and electronic components is anticipated to outpace the overall automotive market's growth rate. While automotive sales are estimated to grow at a CAGR of 3%, software (functions, OS, middleware) has a projected 9% CAGR for the period of 2020-2030.[77] In the healthcare segment, the growth forecast for global mHealth services and devices markets (such as wearables) – with strong software underpinnings – is around 30-40% per annum over the next five years. Similarly, the European smart grid market is foreseen to grow by around 9% on a yearly basis until 2025.[78]

Sectors with a high intensity of microelectronics are the automotive and industrial electronics. The microelectronics component is expected to grow annually (CAGR) between 2017 and 2022 by 7.7% and 7.1% respectively.[79] Other sectors with projected growth are logistics, energy, communications, aerospace, defence and security as well as the smart city, healthcare and consumer markets, with major applications for IoT at home as well as wearables.

For the ECS value chain, **high investments** are needed to keep up with global competition. The semiconductor industry alone ranks among the highest of all industry sectors when it comes to investment levels, in particular due to the constant updating of production

[71] European Commission. (2019). *Study on the Electronics Ecosystem: Overview, developments and Europe's position in the world*. Final Report. SMART 2016/0007; Advancy (2019). *Embedded Intelligence: Trends and challenges*. Commissioned by ARTEMIS-IA, available at ARTEMIS-IA: https://artemis-ia.eu/news/embedded-intelligence-trends-challenges-book-release.html.

[72] ECSEL JU. (2018). *A vision for electronics*, available at https://www.ecsel.eu/sites/default/files/2018-10/Binspired%20-%20A%20vision%20for%20electronics.pdf.

[73] Tractica. (2017). *Artificial Intelligence Market Forecasts*, available at https://www.tractica.com/wp-content/uploads/2017/04/MD-AIMF-2Q17-Executive-Summary.pdf.

[74] PwC. (2019). *Opportunities for the global semiconductor market*, available at https://www.pwc.com/gx/en/industries/tmt/publications/global-tmt-semiconductor-report-2019.html.

[75] Deloitte. (2018). *IoT opportunity in the world of semiconductor companies*, available at https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology/us-semiconductor-internet-of-things.pdf.

[76] Advancy (2019). *Embedded Intelligence: Trends and challenges*. Commissioned by ARTEMIS-IA, from ARTEMIS-IA: https://artemis-ia.eu/news/embedded-intelligence-trends-challenges-book-release.html.

[77] McKinsey & Company. (2019). *Automotive software and electronics 2030. Mapping the sector's future landscape*, available at https://www.mckinsey.com/~/media/McKinsey/Industries/Automotive%20and%20Assembly/Our%20Insights/Mapping%20the%20automotive%20software%20and%20electronics%20landscape%20through%202030/Automotive-software-and-electronics-2030-vF.ashx.

[78] Advancy. (2019). *Embedded Intelligence: Trends and challenges*. Commissioned by ARTEMIS-IA, from ARTEMIS-IA: https://artemis-ia.eu/news/embedded-intelligence-trends-challenges-book-release.html.

[79] European Commission. (2018). *Boosting Electronics Value Chains in Europe*, available at https://ec.europa.eu/digital-single-market/en/news/boosting-electronics-value-chains-europe.

equipment and the high capital and R&D&I investments. Investments in innovation and R&D focuses mainly on the continuation of Moore's Law and even generating 'More Moore'. R&D investments could be as high as 15% of revenues on average; in some ECS segments it could reach 20-25%. At the same time, the interdisciplinary character of research demands collaboration across several technological and scientific areas as well as pulling together competences across several countries.

New production technologies to maintain Moore's Law and to increase the wafer size significantly increases the required investments for new foundries: the increase follows 'Rock's Law', according to which the cost of a semiconductor chip fabrication plant doubles about every four years.[80] The costs reached approximately €12.5 billion in 2015.[81] The investment levels are in total around 15% of annual revenues in manufacturing equipment and fabrication plants. In this context, China has invested significantly in fab capacity on the basis of governmental support through the 'Made in China 2025' initiative.

The semiconductor value chain's **fragmentation and internationalisation** continue due to the:[82]

- need for cost reduction, implying that production transfers to low labour cost countries;
- migration of consumer good production to Asia pulls related semiconductor production towards Asia as well;
- high pace of technological change forces companies to focus on core competences;
- rising cost of building fabs limits companies that can afford to build new factories.

The **shortening of the innovation cycle** and the fast uptake of innovations by markets has become increasingly important; European companies need to adapt to this trend by developing capabilities to react, interact and cooperate directly on the design and production of applications. There is an increasing set of technologies that need to be considered and integrated at the various stages from design to manufacturing and distribution. It results in a **vertical shortening and integration of the value chain,** while at the same time it **expands horizontally** with an increasing number of potential partners and stronger interactions creating more complex **value creation networks.**

In relation to the above trends, the consolidation of the semiconductor industry continues with **mergers and acquisitions** at an increased pace. Examples are the acquisition of the UK-based CSR, the second-largest European fabless IC supplier, by the US-based Qualcomm in 2015, and the purchase of the Germany-based Lantiq, the third-largest European fabless IC supplier, by the US-based Intel in the same year.[83] Roughly 43% of all global chip sales were generated by five companies (i.e. Samsung, Intel, SK Hynix, Micron and Broadcom) in 2017 as a result of this trend. This share has increased by 10% compared to the previous decade.[84] Electronic and electric equipment and machinery are

[80] Fraunhofer IMW. (2018). *Global Competition in Microelectronics Industry from A European Perspective: Technology, markets and implications for industrial policy*.

[81] Armasu, L. (2015). *Samsung's New 14 Billion Chip Plant To Manufacture DRAM, Processors in 2017*, available at https://www.tomshardware.com/news/samsung-14-billion-chip-plant,29058.html.

[82] DTI. (2012). *Study on Internationalisation and Fragmentation of Value Chains and Security of Supply: Case study on semiconductors*. European Commission, DG Enterprise and Industry.

[83] IC Insights. (2019). *Research Bulletin*, March 26. Retrieved October 2019, available at http://www.icinsights.com/news/bulletins.

[84] EE Times. (2018). *The concentration of Semiconductor Market Share*, available at https://www.eetimes.com/author.asp?section_id=40&doc_id=1333179#.

among the sectors with the highest level of acquisitions in 2019. While traditional investors (such as US, Canada, EFTA-countries, Japan and South Korea) have regularly been involved in acquisitions, China has emerged since 2013.[85] There are cases where more than 50% of EU assets are controlled by companies from the afore-mentioned countries; for the manufacture of computer, electronic and optical products, the share of foreign assets was 54% in 2016.[86]

Environmental and other societal challenges

Climate change and the need to safeguard the environment are pressing challenges that cannot be solved without actions taken in the KDT value chain. On one hand, the electronic component systems industry contributes to improving energy efficiency levels (by 14% on average between 2000 and 2015). On the other hand, industry has an increasingly negative impact due to the use of non-environmentally friendly materials, for example, rare earth and the waste it creates.[87] Adopting mass customisation approaches for reducing the waste of mass-market production and approaches to increase the lifespan of electronic systems and the reuse of raw materials could be responses to the environmental challenges faced.

The combination of DKTs is considered to have the potential to deliver transformative solutions, including: autonomous and connected vehicles that may transform mobility while reducing greenhouse gas emissions; distributed energy grids that could decarbonise power grids and increase energy efficiency; intelligent, connected and liveable cities with minimal air pollution and environmental impact; and the combined use of sensors and IoT to register natural products and processes.[88]

The global trend towards electrification calls for better energy management of the grid at large. Electronic value chains are also involved in the energy management of smart buildings and the automotive sector, such as of buildings, renewables, smart grids and electric vehicles.[89]

Energy consumption is an important aspect affecting all computer systems. Firstly, supercomputers and data centres consume massive amounts of power. Secondly, mobile and IoT devices requires= a reduction in the consumption of energy in order to maximise usage of their increasingly smaller and lighter batteries. As a remedy, computer nodes have become more power efficient, but more work is needed in this area to reverse the trend.

As digitalisation affects a growing spectrum of activities, the need for security and safety increases. For devices to be secure and safe, they should neither be influenced by outsiders nor leak information without consent of the user. These issues, which are of immediate

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[85] European Commission. (2019). *Commission Staff Working Document on Foreign Direct Investment in the EU*. Following up on the Commission Communication *Welcoming Foreign Direct Investment while Protecting Essential Interests* of 13 September 2017. SWD (2019) 108 Final, available at https://ec.europa.eu/transparency/regdoc/rep/10102/2019/EN/SWD-2019-108-F1-EN-MAIN-PART-1.PDF.

[86] Ibid

[87] ECSEL JU. (2019). *Multi-Annual Strategic Plan (MASP) 2019*, available at https://ec.europa.eu/research/participants/data/ref/h2020/other/legal/jtis/ecsel-multi-stratplan-2019_en.pdf.

[88] World Economic Forum. (2018). *Harnessing Artificial Intelligence for the Earth*, available at http://www3.weforum.org/docs/Harnessing_Artificial_Intelligence_for_the_Earth_report_2018.pdf.

[89] European Commission. (2018). *Electronics Value Chains: Workshop on energy management, including electrification of cars and smart grids*, Brussels, 22 March 2018, available at http://ec.europa.eu/information_society/newsroom/image/document/2018-13/report-digitisingenergyvaluechain-workshop_0209BF3E-0D40-52CF-48B579B49BE24D96_50739.pdf.

concern for all cyber-physical and network-connected devices, need to be addressed both at software and hardware levels, including in the design (security by design) and manufacturing of ECS. The problem of processor bugs, which is well known, is becoming increasingly important due to the increased complexity of hardware, consolidation of hardware and interconnection of devices.[90]

Political, policy and regulatory framework

The influence of politics is increasing in ECS. The US uses its position in the production of semiconductors and microelectronics increasingly to serve its foreign policy agenda. To exemplify, recently Airbus and ATR, a French-Italian aircraft manufacturer, cancelled signed contracts to supply Iran Air with 100 aircraft (worth around €17 billion) due to a threat by the US to revoke their licence to use equipment including electronics produced in the US.[91] The involvement of microelectronic products in the trade war between the US and China, and the security concerns raised, serve as another example. In other cases, the US prohibits the export of critical electronic components for security reasons.

D.2 EU relative positioning

Position of Europe in fields of microelectronics and software

Europe's share of the entire ECS value chain, including related user industries and services, was estimated at €12.5 trillion in 2018, representing 24% of the world value (see also Figure 42).[92] If only ECS segments are considered, represented by the first four levels of the value chain, namely the materials and tools, components, electronic boards and electronic equipment, the European value grew from €357 billion in 2012 to €469 billion in 2017,[93] experiencing a CAGR of 5%. Given a slower growth relative to the global level, Europe's share dropped from 14% in 2012 to 12% in 2018 (Table 27). If Europe retains its share in global markets, then the value of Europe's ECS could reach €691 billion by 2025.

Europe holds a **strong position** in embedded/professional electronic components and systems for automotive, industrial equipment, aerospace/defence/security and health and care services, where it has a share of 22% of world sales (Figure 42). Europe is also well positioned in materials and tools for the production of electronic equipment (17%).[94] Europe also has a leading position in the areas of lithography (ASML is a world leader), SOI wafers (SOITEC is a key player), use of deposition technologies (ASML and AIXTRON), and in robotic wafer handling (RECIF).

However, Europe's position is rather weak in the production of stand-alone electronics, electronics boards, semiconductors and other electronic components.

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[90] HiPEAC. (2019). *HiPEAC Vision 2019*, available at https://www.hipeac.net/vision/2019.

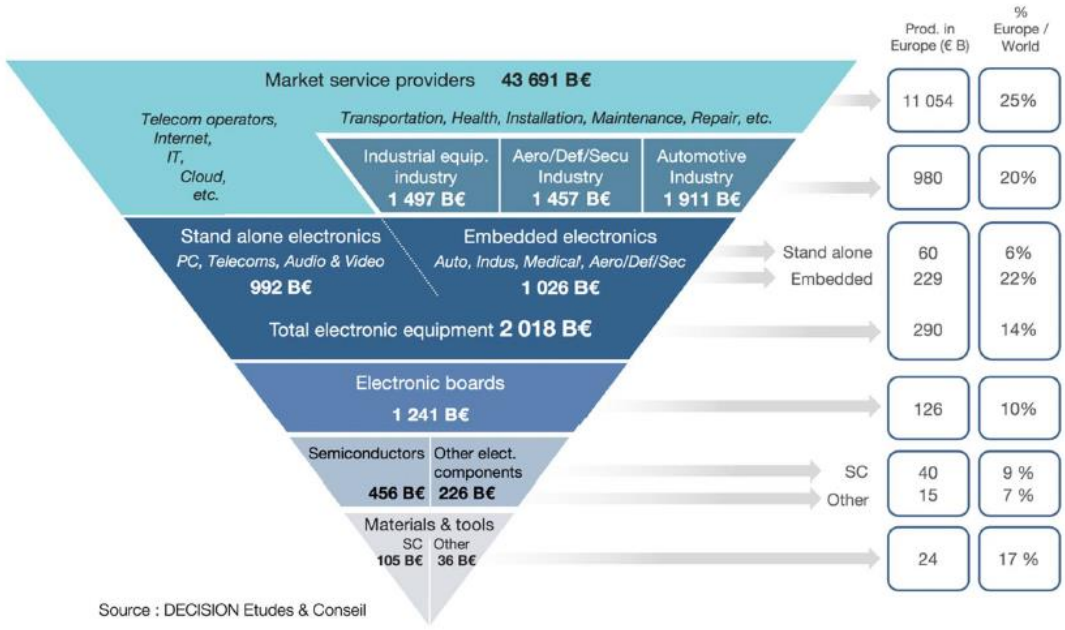
[91] E&T. (2018). *Boeing and Airbus set to lose USD39bn following Iran nuclear deal blow*, available at https://eandt.theiet.org/content/articles/2018/05/boeing-and-airbus-set-to-lose-39bn-following-iran-nuclear-deal-blow.

[92] European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems (ECS): Opportunities ahead*. SMART 2018-0005.

[93] Fraunhofer IMW. (2018). *Global Competition in Microelectronics Industry from a European Perspective: Technology, markets and implications for industrial policy*, available at https://www.imw.fraunhofer.de/content/dam/moez/de/documents/Working_Paper/180301_021_Microelectronics%20from%20a%20European%20perspective_Dornbusch_%C3%B6ffentlich.pdf

[94] European Commission. (2019). *Study on Emerging technologies in electronic components and systems (ECS) - Opportunities ahead*. SMART 2018-0005.

Figure 42: Worldwide electronics value chain and the position of Europe in 2018 – production values in euros



Source: European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems* (ECS): *Opportunities ahead*. SMART 2018-0005.

Table 27: Growth of the microelectronics value chain from 2017 to 2025 (in billion €)

	World	Europe	Europe - Share	World	Europe	Europe - Share	World - Estimations	Europe - Estimations	World - Estimations	Europe - Estimations
	2017			2018			2025		CAGR (2017-2025)	
Level 1: Materials & tools	120	21	18%	141	24	17%	200	34	7%	6%
Level 2: Components	590	49	8%	682	55	8%	800	65	4%	3%
Level 3: Electronic boards	1225	122	10%	1241	126	10%	1500	152	3%	3%
Level 4: Equipment and systems	1947	277	14%	2018	290	14%	3200	460	6%	7%
Total	**3882**	**469**	**12%**	**4082**	**495**	**12%**	**5700**	**691**	**5%**	**5%**

Source: European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems* (ECS): *Opportunities ahead*. SMART 2018-0005; Fraunhofer IMW. (2018). *Global Competition in Microelectronics Industry from a European Perspective: Technology, markets and implications for industrial policy*; Advancy. (2019). *Embedded Intelligence: Trends and challenges.* Study by Advancy, Commissioned by ARTEMIS-IA, from ARTEMIS-IA: https://artemis-ia.eu/news/embedded-intelligence-trends-challenges-book-release.html.

Europe's position in the **semiconductor** segment has declined since from 22% in 1998 to 9% in 2017.[95] Only three European companies are represented among the 15 largest semiconductor companies worldwide in 2019 (Figure 43). Despite the decline in shares in

[95] Ibid

absolute terms, Europe's sales grew with a CAGR of 3.8%, jumping from €28 billion in 2010 to €35 billion in 2017; the growth was driven primarily by demand from the embedded electronics systems.

Figure 43: Top 15 semiconductor sale leaders in 2018-2019 ($M, including founders)

1Q19 Rank	1Q18 Rank	Company	Headquarters	1Q18 Total IC	1Q18 Total O-S-D	1Q18 Tot Semi	1Q19 Total IC	1Q19 Total O-S-D	1Q19 Total Semi	1Q19/1Q18 % Change
1	2	Intel	U.S.	15,832	0	15,832	15,799	0	15,799	0%
2	1	Samsung	South Korea	18,491	910	19,401	11,992	875	12,867	-34%
3	3	TSMC (1)	Taiwan	8,473	0	8,473	7,096	0	7,096	-16%
4	4	SK Hynix	South Korea	7,996	145	8,141	5,903	120	6,023	-26%
5	5	Micron	U.S.	7,486	0	7,486	5,475	0	5,475	-27%
6	6	Broadcom Inc. (2)	U.S.	4,125	434	4,559	3,940	435	4,375	-4%
7	7	Qualcomm (2)	U.S.	3,897	0	3,897	3,722	0	3,722	-4%
8	9	TI	U.S.	3,339	227	3,566	3,199	208	3,407	-4%
9	8	Toshiba/Toshiba Memory	Japan	3,517	310	3,827	2,355	295	2,650	-31%
10	12	Infineon	Europe	1,360	907	2,267	1,352	901	2,253	-1%
11	10	Nvidia (2)	U.S.	3,108	0	3,108	2,220	0	2,220	-29%
12	11	NXP	Europe	2,033	236	2,269	1,885	209	2,094	-8%
13	13	ST	Europe	1,696	518	2,214	1,581	485	2,066	-7%
14	25	HiSilicon (2)	China	1,245	0	1,245	1,755	0	1,755	41%
15	19	Sony	Japan	200	1,335	1,535	192	1,554	1,746	14%
—	—	Top-15 Total		82,798	5,022	87,820	68,466	5,082	73,548	-16%

(1) Foundry (2) Fabless

Source: Company reports, IC Insights' *Strategic Reviews* database

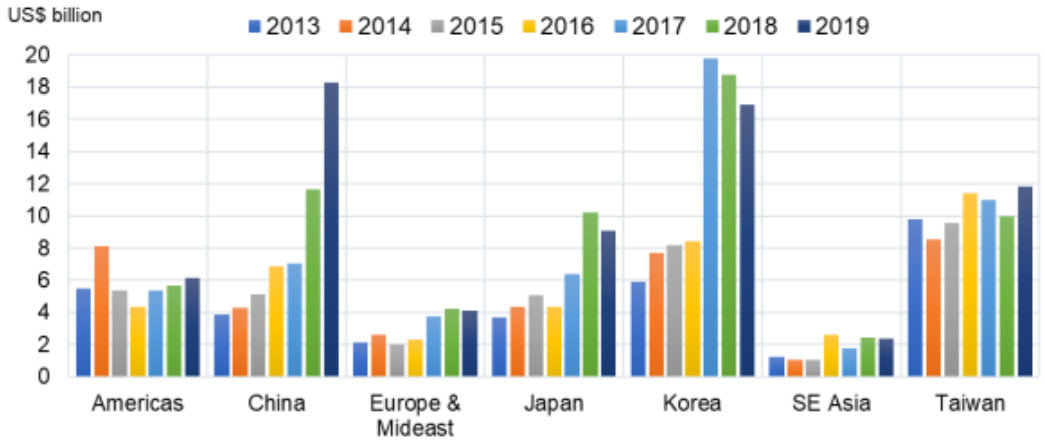
Europe's position is weak in the production of stand-alone electronics, electronics boards, processors and memory devices in the consumer domain. It also has limited capabilities to make FPGA devices. The semiconductor segment has been declining over the last 20 years, and production has gradually been outsourced to fabs based in East Asia. Europe's share is decreasing in the wafer fab capacity for IC manufacturing and it is expected to decrease from 8.1% of the world manufacturing capacity to 5.3% by 2022.[96]

Following the trend of internationalisation of the semiconductor value chain, EU semiconductor producers progressively offshored their factories outside EU or became fabless and focused production on niche markets. In terms of monthly installed capacity in 200mm equivalent, EU is the last region with only 6% of the installed global capacity in 2017.

The above trends resulted in a shift of production capacity to East Asia. This was followed by a significant increase in investments on equipment in the region (see Figure 44) often supported by government subsidies.

[96] European Commission. (2019). *Study on the Electronics Ecosystem: Overview, developments and Europe's position in the world*. Final Report. SMART 2016/0007.

Figure 44: Equipment spending by region



Source: World Fab Forecast reports (May 2018), SEMI

Although offshoring and outsourcing may be the preferred option for individual companies, this has significant implications for the ECS ecosystem, as it causes losses in human resources, industrial know-how and key equipment needed to build state-of-the-art new factories. Thus, it **puts the EU in a weak position vis-à-vis producing countries** in a period of political tension and increased protectionism.

European semiconductor companies, ST, Infineon and Bosch, are investing in building new wafer fabs (Crolles, Agrate, Graz, Dresden). However, building a state-of-the-art semiconductor factory with the necessary capacity could cost €7-15 billion, an investment that goes well beyond the capabilities of individual European companies. A more realistic option is that of an EU 'cooperative factory' involving the main EU semiconductor producers and R&D players.

In electronic equipment for **consumer mass markets,** such as mobile phones and PCs, Asian countries and the US are leaders, while Europe is leading in **downstream industry segments,** such as industrial electronics, automotive, aerospace, defence and security, and health and care electronics. The driver for Europe's success is its strong position in relevant sectors and the pivotal role of electronics in product innovation. The availability of leading-edge ECS – both hardware and software – is a key determiner behind the competitiveness of Europe's industrial domains. Approximately 80-90% of key differentiating competitive features are relying on built-in ECS, which includes an increasing role for sensors and software, according to ECSEL JU's multi-annual strategic plan 2019.[97]

The EU's **automotive electronics** sector is strong not only in production capacity but also in engineering and R&D. In terms of production, Europe is leading with 27% of global production followed by China (20%) and North America (18%). Europe is second in **industrial electronics** with 20% after China (24%) and ahead of North America (19%). In **aeronautics, defence and security electronics,** Europe comes second after the US (41%) with a strong industrial base, representing 22% of global production. Europe holds

[97] ECSEL JU. (2018). *Decision of the Governing Board of the ECSEL Joint Undertaking: ECSEL multi-annual strategic plan 2019*, ECSEL GB 2018.114, available at https://www.ecsel.eu/sites/default/files/2019-01/ECSEL%20GB%202018.114%20-%20MASP%202019%20and%20Annex%20V1.1.pdf.

third position in the **health and care** segment, with a share of 19% of global production; the US and China have shares of 40% and 20% respectively.[98]

Demand from downstream industries draw the whole European supply chain as it can be observed in Table 28. The darker area presents **ECS segments where Europe has its strongest position and with the highest spillover effects on downstream industries.** However, the diversity of applications and markets served, each with specialised characteristics, raises barriers for SMEs, especially in the area of design, packaging and testing, which have become unaffordable for European SMEs.[99]

Table 28: EU28 share of the world production of electronics for downstream industries and mass-market consumer devices – shares in 2018

Sector	Semiconductors	Electronic boards	Electronic equipment (embedded and stand-alone)	Downstream industries (auto, aerospace, etc)	Services related to end user equipment
Automotive	22%	22%	27%	20%	22%
Industrial equipment	14%	17%	20%	18%	13%
Aerospace, defence and security	15%	15%	22%	22%	19%
Health and care	20%	20%	19%		20%
Home appliances	4%	8%	17%		
Audio and video	5%	7%	11%		
Computers and data processing	4%	5%	5%		5%
Telecommunications	5%	4%	4%		18%

Source: European Commission. (2019). Study on Emerging technologies in electronic components and systems (ECS) - Opportunities ahead. SMART 2018-0005.

In terms of R&D in micro- and nanoelectronics, Europe's position is strongly powered by high investments in R&D by companies – European semiconductor companies invest, on average, 15% to 20% of their revenue in R&D – and the existence of renowned research organisations such as IMEC, Fraunhofer Institute and CEA-Leti.[100]

The US has a dominant global position in terms of associated software and digital services (i.e. the fifth level of the value chain) in support of the entire electronic value chain. Beyond legacy telecoms operators, Europe is weakly positioned with digital services players.[101] There is a gap between European companies compared to the US counterparts in R&D investments in software: US-based companies invested around €28.3 billion in R&D compared to €4.9 billion by European companies. The investment in internet and computer science was around €20.2 billion by US companies and €1.6 billion by European companies.

[98] European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems (ECS): Opportunities ahead*. SMART 2018-0005.

[99] European Commission. (2018). *Boosting Electronics Value Chains in Europe, A report to Commissioner Gabriel*, available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53119.

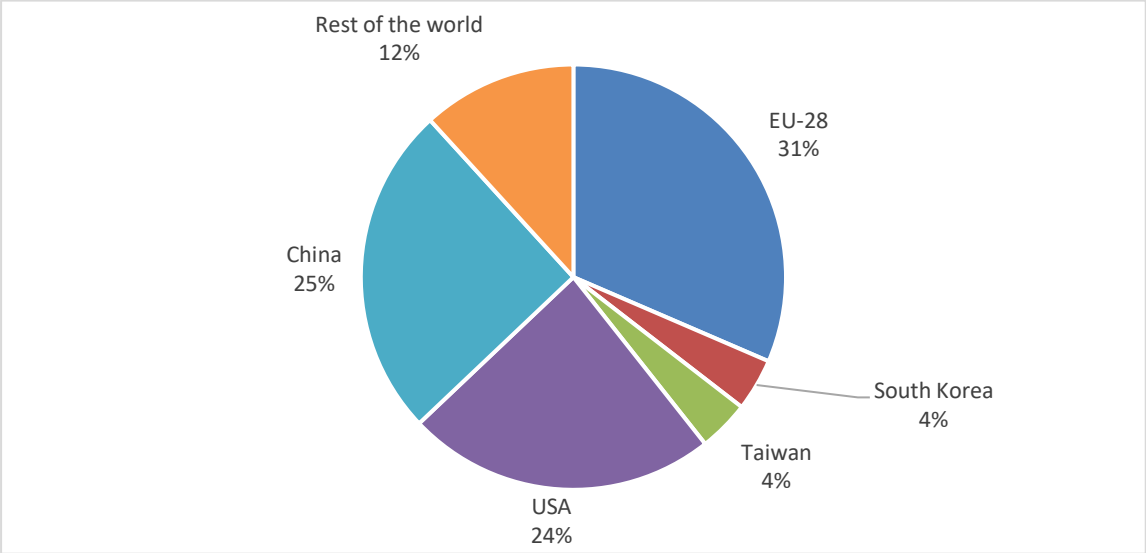
[100] European Commission. (2019). *Study on Emerging Technologies in Electronic Components and Systems (ECS): Opportunities ahead*. SMART 2018-0005.

[101] Ibid

What is more, the distribution of company sizes in the software industry is very uneven with a strong market dominance by US providers in terms of worldwide revenues and in the European software market: the majority of top 10 software providers belong to the US.[102]

The analysis of scientific publications indicate that Europe retains a strong position in microelectronics research[103], producing 31% of publications in the period 2009-2018 (Figure 45). China (25%) comes second followed by the US (24%).

Figure 45: Publications in the area of microelectronics by country (2009-2018)



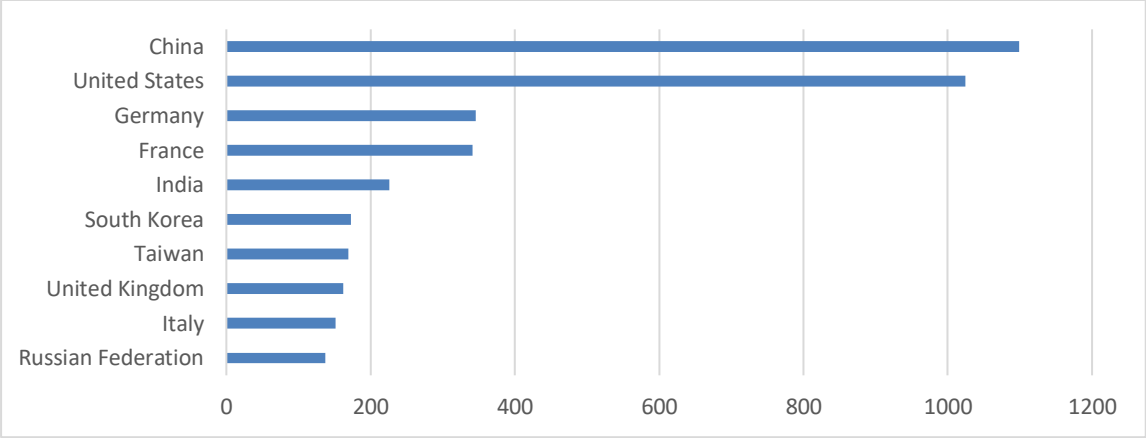
Source: Calculations by Technopolis Group based on Scopus data.

However, looking at the performance of MS, and comparing their performance against other countries, China is the leader followed by the US (Figure 46). The two top European countries, Germany and France, remain far behind. Comparing the two figures and observing the significant differences in the capacity of individual countries, illustrates the limitations of thinking national, while it also sketches out possibilities and the **added value of pooling together resources at the European level**.

[102] PAC, CXP & Fraunhofer ISI. (2017). *The Economic and Social Impact of Software and Services on Competitiveness and Innovation*. SMART 2015/0015. Final Report, available at https://op.europa.eu/en/publication-detail/-/publication/480eff53-0495-11e7-8a35-01aa75ed71a1.

[103] The area of microelectronics was defined by a cloud of keywords suggested by the Expert Panel. The other technological areas included in the analysis were defined in a similar way.

Figure 46: Top 10 Publishing countries in microelectronics (2009-2018)

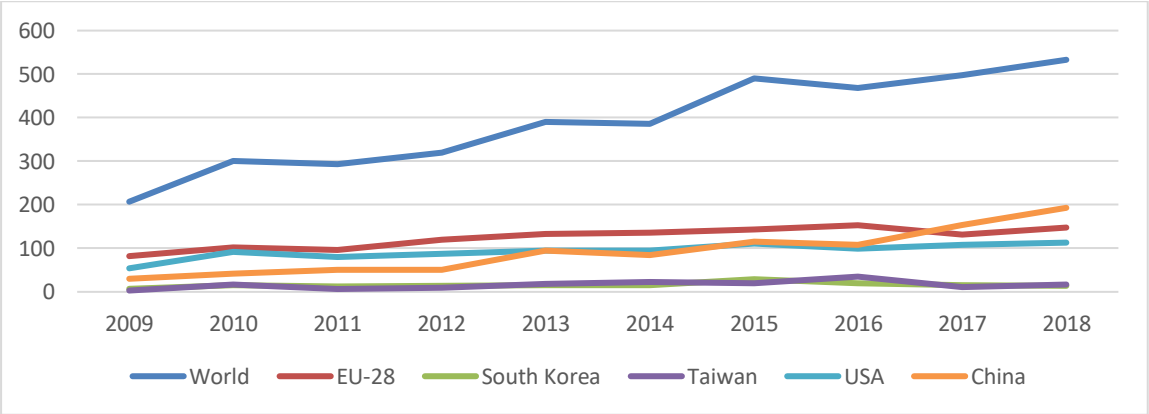


Note: Counting of countries is based on the country affiliation of all authors per publication.

Source: Calculations by Technopolis Group based on Scopus data.

The evolution in production of publications, as illustrated in Figure 47, clearly shows that China has overtaken in 2017 Europe's leading position in research on microelectronics. China has continued to grow faster than Europe since then. This growth has been supported by significant investments made by the Chinese government.

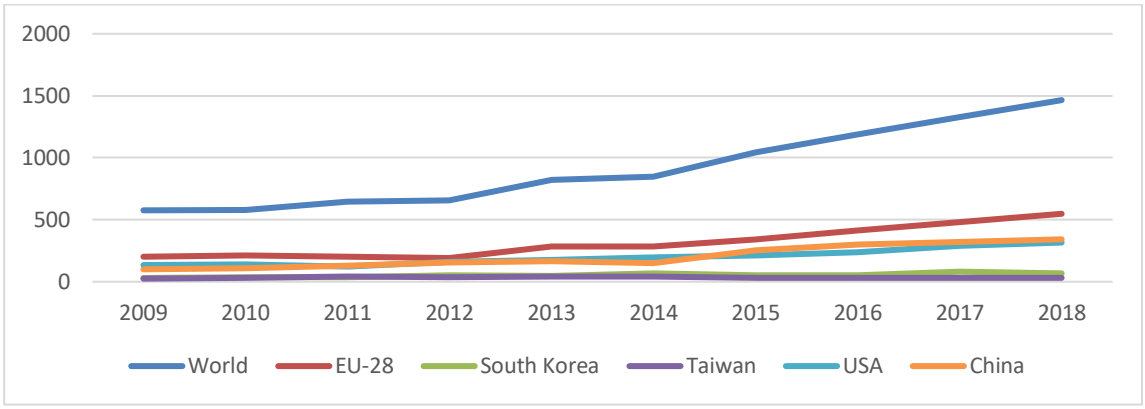
Figure 47: Production of publications on microelectronics per country and year – number of publications (2009-2018)



Source: Calculations by Technopolis Group based on Scopus data.

Europe is among the leading players in the area of **embedded electronics** with a strong research performance; it is the primary producer of research publications, publishing 34% of scientific articles during the period 2009-2018. China and the US follow with 22% each. Europe has retained its leadership during the last ten years and further increased the gap with the main competitors, as illustrated in Figure 48. Germany and Italy have the highest number of publications in the EU28, each representing 6% of global production, followed by France, Spain and the UK with 5% each.

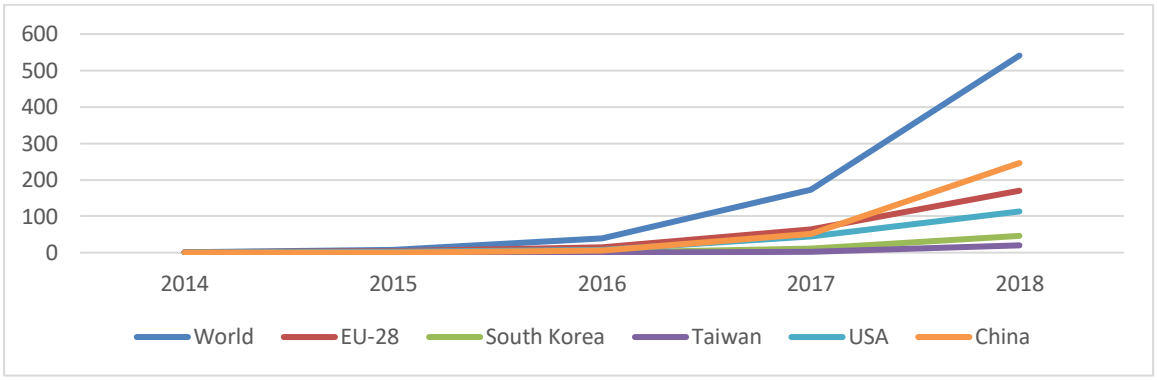
Figure 48: Growth in production of publications on embedded electronics per country and year – number of publications (2009-2018)



Source: Calculations by Technopolis Group based on Scopus data.

The production of publications in the emerging area of **edge computing** has experienced exponential growth after 2016 with China and the EU28 leading the race with respectively 40% and 33% of total publications (Figure 49).

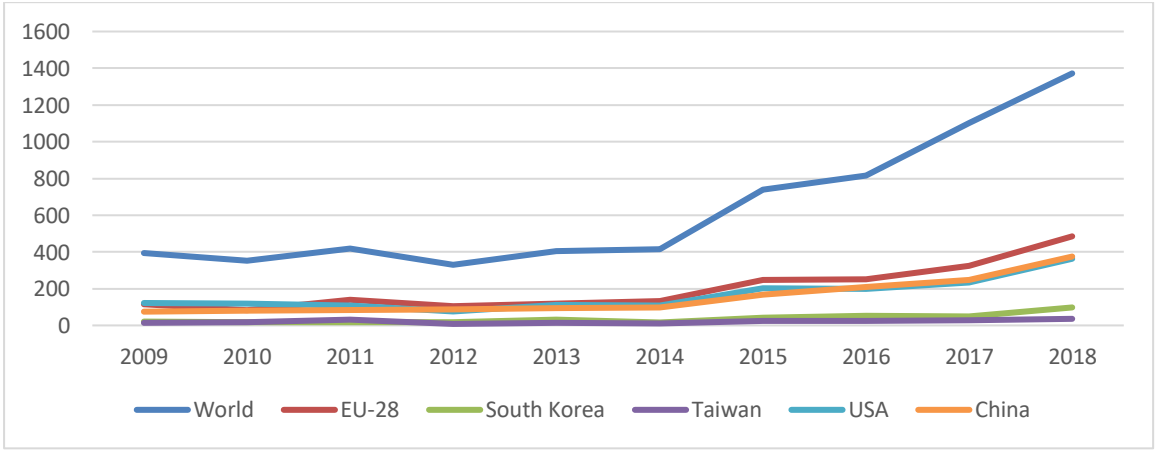
Figure 49: Growth in production of publications on edge computing per country and year – number of publications



Source: Calculations by Technopolis Group based on Scopus data.

In the area of computer architectures, the EU28 leads the race followed closely by China and the US, as outlined in Figure 50. Within the EU28, the UK is leading with 7% of world production, followed by Spain (6%), Germany (5%), Italy (5%) and France (4%).

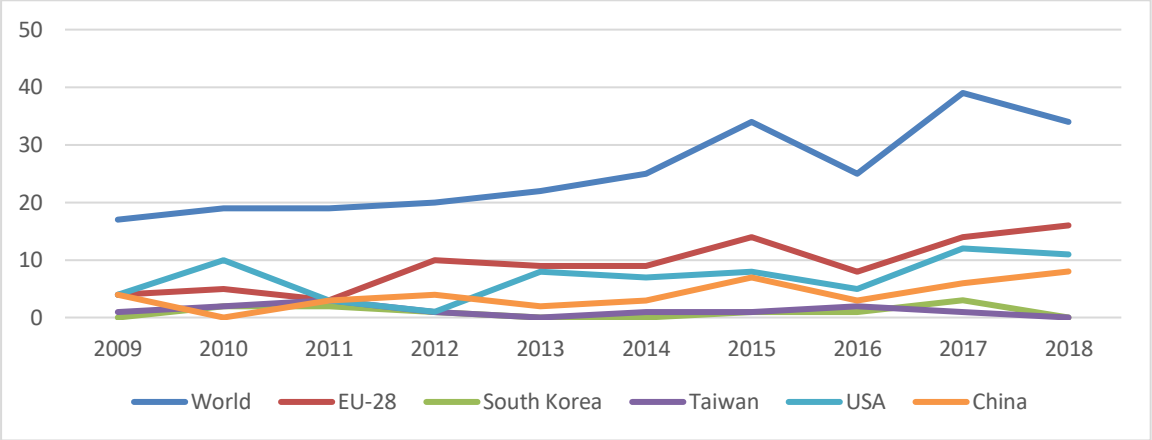
Figure 50: Growth in production of publications on computer architectures per country and year – number of publications



Source: Calculations by Technopolis Group based on Scopus data.

The EU28 (36%) has a leading position in the emerging area of AI related to microelectronics, with the US (27%) and China (16%) ranked second and third respectively (see Figure 51).

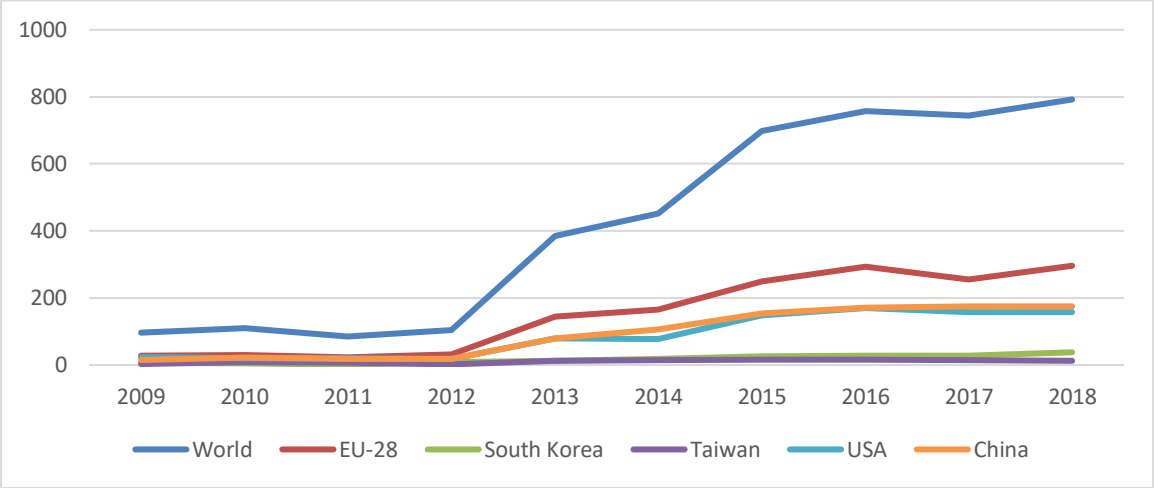
Figure 51: Growth in production of publications on AI per country and year – number of publications



Source: Calculations by Technopolis Group based on Scopus data.

In the software area related to microelectronics, the EU28 (36%) is also ahead of China (22%) and the US (21%) (Figure 52).

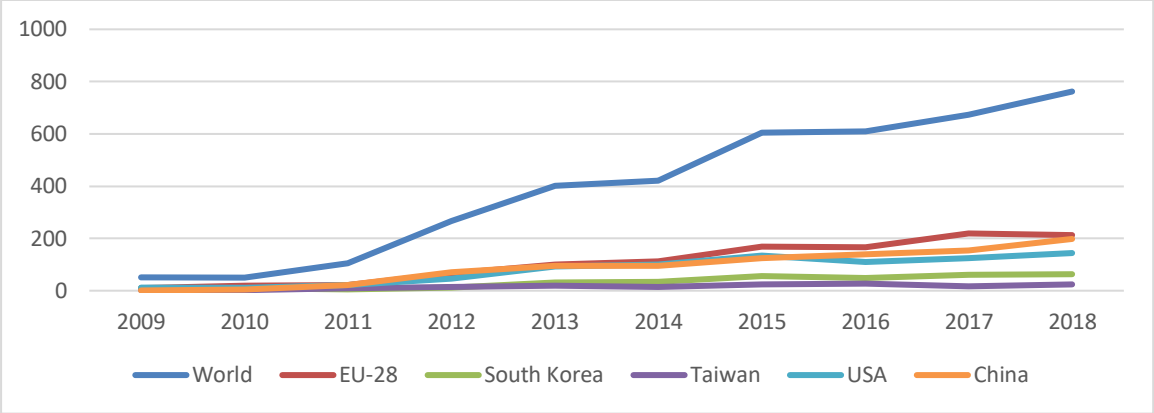
Figure 52: Growth in production of publications on software per country and year – number of publications



Source: Calculations by Technopolis Group based on Scopus data.

The EU28 (28%) is leading in the area of power electronics, followed by China (23%) and the US (20%) (Figure 53); China was almost level (28%) with the EU in 2018 after increasing the number of publications from 2017 to 2018.

Figure 53: Growth in production of publications on power electronics per country and year – number of publications



Source: Calculations by Technopolis Group based on Scopus data.

Despite the relatively high performance in several scientific areas of KDT, 60% of respondents in the public consultation believe that Europe still lacks sufficient expertise in specific KDTs. There is also an innovation gap in the EU in translating research results into innovative digital solutions, according to 85% of the respondents.

Challenges for the future

The previous section provides a positive picture of Europe's research capabilities and future potential not only strictly in the area of microelectronics, but also in fast-growing technological areas that create new challenges for microelectronics and, in turn, are driven by advances in the electronics sector.

Overall, Europe's industry is well positioned to address the challenges brought by the digital transformation of the economy and the new technological paradigms based on AI and the production of related applications. Although Europe is not involved in the production of central processing units or mass storage memories, there is strong know-how relevant for the development of solutions for secure, embedded portable low-power peripheral and edge AI.[104] However, despite the accumulated know-how, high R&D intensity and production capacity, European electronic companies are facing several challenges that are sector specific:

- **AI, low power processors and accelerators**: The technical and social challenges for Europe are significant and include requirements for a broad set of different skills. China and the US are investing heavily in the area, threatening the position of Europe. For example, China has set up a long-term AI plan, seeking to build up an AI industry of some €135 billion. In order to maintain competitiveness in these emerging and fast-growing markets in Europe, investments in leading-edge R&D and capabilities in microprocessors and accelerators, software and algorithms for AI, semiconductor-based neuromorphic components and quantum computing, for more autonomous machines and devices are necessary. The size of companies is also an essential parameter; most European companies in this area are small and face increasing barriers to entry. Yet, Europe has many sectors, such as automotive and pharma, that could drive volume.
- **Manufacturing equipment and materials:** To retain and secure a strong position in materials and tools for the production of semiconductor equipment in Europe, it requires

[104] European Commission. (2018). *Boosting Electronics Value Chains in Europe, A report to Commissioner Gabriel*, available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53119.

research in next-generation equipment and materials, especially in the following areas:[105]

nanoscale patterning, metrology and inspection of sub-3nm node logic and memory technology based on 2D shrink, 3D extension and innovative materials such as graphene;

innovative assembly and packaging approaches for integrating 3D microelectronics, photonics and quantum technologies, both on a chip and in semiconductor component packages.

- **Software:** Private sector R&D in software technologies relevant for embedded and cyber-physical system is lagging; Europe is well below the US and South Korea when it comes to R&D spending in application and system software. Accordingly, there is a need for increased focus on R&D&I investments in software technologies, and also taking into account expected growth rates for 'systems of systems', applications and solutions.
- **Automotive industry**: Notwithstanding the huge investments in R&D, Europe is not yet an attractive space for connected and autonomous vehicles. Better coordination is necessary among the automotive players, smart infrastructure providers and other stakeholders. According to the opinions of semiconductor manufacturers, automotive OEMs and suppliers, system designers, and research and technology organisations,[106] innovation in the sector is largely driven by ECS. A challenge is to **bring together** all the **capabilities and skills** necessary for **human-centred design**, focusing **on safety**, **system security, quality**, **reliability and measurement**. Critical enabling technologies include: 5G and **edge computing** to handle the increasing dataflow; **cybersecurity** to safeguard system safety and personal privacy; **software and systems engineering** to integrate the deployed systems and devices; big data; **AI**; and autonomous systems. It was also largely agreed that geo-proximity is important for supply, testing and manufacturing. The flexibility of the sector depends on just-in-time delivery and agile production; consequently, timely and smooth supply of microelectronic components is essential. Thus, the creation of a seamless environment for the development, testing and deployment of autonomous driving, allowing for cross-border collaboration, is also necessary.
- **Energy management:** There are critical power electronics supply issues with respect to access to SiC substrate and large SiC wafers that need a European response (e.g. the establishment of a Euro SiC foundry). There is also a need to close the gap with the US and Asia on GaN and to ensure that new materials can be tested with regards to reliability. There is also a need for long-term partnerships between manufacturers and users of power components.[107]
- **Aerospace, defence and cybersecurity:** Full control of the value chain and additional certified security layers for standard components are essential for Europe to ensure privacy and safety for its citizens.

Europe retains a strong position in the global market of **photonics**, which is growing annually by 6%. With a share of 15.5% and approximately 5,000 European

[105] European Commission. (2018). *Boosting Electronics Value Chains in Europe, A report to Commissioner Gabriel*, available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53119.

[106] European Commission. (2018). *Electronics Value Chains: Workshop on automotive focusing on connected and autonomous driving, Brussels*, 11 April 2018, available at https://ec.europa.eu/digital-single-market/sites/digital-agenda/files/electronics_value_chains_-_automotive_workshop_report.pdf.

[107] Ibid

photonics companies and organisations, the EU is the world's second-largest manufacturer of photonics products after China.[108]

In addition, keeping up with new demands in expertise and skills is a challenge for Europe, which faces a shortage of engineers with design skills.[109]

Supporting priorities in the previous Framework Programme

Scope, objectives and funding of predecessor initiative

The predecessor initiative, ECSEL JU, was established in 2014 based on Council Regulation 561/2014[110] and replaced the previous ENIAC JU focusing on nanoelectronics and ARTEMIS JU concentrating on embedded systems. ECSEL JU was set up as a tripartite public-private partnership (PPP)[111] to **support research development and innovation projects in ECS**.

ECSEL JU responds to a broad set of challenges:

- importance of ECS for Europe's industrial sector and for product and productivity innovation;
- capacity of ECS to address societal challenges;
- fierce global competition, high research cost and fast pace of technology development faced by Europe's industries;
- need for collaboration, pooling of resources and building expertise.

The **overall funding** for ECSEL JU under H2020 (2014-2020) was approximately €5 billion according, where €1 provided by the Commission leveraged €1 from MS and at least €2 from industry. As for the operational costs dedicated to ECSEL JU, projects in the period from 2014 to 2018, the share of EU's contribution is €824 million and leveraged €743 million from MS and around €1.8 billion from industry.

General and specific objectives of predecessor initiative

ECSEL JU sets the **vision** to promote a major evolution in intelligent and enabling systems, machines and objects in order to become smart, communicate with each other, people and the environment, take advantage of relevant information and services around them, and to become autonomous in the management of resources.[112] The vision is further to offer Europe a controlled technology basis on ECS in order to realise a European digital society that is smart, sustainable and inclusive. The **mission** of the ECS stakeholders is, accordingly, to achieve progress and state-of-the-art innovation when it comes to developing "highly reliable complex systems and their further miniaturisation and

[108] Photonics21. (2019). *Europe's Age of Light! How Photonics Will Power Growth and Innovation: Strategic roadmap 2021-2027*, available at https://www.photonics21.org/download/ppp-services/photonics-downloads/Europes-age-of-light-Photonics-Roadmap-C1.pdf.

[109] European Commission. (2018). *Boosting Electronics Value Chains in Europe, A report to Commissioner Gabriel*, available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=53119.

[110] Council of the European Union. (2014). *Council Regulation (EU) No 561/2014 of 6 May 2014 establishing the ECSEL Joint Undertaking*. L169/152, available at https://www.ecsel.eu/sites/default/files/2017-09/Council_Regulation_Establishing_ECSEL_JU.pdf.

[111] A dedicated Joint Undertaking (JU) manages ECSEL. The JU's governing board, which takes strategic decisions, comprise private members from AENEAS, EPoSS and ARTEMIS-IA, Member States and Associated Countries as well as the European Commission.

[112] ECSEL JU. (2019). *Multi-Annual Strategic Plan ("MASP") 2019*, available at https://ec.europa.eu/research/participants/data/ref/h2020/other/legal/jtis/ecsel-multi-stratplan-2019_en.pdf.

integration, while dramatically increasing functionalities and thus enabling solutions for societal needs".[113]

The Council Regulation (EU) No 561/2014 of 6 May 2014 lists the specific objectives, while the multi-annual strategic plan 2019 sketches out the general objectives as outlined in Table 29.

Table 29: Objectives and intended benefits of ECSEL JU

General objectives	Specific objectives	Intended benefits
• Coordinate resources and funding to contribute to the ERA by achieving coherence of R&D throughout Europe • Achieve higher efficiency by harmonising procedures and removing uncertainty in terms of the available national budgets and integrating related Eureka activities into the JTIs • Promote overall private and public investments in the two sectors • Contribute to the research and innovation ecosystem covering SMEs, the enhancement of education and training and contribute to standards	• a) To contribute to the implementation of Regulation (EU) No 1291/2013, and in particular part II of Decision 2013/743/EU • b) To contribute to the development of a strong and globally competitive ECS industry in the Union • c) To ensure the availability of ECS for key markets and for addressing societal challenges, aiming at keeping Europe at the forefront of technology development, bridging the gap between research and exploitation, strengthening innovation capabilities and creating economic and employment growth in the Union • d) To align strategies with MS to attract private investment and contribute to the effectiveness of public support by avoiding an unnecessary duplication and fragmentation of efforts and by facilitating the participation of actors involved in research and innovation • e) To maintain and grow semiconductor and smart system manufacturing capability in Europe, including leadership in manufacturing equipment and materials processing • f) To secure and strengthen a commanding position in design and systems engineering including embedded technologies • g) To provide access of all stakeholders to a world-class infrastructure for the design and manufacture of electronic components and embedded/cyber-physical and smart systems • h) To build a dynamic ecosystem involving SMEs, thereby strengthening existing clusters and nurturing the creation of new clusters in promising new areas	• Achieve a supply of key technologies in support of innovation through all major sectors of the economy • Foster European independence in the field of ECS • Ensure alignment of strategies with MS in order to attract private investments and limit duplication of efforts • Encourage industry stakeholders to develop a long-term strategic research and innovation agenda • Promote EU policies as outlined in the Europe 2020 strategy for growth • Remove obstacles to impactful research and innovation in this area

Source: ECSEL JU. (2018). *Decision of the Governing Board of the ECSEL Joint Undertaking: ECSEL multi-annual strategic plan 2019*, ECSEL GB 2018.114, available at

https://www.ecsel.eu/sites/default/files/2019-01/ECSEL%20GB%202018.114%20-%20MASP%202019%20and%20Annex%20V1.1.pdf & Council of the European Union. (2014). Council Regulation (EU) No

[113] ECSEL JU. (2018). *Decision of the governing board of the ECSEL joint undertaking – ECSEL multi-annual strategic plan 2019*, ECSEL GB 2018.114, available at https://www.ecsel.eu/sites/default/files/2019-01/ECSEL%20GB%202018.114%20-%20MASP%202019%20and%20Annex%20V1.1.pdf.

561/2014 of 6 May 2014 establishing the ECSEL Joint Undertaking. L 169/152, available at https://www.ecsel.eu/sites/default/files/2017-09/Council_Regulation_Establishing_ECSEL_JU.pdf.

The key application areas of the predecessor initiative ECSEL JU are: 1) transport and smart mobility; 2) health and wellbeing; 3) energy; 4) digital industry; and 5) digital life. The application areas links to ECS essential capabilities: 1) systems and components' architecture, design and integration; 2) connectivity and interoperability; 3) safety, security and reliability; 4) computing and storage; and 5) ECS process technology, equipment, materials and manufacturing.

Stakeholder analysis

ECSEL JU serves as a starting point to understand the current situation with regards to the value chain, the central role in the current networks of specific entities, and the current concentration of funding. ECSEL JU covers a comprehensive set of large companies, research and technology organisations, higher education research labs, and SMEs. Partners are the EU, 30 ECSEL JU Participating States[114] and three private industrial associations, respectively AENEAS, EPoSS and ARTEMIS-IA representing actors from the fields of micro-/nanoelectronics, smart integrated systems and embedded/cyber-physical systems.

Mapping of the value chain

To understand the current involvement of organisations in the value chain, a mapping has been undertaken of 100 organisations receiving more than €1 million in EU funding over the period from 2014 to 2018. Table 30 shows the concentration of organisations per segment of the value chain. The organisations have been allocated to a maximum of two segments based on their main line of business. Those HEIs and research centres that were more difficult to categorise, given their size and wide scope, were classified in the horizontal segment 'Research'.

Table 30: Overview of key stakeholders in value chain[115]

Value chain	Companies	Universities and research centres
Applications (industrial equipment, Aeronautics/defence/security, automotive, energy)	12	3
Stand-alone electronics	1	
Embedded electronics	6	1
Electronics boards	2	
Semiconductors	24	5

[114] The Participating States comprise 26 MS (Cyprus and Croatia excluded) and four Associated States within the EU's Horizon 2020 programme (Switzerland, Norway, Israel and Turkey).

[115] As the list is based on entities with the most significant budget share, it also equally displays entities that are part of the same group, such as INFINEON Technologies (AG; Austria AG; Dresden GMBH & CO KG; Italia SRL), Philips (Consumer Lifestyle bV; Electronics Nederland B.V. Medical Systems Nederland BV; Photonics GMBH), STMicroelectronics (Alps) SAS); (Tours) SAS); Crolles 2 SAS; Grenoble 2 SAS; Rousset SAS; SA; SRL), etc.

Value chain	Companies	Universities and research centres
Other electronic components	7	
Materials	5	
Tools and other (design/manufacture)	24	
Research (semiconductors, design, embedded and components)	1	32

Source: Calculations by Technopolis Group and expert panel of study.

There is a significant **concentration of companies in the segments of semiconductors and tools and other,** according to Table 30: each of the two segments have a share of approximately 30% of grouped companies in the value chain. The segment for applications also comprises a significant share of companies (around 15%). Among organisations with the highest share of EU contributions, there was a relatively low coverage of companies in segments comprising, in particular, stand-alone electronics and electronics boards, but also materials and embedded electronics.

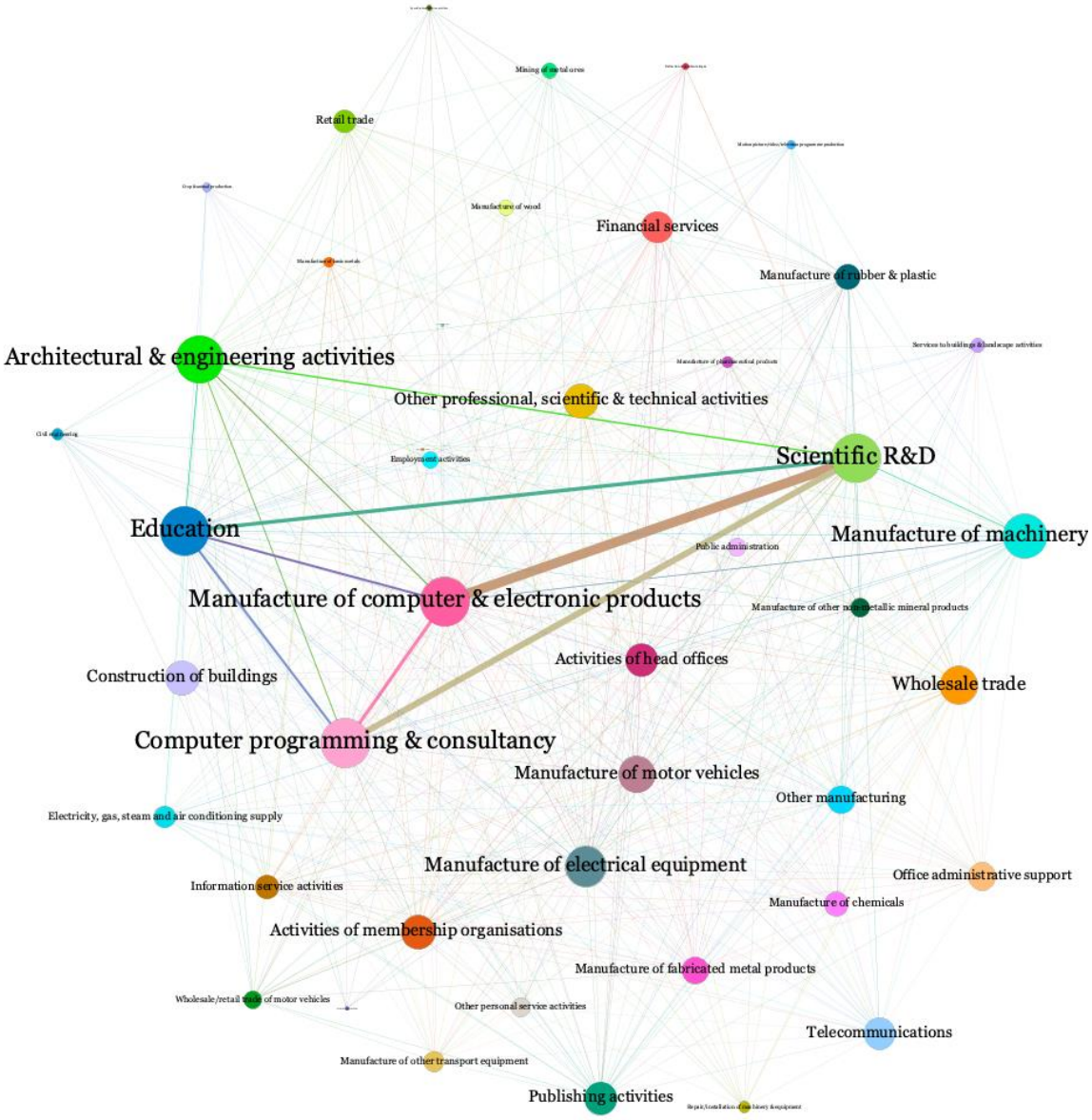
Mapping of network and stakeholders involved

One the basis of the value chain findings, the mapping of stakeholders brings us to the analysis of the 'centrality' in the current network. Collaboration among organisations active in different sectors and according to organisation type was mapped using participation rate data for ECSEL JU obtained from Corda. The mapping of the network, according to NACE[116] industry sector, is outlined below. The bubble size in Figure 54 indicates the frequency of a sector's participation (the bigger the bubble, the more frequent the participation) while the thickness of lines ('ties') between two bubbles display the frequency of collaboration among concerned sectors.

From Figure 54 it appears that the most prominent interlinkages – according to frequency of collaboration – exist among scientific R&D, computer programming and consultancy, architectural and engineering activities and education as well as with downstream industries, such as the manufacture of computers and electronic products, motor vehicles, machinery and electrical equipment.

[116] The matching of companies and sectors is based on the NACE codes of participants in the partnership projects, as derived from ORBIS. Limitations to NACE codes imply that sector indications do not always align with the actual role of organisations in value chains.

Figure 54: ECSEL JU – Mapping of network by NACE code



Source: Calculations by Technopolis Group based on Corda data.

Publications from ECSEL JU participants

The publications from participants in ECSEL JU are primarily in top journals, as outlined Table 31. The most common journals that participants were publishing in are predominantly Q1, indicating the top quartile, i.e. the top 25% of journals in their respective fields. Some 66% of publications were in Q1, while the share was respectively 26%, 14% and 4% for Q2, Q3 and Q4, showing a significant concentration within top-ranked journals. Among the top quartile journals with the highest amount of publications by ECSEL JU participants are *IEEE Transactions on Electron Devices* (14), *IEEE Access* (5), *Journal of Power Sources* (5), *Energies* (5), *IEEE Transactions on Industrial Informatics* (3) and *Electronics* (Switzerland) (3).

Table 31: Ranking of publications from ECSEL JU participants[117]

Ranking of Journals	Number of publications
Q1	66
Q2	26
Q3	14
Q4	4
Total	110

Calculations by Technopolis Group based on Scimago.

In terms of patents, ECSEL JU had a total of **46 patents** registered on the basis of projects in the timeframe from 2014 to 2018. Due to competition, business practices and the pre-competitive nature of collaborative R&D projects at EU-level, it is anticipated that most industrial partners are likely to apply for IPR outside the context of the treatment. Accordingly, the number of IP recorded in the database may be highly underestimating the real effects.

[117] Q1-Q4 are the quartiles of journal ranks and they are based on the SJR indicator.

Appendix E Additional Information on the functionalities of the initiative

Table 32: Mapping of envisaged inputs and type of collaboration between the KDT initiative and other Horizon Europe initiatives

Initiatives	Input from KDT	Input to KDT	Type of collaboration
Priority initiatives for collaboration			
EuroHPC	• Components (processors, accelerators) and ES • Requirements from application domains, e.g. automotive (i.e. video processing, simulation), aerospace, space, etc.	• Processing of (big) data, computing capabilities and new algorithms to address complex 'Systems of Systems' applications • Requirements for microprocessors and components	• Coordination of research agendas • Exchange of algorithmic knowledge and requirements for HPC in application domains (e.g. automotive, aerospace)
Smart Networks and Services	• Technologies and components for advanced networks, 5G and 6G • Requirements for new services (real-time networks for autonomous cars, etc.)	• Connectivity to enable software, CPS, Systems of Systems, IIoT, etc. • Networking requirements	• Coordination of research agendas • Exchange of knowledge on capabilities and requirements
AI, data and robotics	• Hardware components and software (e.g. for AI-optimised chips, neuromorphic computers, image processing, sensors) • Application data to test new algorithms and requirements for new applications	• AI techniques/ algorithms • Requirements for microprocessors and components	• Coordination of research agendas • Exchange of data and requirements as well as AI know-how • Contribution to the European ethical debate on AI to support European values
Photonics	• Integrated circuits (PICs), low-cost manufacturing techniques and high-efficiency devices	• Photonics technologies within application fields and roadmap for the future • Requirements for microprocessors and components	• Coordination of research agendas • Exchange of requirements information and strategic business needs

Initiatives	Input from KDT	Input to KDT	Type of collaboration
Made in Europe	• Technologies and components for IIoT to support factory automation and maintenance monitoring, including sensors, power electronics for efficient drives and processing for process optimisation	• Requirements for factory automation and monitoring	• Coordination of research agenda • Exchange of requirements from both large and SME manufacturers • Strategic actions to support standardisation
Global competitive space systems	• Critical electronic components for space platforms and communications, e.g. FPGAs, GaN and Rad Hard Components	• Requirements for space platforms and testing facilities	• Coordination of research agenda • Visibility of future space requirements
EIT Digital	• Technologies and components for IoT to support factory automation and maintenance monitoring	• Requirements for new technologies and development of new skills	• Collaboration on technology adoption and skills development
Initiatives serving as application areas			
Innovative Health Partnership	• Fast-track and early access to advanced key digital technologies leading to faster market uptake • Prototyping of new concepts and development of European fabrication support	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact • Definition of requirements and pooling of development to enable cost-efficient production	• Co-creation of solutions with end-users, exchange of requirements and fabrication capabilities • Pooling of activities to support SME developers for low production runs
Large-scale innovation and transformation of health systems in a digital and ageing society	• Fast-track and early access to advanced key digital technologies leading to faster market uptake • Prototyping of new concepts and development of	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact	• Co-creation of solutions with end-users, exchange of requirements and fabrication capabilities • Demonstration in the health sector

Initiatives	Input from KDT	Input to KDT	Type of collaboration
	European fabrication support	• Definition of requirements and pooling of development to enable cost efficient production as well as demonstration within the health sector	
Personalised medicine	• Fast-track and early access to advanced key digital technologies leading to faster market uptake • Prototyping of new concepts and development of European fabrication support	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact • Definition of requirements and pooling of development to enable cost efficient production as well as demonstration within the health sector	• Co-creation of solutions with end-users, exchange of requirements and fabrication capabilities • Demonstration in the health sector
Clean Aviation	• Fast-track and early access to advanced key digital technologies leading to faster market uptake • Efficient power electronics for more electric aircraft and electrical propulsion systems for short range aircraft	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact • Demonstration on iron-bird rigs	• Co-creation of solutions with end-users • Exchange of requirements and demonstration on iron-bird rigs
Safe and Automated Road Transport	• Fast-track and early access to advanced key digital technologies leading to faster market uptake • Low power image processing platforms and safety-critical	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact	• Co-creation of solutions with end-users • Exchange of requirements and demonstration and validation in autonomous platforms

Initiatives	Input from KDT	Input to KDT	Type of collaboration
	software development techniques	• Demonstration in autonomous platforms	
Towards zero-emission road transport	• Fast-track and early access to advanced key digital technologies leading to faster market uptake • Power electronics technologies to support battery charging and efficient drive systems	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact • Requirements for and demonstration of electric propulsion systems and charging	• Co-creation of solutions with end-users • Exchange of requirements and demonstration/validation of solutions
Clean energy transition	• Fast-track and early access to advanced key digital technologies leading to faster market uptake • Access to European devices for infrastructure monitoring and control • Power electronics to support efficient conversion of energy for solar (e.g. MPPT) and wind power generation • Processing, sensors and software for smart building management	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact • Requirements from building management systems suppliers, energy distributors, wind turbine and solar farm operators	• Co-creation of solutions with end-users • Exchange of requirements and demonstration of energy monitoring and control technologies as well as high efficiency energy conversion
Global, neutral and circular industry	• Fast-track and early access to advanced key digital technologies leading to faster market uptake • Sensor and processor technologies to monitor emissions and product	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact	• Co-creation of solutions with end-users • Exchange of requirements and demonstration and assessment of the impact of circular economy approaches

Initiatives	Input from KDT	Input to KDT	Type of collaboration
	tracking through life cycle	• Assessment of impact on environment	
Accelerating farming systems	• Key role for agri-food and environment applications, such as food monitoring, soil, water and air quality and precision farming • Monitoring and efficient use of fertilisers	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact • Farming requirements and access to farming associations to promote the uptake of new technologies and upskill farmers	• Co-creation of solutions with end-users • Engagement with farmers via farming associations and promotion of new technologies to enable more efficient production as well as reduction in use of fertilisers
Safe and sustainable food system for people, planet and climate	• Key role for agri-food and environment applications, such as food monitoring, water and air quality and precision farming • IoT and connectivity for monitoring e.g. soil, moisture, pH, weather, as well as devices for automated control of tractors, harvesters, etc. for precision farming, monitoring of livestock for welfare and reduction in the use of fertilisers • Monitoring of food from field to fork and efficient distribution logistics	• Dissemination and interaction with potential users for end-user requirements, validation etc. to achieve end-user leverage/impact • Requirements from different farming sectors, arable, livestock and fruit for growing, harvesting, storage and distribution as well as demonstration of technologies	• Co-creation of solutions with end-users • Requirements from diverse farming segments and demonstration of technology to promote uptake in the Agri food chain
Interconnections with EIT KIC			
EIT Climate	• Processing, sensors and software for smart building	• Requirements for new technologies	• Collaboration on technology adoption, skills

Initiatives	Input from KDT	Input to KDT	Type of collaboration
	management and low-carbon economy	and development of new skills • Information on the impact on the environment	development and raising public awareness
EIT Food	• Key role for Agri food and environment applications, such as food monitoring, water and air quality and precision farming • IoT and connectivity for monitoring and devices for automated control	• Requirements from farmers, logistics companies and retailers	• Collaboration on technology demonstration and raising awareness within farming community
EIT Health	• Prototyping of new concepts and development of European fabrication support	• Requirements from healthcare providers, hospitals and insurance companies	• Collaboration on technology adoption and skills development
EIT InnoEnergy	• Power electronics to support efficient conversion of energy for solar (e.g. MPPT) and wind power generation • Access to European devices for infrastructure monitoring and control	• Requirements from the energy sector, energy companies and consumers	• Collaboration on technology adoption and skills development
EIT Manufacturing	• Sensor and processor technologies to monitor emissions and product tracking through life cycle	• Requirements for manufacturing optimisation, new sensors and processing technologies	• Collaboration on technology adoption and skills development
EIT Raw Materials	• Use of new materials • Information and sourcing regarding sustainability and impact on the environment	• Information on the sourcing of materials and the impact of materials on the environment	• Collaboration on materials needs and impact assessment

Initiatives	Input from KDT	Input to KDT	Type of collaboration
EIT Urban Mobility	• Key enabling technology for mobility solutions connecting both CPS and IoT to optimise traffic systems and provide new services for mobility (e.g. car sharing) and seamless connectivity between transport systems	• Requirements from smart cities and mobility solution providers • Demonstration of new services	• Collaboration on technology adoption, skills development and raising public awareness

Appendix F Additional information on the problem definition

F.1 Taxonomy of failures requiring policy intervention

Market failures	
Market power	• Significant barriers to entry related to high R&D and capacity investments, and specialisation requirements especially for SMEs. • Specific segments of the value chain (e.g. semiconductors, design) are highly concentrated and dominated by few players mainly based in US, Korea and China
Externalities	
Information asymmetry	• Investments in innovation and R&D in KDT value chains are of high risk and volume and the European venture capital market does not always have the necessary focus and technology expertise to properly asses the opportunities. This information asymmetry between ECS companies and investors results in insufficient private financing. • The shortening of the innovation cycle complicates KDT companies' efforts to understand the needs of downstream industries.
Systemic failures	
Capability	• Migration of semiconductor production in other regions drained Europe from the related expertise and skills that is necessary for ensuring the supply of critical components. • To keep-up with the future production needs the technological capabilities in emerging technologies and AI solutions for autonomous machines and devices, demands the development of a critical mass of competences in the design of software and algorithms for AI, semiconductor-based neuromorphic components and quantum computing. • Need for supporting large-scale federated projects that no country could support on its own and to address the need for harmonization when it comes to platforms, standards and testbeds.
Network	• Although the interactions and coordination among the various elements of the value chain in the design and development of new technologies and innovations are increasingly important there is still significant fragmentation and week linkages especially in the involvement of downstream industries in the innovation cycle of ECS. Without continuation of the policy intervention the achieved coordination will be not sustained.
Institutional	• Regulatory and certification issues became important especially for addressing safety, security and quality issues
Infrastructural	• Lack of European production capacity in microprocessors.

	• Lack of sufficient common infrastructures for the design, experimenting and testing of future generation processors and computing technologies. • Lack of pilot lines and large-scale demonstrators.
Transformational failures	
Directionality	• ECSEL JU facilitated the development of a shared vision and streamlining of priorities and budgets; however, there are still barriers to go beyond national priorities and sectoral needs; in the absence of a similar mechanism in the future, it is expected that such coordination will be lost.
Demand articulation	• The shortening of the innovation cycle complicates ECS companies' efforts to understand the needs of downstream industries.
Policy coordination	• Without any EU policy intervention there is an overlap and lack of linkages of EC and national programmes. • Weak coherence between the various EU initiatives and week exploitation of synergies between EU, national and private efforts.
Reflexivity	• No significant issues identified

Source: Based on taxonomy of failures by Technopolis Group (2018), Modified from Weber & Rohracher (2012).

Appendix G Additional information related to the policy options descriptions

G.1 Degree of coverage of the different functionalities by policy option

Table 33: Type and composition of actors (including openness and roles)

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
What is possible? *Any legal entity* in a consortiu**m** can apply to Horizon Europe calls in ad hoc combinations Calls are open to participation from across Europe and the world (not all entities from third countries are eligible for funding)	***What is possible?*** Partners can include *any national funding body or governmental research organisation*, Possible to include also *other type of actors*, including foundations.	***What is possible?*** Partners can include *MS and Associated Countries*.	***What is possible?*** Suitable for *all types of partners*: private and/or public partners, including MS, regions, foundations. By default, open to AC/ 3rd countries, but subject to policy considerations. Can cover a *large and changing community.* HE rules apply by default to calls included in the FP Work Programme, so any legal entity can apply to these.	***What is possible?*** Suitable for *all types of partners*: private and/or public partners, including MS, foundations. By default, open to legal entities from AC/ 3rd countries, but subject to policy considerations. In case of countries participating non-associated third countries can only be included as partners if foreseen in the basic act and subjected to conclusion of dedicated international agreements HE rules apply by default, so any legal entity can apply to partnership calls.

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
What is limited? Systematic/ structured engagement with public authorities, MS, regulators, standard making bodies, foundations and NGOs.	***What is limited?*** Requires substantial national R&I programmes (competitive or institutional) in the field. Usually only legal entities from countries that are part of the consortia can apply to calls launched by the partnership, under national rules.	***What is limited?*** Non-associated third countries can only be included as partners if foreseen in the basic act and subjected to conclusion of dedicated international agreements. Needs good geographical coverage – participation of at least 40% of MS is required Requires substantial national R&I programmes (competitive or institutional) in the field. While by default the FP rules apply for eligibility for funding/participation, in practice (subject to derogation) often only legal entities from countries that are Participating States can apply to calls launched by the partnership, under national rules.	***What is limited?*** If MS launch calls under their responsibility, usually only legal entities from countries that are part of the consortia can apply to these, under national rules	***What is limited?*** Requires a *rather stable set of partners* (e.g. if a sector has small number of key companies). Basic act can foresee exceptions for participation in calls / eligibility for funding.
What is not possible? To have a joint programme of R&I activities between the EU and committed partners that is implemented based on a common vision.	***What is not possible?*** To have industry/ private sector as partners.	***What is not possible?*** To have industry/ private sector as partners.	***What is not possible?***	***What is not possible?***

Table 34: Type and range of activities (including flexibility and level of integration)

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
What is possible? Horizon Europe standard actions that allow *broad range of individual activities* from R&I to TRL 7 or sometimes higher. Calls for proposals published in the Work Programmes of Horizon Europe (adopted via comitology).	***What is possible?*** Activities may range from R&I, pilot, deployment actions to training and mobility, dissemination and exploitation, but according to national programmes and rules. Decision and implementation by "beneficiaries" (partners in the co-fund grant agreement) e.g. through institutional funding programmes, or by "third parties" receiving financial support, following calls for proposals launched by the consortium.	***What is possible?*** Horizon Europe standard actions that allow a broad range of coordinated activities from R&I to uptake. In case of implementation based on national rules (subject to derogation) Activities according to national programmes and rules. Allows integrating national funding and Union funding into the joint funding of projects	***What is possible?*** *Horizon Europe standard actions* that allow a broad range of coordinated activities from R&I to uptake. The association representing private partners allows to continuously build further on the results of previous projects, including activities related to regulations and standardisation and developing synergies with other funds Union contribution is implemented via calls for proposals published in the Work Programmes of Horizon Europe based on the input from partners (adopted via comitology). Open and flexible form that is simple and easy to manage.	***What is possible?*** *HE standard actions* that allow to build a portfolio with broad range of activities from research to market uptake. The back-office allows dedicated staff to implement integrated portfolio of projects, allowing to build a "system" (e.g. *hydrogen*) via pipeline of support to accelerate and scale up the take-up of results of the partnership, including those related to regulations and standardisation and developing synergies with other funds. E.g. setting up biorefinery plants and promoting their replication by additional investments from MS/ private sector. Procuring/purchasing jointly used equipment (e.g. HPC) Allows integrating national funding and Union funding into the joint funding of projects
What is limited?	***What is limited?*** Scale and scope of the programme the resulting funded R&I actions and depend on the participating programmes, typically		***What is limited?*** Limited control over precise call definition, resulting projects and outcomes, as they are implemented by EC agencies.	***What is limited?*** Limited flexibility because objectives, range of activities and partners are defined in the Regulation, and negotiated in the Council (EP).

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
	smaller in scale than FP projects			
What is not possible? To design and implement in a systemic approach a portfolio of actions. To leverage additional activities and investments beyond the direct scope of the funded actions				

Table 35:Directionality

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
What is possible? Strategic Plan (as implementing act), annual work programmes (via comitology). Possible also to base call topics on existing or to be developed SRIA/roadmap	***What is possible?*** Strategic R&I agenda/roadmap agreed between partners and EC Annual work programme drafted by partners, approved by EC Objectives and commitments are set in the Grant Agreement.	***What is possible?*** Strategic R&I agenda/roadmap agreed between partners and EC Objectives and commitments are set in the legal base. Annual work programme drafted by partners, approved by EC Commitments include obligation for financial contributions (e.g. to administrative costs, from national R&I programmes).	***What is possible?*** Strategic R&I agenda/roadmap agreed between partners and EC Objectives and commitments are set in the contractual arrangement. Input to FP annual work programme drafted by partners, finalised by EC (comitology) Commitments are political/best effort, but usually fulfilled	***What is possible?*** Strategic R&I agenda/roadmap agreed between partners and EC Objectives and commitments are set in the legal base. Annual work programme drafted by partners, approved by EC (veto-right in governance) Commitments include obligation for financial contributions (e.g. to administrative costs, from national R&I programmes).
What is limited? No continuity in support of priorities beyond the coverage of the strategic plan (4 years) and budget (2 years Annual work programme).				
What is not possible? Coordinated implementation and funding linked to the concrete objectives/ roadmap, since part of overall project portfolio managed by agency				

Table 36: Coherence (internal and external)

Option 0: Horizon Europe calls	Option 2: Co-funded	Option 3: Institutionalised Art 185	Option 1: Co-programmed	Option 3: Institutionalised Art 187
What is possible? Coherence between different parts of the Annual Work programme of the FP ensured by EC	***What is possible?*** Coherence among partnerships and with different parts of the Annual Work programme of the FP can be ensured by partners and EC Synergies with national/regional programmes and activities	***What is possible?*** Coherence among partnerships and with different parts of the Annual Work programme of the FP can be ensured by partners and EC Synergies with national/regional programmes and activities Synergies with other programmes	***What is possible?*** Coherence among partnerships and with different parts of the Annual Work programme of the FP can be ensured by partners and EC If MS participate: Synergies with national/regional programmes and activities Synergies with industrial strategies	***What is possible?*** Coherence among partnerships and with different parts of the Annual Work programme of the FP can be ensured by partners and EC Synergies with other programmes or industrial strategies If MS participate: Synergies with national/regional programmes and activities
What is limited? Synergies with other programmes or industrial strategies	***What is limited?*** Synergies with other programmes or industrial strategies	***What is limited?*** Synergies with industrial strategies	***What is limited?*** Synergies with other programmes	
What is not possible? Synergies with national/regional programmes and activities				

Appendix H Additional Information on the operational objectives

The following list present the operational objectives and the types of activities that can be implemented by the KDT Institutionalised Partnership.

- Support large-scale pilots for key downstream European industries:
  - Activities accelerating the market readiness of edge AI semiconductor-based neuromorphic components and quantum computing technologies for the development of more secure and energy efficient autonomous machines and devices, by supporting the collaboration of TROs with semiconductor companies, software houses and downstream industries on demonstration projects and pilot lines
  - Large-scale pilot lines for validation and demonstration of applications covering value networks for downstream industries
  - Organisation of a technology platform in the form of Digital Innovation Hubs where RTOs, integrated device manufacturers and foundries can meet to develop and test new integration concepts and designs
- Align strategies and build synergies with MS to attract growing private resources
  - Support activities for aligning the research agendas of the partners
  - Activities for coordinating research agendas and activities with other partnerships, European initiatives and national or regional activities
  - Provide contribution to standardisation regarding the security and quality of components
- Support initiatives aiming at integrating stakeholders around sectoral value networks:
  - Support networking activities
  - Communication activities
- Develop capabilities for base and application-specific designs in strategic application areas:
  - Initiatives for base designs of strategic importance for a range of products including AI accelerators, edge computing, RF IP blocks, ultra-low power, smart and power-efficient computing and embedded memory sources, technologies, etc.
  - Collaboration platforms for application-specific designs
- Support innovative technological approaches contributing to energy efficiency and environmental protection
  - Collaborative research on improving energy efficiency and reducing the environmental footprint of KDT applications
  - Design initiatives for improving energy efficiency and reducing the environmental footprint of ICs
- Leading-edge research activities in emerging technologies:
  - Coordination activities between MS, the Commission, industry and RTOs to develop a roadmap showing weak or missing segments of the KDT value networks
  - Collaborative and multidisciplinary research on software and algorithms for AI, semiconductor-based neuromorphic components and quantum computing
  - Support pilot and demonstration projects

- Develop key digital technologies for secure applications and critical infrastructures: energy, telecom, transport
  - Coordination with other European initiatives and IPCEI for complementary investments in production capacity and the development of human resources
  - Support pilot and demonstration projects
- Support research for the next generation of equipment and innovative solutions for sourcing materials:
  - Research for the formulation of technology concepts, experimental proof of concepts and validation in the lab of production methods and materials that generate ground-breaking increases in functionality and performance of integrated electronics and photonics components
  - Manufacturing pilot lines for the collaboration of RTOs and manufacturing companies for technical validation and demonstration of semiconductor equipment and materials technologies

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