# European Partnership under Horizon Europe

# Key Digital Technologies

**About this draft**

In autumn 2019 the Commission services asked potential partners to further elaborate proposals for the candidate European Partnerships identified during the strategic planning of Horizon Europe. These proposals have been developed by potential partners based on common guidance and template, taking into account the initial concepts developed by the Commission and feedback received from Member States during early consultation[1]. The Commission Services have guided revisions during drafting to facilitate alignment with the overall EU political ambition and compliance with the criteria for Partnerships.

This document is a stable draft of the partnership proposal, released for the purpose of ensuring transparency of information on the current status of preparation (including on the process for developing the Strategic Research and Innovation Agenda). As such, it aims to contribute to further collaboration, synergies and alignment between partnership candidates, as well as more broadly with related R&I stakeholders in the EU, and beyond where relevant.

This informal document does not reflect the final views of the Commission, nor pre-empt the formal decision-making (comitology or legislative procedure) on the establishment of European Partnerships.

In the next steps of preparations, the Commission Services will further assess these proposals against the selection criteria for European Partnerships. The final decision on launching a Partnership will depend on progress in their preparation (incl. compliance with selection criteria) and the formal decisions on European Partnerships (linked with the adoption of Strategic Plan, work programmes, and legislative procedures, depending on the form). Key precondition is the existence of an agreed Strategic Research and Innovation Agenda / Roadmap. The launch of a Partnership is also conditional to partners signing up to final, commonly agreed objectives and committing the resources and investments needed from their side to achieve them.

The remaining issues will be addressed in the context of the development of the Strategic Research and Innovation Agendas/ Roadmaps, and as part of the overall policy (notably in the respective legal frameworks). In particular, it is important that all Partnerships further develop their framework of objectives. All Partnerships need to have a well-developed logical framework with concrete objectives and targets and with a set of Key Performance Indicators to monitor achievement of objectives and the resources that are invested.

Aspects related to implementation, programme design, monitoring and evaluation system will be streamlined and harmonised at a later stage across initiatives to ensure compliance with the implementation criteria, comparability across initiatives and to simplify the overall landscape.

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[1] https://www.era-learn.eu/documents/final_report_ms_partnerships.pdf

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# 1 Summary

The overall objective of the Key Digital Technologies (KDT) Partnership is to reinforce Europe's potential to innovate through contribution of electronic components and systems, including microsystems, software technologies, sub-assemblies, and systems of systems giving secure and trusted technologies to strategic value chains. It aligns R&I policies among its participating states to reach the critical mass needed for achieving Europe's sovereignty through the tri-partite involvement of Participating States (Member States, Associated countries), the EU and industry.

# 2 Context, objectives, expected impacts

## 2.1 Context and problem definition

Electronic Components and Systems are at the heart of the twin priorities Europe has defined: the **Digital Transformation** and the **Green Deal**.

***"Digital technologies (…) are transforming the world at an unprecedented speed. (…) it is not too late to achieve technological sovereignty in some critical technology areas."***

(Ursula von der Leyen, President of the European Commission)

***"… Digital technology can help us become the world's first climate-neutral continent by 2050. Smart electricity grids can help to smooth the transition to renewable energy, by allowing us to adjust the electricity we use to what we produce, not the other way around. Agricultural machinery can use AI to cut the use of pesticides, so farmers can produce more, with less effect on the environment. And this is why investing in digital technology is a crucial part of the European Green Deal."***

(Margrethe Vestager, Vice-President of the European Commission for

A Europe fit for the Digital Age)[2]

### 2.1.1 Policy context

Horizon Europe

The proposal for Horizon Europe, the EU's future research and innovation (R&I) programme for 2021-2027, outlines the approach (Article 8) and criteria (Annex III) for R&I partnerships under the umbrella term 'European Partnerships'. According to the political agreement between the Council and European Parliament, "European Partnerships shall be established for addressing European or global challenges **only in cases where they will more effectively achieve objectives of Horizon Europe than the Union alone and when compared to other forms of support of the Framework programme**".[3]

Different forms of partnerships can be implemented depending on needs and criteria. One such form is institutionalised partnerships set up under Article 185 or Article 187 of the Treaty on the Functioning of the European Union (TFEU). The draft legislation outlines possible areas

2 https://ec.europa.eu/commission/commissioners/2019-2024/vestager/announcements/shaping-digital-future-europe_en
[3] The overall financial framework for the upcoming partnerships still has to be agreed by the co-legislators

in which institutionalised partnerships could be set up, including key digital and enabling technologies and their use. In the course of the strategic planning, **the Commission, in close cooperation with the Member States, has identified Key Digital Technologies (KDT) as a candidate for Institutionalised Partnership under Article 187 TFEU**.

Shaping Europe's Digital Future

Digital technologies are profoundly changing our daily life, our way of working and doing business, and the way people travel, communicate and relate with each other. Digital communication, social media interaction, e-commerce, and digital enterprises are steadily transforming our world, as we are now all experiencing due to the COVID-19 pandemic. They are generating an ever-increasing amount of data, which, if pooled and used, can lead to a completely new means and levels of value creation. It is a transformation as fundamental as that caused by the industrial revolution. With its Strategy on Shaping Europe's Digital Future, the Commission set out its vision for how to make the digital transformation work for people, businesses and the planet, in line with EU values, and how to retain technological and digital sovereignty and be the global digital leader. The White Paper on Artificial Intelligence released as part of this strategy, highlights "the work of the Key Digital Technology Joint Undertaking, proposed to start in 2021".

A New Industrial Strategy for Europe

In November 2019, the Strategic Forum for Important Projects of Common European Interest (IPCEIs) identified[4] both **microelectronics and Industrial Internet of Things (IIoT)[5] value chains as being of key strategic importance to Europe, and as such both require well-coordinated actions and investments**. They are directly linked to the digital transformation and the transition to a climate-neutral, clean, and circular economy and essential to a robust positioning of Europe in the burgeoning cybersecurity, interconnectivity, edge-computing and artificial intelligence (AI) markets.

In its New Industrial Strategy for Europe of March 2020, the Commission announced support for the development of key enabling technologies that are strategically important for Europe's industrial future, including a number of digital technologies. The electronic components, embedded software and integrated systems which make up industrial value chains **underpin crucial digital technology developments in nearly all sectors**. If they are to remain competitive in the context of digital transformation, Europe's automotive, energy, manufacturing, health and aeronautics sectors require access to world-class, secure, trusted and power-efficient key digital technologies.

Furthermore, there will be a new focus on **industrial ecosystems**, encompassing all players operating in a value chain: from the smallest start-ups to the largest companies, from academia to research, service providers to suppliers. Referring to the benefits of industrial alliances as already shown in e.g. microelectronics, the Commission is considering "scope for coordinated investment by Member States and industry in the form of new IPCEIs and the possible follow-up to the first IPCEIs on batteries and microelectronics". The KDT partnership will play a crucial role in getting this new IPCEI up and running.

The European Green Deal

[4] https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6204
[5] IIoT refers to the interaction between intelligent sensors, processors and other devices to optimise industrial processes.

The European Green Deal is one of Europe's top priorities, and the reinforcement of the European Electronics Components and Systems value chain by the means of the KDT partnership proposal will be at the heart of its success:

- On one hand, ECS/KDT are essential elements to enable other sectors to reduce climate change and environmental impact, as elaborated in more detail in section 2.2.10. Elements of the Green Deal such as the supply of clean, affordable and secure energy, resource-efficient buildings, sustainable and smart mobility, as well as a healthy and environment-friendly food supply chains will all rely on ECS to achieve their ambitions. For example, industry's digital transformation is offering new prospects to unlock innovation, provide new opportunities to workers and to decarbonise at the same time. It is estimated that digital technologies have the potential to save almost 10 times more emissions than they produce by 2030[6]. In other words, Key Digital Technologies will allow to decouple economic growth from resource use, which is a key target of the European Green Deal.
- On the other hand, the ECS sector itself needs to use its own potential to improve the energy performance and disposability of electronic components themselves and to reduce their environmental footprint by means of cleaner and greener production processes, more circularity and less energy and material consumption. More information on this can also be found in the sustainability reports of the ECS industry[7].

Current and previous interventions

KDT Partnership builds on the current **Electronic Components and Systems for European Leadership Joint Undertaking (ECSEL JU).** ECSEL was set up in 2014 with the remit to keep Europe at the forefront of technology development in the area of Electronic Components and Systems. ECSEL combines two previous JUs that addressed the areas of embedded systems (ARTEMIS) and nanoelectronics (ENIAC) in the period 2008-2013. Additionally, to gain a more complete integration of the value chain, the EPoSS European Technology Platform on Smart Systems Integration was also combined into ECSEL. The ECSEL JU is a tri-partite public-private partnership (PPP) jointly funded by industry, research organisations, participating Member States and the European Commission (representing the EU).

The reports for the Interim Evaluation of the ECSEL Joint Undertaking and the Final Evaluation of the ARTEMIS and ENIAC Joint Undertakings have been produced by a panel of independent experts.

Some conclusions from the interim evaluation reports:

- **ECSEL-JU** has brought together two previous JUs that addressed the areas of embedded systems (ARTEMIS) and nanoelectronics (ENIAC) with the EPoSS European Technology Platform on Smart Systems Integration. It has been successful in increasing the private and public investment in Electronics Components and Systems. Six calls were launched between 2014 and 2016 and 39 projects have been selected for a total funding of EUR 1.96 billion. Industry provided 56% of these funds. In terms of gearing each Euro contributed by the EC has resulted in 4.3 Euros of research and innovation activity in Europe. Overall considering the previous ARTEMIS and ENIAC JUs combined with the ECSEL JU, 171

[6] See p. 35-37 of https://www.digitaleurope.org/wp/wp-content/uploads/2020/02/DigitalEurope-A-Stronger-Digital-Industrial-Europe.pdf
[7] Some examples of sustainability reports can be found on https://www.nxp.com/docs/en/supporting-information/2017-CR-Report-Final.pdf, https://www.bosch.com/company/sustainability/sustainability-strategy/, https://www.st.com/content/st_com/en/about/st_approach_to_sustainability/sustainability-reports.html,https://www.infineon.com/dgdl/Sustainability%20at%20Infineon%202019.pdf?fileId=5546d4616e8d476e016e9282f50a0008

projects valued at over EUR 6 billion have been funded resulting in 3972 participations and 1000's of researchers being employed.

The transition from ARTEMIS, ENIAC and EPoSS into a combined JU has not been without difficulty. The communities have made considerable efforts to try and integrate their activities into a single community representing the Electronics Components and Systems domain. The introduction of Lighthouse initiatives that cluster projects to tackle sectoral issues, e.g. smart factories and automotive applications, is seen as a very positive development. ECSEL is unique in adoption of a tri-partite funding strategy.

The success in joining EU, national and industrial actors to pursue common goals, in the Electronic Components and Systems global strategy across Europe, can already be seen as a direct result of the JU approach. Though not an easy task and at the expense of complex administration, the tri-partite nature of funding has the advantage of reducing fragmentation across Europe. ECSEL support for R&I on Electronic Components and Systems (ECS) has proven effective and essential to innovation in large parts of the economy.

The recent "Study on the impact of ECSEL funded actions"[8] commissioned by ECSEL JU from Deloitte and VVA finds four major impacts of ECSEL's actions to date:

1. Increased levels of R&I cooperation between ECS players;
   - Strengthened cooperation between public and private ECS R&I performers
   - Reinforced policy dialogue between national authorities, European institutions and the industry;
2. Increased R&D spending for all categories for organisations;
3. Strengthened integration of SMEs in the value chain;
4. Increased innovativeness and competitiveness of the entire ECS R&I ecosystem.

The evidence gathered in the accompanying document "Powering the Digital Transformation in Europe"[9] confirms that ECSEL's way of working yields great benefits for organisations involved in its projects.

The ECSEL JU has been instrumental in creating a well-structured framework where the Union, Member States, Associated Countries, academia, research institutes and industry work together to develop and implement a coherent European strategy for ECS. This enabled support to pilot lines to further mature key digital technologies, which has in turn led to substantial downstream investments by industry and Member States through an Important Project of Common European Interest (IPCEI) on microelectronics. Without public support via ECSEL and the IPCEI, these innovative pilot lines would not have been feasible[10]. Such synergy of instruments is crucial for maintaining technological leadership as well as sustained industrial deployment to the ultimate benefit of downstream markets.

The tri-partite approach with direct involvement of national authorities will be continued in the KDT partnership, as a key feature that ensures strategic alignment between the Private Members, i.e. industry, the European Union, and the participating Member States and Associated Countries. In terms of **improvements**, the following recommendation from the ECSEL interim evaluation report is particularly noteworthy:

> "At the highest political level, a discussion should be initiated towards harmonisation and synchronisation of the Member State participation rules, funding rates and procedures wherever possible, adopting best practice as the guiding principle. Also at

[8] See summary on https://www.ecsel.eu/sites/default/files/2020-07/short_study_web.pdf and full report on https://www.ecsel.eu/sites/default/files/2020-07/Long_study_web.pdf

[9] ECSEL Joint Undertaking powering the digital transformation in Europe; a stakeholders impact assessment of the ECSEL JU programme, 2020; https://www.ecsel.eu/news/powering-digital-transformation-europe

[10] See Commission assessment on https://ec.europa.eu/commission/presscorner/detail/en/IP_18_6862

> the highest political level, efforts should be made to encourage Member States to commit to a multi-annual funding system to provide stability and a longer-term focus."

However, in the interest of participants, the co-funding mechanism of the KDT partnership should be simplified to the greatest extent possible, aiming at a single reporting of costs and activities for each beneficiary (instead of separate reporting to both the JU and national authorities).

The following important recommendation of the ECSEL interim evaluation report has been partially implemented:

> "It is still early days with respect to the integration of activities within ECSEL. In the future there needs to be greater integration of the AENEAS, ARTEMIS-IA and EPoSS communities, that each provide different perspectives but overlap on technologies, to focus on integrated vertical roadmaps so that the European benefits of investing are realised. The three organisations have a leading position in their respective domains and each produce valuable Strategic Research Agendas. However, considering the whole community these should be better integrated into a single roadmap."

The common ECS Strategic Research Agenda (SRA) is now prepared as one single document by experts mandated by the three industry associations. The first edition was published in 2018, and since then it is updated every year. This SRA takes into account the vertical domains as main drivers and explains the challenges for the enabling capabilities as horizontal technology fields. The Strategic Research and Innovation Agenda (SRIA) for the KDT partnership is outlined in section 2.2.11.

Other recommendations from the experts panel focus on the need to place greater emphasis on a strategic approach; to strive for further integration of SMEs; and to implement a closer follow-up of projects' impacts.

For an overview of all actions in response to the recommendations from the ECSEL interim evaluation report see the Action Plan adopted by the Governing Board on April 11, 2018.

### 2.1.2 Problem definition

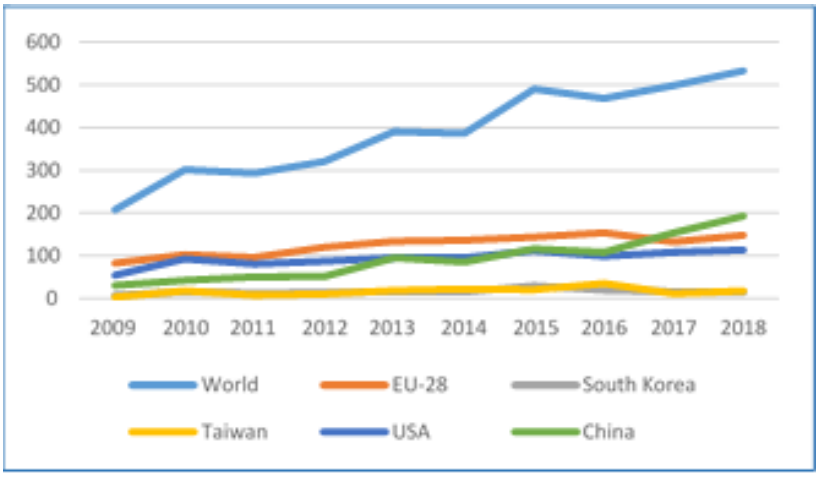
The **problem** to which the KDT Partnership responds can be defined in terms of risks involved in case of no action at the EU level:

*Europe's limited presence in key areas of electronic value chains*

European electronic components and systems suppliers have a strong position in global vertical markets, including automotive, industrial equipment, aerospace, security and healthcare. However, not all stages of development and production take place in the EU. Manufacturing of electronic components and systems mostly takes place in Asia and circuit design is dominated by US and, more recently, by Asian companies. R&I effort would be required to develop the necessary design and manufacturing competences. Additionally Europe has very limited presence in high-volume computing and communications markets, which currently account for 60% of global components market. Limited presence in key areas affects electronics value chains and undermines EU sovereignty.

*Europe not able to reach excellence in emerging components and systems technologies*

Analysis of the number of research publications in microelectronics in the period 2009-18 (Figure 1 below) shows that Europe has been leading, although its leadership has been taken over by China in 2017 and is closely followed by the US. Steep increases in research capacity and R&D investments in these regions are threatening Europe's ability to seize emerging opportunities.




Source: Calculations by Technopolis Group based on Scopus data

*Figure 1. Production of research publications on microelectronics per country and year — number of publications (2009-2018)*

Moreover, the uptake of research output by industry in Europe has been slow, mostly because of its fragmentation and smaller footprint when compared with US and China. Finally, European R&D actors, SMEs and start-ups are often particularly strong in emerging domains, but can lack the connection to a broader ecosystem to develop partnerships, grow their knowledge and eventual customer base, limiting Europe's ability to capitalise on the excellence of the research output.

*Limited exploitation in Europe of electronic components and systems addressing societal and environmental challenges*

In the development of electronic components and systems, focus has traditionally been on performance and costs. More recently the pressure to extend the autonomy of mobile devices and the increasing attention to environmental impacts have made reduced energy consumption a key criterion in technology development. Safety and security considerations have also grown in importance following increasing cybersecurity concerns, as well as the societal demand for trust and privacy in respect to fundamental rights. However, as end-user companies to date have primarily relied on software-based solutions to achieve higher - but still insufficient - levels of energy efficiency and security, the potential of hardware is as yet unexploited.

Main **problem drivers** affecting research and innovation performance in KDTs in Europe are:

- Limited design and production capabilities in electronic value chains
- Insufficient large-scale innovation projects (e.g. pilot lines) in electronic components and systems
- Limited cooperation in research across segments in European electronic value chains
- Weak R&I focus on emerging technologies with low involvement of SMEs
- Limited use of innovative approaches (e.g. hardware/software codesign) for security, trust and energy-efficiency

- Limited alignment of the electronic R&I ecosystem with strategic European policies and initiatives

As described in more detail in section 2.1.3 below, **competition from other regions has increased dramatically,** with US, China, South Korea and other regions investing tens of billions of euro a year in electronic components and systems research.

For example, the "Made in China" policy, published in May 2015, mentions specific targets to increase China's self-sufficiency in IC production to 40% in 2020 and 70% by 2025. It is clear that China aims to accelerate the development of its semiconductor industry and reduce the reliance on imports of chips. To help reach these goals, the Chinese government established the China Integrated Circuit Industry Investment Fund (CICIIF) or 'Big Fund' in September 2014. The Big Fund was set up to invest in and promote mergers and acquisitions in the semiconductor industry. Beijing envisioned spending more than $150 billion over 10 years to stimulate developments in semiconductor design and manufacturing. A new report[11] from the Hinrich Foundation describes in detail how Chinese government intervention is distorting global semiconductor value chains. Furthermore, the Plan for the Development of New Generation Artificial Intelligence, published on July 20, 2017, which laid out plans to become the world leader in AI by 2030, with a domestic AI industry worth almost $150 billion. The first step of that plan is to catch up with the US on AI technology and applications by 2020.

Taking South-Korea as another example, the vision and goals of its "K-ICT" strategy is to focus on ten strategic industries as future growth areas: 5G mobile communication technology, ultra-high definition (UHD), digital content (including virtual reality), smart devices such as wearables, the Internet of Things, cloud system, big data, AI, software and information security. To achieve the goal of increasing added value of ICT production to 240 trillion won and ICT exports to $210 billion by 2020, the government plans to expand its investment in convergence technologies, implement regulatory reforms to facilitate convergence, improve the quality of innovation and workforce and strengthen global cooperation and collaboration.

Europe's competitors, in particular the United States, are becoming increasingly protectionist, thus making difficult the access to some key digital technologies. A lack of technological sovereignty may jeopardise Europe's potential to innovate and provide key industries with the secure, trusted, low-power solutions on which their competitive edge depends. Given the scale and increasing intensity of KDT investment around the world, failure to align strategies and achieve a critical mass of funding in this research-intensive domain would be detrimental to Europe's position in these important markets. **In a globalised world of heightened uncertainties and volatile geopolitical interests, it is essential to secure and assert European autonomy in a number of strategic technology areas and value chains**, while continuing cooperation and exchanges with third countries. This calls for instituting digital sovereignty, so that Europe can pursue its strategies avoiding dependence on outside actors and without outside interference.

Strategic opportunities

i. The **digital transformation** is underpinned by digital technologies. This transformation affects all sectors and it is estimated that disruptive digital technologies can contribute on average 1.1 percent to annual GDP growth in the period 2017-2030.

[11] See https://hinrichfoundation.com/trade-research/global-trade-research/thought-leadership/semiconductors-at-the-heart-of-the-us-china-tech-war/ , in particular chapter 4.

The cumulative effect is 14.1 percent higher GDP by 2030 as a result of these technologies, or 2.2 trillion Euro (real 2017 terms) in the EU.[12, 13, 14, 15]

ii. The **volume of data** produced in the world is growing rapidly, by a factor of five from 2018 to 2025[16]. The way in which data is stored and processed will change dramatically over the coming 5 years. Today 80% of the processing and analysis of data takes place in data centres and centralised computing facilities, and 20% in smart connected objects, such as cars, home appliances or manufacturing robots, and in computing facilities close to the user ('edge computing'[17]). By 2025 these proportions are likely to be inverted. The trend towards **edge computing** will contribute to manage the challenge of the 'data tsunami' created by billions of connected devices[18].

iii. **Artificial Intelligence** is developing fast. It will change our lives by improving healthcare (e.g. making diagnosis more precise, enabling better prevention of diseases), increasing the efficiency of farming, contributing to climate change mitigation and adaptation, improving the efficiency of production systems through predictive maintenance[19]. AI could boost global productivity from 0.8% to 1.4%[20] a year. The Commission is committed to enabling scientific breakthrough, to preserving the EU's technological leadership and to ensuring that new technologies are at the service of all Europeans improving their lives while respecting their rights[21]. EU technological leadership in AI requires mastering of new digital technologies, in particular new computing architectures, software algorithms and semiconductor production.

iv. New **computing architectures** will replace conventional approaches. With Moore's law[22] coming to an end, new approaches are needed to meet expected increases in computing performance. Neuromorphic[23] and –in a longer term- quantum[24] computing will offer a step change in data processing capabilities. The KDT industry needs to explore innovative data-processors including design and industrial scale up of neuromorphic and quantum components and develop viable manufacturing technologies.

v. The global trend towards **electrification** of the energy supply will require innovations in digital technologies. Passenger cars are responsible for around 12% of total EU emissions of carbon dioxide (CO2)[25]. To meet the reduction emission target of at least 50% for 2030[26], new power electronics technologies and intelligent software for cars will be required to support the growing electrification trend.

vi. **Co-integration** of digital technologies. A major technology trend is the increasingly intermix of photonics, microelectronics and software to build complex systems and

[12] Shaping the digital transformation in Europe. Final Report, McKinsey and Company. September 2020, https://ec.europa.eu/digital-single-market/en/news/shaping-digital-transformation-europe
[13] The study was conducted before Brexit and the figure refers to the EU-28.
[14] Industrials Executive Mergers and Acquisitions Report. Kearny. 2019
[15] Global semiconductor market revenue ranking. Omnia. April 2020. https://www.design-reuse.com/news/47763/intel-2019-semiconductor-market.html?utm_content=243804&utm_campaign=47763&utm_medium=socnewsalert&utm_source=designreuse
[16] EC Communication (2020) 66. A European strategy for data. 19 February 2020
[17] It refers to the emerging computing paradigm in which data storage and data processing is done close to the user (rather than in remote data centres)
[18] The worldwide number of connected devices is projected to increase to 43 billion by 2023, from 16 billion in 2018. *Growing opportunities in the Internet of Things. McKinsey & Co. July 2019*
[19] White Paper On Artificial Intelligence - A European approach to excellence and trust. COM(2020) 65
[20] OECD Science, Technology and Industry Scoreboard 2017
[21] White Paper On Artificial Intelligence - A European approach to excellence and trust. COM(2020) 65
[22] Moore's Law states the performance of computers increases every two years as the number of transistors on a microchip doubles every two years. Named after Gordon Moore, co-founder of US firm Intel, the law has been valid for more than 50 years. "*We're not prepared for the end of Moore's Law*". David Rotman. MIT Technology Review. February 24, 2020.
[23] Neuromorphic refers to computing approaches making use of electronic circuits that mimic neuro-biological architectures such as those present in nervous systems.
[24] Quantum computing exploits the properties of matter at atomic dimensions with potential performance far superior than 'conventional' computing. It requires a full new approach to hardware circuitry and software.
[25] EC 2020 Climate and Energy Package
[26] The European Green Deal. COM(2019). 11 December 2019

integrated platforms for new areas of application. This co-integration will drive major innovations in portable and wearable personal devices (e.g. for health monitoring), 5G and 6G communications, data centres, autonomous vehicles, food safety and environmental monitoring.

Rapid advances in AI are opening the door to machine learning for the next levels of robotics and other industrial use-cases, breakthroughs in personalised healthcare, (cyber)-security, autonomous mobility, and sustainable energy management, to name just a few application areas across industry and society. **Pervasive digital transformation** will leave no industrial sector and no societal issue untouched. More than any other "new frontier" technology before, AI can truly improve our chances for solutions as we address our persistent societal challenges. **Therefore, AI is the new opportunity as well as the new challenge in Europe. It calls for a deep, sustained partnership beyond the current levels of cooperation up and down the value chain.** The challenges are simply too big, the risks of failure too high, and the costs prohibitively large for any public or private entity to address it alone.

The **rapid proliferation of AI, ubiquitous automation, autonomous systems and connectivity, as well as digitisation are having a major impact on the way data are distributed across different computing environments**. Nowadays, it is no longer just ICT systems, but an ever-larger share of the infrastructure that supports an increasingly data-based ecosystem.

Distributed intelligence like in fog, swarm, mist or edge -computing will be the next revolution in our data-driven economy, mainly to solve the issues related to latency, bandwidth and security. Such computing techniques extend functions of computation, storage, and networking, and require low power components integrated into systems. **Europe needs to master the essential hardware, software and systems integration to guarantee privacy, security and integrity of the data**, and master data-driven and data-supported innovation in existing and future market segments.

Existing **technological paradigms in microelectronics are reaching physical and economic limits and are being replaced by new ones**. In a sector that already invests around 14%[27] of annual revenues in research and development, this is an unprecedented challenge, where Europe must face worldwide competition. At the same time, it is also a unique opportunity for Europe to strengthen and enlarge its core competences.

To maintain a sustained effort to address these challenges, substantial resources (infrastructure, knowledge, innovation) need to be invested by combining public (national and European) and private investments to assemble the required critical mass.

European value chains making use of KDT, namely automotive, aerospace, manufacturing, health, computing, communications, energy, etc., will be actively involved in the proposed partnership, as participants in actions that address full value chains, thus creating solutions for the end users, addressing major societal challenges, and ultimately improving the competitiveness of Europe.

[27] 2019 SIA Factbook, p. 20.

### 2.1.3 Evidence base and data

#### 2.1.3.1 Markets, value chains and foresight

Electronic components (hardware and software) and systems support end-applications in a variety of industries. Their penetration is growing, driven by increasing system complexity and connectivity. In addition, they are the backbone of the tremendous opportunity provided by the rise of IoT, expected to reach 4 to 11T$ by 2025[28]. The worldwide electronics value chain in 2018 is depicted in Figure 2 below.

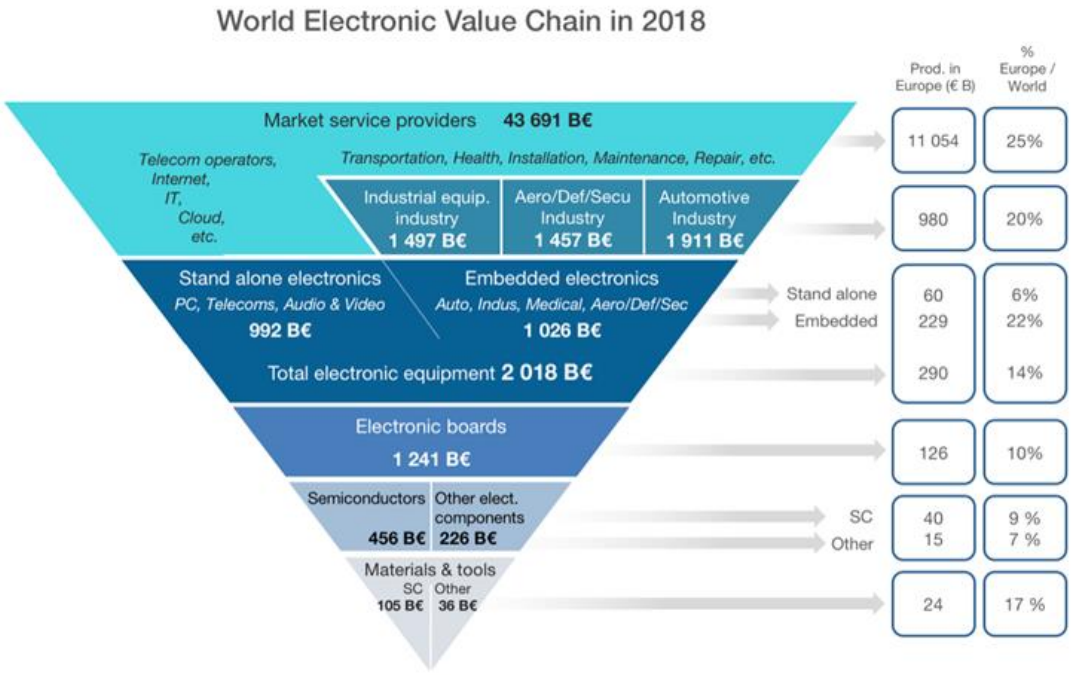



*Figure 2. Worldwide Electronics Value Chain in 2018[29].*

While **Europe is one of the world largest markets for digital products and services,** a newly released Study on the Electronics Ecosystem by DECISION indicates that the EU share of global production of electronic systems has been declining for the past six years. Yet, the EU is still very well positioned on the end-user electronic segments. Whereas in 2018, Europe accounts for 15% of the world electronics systems production, this proportion reaches 22% when considering only embedded/professional electronic systems production, as depicted in Figure 3 below:

- In automotive electronics, Europe (27%) is the first region in the world ahead of China (21%), and North America (17%);
- The EU produces 20% of the global industrial electronics and is the third region in the world after China (27%), and North America (21%);
- The EU produces 21.5% of the global Aerospace/Defence/Security electronics and is the second region in the world after North America (41%), but ahead of China;

[28] https://artemis-ia.eu/publication/download/embedded-intelligence-trends-challenges.pdf
[29] http://www.decision.eu/wp-content/uploads/2020/02/ECS-study-presentation-of-Key-findings.pdf

- The EU produces 19.3% of the global Health & Care electronics and is the third region in the world after North America (41%), and China (20%)[30].

[30] "Emerging Technologies in Electronic Components and Systems (ECS) – Opportunities Ahead", DECISION Etudes & Conseil, 2020, https://op.europa.eu/en/publication-detail/-/publication/582a3802-d6c3-11ea-adf7-01aa75ed71a1/language-en.

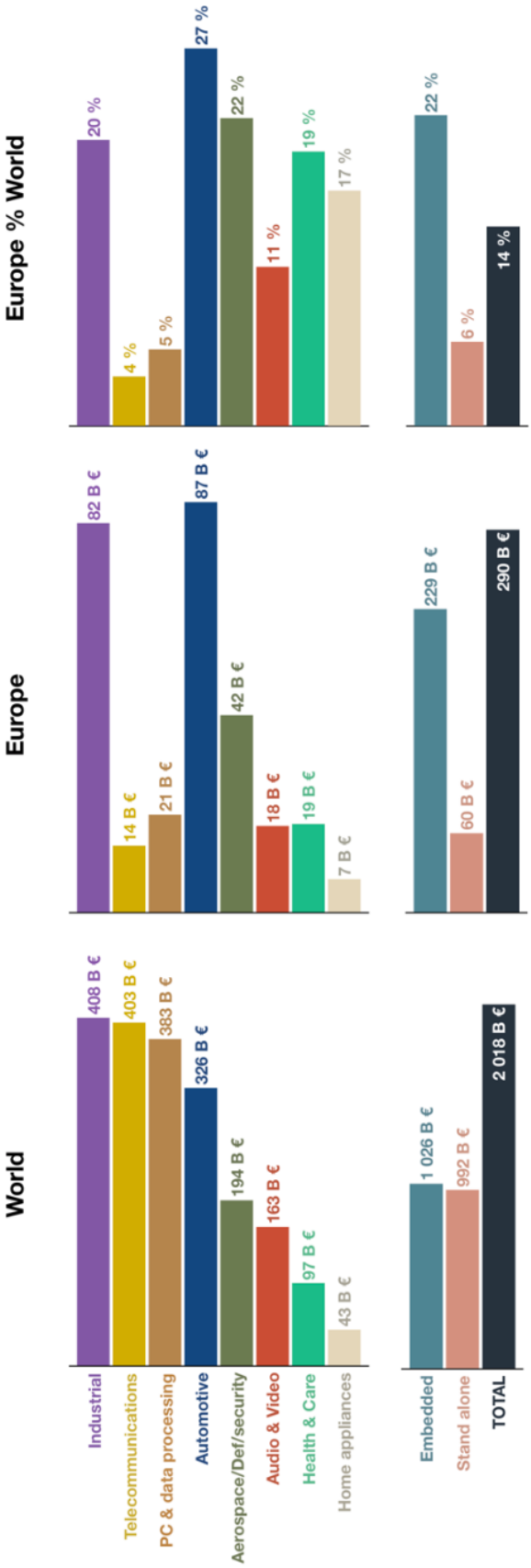



*Figure 3. Electronic systems – Position of Europe in 2018 (in euros)*[31]

[31] Ibid.

Europe also benefits from a **strong R&D ecosystem**, competing with the US and the Chinese ones, and sometimes surpassing them. The main fields of excellence are often linked to Europe's industrial strengths, which are the embedded and professional applications. Fortunately, embedded and professional electronics is forecasted to grow at 6.9% per year on average till 2023 compared 5% for electronic equipment globally[32], creating clear opportunities for Europe. Also the value migration down the value chain constitutes a major opportunity for European players to capture growth in the long term[33].

Semiconductor components is an important and growing sector enabling a very important value chain of industries as shown in Figure 2. Worldwide sales reached 468B$ in 2018 and are expected to reach 1T$ by 2030[34]. Whereas Europe remains a world leader in terms of the production of semiconductor equipment, EU production share of semiconductors has been declining during the last 20 years[35]. **Given its strategic importance any attempt has to be made to improve Europe's position in this sector.** Without EU and national interventions, the European position would have been much worse compared to other parts of the world, which are outspending Europe multiple times in public support of R&D (see section 2.1.3.2). Note that microelectronics represents around 30% of the content of electronic devices.

In Figure 2, "other electronic components" sum up to 226B€. A large part of them are MEMS (Micro-Electro-Mechanical Systems), which is an important segment with growing importance for Europe. Figure 4 below shows a steady growth from the year 2016 onwards.

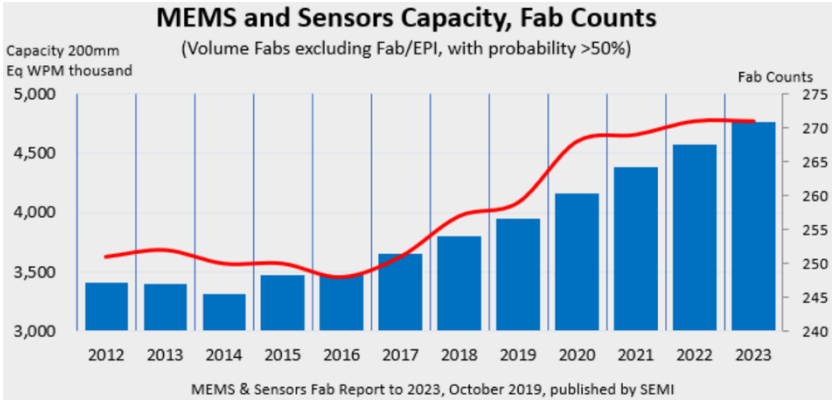



*Figure 4: Installed capacity and MEMS and sensors fab counts[36].*

According to the new MEMS & Sensors Fab Report to 2023[37], "Total worldwide installed capacity for MEMS and sensors fabs is forecast to grow 25 percent to 4.7 million wafers per month from 2018 to 2023, driven by explosive demand across communications, transportation, medical, mobile, industrial and other Internet of Things (IoT) applications".

For embedded systems, **Europe holds specific strengths in safety-critical and real-time systems,** with a market share of about 22%. The **same applies for MEMS and nearly all segments of the sensor market.** Competition from other regions has stepped up dramatically

[32] Source: DECISION Études & Conseil, 2019.
[33] See p. 26 of https://artemis-ia.eu/publication/download/embedded-intelligence-trends-challenges.pdf
[34] https://www.bom-components.com/news/In-2030,the-global-chip-business-will-reach-a-market-size-of-1-trillion-US-dollars.html
[35] http://www.decision.eu/wp-content/uploads/2020/02/DECISION_Study_Electronics_Ecosystem.pdf
[36] https://www.semiconductor-digest.com/2019/10/29/global-mems-and-sensors-fab-capacity-to-grow-25-percent-through-2023-semi-reports/
[37] Ibid.

with 10s of B€ per year being invested by China and other regions in R&D&I and to acquire foreign technology.

The economic value supported by the ECS industry goes even further. A different way of charting the global and European ECS value chains in 2016 and its projected evolution towards 2025 is to put them in context of the solutions and systems in the end applications they support, as presented below[38].

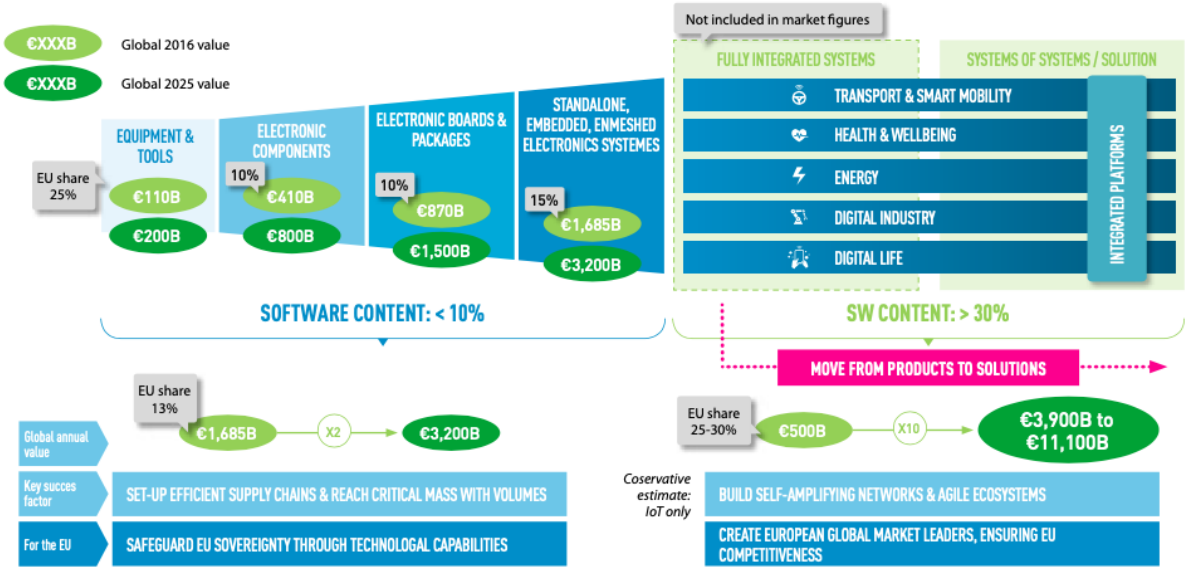



*Figure 5. Global and European value chain 2016-2025.*

The representation above shows how, although the growth on the upstream traditional ECS is expected to be significant, growing from T€1.7 to T€3.2, value will dramatically shift downstream, towards application-specific and software rich solutions and fully integrated systems growing from a mere B€500 today to up to T€11.1 by 2025.

This value shift represents a tremendous opportunity for Europe to grow, as it holds leadership positions in some applications today (c. 25-30% market share in 2016) while its market share on the upstream is smaller and under threat (c. 13% in 2016). Capturing this opportunity will require increasingly software-rich, interoperable, re-usable and easily updated architectures. In parallel, it will call for application-specific know-how in AI & analytics to deliver value at solution and system level. These capabilities remain to be built and will require a sizeable effort in R&D&I in the future, as maintaining Europe's leadership in this area is in no way guaranteed, given the speed and scale of growth that are forecasted, and the increasing international competitive pressure. To that regard, Europe's current position in the world on the various application sectors is depicted below.

[38] https://artemis-ia.eu/publication/download/embedded-intelligence-trends-challenges.pdf

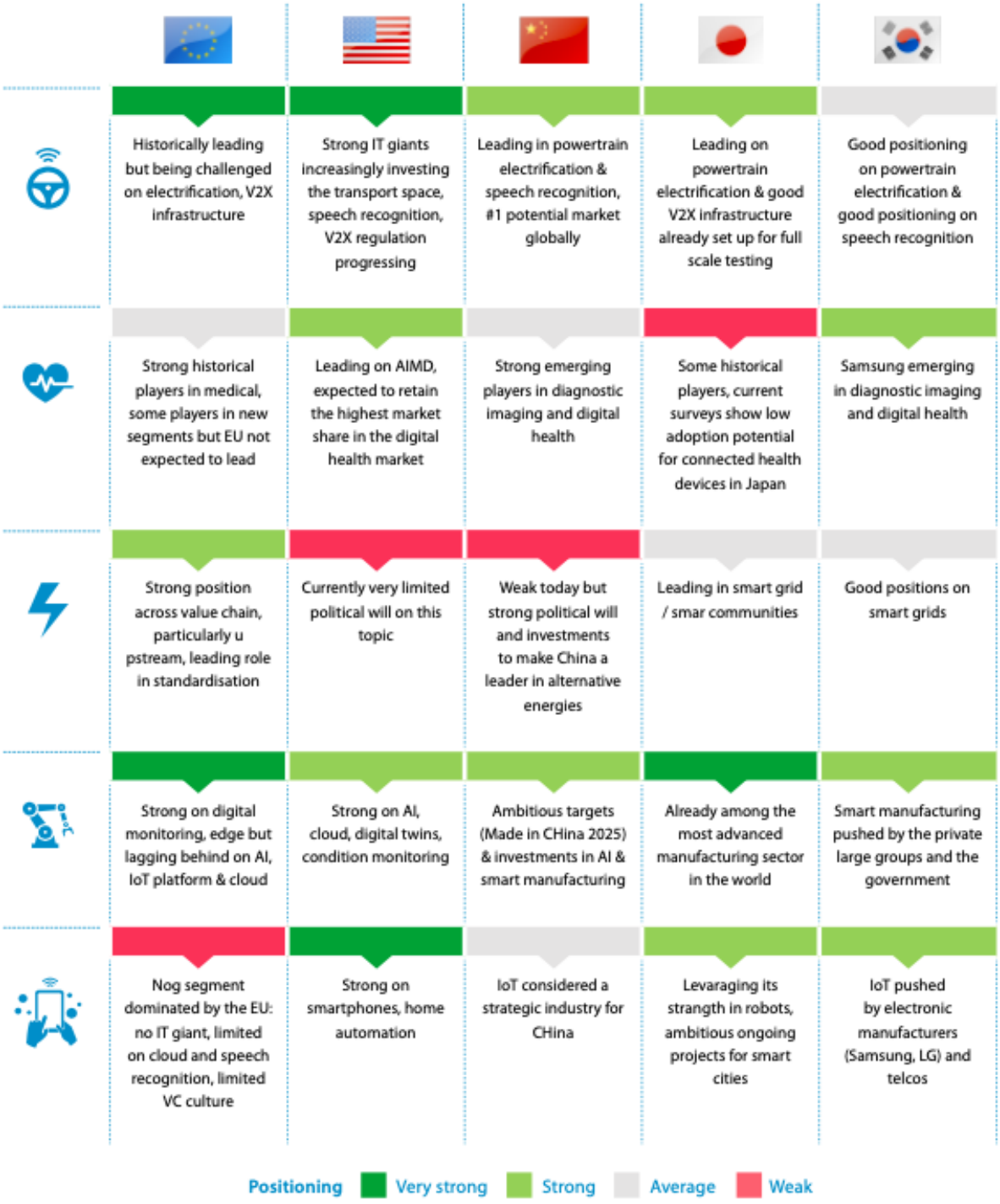



*Figure 6. International benchmarks in Transport & Smart Mobility, Healthcare & Wellbeing, Energy, Digital Industry and Digital Life, respectively*[39]

[39] https://artemis-ia.eu/publication/download/embedded-intelligence-trends-challenges.pdf

2.1.3.2 Benchmarking R&D and public support

Most recently (2017-18), the R&D share of revenues of European industries decreased by more than 8%[40]. **European public investment in R&D in digital technologies is 40% less than in the US; and in critical areas, such as AI, public and private investments in Europe are 4 times less than in the US[41].** Although it is difficult to ensure both exhaustiveness and full comparability of funding mechanisms, Europe seems to be outspent multiple times by other regions in terms of financial support from governments to R&D, even more so when considering this support relative to GDP.

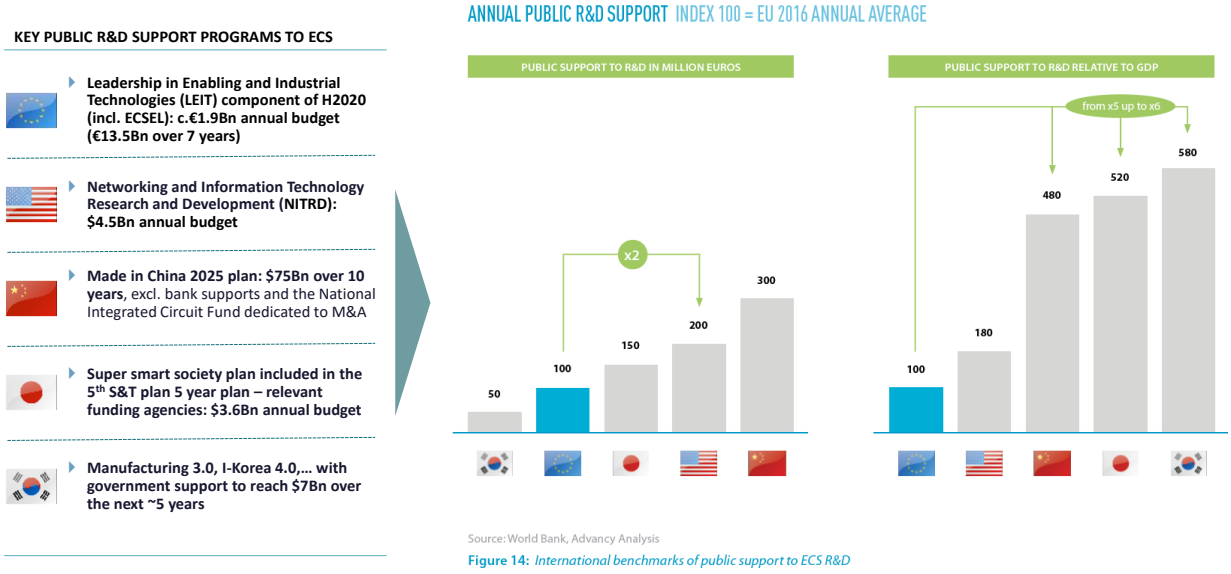



*Figure 7. Annual direct public R&D support (excl. tax incentives) to ECS[42].*

## 2.2 Common vision, objectives and expected impacts

### 2.2.1 Common vision

The vision driving the KDT partnership is one of a **society benefiting from a major evolution in intelligent systems**. This is a human-centred vision of a world in which all systems, machines and objects become smart, exploit relevant information and services around them, communicate with each other, with the environment and with people, and manage their resources autonomously and efficiently. Europe will need the capacity **to create and to master the technologies underpinning this vision** - a cornerstone for the realisation of a smart, sustainable and inclusive European digital society true to European values.

**Digital technologies are an essential part of the answers to many of the daunting challenges that we are facing today:** $CO_2$ emissions, mounting insecurity, cyber-attacks, ageing population, limited access to healthcare, air quality degradation in large cities, traffic congestion, inequalities affecting a large middle class and putting in danger the economy and democracy, unemployment, to name a few. They will impact the everyday life of citizens as well as all business sectors.

**This digital transformation of Europe represents a great opportunity for deployment and take-up of digital technologies**. Europe should master essential features of digital

[40] 2018 EU Industrial R&D Investment Scoreboard.
[41] https://ec.europa.eu/research/pdf/horizon-europe/ec_rtd_orientations-towards-the-strategic-planning.pdf
[42] https://artemis-ia.eu/publication/download/embedded-intelligence-trends-challenges.pdf

technologies such **as privacy & trust, security & safety, and resource & energy efficiency, interoperability & portability**, so that the digital transformation delivers to European values in our products, services, in industry and our society at large.

Accelerating **digitisation could add trillions of euros to economic growth in less than a decade (**McKinsey**).** If its laggards double their digital intensity, Europe can add T€ 2.5 to GDP in 2025, boosting GDP growth by 1% a year over the next decade.

Among the major market segments**, components for automotive and industrial electronics are growing at the highest rate, driven *inter alia* by electrification and automation of vehicles, digitalisation of industry and electrical power grids**[43]**.** Markets such as security, communications (5G and the upcoming 6G), aeronautics and defence are also strategic where dependence on imports can be a real risk. For example, during the past 10 years, Europe's industry has gradually lost its position in components and devices for networks. **With ever-growing global competition and the increasing possibility of global supply chain disruption, it is strategically important for Europe to revive and rebuild a robust component and device value chain**[44]. Maintaining strongholds in key areas is essential to keep a sufficient bargaining position vis-à-vis other regions of the world. Besides European providers of ECS setting and keeping European standards for a sustainable, green production of ECS even at higher prices should be strongly supported against competitors saving on sustainability standards.

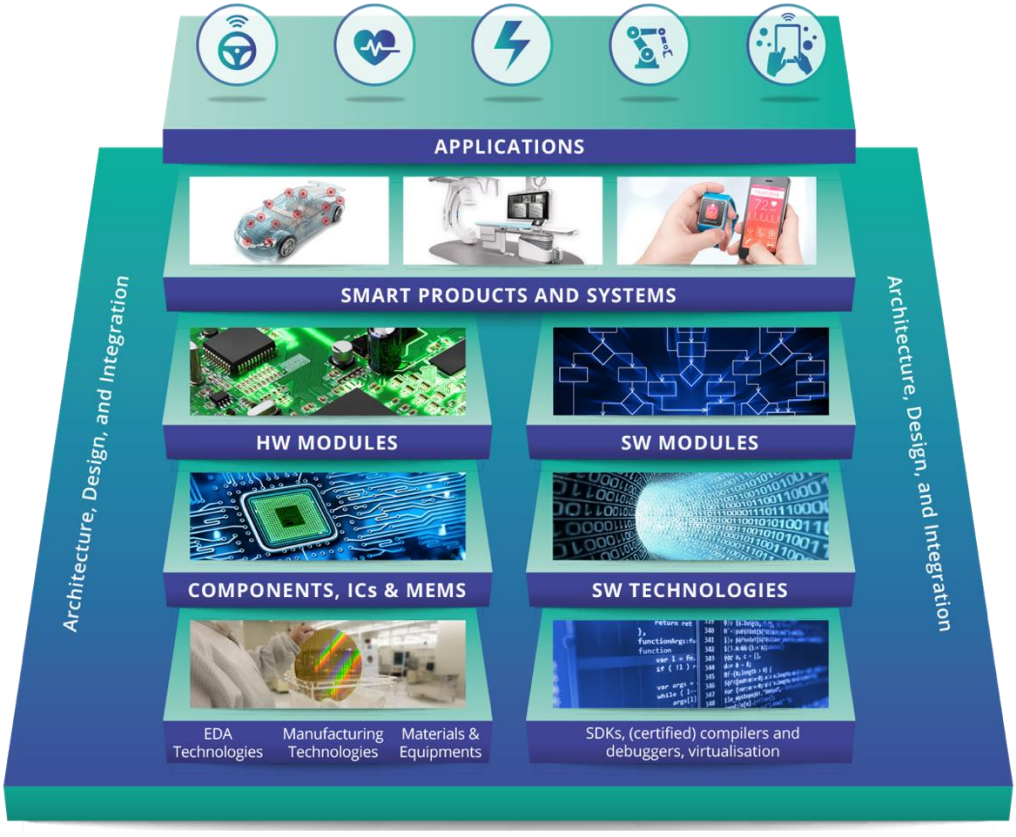



*Figure 8. The electronics value chain.*

While growing markets provide opportunities, speed of innovation and its uptake by markets is becoming increasingly important. Value chains are becoming shorter and more

[43] "Boosting Electronics Value Chains in Europe" report to Commissioner Gabriel by the Electronics Leaders Group, June 2018.
[44] https://www.networld2020.eu/wp-content/uploads/2019/10/networld2020_workshop_component_report_final.pdf

interconnected. **Systems companies need a stable supply of affordable, energy-efficient and trusted components well-matched to the needs of their customers[45].**

### *2.2.2* Objectives

Underpinning the Commission's Strategy on Shaping Europe's Digital Future and its New Industrial Policy, the overarching objective of the partnership is **boosting Europe's competitiveness, and technological sovereignty,** by providing the key digital technologies that underpin the digital transformation of all sectors of economy and society and at the same time support the European Green Deal to the full extent.

The KDT partnership will **reinforce Europe's potential to innovate** through contribution of electronic components and systems, software and smart integration to digital value chains, providing secure and trusted technologies tailored to the needs of user industries and citizens.

It will **contribute to and strengthen Europe's scientific and technological bases** by developing and applying these technologies to address major global challenges in mobility, health, energy, security, manufacturing and digital communications.

Furthermore, the KDT partnership aims to better **align R&I and industrial policies and achieve synergies among its participating countries** (ideally all EU Member States plus some Associated Countries) to reach the critical mass needed to master key digital technologies that are the drivers of innovation. This can be uniquely achieved through the tri-partite involvement and financial support of Member States and Associated Countries, the EU and industry, in an Institutionalised Partnership realising an EU-wide impact.

With these objectives, the KDT partnership contributes to the specific objectives set out in article 3 of the legal base of Horizon Europe. More specifically, while particularly promoting the first three[46] of the Commission's six priorities, the KDT partnership will primarily focus on cluster 4 of Pillar 2 of Horizon Europe, but also contribute to clusters 1, 3, 5 and 6. Furthermore, provided that the EU, participating states and private partners jointly commit to support the development and implementation of a programme of R&I activities, the KDT partnership very well fits the new approach for partnerships set out in the Orientations towards the first Strategic Plan for Horizon Europe. As a public-private partnership, it will serve public as well as private interests, the former by ensuring access to the digital technologies needed for Europe's digital transformation and a range of societal applications. The dissemination activities outlined in section 3.4 will ensure wide sharing of knowledge to the benefit of Europe's economy and society. The active involvement of user industries will foster the exploitation of the R&I results.

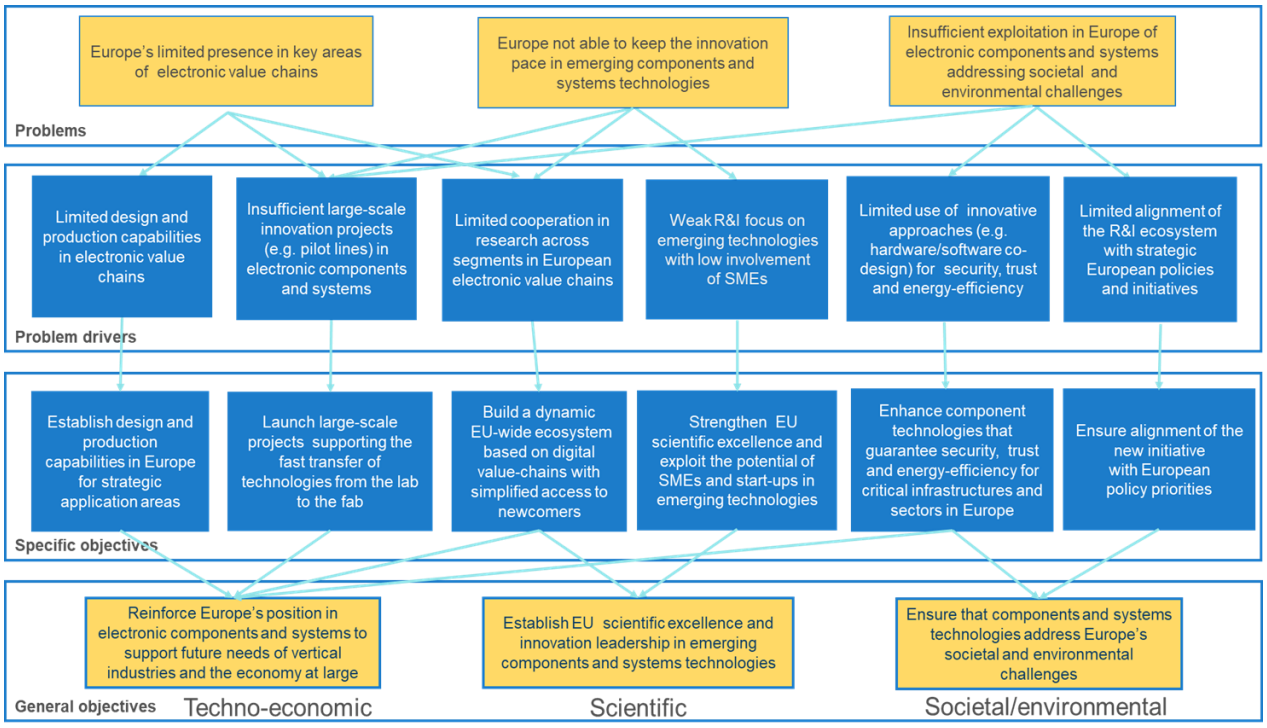
The speed of innovation currently required to maintain competitiveness depends on the capability of various actors from various levels of the value chain to interact directly and cooperate to define, develop and test new solutions that respond to customer needs. At the same time, a wide number of technologies must be considered for integration at various stages of the design and manufacturing process. **A faster time-to-market** will require that in practice the standard electronics value chain be shortened (vertically) and extended (horizontally) with direct connections among various players, so as to become a "value network"[47].

[45] "Boosting Electronics Value Chains in Europe" report to Commissioner Gabriel by the Electronics Leaders Group, June 2018.
[46] 1) A European Green Deal; 2) An economy that works for people; 3) A Europe fit for the Digital Age.
[47] "Boosting Electronics Value Chains in Europe" report to Commissioner Gabriel by the Electronics Leaders Group, June 2018.

The proposed KDT partnership is strongly linked to **EU sustainability policy, in particular the European Green Deal**. Its contribution in this respect focuses mainly on components and systems manufacturing, ensuring that digital technologies set ambitious **and measurable objectives on the impact on energy and climate targets**. Low power operation of electronic components and systems will be of key interest, especially when AI will be applied on a broad scale, like for fog, edge or mist computing (sequential processing units like GPUs will demand an immense amount of energy). Climate targets as well as technical (mainly heat) challenges urge for low power solutions. The partnership will help develop a new generation of electronic systems with much lower energy requirements (thanks to progress in electronics, photonics and software), easier integration into the physical environment (thanks to better microsystems and sensors), and reduced need to move data to remote data centres for processing (thanks to advanced edge computing capabilities). On the one side, this will reduce the impact of electronic systems on the environment, and on the other side will enable applications in environmentally critical domains which are not possible with current technology, thus strengthening the competitiveness of European industry in environmentally friendly applications. For more details on the contributions of the KDT partnership to the European Green Deal we refer to section 2.2.10.

The current COVID-19 pandemic is underlining the importance of the digital transformation, as digital solutions are enabling at least a partial continuation of some core processes in our economy and society that are under severe pressure in these times of crisis; examples are teleworking, on-demand delivery services, online education, remote diagnostics, virtual meetings, etc. The KDT partnership can be expected to play an important role in Europe's economic recovery after the crisis, by strengthening the vital ECS industry and enabling digital applications in other sectors.

### 2.2.3 Intervention logic




*KDT Partnership Intervention Logic*

### 2.2.4 KDT: a reinforced partnership with raised ambitions

Against the backdrop of digital transformation, **ongoing actions in this direction under the ECSEL JU need to be continued and reinforced** due to the fierce competition from other regions in the world outside Europe, the enormous speed of innovation in the digital domain, and very fast evolutions - even disruptive revolutions - in some important (parts of the) value chains. As the key digital technologies concerned are instrumental in so many application fields, it is essential to support them by means of a strong partnership.

The proposed KDT partnership will **build on experience gained from the ECSEL JU** and **satisfy the more demanding societal, economic and technological impact criteria of Horizon Europe**. The objectives and scope will be **adapted to the changing geopolitical situation and continued technological convergence,** going beyond microelectronics to relevant aspects of photonics, beyond embedded software to relevant higher layers of software, beyond Smart Systems to enable intelligent Systems of Systems (SoS), and addressing important trends including the emergence of new computing paradigms, edge-computing and its link with cloud computing - in particular for AI applications.

The **scope** of the partnership should contribute to the application stack based on novel hardware implementations such as relevant elements of photonics, embedded algorithms and data, as well as software (including cloud computing and collaborative systems) providing a broad technology portfolio for the implementation of multi-functional systems in a wide range of applications. Electronics value chains need to be covered in full, taking in both the supply and the demand sides. It is critical to streamline technology development (upstream to R&I) so as to ensure a strong focus on the technologies with the most potential for industrial uptake.

Building on the success of ECSEL, while keeping its strong elements (e.g. direct involvement of participating states, openness, industry-driven objectives) and benefiting from lessons learnt, the KDT partnership will feature the following key improvements to make it more ambitious and impactful than its predecessor:

| **Overview of key improvements in KDT partnership** | **Section** |
|---|---|
| An extended scope | 2.2.5 |
| An intensive R&D effort | 2.2.6 |
| Strengthened collaboration with other partnerships and programmes | 2.2.7 |
| An improved co-funding mechanism | 2.2.8 |
| Measures for maximising impact | 2.2.9 |
| Contributions to the European Green Deal | 2.2.10 |
| A more strategic approach in annual priority setting | 2.2.11 |
| A broadened range of activities | 3.1.2 |
| More synergies with other EU funding programmes | 3.1.3 |
| Increased efficiency | 3.2 |
| A more effective governance | 3.3 |

### 2.2.5 Extending the scope

**Trends in the industry and technology itself have illustrated a need to intensify R&I efforts to cover relevant aspects of photonics and software, advanced computing**

**technologies, flexible electronics and bioelectronics,** 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. The extension proposed below will provide potential beneficiaries with more options for technology choices and for optimal hardware/software co-design.

At the core of Key Digital Technologies (KDT) are Electronic Components and Systems (ECS), where the components and sub-assemblies are the basic parts of the systems, and the word "systems" is used in this context for the respective highest level of development that is targeted within a given segment in the value chain. Components can be hardware-, or software-based, and frequently a combination of both. A "system" designed and implemented within a given development process may be integrated into a higher-level end-product or service.

The traditional ECS scope is strengthened in KDT with the following elements:

i. Related aspects of photonics

Silicon used as optical material is usually patterned with a similar precision as required for electronics. The process techniques used are derived from microelectronics fabrication methods. Devices can be **integrated by hybrid, heterogeneous and monolithic integration to build smart systems that combine electronic and photonic functionalities**. Potential applications cover a broad field: e.g. telecommunication, sensing, data communication, and mobility LiDAR sensors for autonomous driving.

Si-photonics should be integrated into the KDT partnership, based on similarities in fabrication techniques making use of a large technology base and existing infrastructure, and with applications making use of established supply chains. This includes Si-photonic sensors exploiting well-known CMOS fabrication technologies.

A dialog has been started with Photonics21 as the private partner in the future European Partnership on Photonics about a delineation of their activities[48] and the KDT activities with some overlap to optimise the combined approaches, also in the light of the Green Deal.

ii. Related aspects of software

Software technologies beyond embedded software, including their applications within the current domain of ECSEL, should be extended to **cover full value chains and networks**. Software in the KDT JU will therefore include **embedded software, applications and platforms, including the relevant tools.** The larger spectrum of software coverage ensures that critical functions of electronic systems will be fully implemented within the JU.[49]

The possible impact of the technological ecosystem (value-network) generated from embedded and cyber physical systems depends on the combination of five technology areas driven by software advancements:

- Digitalisation is the foundation of the ecosystem. Based on the concept of connecting and mapping the physical world with the digital world, it is driven by software combining application aspects from different domains and the digital technologies that allow to increase efficiency in development, production and in-field operations.

[48] See https://www.photonics21.org/download/news/2020/20_P04_-_New_strategy_-_Photonics_key_to_Europes_Industrial_Future.pdf

[49] Software related only to business and financial processes, pure cloud systems, gaming industry or office software platforms, enterprise level software, etc., **is outside the scope** of the KDT JU.

- Hyperconnectivity allows everything to talk: it enables embedded and cyber physical systems to communicate, cooperate, transmit and share large amounts of information, helps to manage the inherent heterogeneity of the ecosystem and reduce fragmentation.
- System of systems (SoS) platforms represent the distributed software infrastructure that allows the existence of the ecosystem and of the related value network. A SoS platform is software partially centralised and partially distributed. It is the element of the ecosystem that is "conscious" of the ecosystem itself, and it enables full monitoring and control of its parts, manages operations, enables full life-cycle support and ensures trust.
- Embedded and lightweight distributed AI and data analytics are essential to the development of autonomous entities in the ecosystem. They will play a role, for example, in fleet management, preventive and predictive maintenance in manufacturing, pollution monitoring and traffic optimisation in smart cities.
- Engineering tools: new engineering tools for sustainable and efficient engineering processes, capable of assisting the evolution of research results towards products and supporting them across their entire lifecycle.

Several key enablers will be required for the development of these software areas belonging to the cyber world (e.g. edge/distributed software technologies, connected solutions, SoS integration platforms and their engineering/management, control & simulation & digital twins, embedded AI & analytics, software enabling services, engineering and validation tools, connectors/adapters for cloud platforms and enterprise software) in conjunction with their counterparts belonging to the physical world (e.g. sensors, actuators, computing platforms, connected products, control automation systems, HMI devices).

iii. Emerging Computing Technologies

The digital transformation of society and economy is introducing an exponential growth of data traffic, in many cases unmanageable through the infrastructure available today. **A paradigm change is required for the deployment of AI** in many applications, so that data can be processed locally, enabling meaningful information to be extracted, transmitted, stored or acted upon (e.g. a connected autonomous car must be able to take swift decisions without waiting for an answer from a remote server).

In the era of connected intelligence, fast information and decision-making are important. Therefore, special attention is needed for edge computing and embedded neuromorphic computing, being so important for distributed AI.

Applications making intensive use of data processing will push the limits of computing. In particular demand for low power hardware and multi-parallel processing is expected to increase, for which specific components and software are required. In addition to resource efficiency, aspects such as trust (in the context of security, safety and/or privacy as befits the specific application) will need attention.

iv. Flexible electronics

Flexible electronics (printed and not) provide lightweight, low-cost solutions and will be of growing interest in Europe as enablers for the digitalisation of products and services in a broad field of areas (health, logistics, automotive, manufacturing). They will lead to new high-volume display and sensor applications e.g. in personalised healthcare, in vehicles (e.g. lightweight solutions that reduce battery load), in agriculture (e.g. as degradable, eco-friendly sensors) or in local energy supplies for IoT solutions. The total global ma**rket for printed, flexible and**

**organic electronics will grow from $37.1 billion in 2018 to $77.3 billion in 2029**[50]. These figures include also OLEDs, which are not addressed by the KDT partnership. The wider diffusion of Flexible Electronics will contribute to a further reduction of the ecologic footprint of the ECS industry.

### 2.2.6 An intensive R&D effort

The extension of the scope of the KDT partnership will require large R&D investments from industry (including SMEs), universities and institutes, to be supported by corresponding EU and national budgets.

For an estimate how much R&I investments are overall necessary to achieve the above impacts, which parts will be contributed by partners, what the leverage effect will be and how investments will be monitored, we refer to section 3.2 on resources.

### 2.2.7 Strengthening collaboration with other partnerships and programmes

Lighthouse Initiatives can play an important role by building bridges between projects under the KDT partnership and relevant projects in other programmes. Lighthouse Initiatives already in existence in the ECSEL JU are enabling cooperation all along the digitalisation value chains/networks in industry, mobility and health. Their roles are expected to grow in order to facilitate the uptake of the developed technologies for the benefit of the entire European society and economy. For example, the Health.E Lighthouse Initiative champions a coordinated approach to produce new technologies for medical devices and systems more consistently and also ensures there is a broad scope of innovations that can benefit from standardisation of underlying technologies that bring down the costs of making it to the market.

Coordination on scope and priorities setting will ensure synergy between the EUREKA clusters in the KDT domain (in particular EURIPIDES, ITEA and PENTA), the EIT KICs (in particular the KICs Digital, Health, InnoEnergy, Manufacturing and Urban Mobility) and the KDT partnership, whilst contents and timing of calls will be aligned. Furthermore, use will be made of Lighthouse Initiatives to connect ongoing projects.

Of particular interest for collaboration are the proposed European Partnerships on:

- "Smart Networks and Services", for developing underlying technologies (e.g. high-frequency, low-power, antennas) to ensure connectivity in all conditions and reach out to actions in telecommunications, encompassing 5G and 6G, IoT, etc.;
- "High-Performance Computing" (EuroHPC, already in place today), and in particular the "European Processor Initiative", for providing the requisite components (MCUs, accelerators, co-processors for special maths, etc.) and embedded software for exascale computing;
- "Photonics Europe" (e.g. for photonic devices and sub-systems)
- "AI, Data and Robotics", as many projects under the KDT partnership will develop the underlying technologies for AI in fog, edge and mist computing;
- "Innovative Health Initiative" (e.g. for wearable electronics and bioelectronics);
- "Clean Aviation" (e.g. for highly reliable and energy efficient components)
- "Connected, Cooperative and Automated Mobility" (CCAM; for components and systems for electric vehicles and automated driving);

[50] https://www.idtechex.com/de/research-report/flexible-printed-and-organic-electronics-2019-2029-forecasts-players-and-opportunities/639

- "Batteries: Towards a competitive European industrial battery value chain" (e.g. for power electronics).

Reinforced cooperation with these and other R&I initiatives and partnerships, for example to develop common/shared test beds, is foreseen, see section 2.4.2. The KDT partnership could provide these other R&I initiatives and partnerships with fast-track and early access to advanced key digital technologies leading to faster market uptake.

Being a partner in each partnership, the Commission has a pivotal role in ensuring collaboration between partnerships, as part of its processes for coordinating between the six clusters in Pillar 2 of Horizon Europe, for governing the portfolio of partnerships and for preparing and approving the SRIAs and the annual work programmes of the partnerships. Furthermore, the Commission could facilitate a platform for networking and knowledge exchanges between partnerships.

### 2.2.8 Improving the co-funding mechanism

KDT members agree that the additional complexities created by the tripartite model should be reduced to the extent possible.

The Member States and Norway, together with the European Commission will jointly work towards the implementation of the following elements by taking into account the legal conditions and obligations at EU and national levels:

- greater harmonisation across participating states of the conditions/criteria for participation/eligibility and funding,
- single reporting of costs and activities for each beneficiary (instead of separate reporting to both the JU and national authorities),
- multi-annual budget plans to enable more strategic programming,
- any other reductions in red tape for beneficiaries.

### 2.2.9 Maximising impact

The Lighthouse Initiatives will be reviewed so as to reinforce the impact of the KDT partnership by mobilising the critical R&I effort of projects in the area, as well as promoting collaboration and fostering a continuous dialogue within the KDT community and between the KDT community and technology users, decision-making bodies (EU and national) and society, so that technologies and innovations have a real and faster impact.

As part of its impact, the KDT partnership will drive transformational changes in multiple dimensions:

- By ensuring access to KDT, the partnership will be instrumental in enabling the Digital Transformation of Europe's economy and society;
- By aligning European and national R&I efforts, the partnership will further transform Europe's fragmented R&I landscape into a true European Research Area in the domain of ECS/KDT;
- By collaborating vertically (cross-value-chain) and horizontally (cross-industry), the way of working in ECS will transform from traditional, linear value chains to an ecosystem of

interconnected, interdependent value networks[51] and from making products to creating solutions[52];

- By contributing to the European Green Deal, it will help transforming the EU's economy for a sustainable future[53];

In terms of the scientific, technological and societal impacts that Horizon Europe will have to deliver according to article 3 of its legal base and that will be monitored by means of the Key Impact Pathways set out in Annex V, the KDT partnership is expected to contribute the following impacts:

- Scientific impacts

  - Europe's scientific and technological bases will be strengthened by developing and applying KDT technologies to address major global challenges in mobility, health, energy, security, manufacturing and digital communications.
  - The linkages established by the KDT partnership between European and national levels will raise the level of scientific excellence in national KDT programmes, foster the diffusion of knowledge and widen participation, thanks to national authorities reaching out to their national innovation systems by means of dissemination events, communication activities, technical workshops and deployment initiatives.
  - The involvement of users from multiple application sectors will foster trans-sectoral collaboration and cross-fertilisation.

- Societal impacts

  - The emphasis on trustable electronics will give the public and business **access to spaces of trust** in which they can securely interact, operate and trade.
  - Enhanced market penetration of the technologies will benefit the public by enabling **safe** autonomous vehicles and seamless and **secure** means of communication, as well as novel healthcare techniques and devices. For example, eHealth is rapidly influencing our health systems, enabling elderly people to enjoy more healthy years over their life expectancy. Furthermore, nanoscale devices will change diagnostics, targeted drug treatment and local treatments. Biosensing will provide more insight towards personalised treatments. Bioelectronics devices will offer precise, localized and focused regulation of immune pathways and cells versus unfocused diffuse exogenous control by drug-based interventions and their potential adverse effects and could for some patients, possibly eliminate the need for such drugs.
  - KDT has the potential for a high contribution to protecting and promoting the well-being of citizens. The development of a patient centric and decentralized healthcare needs new devices and systems to handle patient data, diagnostics and treatments. The new electronic devices and systems and software platforms aimed to be developed within KDT are cornerstones to accessible and cost-effective healthcare to European citizens wherever they live, in dense urban areas or in the countryside.
  - The combination of efficient, powerful and trustable electronics with advanced sensors and scalable embedded AI enabled software connected with cloud intelligence and other objects will yield an unprecedented compute power that can help better

[51] "Boosting Electronics Value Chains in Europe - Implementation Plan", report to the European Commission, 2019, to be published.
[52] https://artemis-ia.eu/publication/download/embedded-intelligence-trends-challenges.pdf
[53] See Figure 1 of https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

understand burning societal problems such as climate change, ageing society and growing megacities

- KDT research contributes to more **functional, efficient and economical electronics systems** that are thus increasingly accessible to larger parts of the population.
- The contribution to sustainability, in particular environmental protection, will be a major impact of KDT. A number of technologies that have been developed under ECSEL and are to be supported further through the European Partnership for KDT, improve energy efficiency, through **intrinsically low-power technologies, better power-management electronics** (in particular for electric vehicles) and renewable energy sources.
- In addition, improved sensor-actuator based systems will help **reduce the energy consumption** of buildings and vehicles leading to reduction of emissions and emergence of zero emissions or zero impact emission for transportation of people and goods (e.g., road transport, railway, aerospace).
- In the future, as AI proliferates, low-power technology will be all the more important for data processing. Computing at the edge - insofar as it can replace cloud computing - is inherently more energy-efficient. New computing paradigms such as neuromorphic promise 2 to 4 orders of magnitude improvement in energy efficiency.
- KDT will be very effective in improving cost-efficiency in component fabrication – to the extent that European industry is expanding its manufacturing footprint in Europe with positive impact on employment (in particular as manufacturing and R & I are often co-located). There is considerable scope to extend these efforts to embrace resource-efficiency with a particular focus on re-use and recyclability of materials and components.
- Cybersecurity and **data protection** were an essential dimension of the ECSEL strategic research agenda. The cybersecurity package put forward by the Commission will clearly reinforce this aspect of KDT R&I.
- The degree to which any digital system can guarantee **data integrity, privacy and security** depends on its electronic components (hardware and software). A well-resourced and well-structured partnership could have a positive impact on Europe's ability to give systems such capabilities.

- Economic impacts

  - The primary expected impact of a future partnership is **to maintain and develop the competitiveness of the supply sector in Europe** (which includes suppliers of integrated electronics & photonics components, sub-assemblies, equipment manufacturers, suppliers of materials and software, integrators of components & systems into final products & services). It will be measured in terms of absolute value of EU digital technology supply, its year-to-year growth and market share with respect to major competing regions (US, China, Japan, Korea, Taiwan).
  - Equally important expected impact is **the leveraging effect of key digital technologies in the competitiveness of other relevant sectors of the economy** (automotive, manufacturing, medical, energy, etc.). All sectors are currently engaged in a process of digital transformation. A successful digitisation will be possible only with access to advanced, low power, trusted and secure technologies that can be tailored to the needs of user industries is guaranteed.
  - The KDT partnership can be expected to play an important role in Europe's economic recovery after the COVID-19 crisis, by strengthening the vital ECS industry and enabling digital applications in other sectors.
  - To date, synergies achieved under the current ECSEL JU have **reinforced the industrial ecosystems**. Synergies continue to grow, enabling an ever-stronger

innovation capacity, and demanding collaboration with new communities of actors. This dynamic is expected to further bring together technological communities and promote **integral EU digital approaches embracing EU values.**

- The combination of EU and national support through a partnership would **strengthen industrial R&I in KDTs**. The contribution from industry and other beneficiaries, currently based on a factor of 2.4 of the combined EU and national funding, is a direct demonstration of this. It also testifies to the alignment of strategies in this very intensive research field where for example, semiconductor and medtech companies invest on average close to 20% of their revenues in R&D. A KDT partnership is likely to plant the seeds for **further investment in European production capacity and associated research facilities.**
- It is also essential to reinforce the future partnership's capacity in testing the developed and matured technologies in relevant contexts. This is expected to happen through reinforced cooperation with other R&I initiatives and other partnerships to develop common/shared testbeds, facilitated by existing and future Lighthouse Initiatives. It is envisaged that a future partnership could provide other R&I initiatives and partnerships with fast-track and early access to advanced key digital technologies. Such cooperation will contribute to **significantly increased take-up of the funded R&D&I by European industry**. Initial candidates for this type of cooperation will be health, mobility and industrial partnerships.
- A simpler approach to the implementation of KDT will **significantly reduce the administrative burden** for applicants and beneficiaries.
- The governance of the European Partnership for KDT JU will be simpler and more effective than in ECSEL. See implementation in Chapter 3.

### 2.2.10 Contributing to the European Green Deal

A study on the impact of the ECSEL JU by Deloitte and VVA [54] came to the conclusion that "worldwide, the ECS sector has been essential in the development of innovative technologies that consume less energy and help achieving environmental goals. In Europe, sustaining innovation in this sector represents a key ingredient to achieve the mission of the newly launched Green Deal."

In ECSEL so far, one fifth of the funded projects had their focus on energy and environment topics and contributed to major progress in this domain (e.g. to the development of power electronics that allow for more efficient energy use in automotive and energy applications).

Furthermore, projects addressing the energy challenges linked to the miniaturisation of transistors and the development of the Fully Depleted Silicon On Insulator (FDSOI) technologies under the ECSEL programme led to a "European" technology approach which allowed reducing transistors' size while maintaining their performance and consuming up to 50% less energy than traditional bulk silicon. FDSOI will be the basis for many energy efficient solutions for cloud computing and artificial intelligence in the future.

Supporting the development and take-up of energy efficient ECS solutions in a succeeding KDT JU is a pre-condition for meeting the EU ambitions on energy and environmental objectives.

Besides, Europe must further leverage the potential of the **digital transformation, which will be a key enabler for reaching the Green Deal** objectives.

[54] Deloitte and VVA Study on the impact of ECSEL funded actions, February 2020

The KDT JU will therefore cover two major targets to enable a successful implementation of the Green Deal:

1. Develop ECS technology and solutions to enable the further digitalization of key application areas (as e.g. mobility, agriculture, health, industry and energy) by implementing sustainable new technologies and systems to reduce energy consumption and $CO_2$ emission

2. Improving the energy performance and disposability of electronic components and systems themselves by reducing the environmental footprint of the ECS industry and their products by means of cleaner and greener production processes, circularity and lower material and power consumption of the ECS. By (integrated) photonics new functionalities could be provided without increasing power consumption[55].

Agriculture and natural resources

Two of the priorities set by the European Commission in its recent "Green Deal Communication" are

1) "From Farm to Fork" strategy', which will require strengthen their efforts to tackle climate change, protect the environment and preserve biodiversity.
2) "A zero-pollution ambition for a toxic-free environment", which will adopt a zero-pollution action plan for air, water and soil.

The ECS Community will contribute substantially to these two priorities by new technologies, components and systems to target the following topics:

- **Food security and sustainable production** to ensure animal and plant health by means of innovative interoperable farming systems including an end-to-end food supply chain. These new management systems will give consumers better information, including details such as where the food comes from, its nutritional value, and its environmental footprint.

- **Water resource management** to ensure access to healthy water in rural and urban areas will be made by introducing smart sensors-based solution for water quality monitoring. New technologies will allow smart water treatments fostering circular use of wastewater, rainwater and storms water, and smart systems for flood and irrigation management.

- **Environment protection** to monitor, report, prevent and remedy air and soil pollution and waste and to contribute to achieving a circular economy. This will be possible by introducing advanced sensors and diagnostics for air quality monitoring (indoor, urban and rural) and smart systems to control and prevent greenhouse gas emissions. Finally, efficient smart networks for remediation in different ecosystems (water bodies, air, and soil) will be required.

Rapid progress in new advanced (bio-)sensors and (bio-)actuators, ubiquitous low-cost direct monitoring of air and water quality (CO2, NOx, CxHy , small particles, …) through on-chip spectrometers and fibre-tip detectors, and AI-based interoperable systems-of-systems to allow data-driven innovation will facilitate evidence-based decisions and expand the capacity to understand and tackle environmental challenges.

[55] https://www.photonics21.org/download/ppp-services/photonics-downloads/Study_GreenPhotonics_2020_final.pdf

Mobility

Another priority of the European Commission in its "Green Deal" Communication is ''**Accelerating the shift to sustainable and smart mobility**''. This will require a strong boost to multimodal transport, automated and connected multimodal mobility, a ramp-up of the deployment of sustainable alternative transport fuels and less polluting transport, especially in cities.

The ECS Community will contribute substantially to this task by new technologies, components and systems to target the following topics:

- **Autonomous vehicles and coordinated mobility** to make traffic more efficient and thus reduce-pollution by smart and connected sensor systems, radar, LiDAR, in-vehicle controllers and networks, and connectivity devices.
- **Electrification of cars and development of powertrains for carbon-free energy carriers.** Enabling technologies for the above come from the ECS industry in Europe e.g. energy efficient devices, power electronic components and systems, and battery management systems
- New means of transport and interaction including other transport modes (**multimodal transport**) will be enabled only through further developments of new V2X, traffic management devices and guidance systems to enable mobility as a service.
- Rapid advances in **AI and edge computing** will ensure to make a leapfrog in these areas.

Energy

Energy systems "**supplying clean, affordable and secure energy**" are another priority in the European Green Deal. To achieve this goal, the power sector must be further transformed **from fossil fuel based to renewable generation** and at the same time needs to grow in order to enable **decarbonization of mobility and thermal energy supply**. Because of the increasing residual load resulting from the local mismatch between decentralized renewable generation and load, a digitally controlled transmission- and distribution infrastructure is required.

Thus, electronic control systems are the key to future energy systems being optimized both in design and operation for high efficiency, low CO2-emissions, costs, and security of supply. In the KDT JU this challenge will be addressed by developments of

- ECS for **smart, efficient energy conversion and storage systems** such as electric drives, heat pumps, electrolysers, fuel cells, batteries and supercapacitors.

- **Energy management systems controlling renewable generation, conversion & storage**, on-site, in district and community grids, in regional distribution grids and by securing cross-regional transmission infrastructure, with photonics enabling reliable, inherently secure and low latency network control in future energy systems.

Key elements of this development will be **networks of sensors and smart actuators** allowing status monitoring on each of these levels, **smart inverters** (for all voltage levels) allowing real time control of energy system components and grids in case of critical events, and optimized operation based on forecasts of generation & demand. The latter will be based on a

sophisticated information & communication infrastructure including cloud services and **AI technologies**.

Healthcare

In the **healthcare** sector the contributions to greenhouse gas emissions are significant. According to WHO, in developed countries, health facilities are contributing from 3 to 8% of national greenhouse gas emissions[56].
This can be reduced by **healthcare digitization** through

- shift from hospital care to **remote care at home**, thereby relieving travel burdens with better outcomes
- **Personalized medicine** to reduce ineffective treatments and improve patient outcomes, thereby reducing waste in resources

Further Apps promoting behaviour change, in a context of ageing population, will reinforce prevention impact and reduce the number of chronic diseases.

Industry

**Digital manufacturing** will enable material and energy efficiency in key sectors of the EU economy thereby enabling the European manufacturing sector to reinforce its leadership position. Through digitalisation 2.7GT estimated $CO_2$ reduction in the manufacturing sector is possible.[57]

Environmentally friendly production will require **new carbon-free raw materials, closed material flows to avoid emissions or waste, circular business models, electrification of processing, re-use/re-manufacturing, traceability through value chains, sustainability on resources use, human machine interaction, skills-centric manufacturing, material and energy efficiency**.

Necessary developments of ECS technologies as enabling technologies will be in advanced **automation and control, advanced sensors, digital twins, artificial intelligence, collaborative robotics, monitoring through value chains** - to allow for better accuracy and performance, better (predictive) maintenance and higher asset utilization, higher autonomy and productivity, and servitisation in digital manufacturing. To achieve environmental goals means implementing excellent engineering and operation which most obviously will bring along maximum performances in quality, cost, flexibility, operational efficiency, safety and reliability. ECS will be at the core of implementing these new ways of manufacturing.

**Both Artificial Intelligence and edge computing** will be core technologies to drive a sustainable economy. The ECS community embraces the orientation of **"Making ICT products and services sustainable, by prioritizing their energy efficiency as well as climate neutrality, reparability, lifespan and recycling"[58].** The environmental footprint of the ICT sector is significant, estimated at 5-9% of the world's total electricity use and more than 2% of all emissions[59].

Energy efficiency of computing solutions will continue to be a key priority for the ECS Community in their future research and development.

[56] https://www.who.int/sustainable-development/health-sector/health-risks/climate-impacts/en/
[57] https://www.digitaleurope.org/resources/digital-contribution-to-delivering-long-term-climate-goals
[58] https://ec.europa.eu/digital-single-market/en/news/consultation-future-investment-europes-digital-economy
[59] https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf

- One drive, besides improvement of the silicon technology and better optimization and management of the computing, storage and communication resources, is to reduce displacement of data, which is the main factor of energy dissipation in computing systems. 3**D technologies, reducing the size of devices, computing in or near memory and computing where the data are created (edge computing)** instead of moving raw data to distant servers are solutions to reduce the energy cost induced by moving data.

- **Increasing reparability and lifespan** is another challenge considered by the ECS community, and modularity at all levels, extensibility, are examples of directions that need to be further explored. This will also allow to continue to have a diversity of processing engines, more tuned (therefore more energy efficient) for each application domain.

- **Gradual integration of photonic integrated circuits and systems in data centres** will increase data processing capabilities and simultaneously reduce power demand from current 30pJ per processed bit to less than 1 pJ/bit in 2025.

In the Green Deal Communication, it is stated that "While the **circular economy** action plan will guide the transition of all sectors, action will focus in particular on resource-intensive sectors such as textiles, construction, **electronics** and plastics." Indeed, the Circular Economy Action Plan released by the European Commission on March 10, 2020, devotes a specific section to electronics and ICT. The KDT partnership will contribute by improving circularity in the ECS industry and providing digital technologies and solutions to other sectors to improve circularity in their products, processes and services.

Across the Electronics value chain, the aim of the ECS industry is to further minimize waste and maximize resources to extract the maximum value from the materials used and re-purpose products across their lifecycles. This includes moving towards zero emissions for the direct operation as well as enhancing the energy efficiency of the electronics manufacturing process while increasing the productive output.

In addition, **improving process technologies** will allow a more efficient device and system-level use of the energy resources. For instance:

- **New embedded non-volatile memory** (eNVM) technologies enable local processing, decreasing data transmission needs and energy. It also enables a more efficient control of thermal, hybrid and electric powertrain and batteries in vehicles.
- **New power electronics devices**, either based on silicon or new (GaN, SiC) materials increase the energy efficiency of motors, energy storage, lighting systems, etc.
- **Improved RF technologies** (CMOS, SOI based RFCMOS, BiCMOS and passives) enable a better control of the emission and reception channels with more energy efficiency due to finer RF band control and better directionality
- **New sensor technologies and devices** enable a better control of processes (e.g. industrial processes, lighting, etc…) and this contribute to energy saving
- **Device scaling by moving into 3D** for sub 3 nm node memory & computing technologies will also drive down energy consumption

The Green Deal Communication also refers to "Ensuring the supply of sustainable raw materials, in particular of critical raw materials necessary for clean technologies, digital, space and defence applications, by diversifying supply from both primary and secondary sources, is therefore one of the pre-requisites to make this transition happen". Some elements to be further

elaborated upon are the exploration and implementation of materials beyond Si (SiGe, SiC, Ge, GaN, piezoelectric materials) to become more independent from the current supply chain.

In terms of Process Technology for nanoelectronics manufacturing the goal is to **substitute or decrease the use of toxic, hazardous, and critical raw materials** to greatly reduce the environmental degradation, health issues, geopolitical crises, and avoid future supply disruption of key materials. More precisely, elements such as indium, ruthenium, platinum, gallium, arsenic, gold, are already identified as critical for disruptive devices yielding communicating objects. New technologies and materials are investigated to replace them or to limit drastically their amount in some critical devices (sensors, memories, optoelectronics and spintronics), as e.g. unleaded solutions for micro-components in cell-phones and use of silicon-based substrates instead of III-V materials for RF technologies.

### 2.2.11 Strategic Research and Innovation Agenda and annual priority setting

The Strategic Research and Innovation Agenda (SRIA) 2021 for the KDT partnership being prepared under the responsibility of AENEAS, ARTEMIS-IA and EPoSS will aim at ensuring continuity, but at the same time be disruptive wherever necessary, and take into account new developments as well as the lessons learnt in the past.

It is foreseen that the SRIA for the KDT partnership will be updated each year. The SRIA 2021 will be the base document under Horizon Europe, supporting the Calls of 2021. Preparation work has started on the basis of the ECS SRA 2020[60], which is looking ten years out and has just been finalised as part of the annual updating process. For reference, the table of contents of the ECS SRA 2020 is attached as Annex 3; it will be thoroughly revised, with new chapters added, an enlarged scope, etc.

The process of drafting the SRIA 2021 will be transparent and open: experts can join, without being a member of any of the associations, based on their knowledge and the contribution they can bring to the process. It is part of an open policy allowing to anticipate the evolutions in the field and to adapt the partnership to a fast-changing technical environment. An open public consultation of stakeholders and other interested parties is foreseen in the course of 2020.

As the partitioning of the whole field of digitisation is extremely complex, in the first discussions about the SRIA 2021 the preliminary thinking is that the SRIA should cover three aspects:

1. Application areas as drivers;
2. Value chain technologies as basic enablers;
3. Cross-sectional technologies as supra enablers.

Based on these three aspects, the preliminary structure of the SRIA 2021 is depicted below.

[60] That the 2020 document is called "SRA" instead of "SRIA" merely has historical reasons: at the time of establishing the ARTEMIS and ENIAC ETPs in 2004, it was mandatory to deliver an SRA, and that has been regularly updated ever since. Actually, what the Private Members Board puts forward for ECSEL is the Multi-Annual Strategic Research and Innovation Agenda (MASRIA) and the Research and Innovation Activities Plan (RIAP), in accordance with art. 15 of the ECSEL Statutes and clearly including the innovation component.

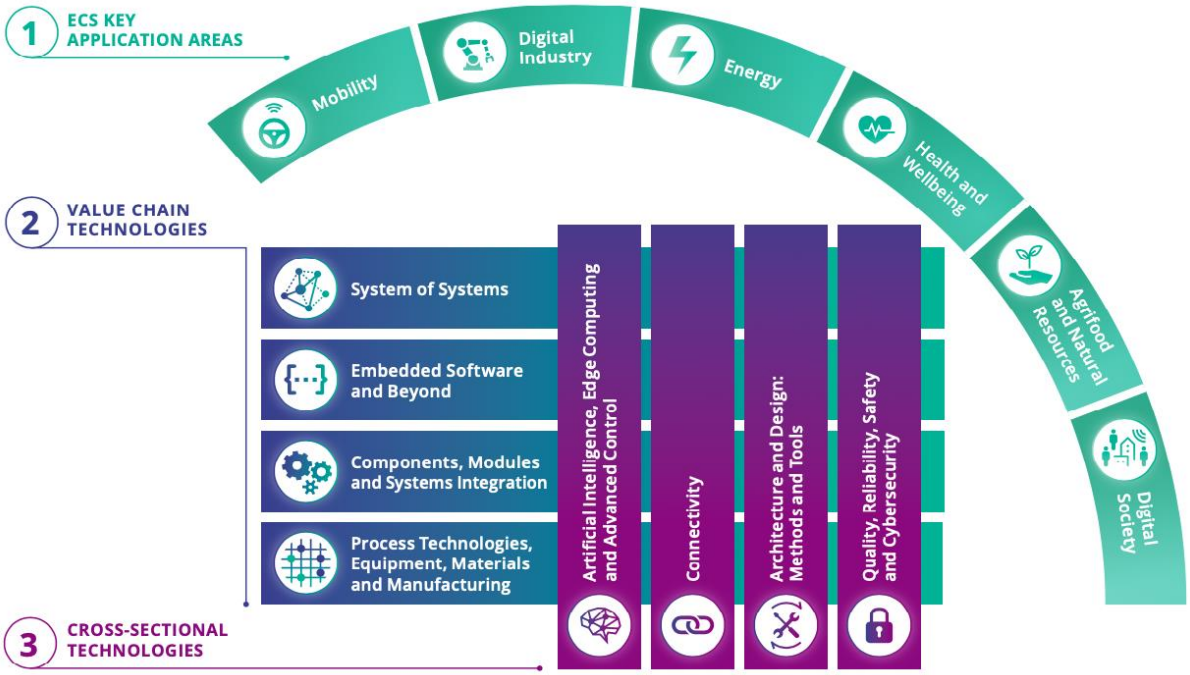



*Figure 9. Preliminary chapter structure of the 2021 SRIA.*

This chapter structure will be further refined in the coming months, particularly based on feedback from participating states and the Commission. Priorities of the new Commission, the European Green Deal and Technology Sovereignty - topics which are of importance also to industrial partners and participating states – will be duly emphasised. A preliminary overview of the Major Challenges, High priority R&D&I Areas and Expected Achievements for each of these 15 chapters is presented in Annex 4.

For the annual work programmes, a more robust process for priority setting will be implemented, where all members – private partners, national authorities and the Commission – have a say. In particular, Public authorities will play a more active role in setting priorities for the work programme each year. This will facilitate an approach taking into account issues such as technology sovereignty for example, but also specific topics or domains that countries wish to promote, and to give some counterbalance to the bottom-up approach which has prevailed for much of ECSEL.

### 2.2.12 Performance Indicators

Operational performance

| KPI | Definition | Baseline | Target |
|---|---|---|---|
| OP-1 | % New participants compared to previous years | 33% | 40% |
| OP-2 | Success rate % | 17% | 25% |
| OP-3 | Budget % of selected projects along value chain | not defined | not defined |
| OP-4 | Time to grant % below maximum time | 100% | 100% |
| OP-5 | Time to payments % Late | 2% | <2% |
| OP-6 | % Projects achieving insufficiently (Monitoring) | 5% | <5% |
| OP-7 | Lighthouse activity | not defined | not defined |

| | | | |
|---|---|---|---|
| OP-8 | Ethics: projects not complying | | <2% |
| OP-9 | Redress requested | 0% | 0% |
| OP-10 | Gender (%women in projects) | Not yet available in SYGMA | |
| OP-11 | Third country: participants from third countries | 0.5% | 0.5% |
| OP-12 | Error rate: % common representative errors | 0% | 0% |
| OP-13 | Events/Communication | not defined | not defined |

Programme performance

| KPI | Definition | Baseline | Target |
|---|---|---|---|
| PP-1 | Number of projects | 12 | >12 |
| PP-2 | National Funding / EU Funding per year | 0.92 | >0.9 |
| PP-3 | Private partners / Public partners | 2.0 | 2.0 |
| PP-4 | Average Size of project RIA | under preparation | under preparation |
| PP-5 | Average Size of project IA | under preparation | under preparation |
| PP-6 | Number of countries with selected participants but having committed no national funding divided by number of countries with participants in calls of that year (excluding third countries) | 20% | 20% |
| PP-7 | Oversubscription | under preparation | under preparation |
| PP-8 | Number of patents per 10MEuro of EU funding | 3 | Not available yet |
| PP-9 | Participation of SME to the programme | under preparation | under preparation |
| PP-10 | Publications | under preparation | under preparation |

### 2.2.13 Exit strategy and measures for phasing-out

The expected timeframe of the KDT partnership necessary to achieve its objectives and impacts is very closely connected with the implementation of the digital transformation of Europe. Activities will provide the key digital technologies that will in turn ensure that the benefits of digital transformation accrue to Europe. Therefore, the relevance of a future partnership is to be over the coming decade.

Just like for ECSEL, an 11-year duration is proposed for the KDT partnership, as needed for reaching its objectives set for 2031 and subsequently winding up all its activities. Therefore, the KDT partnership shall be established for a period up to 31 December 2031. In order to take the duration of Horizon Europe into account, calls for proposals under the KDT partnership shall be launched at the latest by 31 December 2027. In duly justified cases, calls for proposals may be launched by 31 December 2028.

After the end of funding under Horizon Europe and the completion of the projects from the last calls, the KDT partnership will in principle cease to exist, unless by that time some form of

continuation has been agreed. In the absence of renewal, appropriate measures conditions and timelines ensuring the orderly phasing-out of Horizon Europe funding will be agreed between the partners ex-ante, without prejudice to possible continued transnational funding by national or other Union programmes, and without prejudice to private investment and on-going projects.

## 2.3 Necessity for a European Partnership

For launching a European Partnership, Annex III of the legal base of Horizon Europe requires two key conditions to be demonstrated ex-ante:

i. Directionality: a common strategic vision of the partners, underpinned by a Strategic Research and Innovation Agenda or roadmap;
ii. Additionality: long-term commitment from partners to mobilise and contribute resources and investments.

Whereas the directionality argument is developed in section 2.2 above (in particular sections 2.2.1 and 2.2.11), additionality is the subject of this section.

The enabling nature of the technologies underpinning digital transformation is such that action at European level is needed, rather than Member States acting alone. A strong governance that includes Member States and Associated Countries will align European and national strategies and leverage investment. The ambition to connect the supply and demand ends of value chains requires initiatives (pilots, platforms) that combine hardware and software, design and manufacturing and provide the basis for collaborative work. The scale and increasing intensity of investments in KDTs by the major regions US, China, Korea, Taiwan and Japan, is such that **a failure by Europe to align European, national and industry strategies** and achieve a critical mass of public and private funding in this research-intensive domain would be detrimental to its positioning in any markets of significance. It will equally **undermine further digital innovation in most industrial sectors in Europe.**

ECSEL's tripartite model, whereby it is financed by the Union, 26 Member States and 4 Associated Countries and the private sector, has enabled implementation of a coherent European strategy for the sector and supported the case for continued intervention at European level. It makes it possible to draw resources from all actors, whereas no single Member State has the critical mass in its industry or budget to address the issue alone. In the current configuration, **each euro from the EU budget mobilises one euro from the national budget(s) and more than two euros from the private sector and other R&I actors. Similar ratios would be proposed in a future partnership, yielding long-term commitments for additional resources with at least a threefold leverage factor on EU investments compared to traditional calls and regular actions under Horizon Europe**.

The existing ECSEL JU has *inter alia* been instrumental in supporting pilot lines to further mature key digital technologies, something which is quite difficult to envisage with a lighter partnership. The synergies that were achieved under ECSEL show the potential to reinforce the dynamics in the industry, as well as with and among the participating Member States and Associated Countries. It is unlikely that this would sustain/survive without a stable, legal framework and a clear governance and set of rules.

The KDT partnership will aim at involving all 27 Member States, in addition to various Associated Countries. For the participating states, the benefits of the model include contributing to a joint R&I strategy and enjoying access to European wide facilities (pilot lines, application platforms). From the perspective of participating states, benefits also include

important leverage effects from 1:1 EU co-financing, with every euro from national resources matched by a euro from the European Framework Programme. The direct involvement of national authorities promotes openness and facilitates participation at national level, in particular for SMEs. Transnational collaboration with R&I actors in other participating states will enable companies to build new relations, to expose or be exposed to new innovations, and ultimately to grow. Today's digital products and services are so complex that no company alone can master all required technologies, so transnational cooperation between large companies, SMEs, institutes and universities is essential in the fragmented R&I landscape of Europe. For this purpose, the KDT partnership is the ideal vehicle.

The proposed option for implementing the KDT partnership is an institutionalised partnership based on Article 187 TFEU. This option involves the creation of a joint undertaking bringing together the Commission, private partners, and Member States and Associated Countries in a common governance structure to determine strategic objectives, with a solid legal basis for long-term commitments and a stable structure for cooperation that ensures continuity of actions. Ordinary Horizon Europe calls would only lead to collaborative R&I within stand-alone projects and would not benefit from additional industry and national contributions if either party is not fully involved in setting research and innovation agendas.

The research and industrial challenges addressed by ECSEL, and for which an even stronger KDT partnership is required in the future, cannot be addressed in a light partnership either, as it needs strong commitments from all involved. The involvement of Member States as co-funders makes the usage of Art. 187 most suitable. Other envisaged implementation modes currently listed under Horizon Europe do not have the breadth to ensure the much-needed scope, contributions and impact. For example, in principle a co-programmed partnership between the Commission and the three industry associations could be considered as a fallback option, with strengthened EUREKA clusters on related topics in parallel for national funding. However, that would lead to much weaker involvement of national authorities than in a tripartite European Partnership and no or very little strategic alignment at EU level.

## 2.4. Partner composition and target group

### 2.4.1. Partners

The KDT partnership will be composed of

- Public partners:
  - the European Union (represented by the European Commission);
  - Member States on a voluntary basis (ECSEL has all Member States on board as partners, except Croatia and Cyprus; the KDT partnership will aim at involving all 27 Member States);
  - Associated Countries to Horizon Europe, depending on the outcome of political decision making and subsequent negotiations on association agreements in Horizon Europe (ECSEL has Israel, Norway, Switzerland and Turkey among its 30 Participating States);

- Private partners: three associations representing R&I actors from the public and private sectors in the area of KDT:
  - AENEAS is an association, established in 2006, providing unparalleled networking opportunities, policy influence & supported access to funding to all types of R&D&I participants in the field of micro and nanoelectronics enabled components and systems.

- ARTEMIS Industry Association strives for a leading position of Europe in Embedded Intelligence. The multidisciplinary nature of the membership provides an excellent network for the exchange of technology ideas, cross-domain fertilisation, as well as for large innovation initiatives.
- EPoSS e.V., the European Technology Platform on Smart Systems Integration, is an industry-driven policy initiative, defining R&D and innovation needs as well as policy requirements related to Smart Systems Integration and integrated Micro- and Nanosystems.

The scopes and activities of these three industry associations are described in more detail in Annex 1. As expressed in their Memorandum of Understanding of November 20, 2018 (see Annex 2), these three associations have intensified their cooperation, ensuring a yearly update of their common ECS SRA, and jointly organising, together with the European Commission and the ECSEL Joint Undertaking, the annual EFECS event (European Forum for Electronics Components and Systems) to exchange strategic views with a growing community of stakeholders. At the operational level, the three industry associations cooperate on communications activities, joint brokerage events and ECT, the ECS Collaboration Tool facilitating the process of creating and submitting project proposals.

### 2.4.2. Target group and stakeholder community

The KDT partnership will build primarily upon the ECS innovation ecosystem established by ECSEL. User companies in KDT application sectors will be among the active participants in partnership projects that address full value chains. Its projects will also involve relevant partners from areas such as AI, to facilitate the fast development of key technological elements - hardware components and software - providing a leading edge to Europe as a supplier of AI solutions.

The thematic coverage will correspond to the extended scope set out in section 2.2.5. The three industry associations already have very big thematic footprints and a wide coverage of adjacent domains. Therefore, and also to avoid increasing the complexity of the governance of the KDT partnership, there is no intention to engage other types of partners. To accommodate the extension outlined in section 2.2.5, the specific subcommunities concerned will be taken on board in any of the current three associations and/or in the projects of their constituencies under the KDT partnership. This will be more efficient than raising the number of private members. Many members of the three industry associations are also involved in other partnership initiatives and programmes and are building bridges to other networks. Contacts have already been made with Photonics21, ETP4HPC, AIOTI, BDVA and the industrial representatives of the future CCAM European Partnership as a start for discussing optimal delineations/overlaps of the respective SRIAs in the light of the partnerships in Horizon Europe. As the KDT partnership delivers **key** digital technologies, these partnerships and probably many other partnerships can/could/should rely on the results of the KDT partnership; see the figure 10 below.

Regarding the geographical coverage of the target group, the KDT partnership aims at involving all Member States, in addition to various Associated Countries. Participating states can also play a role in reaching out to national innovation systems across Europe by means of dissemination events, communication activities, technical workshops and deployment initiatives, as well as by establishing links to their respective national research and innovation initiatives and to national participants in the Eureka clusters. Through their constituencies, also the three industry

associations have a wide geographical outreach. In addition, national events such as ECSEL in Germany, ECSEL in Italy Day and ECSEL Luxembourg Info Session, as well as national stakeholder platforms such as ECSEL-Austria, ECSEL Germany / ZVEI, ECSEL Italy / AEIT and Holland High Tech will strengthen geographical coverage, also for the KDT partnership. Furthermore, as achieved already with the Consortium Building Day organised by the three industry associations in Warsaw in 2018, complementing an ECSEL Call Forum, or with information days in Switzerland in Neuchatel in 2018 and in Dübendorf in 2019, combining information about the ECSEL programme and about the role of industry associations, communications activities will help reach out to a growing number of countries and potential participants, widening the scope and impact of the KDT JU.

### 2.4.3. International dimension

Like in ECSEL and in conformity with article 18 of the legal base of Horizon Europe, participation in the Calls for Proposals of the KDT partnership will be fully open, also for legal entities outside the Member States and Associated Countries, provided that the eligibility criteria for participation in Horizon Europe are met, together with any conditions laid down in the work programme of calls of the KDT partnership. The KDT partnership community will be open to all public and private stakeholders, international interest groups from Member States, Associated Countries as well as from other countries. International cooperation aspects will depend on the outcome of the negotiations on international association agreements under Horizon Europe and the ongoing debate on EU technological sovereignty.

# 3. Planned Implementation

## 3.1. Activities

### 3.1.1. Funding R&I actions

The core activity of the KDT partnership will be the funding the R&I actions to be performed by project participants. The specificity of the KDT partnership essentially lies in its tri-partite funding scheme: its R&I actions are funded by the private sector, supported by both European and national grants. The KDT partnership provides grants for R&I projects selected through open and competitive calls for proposals. Since the KDT partnership functions as an instrument under the Horizon Europe programme, the submission of proposals does not differ considerably from other Horizon Europe calls, and most Horizon Europe documents apply either completely or to a great extent to the calls of the KDT partnership.

The KDT partnership will offer two main funding instruments that projects may call upon:

- Innovation Actions (IA)
    - Large-scale, integrating projects;
    - Pilot lines and test beds, demonstrators, innovation pilot projects and zones of full-scale testing;
    - Specifically include higher TRLs
- Research and Innovation Actions (RIA)
    - Focused actions, typically addressing lower TRLs

The ECSEL share of IA/RIAs will be the starting point for the desired share in the KDT partnership. The first five years of ECSEL counted 34 selected RIA proposals and 29 selected IA proposals, with a total of 63 projects. IAs and RIAs should not work in isolation, but cluster with other KDT actions or application-specific actions in order to achieve highest impact at the level of end users and society at large. In addition, Coordination and Support Actions (CSA) can be funded. Joint calls with other European Partnerships will be possible, with the 2020 joint call of ECSEL and IMI-2 paving the way.

Built on well identified market-pull demands related to societal needs, Lighthouse Initiatives will offer visionary solutions for those demands, creating ecosystems along the relevant value and supply chains while coordinating activities (see earlier).

### 3.1.2. Other activities

R&D actions alone will not suffice to accomplish the objectives of the KDT partnership. In addition, a range of other activities and accompanying measures will be needed.

Lighthouse Initiatives

Currently being pioneered in ECSEL, Lighthouse Initiatives will focus part of the activities of the KDT partnership on achieving concrete socio-economic objectives along an agreed approach. Lighthouse Initiatives should improve and accelerate the impact of relevant projects by:

- Engaging all needed actors in the supply/value chain to achieve these goals, and

- Connecting investment in R&I by the KDT partnership to investments done, for example, in relevant areas of Horizon Europe or the EUREKA clusters,
- Giving recommendations to R&I investments by the KDT partnership that are in accordance with other policy measures such as standardisation, deployment or regulatory measures.

More specifically, Lighthouse Initiatives will

- Build on well identified market-pull demands related to societal needs;
- Offer visionary solutions for those demands, creating ecosystems along the relevant value and supply chains;
- Have a strong pan-European dimension in each of the steps: demands, solutions, ecosystems, technologies, demonstrators;
- Have a strategic IP management policy when possible and agreed by the consortia;
- Whenever appropriate, work towards clustering of projects in the identified areas and therefore organise the attraction of other contributing projects as needed, through a transparent competitive process;
- Establish a standardisation strategy when relevant and drive it;
- Address the relevant non-technical aspects (such as legislative, regulatory, social, etc.) and where possible develop concepts and take concrete steps for resolving issues linked to those aspects.

To date, the ECSEL JU has established the following Lighthouse Initiatives:

- Industry4.E (centred on the ECSEL project Productive4.0**);**
- Mobility.E (centred on the ECSEL project AUTODRIVE**);**
- Health.E (centred on the ECSEL project POSITION-II**).**

These Lighthouse Initiatives will be reviewed under the KDT partnership, and additional Lighthouse Initiatives will be set up.

Private and national investments in first industrial deployment

Major additional private and national investments for first industrial deployment will come from the IPCEI on microelectronics and its possible follow-up announced in the recent Industrial Strategy.

Activities of the industry associations

In addition to providing financial contributions to the administrative cost and mobilising in-kind contributions from their constituent entities and affiliates, the role of the private partners / industry associations will be (see also section 3.4):

- representing the interest of their members in the Governing Board for the strategy and management of the KDT partnership;
- organising roadmapping and generating the ECS SRIA;
- organising a yearly stakeholder forum;
- facilitating networking and allowing to get feedback on the ECS SRIA;
- organising yearly brokerage events or consortium building days;
- advocating topics and funding conditions towards the EC, the EP and the Council;
- actively supporting the communication and dissemination activities of the KDT partnership, in addition to specific communication activities of each industry association;

- participating in information days of the KDT partnership in various countries;
- gathering their communities and offer more services (e.g. engaging SMEs).

### 3.1.3. Synergies with other EU initiatives and coherence with national policies

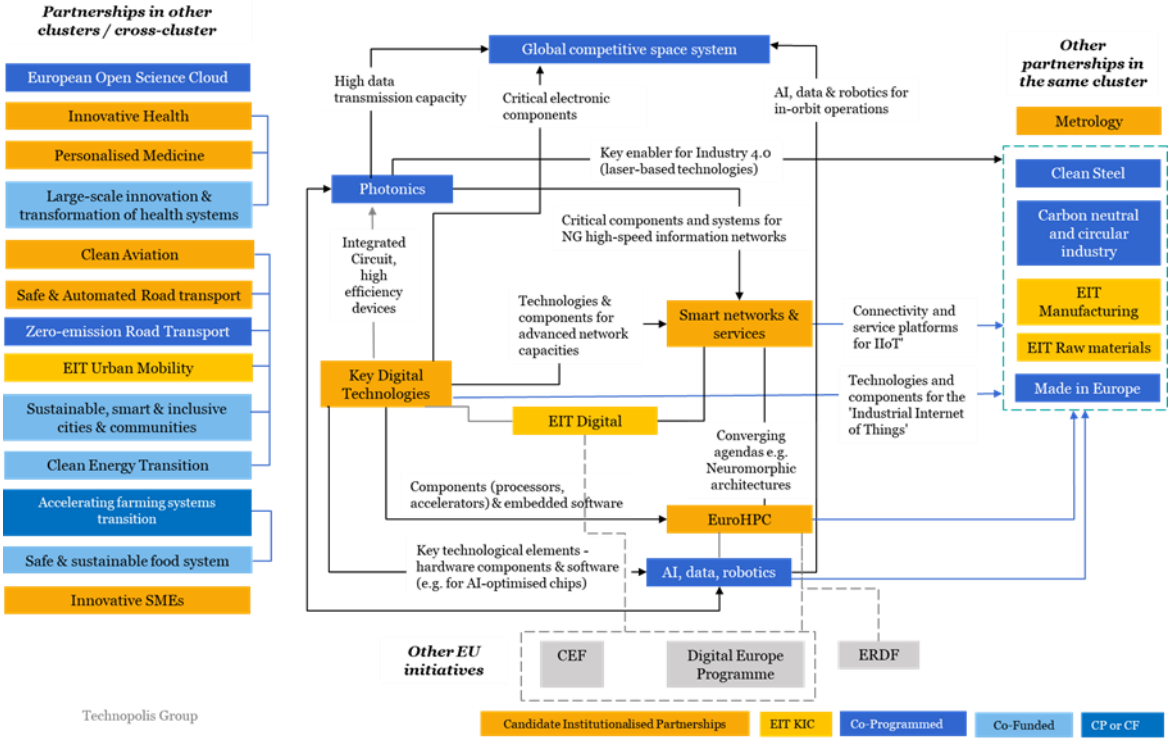



*Figure 10. Portfolio of possible European Partnerships*

Whereas achieving synergies[61] with other EU funding programmes is a key aspect of Horizon Europe, a workable framework is needed to blend various EU funding streams, e.g.

- European Structural and Investment Funds (ESIF)

  In some participating states, not only national and in some cases regional funds[62] have been made available for co-funding ECSEL projects, but occasionally also resources from the European Structural and Investment Funds[63]. Depending on the outcome of the inter-institutional negotiations on synergies in Horizon Europe, this may become easier in the KDT partnership thanks to a new provision proposed in article 8 of the legal base, stating that "financial contributions stemming from ESIF shall be allowed and considered as a national contribution."

  A recent ERA-LEARN "Policy brief on the potential coordination between European Structural and Investment Funds (ESIF) and transnational P2P" describes the possibilities and difficulties in achieving synergies between ESIF and transnational public-public partnerships; in view of its tri-partite approach, these apply by and large also to synergies between ESIF and the KDT partnership. Basically, synergies can be achieved at the programme level and at the project level. Whereas programme-level synergies need to be arranged a priori between the national/regional Managing Authorities responsible for ESIF

[61] See Annex IV of the legal base of Horizon Europe.
[62] E.g. Thuringia and Saxony in Germany.
[63] See https://www.ecsel.eu/calls/calls-2018

and the partnership in the planning phase of all programmes involved, project-level synergies have to be achieved by the beneficiaries themselves in the operational phase of the programmes, allowing to combine funding in four different ways for a single project:

- Sequential: different funds and programmes support different project phases: research infrastructures, R&D phase, market deployment;
- Alternative: alternative resources intervene for a project initially proposed under the scope of a different programme;
- Parallel: different funds in parallel to cover complementary aspects of a project;
- Cumulative: different funds are used in the same project, but for different budget items.

The ERA-LEARN Policy brief mentions two examples of synergies between ESIF and current JUs:

- The Clean Sky 2 JU (CS2) established a set of Memoranda of Understanding (MoUs) with regional authorities to align its thematic objectives with regional strategies and activate the applicable ESIF regional instruments. For this purpose, the JU is granting "synergy labels" to qualifying projects.
- Also the Bio Based Industries JU (BBI) entered into MoUs with Managing Authorities to support proposals with a "synergy label" in searching for alternative funding.

Furthermore, the Fuel Cells & Hydrogen JU (FCH) used ESIF funding for deploying an FCH project (development of fuel cell buses in nine cities or deployment of hydrogen refuelling stations)[64]. Whereas in principle these examples could be interesting, they may have less added value for the tri-partite KDT partnership than for other JUs without any national/regional co-funding.

- Digital Europe Programme (DEP)

With a planned budget of €9.2 billion, the new Digital Europe Programme (DEP, 2021-2027) will shape and support the digital transformation of Europe's society and economy. It will boost investments in supercomputing, artificial intelligence, cybersecurity, advanced digital skills and ensuring wide use of digital technologies across the economy and society. Its goal is to improve Europe's competitiveness in the global digital economy and increase its technological autonomy.

As the development of novel digital technologies and solutions matures through the KDT partnership, these should progressively be taken up and deployed by the Digital Europe Programme; this should lead to synergies between the KDT partnership and DEP in the form of sequential funding. Vice versa, DEP capacities and infrastructures are made available to the research and innovation community, including for activities supported through the KDT partnership, such as testing, experimentation and demonstration.

To ease access to venture capital as well as debt and equity financing for scaling up promising activities emerging from R&I activities funded by the KDT partnership, its Executive Director will explore possibilities for collaboration with the European Innovation Council (EIC, in particular its Accelerator, the former SME instrument). Additional financing sources for projects in various stages of development are the European Investment Bank (EIB, in particular via its European Investment Advisory Hub) and InvestEU.

[64] https://www.era-learn.eu/news-events/events/workshop-supporting-the-preparation-of-future-european-partnerships/f_synergies_funding_sources.pdf

Complementarity with other relevant initiatives of Horizon Europe, including with other relevant European Partnerships, missions and EU actions / initiatives beyond Horizon Europe will be sought and unnecessary duplications avoided. Being a partner in each partnership, the Commission has a pivotal role in this respect, as part of its processes for governing the portfolio of partnerships, preparing and approving the SRIAs and the annual work programmes of the partnerships, coordinating between the six clusters in Pillar 2 and with other initiatives under Horizon Europe and with other EU programmes. In addition, Commission and Member States could use their "Strategic coordinating process for European Partnerships"[65] to ensure coherence and coordination between partnerships. Furthermore, with national authorities of most or ideally all Member States and some Associated Countries sitting on the Governing Board and co-funding the projects of the KDT partnership, coherence and synergies in relation to major national (sectorial) policies, programmes and activities will be ensured.

Finally, synergies between the KDT partnership and relevant national policies and programmes of participating states are foreseen.

## 3.2. Resources

In view of its extended scope and high ambitions, the industry associations would be ready to engage in the new KDT partnership with R&D expenditures by their constituent entities and affiliated entities of roughly up to twice the volume they committed in ECSEL, assuming a proportional increase in public funding from the EU and participating states.

Resources contributed by the private members will be:

1. In-kind contributions to the funded projects;
2. If needed, in-kind contribution for additional activities not covered by public funding;
3. Investments in operational activities as described in the last paragraph of 3.1.4, beyond the work that is foreseen in the SRIA ;
4. Financial contribution to the administrative costs of the Joint Undertaking implementing the programme.

If needed, the Private Members Board will prepare an annual plan of additional activities that will be consulted with the Public Authorities Board and submitted for approval to the JU Governing Board. Additional activities may include:

- investment aiming at the uptake of the project results of the KDT, ECSEL, ARTEMIS and ENIAC Joint Undertakings;
- pilots, demonstrators, applications, deployments, industrialisation, including relevant capital expenditure;
- projects under the IPCEI on microelectronics and its potential successor;
- related research and development activities not publicly funded;
- activities financed by loans of the European Investment Bank and not funded under a grant by the Union;
- dissemination and communication activities;
- activities to develop the ecosystem including building cooperation with verticals and projects in Lighthouse Initiatives.

Project participants themselves will bear half of the total R&D expenditures; a quarter will be funded by the EU and another quarter by national authorities. In terms of leverage this implies that the same 1:1:2 ratio as in ECSEL will apply, with every euro funding from the EU matched

[65] https://www.era-learn.eu/documents/wk-4212-2019-init.pdf

by at least another euro funding from the participating states and two euro contributions in kind from project participants.

## 3.3. Governance

The bodies of the KDT partnership are:

- Governing Board

  The Governing Board is responsible for the overall strategic orientation and operations. It is composed of representatives of the Commission, the participating states and the private members representing industry (including SMEs,) universities and institutes. Each member appoints its representatives and a lead delegate who holds the voting rights of that member in the Governing Board. As much as possible, the three private members with align their voting in the Governing Board, in line with their MoU (Annex 2) and with common practice in ECSEL.

  The voting rights in the Governing Board of the KDT JU should reflect the tri-partite approach, allowing the Commission together with the representatives of the participating states to ensure the public interest.

- Executive Director

  The Executive Director is the chief executive responsible for day-to-day management and acts as the legal representative. The Executive Director is appointed by the Governing Board from a list of candidates proposed by the Commission, following an open and transparent selection procedure. The Commission associates the representation from the other members of the KDT partnership during the selection procedure, as appropriate.

- Public Authorities Board

  The Public Authorities Board is responsible for funding decisions, in particular by setting the rules of procedures for the calls for proposals, ranking the proposals and allocating public funding. It is composed of representatives of the public authorities of the KDT partnership, being the Commission and the participating states. Each public authority appoints its representatives and a lead delegate, who holds the voting rights in the Public Authorities Board. Each public authority shall have a right of veto on all issues concerning the use of its own contribution to the ECSEL Joint Undertaking.

- Private Members Board

  The Private Members Board proposes the Strategic Research Agenda. It is composed of representatives of the private members of the KDT partnership. Each private member appoints its representatives and a lead delegate, who holds the voting rights in the Private Members Board.

The governance structure of the KDT partnership will learn from the experience of ECSEL with as many improvements and simplifications as possible. In particular, more use can be made of dedicated Working Groups to prepare decisions that have to be taken by the Governing Board.

This should allow both even closer scrutiny of proposed decisions and a better division of labour between administrative and strategic decision-making.

## 3.4. Openness and transparency

Open calls

Participation in the Calls for Proposals of the KDT partnership will continue to be fully open, not only for members of the three associations, but also for other prospective project participants and for legal entities outside the Member States and Associated Countries[66], provided that the eligibility criteria for participation in Horizon Europe are met, together with any conditions laid down in the workplan of calls of the KDT partnership.

Calls will be broadly disseminated at EU and national levels. Calls of the ongoing ECSEL JU attract over a thousand participants per year, with over 36% of SMEs, and its openness has been highlighted in the interim evaluation report. About 22% of the total in-kind contributions stem from beneficiaries[67] outside the constituencies of the three associations. To make the KDT partnership more accessible to consortia having limited resources for creating proposals, calls should be adapted to get a significant reduction of the workload for drafting proposals (see section 2.2.8).

Open membership of associations

Membership of each association is basically[68] open to all R&I actors in its respective field in any Member State or Associated Country. As described in section 3.1.2 and Annex 1, each association offers different services to its members, complementary to acting as private partner in ECSEL or the future KDT partnership.

The specific subcommunities from the enlarged scope of the KDT partnership will be taken on board in any of the current three associations and/or in the projects of their constituencies.

Open participation in roadmapping

As explained in section 2.2.11, contributing to the Strategic Research Agenda for 2021 is possible for all experts, and not limited to members of the three industry associations, which jointly organise the roadmapping. An open and transparent recruitment process is in place, where experts are invited to contribute based on their knowledge, as recognised by peers. Commission and national authorities also participate and contribute.

Open participation to brokerage events / consortium building days

The industry associations regularly organise brokerage events or consortium building days, where anyone interested in collaborative projects can participate.

Open information days

The industry associations, in conjunction with ECSEL JU, participate in information days in different countries, in order to reach out to more interested parties and potential project partners. This is often organised in collaboration with national or regional authorities or

[66] Like in ECSEL and in conformity with article 18 of the legal base of Horizon Europe.
[67] Calculated from p. 69 of the ECSEL 2018 Annual Activity Report.
[68] See detailed provisions in their statutes.

organisations who know the local ecosystem and know whom to address. Such events, which will continue to take place under the KDT partnership, are open to everyone having an interest in the field and are free of charge in most cases.

Outreach and dissemination

Consortium building and matchmaking in ECSEL are facilitated by ECS brokerage events and the so-called ECS Collaboration Tool developed by the three associations, both of which are open to association members and other prospective project participants alike. The same or similar mechanisms are foreseen for the KDT partnership.

The associations also offer activities specifically targeted at SMEs, like the SME Engagement Council of AENEAS, in order to reach out to SMEs in the field and give them support adapted to their needs.

Outreach in ECSEL primarily takes place through EFECS (European Forum for Electronic Components and Systems), which is organised jointly by the three industry associations, the ECSEL JU and the European Commission, in association with EUREKA. This yearly event gathers the whole ECS community having an interest in collaborative innovation. Ranging from senior executives to project leaders and participants, it is the place where strategic views are exchanged, and operational plans are discussed. Here also the aforementioned stakeholder forum takes place. It is an event open to all interested parties, and is located each year in a different location, often following the Presidency of the Union. This allows to reach out to many companies across Europe. Such events will also take place under Horizon Europe for the new KDT partnership.

Furthermore, the KDT partnership will actively support the dissemination activities of the individual projects under the KDT partnership, similar to the press releases, news items and publications of ECSEL. A Communication plan of the KDT partnership will be established, in close cooperation with the three industry associations.

In addition, the participating states can contribute by means of dissemination events, communication activities, technical workshops and deployment initiatives at national and regional levels. Industry associations are available to help organise and support such initiatives.

Transparency

Decision making in the KDT partnership will be transparent, with decisions of the partnership bodies published on its website, similar to the documents and transparency reports on the ECSEL website.

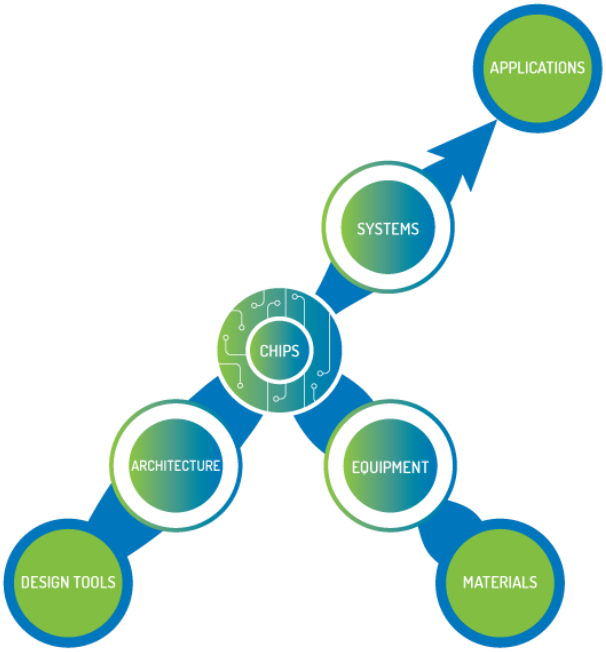
Access to results and confidential information

As prescribed in Annex III of the Horizon Europe Regulation, the Commission will get access to the results and other action related information for the purposes of developing, implementing and monitoring of Union policies or programmes. Just like in the case of ECSEL, such access will pertain to project results, documents (such as: description of the action, periodic reports, deliverables) and related information including confidential information and any personal data, and be granted on the basis of necessity, proportionality, and need to know.

# Annex 1. Scope and activities of AENEAS, ARTEMIS-IA and EPoSS

## AENEAS

AENEAS is an Industry Association, established in 2006, whose purpose is to promote Research, Development and Innovation in order to strengthen the competitiveness of the European industry in the field of Electronic Components and Systems. AENEAS brings together RD&I partners from Large Enterprises, SMEs, Research Institutes and Universities active all along the ECS value chain.

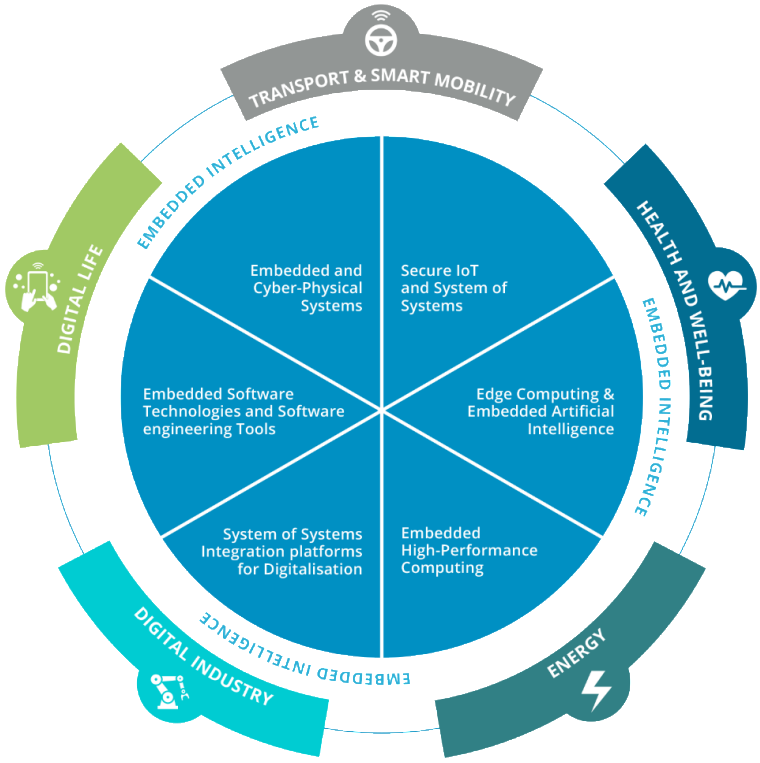



AENEAS was initially founded to represent the industry in the former ENIAC Joint Undertaking under FP7. Its scope and activities have significantly evolved since then. AENEAS now offers a variety of services helping its members to benefit from a dynamic RD&I ecosystem, and plays a pivotal role in stimulating a higher involvement of SMEs in collaborative projects. Through working closely with the European Commission and the Members States, AENEAS helps to shape the future funding instruments, based on the ECS Strategic Research Agenda prepared by Industry. AENEAS is currently involved in the tri-partite ECSEL Joint Undertaking under H2020, where it represents industry with other associations in the Private Members Board. AENEAS also fully operates two EUREKA Clusters, CATRENE and PENTA, providing its members with access to a variety of instruments supporting collaborative innovation in the field of micro and nanoelectronics enabled components and systems.

Four executive bodies allow AENEAS to achieve its mission: its Technical Experts Group, evaluating the projects under PENTA, its Scientific Council, giving guidance on roadmaps and innovation, its SRIA Working Group, gathering inputs from its members to contribute to the ECS SRIA, and its SME Engagement Council, paying special attention to the needs of SMEs. With the support of its executive bodies, the AENEAS office team supports its members, helping them to increase the speed of innovation and participate in projects well adapted to their needs.

**ARTEMIS-IA**

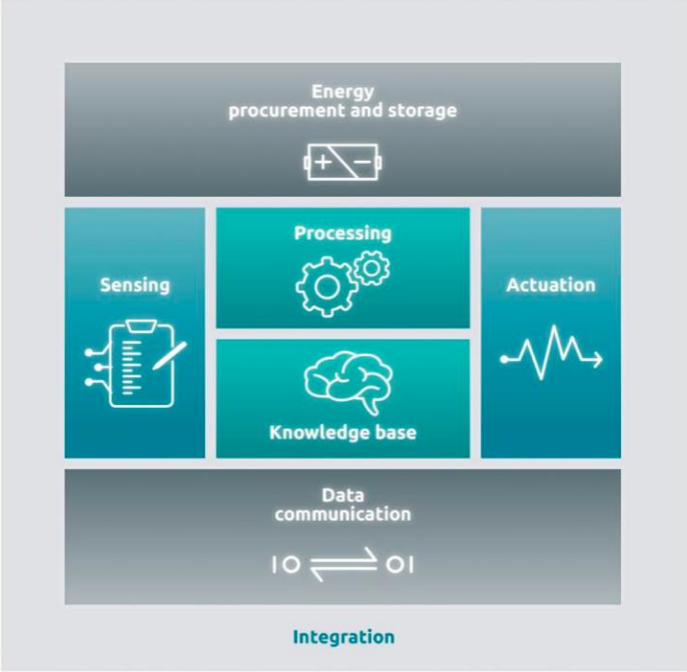
ARTEMIS Industry Association (ARTEMIS-IA) is THE association for embedded intelligence in Europe. The acronym stands for **A**dvanced **R**esearch & **T**echnology for **EM**bedded **I**ntelligent **S**ystems. ARTEMIS-IA was founded in 2007 to embody the ARTEMIS European Technology Platform (ARTEMIS-ETP) and the private membership in the ARTEMIS Joint Undertaking till 2014. Later it became one of the three private members of the ECSEL Joint Undertaking that started in 2014. The ARTEMIS-IA community is nowadays active in six technology domains that create EMBEDDED INTELLIGENCE for many applications.




ARTEMIS-IA organises regularly the ARTEMIS Technology Conference (ATC), where members and guests deeply discuss the topics of the mentioned technology domains.
ARTEMIS-IA publishes two times per year the printed ARTEMIS MAGAZINE.
Members of ARTEMIS-IA are active in many ARTEMIS-IA Working Groups on a variety of topics. An important WG is the ARTEMIS WG SRIA that works together with AENEAS and EPoSS on the common ECS-SRIA.
ARTEMIS-IA has a scientific committee and a management board of 25 persons from corporate companies, SME's, RTOs and universities.

**EPoSS e.V.**

EPoSS e.V., the European Technology Platform on Smart Systems Integration, is an industry-driven policy initiative, defining R&D and innovation needs as well as policy requirements related to **Smart Systems Integration and integrated Micro- and Nanosystems**.




EPoSS brings together private and public stakeholders to create an enduring basis for common initiatives, co-ordinating and bundling European efforts and setting up sustainable structures for Smart Systems Integration Research and Innovation in Europe.

EPoSS:

- gives a voice to the European Microsystems and Smart Systems Community;
- creates a common European approach on Innovative Smart Systems Integration from research to production;
- defines priorities for research and innovation in commonly agreed roadmaps contributing to European R&D&I Policy;
- provides its own strategic R&D agenda for Smart Systems and their integration in Europe;
- mobilises public and private human, infrastructural and financial resources;
- supports its members in coordinating their joint research efforts;
- provides the communication platform for its members as well as towards the European Commission.

The initiative particular focus is on defining research and technology priorities for **the EU Framework Programme for Research and Innovation**, for raising more critical mass as well as resources and for coordinating different initiatives (national, regional, EUREKA, European public funding and industry). EPoSS is one of the three private members of the ECSEL Joint Undertaking and one of the three partners of EGVI, the European Green Vehicles Initiative, a public-private partnership.

# Annex 2. Memorandum of Understanding

**MEMORANDUM OF UNDERSTANDING**

**between**

**AENEAS, ARTEMIS-IA and EPoSS**

**in view of**

**STRENGTHENING THEIR COOPERATION AND JOINING FORCES**

***Parties***

1. **AENEAS**, an industrial Association on micro- and nanoelectronics enabled components and systems, based in Paris (F), established in 2006 (www.aeneas-office.org);
2. **ARTEMIS Industry Association (ARTEMIS-IA)** on Embedded Intelligence, based in Eindhoven (NL), established in 2007 (www.artemis-ia.eu);
3. **EPoSS e.V.**, an Industry Association on Smart Systems Integration, based in Berlin (D), established in 2013 (https://www.smart-systems-integration.org).

***Considerations***

Whereas Parties

- Through their industry-driven representation of actors in Research, Development and Innovation (RD&I) play a prominent and active role in supporting the Electronic Components and Systems (ECS) community in their RD&I activities and shaping programmes for collaborative RD&I;
- Defined a common vision, mission and strategy for the ECS industry in their High-Level Strategic Research and Innovation Agenda of 2012;
- Are the three private members of the ECSEL Joint Undertaking, a tri-partite Public-Private Partnership with the European Union (represented by the European Commission) and 30 ECSEL Participating States;
- Issue a common Strategic Research Agenda (SRA) for the ECS domain, guiding RD&I projects throughout the ECS ecosystem;
- Jointly organise, together with the European Commission and the ECSEL Joint Undertaking (JU), the yearly EFECS event (European Forum for Electronic Components and Systems), gathering all ECS stakeholders to exchange strategic views, inform them about and collect feedback on the draft multiannual strategic research and innovation agenda and draft research and innovation activities plan for ECSEL for a given year, and provide operational information on public programmes for collaborative RD&I in the ECS domain;
- Share the ECS Collaborative Tool (ECT), a common project submission tool supporting the creation of project ideas independent of specific funding instruments;
- Issue common position papers in their joint endeavour for continuing ECSEL beyond 2020 as part of Horizon Europe, the EU Framework Programme for Research and Innovation succeeding Horizon 2020, supported by a common strategic adviser;
- Jointly organise ECS brokerage events, supporting the creation of RD&I consortia and informing them about the different funding instruments available for their activities;
- Have regular meetings ("3A meetings") to arrange common activities and align positions;

they now wish to consolidate their cooperation by means of this Memorandum of Understanding (MoU).

***Purpose and scope***

This MoU aims at reinforcing the already existing cooperation between the Parties and stimulating joint activities by entering into a more visible cooperation with the following key objectives:

- Strengthening the European ECS ecosystem, in particular by facilitating collaboration between SMEs, large companies, universities and research institutes;
- Increasing the effectiveness and efficiency of the participation of the ECS community in ECSEL as the key funding instrument for collaborative RD&I in the ECS domain;
- Helping to pave the way for the continuation of ECSEL beyond 2020 as the institutionalised European Partnership on key digital technologies in Horizon Europe.

***Content of the Cooperation***

Parties intend to:

- Continue and reinforce their existing cooperation as described above under Considerations and extend it where beneficial for their respective constituencies, while retaining their independence, respecting each Party's governance structures, rules and regulations, and preserving their respective ecosystems and communities;
- Highlight potentially interesting complementarities in the competences of their constituencies and bring them to the attention of their respective members;
- Align their respective communication activities where relevant;
- Update the common ECS SRA on a yearly basis through their agreed structures and processes;
- Continue jointly organising the yearly EFECS event together with the European Commission and the ECSEL JU, aiming at reaching out to a growing community in terms of competences, activities and countries;
- Promote wider use of the common project submission tool ECT;
- Pursue advocacy activities with common position papers, meetings, etc. as needed for ensuring continuation of ECSEL beyond 2020 as the institutionalised European Partnership on key digital technologies in Horizon Europe;
- Expand, when applicable, the group of MoU Parties and/or explore the feasibility of additional/alternative modes of intensifying cooperation as deemed necessary for continuing ECSEL beyond 2020 as the institutionalised European Partnership on key digital technologies in Horizon Europe.

***Miscellaneous***

- This MoU shall be effective from the date of signature of the last Party to sign and shall remain in force for three years. It may be renewed by mutual written agreement between the Parties.
- Parties will review the MoU on a yearly basis and amend it as needed.
- A Party may at any time withdraw from the MoU and terminate its involvement in the activities set out in this MoU. Such termination shall be done in writing to all other Parties.

| For AENEAS | For ARTEMIS-IA | For EPoSS |
|---|---|---|
| Reinhard Ploss<br>President | Jean-Luc di Paola-Galloni<br>President | Stefan Finkbeiner<br>Chairman |
| Date: November 16, 2018 | Date: 20-11-2018 | Date: 20.11.18 |
| Place: Neubiberg | Place: Lisbon | Place: Lisbon |

## Annex 3. ECS SRA 2020 – Contents

# CONTENTS

# Annex 4. SRIA 2021: Major Challenges, High priority R&D&I Areas and Expected Achievements for Europe

**Preliminary version**

| ECS Key Application area: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***Mobility*** | Enable electrification & sustainable alternative fuels for $CO_2$ neutral mobility | • Affordable and environment friendly power electronics<br>• Control, diagnostics & predictive maintenance management for batteries, fuel cells, eMotors and charging infrastructure<br>• New sensors to increase environment friendliness<br>• Green life cycle management, material supply, recycling | **Digital innovation to achieve the Green Deal for mobility with the 2ZERO goals of -37.5% $CO_2$ by 2030 vs. 2021** (according to WLTP) and **Zero Emission by 2040 in Cities** and **Zero Net Emission by 2050** in providing the key digital technologies in e.g. reducing power electronics costs by 40% while increase power density per liter by 500% until 2035;<br><br>**Digital innovation to increase Road** Safety (providing the key digital technologies to the **CCAM** program) in reducing the number of road fatalities and accidents caused by human errors to zero until 2050 as well as ensuring that no additional road fatalities are introduced by automated transport while bringing validation costs down to 50% of development costs from current 70-80%;<br><br>**Digital innovation to inclusiveness of mobility** in ensuring inclusive mobility for persons and goods by providing mobility access to everyone with focus on special need reaching 90% of EU population vs. today 60% due to assisted vehicles by 2050 as targeted by **CCAM;**<br><br>**And strengthen competitiveness of European industrial mobility digitalization value chain** by protecting global technological leadership and supply chain consistency in the automotive sector, ensuring long-term growth and jobs. |
| | Enable affordable safe and environment neutral light Mobility (Bikes, tricycles, wheelchairs, small drones, …) and mobile machinery (as smart farming) | • Modular platforms, control software, power electronics, actuators and diagnostics for small vehicles (bikes, scooters, wheelchairs, …)<br>• Control software, power electronics, actuators and diagnostics for small drones, robotics, smart farming movers and shuttles<br>• Distributed logistics systems for smart farming, movers and shuttles | |
| | Enable affordable, automated and connected mobility for road, rail, air and waterborne passengers and freight | • Dependable and affordable environment and localization sensors and V2x communication<br>• Centralized service/function oriented HW/SW architectures for vehicles, ships, trains supporting cloud and edge<br>• Dependable and reconfigurable HW and SW including OTA<br>• Trustworthiness of vehicles' data<br>• Interaction between humans & vehicles<br>• Active safety systems<br>• Autonomous vehicles (cars, trucks, ships, airplanes, agriculture vehicles,…) | |
| | Provide validation & certification for safety, security and comfort of embedded intelligence in mobility | • Validation/certification of ADAS automated and/or connected vehicles systems (methods, tools and platforms)<br>• Validation/certification of embedded AI based systems<br>• Validation/Certification of control systems using Consumer electronics components in automotive systems<br>• Validation of comfort and customer acceptance of automated vehicles<br>• Continuous integration and deployment<br>• Simulation models, stimulators, scenarios and criteria for virtual validation | |
| | Achieve energy optimal multimodal mobility | • Environmental-friendly routing architectures & recommender systems<br>• Green mobility as a service<br>• Environmental-friendly last-mile logistics control | |

| ECS Key Application area: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***Digital Industry*** | **Sustainable manufacturing and production** | • Life-cycle analysis (LCA)<br>• Risk-resilient manufacturing<br>• Recycling/reuse technologies, resource efficiency<br>• Component, material tracing<br>• ECS technologies for new processes, new materials, new concepts, etc., that enable sustainability. Esp. low-carbon.<br>• Proving sustainability, licensing, monitoring | React quickly on changes, efficient work allocation, predictable quality, fair circulation of tasks and ability to tailor tasks for individuals<br><br>Minimum unplanned downtime and optimised OEE (Overall Equipment Efficiency)<br><br>Evidence-based decisions and profitable investments, to optimize the lifecycle costs and the value created<br><br>Preparation for future regulation or market requirements that are due to Green Deal. Zero-carbon or below carbon neutral operation.<br><br>Reducing the throughputs of R&D, product development, factory building and upgrades, down to 1/10, in spite of increased complexities.<br><br>The volume and value of industrial services are increasing 5-10% per year. The share of services has exceeded the share of machinery. |
| | **Competence Management, human aspects** | • Skills related challenges, new job profiles, training, competence and qualification growth<br>• Well-being<br>• Human centered manufacturing, semi-autonomous solutions<br>• Decision support (like AI assistants) | |
| | **Trust, security, Cybersecurity, safety, privacy** | • Cybersecurity, data security, data authority, blockchain<br>• Human safety, environmental safety<br>• Critical engineering technologies and procedures, legislation, licensing<br>• Explainable AI (transparent, descriptive, easier to understand), where to run analysis: cloud, edge, sensor => use cases!<br>• Interchange data, models | |
| | **Excellent, responsive and smart factories:** | • Scalable first-time right production<br>• Agile and robust optimal production<br>• Resilient and adaptive production<br>• Cognitive production<br>• 3D printing<br>• Manufacturing as a service<br>• Distributed, networked production.<br>• Modular factories, i.e., smaller entities to be flexibly called or configured into action<br>• Mastering complexity of products, processes and systems. Mass customization, personalized manufacturing | |
| | **Engineering, tools:** | • Parallel product-production engineering<br>• Multi-domain engineering<br>• Design, engineering tools<br>• Seamless through value chains, end-to-end<br>• Means for digital single market: reference architectures, integration, standardization, interoperability, semantics, digital platforms<br>• Digital twins<br>• Modeling and simulation<br>• Virtual or mixed/augmented reality<br>• Model-based integrated engineering | |
| | **Service business: (add lifecycle & configuration management):** | • Collaborative product-service engineering<br>• Condition monitoring, condition-based maintenance, anomaly detection<br>• Performance monitoring, prediction, management<br>• Remote engineering and operations<br>• Local and global services, fleet-management | |

| Application area | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***Energy*** | Manage high **variability** of **decentralized renewable** generation & efficient conversion<br><br>*"Component Level"* | Increase efficiency of utilization by developing smart energy generation, conversion and storage components:<br>• Residential, commercial, and industrial demand side management (scheduling and load adaption)<br>• High efficiency of electric drives, heat pumps, cooling, HVAC, data centres and other consumers of electricity for variable load operation<br>• DC subsystems for industrial production / data centre applications<br>• Integrate battery driven applications (e-car charging, PV – system local storage)<br>• develop and apply storage optimizing residential, commercial, industrial utilization | Long term 2050 > 80% renewables<br><br>Carbon neutral society in 2050.<br><br>Reach a 45% share of renewable energy in the electricity sector in Europe by 2030, by enabling decentralized, intermittent energy sources, bi-directional grid and storage systems for the energy supply in transport, industrial and smart cities applications;<br><br>European ECS industry as well as SMEs developing, manufacturing, and implementing ECS for application in (critical) energy infrastructure<br><br>Competitive European ECS ecosystem (industry & research) |
| | **Stable, resilient, economic on-site energy systems**<br><br>*"System Level"* | Develop on-site (behind the meter) energy management systems for residential, commercial, and industrial application optimizing generation, storage, utilization, and trading of energy,<br>• interacting with ECS of components,<br>• interacting with distribution system on community / district level,<br>• having plug-and-play capability for components, self-learning,<br>• being connected to AI-based cloud services forecasting e.g. renewable generation profiles,<br>• being coupled to energy trading systems, e.g. local energy market platforms,<br>• Being secure (IT security) | |
| | **Reliable and Secure Energy Distribution on Community and Regional Level**<br><br>*"System of Systems Level"* | Distribution grid comprising commercial scale renewable generation, conversion between different energy modes (electric, heat / cold, chemical), e-mobility infrastructure, and storage, control and protection systems for the grid infrastructure<br>• Interacting with on-site energy systems<br>• Interacting with cross regional energy infrastructure<br>• Connected to cloud services<br>• Being adaptive | |
| | Cross sectional technologies for **Energy System Monitoring & Control**<br><br>*"Cross Sectional Level"* | • Smart sensors & sensor networks<br>• Self-adaptive control based on Artificial Intelligence / Machine Learning<br>• Smart, secure edge devices for secure data management and control<br>• Databases and algorithm forecasting generation, load, … on 24-hour time horizon with at least 15 minutes resolutions (solar, wind, hydro… versus demand profiles)<br>• IT security, connectivity, integrity | |

| ECS Key Application area: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***Health*** | Enable **digital health platforms** based upon predictive, preventive, personalized and participatory **(P4) medicine** | • Smart instruments for faster and more effective minimally invasive intervention<br>• Person-centred AI/Embedded AI-based medical devices and systems<br>• Multimodal data fusion devices & systems<br>• High level of digital Trust<br>• Robotics to improve treatments either in the operating room, at general practitioners or at home<br>• Energy efficient local processing and transmission of medical (e.g. imaging) data<br>• New optical and acoustic based technologies to eliminate the use of X-rays<br>• Organ-on-Chip platforms | Establish Europe as a **global leader in personalised medicine deployment**<br><br>Lead the Healthcare system paradigm shift from treatment to health promotion and prevention<br><br>Tackle the burden of chronic diseases and face the demand for the prevention, management, and reduction of chronic disease<br><br>**Adding three healthy life years by 2030**, while maintaining costs at below 10% of GDP |
| | Enable the **shift to value-based healthcare**, enhancing access to game changing technologies | • Optimisation of hospital workflow<br>• Point of care diagnostic systems based on optical, chemical, MEMS, photonics and other sensors<br>• Information sharing to anticipate and contextualize acute or chronic conditions<br>• patient generated health data Biomedical models to enhance AI based clinical decision support | |
| | Support the development of **home as the central location** of the patient, building a more **integrated care delivery system** | • Integration of heterogeneous devices and systems used at home with hospital units to optimize Patient generated health data<br>• Ownership and secure storage of health data<br>• Support prevention, diagnosis and aftercare with sensors and actuators<br>• Connect sensors and actuators to Robotics to improve treatments either in the operating room, , at general practitioners or at home<br>• Smart drug delivery to improve drug adherence<br>• Smart wound care to treat people with chronic wounds in their home | |
| | Enhance **access to personalized and participative treatments** for **chronic and lifestyle related diseases** | • Wearables or minimally invasive implants, measurement of physiological parameters<br>• Devices or systems using predictive models to anticipate the appearance of co-morbidities<br>• Small implantable devices that modulate the functions of organs in the treatment of chronic diseases<br>• Devices or systems using biomedical models<br>• Integrated care for person under chronic conditions through care providers coordination, data fusion & risk modelling | |
| | **Ensure more healthy life years for an ageing population** | • Daily Activity Monitoring with "easy to use" user interfaces<br>• Assistive technologies to remain active (exo-prosthesis)<br>• Monitoring outside home, using Cognitive Stimulation | |

| ECS Key Application area: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***AgriFood & Natural Resources*** | **Food Security and Sustainable production** | • Animal and plant health<br>o Pest Management and minimize antibiotics use<br>o Systems for antimicrobial resistance<br>o Move from conventional to organic agriculture<br>o Reduce then eliminate the use of phytosanitary products<br>o Mechanical Weeding<br>• Farming systems<br>o Interoperable IoT systems, Robots, Drones and Satellites<br>o Vertical Agriculture to produce and consume locally<br>• Food supply chain management<br>o Intelligent Food production<br>o intelligent logistic systems<br>o End-to-end food Traceability and certifying food origin | From "Farm to Fork":<br>a **fair healthy end environmentally friendly food system for 2030** through:<br><br>Reduction of the use and risk of synthetic chemical pesticides, fertilisers and antibiotics<br><br>Increase adoption of least-spread farming systems such as organic and vertical agriculture<br><br>Reduction of environmental impact related to transport, storage, packaging and food waste<br><br>**Natural resource optimisation and remediation towards climate-neutrality** first step for 2030 and then 2050 through:<br><br>Reduction of water pollution and greenhouse gas emission incl. methane and nitrous oxide<br><br>Reduction of European cumulated carbon and cropland footprint by 20% in the next 20 years, while improving climatic resilience of European agricultural and stopping biodiversity erosion. |
| | **Water resource Management** | • Healthy water<br>o Sensors and diagnostics for water quality monitoring<br>• Access to clean water (urban or rural)<br>o Integrated systems for demand reduction and conservation of water<br>o Smart diagnostics for water leakage detection<br>o Management of water usage<br>• Resource Management<br>o Smart water treatments fostering circular use of wastewater, rainwater and storms water<br>o Smart systems for flood and irrigation management | |
| | **Environmental Protection** | • Soil health, air quality and environment<br>o In-situ, real-time monitoring of soil nutrients<br>Smart waste management systems<br>• Healthy air skies<br>o Sensors and diagnostics for air quality monitoring (indoor, urban and rural)<br>o Smart systems for controlling and preventing greenhouse gas emissions<br>• Smart waste management<br>o Integrated bio-waste systems<br>o Intelligent sustainable/biodegradable packaging<br>• Remediation processes<br>o Efficient smart networks for remediation in different ecosystems (water bodies, air, and soil. | |

| ECS Key Application area: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***Digital Society*** | Maximize the *individual* development and protection of citizens<br>• Increase inclusion and prevent exclusion<br>• Privacy protection<br>• Personal resilience<br>• Life-long learning and training | • Digital inclusion: tools, infrastructure, training, connectivity<br>• Online education & examination<br>• Improved human-machine interaction solutions<br>• VR/AR training and support<br>• Support devices (wearables, robots, cobots, chatbots, …)<br>• Nudging, gamification (for development or health reasons) | Digital inclusion for all individuals<br><br>Protected privacy<br><br>Employability through life-long learning and training |
| | Safeguard the *collective* wellbeing and resilience of a society<br>• Societal & Digital inclusion<br>• Acceptance of new technologies (AI)<br>• Societal resilience / protection / surveillance<br>• Citizen protection (against identity theft / digital exclusion) | • Reliable and ubiquitous digital infrastructures<br>• Responsible AI, Explainable AI, Trustworthy AI, Philosophy of AI<br>• Access control / intrusion detection / surveillance<br>• Social media / serious gaming / AR/VR<br>• Dynamics of society: systemic change<br>• Emergency / Crisis response solutions and services<br>• Protection against terrorist and cyber-attacks: surveillance & emergency response systems<br>• Homeland security and cybersecurity (adjacent to the "Q,R,S&S" chapter 14 and "Connectivity" chapter 12)<br>▪ Crisis management<br>▪ Crowd management<br>• Off-grid living and emergency survival (adjacent to the Energy chapter) | Societal acceptance of novel technologies<br><br>Digital inclusion for the society<br><br>Resilient society against setbacks<br><br>Reliable and ubiquitous digital infrastructures<br><br>Fall-back solutions in case of crisis |
| | Contribute to the *environmental* sustainability (natural, physical, digital/cyber, …)<br>• Towards carbon neutrality<br>• Energy saving<br>• Water saving<br>• Food<br>• Air pollution (measuring and filtering) | • Supporting citizens instead of replacing them<br>• Physical Infrastructure management / physical resilience<br>• Intelligent Infrastructure management (Buildings, Industry, Traffic, …)<br>• Logistics management (adjacent with the Mobility chapter)<br>• Digital Infrastructure management / digital resilience<br>• E-government / Citizen support<br>• Smart Cities (incl. Smart Home and Smart Office)<br>• Resource monitoring and feedback | Sustainable environment (both physical and digital)<br><br>Carbon neutrality<br>Clean air<br><br>Intelligent Infrastructure management in place<br><br>Resource monitoring systems in place |

| Value Chain Technologies: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| **Process Technologies, Equipment, Materials & Manufacturing** | **Materials, process modules and integration technology** for novel devices and circuits for **advanced compute, memory and compute-in-memory concepts**, based on nano-electronic, photonic or quantum technology. | • Extensions of the scaled Si technology roadmaps, and further pitch scaling where parallel conduction paths (i.e. nanowires, nanosheets…) are brought even closer together<br>• Exploration and implementation of materials beyond Si (SiGe, SiC, Ge, functional oxides, 2D material heterostructures)<br>• Novel device, circuit and systems concepts for optimum power-performance-area-cost specifications, high energy efficiency and novel paradigms like for near/in-memory, neuromorphic, optical and quantum computing<br>• Long-term challenges such as Steep Slope Switches, spin-based transistors, and alternative high-performance switches<br>• Unconventional devices and materials, like 2D-materials, nano-wires, nanosheets, quantum dots, spin effects, functional oxides which are being investigated to overcome the limits of conventional CMOS logic and memories<br>• Device scaling by moving into 3D for sub 3 nm node memory & computing technologies to drive down energy consumption<br>• New embedded Non-Volatile Memory (eNVM) technologies enable local AI processing, decreasing data transmission needs and energy<br>• the same eNVM progress enable a more efficient control of thermal, hybrid and electric powertrain and batteries in vehicles | 1. Ensure European sovereignty on key electronic components and key semiconductor equipment solutions<br>2. Enable relative energy consumption for ICT in computations/kWh reduced to 1% of level of 2020.<br>3. Development of a EU supply chain for the wide-bandgap materials including the move from 150 to 200mm wafers (ie SiC) |
| | **Materials, process modules and integration technology for** novel devices and circuits that enable **advanced functionality** (sensing, actuating, power, connectivity, biomedical, etc), including (wafer or flexible) **substrate technologies**. | • Advanced Sensor technologies (Mechanical, Chemical, Physical, quantum, Optical/RF & Biomedical)<br>• Improved RF technologies (CMOS, SOI based RFCMOS, BiCMOS, filters and integrated passives) enable a better & energy efficient control of the emission and reception channels for 5G connectivity and for preparing 6G<br>• Advanced Power and smart power Electronics technologies (Si-based, BCD, SiC, GaN, $Ga_2O_3$…) efficiency of motors, energy storage, lighting systems, etc.<br>• New sensor technologies and devices enable a better control of processes (eg industrial processes, lighting, etc…) and this contribute to energy saving | |

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| **Process Technologies, Equipment, Materials & Manufacturing (Part 2)** | **Advanced heterogeneous integration and packaging solutions** for System-on-Chip (SoC), 2.5 and 3D stacking (incl chiplet technology), smart System-in-Package (SiP), sensor integration, power electronics, and other functionalities required for application domains like e.g. AR/VR, automotive, biomedical, etc. | • Application-specific logic: Heterogeneous System-on-Chip (SoC) Integration can require specific solutions for logic to be integrated with More-than-Moore technologies<br>• Advanced RF and Photonics Communication technologies to interface between semiconductors components, sub-systems and systems<br>• Advanced interconnect and encapsulation technologies<br>• 3D integration technologies<br>• Enhanced reliability, robustness and sustainability technologies | |
| | **Semiconductor Equipment and manufacturing** solution development for processing novel materials and enabling advanced process integration required for the state-of-the-art sub 3 nm node logic and memory roadmaps according to PPAC requirements, chips/chiplets with single and/or multi node layers, advanced functionality devices and heterogeneous integration technology options as described under challenges 1 to 3. | • Manufacturing technologies/equipment for nanoscale patterning, layer deposition, metrology & inspection for future sub 3 nm node logic and memory technologies<br>• Manufacturing technologies/ equipment for new transistor (FEOL) and new interconnect (BEOL) concepts enabling sub-3nm nodes according to PPAC requirements<br>• Manufacturing technologies/ equipment for new processes enabling sub-3nm nodes.<br>• Manufacturing technologies/ equipment enabling advanced packaging of single and/or multi-node chips/chiplets<br>• Manufacturing technologies/ equipment enabling IC-fabs with interconnected tools that support flexible, sustainable, agile and competitive semiconductor manufacturing of advanced functionality devices and heterogeneous integration technology options in Europe<br>• Manufacturing technologies/ equipment for improved sustainability of IC-fabs<br>• Manufacturing technologies/ equipment for advanced integrated photonics<br>• Manufacturing technologies/ equipment for Quantum-chips | |

| Value Chain Technologies: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***Components and Modules and Systems Integration*** | **Physical and functional integration** of smart components and modules and systems | • Selective gas (CO, CO2, NOx, VOC, etc.) sensing components<br>• Selective detection of allergens, residues in food/water, atmospheric particles, etc.<br>• Disease monitoring & diagnostics (at home, POC, animal health)<br>• Bio-sensors and bio-actuators<br>• Flexible/robust/multimodal sensing for wearables<br>• Low-power/low-loss sensor nodes for real-time data processing (e.g. for neuronal networks)<br>• Reducing energy on all levels, enabling powering with energy harvesting<br>• Smart power modules for low-power sensing/actuation and efficient power transfer<br>• MOEMS and micro-optics<br>• Photonics features like optical sources, waveguides and connectors integrated into photonic integrated circuits or photonic systems in a package on Silicon, PCB or other substrate<br>• Board-level high-speed communication features<br>• Low-power wireless architectures + communication<br>• Component-level features for self-diagnosis<br>• Board-level signal processing and control features for self-diagnosis and self-learning<br>• Data analysis embedded on different levels for smarter devices including AI on sensor level<br>• Harvesters and storage devices<br>• Components enduring harsh environments<br>• Hardware solutions for security and privacy<br>• Machine learning and artificial intelligence High-perf. signal quality in harsh environmental<br>• Advanced/active cooling, thermal management<br>• EMI optimized boards and modules<br>• 3D board & module design and simulation | The global MEMS and sensor market (excluding RF filter modules) will almost double from $48B in 2018 to $93B in 2024 *(Yole Développement: Status of the MEMS Industry 2019, Market and Technology Report, 2019 edition.)* Provide the same annual growth rate the market should reach **$180B in 2030**, and **Europe shall have at least one third to one half of this market** and the same with other microsystems' markets. |
| | **Materials** for smart components, modules and systems | • Surface coatings for multi-functionality on the same base structures, including self-cleaning materials<br>• Protective housing and coating features (e.g. against aggressive environments)<br>• New/alternative organic and bio-compatible materials, housings and coating features (implants, ingestibles, wearables, biosensors)<br>• Non-fossil/recycled bioplastics, compostable/biodegradable materials<br>• Functional materials for printing, coating, potting, thermal forming, lamination, over/injection-molding<br>• High-efficiency photonic materials<br>• Materials for affordable infrared imaging<br>• New materials and features for sensing (metal nanowires, CNT, graphene, cellulose nanofibers, biocarbons, MOFs - Metal-Organic-Frameworks, nitrogen voids, e.g. in diamond, etc.)<br>• Topological insulators for low loss electronics<br>• Low quiescent/leakage power materials for sensors<br>• Metamaterials for sensors<br>• Materials for low power, fast responding gas sensors and occupancy sensors<br>• Non-toxic, scalable, high-density feature materials<br>• High performance materials for passives<br>• Transducer materials (e.g. CMOS compatible piezo, e.g. flexible solar panels) integratable into SiPs<br>• RF > 10 GHz: CMOS or GaN compatible thin film piezoelectric materials, materials for high efficiency acoustic transduction, conductive materials<br>• Rare earths replacement, e.g. for magnetics<br>• Functional materials for flexible/stretchable devices<br>• New thermal interface materials<br>• New substrate materials at the board level Replacement materials to comply with ROHS | |

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| | | • Recycling and repair Material properties database (simulation/reliability) | |
| | **Technologies, manufacturing and integration processes** of smart components, modules and systems | • Robust heterogeneous 3D integration of sensors, actuators, electronics, communication, RF FE components, energy supply, (including fluidics and photonics), integration of external matching networks<br>• Direct manufacturing and rapid prototyping technologies (additive manufacturing, etching, coating, 2D/3D additive technologies, lamination …)<br>• Use of flexible Si-substrates to form random bodies<br>• Submicron LAE processes (nanoimprinting, reverse offset printing, etc.)<br>• Additive transfer of heterogeneous components on various substrates (e.g. 3D additive manufacturing of ICs on top of PCBs)<br>• Chips, passives and components embedded in integration substrate<br>• Embedding of power sources (batteries, energy harvesting transducers, supercaps, etc.) in package (PwrSiP) & on chip (PwrSoC)<br>• Quantum sensors and associated integration<br>• Highly miniaturized engineering and computer technologies with biochemical processes<br>• Bio-mimicking (bio-hybrids, fluidics)<br>• Flexible and stretchable devices and substrates<br>• Photonic system integration based on silicon photonics (and other substrates), and hybrid integration to photonic systems, including RF, MEMS, sensors, etc.<br>• Structural electronics (in glass, plastics, laminates)<br>• Automation and customization ('towards I4.0') in component and module manufacturing<br>• Manufacturing & health monitoring tools (including tests, inspection and self-diagnosis)<br>• Testing tools for non-electrical properties<br>• Automated manufacturing equipment for flexible substrates (e.g. roll-to-roll manufacturing) | |
| | **Decarbonisation and disintegration** of smart components, modules and systems | • Designing and developing integration processes, allowing dismantling and material recycling (urban mining)<br>• Recycling technologies, second life and re-use approaches<br>• Design tools for optimized recycling and re-use strategies of materials<br>• Biodegradable materials (in some cases even required, e.g. in medical implants)<br>• System parts made of degradable or compostable materials (new environmentally friendly materials).<br>• Usage and health monitoring is required for repair, maintenance and even updating of systems to allow new business models based on servitization and pay-per-use schemes for consumer/capital goods<br>• Methods to determine the quality or "health" of the system or device, or its remaining lifetime for second life and re-use (life-cycle analysis (LCA), lifetime assessment, advanced diagnosis methodologies)<br>• Decarbonise transport and industry (electrification and use of CO2-neutral fuels, e.g. green Hydrogen) | |

| Value Chain Technologies: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***Embedded Software and beyond*** | Efficient Engineering of Embedded Software | • Model based software engineering<br>• Interface management<br>• Model inference<br>• Model based testing<br>• Safe and dependable software ecosystems<br>• Middleware controlling embedded hardware<br>• Programming languages for developing large-scale application for embedded systems<br>• Compilers and link to new hardware<br>• Software Architecture<br>• Added value of and Embedding AI in SW Architecture & Designs<br>• How to deal with open source<br>• Design for software evolution over time, cater for distinct phases | **Creating 100.000 new jobs by 2025 in Embedded Software and Beyond** by innovating embedded software technologies |
| | Continuous Integration and deployment of Embedded Software | • Continuous certification with automated testing<br>• E.g. Certification of safety critical software<br>• (Model based) Test automation,<br>• Enabling secure updates (DevOps)<br>• Continuous integration, verification and validation (with and without AI) | |
| | Life Cycle management of Embedded Software | • Software Legacy and Software rejuvenation<br>• Interplay between legacy SW and new development approaches<br>• Reduce re-release/ re-certification time<br>• Distinct core system versus apps<br>• Design for X (test, evolvability, diagnostics, adaptability etc.)<br>• Vulnerability of connected systems<br>• Continuous certification of updates in the field (reduce throughput time)<br>• Diagnostics of systems in the field<br>• End of life and evolving off-the-shelve/Opensource Hardware & Software | |
| | Embedding Data Analytics and Artificial Intelligence | • Predictive maintenance, third party servicing<br>• Premium logging and basic logging<br>• Big Data/AI to improve functionality | |
| | Green Deal and Embedded Software | • Computation power on embedded hardware<br>• Power/Energy consumption of embedded hardware | |
| | Embedding Reliability & Trust | • Reliable software on new hardware (multi-core systems, GPUs, and heterogeneous)<br>• Robustness against unexpected uses (Secure, safe, privacy aware)<br>• Security and privacy as a service<br>• Reliability by construction | |

| Value Chain Technologies: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***System of Systems (SoS)***<br><br>***System of Embedded and Cyber Physical Systems (SoE&PCS)*** | SoS architectures and associated tools | Design and architecting of SoS and high tech systems must include extra-functional aspects such as, among others, performance, evolvability, interoperability, maintainability, trustworthiness, sustainability. Design and architecting tools must evolve into multidisciplinary tools that can optimise for any combination of these extra-functional aspects, leveraging AI techniques to tackle these highly complex design time problems. The tools must be able to take all levels of abstraction into account, starting from the component level up to the full SoS level. | To support EU sovereignty, international leadership internal ecosystem regarding:<br>• Open, interoperable, trustworthy and robust SoS architectures and integration platforms capable of supporting a wide range of solutions in diverse field of applications.<br>• Provision of engineering tools supporting the complete and continuous engineering process of SoS in both design- and run-time.<br>• Addressing the SoS market growth opportunity. SoS locate in the market segment of the ECS value chain that is expected to growth tenfold by 2025. [See Advancy report] |
| | Open SoS platform technologies | Platform technology with key aspects on e.g information security management, SoS scalability, SoS engineering efficiency, SoS real time performance, SoS robust control, SoS QoS, SoS distributed intelligence. | |
| | SoS engineering | Engineering technology with key aspects on engineering methodologies, tools, tool chains, tool interoperability enabling implementation of SoS architectures using SoS platform technologies supporting the whole life cycle. | |
| | SoS composability: | The composition and/or integration of embedded and cyber-physical systems in SoS generates emergent properties and functionalities at SoS level that are characterised by an inherent uncertainty about the effect of the composition and/or integration. A certain level of trust guaranteed at subsystems level is not necessarily guaranteed at SoS level, and the same applies to many other aspects, including interoperability, scalability, availability, resilience to failures, etc. SoS architectures and platforms, in conjunction with the proper engineering support, should provide solutions to control this uncertainty and provide adequate countermeasures. | |
| | SoS interoperability: | Technology that enabling instant and seamless understanding of data/information exchanged within and between networked and distributed systems. | |

| Cross-Sectional Technologies: | Major challenges | High priority R&D&I areas | Expected achievements for Europe |
|---|---|---|---|
| ***Artificial Intelligence, Edge Computing & Advanced Control*** | ***Increasing the energy efficiency*** of computing systems, especially in the field of systems for Artificial Intelligence, edge computing and advanced control. | • Development of innovative hardware architectures or hardware/software architectures<br>  o on device (e.g. transistor) level,<br>  o on circuit level,<br>  o on appliance/device level,<br>  o on distributed systems level<br>• Promoting solutions based on:<br>  o Processing data where it is created, or where it is the most efficient<br>  ▪ Edge computing<br>  ▪ Distributed decision making<br>  o Hybrid architecture in embedded system<br>  o Embedded High Performance computing<br>  o High performance AI based architectures<br>  o AI on chip platform<br>• Taking carefully into consideration the various storage of data; act both on learning and inference parts for AI systems | Becoming one of the **top players in** the domain of efficient and trustworthy **advanced edge computing solutions** |
| | ***Managing the increasing complexity*** of systems | • Improving interoperability of systems<br>• Facilitating the easy addition of modules to a system<br>• Developing common interfaces and standards<br>• Using AI techniques to help complexity management | |
| | Supporting the ***increasing lifespan*** of devices and systems | • Developing HW/SW architectures and hardware that support software upgradability and extension of software useful life.<br>• Realizing self-X (adaptation, reconfiguration, …) for embedded systems<br>• Improving interoperability, modularity and complementarity between generations of devices<br>• Developing the concept of 2nd life for components | |
| | ***Increasing "trustworthiness"*** of computing systems, including ones using AI techniques | • Developing approaches to verify/certify/audit/trace computing systems<br>• Making systems correct by construction<br>  o Stable and robust by design<br>  o Predicable behaviour, including for systems using Deep Learning techniques<br>  o Real-time and predictable results<br>  o Mixed-criticality tasks on the same system<br>• Developing solutions for secure AI-based systems<br>• Promoting certified data-sets | |
| | Ensuring ***European sustainability*** in AI, edge computing and advanced control | • Leveraging open-source to help developing European advanced solutions:<br>  o Open source hardware<br>  o Open source software<br>  o Open source training data-sets | |

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| ***Connectivity*** | Strengthening EU connectivity technology portfolio in order to maintain leadership, secure sovereignty and offer an independent supply chain | • Strengthen EU differentiated technologies portfolio (GaN, RF SOI, BiCMOS, …) and packaging one in coordination with process and technology chapter<br>• Enable a European ecosystem able to support heterogeneous integration (multi die System in Package, advanced assembly capability, advanced substrate manufacturing ...) in order to ease the rise of new EU champion able to develop more complex connectivity system and capture higher value. | • Secure EU sovereignty on key connectivity technology required by key ECS application<br>• Secure EU connectivity business by ensuring an independent supply chain<br>• Capture higher value by being able to develop higher complexity connectivity system (leveraging EU differentiated core technologies)<br>• Maintain EU long term leadership on connectivity technology |
| | Investigate innovative connectivity technology (new spectrum or medium) and new approach to improve existing one in order to maintain EU long term leadership | • Evaluation of a new frequency band with a special focus on an unlicensed band > 200 GHz foreseen for 6G (for example, targeting the 250 GHz - 325 GHz range promoted by IEEE 802.13.c).<br>• Evaluation of new medium (RF/mmW signal propagation over plastic, single mode optical waveguide using laminated polymer platform …).<br>• Investigate the improvement that AI can bring to connectivity networks (efficiency, quality of service, …) | |
| | Autonomous interoperability translation for communication protocol, data encoding, security and information semantics | • Semantics interoperability.<br>• Autonomous translation of protocols, encodings, security and semantics.<br>• Evolvable SoS connectivity architectures and technologies over time and technology generations. | |
| | Architectures and reference implementations of interoperable, secure, scalable, smart and evolvable IoT and SoS connectivity | • SoS connectivity architecture as a *de facto* standard.<br>• Reference implementation of *de facto* SoS connectivity architectures.<br>• Engineering frameworks for *de facto* standard SoS connectivity architecture. | |

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|---|---|---|---|
| ***Architecture and Design: Methods and Tools*** | **Extending Development Processes and Frameworks** (to handle intelligent, autonomous, evolvable systems) | • Virtual Engineering of ECS System and Component Design (Methods and Tools)<br>• Lifecycle-aware holistic design flows<br>• Integration of new Verification and Validation methods & green processes | **a) Key enabling technology of all future high-quality ECS based applications**<br><br>The technologies developed here (architectures, methods and tools implementing them) are the **key enabler** for European Engineers **to build future ECS** (a) **at all** and (b) **with the desired qualities** (safety, security, reliability etc). As such, these technologies are essential for all the achievements enabled by those applications.<br><br>**b) Sovereignty of Europe in key Engineering capabilities**<br><br>Research in this area **ensures that key Engineering capabilities** in Embedded Systems Engineering, Systems Design and Integration, and Validation, Test and Certification **stay in Europe**, thus enabling European industries **to create and sustain jobs**, set **standards** and enable '**Quality made in Europe**' applications<br><br>c) **Competitiveness of European industries**<br><br>The existence of **cost-efficient processes** implemented and supported by **innovative development tools and frameworks** which guarantee high quality products typically **reduces development time and costs by 20%-50%** (as proven in previous projects like ENABLE-S3, Arrowhead-Tools, etc.)<br><br>d) **Sustainable Jobs in Europe**<br><br>Since these technologies are pre-requisites to **enable future ECS based applications**, they ensure sustainability of jobs and continued competitiveness of key European industries |
| | **Managing new functionality** in safe, secure, and trustable systems | • Modelling Techniques for new functionalities<br>• Design and V&V methods for ECS (incl. AI enabled systems) evolving during lifetime<br>• Ultra-low power design methods | |
| | **Managing complexity** | • Methods and tools to increase design efficiency<br>• Complexity reduction methods and tools for V&V and Test<br>• Methods for advanced Architectures | |
| | **Managing diversity** | • Multi-objective Design & Optimisation of Components and Systems<br>• Modelling, analysis, design and test methods for heterogeneous systems<br>• Automation of analogue and Integration of analogue and digital design methods<br>• Connecting the virtual and physical world of mixed disciplines in real environments<br>• Efficient modelling analysis and test, considering properties, physical effects and constraints | |

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| ***Quality, Reliability, Safety & Cybersecurity (QRS&C)*** | Quality & reliability | • **Quality** - in-situ & 'real time' assessments: Inline inspection and highly accelerated testing methods for quality and reliability monitoring during production of ECS with ever increasing complexity and heterogeneity for demanding applications ⇒ Yield improvement<br>• **Reliability** - Reality (to Model): Continuous improvement of physics of failure based methodologies combined with new data driven approaches: tests, analyses, degradation & lifetime models (incl. their possible reconfiguration)<br>• **Design for (EoL) Reliability** - (Model to) Reality: Approaches for exchanging digital twin models along the supply chain while protecting sensitive partner IP and adaptation of novel standard reliability procedures across supply chain<br>• **Prognostics Health Management**: Self-monitoring, self-assessment, and resilience concepts for automated and autonomous systems based on the merger of PoF, data science, and machine learning for safe failure prevention by timely predictive maintenance | Metamodeling (incl. AI/ML based models) will allow reaching **accuracy** level of **digital twin** up to **80%**.<br>Identification of field related failure modes based on condition monitoring of will reduce **development costs by 30%**<br>Prognostics, health management and predictive maintenance will reduce costs of **unpredicted downtime** by **50%**.<br>Safe and reliable communication systems will pave a way of life-saving actions performed over long distances<br>In 2030, citizens will have to remember 90% fewer passwords and other credentials in their everyday lives with secure systems.<br>The establishment of transparent systems for processing of personal data will pave the way for ensuring that individuals do not have to worry about their privacy.<br>In 2030, 90% of European citizens will feel comfortable when dealing with AI decisions thanks to explainable AI systems.<br>In emergencies, such as COVID19 or the Notre-Dame fire, the use of autonomous systems (drones, robots) can help humans. These systems will be human's understandable, resilient to cyberattacks and to errors - thus increasing confidence on their adoption |
| | Secure & Safe Connectivity | • IoT Device Security, Safety, Trustability<br>• Communication Protocols Security, Safety, Trustability<br>• Infrastructure Security, Safety, Trustability | |
| | Safety & Cybersecurity | • Safety and Cybersecurity of AI System, included human embedded chip implants for loss functionality<br>• Modular (pre-)Certification of AI systems<br>• Find solution that ensures Safety and Cybersecurity with a greater green impact<br>• End-to-End trust | |
| | Privacy & Human Interaction | • Privacy-by-design, to ensure both the AI development (which requires data) and the guarantee of RGPD<br>• Design human interaction for acceptable and trusted operations<br>• Designing predictable behavior for human understandability in nominal and non-nominal operations, especially for AI applications | |