MARKETS, OBJECTIVES, CHALLENGES AND REQUIRED ACHIEVEMENTS FOR THE EUROPEAN DIGITAL AGE

Electronic Components and Systems

A DOCUMENT FOR DECISION MAKERS
WITH A SYNOPSIS OF THE ECS-SRIA

PREPARED ON BEHALF OF:

CONTENTS


E
C
S

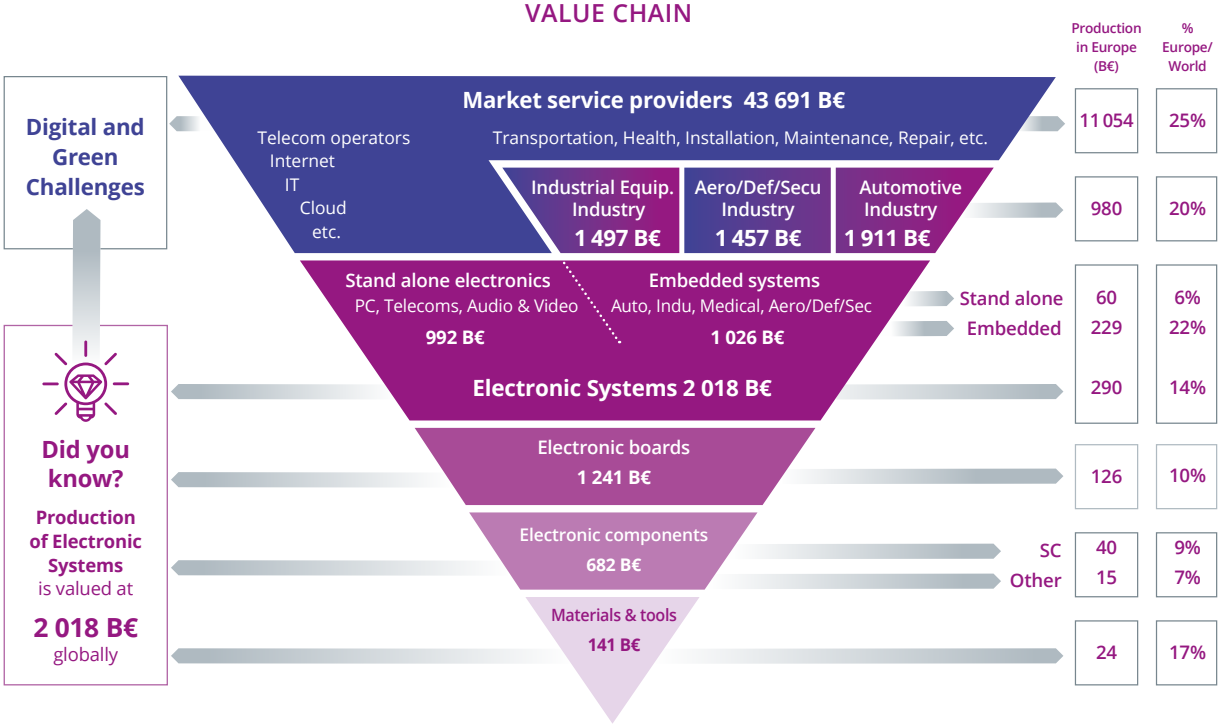
1. THE EVER-GROWING NECESSITY TO RELY ON ELECTRONIC COMPONENTS AND SYSTEMS (ECS)

TO FACE TOMORROW'S CHALLENGES AND BUILD A GREEN, DIGITAL, COMPETITIVE AND AUTONOMOUS EUROPE

Europe faces unprecedented challenges ranging from climate change to global competition for technological leadership, requiring new and, above all, joint investment strategies to build the green, digital, competitive and autonomous Europe of tomorrow. To meet these challenges, Europe must provide the key technologies that underpin the green and digital transformation of all sectors of the economy and society.

Today, Electronic Components and Systems (ECS) – integrated circuits, sensors/actuators, embedded and cyber physical systems, software, … – are in increasing values and numbers in almost all products and services. The continuous improvements in terms of performance, connectivity, reliability and miniaturisation generated by key digital technologies enable ever-more complex functionalities to be embedded into electronic products, paving the way to the cutting-edge solutions for 5G/6G communications, edge computing and artificial intelligence that are necessary to build a modern digital world and sustain the European competitiveness.

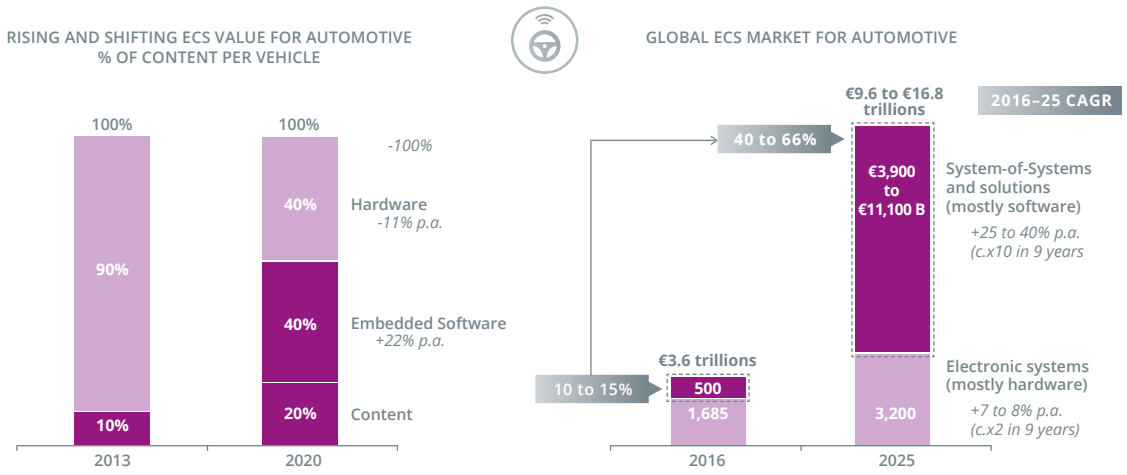
WORLD ELECTRONIC COMPONENTS AND SYSTEMS (ECS) VALUE CHAIN



World Electronic Components and Systems (ECS) Value Chain (Source: DECISION Etudes & Conseil, Data for 2018)

F.1

AN EXAMPLE OF RISING CONTENT OF ECS IN AN APPLICATION DOMAIN



F.2 *An example of rising content of ECS in an application domain (Source: Study on Embedded Intelligence: Trends and Challenges / ARTEMIS-IA, 2019 [Advancy])*[1]

Electronic and digital content in automotive, industrial, energy, agricultural and medical applications is also booming, becoming the backbone of all value chains, and offering solutions to many of the basic needs of European citizens, from transport and smart mobility to health & well-being and smart energy grids, and playing an increasing role in almost everybody's life in the digital age.

The ECS domain is valued at €2,018 billion and brings embedded intelligence to almost €5,000 billion of industrial equipment, aero-defence systems, security and automotive. ECS also generate around €44 trillion of associated services, essentially through digital services (see *Figure F.1)*.

Therefore, almost 75% of the world GDP (worth € 72.7 trillion in 2018[2]) is built on ECS, demonstrating the rising and crucial importance for the strategic autonomy of Europe to master the key elements of this value chain. ECS also accounts for major shares of global employment in Europe, as well as major Research, Development and Innovation (R&D&I) activities.

The ECS value chain, starting from materials and semiconductor equipment for the development and manufacturing of the nano-microelectronics technologies adopted in electronic devices, modules and smart systems, requires capital intensive production facilities for hardware and systems integration as well as development of sophisticated software for systems and System of Systems. Moreover, there are many sub value-chains that cover an enormous number of partial technologies and specific applications in which break-throughs are foreseen.

↑

1 *https://artemis-ia.eu/publication/download/embedded-intelligence-trends-challenges.pdf*

←

2 *See p. 66 of https://ec.europa.eu/eurostat/documents/3217494/10934584/KS-EX-20-001-EN-N.pdf/8ac3b640-0c7e-65e2-9f79-d03f00169e17*

In the future, the trends of digitalisation and autonomy will lead to further growth of ECS content in almost all products. As can be seen in *Figure F.2* on the example of mobility, the global ECS market for automotive will grow significantly and especially in the area of System of Systems solutions.

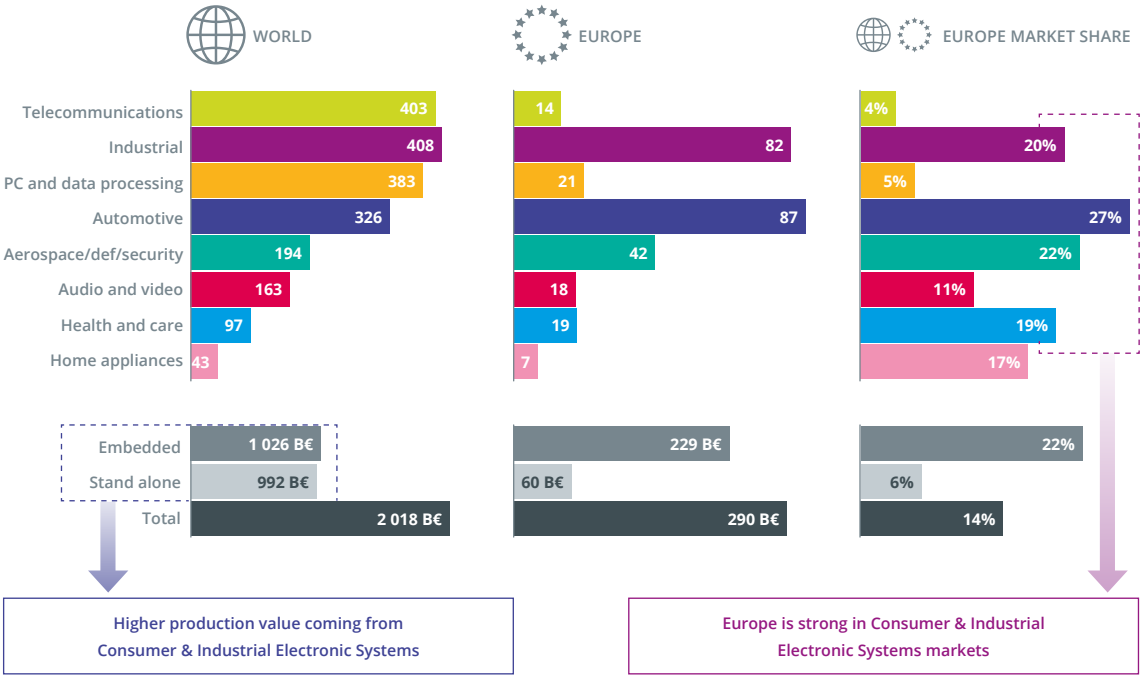
The rise of embedded intelligence in the automotive sector mandatory for autonomous cars will request further ECS innovations stemming from both hardware and especially software developments. It also makes the automotive ECS value chain evolve towards more complexity as value is shifting downstream.

This trend of rising ECS content applies to numerous vertical applications like digital industry, robotics, energy, agriculture, health and well-being, aerospace, defence and security, etc. and transforms the structure of the world ECS market.

With a global output of more than €1,000 billion, electronic systems for consumer and industrial applications have overtaken, in production value, the amount dedicated to the traditional stand-alone electronic goods encompassing smartphones, PCs, TVs, etc. as shown in *Figure F.3* below.

WORLD AND EUROPE PRODUCTION OF ELECTRONIC SYSTEMS BY APPLICATION DOMAIN

(IN €B)

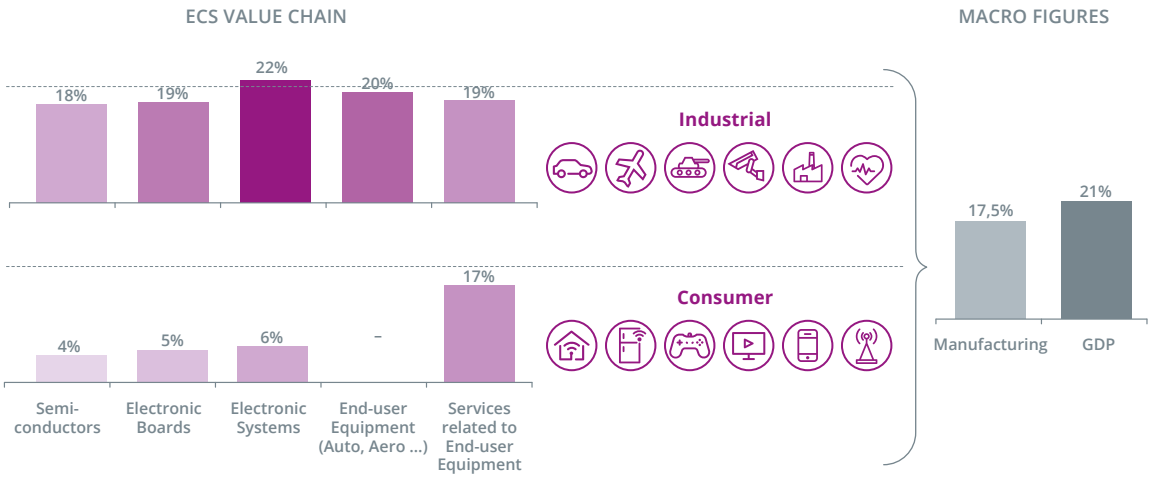


World and Europe production of Electronic Systems by application domain (Source: Study on Emerging Technologies in Electronic Components and Systems – Opportunities Ahead / DG CONNECT, 2019–2020, (DECISION Etudes & Conseil, with data for year 2018)

F.3

The following figure (*Figure F.4*) outlines that Europe is well-positioned to continue to address the fast-growing consumer and industrial ECS markets at all the levels of its value chain. It also shows the weaknesses of Europe in terms of ecosystem position to address consumer/industrial applications like ECS for telecommunications or data processing.

EUROPEAN SHARE OF WORLD PRODUCTION AT EACH LEVEL OF THE ECS VALUE CHAIN



F.4 *European share of World production at each level of the ECS value chain (Source: Study on Emerging Technologies in Electronic Components and Systems – Opportunities Ahead / DG CONNECT, 2019-2020, [DECISION Etudes & Conseil, with data for year 2018])*

However, even if Europe currently plays a significant role at numerous levels of these value chains, European positioning is jeopardized by other nations which are investing massively and strategically in ECS R&D&I and manufacturing in ECS.

Did you know?

- **China** is investing **$100 billion** in its Made in China 2025 plan targeting **AI and Smart manufacturing**[3]
- **US** have **40% more public investment in digital technologies** compared to Europe[4]
- **75% of the world's semiconductor manufacturing** capacity is concentrated in **East Asia** in 2020[5]
- The US Semiconductor Industry Association (SIA) is promoting the expansion of current US government incentives with a new **target of between $20 billion and $50 billion** over the next ten years to reestablish the **US as an attractive location for advanced semiconductor manufacturing** and to be in line with those offered by Taiwan or South Korea

Europe's competitors have identified ECS technologies enabling smart manufacturing or technologies present all along the ECS value chain like AI, as being of strategic nature to keep control of their sovereignty, preserve their competitiveness and benefit from tomorrow's growth. The following SWOT matrix summarizes the opportunities, weaknesses, strengths and threats that the European ECS ecosystem will have to face in the current decade.

STRENGTHS

- Whole **ECS value chain well positioned to address consumer and industrial ECS** markets (mobility, industry, energy, medical etc.) necessary to build a competitive and green European society.
- **Strong R&D ecosystem based on private high-tech and research-intensive centres** (from SMEs to large companies) and **world-class public centres**, RTOs and universities with collaborative skills.
- **Strengths in key emerging technologies**, especially in **security** (cryptography, hardware-based security or blockchain), **sensing and edge computing** (smart sensors, MEMS, IoT communication), etc.
- **Unique position** of European semiconductor manufacturing equipment and materials companies.

WEAKNESSES

- **No strong industrial base** to manufacture **advanced semiconductors** (e.g. AI or neuromorphic chips).
- Very **few market leaders for new IT technology** such as the FAANG[6] **driving technologies, the demand and the investments in the cloud, big data and AI.**
- **Weak industrial positions in the ECS dedicated to key emerging technologies** such as HPC, quantum computing, etc.

OPPORTUNITIES

- **Consumer and Industrial ECS markets are the fastest growing ECS markets.**
- **New energy paradigm** with ambitious but necessary goals to target the Green Deal's objective, which **cannot be achieved without ECS technologies.**
- **New cybersecurity paradigm** to build the trustworthy **European society of tomorrow.**

THREATS

- The EU is **not the only player to be well positioned in consumer/industrial ECS:** the US and China are already better positioned in many sub-segments.
- **Massive investments from foreign countries in the ECS value chain at all levels**: semiconductor manufacturing capacities, artificial intelligence, quantum computing, 6G communications, etc. is increasing the competition and Europe risks lagging behind.
- **Over reliance of the European ECS value chain on foreign technologies** could expose the EU to **supply chain disruptions and cyberattacks.**

←

3 Made in China 2025

4 Horizon Europe Next-Generation European Partnerships (DG for Research & Innovation, European Commission)

5 Government Incentives and US Competitiveness in Semiconductor Manufacturing (SIA / BCG September 2020)

↑

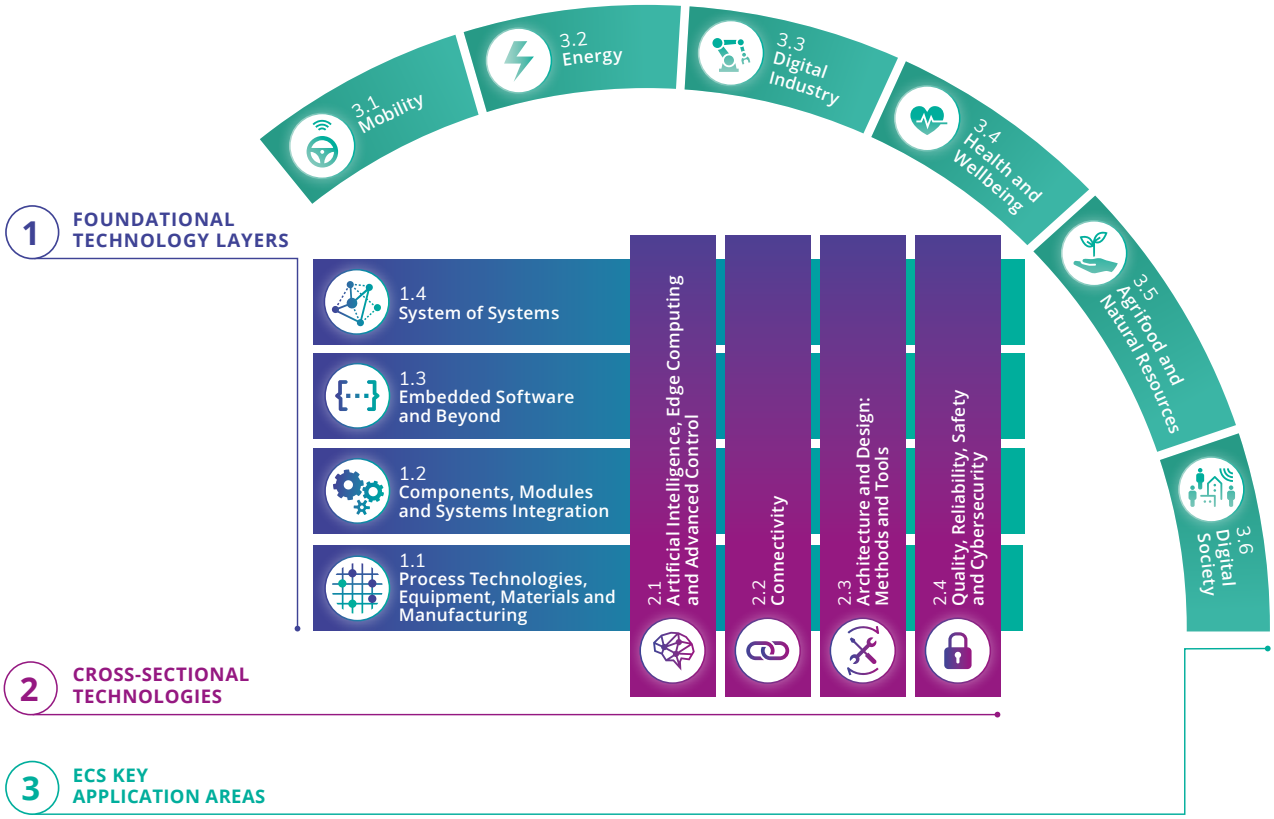
6 FAANG: Facebook, Apple, Amazon, Netflix and Google

2. THE ECS SRIA: VECTOR OF INNOVATION FOR EUROPEAN KEY DIGITAL TECHNOLOGIES

Representing the largest part of the European ECS R&D&I community with its industrial and scientific members, the three associations AENEAS on Micro and Nano-electronics, ARTEMIS-IA on Embedded Intelligent Systems and EPoSS on Smart Systems Integration, have joined forces to federate the actors in the field and to combine their Strategic Research Agenda's into one common ECS Strategic Research and Innovation Agenda (SRIA).

2.1. Strategic Research Innovation Agenda's purpose

Recently, the European Commission has coined the term Key Digital Technologies (KDT) to express that ECS is the fundament on which many other digital technologies are functioning, like Internet of Things, Artificial Intelligence, Edge Computing, etc. The ECS SRIA 2021 is a document that looks ten years ahead, giving direction not only to the new KDT JU, but also to longer-term R&D&I activities on ECS in Horizon Europe, as well as to EUREKA clusters such as PENTA, EURIPIDES and their potential successors. This SRIA is updated every year, giving an overview of the vision, challenges and technological options for solutions to improve Europe's current position and strengthen it in the years to come. It will serve as the basis for the specific KDT SRIA 2021.



F.5 *SRIA 2021 Overall structure: from technologies to key application areas (Source: ECS–SRIA 2021)*[7]

This ECS SRIA covers in three chapters all key digital technologies, describing in *Chapter 1* the **Foundational Technology Layers**, in *Chapter 2* the **Cross-sectional Technologies** focusing on transversal areas of ECS scientific research and engineering, and in *Chapter 3* the **ECS Key Application Areas**.

The innovations generated by these interdisciplinary Cross-sectional Technologies further fertilise the Foundational Layers, creating the virtuous cycle that is necessary to amplify the effects of innovation and injects them into the ECS Key Application Areas.

Finally, in a Long Term chapter, the community's vision of ECS developments beyond the time horizon of the ECS SRIA is given.

7 The ECS SRIA identifies many different challenges, emerging from the analysis of the foundational technology layers, the cross-sectional technologies and their key application areas. The challenges are frequently interdependent, influencing each other, becoming more demanding, and impactful on several aspects, including technology innovation, industrial competitiveness, security, safety, business and environmental sustainability.

2.2. ECS Main objectives

In this ECS-SRIA, all major challenges identified by the experts were analysed and classified depending on their impact on the following main common objectives that are aligned with the European Commission's strategic priorities[8]:

8 https://ec.europa.eu/info/strategy/priorities-2019-2024_en

ECS-SRIA'S OBJECTIVES INTERTWINED WITH EC'S STRATEGIC PRIORITIES

1. **Boost industrial competitiveness** through interdisciplinary technology innovations
2. **Ensure EU strategic autonomy** through secure, safe and reliable ECS supporting key European application domains
3. **Establish and strengthen sustainable and resilient ECS value chains** to support the objectives of the European Green Deal and for a more solid European economy.
4. **Unleash the full potential** of intelligent and autonomous ECS-based systems for Europe's Digital Age

Main objective 1: Boost industrial competitiveness through interdisciplinary technology innovations

ECS, by their inherent nature, are the result of interdisciplinary research and engineering, which require:

The foundational technology layers for digitalisation:

- Process technologies, equipment, materials and manufacturing
- Components, modules and systems integration
- Embedded software and beyond
- System of Systems

Cross-sectional technologies like:

- Artificial Intelligence, edge computing and advanced control
- Connectivity
- Architecture and design, methods and tools
- Quality, reliability, safety and cybersecurity, etc.

ECS technologies are turning each digital good and equipment into an intelligent cyber-physical system, thereby driving new market needs. Embedded platforms for automotive (electric mobility, autonomous driving, etc.), digital industry (Industry 4.0, IoT for agriculture, etc.), health and well-being (medtech for connected patients, etc.) will need to rely extensively and increasingly on ECS technologies.

These trends compel ECS research to be interdisciplinary to benefit from the multiple available sources of innovation as well as to be research intensive and market-oriented to create the next ECS innovations that will be of strategic value for Europe. The aim here is to boost the industrial competitiveness of all its value chains by building:

- a strong industrial base;
- a market-winning downstream ecosystem essential for European strategic autonomy.

Main objective 2: Ensure EU strategic autonomy through secure, safe and reliable ECS supporting key European application domains

Strategic autonomy is about Europe able to:

- Fulfil its own digital technology needs in a way that reflects its interests and values.
- Improve the resilience of its critical infrastructure and ICT systems.
- Shape international rules, norms, and standards.

European sovereignty needs to rely on trustworthy solutions based on innovative ECS technologies focused on security, safety, reliability, dependability and privacy.

ECS should:

- Facilitate the implementation of the European Strategy for Data[9]; Ensure security, privacy-by-design and strategic autonomy all along the industrial and digital value chains.
- Enable the design and development of secure, safe, reliable, dependable, privacy-compliant electronic components and systems.
- Generate new requirements, which will push the development of new technologies.

←

9 *https://ec.europa.eu/digital-single-market/en/policies/building-european-data-economy*

→

10 *Rethinking Strategic Autonomy in the Digital Age (EPSC – July 2019)*

11 *https://www.digitaleurope.org/resources/digital-contribution-to-delivering-long-term-climate-goals*

12 *Proposal for the European Partnership for Key Digital Technologies under Horizon Europe*

Did you know?

- **The US CLOUD Act gives legal access to data stored on US cloud providers, and similar legislations exist in China[10]. While we are investing in European cloud platforms that are still in an early stage of development, Google, Amazon and Microsoft have already built several large data centers in Europe offering cloud services.**

Threats to Europe's strategic autonomy are found first of all in the microelectronics value chain, and then downstream in the component user segments of the electronics industry. In this context, the challenges identified by the ECS SRIA will help to develop innovations in secure, safe and reliable ECS technologies for creating EU-based/made solutions in the different economic sectors.

Secure, safe and reliable ECS based on European technology and combined with European AI solutions are critical to secure global leadership and autonomy in key areas such as ICT and ensure compatibility with EU values.

Digital autonomy also links to taking a confident yet justified position with respect to the US and China. Building on our strengths creates a negotiating position (or strategic control point) with other continents that cannot be ignored.

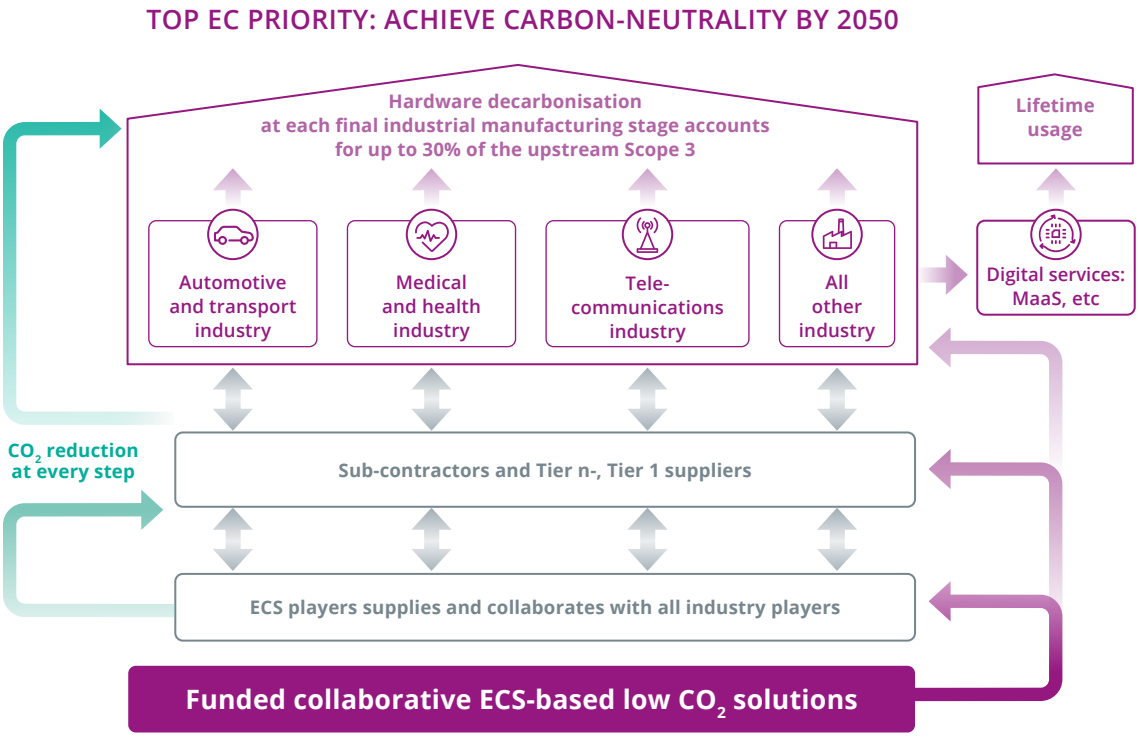
Main objective 3: Establish and strengthen sustainable and resilient ECS value chains supporting the Green Deal and for a more solid European economy

To reach the top-priority goal to be climate-neutral in 2050, Europe needs to step up its transition. This challenge must be perceived as an opportunity to create a new environment for boosting modern aspects of industry in terms of business models by:

- Relying extensively on ECS-based technologies and digitalisation as key factors for lowering the energy footprint at all the levels of the economy and by placing sustainability at the core of the link between the digital and the green transitions.
- Positioning the European players in hardware as front runners in sustainability to secure a wider market where they will set the world standard by taking into account the circular economy, a new market positioning (by turning small market shares into specialization areas), global manufacturing environmental impact, etc.
- Establish a carbon-neutrality challenge based on the deep link between the digital and the green transitions at the core of future funded collaborative research and innovation in ECS. This challenge will have a positive impact at each step of the value chains and will help to achieve carbon neutrality down to the final application / digital service.

Did you know?

- **Digital technologies have the potential to enable a 20% reduction of global CO_2 emissions by 2030[11]**
- **Digital innovation in ECS for mobility have the goal to achieve a 37.5% reduction of CO_2 emissions by 2030 vs. 2021[12]**
- **Innovations on process technologies in ECS manufacturing will enable energy consumption for ICT reduced to 1% of the level of 2020[12] in ten years.**



F.6 *Top EC Priority: Achieve carbon-neutrality by 2050 (Source: ECS–SRIA 2021)*

Main objective 4: Unleash the full potential of intelligent and autonomous ECS-based systems for Europe's Digital Age

ECS must be provided with a certain level of intelligence and autonomy to control their complexity more efficiently and more cost-effectively, to provide novel advanced functionalities and services, improve the human involvement in every kind of processes (operational, organizational, optimise the efficiency of vertical applications, etc.

Intelligence and autonomy are also required by the role of ECS in the application domains and represent an important factor for the sustainability and resilience of the value chains.

For example, an ECS-based system providing intelligent energy management, relying on technologies like AI, should strengthen the global competitiveness of European companies and help to achieve the EU Green Deal's objectives as this:

- Represents a key building block, for example for smart home and energy applications and improves the resilience by ensuring optimal energy consumption in critical conditions.
- Contributes to the sustainability of the value chain associated to the vertical application by reducing operational costs, environmental impact and improving the Quality of Service (QoS), the Return On Investment (ROI), etc.

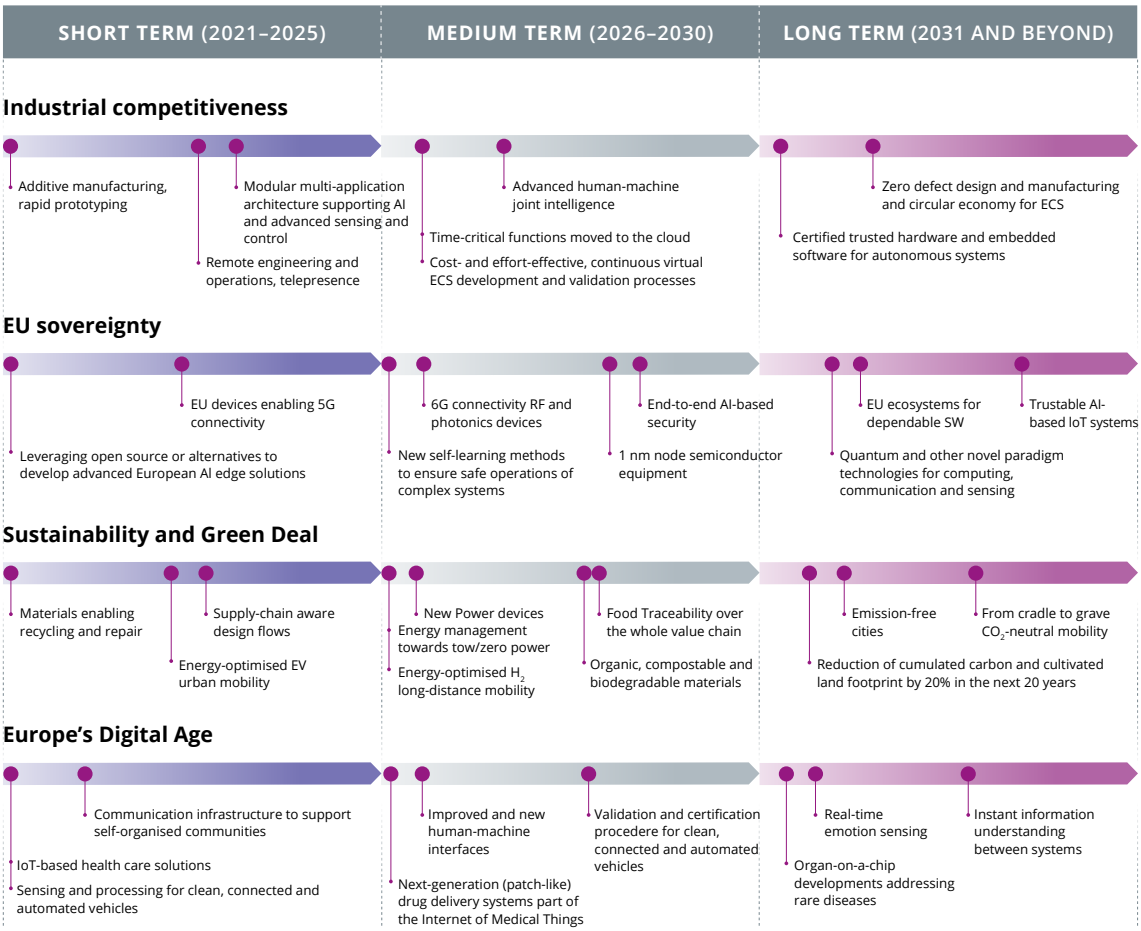
As seen previously, modern digitalisation systems are becoming more complex and heterogeneous. Therefore, ECS-based future products cannot be developed without the appropriate engineering support across the entire lifecycle. This includes phases of requirements analysis, design, development, deployment/commissioning, operation/management, remote maintenance, repair and overhaul, retirement/recycling and evolution.

Engineering support represents a key factor for achieving the previous four main objectives as it will:

- Impact industrial competitiveness by simplifying lifecycle management and making the engineering process more cost-effective and agile.
- Simplify and improve native development of trustworthy ECS technologies, products and applications.
- Support sustainability and resilience by reducing lifecycle management costs, as well as ensuring automation and continuity of operations.
- Unleash the full potential of intelligent and autonomous ECS that require completely new approaches to engineering, new design and development methodologies, as well as new toolchains and tools.
- Enable professional training and education of new and specific skills.

2.3. European ECS Roadmap

The ECS SRIA 2021 lists a number of milestones to be reached in the short (2021–2025), medium (2026–2030) and long (2031 and beyond) terms via collaborative research projects across Europe, reflecting the ambition of the ECS industry towards the achievement of the four objectives identified above. The following diagram positions some of the most salient of these milestones onto the European ECS roadmap[13].



F.7 *Milestone list of ECS-SRIA 2021 via collaborative research projects across Europe (Source: ECS–SRIA 2021)*

↑

13 *The reader is invited to refer to the SRIA for more detailed timelines including additional milestones.*

3. CONCLUSION: CHALLENGES ARE AHEAD BUT OPPORTUNITIES TOO

Electronic Components and Systems (ECS) are the key technologies to enable and master modern digital societies. To reinforce Europe's competitiveness, improve its resilience as well as master the digital and green challenges of the next three decades, strengthening the ECS value chains in Europe will be mandatory. In this fast-changing digital age, Europe must rely on ECS technologies that transform today's digitalisation challenges into tomorrow's opportunities.

To reach these goals, **a concerted approach between countries will be needed all along the ECS value chains: think, propose, and act together to make a strategic difference.** Based on the development of a larger and more holistic vision as explained in this document, Europe will need to deploy a set of complementary programmes supporting the efforts of our European ECS community, for the next decade and beyond. This means more coherence for a truly global European digital strategy in key application domains.

As a source of constant innovations, increasing added-value, and solutions to reduce CO_2 emissions, and by embracing cross-sectional technologies like Artificial Intelligence or high-speed connectivity, ECS are becoming the backbone of all value chains.

Not only more investment but also closer collaboration will be needed for Europe to achieve the described goals to stay competitive and to strengthen the European ECS value chain in the coming years. To remain in this technological and market race, Europe needs to rely on:

01. A COLLABORATIVE APPROACH THAT HELPS TO ACCELERATE INNOVATION

Increased support to pre-competitive cooperation in R&D&I based on EU-wide collaboration and coordination given the complexity and variety of technologies to involve.

02. A RESEARCH AND INNOVATION AGENDA DEDICATED TO ENSURE THE RIGHT SKILLS AND THE RIGHT SOLUTIONS FOR WINNING MARKETS

A sound / competitive / executable R&D&I agenda for ECS technologies, in order to strengthen the competitiveness of Europe plus contribute to re-skilling and up-skilling the jobs related to the new technologies and not to lose out in the global competition in this important area.

03. AN OPTIMISED AND MULTIPLYING EFFECT OF PUBLIC-PRIVATE FUNDING OPPORTUNITIES

- Public-Private partnership on Key Digital Technologies, including continuation of lighthouse initiatives (Industry 4.E, Health4.E, etc.).
- Eureka cluster programmes in the field of ECS.
- Investments in Important Projects of Common European Interest (IPCEIs) to close the gap between Europe and other regions in tomorrow's ECS key technologies necessary to maintain Europe's autonomy.
- Improved testing and experimentation with initiatives such as TEFs.

- Optimised funding schemes in research and innovation to have efficient investment by combining efforts in the interdisciplinary programmes (Common KDT calls with e.g. IHI in the medical domain, 2ZERO in the mobility sector, etc.).

04. STRATEGIC AUTONOMY AND SECURITY

ECS are essential for the digital transition and represent a fundamental asset to ensure European strategic advantage in the digital age. But ECS need to be built by resilient and secure ECS value chains, following European security standards and European values. Trustworthy ECS require investments and innovation in digital, physical, environmental security, information protection, supply chain resilience, new business models, ...

05. THE DIGITAL CONTRIBUTING TO THE GREEN DEAL

Establish the deep link between the digital and the green transitions at the core of future funded collaborative research and innovation in ECS, in order to have a positive impact at each step of the value chains to reach Europe's over-arching goal of carbon-neutrality by 2050.

Europe can show numerous assets to play a leading role in the global ECS market and the future digital world, providing however that Europe can:

- Bring about potential capacities along the production value chain.
- Combine all resources of higher education, research, development and production.
- Obtain clear commitments and support from the public authorities in order to obtain a level playing field by complementing the investments made by the private sectors.

Authors

Jean-Luc di Paola-Galloni, *Valeo*

Caroline Bedran, *AENEAS*

Jan Lohstroh, *ARTEMIS-IA*

Wolfgang Gessner, *EPoSS e. V.*

Fabrice Graignic, *STMicroelectronics*

Paolo Azzoni, *EUROTECH*

Elisabeth Steimetz, *VDI/VDE-IT*

Patrick Cogez, *AENEAS*

Jan van den Biesen, *Europolaris*

Imprint

Graphic design / Layout
Juliane Lenz – Berlin, Germany

Editing
Olivier Coulon (DECISION Etudes & Conseil) – Paris, France

March 2021
ecscollaborationtool.eu