Digital Directions, Greener Connections:

An Industrial Policy Report on European Electronics Manufacturing

April 2021

DECISION ETUDES & CONSEIL

IPC

BUILD ELECTRONICS BETTER

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In support of its mission, IPC works collaboratively with the electronics industry to develop technical standards and workforce credentialing programs, in addition to a policy agenda that aims to cultivate a favourable environment manufacturing, research and development and environmental stewardship.

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FOREWORD

Today, electronics are everywhere–from our personal devices to our electric cars, from industrial robots to spacecraft. Electronics, in fact, are foundational to almost all modern technology, and as such, electronics manufacturing is crucial to a region's economic competitiveness, industrial resiliency, and technological innovation.

However, despite the importance of electronics manufacturing to all other sectors of the economy, it is rarely considered as an independent vertical industry. Electronics manufacturers tend to be viewed in the context of the industries they support: automotive, aerospace, industrial, and medical, to name just a few. So, when IPC first commissioned this report from DECISION, we sought to quantify and highlight the importance of electronics manufacturing in Europe, with a goal of drawing greater attention to the opportunities and challenges the industry faces in today's highly competitive global marketplace.

In the course of producing this report, the COVID-19 pandemic emerged and reshaped, in part, its purpose. The pandemic has served as a wake-up call for European policymakers as well as for European Industry by exposing vulnerabilities in European and global supply chains. These vulnerabilities, which developed over many years, need to be addressed to achieve the resiliency and "open strategic autonomy" the European Union has set as a goal. This report includes some key recommendations to this end.

As we await further elaborations as to the ecosystem approach proposed by the European Commission we note the intricacies of the electronics manufacturing ecosystem. That ecosystem must be robust to support economic growth across the entire European economy, including those sectors most closely associated with future innovation, such as renewable energy, quantum computing, artificial intelligence, robotics, and 5G. Electronics manufacturing can be a driver for Europe's competitiveness in these areas and can further important policy goals, including those related to the green and digital transitions.

Europe's transition and economic and technological leadership, however, will hinge on policymakers thinking holistically about the electronics industry to better support its constituent segments through new and existing mechanisms, including Industrial Alliances, future Important Projects of Common European Interest (IPCEIs), and Recovery and Resilience Funds. Investments should be focused on helping companies become factories of the future, the term IPC uses to describe the full suite of standards, technologies, processes, and skilled people that businesses will leverage to create smart, connected, highly efficient manufacturing environments.

The factory of the future is upon us, and the time for Europe to invest in a robust electronics manufacturing ecosystem is now. This report authored by one of Europe's premier economic research firms helps illuminate the path forward for a greener, more digital and resilient European Industry.

IPC and the European electronics manufacturers it represents stand ready to support policymakers in seizing the opportunities.

John Mitchell
President & CEO
IPC

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EXECUTIVE SUMMARY

The global electronics industry has changed dramatically over the last fifty years. The industry has grown 8% annually while annual GDP growth has averaged only 3%. But the most impressive gains have been technological in nature. Just as quickly as the industry ushered in an era of mechanical and analogue electronics, it moved the world into a digital age. Semiconductor chips increasing in power and decreasing in size made much of this change possible, but not without the groundbreaking developments in electronics manufacturing. In the 1960s, for example, a calculator had about 30 transistors. Today's smartphones often have billions of transistors, and they all need to fit and interconnect on ever smaller Printed Circuit Boards (PCBs).

North American and European companies were once clear market leaders in electronics manufacturing, but today fierce competition from Asia and elsewhere has forced them to increasingly specialize in higher value, lower volume goods to remain competitive in the global marketplace. This shift has led Europe to focus on «embedded and professional systems» (hereinafter referred to in the report as «embedded systems»), that is electronic systems embedded into automotives, diverse industrial equipment, aerospace/defense/security equipments, telecommunication infrastructures, and health & care equipments. The vast majority of these end-user segments are professional, and as a consequence, professional PCs (servers), are also considered in this category. Embedded systems are opposed to "stand-alone systems", traditionally corresponding to consumer electronics (phones, consumer PCs, consumer audio & video systems and home appliances).

But in ceding to Asia the high volume, low mix manufacturing associated with consumer products, European electronics manufacturers have seen an overall decline in market share and profitability. Today, the EU accounts for around 5% of overall global production of PCBs and 10% of the Electronics Manufacturing Services (EMS) production. In addition, the European ecosystem of these two industries is composed almost exclusively of Small and Medium-sized Enterprises (SME).

The good news is that manufacturing for embedded systems is a growth market as electronics become integral to the workings of just about everything -from an Airbus A350 to 5G infrastructures to the factories that make both. Given Europe's global leadership in key market segments, like clean, connected and autonomous mobility, industrial Internet of Things (IoT) and Industry 4.0, cybersecurity solutions and 5G-6G, it increasingly makes sense to locate related manufacturing in close proximity. These markets have specific production needs that can make interaction between customer and supplier ideal, if not necessary. Global supply chain volatility related to trade wars, health crises and natural disasters underscore the importance of resilient, regional supply chains.

Key to maintaining European leadership in the digital technologies and sectors that underpin Europe's industrial future which are enabled by electronics is appreciating that the industry constitutes an ecosystem.Like any ecosystem, weakness in one area can undermine the health of the entire ecosystem and the entities that comprise it.

The European Union and Member States have allocated billions of euros to support the semiconductor and broader microelectronics industries. And yet, advances in electronics will also rely on innovation in PCB and assembly—advancements that lag for lack of investment. The thin margins associated with electronics manufacturers make it difficult for many companies to invest in Research & Development (R&D), and governments outside Asia have historically not prioritized electronics manufacturing. In this context, support is needed for PCB and EMS in order to enhance the ecosystem as a whole.

As the European Union seeks to implement an ambitious agenda related to environmental sustainability and industrial resiliency and competitiveness, government leaders have a ripe opportunity to enact policies now that further the twin goals, while also positioning electronics companies for success in the cut-throat global market.

1. To achieve a successful digital and green transition, the EU should capitalize on its industrial strengths in embedded electronic systems:

- Automotive electronics for clean, connected and autonomous vehicles
- Industrial & robotics electronics for Internet of Things and Industry 4.0
- Electronics enabling smart health
- Electronics enabling cybersecurity applications
- Electronics enabling smart home

2. Consider the electronics ecosystem as a whole and invest in neglected parts of the value chain.

Thankfully, there is a growing awareness of the central role of the electronics industry for Europe's dual transition and the open strategic autonomy of the EU. Beyond and supporting microelectronics, Electronic Manufacturing Services (EMS) and Printed Circuit Boards (PCB) manufacturers play a crucial role.

3. Support investments in Industry 4.0.

Above all, EU and national policies will need to provide support to companies that are investing in the future through acquisition of equipment and processes associated with factories of the future. Such facilities will rely on digital transformation, modernization of operations, greater automation, better skilled employees, and higher productivity to support industrial strength and a circular economy.

4. Combine strategic autonomy and trade openness

As a multi-layered industrial ecosystem, the electronics manufacturing sector traditionally relies on sophisticated global value chains through which services, raw materials, parts and components are exchanged between countries to support intermediate and final production of goods.

Geopolitical shifts, the impact of trade conflicts and COVID-19 have led to a re-analysis of supply chains and a focus on resiliency and diversification. It is however a reality that global supply chains that have evolved, and continue to evolve, to meet business requirements and optimize cost.

It is important in this context that the evolving European concept of "open strategic autonomy" continues to strike a careful balance between support for regional production and a flexible global supply chain.

5. Enhance vocational training and lifelong training

The EU benefits from an excellent education and Research & Development (R&D) ecosystem leading to a great ability to train high-skilled employees in many areas (data science/analytics, machine learning, cybersecurity, etc.). Yet, major challenges need to be addressed in order to remain competitive: a faster than ever pace of innovation of the sector, a lack of electronics engineers in the EU compared to its new Asian competitors, an aging workforce with a hole in the middle of the age pyramid (employees from 30-50 years old) combined with an ever-decreasing interest from the young European generation in manual and hardware engineering jobs associated to a difficulty to understand the links between electronics manufacturing (hardware) and digital innovations (software, data, coding, artificial intelligence…).

The recent **Skills Partnership for Microelectronics** launched in November 2020 under the Pact for Skills provides a good first step to address ever growing shortages in the sector. Given the gaps in other vital parts of the electronics value chain, the partnership should also involve PCB manufacturers, Electronic Manufacturing Services (EMS), and passive and electro-mechanical component suppliers. In addition, an EU **Sectoral Skills Alliance** could be set-up following the example of **METIS**[1] but focused on the other essential sectors of the electronics ecosystem: PCB, EMS, and passive and electro-mechanical components.

[1] The EU Sector Skills Alliance for Microelectronics launched in November 2019. METIS stands for MicroElectronics Training, Industry and Skills.

6. Support Europe's leadership in voluntary, international, and industry-driven technical standards

The electronics ecosystem is highly globalized and experiences rapid technology changes that require the development of international standards. To remain competitive, Europe needs to establish processes and practices that help the delivery of state-of-the-art solutions in a timely and cost-efficient manner, i.e., develop an approach on standards as a market-driven implementation tool rather than being overly prescriptive.

1. ELECTRONICS: A DRIVER FOR GLOBAL GDP GROWTH

1.1 Electronic systems are driving the world's growth...

For the past 50 years, thanks to successive waves of innovation, the global electronics industry has enjoyed strong growth of more than 8% per year on average, while the world's GDP has grown at an average rate of 3% annually.

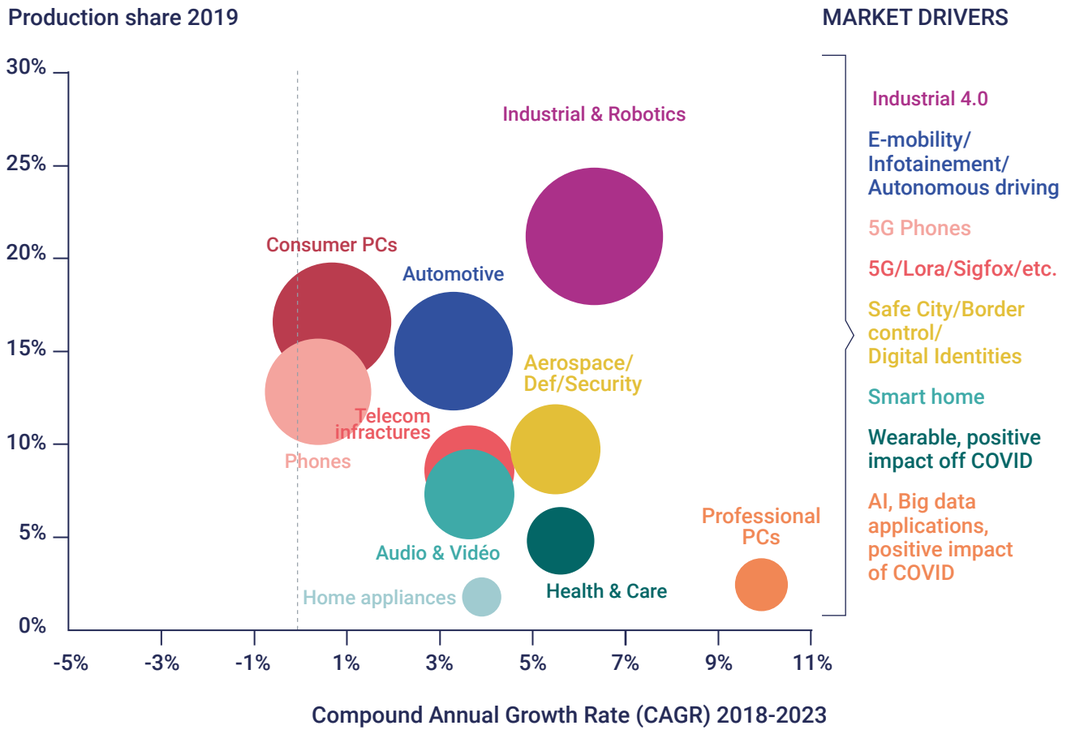
The European electronics industry[2] accounted for €301B in 2019. Moreover, the European electronics manufacturing industry have a direct impact on approximately 20% of the European GDP, or nearly €3800B, when considering the industry's end-user industries (transport, industrial, aerospace/defense/security, IT, telecommunication and health & care products and services).

This economic impact is growing each year as electronics are integral to an increasing percentage of manufactured products.

The electronics ecosystem is one of the main drivers of the global growth. This trend will continue over the coming decade. DECISION forecasts a global compound annual growth rate of 3.7% per year for the electronics industry over the 2018-2023 period while the World Bank forecasts a rate of 1.8% for the World GDP growth[3] over the same period.

[2] EU-28, including the UK.
[3] World Real GDP growth forecast, Global Economic Prospects, World Bank, January 2021.

GLOBAL ELECTRONIC SYSTEMS PRODUCTION BY SEGMENT 2018-2023



Source: DECISION Etudes & Conseil

Electronics systems are segmented by DECISION into ten main end-user segments regrouped in two main categories (embedded systems and stand-alone systems):

Embedded systems, regrouping six end-user segments:

1. Industrial & Robotics electronic systems. Including factory automation, home & building automation, electronic test & measurement, smart meters, UPS, supplies, inverters, distribution, solar energy, electronic lighting, signaling, railway and marine equipment, etc.

2. Automotive electronic systems. Including infotainment systems, electronics for comfort & body, electronics for powertrain, electronics for chassis and autonomous driving electronics (ADAS).

3. Aerospace - Defense – Security electronic systems. Including aeronautics electronics, electronics for the space industry, electronics for Defense and electronics for security.

4. Telecommunication infrastructures. Including terminals, carrier networks and private networks.

5. Health & Care electronic systems. Imaging systems, heart simulators, etc.

6. Professional data processing. Including servers and supercomputers.

Stand-alone systems, regrouping four end-user segments:

1.Consumer PC. Including desktops, laptops, tablets, monitors and e-readers.

2. Phones. Including smartphones and other mobile phones.

3. Audio & Video. Including TVs, game consoles, set top boxes, radios, etc.

4. Home Appliances.

GLOBAL ELECTRONIC SYSTEMS PRODUCTION BY SEGMENT 2018-2023

Segments	2019 (B€)	2019 (%total)	CAGR 2018-2023 (%)
Industrial & Robotics	437	21%	6.1%
Consumer PCs	334	16%	0.5%
Automotive electronics	321	15%	2.8%
Phones	235	11%	0.3%
Aerospace/Defense/security	206	10%	5.4%
Telecom infrastructures	189	9%	4.0%
Audio & Video	170	8%	4.0%
Health & care	102	5%	5.5%
Professional PCS	56	3%	10.0%
Home Appliance	37	2%	3.9%
Embedded systems	**1,312**	**63%**	**5.0%**
Stand-alone systems	**765**	**37%**	**1.4%**
Total	**2,088**	**100%**	**3.7%**

Source: DECISION Etudes & Conseil

1.2 ...despite the COVID

Due to the COVID pandemic, the projected average annual global growth of electronic systems production loses 1 point over the period 2018-2023 compared to DECISION's previous forecasts (3.7% compared to 4.7%). The negative impact has been significant in 2020 but the structural determinants of growth remain generally positive by 2023.

The growth prospects significantly worsened for four segments:

- **Automotive electronics** is the segment that is the most impacted by COVID. The 2020 COVID crisis follows downturns on the Chinese automotive market since late 2017. In addition, COVID leads to modifications of the investments' strategies of automakers. If the transition towards the electrification of powertrains accelerates, several automakers are reducing their investments in the field of Advanced Driving Assistance Systems (ADAS) leading to autonomous vehicles. ADAS is currently one of the main drivers of growth in automotive electronics.

- **Industrial & Robotics electronics** is the second cause of the decline in growth. Investments slowed sharply in 2020 due to COVID, but it is believed to be a sustained recovery driven by the structural drivers of growths that remain unchanged: industrial IoT and industry 4.0. The impact of COVID is therefore more cyclical than structural. The growth prospects for this segment remain very positive but as this segment is the main driver of the global growth of ECS (Electronic Components and Systems), a slight decrease in growth prospects of industrial electronics has a large impact on the growth prospects of ECS in general.

- **The mobile phone market** is suffering from a drop in demand as a result of COVID reinforced by the United States' trade war against Huawei which has plunged smartphone production in volume. The growth prospects by 2023 are very low (0.3% on annual average).

- **Telecom infrastructures** are suffering from a slowdown in investment, despite the rollout of 5G, aggravated by the US trade sanctions against Huawei. Growth forecasts remain positive despite the global deployment of 5G.

The growth prospects remain similar for five segments:

- Due to COVID, a significant increase in demand was observed in 2020 due to teleworking in **the consumer PC segment**. Despite this rise in 2020, this market remains very mature with very modest medium-term growth prospects.

- Strong defense budgets support the growth of the **Aerospace / Defense / Security electronics segment**, and the broader security market including cybersecurity is doing well. These two aspects compensate for the drop

in aeronautics electronics production.

• The growth of **the professional PC segment** has not been impacted by COVID in 2020. The fundamentals drivers of growth remain very good and is even rather reinforced by the COVID: Cloud computing, migration to the cloud, etc.

• **Home appliances** experienced a slowdown in growth in 2020 due to COVID but prospects for 2021-2023 remain good especially due to the smart home trends.

• Finally, in **Health & Care electronics**, COVID has supported the global demand in 2020 regarding both professional electronics (the needs of hospitals) and the consumer trends (connected patients, smart watches, oximeters, tensiometers, etc.). Growth forecasts have therefore improved.

2. GROWING IMPORTANCE OF ELECTRONIC SYSTEMS

For nearly a century, the electronics industry has benefited from the miniaturization of electronics with ever more powerful computing capacities even as relative costs have fallen. Moore's Law, as this idea is known, has led to a phenomenon called "pervasion" of technology: the permanent and ubiquitous extension of electronic applications which can be assimilated in external growth opportunities. First confined to government applications until the 1970s (radio, defense, etc.), electronic systems gradually affected business applications (B2B: office PCs, tape recorders, etc.), households (color TVs, audio CDs, etc.), and finally individuals (laptops, smartphones, tablets, etc.).

The latest wave of pervasion in progress now corresponds to digitization. Digitization is shaping society anew by leveraging electronic applications to design industrial tools and services that produce integrated, intelligent systems, that is to say: which integrate electronic components that are able to communicate with each other generating data that can be exploited for greater utility, efficiency, and productivity.

The digital applications these systems allow often provoke considerable media and governmental attention. That is understandable. After all, the digital applications are what users typically interact with, and the way they are utilized by users (individuals, businesses, and governments) can generate great enthusiasm and great concern, sometimes simultaneously. Unfortunately, the electronic hardware and the industrial capabilities necessary to run these digital applications receive much less attention though it is this hardware that is powering the information economy.

Digitization is disproportionately affecting embedded electronic systems in automobiles, industrial equipment, aerospace/defense technologies, and health care products. In 2018, in fact, embedded/professional electronic systems production exceeded for the first time stand-alone/consumer electronic systems production. The proportion of embedded/professional electronic systems reached ~60% of the total electronic system production if one considers

telecommunication infrastructures & professional PCs as part of embedded/ professional electronic market. In coming years, and as the EU moves to greater focus on digitization and green transition, the main growth opportunities will be:

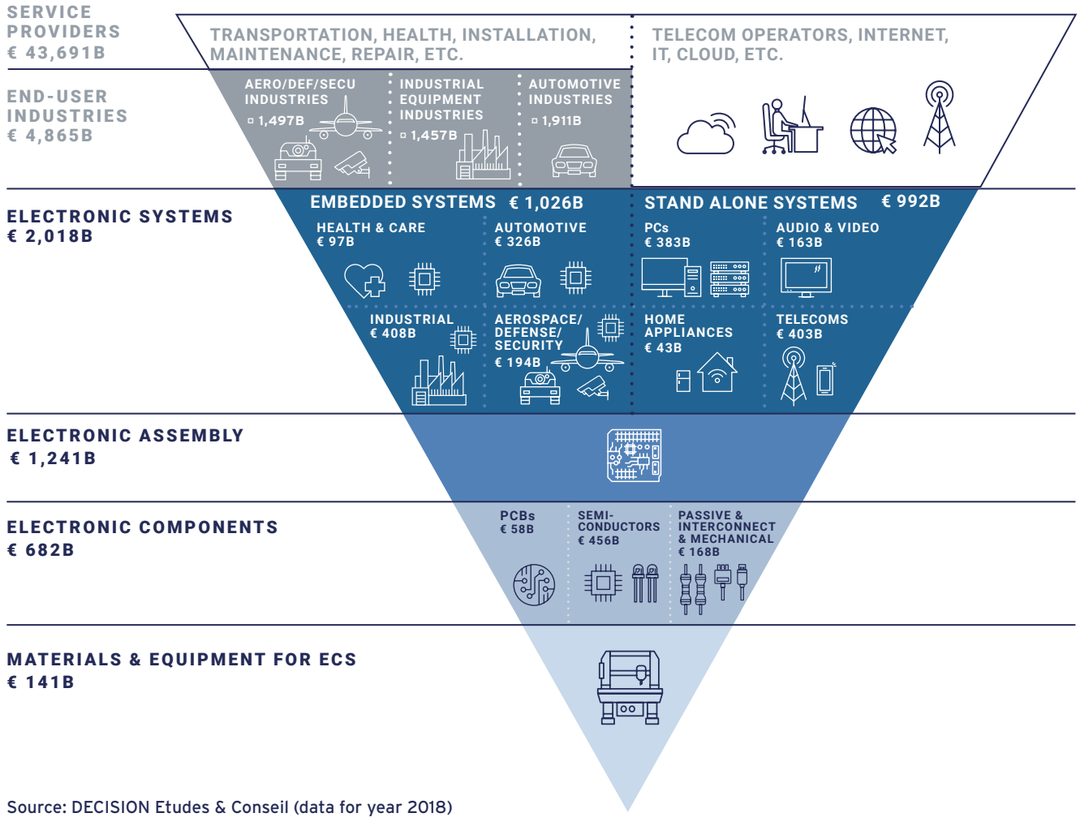
- Clean, connected and autonomous mobility
- Industrial Internet of Things (IoT) and Industry 4.0
- Cybersecurity
- Connectivity: 5G-6G and IoT communication architectures (Lora, Sigfox, etc.)
- Smart health
- Smart home

Key to making the right investments is strengthening the understanding of the approach more recently taken by the European Commission in its analysis of ecosystems; namely that the electronics industry itself comprises many segments that collectively constitute an ecosystem. The long-term strength of each segment is linked to the overall strength of the ecosystem.

3. ELECTRONICS AS AN ECOSYSTEM

The electronics industry is characterized by strong synergies among the links of the value chain. Each link has its own community and supply chain, but collectively they constitute an ecosystem for electronics manufacturing. Each link must be strong for the overall value chain to be strong.

GLOBAL ELECTRONIC COMPONENTS AND SYSTEMS (ECS) VALUE CHAIN



Source: DECISION Etudes & Conseil (data for year 2018)

The Electronics Supply Chain

• **Original equipment manufacturers (OEMs)** are the best recognized companies in the electronics industry because their products carry their names. While some OEMs do actually manufacture, the business model is primarily and increasingly focused on product design, innovation and development. OEMs own the intellectual property and, therefore, the right to manufacture and distribute as they see fit.

• **Electronics Manufacturing Services (EMS)** mount, connect, and assemble various electronic components onto an electronic board or module. Historically, electronics assembly was largely internalized by OEMs, especially in sensitive domains associated to specific end-user applications (automotive, aerospace, defense, security, industrial, etc.). Over the last two decades, however, the trend has been towards outsourcing production to third-party electronic manufacturers. EMS companies also offer an array of value-add services, including design, supply chain management, packaging, final system assembly, and fulfillment/distribution. EMS companies play an essential role in the market: they offer technical knowledge and industry connections that many OEMs no longer possess.

• **Electronic Component manufacturers** produce the electronic components that are placed on printed circuit boards. Today's electronics can contain thousands of components on single board. Many components -including passives (capacitors, resistors), active logic, and connectors- are bought and sold in a commodity-like market. Quality is paramount but a wide range of differentiation does not exist for most passive components and interconnect. Semiconductor containing electronic packages are the glaring exception. Sophisticated and miniaturized silicon chips continue to increase the compute and memory power of information technology, making them a driver for innovation in information technology.

• **Printed Circuit Board (PCB) manufacturers** produce the boards that mechanically support and electrically connect electronic components using conductive traces, pads, vias and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate. PCBs have becoming increasingly sophisticated to accommodate ever smaller, more powerful electronics. Today, from a technological point of view, the PCB is no longer a passive base where components are placed, but rather an integral part of the final product.

• **Mechanical Component suppliers** produce necessary mechanical hardware that is needed for final finished electronic products. Components including heat sinks, insulators, bezzles, frames, etc. are all necessary elements that make up an electronic product. Electronic elements such as printed circuit boards and electronic component placements are co-designed with mechanical hardware. To ensure product safety, OEMs work very closely with third party mechanical suppliers to ensure proper electrical-mechanical system integration. This is yet another area where

OEMs once had internal mechanical design/production capability, but over the past two decades has been outsourced.

• **Wire harness manufacturers** produce the electrical cables that enable connectivity, both power and electronic signals, between two or more electronic systems. The cables are bound together by durable material to form harnesses that are safer, more reliable and easer to install than loose wiring. Wire harnesses are frequently used in automobiles and airplanes.

• **Equipment manufacturers** produce the equipment needed to manufacture wire harnesses, electronic components and PCBs: lithographic equipment, deposition machines, etching and cleaning machines, process control machines, etc. And to assemble electronic boards and equipments: solder past printers, pick and place machines, reflow ovens, etc. The sophistication and miniaturization of electronics has forced equipment manufacturers to develop equipment radically more precise and advanced than even a decade ago.

• **Raw materials producers** provide the inputs needed to manufacture electronic components and PCBs. Raw materials, including rare earths, are sourced all over the world, but increasingly companies are focused on recovery and reuse of raw materials to reduce environmental impact and bolster supply chain resiliency.

Power electronics for high voltage or high current applications of electromobility (charging and motor control) or green energy (solar, wind) are becoming increasingly important. Europeans are well positioned in these segments which involve an increased mix of typical PCB assembly applications and semiconductor backend processes.

3.1 Spotlight: European electronic assembly industry

The externalization of electronics assembly to electronics manufacturing services (EMS) represents significant activity in the European territory with approximately €43B in annual revenue in 2020 and around 2,150 companies. The industry benefited from solid growth with a nearly 5% CAGR over the 2015-2020 period, despite a decrease in 2020 due to the COVID crisis, thanks largely to the growth of manufacturing in Eastern Europe. This growth has been fueled by relocations of factories within Europe and also by investment in the region among large global subcontractors (Hon Hai Precision aka Foxconn, Flex, Jabil, etc.).

The European electronics assembly ecosystem is composed of two large companies, Zollner and Asteelflash (recently merged with Chinese Group USI), many medium-sized companies (Videoton, Scanfil, Enics, Neways, Katek, All Circuits, Eolane, Lacroix Group, Fideltronik, Selcom, Bitron, GPV, Kitron, Cofidur, Inventec, etc.), and many small businesses spread across Europe, generating

similar revenues in Eastern and Western Europe.

The European ecosystem of electronics assemblers might seem small compared to other regions, Asia in particular (China, Taiwan, Malaysia, Thailand, Singapore, etc.), but its size and character align well with the European electronics industry. The industry in Europe specializes in embedded systems (automotive, industrial electronics, etc.), representing smaller volumes but generally greater value added on average. In this regard, European electronics assemblers are essential for the competitiveness of the main European verticals: Automotive, Aerospace/ Defense/Security, Industrial and Health & Care electronics.

3.2 Spotlight: European Printed Circuit Board (PCB) industry

The European ecosystem of PCBs manufacturers is rather small as a percentage of the global production with a production of slightly more than €3.4B in 2020 in the EU, corresponding to ~5-6% of the global production. The relative size of the European ecosystem has decreased during the past 40 years as the great majority of the global production has moved to Asia (from ~50% of the global production in 2000 to more than 80% today). In the 1980s, the European production accounted for 20-30% of the World.

The European PCB manufacturers are today specialized in products with very high added value (complexity, reliability, quality, speed of delivery and services) supplied in small series (from one unit to around 10,000 pieces), for embedded systems (aerospace/defense/security, industrial & robotics, transport, energy and health & care industries). This type of business model is named “high-mix / low volume” and the American PCB ecosystem is also specialized in “high-mix / low volume”. On the contrary, the Asian ecosystem is dedicated to “low mix / high volume” production, serving mass markets (smartphones, PCs, etc.).

The great majority of European manufacturers are small and medium-sized enterprises (ACB, Atlantec, Cimulec, Finmasi, etc.). The European ecosystem also includes one large company (AT&S), a few mid-size companies -Wuerth Elektronik CBT, Schweizer Electronic, KSG, Elvia, NCAB (Swedish PCB distributor), etc.), and many start-ups. Germany and Austria account for more than half of the European production.

4. EUROPEAN COMPETITIVENESS IN GLOBAL ELECTRONICS MANUFACTURING

Europe is up against stiff competition in the electronics manufacturing sector. Asia has conquered a lion’s share of electronics manufacturing for mass market segments (computers, telephones, consumer audio-video), and is rapidly and significantly progressing into the more professional segments. China is already the world’s largest producer of Industrial & Robotics electronics, Home Appliances electronics and telecommunication infrastructures. China is the world’s second leading producer of Automotive electronic systems.

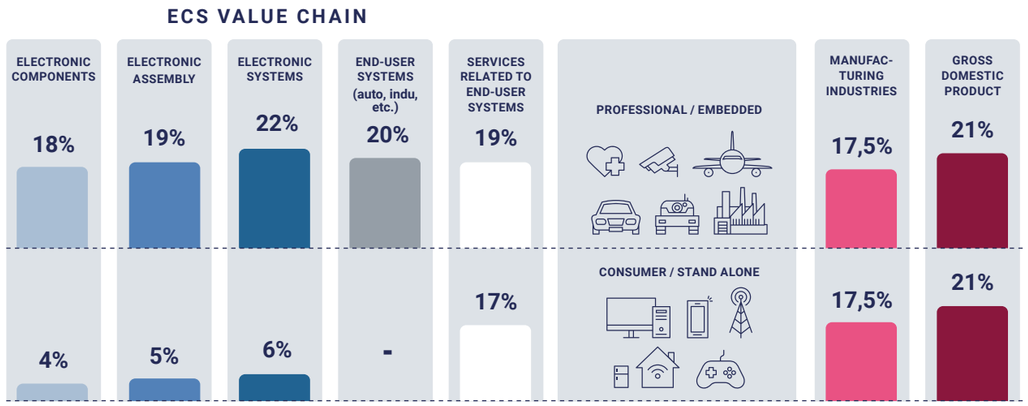
Value chain level	Production in Europe	% Europe / World
Service providers	**€ 11,054B**	**25%**
End-user industries	**€ 980B**	**20%**
Automotive	*€ 381B*	*20%*
Aerospace/Defense/Security	*€ 276B*	*25%*
Industrial & Medical equipment	*€ 276B*	*19%*
Electronic systems	**€ 290B**	**14%**
Stand alone electronics	*€ 60B*	*6%*
Embedded electronics	*€ 229B*	*22%*
Electronic assembly	**€ 126B**	**10%**
Electronic components	**€ 55B**	**8%**
Material & equipment	**€ 24B**	**8%**

Source: DECISION Etudes & Conseil

Over the past decade, east and south-east Asia has been the region benefiting from the fastest growth of its electronics industry, with countries such as South Korea, Taiwan and Singapore, but also Malaysia, Thailand, Vietnam, etc. However, this trend should slow down during the next five years as the countries of this region are mostly specialized in consumer products while embedded and professional systems are expected to benefit from the highest growth.

North America is by far the leading region in Aerospace/Defense/Security electronics and in Health & Care electronics. North America is also well positioned in Industrial & Robotics electronics and automotive electronics.

EUROPEAN ELECTRONIC COMPONENTS & SYSTEMS VALUE CHAIN (% WORLD)



Source: Study on Emerging Technologies in Electronic Components and Systems - Opportunities Ahead / DG CONNECT, 2019-2020, (DECISION Etudes & Conseil, with data for year 2018)

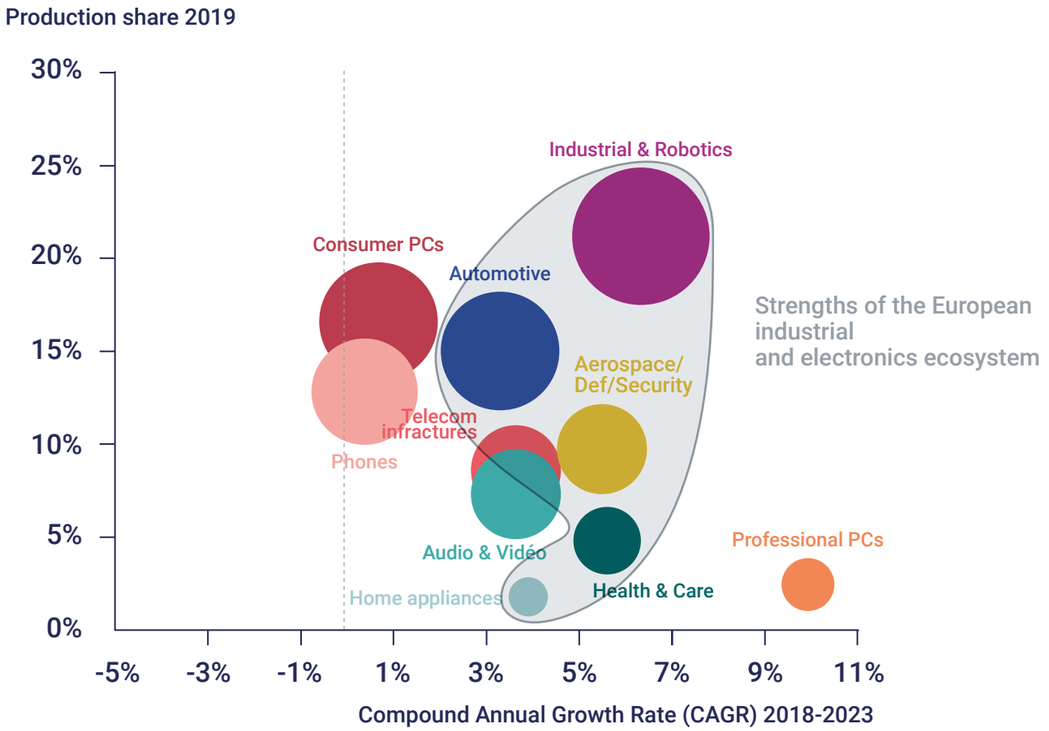
In 2018, Europe[4] accounts for 14% of the global electronic system production, way behind China (37%) and behind north America (15%). Japan accounts for 7% of the global production, the other Asian countries account for 20% and the rest of the World 8%.

The EU's share of global production of electronic systems has been declining during the 2010-2018 period. This relative decline is largely attributable to the decline in European production of telecommunication systems, audio & video systems, and consumer PCs. As a result, the European electronics ecosystem is performing below its potential, but it can take advantage of global growth opportunities provided European governments and industries enact the right policies and support the right investments.

Indeed, the EU is very well positioned on the main end-user electronic segments with the highest potential growth over the decade 2020 as shown on the graph below:

[4] EU-28, including the UK.

GLOBAL ELECTRONIC SYSTEMS PRODUCTION BY SEGMENT 2018-2023



Source: DECISION Etudes & Conseil

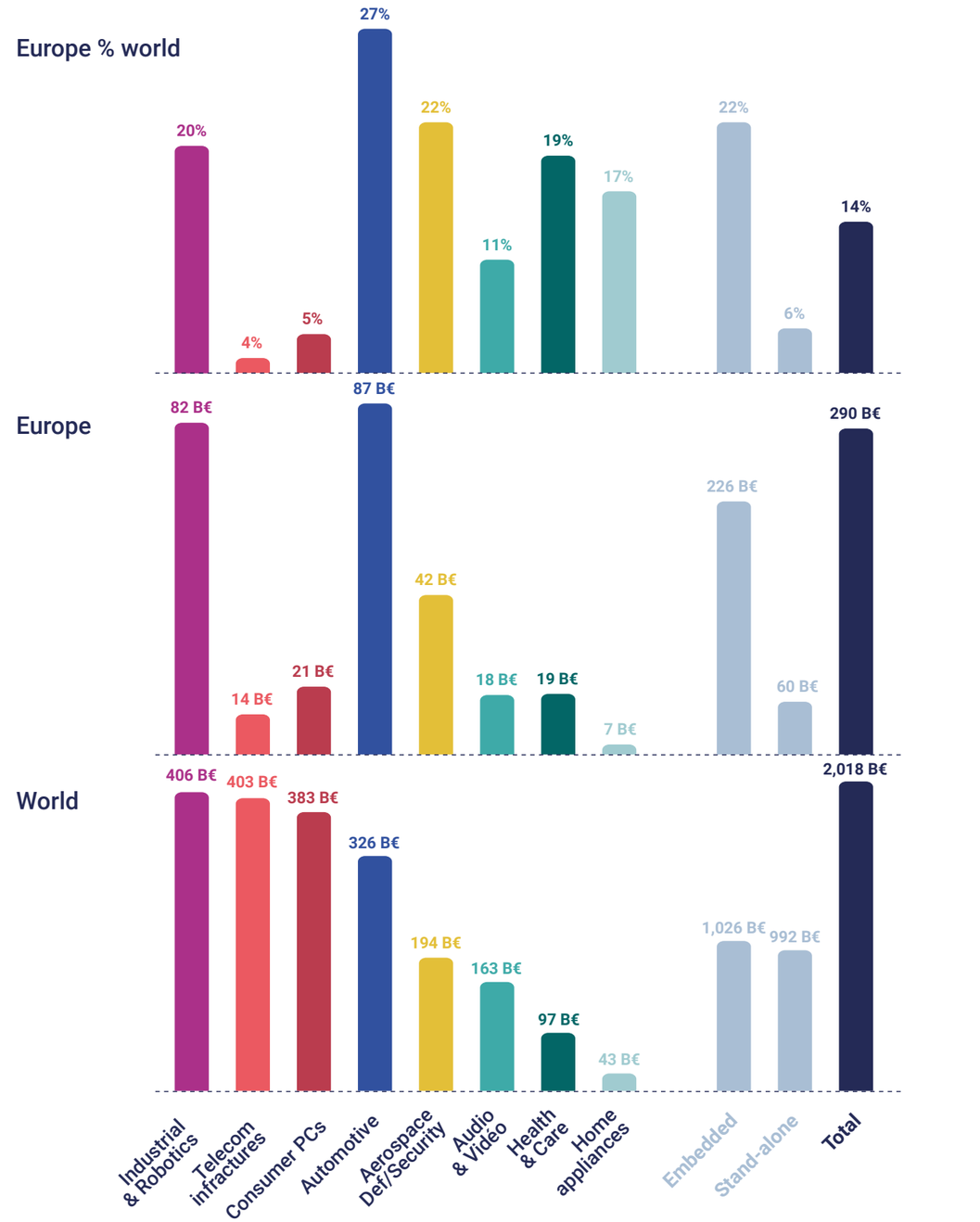
These windows of opportunity have been identified by the EU and most of the nine key and strategic value chains identified so far by the Strategic Forum for Important Projects of Common European Interest are linked to these segments:

End-user electronics segments form the highest potential growth over the 2018-2023 period at the global scale	Production in the EU in 2019 (B€)	Associated key and strategic value chains identified by the Strategic Forum for Important Projects of Common European Interest (IPCEI)
Automotive electronics	€ 87 B	• Batteries • Hydrogen technologies and systems • Clean, connected and autonomous vehicules
Industrial & Robotics electronics	€ 82 B	• Industrial Internet of Things (Industry 4.0)
Aerospace/Defense/ Security electronics	€ 42 B	• Value chain "Cybersecurity"
Health & Care electronics	€ 19 B	• Value chain "Smart health", aiming notably to stimulate demand and uptake of Smart Health products and services
Telecom infrastructures	€ 14 B	• Cybersecurity • Industrial Internet of Things ...supporting notably measures to develop secrue 5G industrial infrastructures
Home Appliances	€ 7 B	• Industrial Internet of Things (Smart home)

Source: DECISION Etudes & Conseil

The four other key and strategic value chains identified by the EU (Microelectronics and Low CO2 emissions Industry and High-Performance Computing), as well as Cybersecurity should benefit to all the verticals of the European electronics ecosystem as they are all impacted by microelectronics, the necessity to adapt to climate change and to integrate new cybersecurity tools.

GLOBAL ELECTRONIC SYSTEMS PRODUCTION - SHARE OF EUROPE (% WORLD)



Source: DECISION Etudes & Conseil (data of year 2018)

As a consequence of the slow growth of stand-alone electronics and the high growth of embedded electronics, the growth of China over the 2018-2023 period (4.1%), should not be significantly higher than the growth of North America and Europe (respectively 3.6% and 2.8% per year). Europe represented 14.3% of the global electronic production in 2018 and should represent 13.2% of the global electronic production in 2023 (that is an almost constant share).

The following sections provide an overview of the European electronics industry by end-user segments. Remember, overall electronics end-user segments can be regrouped under two main categories: embedded systems on the one hand and stand-alone systems on the other hand. Embedded systems (or embedded and professional systems) are electronic systems embedded into automotives, diverse industrial equipment, aerospace/defense/security equipments, telecommunication infrastructures, and health & care equipments. The vast majority of these end-user segments are professional, and as a consequence, professional PCs (servers), are also considered in this category. Embedded systems are opposed to "stand-alone systems", traditionally corresponding to consumer electronics (phones, consumer PCs, consumer audio & video systems and home appliances).

4.1 Embedded electronics

The European electronics ecosystem has seemingly been tailored for embedded systems. Indeed, the European embedded systems industries (automotive, industrial & robotics, aerospace/defense/security, health & care) require industry supply chains specifically for these markets. These markets have particular needs concerning production lines, that must:

- Be flexible
- Be compatible with special substrates or products
- Enable heterogeneous integration of non-standard components
- Enable very sophisticated packaging
- Be very near to the system integration and the incorporating manufacturers

Industrial & Robotic electronics

The EU holds very strong positions in industrial electronics. The EU supplied 20% of the global industrial electronics production in 2018 and was the second region in the world after China (25%), and on equal footing with North America (20%).

Europe's strength is due, in part, to its legacy electrical engineering companies. For over a century, these companies have established important market positions beginning with harnessing electrification (replacing steam power) and introducing automation into the manufacturing process. Electrical engineering companies—such as ACEC, AEG, ASEA, BBC, CGE, GEC, Philips, Schneider and Siemens—were leaders in developing electromechanical and electronic automation systems.

In the latter half of the 20th century, these companies helped spearhead innovation in computer electronics and, in the process, underwent major consolidation during the 1980s and 1990s. Large trans-European global groups such as ABB, Alstom, Legrand, Schneider and Siemens formed during this period. The same happened in the USA with GE and Westinghouse, or in Japan with Hitachi, Mitsubishi and Toshiba.

However, the development of electronic controls and automation favored new entrants, especially in the fields of power electronics, measurement and testing, programmable controllers, industrial computers and robots. The heart of power electronics is semiconductors, where Europe has two of the top five global suppliers (Infineon and Semikron), alongside two Japanese (Mitsubishi and Fuji Electric) and one American (ON Semiconductors).

The strength of the German and Italian machine tool industries which ranked foremost in the world in the 1980s and 1990s supported European leadership in devices such as machine tool numerical control, with German specialists like Heidenhain alongside Siemens and Bosch Rexroth, and the Italian Comau, a Fiat subsidiary.

In robotics, Europe is favorably positioned. In 2018 Europe ranked second in the world for industrial robots installed behind China and in front of Japan, the USA and South Korea. Europe currently manufactures around 30% of the global market, and European manufacturers share 45% of the booming service robot market with the USA. Although Europe is above the world average of industrial robots installed per employee, it is significantly behind the two "stars", Singapore and South Korea, each with about ten times the global average, Japan (three times the world average), the USA (twice the world average), and China who is rising fast.

Automotive electronics

The European automotive electronics ecosystem has been built on the historically strong automotive industry—led by leaders such as Volkswagen, Renault (now Renault-Nissan-Mitsubishi), Peugeot-Citroen-Fiat (now forming the Stellantis alliance), Daimler and BMW.

The global strength of these companies has been associated with the development of a great and complex supply chain upstream with Tier 1 suppliers (Bosch, Continental, ZF, Valeo, Faurecia, etc.). Many of these players have thrived from the progressive electrification of cars beginning in the 1980s extending to infotainment, driving assistance and connectivity solutions today. The European automotive electronics sector, in fact, outpaces the automotive industrial base in global market share, both in terms of high value-added activities (engineering, Research & Development, etc.), and factory production. The EU produced 26% of the global automotive electronics in 2019, leading north America (17%), China (22%), Japan (10%) and the rest of Asia (19%).

The production in Europe is largely dominated by Germany, followed by France in second position and a group of countries that vie for third position (Czech Republic, Austria, Romania, Spain, Hungary, Italy, the UK, Slovakia and Poland). Europe's three main competitors globally are China, the USA and Japan. The European automotive electronics manufacturers are well positioned to maintain their dominant position but will face numerous challenges in coming years:

- On the short run, the European ecosystem has to face **the downturn of the world automotive industry due to the COVID crisis in 2020, which follows downturns on the Chinese automotive market since the end of year 2017.** After two years of decrease in 2018 and 2019 (respectively -0.3% and -4.5%[5]), the annual sales of cars at the global scale have decreased of 14-18% in 2020. Fortunately, this crisis appears to be cyclical and the outlook for the global automotive market is very positive for the year 2021: from +7% to up to +15% depending on the sources. The rebound in the automotive industry is such that a shortage of electronic components has been going on globally since the end of 2020 and is expected to last until the third quarter of 2021.

- **The transition towards electric vehicles in which Europe risks missing the market shift.** Global sales of electric vehicles (BEV) jumped from less than 300,000 units in 2015 to nearly 2.2 million units in 2019 (with a 70% average annual growth rate). The COVID-19 crisis has accelerated the awareness of the impact of climate change and as a consequence the transition of the automotive market to electric mobility. The Chinese electric vehicle market (BEV) has benefited from an 8% annual growth in 2020, while the Chinese automotive market at large has suffered from a downturn of -2% (in units). This transition has major implications for the European automotive electronics industry. On the one hand, it is a great opportunity as the electronic content of electric vehicles (BEV) is greater than the electronic content of petrol/diesel vehicles, especially due to power modules. But on the other hand, the transition towards e-mobility is a great challenge and a potential threat for the European automotive industry as the Chinese industry is in a dominant position. Mastering the development of diesel/petrol engines is a very complex task and the Chinese manufacturers were struggling to compete foreign manufacturers (including the European ones) on this segment. The situation is opposite regarding electric engines. Indeed, the battery represents 30-50% of the total cost of an electric vehicle (BEV) and 80% of the automotive batteries' cells capacities are currently located in China. China also dominates the raw materials value chain associated to automotive batteries (80% of rare earths are produced in China, 50% of the global cobalt production is secured by Chinese players over the coming years, etc.).

Finally, China is the first automotive market with nearly 30% of the global sales in 2019 and has the willingness to build a strong industry at all the steps of the future automotive value chain. Therefore, within the coming years, the European automotive industry faces the risk of being overtaken by Chinese industry on the transition to electric mobility, with China in a dominant position upstream of

[5] OICA, February 2021.

the value chain (raw materials and batteries) and downstream with its market. Three of the nine key and strategic value chains identified by the EU (Batteries, Connected and Autonomous Vehicles and Hydrogen) aim to face this risk.

- **Increasing importance of automotive embedded software and a move toward designing cars around their IT systems.**

- **Increasing importance of four main applications fields**: e-mobility leading to a rising demand for power electronics, infotainment solutions, driving assistance solutions (ADAS) and interconnections solutions (V2V, V2I, etc.). The COVID has led to modifications of the investments' strategies of automakers in 2020: the transition towards the electrification of powertrains has accelerated while several automakers have reduced their investments in the field of Advanced Driving Assistance Systems (ADAS) leading to autonomous vehicles.

Aerospace/Defense/Security electronics

In 2018, the EU aerospace/defense/security electronic industrial base produced 22% of the global Aerospace/Defense/Security electronics and ranked as the second region in the world after North America (41%), and ahead of China.

Historically, the defence industry developed in Europe, the USA, Japan and former Soviet Union. Both technology and production have remained strongly concentrated in these areas (except in Japan), with a developing industry in emerging countries such as China, India, Brazil and Israel. The aerospace and defence industries are made up of a complex supply chain ranging from parts and components to general supplies and commodities, electronic systems, and complete assemblies (aircraft, ships, etc.), with a willingness from countries mastering the latest technologies to keep the production on their territory for both sovereignty and strategic reasons. As a consequence, after the collapse of the USSR, Europe became with the USA the two largest providers of aerospace/defence & security systems worldwide.

While the US remains the undisputed leader on the defense side, with historical industry leaders in almost every market subsegment (Boeing, Lockheed Martin, Raytheon, etc.), Europe has created its own defence industrial base through national champions like BAE Systems, Leonardo, Safran or Thales-Gemalto and through mergers of European companies like Airbus Defence & Space. The U.S. defense industry, however, is heavily fueled by the growth of US military expenditures, which accounts for nearly 40%[6] of total global defense expenditures.

On the civil side, the success of the European Airbus on both the large commercial aircraft market and the civil helicopter market but also the civil space markets with the Ariane rockets has consolidated Europe as the top worldwide supplier of civil aerospace platforms. With only 13% of market share in 1985, Airbus managed to catch up its historic competitor Boeing and now claims 50% of the market creating a duopoly situation with the American manufacturer. Like

[6] The US military expenditures accounts for 39.2% of total global defense expenditures in 2019 according to the World Bank.

Airbus, its subsidiary Eurocopter (now Airbus Helicopters) has achieved the same success by being for several years now, the worldwide leader in the civil helicopters market segment. As a consequence, like in the US, the European aerospace/defense & security industry can rely on a strong and local value chain at every of its stages from final OEMs to the suppliers: the component manufacturers, printed circuit board fabricators and assemblers.

Health & Care electronics

The EU has a competitive Health & Care electronics industry. In 2018, the EU produced 19% of the global Health & Care electronics and ranked third in the world after North America (42%), and close behind China (20%).

European companies rank high in the global market, with Philips and Siemens second and third, behind the American Medtronic and before GE Healthcare. In 1987 the third major European, CGR, the healthcare subsidiary of the French Thomson group (now Thales), was sold to the American General Electric. The Japanese Toshiba Medical (now Canon) and Hitachi had always focused more on the domestic market.

However, the health and care market is fundamentally changing, with new fast growing connected care, home care, and wearable devices market and service segments. The historic markets of costly institutional equipment will recede relative to massive new markets of consumer-type health products. European suppliers should have a proximity advantage on these markets, which are strictly supervised by the various national health and social security systems. However, within the EU Health System lack of compatibility between national standards and regulations may easily offset this asset.

4.2 Stand-alone electronics

Personal Computing

In 2018, Europe represented only 5% of the global computer production after China (54%), and the rest of Asia (32%), and on equal footing with North America (6%).

European computer manufacturing has historically trailed other regions. Today, Atos/Bull remain the main European player in PCs, focused on professional applications (datacenters, servers, etc.), with significant market shares worldwide. The new innovation waves occurring in PCs are concentrated in professional PCs (datacenters, servers), around supercomputing and quantum developments. Thanks to the presence of Atos/Bull and a high level of interest from the European Commission (€2.7B for supercomputing within the Digital Europe Program, initiatives in Quantum Communication Infrastructure to secure communications, entities such as the Quantum Technologies Flagship, HiPEAC, ETP4HPC, etc.), the EU as an opportunity regain significant positions despite the fierce competition from the USA (world leaders), China and Japan.

Telecommunications

In 2018, Europe represented 4% of the global telecommunication electronics production. Europe was the 5th region in the world. The rest of the world production is distributed between China (52%), Japan (4%), other Asian countries (27%), North America (5%), and the rest of the world (8%).

The decline of Europe's telecommunications industry is surprising given the region's historical leadership. Europe, in fact, succeeded in establishing GSM as the standard for the emerging mobile phone market, which Nokia and Ericsson championed and leveraged to become global market leaders. Establishing GSM as the leading global standard was a long-term effort that began in the early 1980s and resulted in a unified, open, standard-based network which was larger than that in the United States.

Nokia was able to take advantage of this favorable environment and became world leader with nearly 60% of the global market in the early 2000s. Nokia, however, has since lost market share with the explosive growth of smartphone sales. Today, Apple, Samsung, BBK, Huawei and Xiaomi today lead the market. Nokia and Ericsson, nonetheless, remain European world leaders in telecommunication infrastructures, although most of their production is located in Asia.

The coming 5G, as well as the rise of IoT-dedicated communication architectures, will bring a new revolution, extending communications to most domains of human activity.

Audio & Video

Europe, in recent years, has lost market share in global TV production. In 2018, Europe represented 11% of the global audio & video production. Europe was the 3rd region in the world after China (53%), and the rest of Asia (31%). North America accounts for 2% and the rest of the World 4%.

The decision to develop European specific standards was a major setback for the European ecosystem and led Europe to gradually abandon a large segment of TV production, despite the leadership position of Philips until its purchase by the Chinese TPV in 2012. Asian companies (Japanese, South Korean and Chinese) have acquired a quasi-monopoly on television production as well as on other audio and video products.

However, Europe remains strong in audio niches, innovating in areas such as sound systems and speakers for smartphones as an example. Moreover, the Asian leaders have diversified their production locations in order to get closer to their major markets. In particular Samsung and LG, who hold large shares of the European market, have significant production facilities in Europe. This helps explain why European production of consumer electronics, although it has decreased, remains relatively strong.

After having demonstrated the importance of the electronics industry as an enabling industry for both the digital and green transition and the open strategic autonomy of the EU, this report has assessed the strengths and weaknesses of the European electronics ecosystem in the global competitive landscape and identified the market opportunities for the coming years. The last part of the report proposes a series of industrial policy recommendations to support the growth of electronics manufacturing industry.

Home appliances

In 2018, Europe represented 16% of the global home appliances production. Europe was the second region in the world after China (39%), but ahead of Japan (9%) and the rest of Asia (13%), north America (10%), and the rest of the World (13%). In the global domestic appliance top 15, Europe is well represented with European companies Bosch and Electrolux ranking second and third, behind the American world leader Whirlpool. The European Miele ranks 10th, and the European small appliance specialists SEB, Philips and Dyson respectively rank 9th, 13th and 15th.

Globalization has been slower in this domain, due to differences in national habits. Penetration of Asian products has mainly been through OEMs sales, under the European company brand names. This is now changing and companies like the Chinese Haier and Midea are introducing their own brands. Domestic appliances have become a growing market for electronic devices, as electronic controls have increasingly been used, from the 1980s onwards.

5. CHARTING A PATH FORWARD: RECOMMENDATIONS

5.1 Focus on Europe's continued leadership in embedded electronics to achieve successful green and digital transitions

The growth of the global electronic ecosystem will be driven by the embedded/professional systems over the coming decade.

Embedded/professional systems (within Industrial & Robotics, Automotive, Aerospace/Defense and Health Care, Professional PC and Telecommunication Infrastructure segments) are expected to grow at an annual rate of 5.0% over the 2018-2023 period, while consumer/stand-alone electronics (Phones, Consumer PC, Stand-alone consumer Audio & Video applications and Home Appliances) are expected to grow at an annual rate of only 1.4% over the 2018-2023 period[7].

In particular, the automotive and industrial electronics segments are the two leading segments, as were Consumer PCs and Phones 10-15 years ago. Each account for around 20% of the global electronic system production and concentrating the majority of the growth of the electronics ecosystem.

Most of the current innovation trends, regrouped by DECISION under the term "Industrial IoT", are impacting embedded/professional applications. In comparison, Consumer PCs and Phones are driven by fewer innovations.

The European Union industrial ecosystem is highly specialized in embedded/professional systems that accounts for **85%** of the EU production of Electronics Components and Systems (ECS). In particular:

- **Automotive** electronics accounts for 30% of the EU ECS production.
- **Industrial** electronics accounts for 28% of the EU ECS production.

[7] Estimates carried out in December 2020 and taking into account the effects of COVID-19

• **Aerospace/Defense/Security** accounts for 15% of the EU ECS production.

• The EU has also one of the greatest industrial ecosystems of **Health & Care** electronics, although it only accounts for 7% of the EU ECS production.

The EU should therefore highly benefit from the strong growth prospects of these segments over the 2018-2023 period compared to stand alone segments.

These end embedded markets should be supported in priority as they represent the largest industrial base in the EU and offer large growth prospects, but also as they are incremental to meet the EU's twin digital and green objectives.

E-mobility: ECS are essential parts of the development of energy-optimized e-mobility and hydrogen mobility thanks to innovations such as: smart sensors, edge AI chips, neuromorphic computing, emerging non-volatile memories, etc. Digital innovation in ECS for mobility have the goal to achieve a 37.5% reduction of CO2 emission by 2030 vs. 2021 according to the partnership for Key Digital Technologies of Horizon Europe.

Industrial electronics concentrates a number of essential innovations to meet digital and green objectives:

• ECS enable improvements in supply-chain management thanks to Industry 4.0, reducing the associated pollution emissions.

• Many ECS innovations are linked to energy management and enable the creation of new power devices towards zero power consumption.

• The use of low-power and green industrial IoT are needed to build smart and green cities.

But ECS also enable the use of new and greener materials: organic, compostable and biodegradable enabling recycling and repair. Some ECS innovations enable food traceability over the whole agro-food value chain, etc. Digital technologies as a whole have the potential to enable a 20% reduction of global CO2 emissions by 2030 according to Digital Europe.

In other words, the EU should capitalize on its industrial strengths in embedded electronic systems to achieve successful green and digital transitions:

• Automotive electronics for clean, connected and autonomous vehicles

• Industrial & robotics electronics for Internet of Things and Industry 4.0

• Electronics enabling cybersecurity applications

• Electronics enabling smart health

• Electronics enabling smart home

5.2 Recognize electronics and electronics manufacturing as a strategically important industry and invest in neglected parts of the value chain

a. Growing awareness of the central role of the electronics ecosystem for the open strategic autonomy of the EU

Electronics are an integral part of, and enabler for, Europe's industrial ecosystems, as well as constituting an ecosystem in their own right. In this way, electronics are both a stand-alone vertical and a horizontal that runs across every sector of Europe's economy. They play a decisive role in driving technological innovation and ensuring broad-based and sustainable growth across the economy.

Recognition of the strategic importance of the electronics sector is growing as reflected in numerous initiatives:

• The approval of **the first IPCEI[8] on Microelectronics** in 2016 that will run until 2024.

• The set-up of the **EuroHPC Joint Undertaking[9]** in 2018 and the creation of the **European Processor Initiative (EPI)** the same year.

• The **Joint Declaration on processors and semiconductor technologies** in December 2020, involving 18 EU member states. This declaration should notably lead to the set-up of a second IPCEI on Microelectronics in the course of 2021, aiming to scale towards leading-edge processors production capacities in the EU and to support to microelectronics design.

• The **Recovery and Resilience Facility (RRF)** which should devote significant importance to the electronics ecosystem since 20% of the installation must be dedicated to digital projects (i.e., up to 145 B € over the next 2 to 3 years), and as one of the seven flagships of the facility is dedicated to scaling microelectronic and cloud capabilities.

• The **recent announcement by Commissioner Breton of an incoming European Alliance on Microelectronics,** to be launched in April 2021, aiming to reach public and private investment of €20 billion to €30 billion in microelectronics over the 2021-2027 period.

[8] IPCEI: Important Project of Common European Interest.
[9] The European High Performance Computing Joint Undertaking (EuroHPC JU) is a legal and funding entity, created in 2018.

- The launch of the **Pact for Skills dedicated to microelectronics in November 2020,** encompassing initiatives expected to draw € 2 B in public and private investment to train more than 250,000 workers and students in the European electronic components & systems sector over the 2021-2025 period.

- Finally, there is a heightened recognition in the EU of the need to reinforce Research & Development (R&D) cross-border collaboration in order to develop the technologies enabling Europe to achieve sovereignty in key areas, as electronics concentrates most of today's innovations. The next Joint Undertaking on electronic components and systems to fund Research, Development and Innovation projects (RDI) is on its way and will start in 2021. **The KDT JU** (Key Digital Technologies), the follow-up to the ECSEL JU under Horizon Europe, will benefit from a greater budget than ECSEL, that is more than €5B investment over the 2021-2027 period.

European policymakers appear poised to pivot to a more holistic, ambitious strategy for bolstering the industrial strengths of the region's manufacturers. The recognition is driven in part by a concern for external dependencies, that undermine Europe's industrial resiliency and, in some cases, security, as the electronic components and systems that are produced in Europe are crucial in several sovereign applications (aerospace, defense, security, industrial & robotics, transport, energy, health & care).

European dependencies correlate with strong industrial strength in China and in other countries which have proactively and intentionally bolstered electronics manufacturing capabilities.

There is an opportunity now to take stock of the state of **the European electronics manufacturing ecosystem and make it a priority to ensure resiliency of electronics manufacturing supply chains.** This can be done through fostering production and investment in Europe and developing a network of trusted trading partners.

b. Considering the electronics ecosystem as a whole is crucial: Beyond supporting microelectronics, Electronic Manufacturing Services (EMS) and PCB manufacturers also play a crucial role for the European open strategic autonomy

In this context a **holistic approach to the electronics manufacturing sector is needed** to strengthen Europe's electronics manufacturing ecosystem as a whole, while remaining open. as each link in the chain which constitutes this ecosystem is vital and interlinked.

A focus on semiconductors and microelectronics with benign neglect toward other segments, including printed circuit boards and printed circuit board assemblies,

risks undercutting European innovation and industrial competitiveness

In taking stock of the state of the ecosystem, as noted in this report, the EU has a number of external dependencies in the area of electronics, especially regarding electronic cards assembly (EMS) and Printed Circuit Boards (PCBs) manufacturing:

- The EU has only one company in the global TOP 20 for EMS (Zollner) and one company in the TOP 20 for global PCB manufacturers (AT&S), with these numbers decreasing over the years. In comparison, four European companies are among the top 20 companies of the microelectronics ecosystem: ASML, NXP, Infineon and ST Microelectronics. As a result, the EU runs the risk of no longer having industrial and technological leaders in these two industries (EMS and PCB). In addition, due to competitive constraints in world markets, the production of large companies in these industries has gradually relocated outside the territory of the EU, which is likely to increase the risk related to the capacity of resilience of the European economy.

- The production of PCBs in Europe is particularly low. With slightly more than 3 billion euros in 2020, the production of PCB in the EU is ten times smaller than the production of semiconductors, while globally, PCB production represents 16% of semiconductor production. As a consequence, 60% of the consumption of PCB in the EU is imported. This proportion rises over the years and is likely to increase the risk related to the capacity of resilience of the European economy. In 1995, the EU imported less than 30% of its consumption of PCB.

Printed Circuit Board Assembly (PCBA) and PCB manufacturing are however two crucial activities for both the green and digital transition.

The European ecosystem of PCBs manufacturers is specialized in high technical-level products for high-tech industries. As such, it is one of the ecosystems driving electronics innovation with the development of build-up, organic, flexible and printable electronics enabling new low-cost applications (e.g., innovative flexible displays embedded in car, Health & Care wearables, etc.), substrate-like PCB (SLP), etc. PCB are essential for smart mobility solutions (including automotive), Industry 4.0 solutions, Industrial IoTs, green energies (wind turbines, solar panels, etc.), in other words ecosystems that are crucial for the success of the **European green deal**[10] and digital transition.

In turn, printed circuit board assemblies provided by Electronic Manufacturing Services (EMS) companies, play an increasingly central role in driving the digitization trend, playing a key role of both intermediates and knowledge/training providers. The electronics manufacturing ecosystem is indeed particularly complex, comprising a multitude of very different players: software or hardware specialists, design or production specialists, all in the midst of a constantly evolving technological landscape. The new consumers of electronic products, more and more numerous and from digital services (creators of applications,

[10] The European Green Deal is one of the six political priorities of European Commission President Ursula von der Leyen over the 2019-2024 period.

connected objects), are struggling to identify trusted partners within this complex ecosystem and EMS providers play the role of experts and advisers to these actors. As a result, the presence of a strong industrial fabric of EMS is an essential factor for a rapid and successful digital transition.

EU policy making should systematically take into account the whole electronics value chain:

- In investing in Microelectronics there should be gap analyses to assess corresponding needed investments in PCB fabrication and Printed circuit board assembly.

- As the EU looks to next steps within the context of the **Expert Forum on Industrial Strategy,** the future **Alliance on Microelectronics** and other fora, the requirements of the electronics ecosystem as a whole should be considered in order to identify investment needs and co-design solutions: Electronics Manufacturing Services (EMS), PCB, and microelectronics players should be represented.

- More generally, EMS and PCB manufacturers should be considered as essential stakeholders and partners in any European initiative on processors and semiconductor technologies.

- Finally, electronic assembly and PCB should also benefit from dedicated support initiatives where funding is considered, including in the framework of **Recovery and Resiliency Funds.** For instance, the French EMS Lacroix Electronics, Tronico, EMS Proto, as well as the French PCB manufacturers Cirly and Elvia are part of the beneficiaries of the industry section of the **"France Relance" plan (France Recovery).**

Both the European ecosystems of PCB manufacturers and EMS are mainly composed of Small and Medium-sized Enterprises (SMEs) and mid-sized enterprises that suffer from difficulties to compete with large Asian players in terms of investments (Industry 4.0, etc.), R&D expenses and trainings.

Therefore, support should enable manufacturers to meet future regulatory requirements for a sustainable industry delivering on 2050 climate neutrality objectives; and spur investment in capital equipment and transition to Industry 4.0, investment in AI and other technologies that make European manufacturers more globally competitive.

Investment in smart factories is a key element in this context; -bringing down the cost of production and enabling more environmentally friendly processes.

5.3 Support European manufacturers in their transition to factories of the future to support industrial strength, digital transformation and a circular economy

Factories of the future, also named Industry 4.0, is the next wave of innovation within factories. It corresponds to the rising connectivity between industrial machines and tools thanks to 5G/6G developments and new IoT communication architectures, associated with the development of software tools to analyze the data generated (big data, machine learning), leading to new applications (operational predictive analytics, real-time supply chain management, stock pooling platforms, etc.). It implies a great use of industrial IoTs within factories.

The adoption of Industry 4.0 solutions by electronic assemblers is key, benefits the entire supply chain as it improves their productivity. But Industry 4.0 electronic solutions also increases the productivity, efficiency, and yield of other manufacturing value chains and strengthens their competitiveness towards other regions.

Yet, investments in Industry 4.0 are heavy and need to be very diversified. An April 2020 survey-based study from the EIB[11] shows that:

1. European manufacturing firms lag behind the US generally in the adoption of digital technologies[12].

2. Larger manufacturing firms have higher rates of digital adoption than smaller firms.

3. Many small manufacturing firms in the EU do not invest in digital technologies at all, mainly due to a lack of internal skills and the high costs of investment.

As most of the European Electronic Manufacturing Services (EMS) and Printed Circuit Boards (PCB) companies are Small and Medium-sized Enterprises (SME), they particularly need to be supported to mutualize their investments. This mutualization should encompass R&D, equipment upgrades, and workforce training. The key levers to help EMS and PCB manufacturers in their transitions towards Industry 4.0 are:

- **Support investment in Industry 4.0 through:**

  - **The set-up of an IPCEI[13] dedicated to Industry 4.0**, in order to support the adoption of Industry 4.0 tools by the European ecosystem and especially SMEs. Such an initiative would be beneficial for the European ecosystem at large and for the European EMS and PCB industries in particular. The recognition by the strategic forum for IPCEI of the value chain "Industrial Internet of Things (IIoT)" as key and strategic is an encouraging sign.

[11] European Investment Bank (EIB), April 2020, Who is prepared for the new digital age?
- Evidence from the EIB Investment Survey, https://www.eib.org/attachments/efs/eibis_2019_report_on_digitalisation_en.pdf
[12] Digital technologies considered in the study: 3D printing, Robotics, IoT, Big data, Drones, Virtual Reality (VR), and services platforms.
[13] IPCEI: Important Project of Common European Interest.

- On a lower scale, the set-up of European Digital Innovation Hubs (EDIHs) and the potential creation of Testing and Experimentation Facility for Edge AI under the Digital Europe Programme should help the EMS and PCB industries to familiarize with and adopt Industry 4.0 tools.

• Support the creation of Consortium / Alliances / Clusters on Industry 4.0.

Such clusters support and/or mutualize investments in R&D&I[14], investments in equipment upgrades, and workforce training (notably through partnerships with Universities and Vocational Education and Training providers). Such clusters provide technical expertise to support industrial projects, offer mutualized production pilot lines, etc. Such clusters can also support the internationalization of companies (support to business plan, development of international communication tools, internationally oriented skills management, etc.).

Many clusters of this kind exist across Europe thanks to EU and member states funding and are completely or partially devoted to the transition towards Industry 4.0: WeNetwork (France), Captronics (France), the Bavarian Cluster Mechatronics & Automation (Germany), MicroTech SudWest (Germany), the Silicon Alps cluster (Austria), MESAP Innovation Cluster (Italy), DSP Valley (Belgium), VTT Research (Finland), and many others. Such initiatives should be encouraged and taken as an example, especially in the context of the Recovery and Resilience Mechanism (RFF).

• Drive industry standardization for electronics manufacturing data communications

For Industry 4.0 to be adopted and efficiently utilized at scale, a common industry data communications protocol is required to enable real-time, large data sets (Big Data), to be collected from manufacturing production lines. Data needs to be collected, organized, then analyzed using a large variety of equipment platforms. Without a common communications protocol (such as IPC-2591 **Connected Factory Exchange CFX**), data contextualization, analysis, and contextualiztion is not possible. Artificial intelligence, machine learning, and other advanced Industry 4.0 techniques are dependent upon an open-source manufacturing machine data protocol.

• Prepare human resources for the production of tomorrow

The pace of investment in Industry 4.0 is insufficient because of a training deficit and a lack of access to skills. The possible initiatives to upskill the workforce are numerous:

- **Upskill the workforce in Industry 4.0 ways of working and tools.** "Reskill and upskill" is one of the seven flagship areas for which the Commission strongly encourages Member States to invest in for their recovery plans (RFF). Member States' recovery plans should include projects dedicated to upskilling workforce in Industry 4.0 tools and technologies, paying attention especially to SMEs.

- **Raise public awareness of industrial careers associated to Industry 4.0.** Similarly, projects under the flagship "Reskill and upskill" could be dedicated to the teaching of Industry 4.0 related topics at early stage of education systems, to familiarize young students with this topic.

- **Launch a Sectoral Skills Alliances dedicated to Industry 4.0.** **Erasmus+** provide funding dedicated to **Sectoral Skills Alliances,** designed to tackle skills in specific sectors, aligning Vocational Education and Training (VET) systems with labour market needs: modernizing VET by adapting to skills needs and integrating work-based learning, strengthening the exchange of knowledge and best practices, improving labour market mobility, and increasing the recognition of qualifications. The set-up of a Sectoral Skills Alliance dedicated to Industry 4.0 would regroup players of the electronics, software and telecommunication industries as well as players of any industry affected by Industry 4.0 in order to precisely identify the needs and upskill the workforce through dedicated training programs.

- **The Microelectronics Pact for Skills** can help upskilling the workforce in Industry 4.0 tools provided PCB manufacturers and electronic manufacturing services (EMS) are included in the resulting initiatives.

• Accelerate the development of telecommunications infrastructure

The successful deployment of Industry 4.0 depends on internal investments in companies, but also on investments in infrastructure associated with connectivity: first and foremost, the deployment of 5G-6G and optical fiber. Connectivity is one of the three industrial priorities of Commissioner Breton, targeting a widespread Internet coverage across the EU by 2025 (1 gigabit per second download, 100% of the population), through the deployment of 5G, the preparation for 6G and the linking of connectivity with space (secured satellite communication infrastructures). A rapid deployment of 5G and optical fiber appear crucial to help the entire electronics supply chain in its transition towards industry 4.0, including SMEs. By leveraging factories of the future, European manufacturers will become more competitive while also facilitating the ecosystem's transition to a digital and circular economy.

a. Leverage factories of the future to support industrial base competitiveness

To remain competitive in the global marketplace, European electronics manufacturers will need to migrate to factories of the future. Technologically, these factories of the future will be able to perform the increasingly sophisticated manufacturing required, but they also promise to make these European manufacturers more cost efficient, by increasing output and bringing down costs.

[14] Research & Development & Innovation.

Investing in digitization, artificial intelligence, and automation offers a meaningful path for European manufacturers to gain market share, especially in an environment in which thin margins govern decisions.

b. Leverage factories of the future to support Europe's digital transformation

Electronics are at the heart of Europe's digital transition and objectives to develop the next generation of digital technologies, including supercomputers, quantum computing, blockchain, and human-centered artificial intelligence. Digitization is a key factor of competitiveness and a priority for the European Union. As digitization spreads over more and more sectors, more and more industrial players need to integrate electronic functions into their products & services. Thus, one of the main effects of digitization is the arrival of new consumers (BtoB[15]) downstream the value chain, that are companies whose traditional business is outside the electronic ecosystem, but which need to integrate digital tools (hardware & software).

The ecosystem of electronics printed circuit board assemblers is one of the first interfaces between these newcomers and the electronics value chain. The historical knowledge of the electronics value chain from Electronic Manufacturing Services (EMS) and their position at the middle of the value chain make them the ideal players to drive the digitization trend, playing a key role of both intermediates and knowledge/training providers.
Hence, investment in smart factories for EMS companies provides a knock-on effect in boosting the digitization process and potential across industrial sectors which incorporate electronics.

c. Leverage factories of the future to meet the European Union's environmental goals

Europe has set ambitious environmental goals with the **European Green Deal's** objectives to reach a climate-neutral economy in Europe by 2050. The European Union is also setting new goals for a circular economy that is fundamentally reliant on greater transparency about the production and flow of goods through the supply chain and into the marketplace.

In addition to manufacturing electronics that will allow other industries to help achieve Europe's environmental goals from smart meters to wind turbines to e-mobility/electric vehicles, the electronics manufacturing industry also has the opportunity to leverage factories of the future to ensure that it is a constructive EU partner in its own right. Factories of the future mean more data, and more data will allow the ecosystem to be more proactive in its use of raw materials, consumption of energy, and disposal of waste. In other words, Industry 4.0 enable improvements in supply-chain management, reducing the associated pollution emissions.

[15] BtoB: Business to Business is a situation where one business makes a commercial transaction with another

5.4 Combine strategic autonomy and trade openness

As a multi-layered industrial ecosystem, the electronics manufacturing sector traditionally relies on sophisticated global value chains through which services, raw materials, parts and components are exchanged between countries to support intermediate and final production of goods.

Geopolitical shifts, the impact of trade wars and COVID-19 have led to a re-analysis of supply chains and a focus on resiliency and diversification. It is however a reality that global supply chains that have evolved, and continue to evolve, to meet business requirements and optimize cost.

The electronics manufacturing industry requires a robust supply chain for raw materials, connectors, electronic and microelectronic components and printed circuit boards as well the manufacturers that assemble these into electronic systems that are incorporated into the final product.

It is important in this context that the evolving European concept of "open strategic autonomy" continues to strike a careful balance between support for regional production and a flexible global supply chain.

This requires a network of trusted trading partners to build a reliable, strategic trade area. This implies seeking alliances and continuing to work with like-minded partners at the multilateral and bi-lateral level to avoid the creation of new tariff and non-tariff barriers.

Recommended priorities in this context are as follows:

- Continue to pursue strong and managed relations with China through the Comprehensive Agreement on Investment and other means. China remains a hub for production of electronics, a major export market for Europe's industries and an important foreign investment destination.

- Re-set the Transatlantic dialogue with an objective to jointly work toward creating more secure and resilient electronics supply chains.

- Ensure well-functioning EU/UK relations to limit the impact on electronics manufacturing in terms of potential tariffs, standards, rules of origin and trade facilitation. As our closest neighbor, the UK plays an important role in diversification of supply chains and is intricately interwoven into existing supply chains

- Support a stable multilateral trading system that provides predictability, transparency and removes barriers to free trade and in which businesses can thrive.

5.5 Enhance vocational training and lifelong training

The EU benefits from an excellent education and R&D ecosystem leading to a great ability to train high-skilled employees in many areas (machine learning, cybersecurity, cryptography, blockchain, photonics, etc.). Yet, four main challenges need to be addressed in order to remain competitive in the fast-changing innovative landscape.

1- **Faster than ever pace of innovation of the sector: Data science & analytics, artificial intelligence, big data, IoT, smart systems.** The school-to-work transition is currently very challenging, requiring costly, extensive in-house training for new workforce. The associated costs are especially difficult to support for the large European ecosystem of Small and Medium-sized Enterprises (SME).

2- **A lack of engineers.** Since the early 2000s, the demand for electronics talent in the EU has constantly increased while the corresponding supply has dropped in relation. The current number of open vacancies regarding electronics engineers in Europe now stands at 64,000[16]. During this period, China has impressively raised its number of trained engineers in electronics so that there is currently a huge gap as Europe seeks to compete with China. According to the OECD[17] on the STEM graduates (Science, Technology, Engineering and Mathematics), if the proportions of STEM graduates continue at the current levels, China and India will account for nearly 2/3 of the OECD and G20 STEM graduates in 2030 (respectively 37% and 27%). Considering the BRIICS countries (including Indonesia), it is estimated that they will produce three-quarters of the global STEM graduates in 2030. Europe and the United States will be lagging well-behind with 8% and 4% of STEM graduates by 2030, respectively.

3- **An aging workforce: Increasing rates of losing key skills & knowledge.** The EU electronics ecosystem suffers from a hole in the middle of the age pyramid (employees from 30-50 years old), combined with an ever-decreasing interest from the young generation in manual and engineering jobs. The image of manufacturing jobs should be improved in this regard, the main threat being to lose key skills and knowledge if this hole is not filled soon enough.

4- **Gap between hardware and software.** Learners and future workforce insufficiently connect electronics manufacturing (hardware) with Digital innovations: Software, data, artificial intelligence.

In November 2020, Commissioners Breton and Schmidt have launched **the European Pact for Skills,** a central element of the European Skills Agenda. The Pact for Skills promotes joint action to maximise the impact of investing in improving existing skills (upskilling) and training in new skills (reskilling). It calls on industry, employers, social partners, chambers of commerce, public authorities, education and training providers and employment agencies to work together and make a clear commitment to invest in training for all working age people across the Union.

[16] Source: European Commission ICT Monitor
[17] Source: Report" Education Indicators in Focus N°31" of the OECD published in 2015

The EU has launched three Pacts for Skills associated to three industries: Automotive, Aerospace & defence and Microelectronics. The **Microelectronics Pact for Skills** encompasses initiatives representing an overall public and private investment of €2bn in order to upskill and reskill more than 250,000 workers and students (2021-2025) in Europe's electronics clusters.

Here again, taking into account the electronic supply chain as a whole appears essential.

Printed Circuit Board (PCB) manufacturers and electronic manufacturing services (EMS) should have the opportunity to participate in the Microelectronics Pact for Skills on the same basis as players in the microelectronics value chain itself.

Similarly, **Erasmus+** provide funding dedicated to **Sectoral Skills Alliances,** designed to tackle skills in specific sectors, aligning Vocational Education and Training (VET) systems with labour market needs: modernizing VET by adapting to skills needs and integrating work-based learning, strengthening the exchange of knowledge and best practices, improving labour market mobility, and increasing the recognition of qualifications.

In 2019, the **METIS**[18] project was launched: A Sector Skills Alliance for Microelectronics. This project will run until 2023. **A Sectoral Skills Alliance could be proposed for other stages of the electronics value chain: European PCB manufacturers, passive component suppliers, interconnection manufacturers and electronic manufacturing services (EMS).**

5.6 Support Europe's leadership in voluntary, international, and industry-driven technical standards.

European policymakers need to adopt a more intentional and proactive strategy aimed at helping European stakeholders to shape international technical standards. China, for example, is developing its Standards 2030 plan and supporting companies that take part in international standards committees.

Given the crucial importance of standards to technological innovation and adoption, Europe needs to place equal emphasis on new digital standards development activities, and it must do so with an eye toward leveraging industry-led standards development. Industry Standards Developing Organizations (SDOs) have proven be nimbler and more responsive to industry concerns and needs.

[18] METIS stands for MicroElectronics Training, Industry and Skills.

The electronics ecosystem is highly globalized and experiences rapid technology changes that require the development of international standards. To remain competitive, Europe needs to establish processes and practices that help the delivery of state-of-the-art solutions in a timely and cost-efficient manner. Industry competitiveness highly depends on effective harmonized standardisation and the EU could take actions to foster the competitiveness of its electronics sector by:

- Seizing the opportunity of the new Industrial Strategy for Europe to reconsider industry standards as market-driven implementation tools rather than legislative tools impeding or slowing down delivery of products on the market. Europe needs to adopt harmonized European standards to match the latest state-of-the-art developments in a timely manner in order to prove its global leadership.

- Re-establishing the standardisation processes which have worked as a successful model under the New Legislative Framework (NLF) for many years, with the right balance of participation in the process from the Commission, Member States, European standardisation organisations and stakeholders.

- Giving priority to the well-established NLF route of the consensus-based harmonized standards over technical specifications in delegated or implementing acts.

The recent Joint Declaration of 18 member states for a **European Initiative on Processors and semiconductor technologies** goes in the right direction and calls for a "work towards common standards and, where appropriate, certification for trusted electronics, as well as common requirements for procurement of secure chips and embedded systems in applications that rely on or make extensive use of chip technology".

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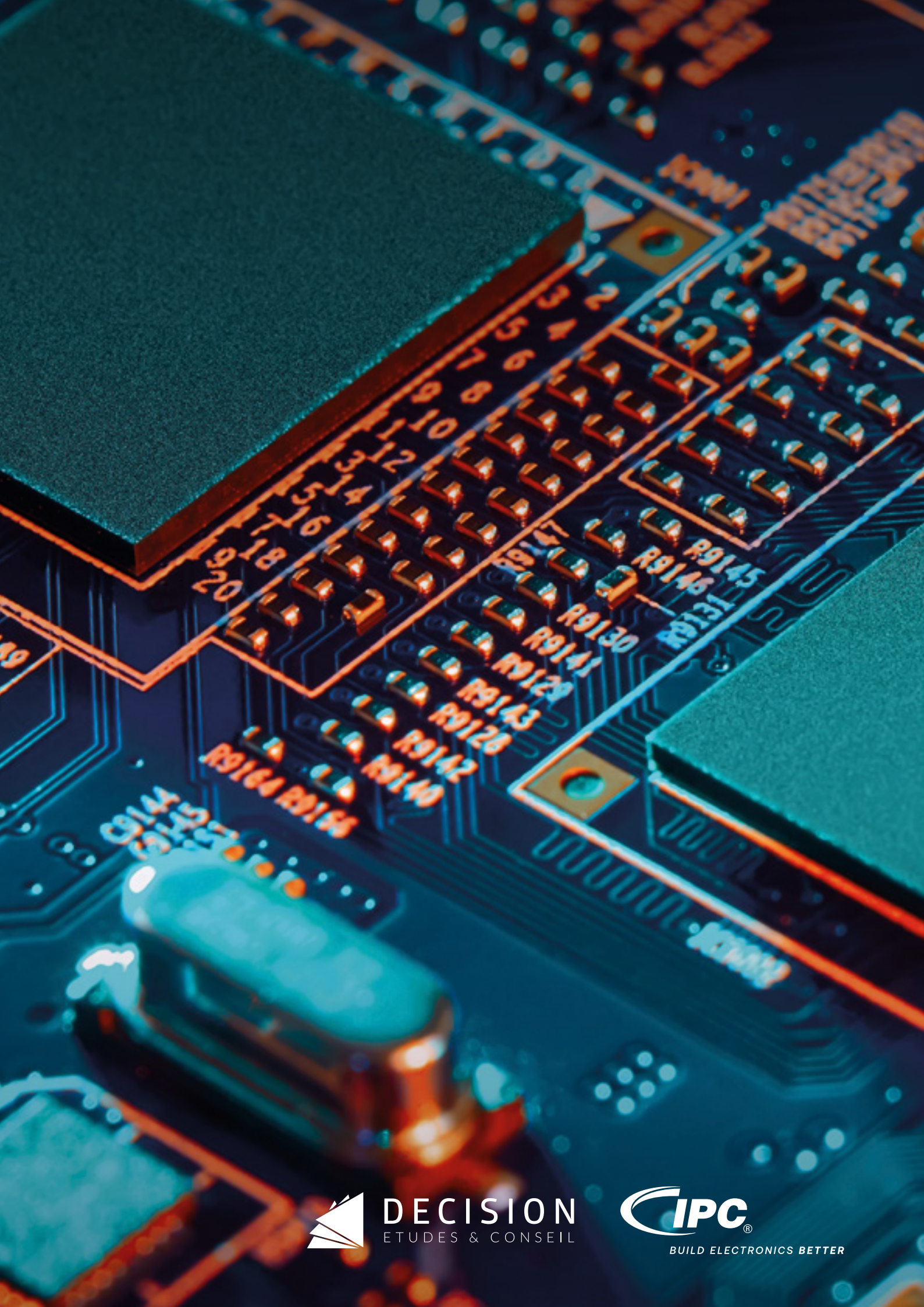
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