COREnect

European Core Technologies for future connectivity systems and components

5G PPP

PASSIVE USER OR INNOVATIVE DRIVER?

EUROPE'S FUTURE ROLE IN MICROELECTRONICS AND CONNECTIVITY.

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LIST OF ABBREVIATIONS

API	Application Programming Interface
GDP	Gross Domestic Product
IoX	Internet of X
IPCEI	Important Projects of Common Interest
KDT	Key Digital Technologies
OEM	Original Equipment Manufacturer
OTA	Over the Air
R&I	Research and Innovation
SNS	Smart Networks and Services
SoC	System on Chip
V2X	Vehicle to Everything
VC	Venture Capital
WTO	World Trade Organization

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01 INTRODUCTION

In the advent of an intelligent and connected world, the underlying, enabling technologies have made headline news. Modern societies' dependence on semiconductor technologies, microprocessors, and system-on-chip (SoC) has become painfully obvious in a very short time. In parallel, the evolved digital infrastructure and related technologies are becoming undisputable cornerstones for economic development. Like roads, power grids and other basic infrastructure that once propelled societal development in the 1900s, digitalization will do the same for this century. However, the roads towards future, sustainable prosperity are not made of asphalt – they are spelled waveguides, photonics, wireless and silicon.

In this whitepaper the intention is to showcase how the mobile connectivity revolution will affect existing ecosystems and verticals, and present proposals to secure European relevance in future global ecosystems and position European wide industry and economy ideally in this coming digital revolution despite ever-growing global competitions. To make the discussion as inclusive and comprehensible as possible we will use the automotive industry - one of the most reputed and long-standing European industry champions - as an exemplary case study, with the aim to exemplify how evolved software, hardware and connectivity are transforming the very core of the business. To do this with the deepest level of competence, a selected set of questions were used in interviews with key representatives from the automotive business. Their unfiltered answers are the foundation for the discussion in section 2 where key trends for the coming 10 years are elaborated on.

As a second step we apply acquired insights at a higher level in section 3 and discuss how other verticals may follow a similar path as the automotive industry. We discuss the role of European telecommunication and microelectronic industries as key enablers to maintain European value creation across business segments. To guide the analysis, the COREnect expert groups have provided valuable perspectives - representing leading institutions and companies across Europe.

Finally, section 4 suggests important strategic directions for Europe to consider. Despite outlining clear recommendations for the coming years, the main objective with this whitepaper is not to provide a golden recipe. Our goal is primarily to catalyze a continued discussion and bring general awareness about the inevitable challenges and opportunities Europe will face in an intelligent and fully connected green and digital world.

02 AUTOMOTIVE INDUSTRY CASE STUDY

IN THIS SECTION WE WILL FOCUS ON THE AUTOMOTIVE INDUSTRY AND THE CLEAR TRENDS CURRENTLY EXPERIENCED BY THE BUSINESS.

- From mechanics to electronics & software
- New drive trains
- From stand-alone to in-the-cloud
- From utility element to lifestyle
- New continents
- New business models

It is expected that these trends will continue. No major disruptions or revolutions are expected, but the six trends listed will continue to evolve with different speeds throughout the automotive value chains. Key aspects include what type of components will be needed for future cars, how to embed more and more intelligent systems in vehicles and how to get a viable solution for key challenges as e.g., security, privacy, and safety. We now will zoom into these major trends one by one.

FROM MECHANICS TO ELECTRONICS & SOFTWARE

In the past, almost all focus of car manufacturers was on the engine and horsepower. The engine development departments grew as every control point contained a sensor and an electronic control unit (ECU). Hundreds of sensors and ECUs were present around the engine and there was no real well-thought electronics architecture design. In line with how mechanical systems are traditionally designed, the practice was one black box per function. However, this mindset is undergoing a rapid change. Today's electronics architecture in a car consists of a number of functional domains, each having a domain controller. It is expected that future architectures will evolve into full-scale compute and server platforms as depicted in Figure 1. Thus, the automotive industry will become even more dependent on electronic components and integrated systems in the future.

Besides electronics and software to get the car moving, there is also complexity added in terms of performing safety and security checks as well as monitoring health or lifetime of electronic components and batteries. In addition, the evolution towards autonomous driving adds even higher software complexity to vehicles e.g., driver monitoring to detect health issues or fatigue.
As a result, automotive OEMs will have to drastically ramp up investments in electronics architecture, ECU semiconductor development, and software. It is envisaged that IT infrastructure will become heavily involved in future car architectures and lifetime operations. In the most recent car platforms, the software content is tenfold that of previous generations. Virtual development processes and virtual prototyping is also transforming the way vehicles are developed.

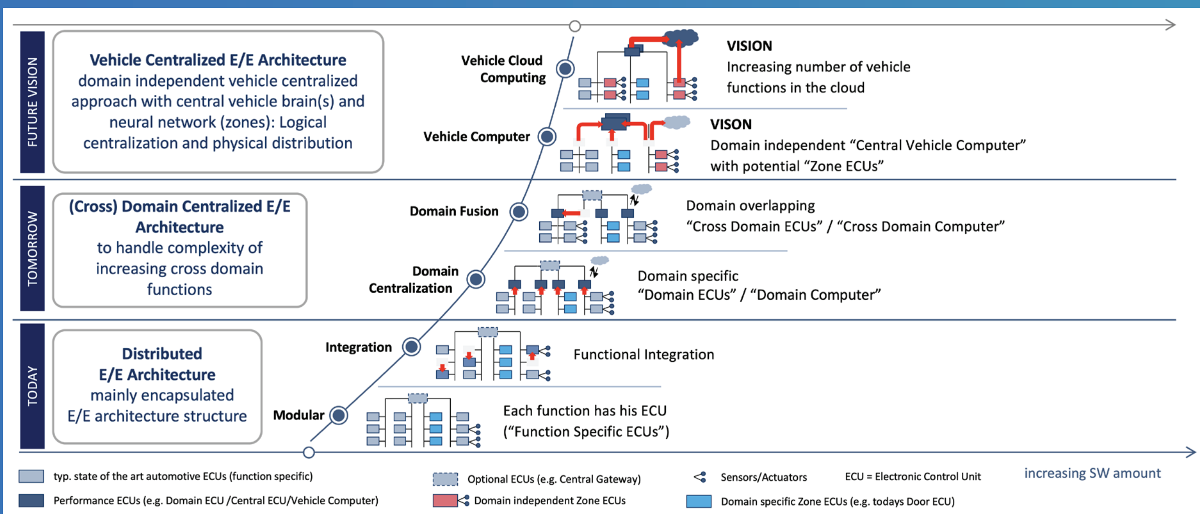

Figure 1 **Evolution of the electronics architecture in a car** / Source Bosch

Today's vehicles contain more software than most other embedded systems and tomorrow's vehicles will contain far more. The semiconductor value in a car is also anticipated to more than double over the next decade.

Source McKinsey 2018

NEW DRIVE TRAINS

In the past the classical Diesel or Otto combustion engines were the norm. Hybrid cars was a niche market, in which Tesla has started, and fully electric drive trains were non-existing. The current trend towards electric drives is exponential. Electric drive trains are much simpler from a mechanics and maintenance point of view but much more complex in terms of control. Cars have become data centers on wheels.

Battery capacity and mileage is expected to stay important for the next five years or so, but when cars reach a battery mileage of perhaps 600km the race will end and be viewed as good enough by most customers. This is very much like the standby time for cellphones 15-20 years ago, which needed to increase at that time, but now has been accepted as a de facto standard. However, research will continue to pursue advanced algorithms to reduce energy consumption.

FROM STAND-ALONE TO IN-THE-CLOUD

In the past, the automotive OEMs very much used the business model "sell and forget". A car was sold on the market and the car manufacturer had almost no continued interaction with the car. Maintenance was almost completely handled by the car dealer network.   Nowadays this has completely changed as the car is connected and part of the cloud. It is important to the OEM to monitor, interact with, and update the car remotely. Software upgrades need to be done over-the-air (OTA). Some semiconductors have a shorter economic or obsolesce life than the car itself and hence it is needed to predict their end-of-life and replace them before the car malfunctions. So, future vehicles will keep the development departments of OEMs busy over the whole lifetime of the car, whereas in the past they were only involved in the manufacturing of the car.

Data rates inside vehicles have also exploded the last ten years, going from megabits to gigabits per second. It is expected that within the next decade transfer speeds of more than 25 Gbit/s will be required.   This has to do with both the increased complexity of the electronics and the connectivity requirements.

Also, external connectivity will become increasingly important and demand high bandwidths with low latencies[1]. This is important to support a number of advanced services for users, awareness, safety, and entertainment. The roll-out of 5G and 6G will also play an important role into this as well as the interplay with different connectivity standards and functions (e.g., radar technologies combined with 5G/6G, V2X, LTE, etc.). Supporting the aforementioned use cases to the level of fully autonomous driving (i.e., level 5 – full driving automation[2]) requires further extensions in multiple network domains and appropriate application programming interfaces (APIs) for the V2X service provision. Thus, it is expected that cars will become an element in the cloud. Moreover, customers will require bringing their digital environment (e.g., built around their smartphone) into the vehicle. It is expected that infotainment and entertainment requirements will turn the car into a sound-and-vision environment on wheels, especially considering the dawn of autonomous driving.

FROM UTILITY ELEMENT TO LIFESTYLE

In the past, a car was used to move from one point to the other. Nowadays buyers look much more into the functionality of the car. The perception of the vehicle, the type of materials used, and the connectivity/infotainment have become more important than the physical performance. We can make a comparison with the cellphone. In the past a mobile phone was used to call a person. Nowadays a phone has become a smartphone with extended functionalities, which also shows what type of person you are. The same is happening with the car. The type of car and selected functionality show what type of person you are, and people are very sensitive to this. It has become an important element of everyone's lifestyle. Software differentiation is thereby important and open APIs will make it possible for fleet operators to put own software on top of the manufacturer baseline to create extra value and enables customer retention.

NEW CONTINENTS

In the past Europe and the US were the two dominating continents for the car industry. However, today China has become the biggest market with 50% of all vehicles produced sold there. The value chain in the Chinese market is different compared to the US and the EU and on top of this comes geopolitical challenges. For OEMs it is therefore important to produce in or close to the market and to closely follow and understand the expectations of Chinese customers.

1 1. 5GAA TR S-200137, Working Group Standards and Spectrum Study of spectrum needs for safety related intelligent transportation systems - day 1 and advanced use cases, June 2020.

2. 3GPP TR 22.886 (V16.2.0), Study on enhancements and support for 5G V2X services, Release 16, December 2018.

3. 3GPP TS 22.186 (V16.2.0), Enhancement of 3GPP support for V2X scenarios, Release 16, June 2019.

2 SAE International, Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, accessible at https://www.sae.org/standards/content/j3016_202104/

NEW BUSINESS MODELS

Pay-per-use instead of ownership-based business models are spreading in the car industry. The concept of owning a personal car is questioned by younger generations who live in apartments, enjoy good public transportation, and have a high degree of sustainability awareness. With a pay-per-use or rent model for car usage, the incentives for manufacturers change. With such a business model, subsystem or component wear or even failure is no longer an income opportunity but an expense. This will create an even stronger drive towards the intelligent, electrical, self-diagnosing car with a minimal environmental impact.

Another change in the business is that OEMs now work directly with semiconductor and software companies. In the past, the value chain was multi-layered, structured as an OEM-TIER1-TIER2 operation. This has now been transformed into a value network where TIER1 players are not always in-between the OEM and TIER2 suppliers (semiconductor companies). New players have entered the market, e.g., Mobileye and NVIDIA, and global technology giants such as Google and Apple are accelerating their investments. Some automotive OEMs are even considering building their own chips for strategic subsystems, which is already the case with for instance Tesla.

A lot of start-ups have been created in recent years to work on hardware and software technologies for self-driving cars. This creates a lot of pressure on established OEMs to adapt and accelerate their development processes. Until now, the automotive market has been an "evolution", whereas today it is more of a "revolution", with new players entering and new features constantly being requested by customers. As a result, there is a clear wish to have system ownership and maximum flexibility to replace subsystems and computational platforms when desired.

03 ANALYSIS AND LEARNINGS

IT IS OBVIOUS THAT THE CAR INDUSTRY IS UNDERGOING A SIGNIFICANT CHANGE AND HAS BEEN DOING SO FOR SEVERAL YEARS.

The accelerated value transformation as outlined in section 2 is fueled by connectivity, microelectronics, and software, including specific requirements on safety, security, and privacy. Areas where Europe has gradually been falling behind over multiple years. Old strongholds for established manufacturers, e.g., mechanics and drive trains, will lose importance in favor of abilities to connect to consumer's digital ecosystems[3]. Replacing combustion engines with electric power trains will not change this journey.

As a first step, classical measures related to the physical performance of combustion powered cars as we have known it for decades (acceleration, horsepower, cylinder count etc.) will reach an endpoint and be transformed into battery capacity and mileage. This is happening already today and will continue for some time.

However, as technology progresses and these initial key technical differentiators reach a maturity and performance level viewed as good enough by the bigger audience, the market segmentation will change. Adding new capabilities such as autonomous driving and sensing will underpin this transformation further and eventually completely alter the value proposition. By that time, cars will be designed like mobile computers and the value chain and supplier landscape will look fundamentally different.

3 "The car of the future is connected, autonomous, shared, and electric", ZDNet special feature, https://www.zdnet.com/article/the-car-of-the-future-is-connected-autonomous-shared-and-electric/

The value creation and differentiation among car manufacturers will to an overwhelming degree be linked to platform chipsets and software.

Addressing the bigger picture, observations from the automotive industry case study are important to consider for several reasons. Although belonging to a specific vertical, the background mechanisms are applicable to almost every European industry today. Everything benefitting from being connected will be connected as part of the IoX (internet of everything) mobile revolution. As a result, IoX will enrich all product segments and create added value for consumers - but is the European ecosystem equipped to embrace and capitalize on this transition?

forward. In fact, leading microelectronic businesses in Europe have no significant impact on the global software ecosystem. The only hardware players that can rightfully claim to have any impact are global giants such as Qualcomm, Nvidia, Intel, and ARM who invest heavily in software development. To participate in the market, all others are simply forced to comply with rules and requirements defined by those controlling the ecosystem. Consequently, it is unlikely that the European microelectronics industry will be able to drive any disruptive or truly differentiating innovation beyond its existing position at the bottom of the value chain in IoX.

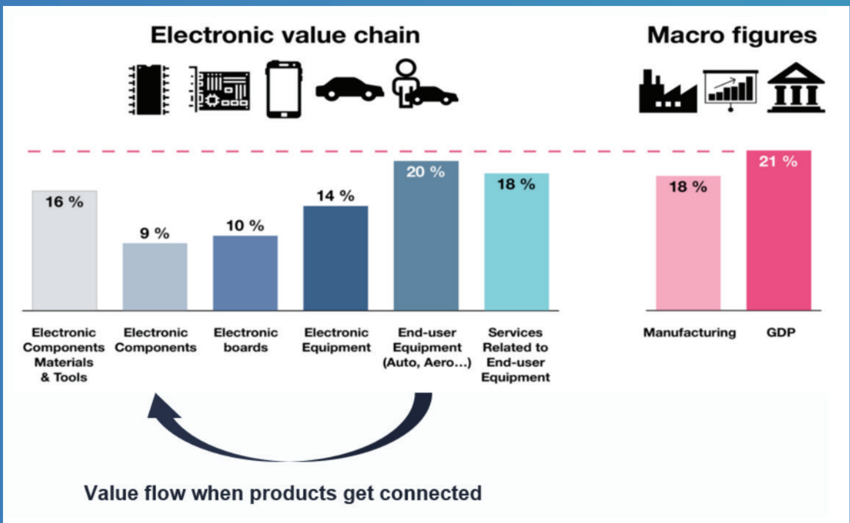

Figure 2 **The European value footprint globally for different segments**[4]

As seen in Figure 2 Europe is today positioned close to the end customers with a large relative footprint for end-user equipment and related services. The percentage is much smaller for electronics and embedded systems. When added value is created thanks to connectivity and software, Europe's share of the total value add will be diluted and shifted to areas dominated by other regions.

The main powerhouse for IoX will be software applications and the associated ecosystems, much like for mobile handsets over the past decade, and the enabling technologies will be largely similar. Whoever controls the (de-facto) standards, architecture, and interface specifications will indirectly control the software ecosystem as well. None of today's major software and developer ecosystems for IoX are of European origin and there are no signs of change going

This reality will not only hamper the communications industry in Europe, but more importantly, affect the European competitiveness and growth across multiple domains. Europe will relentlessly fall further behind the dominating 5G ecosystems today (US and far East) and lose the race towards 6G before it has even started. Unless Europe breaks this trend and proactively establishes investments to enable IoX leadership, the European share of the global GDP will be challenged.

4 DECISION Etudes & Conseil, 2018, https://www.decision.eu/en/our-expertise/#electronique

04 PROPOSED ACTIONS FOR EUROPE

THE LONG-TERM SUCCESS OF EUROPEAN DIGITAL INDUSTRY WILL DEPEND ON HOW EUROPE CAN SECURE ITS PRESENCE IN THE OVERALL 5G VALUE CHAIN, I.E., ON EU'S CAPABILITY TO CAPTURE ITS STRENGTHS ON DIGITAL INFRASTRUCTURE AND INDUSTRY VERTICALS, CATALYSE RESEARCH AND INNOVATE IN THE MICROELECTRONICS DOMAIN, AND EVENTUALLY BUILD A FULL STRATEGIC VALUE CHAIN.

This shall serve as a solid industry base for attaining European open digital autonomy. This however does not mean necessarily to control all elements of the entire value chain, but rather to focus on controlling essential parts of it, by mastering advanced and competitive technologies, and meanwhile ensure mutual dependencies between different regions. Such a strategy would coincide better and be more secure with respect to global free trade, that benefits Europe and other continents, and at the same time position Europe well, while facing global industry and political challenges. There should be different sources in the supply chain in each technology area, to minimize dependencies, and to maintain alternatives in the supply chain.

To achieve such a strategic goal in the next 10 years, COREnect recommends focusing on the following:

- Secure Europe's leading role in digital infrastructure in terms of demand and supply.
  - Use digital infrastructure such as 5G/6G as a general-purpose innovation and business platform to improve Europe's position in services and applications.
  - Accelerate digital adoption among industries, public administrations, and citizens, to enhance European market drivers.
  - Apply strategical R&I investments to strengthen Europe's capability to supply technologies targeting both infrastructure and devices.
- Establish coordinated R&I funding programmes to support a value chain strategy.
- Employ complementary actions at regulatory level in terms of education, early-stage investments, IPR, and other policy-oriented issues such as public procurement.

The above recommendations will be further addressed by COREnect during 2022 and made available as part of the project dissemination. In section 4 some initial orientations and findings are discussed.

THE DIGITAL INFRASTRUCTURE AS AN INNOVATION PLATFORM

The pandemic crisis has shown that Europe is lagging in the availability of a sufficient and reliable broadband infrastructure and services and applications in different domains compared to other regions. The availability of broadband internet access is in general not sufficient in Europe, especially in less densely populated areas. Governments now acknowledge the need for such investments to harmonize digitalization between regions in Europe. On one hand, the COVID-19 crisis provided a big push for digitalisation in Europe, but on the other hand it also showed painful deficits to overcome.

In addition to infrastructure, Europe should also strengthen its capability on end user devices. While it might be difficult to regain a leading position on the mobile handset market, all kinds of novel devices and consumer goods are expected to be connected with 5G/6G, including industrial applications. This is an opportunity for Europe to gain control of important pieces of the value chain as the European ecosystem still holds a strong manufacturing industry in multiple domains, e.g., chemistry, machinery, automotive, electrical engineering, medicine, etc., as well as sectors such as logistics and health targeting more environment friendly processes and business models. This is in line with policy objectives of the European Union such as Green Deal, Cybersecurity, and Digitalisation of Society and Economy.

The impact of cloud/IaaS/SaaS providers on the value chain must also be addressed. To support the growth of their service business, GAFAM (Google-Apple-Facebook-Amazon) have moved to vertical integration, including designing customized chips to meet their needs (Apple MX, Amazon Graviton2, Google TPU). The same trend is true for Asian players (Alibaba Hanguang & Xuantie, Baidu Kunlun). The objective is to optimise both software and hardware to the targeted application, to differentiate through innovation, and to drive cost structure down by having more control on the required computational hardware (for example, Graviton vs. Intel solution in the AWS offer).

Since Europe does not have any top tier Cloud/IaaS players, this may limit the addressable market of European semiconductor suppliers and in turn Europe's capability to spearhead connectivity and cloud technologies. Consequently, the European Cloud/IaaS ecosystem needs to be supported to secure European sovereignty and leadership.

The diversity of the European economy provides multiple opportunities to develop new services and applications based on 5G/6G in various sectors, and these can also be applied in other regions around the world. Industry alliances could be supported, e.g., with the following process-oriented matrix approach:

- Vertical industry alliances to identify drivers for new chip technologies and technical requirements for different application scenarios such as 5G/6G, automotive, health, logistics, manufacturing etc., as well as consumer products considering Europe's strong industry base. This would enable new drivers and industries benefitting from the digitalization to formulate technical requirements and eventually increase the demand on new chip technologies developed in Europe.
- Horizontal industry alliances to master commonalities between different application scenarios and technical requirements. By combining competences and pooling resources, this may also lead to an enhanced market position and a more competitive product portfolio.

The cross-fertilization of both vertical and horizontal industry alliances would allow for a strategic roadmap in terms of market potential of different chip technologies. This would guide public authorities and private actors where and how to place funding.

One of COREnect's main objectives is to "create the condition for one or more European champion(s) in core technologies for attaining technology sovereignty in future connectivity systems". Such champions could be start-ups or SMEs, either in a horizontal technology or in specific verticals, but could also be driven by key European organisations in the ECS domain, able to build a European community around components for 6G. Those two options could complement each other eventually.

Cooperation between companies, research organisations, and SMEs, must be promoted. R&I programmes should enable matchmaking between European SMEs and other stakeholders, covering not only technology and verticals, but also innovation, education, finance, and funding. Strengthening the interaction between SMEs and other players in the telecom and the ECS domains, as well as with vertical stakeholders, shall be a priority.

In general, there should be a clearer link between the overall European industrial strategy towards a sustainable technological sovereignty and activities supported by R&I funding programmes.

FUNDING FOR RESEARCH & INNOVATION

To make Europe a true champion of digital infrastructure for both supply and demand, it is paramount to develop and foster European ecosystems and value chains with coordinated public and private actions. Europe must support funding programmes to allow both vertical and horizontal industry alliances, thus building up knowledge, know-how, and IPRs for all elements in the value chain. This may require multi-year programmes with a value chain strategy, using instruments such as:

- Horizon Europe including Public-Private Partnerships, e.g., Key Digital Technologies (KDT)[5] and Smart Networks & Services (SNS)[6];
- EUREKA Clusters[7], e.g., Xecs, Celtic-Next;
- Important Projects of Common Interest (IPCEIs)[8];
- National R&I programmes.

In addition to long-term and large-scale funding programmes, Europe could further explore the possibility to provide flexible and fast-track options, with potentially lower funding amounts to stakeholders from industry, RTO, and academia, in the chipset value chain. As demonstrated by the COVID-19 emergency research program, such small or mid-scale flexible programmes would help the timely formation of research alliance and development in R&I areas where urgent actions are required.

5 Key Digital Technologies: new partnership to help speed up transition to green and digital Europe, https://digital-strategy.ec.europa.eu/en/news/key-digital-technologies-new-partnership-help-speed-transition-green-and-digital-europe

6 Smart Networks and Services Proposal, June 2020, accessible at Source: SNS proposal. June 30, 2020, https://ec.europa.eu/info/sites/info/files/research_and_innovation/funding/documents/ec_rtd_he-partnership_smart-networks-services.pdf

7 https://www.eurekanetwork.org/countries/canada/clusters/

8 https://www.ipcei-me.eu/

COMPLEMENTARY ACTIONS

In addition to strategic investments, it is also critical for Europe to reform its regulatory frameworks to meet the technical, economic, and geopolitical challenges while preserving and promoting European values.

The European economy is based on free global trade with a strong export sector. This requires an all-partner respect of trade agreements and rules set by the World Trade Organization (WTO). It is essential that governments and the EU Commission ensure a level playing field for actors from different regions. There should be a careful balance between open global trade and securing European interests. To achieve this goal, a clear export control strategy defined at European level (rather than state level) will enable Europe to better secure strategic know-how and support companies while remaining transparent and open towards business partners.

Like other regions (e.g., China and the USA) Europe should request state-aid rules to become more flexible to provide attractive conditions for investments in R&D and manufacturing - especially in the microelectronics domain. Potential means to be considered could include:

- Flexible and streamlined applications for state aid programs.
- Tax benefits for R&D investments on identified critical technologies.
- Incentives to invest and drive global standardization activities.
- Incentives for deploying and using leading digital technologies.
- Financial instruments to support company acquisitions within Europe in strategically important areas.
- Easier real estate and property handling for emerging and fast-growing businesses.
- Investments in education to secure leading skills in cutting edge technologies.
- Public procurement policies to favour a European open digital autonomy.

Supporting SMEs shall go beyond R&I programmes and activate policy-oriented actions as well. Corporate participation in venture capital (VC) funds targeting early-stage SME development and expansion should be encouraged. In addition, a 6G component platform could be created as well as pan-European sandboxes, where SMEs would automatically be eligible to offer products and services throughout the EU market.

Knowledge in computer science, software technology, telecommunications, and microelectronics is essential. Higher education curricula should reflect these needs to champion competence for advanced R&D and market exploitation. In these key areas Europe must be able to attract world leading educators and researchers. To address this challenge a multitude of measures should be explored including practical benefits and attractive conditions for talents to study, work, and live in Europe.

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