High Level Strategic Research and Innovation Agenda of the ICT Components and Systems Industries as represented by ARTEMIS, ENIAC and EPoSS

25 april, 2012

EPoSS
European Technology Platform
on Smart Systems Integration

ARTEMIS Industry Association
www.artemis-ia.eu

AENEAS
www.aeneas-office.eu

EpoSS
www.smart-systems-integration.org

Executive Summary of the High Level Strategic Research and Innovation Agenda of the ICT Components and Systems Industries as represented by ARTEMIS, ENIAC and EPoSS

VISION-MISSION-STRATEGY

The European ICT Components and Systems Industry, including knowledge institutes, share a common Mission, Vision and Strategy at the highest level of their Strategic Research and Innovation Agenda's. Based on a very wide set of technologies they will together enable the provision of breakthrough products and services.

VISION

The vision driving the ICT Components and Systems industries is of mankind benefiting from a major evolution in intelligent systems, a world in which all systems, machines and objects become smart, have a presence in cyber space, exploit the information and services around them, communicate which each other, with the environment and with people, and manage their resources autonomously. The vision of the European ICT Components and Systems industries is to provide Europe in a concerted approach with the controlled access for creating the indispensable technology basis for new products, systems and services and their applications essential for a smart, sustainable and inclusive European 2020 society.

MISSION

The mission of the European ICT Components and Systems industries is to progress and remain at the forefront of state-of-the-art innovation in the development of highly reliable complex systems and their further miniaturisation and integration, while dramatically increasing functionalities and thus enabling solutions for societal needs.

STRATEGY

The strategy of the European ICT components and systems industries is based upon exploitation of European strengths and opportunities:

- Exploiting strengths implies building on the leading positions in specific technology and application domains by increasing industry effectiveness, and reducing fragmentation,
- Creating opportunities implies for Europe to be positioned at the forefront of new emerging markets with high potential growth rates and to become a world leader in these domains.

Innovation is a key point for the strategy. It is propelled by efficient transnational eco-systems of industry, institutes, universities and public authorities. Detailed Vision-Mission-Strategy elements are published in the strategic documents (VMS resp SRA's) of each ETP.

TECHNOLOGIES and SOCIETAL NEEDS

The technologies, products and services of the ICT Components and Systems industry span information and communication technology, embedded systems, nanoelectronics, advanced manufacturing and processing and smart systems integration technologies. These technologies will offer major contributions to societal needs and challenges like smart transport, inclusive innovative society, health and well-being, energy efficiency and sustainability and climate.

POSITION and FUTURE of EUROPE

ICT components and systems, that are so important to tackle the societal challenges, are extremely important for Europe. About 10% of our GDP is depending on the enabling technologies provided by the ICT Components and Systems Industries, which implies a significant impact on employment as well. From an R&D perspective Europe has currently a good position in all these technologies. In the highly complicated products and services, as provided by the ICT industry, cooperation is essential as one company cannot master all technology elements in one house any longer. Therefore the initiatives to fund industry driven R&D&I programmes contribute significantly to the attractiveness of Europe. To make Europe also attractive for large investments in ICT a level playing field is mandatory. This must be accomplished by Member States and the European Union in comparison to other countries/areas in the world.

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1 Introduction

The Strategic Research and Innovation Agenda presented in the document in hand is the result of a discussion involving the three European Technology Platforms (ETPs): ARTEMIS, ENIAC and EPoSS. The ARTEMIS-ETP is incorporated in the ARTEMIS Industry Association and the ENIAC ETP is incorporated in the AENEAS Industry Association. These industry associations are the private partner in the ARTEMIS Joint Undertaking and ENIAC Joint Undertaking respectively. EPoSS is an independent ETP. AENEAS, ARTEMIS-IA and EPoSS are financed by their members.

The importance of the presented considerations is due to the fact that ARTEMIS, ENIAC and EPoSS gather the major players of the European ICT landscape addressing ICT technology priorities that are crucial for the competitiveness of European industry:

- ARTEMIS, focusing on Embedded Systems and adding intelligence at all levels of dependable, complex and networked distributed HW/SW systems, interfacing with the physical world;
- ENIAC focussing on Micro- and Nanoelectronics components, Wafer-level integration, materials and manufacturing equipment;
- EPoSS focussing on subsystems and systems with advanced functionalities addressing bottlenecks of hardware development and systems integration.

In spite of the clear differences between them they share a series of objectives and common intentions, particularly in view of future R&D&I policy strategies at European level. The strategic dimension of the considerations as presented in this document goes well beyond the horizon of the mentioned ETPs and are also overlapping with the intentions of a series of others, in particular Photonics 21, NESSI, EUROP, Net!Works and various Eureka clusters.

The present document offers a common denominator of a Strategic Research and Innovation Agenda (SRIA) describing the Research & Development & Innovation (R&D&I) vision, mission and strategy of companies, which – in order to simplify - in this document are called **ICT Components and Systems Industries**. "ICT Components and Systems Industries" **therefore is to be interpreted in a wide sense, including systems integrators and equipment and material suppliers**. This high-level document was prepared in response to a request by DG INFSO to the ARTEMIS-, ENIAC-, and EPoSS ETP's, as representatives of these industries.

The SRIA covers the time span from now to 2020 and Technological Readiness Levels (TRL) 1-8 (see chapter 2.3.1), thereby covering all necessary steps starting from fundamental research and ending at large-scale innovation pilots and qualified pre-competitive pilot productions. It is intended as the high level strategic document for the National and Europe-wide research bodies policies and funding instruments in this field.

The SRIA is focussing on Europe. It provides a vision, mission and strategy dedicated to (re)enforce the European position in the world and it highlights methods to reverse the current decline of manufacturing infrastructure for capital intensive industries and to increase market share for the European industry. It aims to keep activities of the ICT Components and Systems Industries in Europe and to make Europe not only an attractive market but also a very attractive continent for investments by these industries.

To implement the strategy developed in this SRIA, a strong and sustainable commitment for Europe is needed, in terms of both financial investments and human capital availability. This can be achieved only in a joint effort of public authorities, including the EC, and the involved industries by building an attractive ecosystem consisting of large companies, SME's, knowledge institutes, and authorities operating on a truly level playing field.

The ICT Components and Systems Industries are in principle willing to take up the commitment of implementing the strategy, in fair and balanced public-private partnerships with all ecosystem partners. However, at the time of writing of this document, the visibility of future EC regulations in respect to R&D&I is limited, resulting in continued uncertainty on the operability of the necessary public-private partnerships and on R&D&I policy in Europe. A disclaimer on the commitment of the R&D actors is necessary, therefore, pending the evolution of relevant information on critical items, including for example:

1 The response to the on-going EC consultation on state aid for R&D&I and on regional funding is not yet known, neither for the long term, nor for any bridging measures in order to, e.g., increase the response speed in notifications of large scale projects, as needed urgently for approval of KET pilot line projects.
2 The financial means and instruments for funding of public-private partnerships are at discussion in both the member states and the EC. The resulting uncertainty hampers collaboration in the broad ecosystems with ICT Components and Systems Industries in Europe today, and endangers conditions moving to the next level. Limiting funding to a limited set of ecosystem partners will be counterproductive.
3 The present Horizon 2020 document is vague in addressing economic and industrial sectors, especially in the technology domain. Communication, e.g., the C in ICT, seems to be deemphasized at this point. This makes the interpretation of future EC priority allocation and processes unclear. Furthermore some intellectual property regulation proposals lead to industrial inefficiencies.

2 Vision, Mission and Strategy

2.1 Vision

The vision driving the ICT Components and Systems Industries is of mankind benefiting from a major evolution in intelligent systems, a world in which all systems, machines and objects become smart, have a presence in cyber space, exploit the information and services around them, communicate which each other, with the environment and with people, and manage their resources autonomously.

In this vision the role of the European ICT Components and Systems Industries will be to (re)enforce their global competitive position by leveraging and aligning individual core competencies and strengths in design, in products and services delivery and in their European integration and production capabilities and infrastructures, while remaining viable and profitable.

An important vision element is that ICT based systems are addressing the challenges and opportunities created by today's and tomorrow's societal demands in health and wellbeing, energy efficiency and smart transport and smart communities, to mention a few.

The vision of the European ICT Components and Systems Industries is to provide1 Europe in a concerted approach with the controlled2 access for creating the indispensable technology basis for new products, systems and services essential for a smart, sustainable and inclusive European 2020 society[3].

[1] Because the enabling character of the industry, choices for R&D&I priorities have to be made in very early and uncertain stages, where societal needs are not yet very clear. It is the role of the R&D&I actors to find the optimum balance between "provide" technologies or applications and being cost conscious. R&D&I actors will fulfil this role by continuous interaction with their stakeholders: customers, shareholders, employees and public authorities. As already stated in the introduction, the R&D&I actors in principle commit to contribute out of their own resources their share in the costs. They will, whilst interacting with the same stakeholders, also continuously indicate and evaluate "what needs to be done" (and by consequence what risks can be taken) in order to ensure the "provide".

[2] European industry has a responsibility to keep **control** over critical elements of our high-tech society to ensure its welfare and sustainability. This is not only the case for security and military applications, but also for applications in the field of health-care and environment. These are domains, where Europe is actually leading – and this not without reason. Europe is one of the first regions in the world facing a dramatic demographic change and Europe has the highest awareness with respect to climate changes and to energy saving. But, to make sure, that Europe can realise its challenging targets following its own roadmap, it needs the **control** over the sensitive parts of the respective value chain.
Europe does not have time. It needs to act urgently to save its environment. It needs to increase the efficiency of its medical staff to respond to the upcoming dramatic changes in its age pyramid. It also wants to influence matters related to safety in conformance with its own cultural values. For these and many more reasons Europe cannot "wait" until technologies developed elsewhere, will over time become available. It needs to create a **control** point in order to make solutions available on time and at proper conditions. Because of Europe´s outstanding R&D&I facilities and know-how it can also pave the way towards world-wide solutions that most probably will also fit into extra-European environments. Not only will such a move contribute to Europe's own prosperity; it will also help fixing a couple of global challenges.
Europe has unique characteristics in very different areas like attitude to privacy, average distance between its population centres, age pyramid and political landscape. In many aspects the complexity of "Europe" is higher than elsewhere. This makes solutions working for Europe probably adaptable to other parts of the world. Also for this reason Europe should take **control** and show leadership in initiating and steering the needed developments that will enable future societal solutions.
The R&D&I actors will take leadership and control by initiating the R&D&I in European PPP's, executing the R&D&I in vast majority inside Europe and above all having the resulting know-how and applications embedded into the European culture. These elements will provide **controlled** access by Europe to needed technologies.

[3] In line with the proposed Europe 2020 strategy, micro- and nanoelectronics are key enablers and contributors to the three mutually reinforcing priorities:

1 **Smart growth**: developing an economy based on knowledge and innovation
ICT is the most knowledge intensive industry re-investing up to 20% of its revenues in R&D

2 **Sustainable growth**: promoting a more efficient, greener and more competitive economy
ICT contributes to 10% of global GDP thanks to their enabling roles for both industry and services. In addition they are key for energy generation, management and efficiency.

3 **Inclusive growth**: fostering a high-employment economy delivering social and territorial cohesion.
ICT is a very high-tech, high added value industry that produces and induces high educational level employment and are a key enabler to address new societal needs.

2.2 Mission

The mission of the European ICT Components and Systems Industries is to progress and remain at the forefront of state-of-the-art innovation in the development of highly reliable complex systems and their further miniaturisation and integration, while dramatically increasing functionalities and thus enabling solutions for societal needs.

"Remain at the forefront" and "miniaturise while dramatically increase functionality" are clearly prerequisites for realising the vision.

The experience that Europe has in R&D in ICT Components and Systems matches and in most cases surpasses the R&D capabilities elsewhere. Europe is at the forefront of many technologies, both established (like automotive, aeronautics or communication) and emerging (like medical- or energy-efficiency related research). Europe is therefore in the somewhat luxurious position that it can write in its mission "to remain at the forefront" rather than "to become at the forefront". Nevertheless, the worst thing to do is underestimating the competition. A healthy European industry is a prerequisite for achieving the mission. To "remain at the forefront" cannot be done by universities and scientific institutes alone. Neither can it be done without their contribution. Without a state of the art European industrial infrastructure it will not be possible for Europe to "remain at the forefront" of innovation. An industry led eco-system of SME's, large companies and academia supported by a public private cooperation is the preferred solution.

The "food chain" is rather complex in case of ICT Components and Systems Industries because a plurality of technologies is always needed to address ICT-services or to address societal needs. The R&D&I actors will answer the question what actions need to be taken with highest priority to "remain at the forefront". The answer, in the form of grand technology challenges is not "pick and choose". It is an action-plan that needs to be executed in its totality to accomplish the mission. Although the R&D&I actors will focus in specific time slots on some of the grand challenges, they will at the same time make sure that the total package can be timely executed.

From a shareholders perspective there exists a need for continuous miniaturization. Simultaneously users request an increased performance of systems with simultaneous increase of functionality thereby taking over complex human perceptive and cognitive functions. This is also a need both from customer and societal perspective. Perhaps even more important, this combination determines the dynamics of the industry as a whole. Looking backwards, it is an achievement of the industry since its existence. Looking forwards, the options, which become imaginable, when extrapolating the trend of miniaturisation and extending functionality, are mind boggling. They are one of the most important reasons for the attractiveness of the industry and in particular the R&D&I for young people. The promise to continue on this track is the very reason for the strategic importance of the industry. This promise is the "adrenaline" for the R&D&I actors in the field.

2.3 Strategy

The vision and mission statements above demonstrate the two-fold role and responsibility of the R&D&I actors. They need to develop strategies that will lead to the accomplishment of the mission and therefore will be derived from the pan-European societal needs and – at the same time – technology platforms, competences and industrial infrastructure, which enable the respective industrial solutions.

The strategy of the European ICT components and systems industries is based upon exploitation of European strengths and opportunities

- **Exploiting strengths implies building on the leading positions in specific technology and application domains**
- **Creating opportunities implies for Europe to be positioned at the forefront of new emerging markets with high potential growth rates and to become a world leader in these domains**

Innovation is a key point for the strategy. Its efficiency increases significantly by efficient transnational eco-systems between industry, institutes and universities with support of efficient technology- and tool-platforms.

To illustrate some strengths, it is observed that Europe has demonstrated its capability to create innovation over the past 15 years with major success stories such as GSM mobile systems, automotive electronics applications, smart cards, lithography equipment and Silicon on Insulator (SoI), Fly by wire or Near Field Communication (NFC), just to name a few. Europe has a leading position in several domains including multi-market and industrial applications – such as lighting, robotics, automation, engine management, non-invasive medical treatment, chip cards and security –, mainly based on Software, Module and so-called More-than-Moore[4] technologies and smart systems devices. Here, the value of existing cumulative knowledge and skills is extremely high and must be exploited through both evolutionary and revolutionary approaches. This will result in market penetrations of existing markets with innovative technologies and products.

The part of the strategy dealing with opportunities focuses on today's emerging markets including "Health and Well-being" and "Sustainability and Climate" as well as some specific areas within "Smart Transport" and "Inclusive Innovative Society".

The synergy of strengths and opportunities will enable the European ICT Components and Systems Industries to expand their leadership position in Information and Communication Technology, Embedded and Smart Systems, Nanoelectronics, Advanced Manufacturing and Processing. The intimate co-operation with world-class R&D laboratories from academia and from large institutes such as IMEC, LETI and Fraunhofer as well as the involvement of highly specialised and flexible SMEs are the key elements for developing leading edge technologies and solutions.

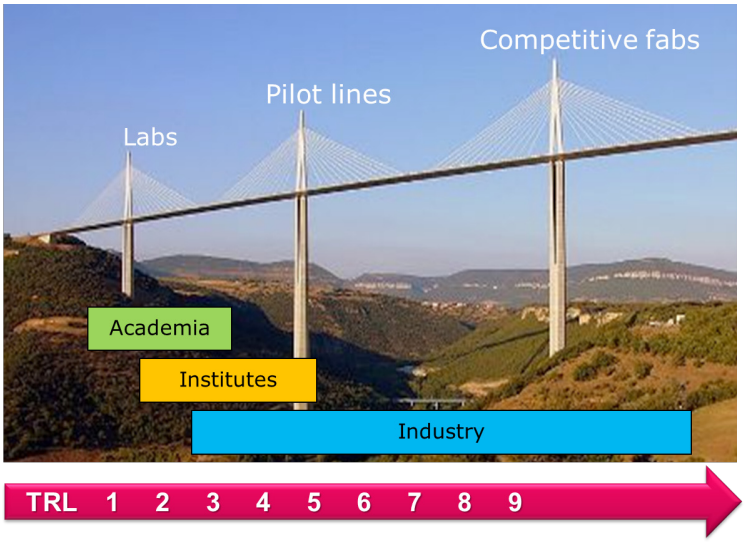
2.3.1 The need of a healthy industrial infrastructure

Although individual company strategies exclusively based upon design and R&D can prove quite successful, such an approach can never guarantee the competitiveness and strategic independence of Europe as a whole. Therefore, Europe has to maintain a sufficient level of manufacturing to secure its future competitiveness on advanced integrated products and platforms. This holds in particular for the capital intensive parts of the industry, where salary levels differences play a lesser role.

It is of utmost importance to maintain and/or extent the expertise in Europe to the higher TRL[5]'s as recommended by the report of the High Level Group on Key Enabling Technologies. In this report Innovation is described with help of a metaphor: a bridge that crosses the valley between fundamental discoveries and the market. The TRL levels can easily grouped into metaphorical pillars of this bridge as indicated in the illustration on the next page.

[4] More-than-Moore technologies = the knowledge intensive addition of additional options like sensors, energy harvesting, high power, RF capabilities etc. to existing CMOS IC-processes.

[5] Brief definition of Technology Readiness Levels:
TRL 9 = Actual technology system qualified through successful mission operations
TRL 8 = Actual technology system completed & qualified through test & demonstration
TRL 7 = Technology prototype demonstration in an operational environment
TRL 6 = Technology demonstration in a relevant environment
TRL 5 = Technology validation in a relevant environment
TRL 4 = Technology validation in a laboratory environment
TRL 3 = Analytical & experimental critical function and/or characteristic proof-of-concept
TRL 2 = Technology concept and/or application formulated
TRL 1 = Basic principles observed and reported



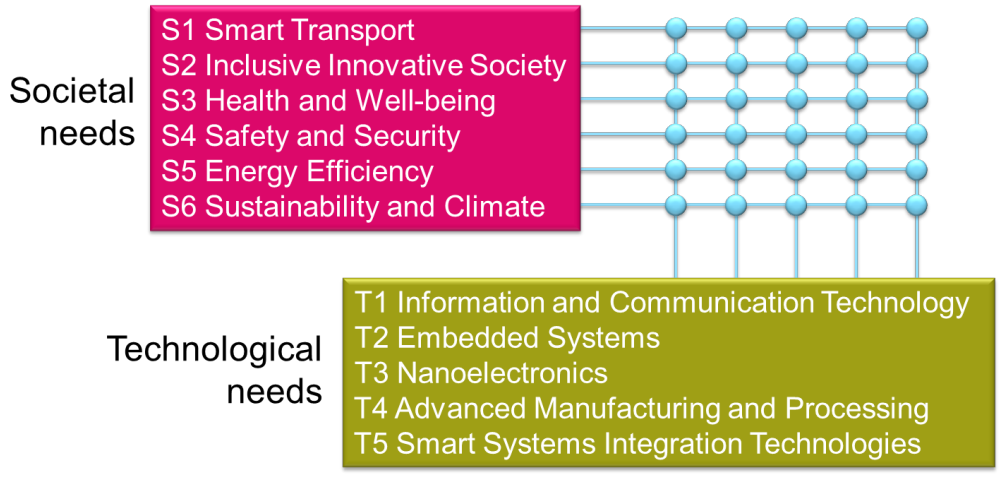
This picture is paraphrasing the KET report to illustrate the issues of the capital intensive industries.

A healthy return of investment (RoI) is key to any innovation. Although this is the primary responsibility of the ICT Components and Systems Industries, the boundary conditions to achieve good RoI are set by Public Authorities and therefore Public Private Partnerships are essential to implement this strategy.

2.3.2 Elaborating the chosen strategy

This chapter elaborates on the before mentioned strategy. 6 focussed domains are defined, each addressing important societal needs. With the first 2 domains ("Smart Transport" and "Inclusive Innovative Society") the industry continues to build on its existing strength (1st element of the strategy) and with the remaining 4 ("Health and Well-being", "Safety and Security", "Energy Efficiency" and "Sustainability and Climate") it exploits opportunities for Europe by positioning itself at the forefront of emerging markets (2nd element of the strategy).

The technological enablers for the contribution of the ICT Components and Systems Industries to these 6 before mentioned societal needs are defined by 5 technology work areas ("Information and Communication Technology"[6], "Embedded Systems", "Nanoelectronics", "Advanced Manufacturing and Processing" and "Smart Systems Integration Technologies"). Work areas and technological enablers depend on each other as sketched in the figure below.



[6] ICT Technology in its broadest sense for those areas that are not covered by Embedded Systems, Nanoelectronics, Advanced Manufacturing and Processing or Smart Systems Technology (for instance in information/communication theory, non embedded-software, networks, infrastructure, etc.).

2.3.2.1 The focussed domains responding to societal needs

In domains like security, defence and avionics Europe cannot depend on other regions. Any new development here should be mastered in Europe and in our vision this is embedded on the 6 focussed domains detailed below.

All new developments in the mentioned domains are cost and business driven, implying that they are addressing important emerging or existing societal needs. With the right conditions they will materialise in Europe, ahead of other regions of the world and, as such, will provide Europe with the opportunity to build up the new competences and skills required for global leadership in the selected domains. Following gives a more detailed description of each of them.

S1 Smart Transport: Innovation in the car industry is, by and large, enabled by ICT as is the case in other transport domains such as aviation, railways and shipping. The automotive domain is pivotal for our transportation needs, but aviation, railways, shipping and co-operative transportation solutions are becoming increasingly important. Elements such as sensors combined with intelligent decision making software, power electronics and embedded multicore processors with associated system software layers are key enablers for sustainable and energy-efficient projects. Safety, security and automatic mobility-assistance systems, road pricing and virtual offices are other key innovative solutions that affect our needs for mobility.

S2 Inclusive, Innovative Society: The increased complexity of European society calls for attention to include all citizens in future innovations, with special attention for their privacy and safety. The "internet of things" and embedded systems behaving as the "neural network" of society will add new dimensions to this. An efficient, omnipresent, green and economic network for communications is an important infrastructural enabler. Many applications will improve interaction between citizens, access to information, entertainment or relaxation. Cost effectiveness is important to avoid that groups in our society are excluded from these innovations. The ICT Components and Systems Industries have built up an extremely good track record for cost reduction.

S3 Health and well-being: Society is ageing as a result of a declining birth rate and longer life expectancy. This phenomenon causes increased competition for a qualified workforce. It also represents a huge opportunity for the development of entirely new applications and services derived from technological R&D&I in medical electronics, intelligent drugs, biotronics, measurements and diagnostics, and ambient-assisted living (AAL). The key challenge is to encourage specialists from varied disciplines to work together and demonstrate the overall financial and social benefits offered by this area.

S4 Safety and Security: The increased complexity of European society and the growing role of ICT in all aspects of daily life calls for innovation in the protection of consumers and citizens, information and goods and privacy, and, at the same time, for homeland, energy, complex machinery, trustworthy identification and communications, reliable, safe and secure and transport of people, data and money. Such innovation must also strive to address the exploding costs associated with safety and security.

S5 Energy Efficiency: One of the most important and urgent conditions for safeguarding our future is the responsible use of energy resources with a concurrent limitation of worldwide pollution. In the global energy strategy, developing sustainable energy sources and enhancing energy efficiency for energy management and transportation as well as for energy consumption is key. Smart energy solutions – smart cities, smart buildings, smart appliances, smart systems, smart grid, etc. – use ICT Components and Systems such as driver software, middleware, system integration, sensors, microsystems, communications chips, memory chips, microprocessors and power-management chips. A huge (multi-) market is emerging in the domains of energy-efficient intelligent lighting, energy-efficient houses, remote metering and power control, alternative energy sources and smart, energy-saving motor controls for private and industrial applications.

S6 Sustainability and Climate: To prevent detrimental climate changes new ways must be found to organise the economy and societal welfare e.g. by reducing greenhouse gases, by stopping deforestation or by gentle usage of water.

Human activity such as industry, traffic, etc. leads to higher emissions of gases and thus to amplification of the greenhouse effect. A momentous consequence of the amplified greenhouse effect is an increase in temperature which leads to a range of impacts such as defrosting of the North and South Pole, flooding, crop failures and reduced living space. The concentration of atmospheric CO2 has increased from about 280 parts per million (ppm) in pre- industrial times to more than 387 ppm in 2008. At the same time, the average global temperature increased dramatically and is expected to continue to increase.

The ICT Components and Systems Industries provide technologies to watch the environment and treat it with the aim to minimise GHG emissions and to reduce the energy consumption of processes, machines and buildings. Smart Systems solutions and their underlying components can feature in all this and furthermore drive forward concepts for sustainability.

2.3.2.2 Technologies to enable innovations that address societal needs

T1 Information and Communication Systems[7]: The European knowledge society is entering a new phase of development where ICT is providing the key basic infrastructures for all vital social and economic processes and is the most influential key technology in most innovations across all industries. All private and public services are being provided through and shaped by these infrastructures. ICT is becoming indispensable to address key social challenges and continues to play a defining role in our economy, providing a critical infrastructure for the global economy. The ICT infrastructure thus becomes an issue of the highest social concern. Therefore, in this new phase social innovation will be a key driver for ICT development.

Social innovation refers to new strategies, concepts, ideas and organizations that meet social needs of all kinds. Technological innovation can inspire social innovation, for example e-health, distance learning and the use of texting on mobile phones, but technological innovation is also driven by our desire to build systems to meet social needs, for example the Google search engine was developed to enable people to find things on the Web. The two processes are becoming increasingly inter-connected.

The shift towards social innovation also implies that the dynamics of ICT-innovation has changed. Innovation has shifted downstream and is becoming increasingly distributed; new stakeholder groups are joining the party, and combinatorial innovation is becoming an important source for rapid growth and commercial success. Continuous learning, exploration, co-creation, experimentation, collaborative demand articulation, and user contexts are becoming critical sources of knowledge for all actors in R&D & Innovation.

The rapid deployment of the Internet as a global infrastructure available practically anywhere anytime has led to a new dimension of integration across time and distance. Never before in history could global distributed systems be connected like today.

T2 Embedded Systems: Digital convergence by emancipation of data, building embedded intelligence to every place and the internet revolution are the opportunities of our time. These will change the way we live as citizens of the new knowledge based society and do business in the new digital economy.

Networked Embedded Systems - also referred to as Cyber-Physical Systems - are THE NEURAL SYSTEM OF SOCIETY. Embedded Systems pervade all artefacts of life, from children's toys and mobile phones to space probes and from transportation vehicles to healthcare systems. In fact, Embedded Systems will be part of all future products and services, providing intelligence on the spot and capabilities to clever connect to the abundance of "things" or systems in their environment, either physical or at cyber-space level, in real time.

These connections can be direct or via a network, such as the Internet. In this sense, Embedded Systems form the edges of the 'Internet of Things' bridging the gap between cyber space and the physical world of

[7] quoted from ISTAG. draft Strategy document 2011

real 'things', and are crucial in enabling the 'Internet of Things' to deliver on its promises. In fact, Embedded Systems are the technologies that make the future Internet work, full stop.

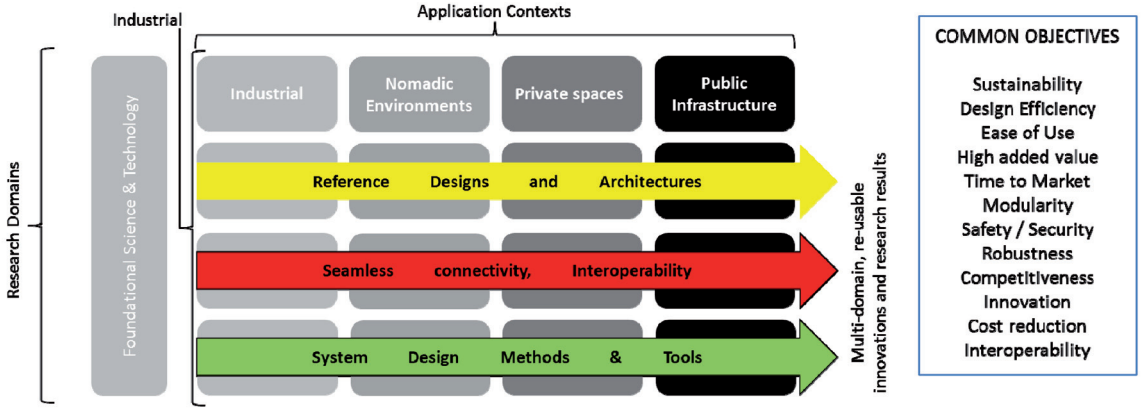
By nature, internet communication cannot be expected to provide the same quality as dedicated Embedded Systems networks. Therefore Embedded Systems must be made more autonomous, cognitive and robust to compensate for the reduced real-time and reliability guarantees, operating dependably even in the presence of network degradation or temporary failure. This dependable, safe and secure operation of such increasing complexity will impose huge challenges on design, operation, interoperability and maintainability of Embedded Systems, be it in software, electronics, sensors, actuators or a combination of those.

Embedded Systems become part of bigger systems in a world of 'systems of systems'. This imposes even larger challenges on the functionally of Embedded Systems with higher performance and lower power consumption.

Internet connected intelligent embedded systems will provide the core of solutions for the big societal challenges like affordable healthcare and wellbeing, green and safe transportation, reduced consumption of power and materials, reduction of food waste, smart buildings and communities of the future, and an imminent lack of natural resources. Such solutions to our pressing societal challenges will spur on European competitiveness. Embedded Systems are key to enable intelligent applications that are based on the supporting KET's identified in the KET Report, as Embedded Systems pervade in all artefacts of life and enable providing intelligence on the spot and capabilities to clever connect to the abundance of systems in their environment, either physical or at cyber-space level, in real time and in the cloud.

This enabling key role of Embedded Systems is getting deeper and deeper involved in the European society as indicated by the 2011 ISTAG Report[8]. This role envisioned for ICT underlines the importance of Embedded Systems as key enabling technology in the move from localised, sector-specific improvements - in homes, offices, vehicles, factories, traffic management, healthcare, and so on - to smart cities, smart regions and even smart societies. And, apart from their contribution to energy management and especially to reduced consumption in other domains, new techniques to reduce the energy consumption of Embedded Systems themselves become increasingly important.

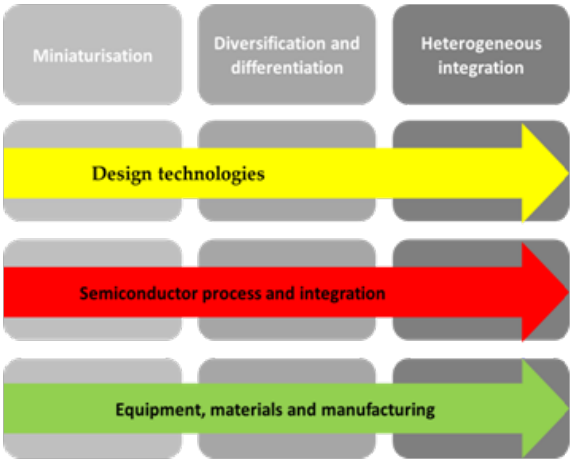
The relationship between the application and research dimensions of the ARTEMIS strategy is shown in the figure below that highlights the importance of synergies of the cross-domain research approach to satisfy a variety of application areas and services.



[8] "Orientations for EU ICT R&D & Innovation beyond 2013", July 2011.

T3 Nanoelectronics and T4 Advanced Manufacturing and Processing: When taking the hardware perspective, the availability of new solutions, enabling European key applications, is mostly based on strong and steady progress in three generic technology directions: "miniaturisation", "diversification and differentiation", "heterogeneous integration". These three technology directions are strongly interlinked and interdependent. It is only by combining and mastering these technology directions that the European ICT enabling industry can offer competitive system solutions which address European needs. Depending on the application, the miniaturised and diversified technologies will be integrated as system-on-chip (SoC) devices at the wafer level or in a package – system-in-package (SiP).

As schematically shown in the figure below, progress in all three of them is depending on major efforts in R&D&I in "design technologies", "semiconductor process and integration" and "equipment, materials and manufacturing". In the following, the columns and rows are described:



Miniaturisation, doubling integration density every two years, reducing cost by about 30% a year and power consumption per function is known as More Moore. The More-Moore trend is crucial for digital data processing and storage, using mostly CMOS technologies. It is the prerequisite for new solutions, which require ever-increasing integration, functionality and complexity. This miniaturisation is obtained by reducing the critical dimensions, and by breaking the current physical barriers through the introduction of innovative materials, processes and devices.

Diversification and differentiation of the technologies allows a richer functionality in the integrated systems. This may include new memory concepts where dedicated applications require specific process solutions. Such diversified technologies are required for interfacing with the outside world and managing the energy needs and power consumption of the electronic system – the More-than-Moore technologies. For every technology generation, a greater variety of semiconductor devices and technology options needs to be integrated into the technology platform.

Heterogeneous integration is the technology of packaging components from different origins and technologies in a single package. This approach allows the integration not only of electronic functions, but also of many more functionalities performing for example mechanical, optical or biochemical tasks.

Design technologies: Increasing levels of system integration, involving the combination of complex IP and different technologies in a single chip or package imply the capability to handle complex architectures and require advanced tools, design flows and methodologies. At the same time, deep submicron effects, 3D integration and heterogeneous technologies call for a strong convergence between design – hardware and software – and fabrication technologies to overcome design-process limitations and to improve yield and reliability. Miniaturisation and complexity progress more rapidly than design capability, creating the famous design gap. In addition, the increased weight of early architectural choices, involving also embedded software, on final performances requires new approaches such as higher representation/ abstraction levels, tools and methodologies to handle hardware/ software co-design and 3D architectures, and open standards for IP and subsystem integration. Increasing efforts are needed to develop adequate design capabilities, leading to new design tools and methodologies, improving the "handshake" between system and chip design.

Semiconductor process and integration: A strong European R&D programme on advanced CMOS is essential to master and access the latest technologies, ensure manufacturing competitiveness and thus secure further growth in new applications and European lead markets. The guaranteed access to leading-edge More-Moore technology is enabled through alliances as a consequence of the extremely high costs of generic developments for future technology nodes. In addition, a More-Moore manufacturing capacity in Europe is crucial to master these technologies. Such capacity will also help the future European More-than-Moore manufacturing capacity to grow. Differentiated technologies will build upon this generic CMOS excellence. Today's More-Moore fabs capacity will be the More-than-Moore capacity of tomorrow. Moreover, heterogeneous processes including photonics and organics will emerge in the following five years. These specific developments needed for differentiating strategies are performed in European platforms and projects. By developing generic expertise in fields such as analogue, mixed signal, RF and smart power, and leveraging its historical strong links between applications, systems and processes, Europe will be in a position to lead in differentiated markets. With the emergence of new approaches – such as 3D – for the heterogeneous integration of diversified technologies, there is a clear opportunity for Europe to develop a SiP supply chain by setting its leadership in the heterogeneous integration of complex systems.

Equipment, materials and manufacturing: Competences create competitive advantages in the domain of equipment, materials and manufacturing. This is the case for More-Moore as well as for More-than-Moore technologies by breaking the current physical performance barriers with the introduction of innovative materials and process technologies provided by advanced equipment. This sophisticated advanced technology requires the development of specific metrology, characterisation and failure-analysis methodologies, tests and tools. To improve competitiveness in manufacturing, it is necessary to reinforce manufacturing-science excellence. The 450-mm production standard will provide new opportunities for European equipment manufacturers in the medium term.

T5 Smart Systems Integration Technologies: Legions of intelligent functions based on micro systems technologies can be found in many applications of everybody's daily life and transformed from a technically challenging, but ordinary single-functional mobile communication device into the most important element of the networking of individuals in (and with) the Information Society. Also cars are getting more and more equipped with supporting functionalities; some are serving the convenience of the driver, others are of lifesaving importance - driven by a myriad of smart systems. Airbags, EPS and roll over protection are currently in use as a matter of course as well as navigation systems and parking aids. Even in the conservation and recovery of health smart systems are indispensable - and quite naturally in use. Minimally invasive therapy is not conceivable without miniaturized smart systems including sensing functions, signal processing and actuators. Contrary to microsystems, which are only designed and capable to measure a single physical, biological or chemical parameter, smart systems -with their steadily increasing functional diversity- have capabilities far beyond such of already known and broadly used microsystems and are equipped with signal processing and actuating abilities. Smart systems integration addresses the demand for miniaturised multifunctional devices and specialised connected and interacting solutions. Multidisciplinary approaches featuring devices for complex solutions are among the most ambitious challenges. Such solutions can use shared and increasingly self-organising resources or provide cognitive as well as bio-based properties.

Smart Systems are able to interact with their environment by using highly developed methods and sophisticated interfaces between systems and users. They can be standalone, networked, or embedded into larger systems; they comprise heterogeneous devices providing different functionality (e.g., sensing, actuating, information processing, energy scavenging, communication, etc.) and excel in self-reliance and adaptability. Their development thus requires the integration of inter-disciplinary knowledge.

For realising complex functionalities and linking technology between the nano-, micro- and macro-world Systems integration is the key challenge. In this context, a particular relevance is to be attributed to Micro-Nano Bio Systems (MNBS) given their growing importance for various application sectors. MNBS

are understood as "Smart Systems combining micro-sensing and micro-actuation, microelectronics, nano-materials, molecular biology, biochemistry, measurement technology and ICT".

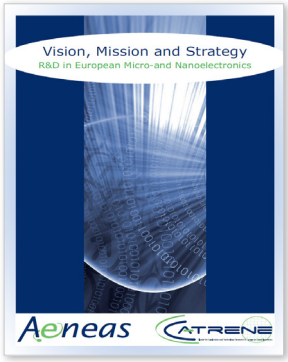
Final products often owe their competitiveness to the incorporated Smart System. Therefore, Smart Systems will radically change our daily environment, on a par or even exceeding the uptake of the Internet. Ultimately, Smart Systems Integration will provide the functional connection of devices and subsystems at the component level (manufacturing), at the system level (integration into a macro system, or "handling level"), at the application level (integration into the overall system, or "product level ") and at the process level (integration of manufacturing processes including design, simulation, verification and testing). Systems integration may be based on monolithic, hybrid, multi-chip module or other techniques spanning several scales ranging in size from nano to micro to macro.

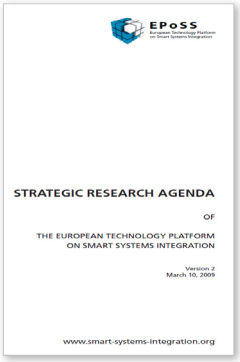
These developments include also an impetus of electronic components development leading to smart components which "demonstrate enhanced performance and functionality enabled by the re-use of nano-electronics processes and building blocks" offering "very advanced performance, high voltage and high power operation or operating under special conditions."

2.3.3 Further detailing of the developed strategy

The section 2.3.2 gives only the headlines of the developed Strategy. Much more detail can be found in:

1 ARTEMIS-SRA by the ARTEMIS Industry Association (that incorporates the ARTEMIS ETP) issued in 2011,
2 Part C of the VMS by AENEAS and CATRENE dd. January 2011,
3 EPoSS-SRA dated 2009 (update 2012).

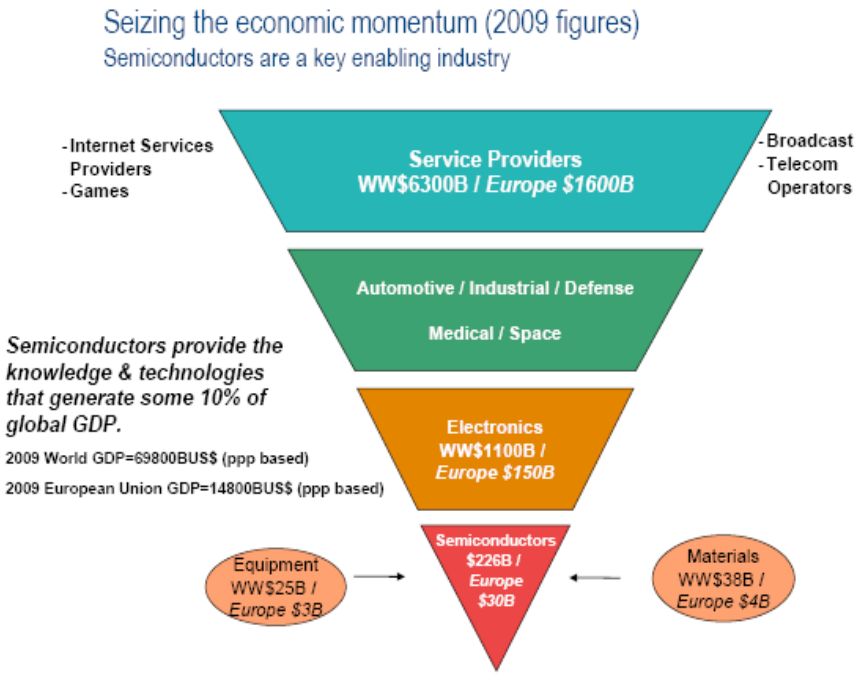




3 Landscape of the ICT Components and Systems Industries

3.1 The global landscape (value chain) of ICT Components and Systems Industries

The ICT sector and related service providers are the largest and fastest-growing manufacturing industries with 5% average growth per year in the past decade, representing a market of $6.3 trillion in 2009 – equivalent to 10% of global GDP. Even taking differences in average remuneration into account, the impact on employment is significant. Moreover, the growth rate of the ICT industry is higher than that of global GDP and this will continue, at least, for the next decade.



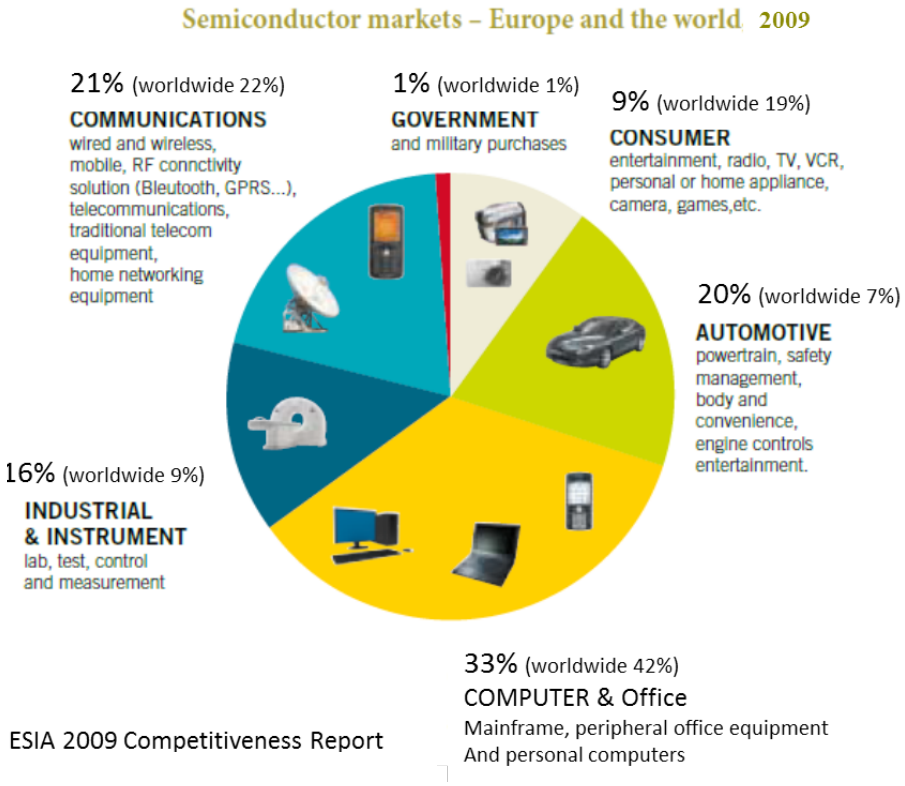
The ICT Components and Systems Industries are driven by the replacement of existing equipment with innovative solutions, by new lead markets, by the grand socio-economic challenges such as an ageing society, energy shortages and global warming and by the fast penetration of ICT equipment in emerging regions.

Differentiation in products and services is increasingly reliant on ICT technology. Access to advanced ICT technologies optimises product performance, keeps development costs under control and protects intellectual property (IP). This interdependence between ICT components and ICT systems industries has been demonstrated in many applications sectors, such as the German automotive industry in the past two decades.

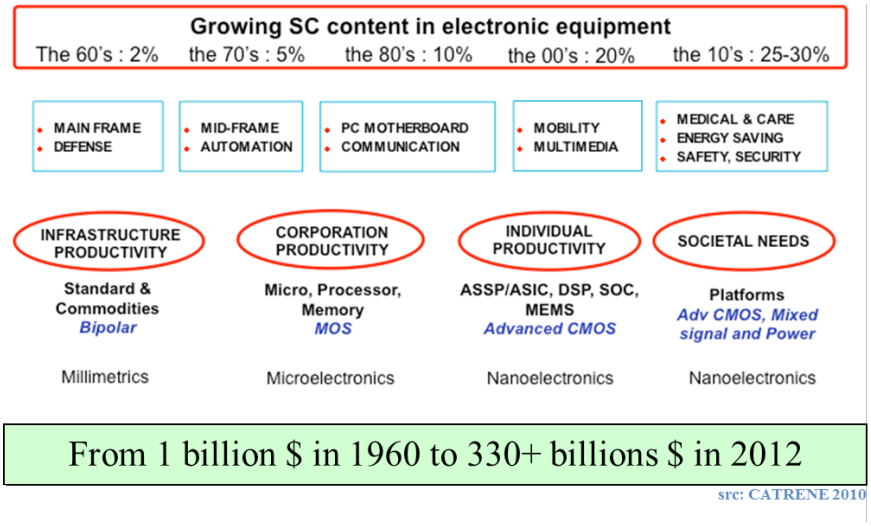
Micro- and nanoelectronics (including its embedded software) represent a global market worth $226 billion in 2009 directly stimulating a larger electronics industry valued at $1,100 billion.

3.1.1 The global landscape of ICT Components Industries

The semiconductor market is segmented as outlined in the following figure:



The demand for continuous innovation puts high requirements on the ICT components industries.



In Europe the Semiconductor industry investments are – as a percentage of net sales - the highest compared to other industry branches.

Semiconductors driving R&D in Europe

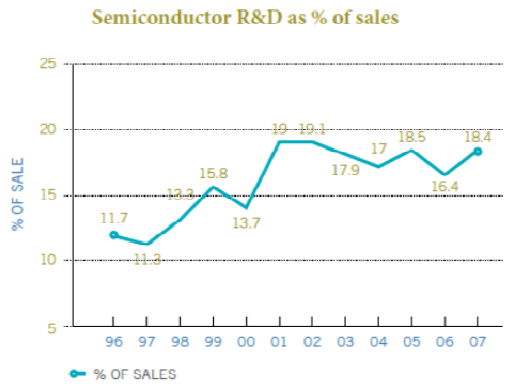
Ranking of high R&D intensity EU industries in the 2009 Scoreboard*

Rank	Sub-sector (4-digit ICB)[2]	R&D investment 2008 (€m)	Net sales in 2008 (€m)	R&D intensity (%)
1	Biotechnology	770.7	4075.9	18.9
2	**Semiconductors**	**3942.9**	**21818.2**	**18.1**
3	Pharmaceuticals	19485.3	122097.6	16.0
4	Software	3188.8	22976.8	13.9
5	Telecommunications equipment	11848.8	89651.6	13.2
6	Leisure goods	1856.1	30057.6	6.2
7	Aerospace & defense	7376.3	122563.2	6.0
8	Automobiles & parts	30116.7	567862.8	5.3

* High R&D intensity = Ratio of R&D investment over net sales higher than 55%.

Source: The 2009 EU Industrial R&D Investment Scoreboard European Commission, JRC/DG RTD.

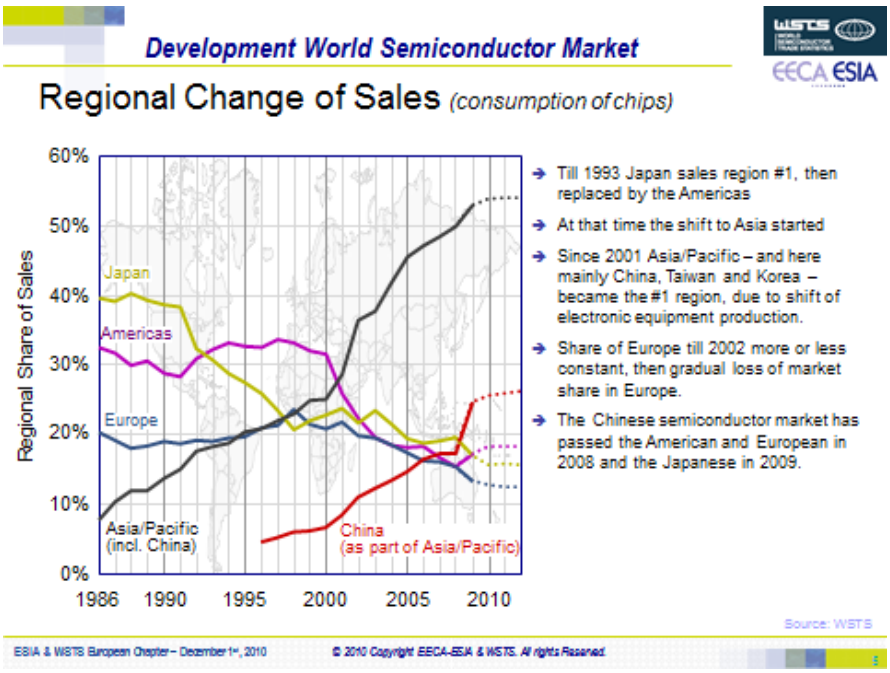
November 22, 2010



SOURCE: ESIA MEMBERS; PUBLICLY AVAILABLE INFORMATION

Not only does this investment underpin a large part of our economy (see inverted pyramid above) but it also creates a large number of high level jobs with large leverage effects on the local economies.

Since the 2001 ICT recession, the global landscape has changed dramatically, leading the industry to adopt new business models whilst remaining very dynamic, hyper competitive and highly innovative. The ICT Components and Systems Industries and their entire supply chain are now truly global. However, the focus of the ICT components market has shifted from developed to developing countries, particularly Asia Pacific. This region increased its market share from 25% in 2001 to around 50% in 2009 with a forecast by WSTS (World Trade Semiconductor Trade Statistics) to increase further, whereas Europe's market share declined from 20 to 13%, and America and Japan have dropped even more dramatically.



3.1.2 The global landscape of Embedded Systems Industries (including the System Integrators)

The use of embedded systems, which are always a combination of hardware and software, has grown enormously over the last decade. The percentage of products and services that rely on embedded systems is constantly increasing. A very rich spectrum of strongly fragmented ICT system design activities by many small, medium and large enterprises does exist nowadays in many countries in the world to develop and integrate embedded systems in the objects of everyday life. The system integrators (either SME's or large companies), which as a norm develop and/or produce at least the core of the embedded systems themselves, embed the embedded systems in their final products and services to enrich their value in the eye of the final customer and differentiate them from competition. As a matter of fact, the value of the final products and services, is already determined for a significant part by embedded systems, and will further grow in the next five years, for instance for the automobile vehicles (35-40%), industrial automation (22%), telecommunications (37%), consumer electronics and intelligent homes (40%), health and medical (33%).

A study in 2006[9] estimated R&D expenses and the percentage of all (embedded and non-embedded) software in the R&D expenses in the year 2015, reaching these levels after an average growth of 7% in the period 2002-2015:

2015	R&D expenses (Billion EUR)	Software R&D expenses as a percentage of total R&D expenses	Software R&D expenses (Billion EUR)	WW market size (Billion EUR)	Value added (Billion EUR)
Aerospace	51	45%	23	341	191
Automotive	129	35%	45	1 355	705
Consumer Electronics	21	60%	13	197	110
Medical Equipment	84	33%	28	471	280
Telecom Equipment	36	65%	23	257	144
Automation	3	15%	0.5	42	30
TOTAL	**EUR 324 Billion**		**EUR 132 Billion**	**EUR 2 663 Billion**	**EUR 1460 Billion**

Companies normally do not publish the value percentage of embedded systems in their turnover figures, so it is difficult to give exact numbers of turnover of the embedded systems values and business, being a mix of Business to Business and Business to Consumer. For this reason the turnover of embedded systems is less discernible compared to components, so an exhaustive/ accurate overview of the sizes of all business that include embedded systems cannot be given.

Still some detailed data from specific markets that use embedded systems are available from the transportation and energy sectors[10].

TRANSPORTATION

Automotive

The worldwide automotive market size in 2010 is 78 million motor vehicles, of which 17 million units produced in Europe. 2.3 million jobs are directly related to automotive, 10.4 are indirectly related. So in total 12.7 million jobs are automotive related, which is 6% of the EU employed population. The automotive industry is a leading EU export sector with a net trade contribution of 57 billion Euro. By 2015 as much as 35-40% in average of an automobile's value will be in embedded and cyber-physical components (electronics, embedded software, smart systems, sensors and actuators). The automotive industry is central to Europe's prosperity.

Aerospace

The European aerospace industry is one of the key, high-tech sectors of the EU, employing in 2008 about half a million people and generating a turnover of approximately €94,5 billion. In a growing global aeronautics market, which has currently a total volume of about €284 billion, the European aeronautics industry is second

[9] Software Intensive Systems in the future, TNO/IDATE, Sept. 2006

[10] Position Paper – Cyber Physical Systems, by Alberto Sangiovanni Vincentalli, 2011

in the market share (36.4% on average) behind the US (51%) and in front of Canada (5.5%) and Japan with 3%. Today, the value share of Embedded Systems in an airplane amounts to 12%[11]. As a an example, the Airbus 380 comprises 400 km of wiring harness connecting some 600000 signal interfaces, and requires some 450 MB embedded software for flight-control applications[12].

Rail

The European rail supply industry has an 80% market share in Europe and manufactures more than 50% of the worldwide production of rail equipment and services. The total annual world market for the rail supply industry in 2007 is estimated at more than €120 billion, with an expected annual growth rate of between 2.0% and 2.5% until 2016[13]. In 2015, the part of software R&D in this sector is expected to represent 35% of the total R&D expenses[14].

ENERGY

Power

The Power sector in the EU in 2007 has an annual turnover of about 400 billion €. The objective of the European Industrial Initiative on electricity grid is to enable the transmission and distribution of up to 35% of electricity from dispersed and concentrated renewable sources by 2020 and a completely decarbonised electricity production by 2050[15]. According to the International Energy Agency, 1000 b€ by 2030 (average of 45 b€ a year representing a capex of 11% based on 400 b€ annual turnover of the Power sector) divided between Generation and Transmission and Distribution will need to be invested to achieve these goals[16]. Some $120 billion will be inve sted in Transmission and $413 billion in Distribution networks and a conservative estimation of 20 b€ (based on 100 € per connection) will be spent on Data and information for Markets and regulations by 2030. According to Energy Insights and Pike Research forecasts, total IT spending (Hardware, Services and Software) for year 2008 in Europe was 11.5 $US Billions and will reach 13.9 $US Billions in 2011. The direct and indirect potential of CO2 – reductions from smart grid deployment will be 2.2 Gt/yr. worldwide[17]. A lot of the manufacturers of smart grid equipment are located in the EU. The smart grid will lead to a job creation boom. Cities are considered a priority as they consume over 75% of the world's energy and produce 80% of its CO2 emissions. Energy generation and distribution uses one third of all primary energy. Electricity generation could be made more efficient by 40% and its transport and distribution by 10%. ICT could make not only the management of power grids more efficient but also facilitate the integration of renewable energy sources.

Buildings and Cities

Buildings consume almost 34 % of the energy consumed in Europe[18]. Even a modest 20% improvement in energy using smart environment-aware technologies that minimize energy consumption while maintaining human comfort will yield enormous economic benefits in addition to energy independence.

In the next years, by further exploiting the Internet and the world-wide-web, embedded systems will increase the intelligence, control and communication capabilities of a wide range of artefacts and objects, enabling their interaction and cooperation with people and organizations. Such smart objects will be joined together to create highly distributed systems able to dynamically grow and adapt to the needs of individual users and communities[19].

[11] German National Roadmap Embedded Systems 2009
[12] CESAR, ARTEMIS project 2008
[13] The Global Rail Market, now to 2016 (UNIFE Study 2008)
[14] CESAR, ARTEMIS project 2008
[15] Communication of the Commission on investing in the development of Low Carbon Technologies 2009
[16] ICT for Energy Efficiency Groups-Sectors Report 2008
[17] Energy technology Perspective 2010, IEA, 201
[18] EU Statistical Pocketbook
[19] ISTAG, Shaping Europe's future through ICT, March 2006

This convergence will bring a wealth of opportunities and innovations in technology, applications and business models. For instance, innovative products, services and solutions will be created to respond to key societal needs through accurate and continuous real world knowledge[20], [21]. As a consequence, the potential of industries to innovate throughout the world will be influenced to a large extent by their capability to leverage the sophisticated technical solutions provided by the future embedded systems.

3.1.3 The global landscape of Smart Systems Industries

European Smart Systems industry demonstrated up to now to be rather robust in the global landscape providing internationally competitive products. Smart Systems production and markets have grown in Europe during the last decade providing significant breakthroughs in e.g. the automotive industry (driver assistance systems, systems for combustion engine optimisation, etc.), environmental technologies (measurement and control devices) and medical equipment (systems for minimal invasive instruments). The European Smart System industry is the global market leader in providing high quality solutions ranging from large scale mass production in the automotive sector to batch-of-one customisation in medical products. It has the potential to fulfil emerging global customer expectations for smart products in nearly every sector. This performance is provided by approx. 6.000 companies, forming complete value chains and clusters including start-ups, SMEs, large corporations and research institutes and spreading over all European Union countries.

3.2 The European position in the global ICT Components and Systems landscape

3.2.1 Strengths

In the ICT components sector, the relative stability of Europe as compared to the decline in Japan and the USA may be explained by the strong presence of key OEMs here that have maintained the importance of Europe as a manufacturing base for ICT enabling applications and new functionalities – and hence as a market for software, smart systems and semiconductors.

Meanwhile, the gradual market saturation by large killer applications and growing competition led to enormous price pressure resulting in a lasting market slowdown in particular in the Semiconductor markets. The semiconductor annual market growth rate has more than halved since 2001, differing from the trend in previous decades. However, new market opportunities with dynamic growth patterns are emerging in developed regions, including Europe, addressing societal needs. In these domains, Europe has the assets to support the market pull thanks to its strength in multi-market applications, its leadership in embedded systems, manufacturing technologies, radio-frequency (RF), analogue/mixed signal and More-than-Moore technologies, its excellent R&D&I capabilities in industry, institutes and universities and the close interdisciplinary co-operation in its well-known clusters.

Similar observations can be made for the ICT Systems and Smart Systems industries. Embedded computing and more generally the ICT Systems industry has been traditional an area of strength for the European ICT sector. Europe's strength is based on two different factors.

The first is related to the wide range of application domains for which ICT is emerging as a key driver of innovation and where Europe is a world industrial leader. Such domains include transportation (aeronautics, automotive, rail and maritime), healthcare, energy (production and distribution), telecoms and security. Strong in-house system design and development capabilities characterize European system integrators, facilitating also the transformation of research into products and services in line with market needs.

[20] Recommendations of ISTAG on FP7 ICT Work Program 2013, March 2012
[21] Position Paper – Cyber-Physical Systems, by Alberto Sangiovanni Vincentelli, 2011

The second factor concerns a number of technical areas where Europe, as a result of the tight cooperation historically linking Research Organizations and industry, has enjoyed world leadership, like embedded and distributed software, hard real-time design, dependable computing systems, software agent technologies, system of systems design.[22]

As a consequence of the breadth and depth of the embedded systems sector in Europe, the economic impact of embedded systems on European industrial success is therefore huge and it will increase in the future.
Smart Systems provide the indispensable hardware basis for radical innovations by incorporating disruptive technologies from the nano- micro- and biotech fields. Europe possesses the right characteristics in the Smart Systems sector for building-up a solid and sustainable innovation system of highest value creation:

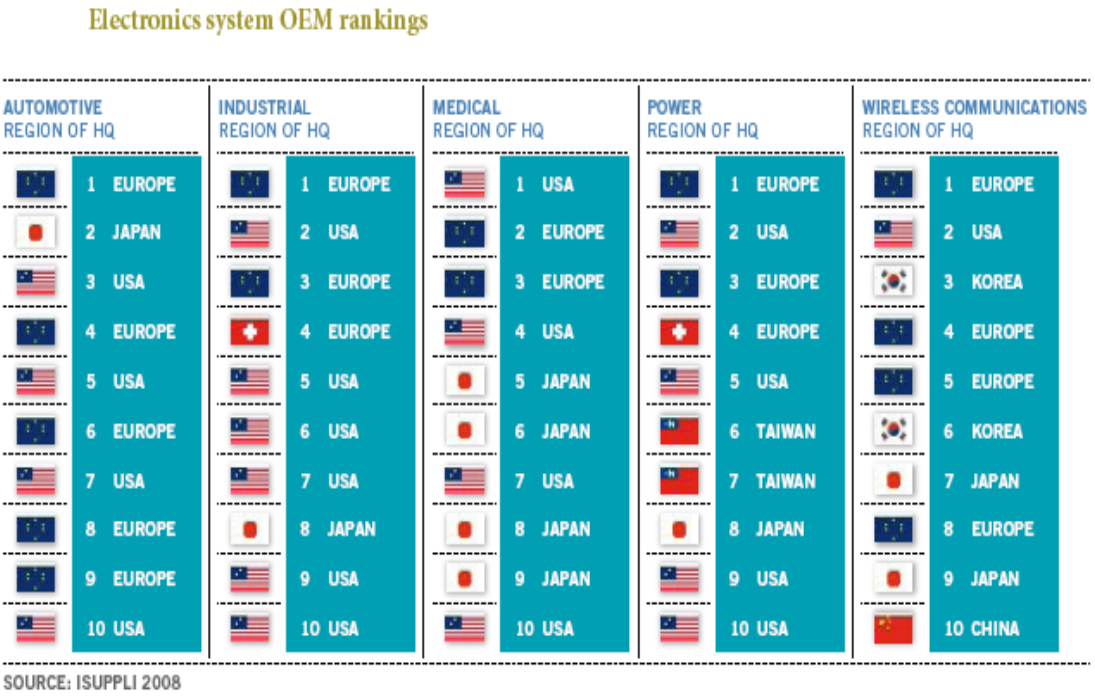
- outstanding institutions of basic and applied research,
- internationally renowned higher educational institutes,
- well networked large companies with global recognition and market reach,
- numerous flexible and highly innovative SMEs - including "hidden champions" and high-tech start-ups,
- a labour market providing an enormous potential of high-skilled people supplying specialised and multidisciplinary expertise,
- a differentiated diversity of innovation support systems consisting of vocational training institutes, technology transfer organisations, business innovation centres, dense private service sector, etc.
- a critical mass of competitive user industries able to create European lead markets, which attract further innovation, establishing a head start into global markets for Smart System solutions.

The numerous and highly qualified European stakeholders employing a highly-skilled workforce constitute differentiated and competitive all-embracing value chains in the Smart Systems sector which cannot easily be transferred to other world regions in the near term. Despite a high degree of automation, human experience, inspiration and systems know-how are still essential in order to bring forward innovations based on Smart Systems.

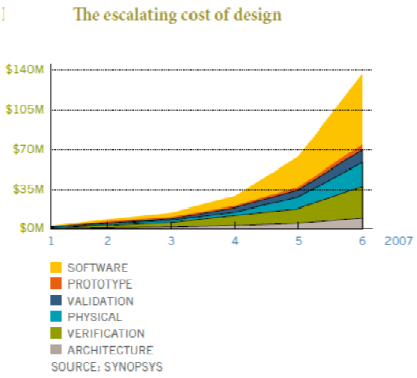
The leading position of Europe also results from the existence of R&D cooperative organisations aimed at developing innovative solutions for the technical and technological domains needed in the today applications and system solutions. CATRENE and ENIAC are the cornerstones for the public support of the European semiconductor industrial R&D. They are complemented by ARTEMIS and ITEA, which focus on embedded software and system aspects. Other ICT clusters such as EURIPIDES and EPoSS focussing on Smart Systems modules and their application using a broad range of micro-technologies aim to advance complex functionalities and further miniaturisation.

European strength is also demonstrated by the fact that one to three European semiconductor companies are in the top five of each of the major application segments, particularly in automotive and industrial applications – including medical and power – and to a significant extent in wired and wireless communications.

[22] ISTAG, Shaping Europe's future through ICT, March 2006



Although Europe has almost completely lost segments such as computer and analogue consumer, the ability of European industries to innovate in existing and new market segments has enabled Europe to face increasing competition. Differentiation between products is increasingly based upon innovative functionalities and not only upon price.



With the commoditisation of mainstream manufacturing, the increasing functionality of products together with the exploding complexity of designs and the embedded software in semiconductor, Smart system solutions become increasingly the differentiating factor between providers of ICT components. R&D spend went up from 14% in 2001 to a current 20% in European ICT components companies.

The ICT components industry is one of the most R&D-intensive industry sectors and a driver for innovation in Europe. This trend is supported by the widespread presence of R&D locations and the network of knowledge-based clusters in which these activities are embedded. These installations are a significant part of Europe's strength.

A map with ICT systems industry is not included; it would be a densely dotted picture with locations all over Europe.

3.2.2 Weaknesses

Although Europe accounts for approximately 13% of worldwide semiconductor consumption, it has only around 9% of the global wafer-processing capacity. The centre of gravity for production has moved from Japan, the USA and, more gradually, Europe to Asia Pacific, which now has more than 50% of the worldwide capacity. The main reasons for this are the move of the ICT market to this region and particularly the unfavourable cost structures of manufacturing facilities in Japan, the USA and especially Europe. The various and rich incentive packages – including reduced taxation – which Asian governments offer to companies building up manufacturing capacities in their countries drive a more advantageous financial return of investments compared with Europe.

The required economies of scale and increasing process complexities cause a more than proportional increase in investments needed for next-generation fabs. Without a paradigm shift in the current European policies a further decrease of Europe's share in production is thus foreshadowed. This is illustrated also by the continuous decline of investments in new production equipment in Europe. In 2000, Europe represented 14% of the worldwide semiconductor market for manufacturing equipment; this dropped to around 5% in 2009.

Today Europe is still the world's number one in Smart Systems research and production. However there are a series of risks will have to be addressed. Intensifying innovation in the Smart Systems sector - in quantitative and qualitative terms - requires tighter co-operation both along value chains to particular markets as well as across value chains supporting diversified technologies. Cluster policy approaches are also rare in the Smart Systems sector.

Only partial use is made today of the innovation potential of SMEs. The intensity and frequency of co-operations of SMEs, in particular cross-border co-operations – are below of what the existing potential would allow. Often opportunities of working together with other companies or applied/contract research organisations (both at national and European level) are not taken. SMEs cannot sufficiently benefit from the potential of the labour market, as career progression for "high flyers" is limited and finally, particularly for SMEs, high equipment costs in areas of advanced technologies are a hindering factor.

There is a lack of coherent strategies for international partnerships of Smart Systems companies, particularly related to the BRIC countries. Individual strategies are dominating with sometimes counterproductive effects for Europe.

To the entire ICT Components and Systems sector applies that:

- Unfavourable regulations in various application areas of ICT Components and Systems produce competitive disadvantages in terms of costs, decelerate innovations and affect negatively technological development (cfr. medical equipment).
- Seed capital markets and programmes in order to facilitate the setting-up of new technology based companies are under-critical related to the actual economic needs in Europe's ICT Components and Systems sector, particularly compared to the dynamics of this market in the US.
- There is a lack of entrepreneurial skills of Technology Based Company founders. Europe furthermore shows a national patchwork of impedimental conditions and unfavourable regulations for start-ups.
- European R&D&I policies which potentially could intensify and improve co-operation, do not sufficiently take into account industry needs and therefore lose impact on innovation. In general, EU public investments are underdeveloped compared to those in other world regions.
- Insufficient speed in solving issues around European patents.

3.2.3 Opportunities

The economic importance of the ICT industry is not only represented by its enabling nature but also by its direct economic contribution. In the next wave of applications that will address societal needs, the semiconductor, software content and systems in electronic equipment could rise to 25 or 30% of its value. The technological base supporting these new applications has a broader scope than in the past. As the development of all these technologies and applications is very R&D intensive, the degree of expertise in Europe will need to be clearly uplifted, generating a lot of high-qualification jobs.

Product performance and functionality is growing. Interoperable embedded systems create new services that drive product innovation, push energy efficiency forward, reduce waste and enable e-government solutions. Advances in miniaturisation allow ICT to be embedded everywhere, providing enhanced functionality, greater intelligence and more personalised products and services.

Technological advances in embedded systems will help transform our world with systems that

- respond faster to the environment (e.g., autonomous collision avoidance),
- are more precise (e.g., robotic surgery and nano-tolerance manufacturing),
- work in dangerous or inaccessible environments (e.g., autonomous systems for search and rescue, fire fighting, and exploration),
- provide large-scale, distributed coordination (e.g., automated traffic control, smart grid),
- are highly efficient (e.g., zero-net energy buildings),
- augment human capabilities, and
- enhance societal well-being (e.g., assistive technologies and ubiquitous healthcare monitoring and delivery).

These capabilities will be realized by deeply embedding computational intelligence, communication, control, and new mechanisms for sensing, actuation, and adaptation into physical systems with active and reconfigurable components and their connection and interoperation by global digital networks. Cyber-physical systems will transform how we interact with the physical world just like the Internet transformed how we interact with each other.

Excerpt from: "Position Paper – Cyber-Physical Systems", by Alberto Sangiovanni Vincentelli, 2011.

These added-value operations are key elements for product diversification and strong European competence. They form the basis for a European strategic research agenda aimed at key European lead markets that hold a huge economic potential in the knowledge-based society.

These emerging lead markets which are driven by the grand socio-economic challenges represent an historical chance for the European ICT Components and Systems industry and service businesses to become world leaders. Important factors that underpin this unique set of opportunities are the open-mindedness of the European public vis-à-vis socio-economic topics, innovation capability of the industry, excellence of R&D&I in academia, institutes and industry, and, last but not least, leadership of the European ICT Components and Systems Industries in merging a large amount of different technologies into system solutions.

The ability to handle multidisciplinary issues by a highly-skilled workforce constitutes a competitive advantage particularly for European Smart Systems stakeholders. Intelligent integrated sensing and microsystems technology provides a broad interdisciplinary basis for innovations and for addressing a heterogeneous spectrum of applications and customers.

Process knowledge and application know-how ensure that worldwide customers can expect the best fitting technology tailored to their specific needs: the European Smart Systems sector is characterised by representing nearly all necessary technologies and disciplines.

Current and new societal challenges will open-up new markets which will offer new opportunities for Smart Systems innovations in the near future - from intelligent implants and pacemakers in medical technology to Smart Systems in the automotive industry, where they add to the efficiency of propulsion technologies while also increasing the safety of occupants. Smart Systems in intelligent industrial control systems reduce emissions and enable more efficiency in the use of resources. They make aviation safer, and allow for the detection of hazardous and harmful substances in safety and security applications and provide the crucial functionalities for the Internet of Things – the next global product revolution.

New tailor-made and multi-functional materials promise the provision of entirely new properties, the integration of bio-components are beginning to blur the barriers between living and inert matter. The design, manufacture, testing and assurance of the smooth running of these systems will engender methods and tools bringing not yet foreseeable challenges – but undoubtedly innovative answers.

Existing research and industry structures and the technological achievements in the microsystems field provide an excellent basis for a transition towards Smart Systems which better satisfy the customer requirements by offering more sophisticated, complex and intelligent functionalities.

Close co-operation along the value chain will boost innovations given the numerous consumer and industrial application areas where a) Europe is offering significant entry market sizes and lead market/supply potentials and b) where European multinational companies hold leading positions in global markets.

Particular upturn is seen for intelligent and resource-efficient manufacturing, a sector which will benefit heavily from innovations in the Smart Systems sector.

Today differentiation in the emerging markets is based on ability to build complex interoperable ICT systems that serve as backbone of society, integration of technologies, design capabilities in hardware and software, and the intimate understanding of systems through close co-operation with both equipment and systems and service providers. These reasons underline the necessity for European R&D&I actors to continue to invest in ICT enabling activities. **Public-private partnerships (PPPs)** are a concept with a proven track record that reinforces the close co-operation of all stakeholders in the value chain at the European level in a focused and efficient way.

European regional clusters of excellence, like Silicon Saxony in Dresden, Minalogic competitiveness cluster (pôle de compétitivité) in Grenoble, System@tic in the Paris region, the Nijmegen-Eindhoven-Leuven area, Point One in the Netherlands, the Smart Systems Cluster in Baden-Wurttemberg, microsystems industry agglomerations in the French and Swiss Jura region, etc. create suitable ecosystems, offer the possibility for new applications to be developed, new SMEs to be started and new patents to be generated, and thus enlarge the positive effect for ICT industries of being located in Europe. In ARTEMIS labels are granted for Centres of Innovation Excellence that have proven cross border cooperation models.

All these clusters and initiatives are a major asset for Europe and should be further strengthened, for example through collaborative programmes mobilising their individual competences and by targeting even more ambitious goals at a European level. A healthy mix of large and small companies and knowledge institutes is essential for fostering eco-systems. An equal attention to all constituencies of ecosystems is a prerequisite.

The development of lead markets in Europe will greatly facilitate the successful introduction of new products and services. Experiences around the world have demonstrated the importance of lead customers. For instance, the USA have traditionally enjoyed the benefits provided by the large research funds of the Defence and Space administrations, which often play the role of early users of ICT systems.

The initiative of the European Commission to concentrate the largest part of the next Framework Programme for Research and Innovation (Horizon 2020) on societal challenges is a right step in this direction. It should enable the development of common European solutions across EU member states, allowing also European industry to compete successfully in global markets. In particular, European system integrators will have the opportunity to develop innovative ICT products and services as key components of the solutions addressing Europe's societal challenges. A common technical approach from the ICT perspective across the six societal challenges of Horizon 2020 should be ensured.

Along lead markets, other support actions by the European Commission will also be required to increase the impact of Europe's ICT system research. These might include: pre-commercial procurement of innovative solutions, funding of centres of excellence across member states, providing seed money to SMEs facilitating the

participation of Venture Capital in Horizon 2020, complementing research funds with European structural funds.

In implementing the above measures, an important role shall be played by PPPs, which are based on common European research agendas and facilitate the buildup of consensus around technology development strategies and other measures needed to turn research into marketable products and services. The advantages provided by PPPs with their long-term research agenda's (focused on market acceptance and creation of critical mass) should be exploited in addressing societal challenges in Horizon 2020.

3.2.4 Threats

Far from being static, ICT is developing more quickly than ever because of technological progress and the massive technical and financial resources deployed worldwide. The new trajectories of ICT however might not favour Europe. As noted by ISTAG[23]:

"In the last few years, the introduction of large server farms with more than 1 000 000 computers comprising huge data storage facilities, connected to the Internet, and the development of software for the nearly autonomous management of this multitude of computers has created a computing infrastructure that has improved the price/performance ratio by one or two orders of magnitude over the price/performance of conventional data centres. Such an economic advance will have a profound impact on the future computational infrastructure. This future infrastructure is expected to consist mainly of *smart personal devices* and *embedded systems* at one end of the Internet and a diversity of server farms (the *cloud*) at the other end".

While the convergence between embedded systems and the Internet will open up huge opportunities for the ICT system sector in Europe, neither smart personal devices nor the cloud are among Europe's strengths. Furthermore, the main actors in the Web are not European and they have already fully grasped that the future generation of ICT will be networked, mobile, embedded in into everyday life, based on a rich and multimodal interaction (see for instance Google's recent Glass project).

Therefore, the competitive environment looks increasingly hostile. Europe will need to develop new technologies, applications and business approaches if it wants to remain at the forefront of ICT innovation and to address, through ICT, its societal challenges.

For the ICT system sector, technological progress will mainly concern: addressing increased system complexity, exploiting the ubiquity of broadband mobile connectivity, managing the growth of intelligence "at the edge", maintaining dependability and security of use, exploiting storage and processing power on-demand, enriching content, user experience and performance through the convergence/integration of applications, processes and services, creating new interfaces able to manage 3D, multimodal and geo-referenced data (for a more detailed account on future technological challenges for the ICT system sector; see the SRA developed by ARTEMIS Industry Association, 2011).

There is also a need in Europe to overcome fragmentation and to progressively build on research results to feed excellence in innovation. The aim is to reduce development and PLM costs, shorten time to market, and increase affordability while continuously improving performance.

However, all the above will not be enough for Europe to bring to market all the new opportunities which will emerge in this decade in terms of breakthrough services and applications. Successful exploitation of ICT research results will require also nurturing entrepreneurship and the creation of new businesses and business models, in other terms, overcoming the innovation gap that has limited so far Europe's economic success.

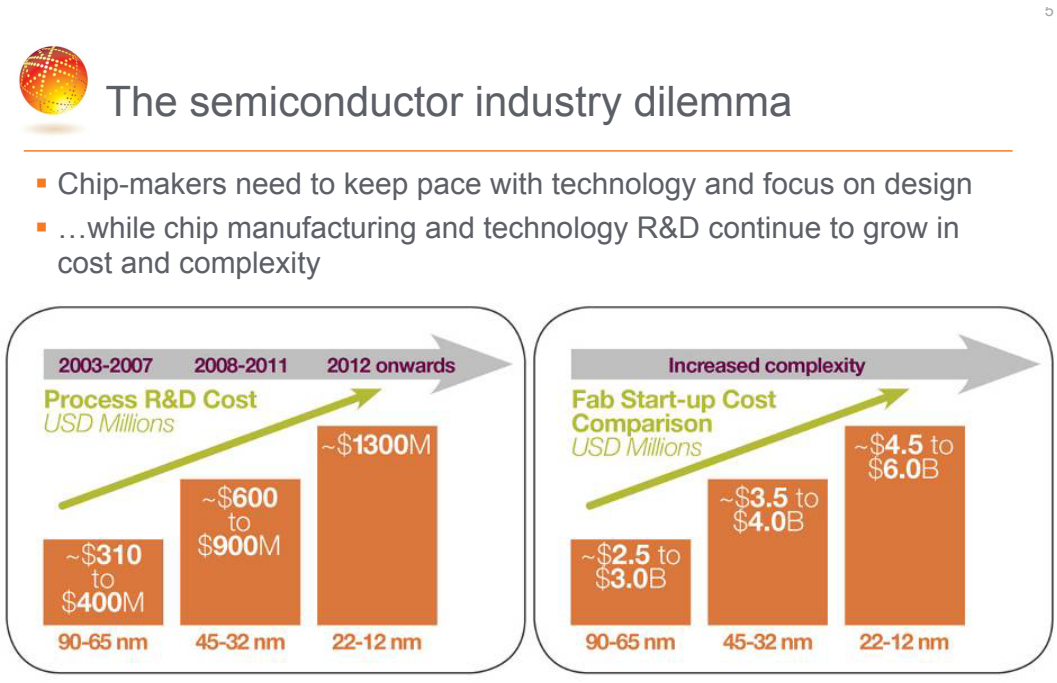
[23] Recommendations of ISTAG on FP7 ICT Work Program 2013, March 2012

Europe cannot afford to miss this future and so become dependent on other regions of the world for its social progress and well-being. Currently, the ICT enabling industry reinvests about 10-20% of its turnover in R&D. The percentage of reinvestment continues to grow as industry faces the challenge of combining shortened product life cycles with the increased complexity of those products. It is only with significant additional investment in advanced R&D that a region can keep up with the pace of innovation in this sector.

However, Europe is not gaining market share in a series of ICT market segments and is a net importer of ICT components and systems. E.g. 10% of the worldwide semiconductor production capacity is located in Europe, while 13% of worldwide semiconductor products are consumed in Europe. Without adequate capital investment, these gaps will widen. The global competition is fierce, especially from countries such as Taiwan, South Korea, China and the USA.

Integrated design and manufacturing companies are increasingly relying on foundries – third-party fabs – and go fab-light for their added-value operations or even fab-less, co-operating in ecosystems of knowledge for their R&D and in strategic alliances for their access to the most advanced technologies.

This is the result of the growing capital investments – a mega fab costs €5.5 billion typically –required to research and manufacture the new generations of ICT enabling components. This goes above what individual companies can afford – apart from Intel – in terms of return on investment.



(1) Industry average for Logic process R&D;
(2) Average capex of 300mm Logic fabs in World Fab Watch database.Source: In-Stat 1/07, World Fab Watch; analyst reports; press clippings;

Src: Key Enabling Technologies (KETs) Open Day on Micro/ Nanoelectronics 18.10.10 Brussels. Olivier Vatel, Vice President Technology Development division, Global Foundries.

Consequently, generic micro- and nanoelectronics technology research is executed by a few major alliances, while manufacturing of advanced commodity products is done in a few mega fabs. Europe must ensure that its companies can play a strategic role in these global alliances and keep added-value operations including advanced manufacturing in Europe, accessible to European partners – including SMEs active in equipment, support, systems integration and design.

New solutions are mainly driven by innovation in embedded software and associated micro- and nanoelectronics, and by the integration of components at systems level. New societal needs require dedicated system solutions where a variety of technologies are integrated on a single chip or in one package or a (sub-)system). Access to

these technologies is crucial to developing and providing the required innovative solutions and to securing the technological independence and competitiveness of European industry as a whole.

Europe is standing at a crossroads. It can either seize the opportunities given by the grand challenges and take up the leadership by solving the problems that society faces – and thereby build a prosperous economy – or, as was the case in the past decade, it can choose to sit back and lose the last bastion of production capability and, eventually, its development and innovation competences. Determinants of competition, however, are not a sole issue of companies, but of socio-economic systems wherein the political side plays a decisive role (cfr. next paragraph). Without a radical uplift in joint efforts, and the acknowledgement of the urgency of the situation by industry and public authorities, opportunities as defined by the grand challenges will be lost.

Bottlenecks have already been experienced in the high-technology labour market in that it has failed to supply the necessary skills. There is a high risk in the future that this situation will further deteriorate caused by a progressive drain due to better conditions for researchers and engineers in other world regions.

Other competitors might catch-up: The U.S. demonstrated that Smart Systems for military and security applications have an enormous potential for civilian applications. "Dual use" constitutes a significant favourable competition factor for the U.S. economy. Stakeholders in Japan, China and Korea focus their efforts on the other hand on the use of Smart Systems technology to strengthen their already claimed application fields, such as the consumer sector, and continue to set themselves apart from the competition with innovative developments.

Public authorities in non-European countries are heavily investing in Smart Systems research including basic research, particularly Japan, Korea and the USA: the budget of the US Microsystems Technology Center is the global benchmark for public investments in Smart Systems research.

There is a lack of capital intensive investments especially for SMEs needed for the transition from micro-techniques towards integrated Smart Systems (with dramatic consequences, as in the watch industry in the 1970s).

3.2.5 The level playing field

In general the prosperity of, and the employment in, many industrial countries depend on the industrial climate, as in these countries a significant amount of the jobs are in industry. If the industrial climate is OK, industry will invest in factories, laboratories, offices, machines, technology and R&D, which will keep or, even better, increase the number of jobs in their companies. This in turn is good for the prosperity of the countries in which the industry has located their activities.

About the industrial climate and the influence on prosperity and innovation many reports are written. Important reports are the Ministerial report on the OECD Innovation Strategy (May 2010) that mentions the need for a level playing field, and the Communication from the European Commission on the Innovation Union SEC(2010)1161 (Oct. 2010). The last report does not use the wording 'level playing field' but makes similar observations as the OECD report.

If companies make products for the international markets, they have to be competitive on a global scale, which means that the net result of all parameters that determine the success of a company should be close to that of best-in-class-companies, wherever located. The number

> 'The importance of framework conditions, including the need for a level playing field, has increased in recent years as businesses and capital seek the most favourable environments and become more mobile. Reaping the benefits of innovation at the national, regional and local level increasingly requires governments and other stakeholders to undertake the investments and policy reforms that provide a good environment for engaging in innovation. In addition to the quality of framework conditions, human capital, research and communications infrastructure, as well as the size and quality of local markets are factors that help economies attract investment in innovation.'
>
> *OECD Innovation Strategy May 2010*

of these parameters might be quite high (20-50), and a lot of them are internal company parameters, like trained and motivated personnel, a good working organization, effective marketing and sales, efficient production, quality and reliability of the products, etc. However a significant amount of parameters are external company parameters.

'Our education systems at all levels need to be modernised. Excellence must even more become the guiding principle. We need more world-class universities, raise skill levels and attract top talent from abroad.'

EU Innovation Union Oct. 2010

Related to the external company parameters, like the local conditions in countries, successful companies continuously monitor the local conditions of countries in which their (successful) competitors have operations or activities, and also look out for opportunities in countries which can soon offer favourable conditions. Local conditions monitored are amongst others tax climate, education system, availability of adequately trained personnel, labour cost level, IP protection, environmental regulations, cost of energy, and, important for this document, the governmental funding level of (pre-competitive and transnational) R&D projects.

These monitor- actions determine whether a company should move their activities to other countries to remain competitive. Of course this is a threat for the employees of companies that are (still) located in countries in which the conditions have deteriorated or are no longer favourable in comparison to other places in the world, where the conditions have been improved. And subsequently it is a threat to the prosperity of a country, because industry moving out activities means losing jobs and tax income.

Needless to say, that the actual threshold to decide to move to another location is rather high in practice. No company wants to move every few years, no company wants to displease its employees or make the feel unsecure and most companies are deeply embedded in the eco-system of their location. However, if conditions are worse for an extended period of time, a change of location becomes unavoidable.

One can only compete on a level playing field. Not the players but the owner of the stadium is responsible for this.

Some countries outside Europe have therefore developed special incentives to attract and retain foreign investment in manufacturing, whereas the EU lacks a dedicated industrial approach to support this key enabling ICT technology industry. The European governments including the European Commission must react with comparable and/or compensating measures to keep the employment and the prosperity in Europe.

Currently however, the right mix of conditions does not exist in Europe to guarantee a global level playing field, specifically for capital intensive industries. To be in a position to retain and attract new investment in the entire value chain of the ICT components and systems industries appropriate governmental action in Europe should guarantee an equal level playing field with other global regions.

The responsibility to maintain and improve the local conditions is mainly the responsibility of the local government and "umbrella governments" like the European Union. The companies can give a helping hand by specifying their needs and participate in public

'Unsatisfactory framework conditions, ranging from poor access to finance, high costs of IPR to slow standardisation and ineffective use of public procurement. This is a serious handicap when companies can choose to invest and conduct research in many other parts of the world.'

EU Innovation Union, Oct. 2010

private partnerships but the politicians in governments and parliaments set the scene and must understand that their actions determine for a significant part the successfulness of the industry in their countries, and as a result the countries' prosperity, as a whole. The governments must, as the companies do, continuously benchmark their local conditions versus the rest of the world to know which actions they have to take to maintain or improve their conditions for those industry branches they like to keep or be initiated in their countries, and then take all measures and actions needed.

It is not just a bonus for companies to receive better external conditions, for instance by receiving tax reduction or funding for transnational R&D projects. It is the responsibility for the governments to create favourable conditions for their own countries' benefit. Companies that give signals that the external conditions in the countries in which they have activities are no longer close to benchmark and that they therefore might consider to move out activities if these conditions are not going to be improved, do this for a good reason: to help to safeguard the prosperity of Europe.

In many regions of the world, there is a dedicated and focused governmental industrial policy which creates better conditions for high-tech industries and related R&D institutions than in Europe. As an example see the table on the next page which gives an overview of state aid for the Semiconductor industry.

The relevance of ICT Components and Systems Industries as key enabling technology providers for nearly all branches of the European high tech industry and for the solutions of today's societal and consumer demands is beyond dispute. In several typical European domains, European companies are world leading and contribute to the global dominance of the relevant European systems houses.

An important factor for this strength is the effort spent for R&D. But, nevertheless, from a general perspective, Europe is losing ground and approaching a critical situation. This holds in particular for capital intensive ICT Components industries (Nanoelectronics) and it is due to the fact, that other regions in the world follow a very appropriate industrial policy to strengthen their key enabling technologies.

The identification of nanoelectronics as one of the key enabling technologies for Europe and the report of its high-level expert group open the possibility for addressing this unbalanced situation and to propose specific measures above and beyond pure R&D programmes.

To summarise: **Europe needs a strong pan-European approach to R&D&I and a coherent industrial innovation policy.**

Country	Primary Incentive Type	Potential comparative value of incentive programs for Semiconductor
China	> Tax abatements	Low/High- Significant government assistance will general require companies share intellectual property…or being local
Malaysia	> Tax abatements > Cash grants	Strong – The Malaysian government can be very aggressive and creative in efforts to win projects deemed of significant value. Long-term tax abatements and potential cash and training grants can be valuable
Singapore	> Tax abatements > Cash grants > Equity/capital investment	Strong – Singapore has had tremendous success using its combination of aggressive economic development, strong talent base and significant sovereign wealth fund resources to win major projects
Eastern Germany CEE	> Tax abatements > Cash grants > Loan programmes	Moderate – Because cash grants are based on capital expenditures, grant values can be relevant in regions that are eligible to provide structural funding. Many areas of Germany will be phasing out of convergence status
Western Europe	> Cash grants > R&D tax credit	Low – Some programs are available. However, the cash value is usually minimal except to R&D in specific countries
USA	> Refundable tax credits > Training assistance > Property tax abatements if located within Enterprise Zone > State income tax abatement	Low/Moderate – Refundable tax credits are similar to cash and generally based on capital investment and job creation. By US standards would be strong, but poor to moderate when compared globally.

c.: Key enabling technologies (KETs) open day on micro-/nanoelectronics 18.10.10 Brussels. Deloitte Consulting LLP

3.3 Summary of SWOT analysis for the European ICT Components and Systems Industries

Strengths	Weaknesses
> Excellent R&D capabilities/capacities in industry, institutes and academia > Global leadership in More-than-Moore technologies and applications > Competence leadership in Smart Systems Technologies > Complete, differentiated and intact value chains in the Smart Systems sector > Leading position in several market segments and applications – e.g. automotive, healthcare imaging, industrial automation, security and communications > Market leaders in equipment and material, such as lithography, SOI and deposition technologies > Big ICT home market in key domains > Highly skilled employees with outstanding professional experience	> Insufficient alignment of member states on a European ICT strategy > Lack of European industry policy; inadequate economic framework conditions > Very limited strategic approach for deployment of ICT system solutions for societal challenges > Inadequate venture culture for commercialisation of inventions and R&D results; lack of venture capital > Insufficient focus on high-tech products within the European manufacturing industry > No broad coverage of equipment and material suppliers > Shortage of well-educated new talents > 40 % less patent applications than USA or Japan > Limited role in desk/lap-top/tablet/smart-phone related applications

Opportunities	Threats
> New societal challenges, which create new markets > Creation and steering of lead markets by setting standards and regulations – e.g. GSM and photovoltaic feed-in tariffs > Need for proprietary leading solutions in European industry – e.g. in automotive, industry, security and healthcare > Increased public procurement for stimulation of new markets > Industrial exploitation of new materials and corresponding equipment > Increase R&D employment to address emerging societal needs > Expansion of PPP's and eco-systems will increase the attractiveness of Europe as location for manufacturing and R&D	> Deterioration of the already uneven level playing field > Persistence of the unfavourable European framework conditions > Further loss of competitiveness with respect to production cost – labour, energy, > Loss of major parts of technology and production expertise and as a consequence, risk of degradation in leading-edge R&D&I > Loss of major parts of proprietary intellectual property > Brain drain to other regions > Dependence on non-European production > Increasing currency variations > Fragmented regulatory framework preventing economy-of-scale exploitation

4 The roles of the Industry and the Public Authorities

Before specifically addressing the roles of Industry and Public Authorities it must be emphasized that the fulfilment of the mission will only be achieved if this is in the first place considered by all stakeholders as a shared responsibility. However, to get focus, the following sub-chapters elaborate specifically the roles of the Industry and the Public Authorities in their shared responsibility.

If, in the following, the role of European R&D&I actors is described, this is of course not limited to large industries alone, but to all players in the field – including SME and academic research. However, in order to be pragmatic, large industries shall clearly be in the lead and shall be key element and in the centre of ICT Components and Systems eco-systems either of local or of cross-border character.

4.1 Role of the Industry

Technological challenges in the ICT Components and Systems Industries are too complex to be solved by any single player in Europe, be it industry or country. The comprehensive R&D&I efforts needed to resolve these challenges require joining forces across industry and country borders. This has been recognized by European industry and governments already more than 20 years ago, when collaborative R&D projects have been adopted as an effective means to accommodate such R&D. These projects have enabled substantial economic growth in this sector with a rate that was substantially above the average for Europe.

Industry will continue to invest in collaborative R&D in Europe and would even be ready to invest more than in the past; a clear signal is given by the large number of proposals for collaborative projects and by expression of interest to extent these collaborations to higher TRL's including pilot lines. Industry will also continue to invest in innovation and industrialisation to capitalize on this R&D. This innovation will address both the supply and the demand side of the European value chain. Investments in collaboration have demonstrated in the past to create substantial leverage and it is the firm belief that such leverage will continue to exist. Through such collaboration the European Industry will continue to demonstrate above average economic growth. Next to growth, this collaboration will continue to provide a fertile breeding ground for SME development, including starters, spin-offs, and spin-ins (=acquisitions).

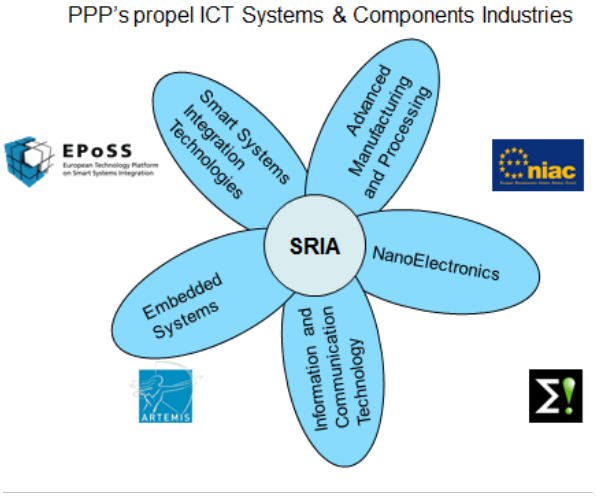
4.1.1 Eco-systems around ICT Components and Systems Industries

The industries take the responsibility to create and maintain healthy ICT components and ICT systems eco-systems in Europe spanning the other R&D&I actors in these domains.

Sometimes, the ecosystem is shaped as a consortium or a loose connection of cooperation between large corporations, SME's, public research institutes and universities. It can be ad-hoc for specific projects, but in practice, due to cooperation in the past in similar projects, that were supported by public private partnerships, the ecosystem becomes more intertwined and companies and institutes benefit mutually from each other's expertise and from the trust that was created by fruitful cooperation. In particular for SME's such cooperation has proven to be very useful.

Often, however, the ecosystem has a more formal character, either bound by location or by organisation. Famous are the clusters of companies, institutes and public authorities in Grenoble, Dresden and Eindhoven/Leuven, but there exist more examples of such geographically bound excellent co-operations. Quite a few SME's (often not so small anymore!) have been created within this context. Industry commits to continue to support these initiatives.

Non-geographical, but organisationally bound clusters can be found in Public Private Partnerships like ARTEMIS, CATRENE, ENIAC, EPoSS, EURIPIDES and ITEA. The initiatives leverage the potential of Europe as whole and their importance for the industry can hardly be overstated. In return Industry guarantees exploitation of the results obtained through these clusters to the benefit of Europe and of the position of the European based R&D actors in the global competition.



Ecosystems and clusters have an R&D&I scope from very advanced research to pilot production. They are excellent "tools" to ensure that very advanced results (as obtained mainly by Academia, Research Institutes and Universities) find quickly and efficiently their way towards integration in products and manufacturing methods of members of the same eco-system.

4.1.2 Collaboration in Eco-systems

The ICT Components and Systems Industries will foster in Europe a shift from the linear model where research results were transferred from universities to institutes and industry, into a model where research is carried out in partnership, deeply embedded in the industrial web supporting the knowledge ecosystems. Such collaborative research must produce sufficient critical mass to allow for sharing of costs associated with the access to expensive state-of-the-art infrastructures.

Collaborative research will also support the European industry and its researchers in acting globally as global co-operation between the different research actors is becoming an increasingly important prerequisite for success.

4.1.3 SME creation (spin in, spin out, embedding in ecosystem)

Fostering co-operation will also encourage the inclusion and creation of SMEs in the most demanding and promising fields. Such co-operation will expand the size of the ecosystem and make it more attractive to all participants, thereby effectively and significantly increasing the threshold to move to locations outside the ecosystem. The continuous spin-in and spin-out of small and medium-sized companies to larger ones make the ecosystem even more attractive. Notably, the creation of highly-competitive SMEs is often the consequence of research results from universities and the sharing of know-how and facilities within an ecosystem or region.

Similarly, the presence of large industries in a region or ecosystem often depends on SME suppliers. The customer-supplier intimacy within the ecosystem greatly contributes to the stability of the industrial activity in a region.

4.1.4 Summary of the role of the private R&D actors

The industry will continue to invest in average 10-20% of its turnover in R&D. Thus it will create global leadership through growth and this holds especially for SME's. Cooperation in Europe between Industry, Universities and Scientific Institutes will be intensified. Public Private Partnerships and working within ecosystems are the methods of choice to achieve this. The powerful combination of investment and cooperation is a guarantee for Europe for access to the technologies and applications that it will need. Meeting the grand challenges will be the insurance that Europe will stay at the forefront of the strategic miniaturization with dramatic increase of functionality of systems, modules and devices. Investment and cooperation will therefore consolidate and expand the top ranking positions, which European Industries occupy in many segments.

4.2 Role of the Public Authorities

The challenges are complex and need to be addressed by all actors, including public authorities. Their activity should not be limited to financial support aiming at restoring a level playing field for European actors through financial means but also to include public procurement of innovative products and services, as well as political, regulatory and standardisation actions which mainly focus on setting priorities and creating frameworks. Such support includes:

4.2.1 Fixing Global Priorities for Europe

Since its origin, the value chain of ICT components and systems industries has been considered a guarantee for sovereignty by major economic forces and has benefited from intense political support worldwide. Defence applications and the space race were the main drivers when the industry first took form in the early 1950s. Later, when professional and consumer applications became dominant, public commitment and industrial policy continued to determine the competitive position and attractiveness of the various players or countries. The economic environments – including fiscal incentives – structure the value chain of the ICT industrial landscape. Asia has demonstrated a strong political commitment to its domestic industry by massively supporting new investment and research programmes as well as by elaborating a long-term industrial strategic plan and policy.

The EU Europe 2020 strategy recognises that mastering smart growth requires improvement in the quality of our education system, strengthening our research performance and promoting innovation and knowledge transfer throughout the EU. "*Agreeing on thematic priorities of the Europe 2020 strategy and calling on all parties and stakeholders to help implement the strategy, working in partnership by taking action in areas within their responsibility*" is considered to be a key element for success.

It is very important for a competitive Europe to conclude rapid and firm agreements jointly between the EU and Member States on priority segments where the convergence of the ICT enabling technology capabilities with emerging societal needs is able to generate high value-added market opportunities (= the opportunity-element of the strategy). These opportunities can be fully exploited at the dimension of the European market while even creating new opportunities for global leadership in some of these new markets.

4.2.2 Providing the Right Framework Conditions

The ICT components and systems industries function in a globalised sector and determine the localisation of their activities with the aim to continuously to improve competitiveness and performance. It is the responsibility of the public authorities to establish an industrial policy that creates the best environment and framework conditions to maintain and develop a strong and competitive industrial base in Europe.

The Europe 2020 strategy proposal combines different instruments including smart regulation, modernised public procurement, competition rules and standards setting, affordable access to finance, promotion of internationalisation – especially for SMEs –, improved conditions for enforcing IP rights, reduction in the administrative burden on companies, improvement of the quality of business and labour legislation.

This is reinforced by the European Semiconductor Industry Association (ESIA) 2008 Competitiveness Report (see chapter 2): "*Europe should revise its industrial policy, using the complete set of political tools (as done by many countries, including the newly developed Asian ones), considering also the regulations and provision aimed to facilitate access to capital and to generous incentives in order to restore better parity to competitive chances on a global level playing field*".

A set of regulatory and legislative supervisory measures is required to shape the future. These should aim to limit disadvantageous currency distortions, to create a labour policy that anticipates and manages change better, and to contribute to the removal of roadblocks surrounding the introduction of new technologies and systems in the

environmental, health and safety arena. The measures must leverage the public R&D funding potential that exists in Europe, help maintain and renew Europe-based manufacturing capabilities and encourage the role played by education as the foundation of intellectual innovation capital and of a solid science base.

4.2.3 Supporting the Creation of Lead Markets

Apart from manufacturing equipment and material, Europe has consistently lost share of the worldwide ICT market even though the ICT components and systems industries continue to be the key enablers for nearly all high-tech innovations. To reverse this trend, it is imperative to focus on and develop further areas where Europe has recognised strengths, as well as new market opportunities. These require a very significant degree of innovation which is first and foremost based on solutions enabled by ICT technologies.

EU and Member States public authorities can trigger and support such developments by proactively establishing regulatory frameworks that set standardised targets for the industry that focus on achieving appropriate solutions in specific critical areas, supported by stimulus packages to accelerate the development and diffusion of required innovative technologies and products within a defined time horizon.

4.2.4 Managing Human Capital

Europe should boost its prosperity by making better use of its most precious resources – its people. Much of the intellectual property embedded in future European products will be the result of partnerships between education, business and government agencies. Motivation, commitment, dedication and readiness for hard work are important qualities that allow business to improve continuously its innovation capacity and productivity.

Therefore, Europe should strengthen its position through specifically-initiated programmes for education to provide a solid science base, qualitatively and specifically quantitatively, for future generations of researchers and engineers. Europe should further facilitate the mobility of highly-skilled experts in science and technology (S&T) disciplines by increasing the attractiveness of Europe for high potential individuals and creating an open innovation environment.

Although there is a strong awareness that the number of young people choosing for a technical study is not enough, the success of the various national programmes to interest young people for technical studies (including the ICT domain) is rather limited.

4.2.5 Ensuring adequate infrastructure

Segments of R&D will have to focus on improving the efficiency of production and the capabilities to design new products are lagging behind technological progress. These are just 2 examples that illustrate the need for the European research fabric to redirect itself to grasp better technological opportunities such as architecture, processing, platform design and software. It will need to invest more in such applied research. This requires a fundamental shift from single science, technology thinking into multi-disciplinary systemic thinking. It will result in mentalities and infrastructures that are focussed on cooperation and on sharing of knowledge and expensive equipments or large scale field experiments.

Serving the same aim, European governments should sustain the creation of new and the improvement of existing research infrastructures such as science parks, incubators and venture partnering to support the creation of new, high-tech SMEs.

Last but not least: the ICT Components and Systems ecosystems. Each contributor in an eco-system (large industries, SME's, Academia) plays its own important role. It is the mutual interaction and the leverage of the strengths of each contributor that will strengthen the ecosystem as a whole. The Public Authority's role is to invest in ecosystems and to manage a good balance between all its contributors. Healthy growth will be the result.

Appendix

AENEAS Industry Association - members - A Chamber: Small Medium Sized Enterprises:

- AMO GmbH
- Archimede Elettronica Srl
- ART S.r.l.
- Artemis Control AG
- ASYS Automatic Systems GmbH & Co.KG
- Boschman Technologies B.V.
- Bronkhorst High-Tech BV
- CISC Semiconductor GmbH
- Coventor SARL
- DAS Environmental Expert GmbH
- HAP GmbH
- Infinitesima Limited
- INSTITUT MIKROELEKTRONICKYCH APLIKACI S.R.O.
- Integrated Systems Development
- Ion Beam Services
- AlphaSIP
- memsstar Ltd.
- Nanda Technologies GmbH
- Nanophotonics AG
- RECIF Technologies
- RoodMicrotec Nördilingen GmbH + Co. KG
- SEMILAB Ltd.
- Semilev
- SemiQuarz GmbH
- SenSiC AB
- Sensonor Technologies AS
- SEPS Technologies AB
- SHT Smart High Tech AB
- System Integration Laboratory R + D
- Technolution
- TopGaN Sp.z.o.o.
- Vistec Electron Beam GmbH

AENEAS Industry Association - members B Chamber: Research & Technology Organisations

- Acondicionamiento Terrassense (LEITAT)
- Acreo AB
- Agencia Estatal CSIC
- Alma Mater Studiorum - Università di Bologna

- Aristotle University of Thessaloniki
- Brno University of Technology
- CEA-LETI
- CNRS
- Consiglio Nazionale delle Ricerche
- CSEM
- Delft University of Technology
- Dublin City University
- Eindhoven University of Technology
- Forschungszentrum Jülich GmbH
- Fraunhofer
- Fundación CIDETEC
- FUNDACION TEKNIKER
- Graz University of Technology
- IHP GmbH
- IMEC
- IMEL/NCSR Demokritos
- INRIA
- Institut Català de Nanotecnologia
- Institut Polytechnique de Grenoble
- Instytut Technologii Elektronowej
- INL
- IU.NET
- Kungliga Tekniska Högskolan
- Nat. Inst. for R&D in Microtechnologies
- Physikalisch-Technische Bundesanstalt
- Politecnico di Milano
- POLITECNICO DI TORINO
- RWTH Aachen University
- Research Inst. for Techn. Phy. & Mat. Sci. - MFA
- Sapienza Universita' di Roma
- Sincrotrone Trieste S.C.p.A.
- SINTEF ICT
- Télécom ParisTech
- TNO Netherlands Organisation
- Tyndall National Institute
- Universidad de Cantabria
- Università degli Studi di Milano Bicocca
- Università della Calabria
- Universitat Politècnica de Catalunya
- Universite Catholique Louvain
- University of Erlangen-Nuremberg
- University of Modena
- University of Patras
- University of Perugia
- Uppsala University
- Vilnius University
- VTT Technical Research

AENEAS Industry Association - members C Chamber: Large Enterprises

- AIXTRON AG
- Applied Materials Israel Ltd
- ARM Ltd
- ASM International N.V.
- ASML Netherlands B.V
- ATMEL
- AUSTRIAMICROSYSTEMS AG
- Carl Zeiss SMT GmbH
- CASSIDIAN SAS - EADS
- Eurotech SpA
- Infineon Technologies AG
- Intel
- LAM
- Landshut Silicon Foundry GmbH
- Mattson Thermal Products GmbH
- Micron Semiconductor Italia srl
- NXP Semiconductors Netherlands B.V.
- ON SEMICONDUCTOR BELGIUM BVBA
- Philips Electronics Nederland B.V.
- PVA TePla AG
- S.O.I.T.E.C
- Siltronic AG
- Sorin CRM
- ST-Ericsson (GRENOBLE) SAS
- STMicroelectronics International NV
- SUSS MicroTec AG
- Thales Research & Technology France

AENEAS Industry Association - Associated members:

- 24IP Law Group
- ALMA Consulting Group
- CATRENE
- edacentrum e.V.
- EECA-ESIA
- FEEI
- Minalogic
- SEMI Europe
- VDMA Productronics

ARTEMIS Industry Association - members A Chamber: Small Medium sized Enterprises

- AbsInt Angewandte Informatik GmbH
- Aicas GmbH
- AICO EDV-Beratung GmbH
- Akhela srl
- Atego Systems Limited
- Berner&Mattner Systemtechnik
- BTC - Embedded Systems AG
- CNet Svenska AB
- CoFluent Design
- Critical Software
- Demcon Advanced Mechatronics BV
- Duracar Holding B.V.
- ELVOX Costruzioni Elettroniche S.P.A.
- Esterel Technologies SA
- ETIC-Embedded Technologies Innovation Center
- FIMECC LTD.
- Fluidhouse Oy
- GAIA, Asociacion de Industrias de las Tecnologias
- Gliwa GmbH
- Greenpower Technologies
- Hermia Ltd
- HI-Iberia Ingenieria y Proyectos
- HPC Project
- I+ SRL
- ICT-Norway
- Igalia, SL
- IMA s.r.o.
- IMS: Information & Image Management Systems S.A.
- INTECS
- INTEGRA renewable energies s.r.l.
- Integrasys S.A.
- ISA: Intelligent Sensing Anywhere S.A.
- ISD: Integrated Systems Development S.A.
- Itemis AG
- Kompetenzzentr. Das virtuelle Fahrzeug Forsch.
- Magillem Design Services
- MeshWorks Wireless Ltd
- Metodos y Tecnologia de Sistemas y Procesos
- MFKK Invention and Research Center Services Co. Ltd.
- Movation AS
- Nanosens
- Nito Telecom AB
- Novelda AS
- NUUBO Smart Solutions Technologies S.L.
- ON2 Technologies Finland Oy
- OptXware Research & Development Ltd.
- PrismTech Limited

- Prodatec Oy
- Scaleo chip
- Sirris
- Symtavision GmbH
- SYSGO AG
- Systonomy Limited
- Technoconsult 2970 ApS
- Technolution B.V.
- TECHNOSAM Ltd
- Thyia Technologies
- TIVIT Ltd.
- TTTech Computertechnik AG
- Union Economique Gestoria S.A
- UNIS a.s.
- Validas A.G.
- Vista Silicon S.L.
- WLAB

ARTEMIS Industry Association - members B Chamber: Research & Technology Organisations

- Aalborg University
- AALTO University
- Åbo Akademi / TUCS
- Åbo Akademi University
- AICIA
- AIT Austrian Institute of Technology GmbH
- Aragon Institute of Engineering Research (I3A)
- Aristotle University of Thessaloniki
- Brno University of Technology
- CARTIF Foundation
- CEA
- CEIT
- CENTRIA
- CIMNE
- CITIC
- CRAT
- CTAG - Centro Tecnológico Automoción de Galicia
- CTTC: Centre Technòlogic de Telecomunicasions de Catalunya
- Czech Technical University in Prague
- EECI
- ENSTA - Bretagne
- ESI, Embedded Systems Institute
- FAICO, Andalusian Foundation of Image, Colour and Optics
- Fondation de Cooperation Scientifique DIGITEO
- Fondazione Bruno Kessler
- Fondazione Politecnico di Milano
- ForTISS GmbH

- Fraunhofer
- Ghent University
- Högskolan i Halmstad
- IHP GmbH
- IKERLAN
- IMEC
- Industrial Systems Institute
- INRIA
- Institut TELECOM
- Institute of Communication and Computer Systems
- Institute of Mathematics & Computer Science, Univ. of Latvia
- ISEP - CISTER
- ITI, Instituto Tecnológico de Informática
- Kemi-Tornionlaakson koulutuskuntayhtymä Lappia
- Kungliga Tekniska Hogskolan
- Leitat Technological Center
- Lulea University of Technology
- Mälardalen University
- Mondragon Goi Eskola Politeknikoa
- Norwegian University of Science and Technology
- OFFIS
- Politecnico di Torino
- Riga Technical University
- Saint Petersburg State University of Aerosp. Instrument.
- SINTEF
- SUPELEC
- Tallinn University of Technology
- Technical University Eindhoven
- Technical University of Denmark
- Technical University Sofia
- Technische Universität Berlin
- Technische Universität Braunschweig
- Technische Universität München
- TECNALIA
- Tekniker IK4
- Telecommunication Systems Institute
- TNO
- Trinity College Dublin
- TUT Foundation
- TZI - Universität Bremen
- Umeå University
- Universidad de Sevilla
- Universidad Politécnica, Madrid
- Universitá degli Studi del Sannio
- Universita degli Studi di Cagliari
- Universita degli Studi di Genova
- Università degli Studi di Roma La Sapienza
- Università di Bologna - Alma Mater Studiorum
- Università di Pisa
- Université Joseph Fourier Grenoble 1
- Universiteit Twente

- University of Applied Sciences Leipzig (HTWK Leipzig)
- University of Cantabria
- University of Eastern Finland
- University of Girona
- University of Hertfordshire
- University of Oulu
- University of Padua
- University of Parma
- University of Technology Delft
- University of the Balearic Islands
- University of Trieste
- University of West Bohemia
- Ustav teorie informace a automatizace (UTIA)
- VICOMTECH-IK4
- Vienna University of Technology
- VTT Technical Research Centre of Finland

ARTEMIS Industry Association - members C Chamber: Large Enterprises

- ABB AB
- Acciona Infraestructuras S.A.
- AIRBUS France
- ARM Ltd
- Austriamicrosystems AG
- AVL List GmbH
- Barco
- Bitron S.p.A
- CRF, Centro Ricerche Fiat
- Daimler A.G.
- Danieli Automation S.p.A.
- Dassault Systemes SA
- EADS Deutschland GmbH
- ERICSSON AB
- European Microsoft Innovation Center
- Eurotech
- Finmeccanica
- Gemalto S.A.
- Hellenic Aerospace Industry S.A.
- Honeywell
- INDRA SISTEMAS, S.A.
- Infineon Technologies AG
- Israel Aerospace Industries
- KONE Corperation
- Metso Oyj
- MONDRAGON Group
- Nokia Corporation
- NXP Semiconductors
- Philips

- Robert Bosch GmbH
- Rockwell Collins Deutschland GmbH
- Rockwell Collins France
- SAFRAN
- Schneider Electric Automation GmbH
- Siemens AG
- STMicroelectronics NV
- Thales
- Thomson Video Networks SA
- Volvo Technology AB

ARTEMIS Industry Association – Associated members

- Aerospace Valley
- Confederation of Danish Industries/ ITEK
- DSP Valley
- Electronics Knowledge Transfer Network
- NMI
- SafeTRANS e.V.
- System@tic

EPOSS - members: Small Medium Sized Enterprises

- ADVANTIC SISTEMAS Y SERVICIOS S.L.
- Arts and Science
- e-laborat
- maris TechCon Technology and R&D Consulting
- MIRA Ltd.
- PARAGON S.A.
- Fundación Tecnalia Research & Innovation
- Sensonor Technologies AS
- Starlab
- Vermon S.A.
- CTAG
- INTEGRASYS, S.A.
- VDI/VDE Innovation + Technik GmbH

EPOSS - members: Public Research Organisations & Universities

- Fraunhofer-Institut fuer Silicatforschung ISC
- AIT Austrian Institute of Technology GmbH
- CEA-LETI
- CIDETEC
- CiS Forschungsinstitut für Mikrosensorik und Photovoltaik GmbH
- CNM-CSIS
- Consorzio Ferrara Ricerche
- CSEM SA
- Fondazione Bruno Kessler
- Fondazione Politecnico di Milano
- Fraunhofer ENAS - Einrichtung für Elektronische Nanosysteme
- Fraunhofer Heinrich-Hertz-Institut (FhG-HHI)
- Fraunhofer IIS - Institute Integrated Circuits
- Fraunhofer IML
- Fraunhofer IOF - Institut Optik und Feinmechanik
- Fraunhofer IPMS - Institute for Photonic Microsystems
- Fraunhofer IZM - Institute for Reliability and Microintegration
- Fraunhofer LBF - Institut für Betriebsfestigkeit und Systemzuverlässigkeit
- Tekniker - IK4
- HSG-IMIT
- IKERLAN-IK4
- Stichting IMEC Nederland
- IMT Bucharest
- Institut für Mikrotechnik Mainz GmbH
- LAAS CNRS
- Leitat Technological Center
- SINTEF ICT
- Swerea IVF AB
- VTT
- TNO

EPOSS - members: Large Enterprises

- Alcatel-Lucent
- Gemalto SA
- BUMAR Sp. z.o.o.
- Continental Teves AG & Co. oHG
- CRF - Fiat Research Centre
- Sorin CRM
- Hitachi Europe SAS
- SMC The University of Edinburgh
- ISIS Sensorial Materials Scientific Centre Aalborg University
- Institut FEMTO-ST
- Aalto University School of Science and Technology
- Heriot-Watt University
- Infobotica Research Group from University of Oviedo
- PMC
- University of Erlangen
- University of Sheffield
- Uppsala University
- Infineon Technologies AG
- Landis+Gyr
- Magneti Marelli SPA Division Sistemi Elettronici
- Melexis GmbH
- NXP Semiconductors Germany GmbH
- Philips Research
- Robert Bosch GmbH
- Siemens AG
- STMicroelectronics N.V.
- Thales Communications
- VTI Technologies Oy

EPOSS - members: Others

- IFEVS - Interactive Fully Electrical Vehicles