ITEA ARTEMIS-IA HIGH-LEVEL VISION 2030

OPPORTUNITIES FOR EUROPE

The impact of software innovation on revenue and jobs

ITEA 2
INFORMATION TECHNOLOGY FOR EUROPEAN ADVANCEMENT

ARTEMIS

VERSION 2013

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The impact of software innovation on revenue and jobs

Global challenges, need for R&I and economic dimensions of Digital Technology

AUTUMN 2013

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ARTEMIS

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Preamble

This updated document[1] is the joint result of the industry represented in the ARTEMIS Industry Association and ITEA and expresses the common industry ambition. Its creation was initiated by the ARTEMIS ITEA Cooperation Committee (AICC).

The main goal of this update of the ITEA-ARTEMIS high-level vision 2030, version 2012 is to add a quantitative description of the impact of software innovation on revenues and labour. There are also other aspects of the impact of software innovation, like eco-systems, community building and standardisation. However these are not the focus of this year's update.

Disclaimer

The trends and predictions presented in this document are based on publicly available sources. We rely on these sources, without independent verification of the information presented. The nature of this document is for a large part rather a compilation of existing material, than a reinvention of insights.

The statements made by Roland Berger Strategy Consultants are based on assumptions held to be accurate on the basis of the information available. However, Roland Berger Strategy Consultants assume no liability for the correctness of the assumptions made herein.

[1] *Compared to the ITEA-ARTEMIS high-level vision 2030, version 2012*

Contents

Executive summary

There is a wide consensus that the time from now to 2030 will be one of permanent change and disruption. In 2030 the world population will reach the magic number of 8 billion people, only 23% of whom will live in Europe and the Americas. The way of living and doing business will be fundamentally different from what it is today.

ICT has a major role to play in mastering the changes. For Europe, an industry strong in ICT-based innovations is a prerequisite for maintaining global competitiveness. Moreover, such an industry creates and secures high-value jobs in ICT and in other, more traditional industries that are dependent on ICT.

Current public discussion does not always use the terms software, IT, ICT, semiconductors and embedded systems in a consistent way and therefore, for the purpose of this document, we have coined the term of "Digital Technology", which encompasses all these notions:

- Hardware (semiconductors, PCs, tablets, servers, storage, peripherals)
- Software (including packaged embedded software)
- IT Services
- Internal IT
- Embedded software in products of "vertical markets" like automotive, healthcare, etc.

Note that the scope of Digital Technology thereby covers the scope of the previous 2012 version of the Vision 2030, extended with the digital hardware on which the software-intensive systems and services and embedded systems are executed.

Chapters 1 and 2 are updates of the previous 2012 version of the document. Chapter 1 describes the seven areas of major change and Chapter 2 the need for research and innovation in Digital Technology.

The new Chapter 3 describes the economic impact of Digital Technology in terms of revenues and jobs [RB2013]. The global market of Digital Technology is estimated at USD 3,300 billion, corresponding to around 50 million jobs. The share of Europe in digital technologies is about 9.1 million jobs. Europe's position is characterised by a strong presence in vertical markets. In Europe we have 0.2 million jobs in hardware, including semiconductors, and 8.9 million jobs in software and services. Within Digital Technology, ARTEMIS and ITEA are addressing innovation in Software, IT Services, Internal IT and Embedded Software, collectively denoted as 'Software innovation', we can state that: Software innovation thus addresses a global market of around USD 2,600 billion, corresponding to 44 million jobs.

The updated Chapters on ARTEMIS (4.1) and ITEA (4.2) incorporate considerations on the economic relevance of both programmes. In addition to the chapter 3 statements, bottom-up data collected from relevant industries indicate the strong significance of the embedded digital systems part. Today already more than 50% of the key selling features of our technical products are determined by Digital Technologies, with a firm increase to more than 70% expected within the next 5 to 10 years.

Both ARTEMIS and ITEA have built innovation eco-systems of closely interacting companies and research organisations. These eco-systems are essential to enable European organisations, including SMEs, to keep up with the fast changing reality in Digital Technology, its increasing complexity and to remain at the forefront of innovation.

The ARTEMIS-IA vision nurtures the ambition to strengthen the European position in Embedded Intelligence and Cyber-Physical Systems and to ensure its achievement of world-class leadership in this area by establishing an environment that supports innovation, stimulates the implementation of the latest achievements of Cyber Physical and Embedded Systems on European scale, and avoids the fragmentation of investments in R&D&I.

As a very conservative estimate, the European applications industry spends only 20% of its R&D effort in the domain of Embedded Digital Technologies, resulting in a cumulative total R&D&I investment of €150 billion in the period 2013-2020, €15 billion of which is expected to be allocated to collaborative R&D&I projects in Embedded Digital Technologies. Based on [EUSB2012] and indications from the consulted industries that about 60% of all product features will depend on Embedded Digital Technologies, we also estimate growth of about 800k jobs in the application industries, directly resulting from the impact of Embedded Digital Technologies.

ARTEMIS has identified three main objectives that are essential to prepare the European high-tech ICT-based industry for the future:

- Consolidation of current EU strengths
- Innovations to unlock new business potential
- Opportunities to recover positions

The importance of EUREKA projects in general is demonstrated by positive results in econometric evaluations of the impact of EUREKA that relate the amount of public funding in a EUREKA project to the additional turnover and jobs created or saved [EUREKA]. Taking the overall planned costs of ITEA 3[2] of €3 billion and using an estimated 40% rate of public funding for ITEA Projects[3], we arrive at an estimated total of €1.2 billion of public funds invested in ITEA 3 projects. Extrapolating the EUREKA impact study results, ITEA 3:

- creates or maintains 44,400 jobs
- generates €11.4 billion additional turnover
- generates annual public tax revenue of €266 million

This quantitative impact is further elaborated and underpinned using three concrete examples from ITEA project successes.

In the ITEA quality management system (QMS), we defined the Call Funded Industrial (CFI) budget as one of ITEA's key performance indicators (KPI). The CFI budget is the total cost of all industrial partners in all projects in an ITEA Call. At present the average CFI budget of an ITEA Call is €160 million. In order to achieve the ambition of €1.2 billion total public funding for ITEA 3, the average CFI budget in ITEA 3 should be at €320 million, double the current size. Based on the importance of software innovation and open innovation in general, we see plenty of opportunities to increase the Call size in the coming years. The target domain of ITEA 3, addressing all verticals and all categories of Digital Technology, offers plenty of opportunities for high-quality proposals. The QMS processes with Public Authority involvement are the right instruments to expand the ITEA programme based on initiatives focused on "Seizing the high ground".

With the arguments presented in this updated Vision 2030, ARTEMIS Industry Association and ITEA collectively request a doubling of the investment in software innovation to keep Europe on par with the rest of the world in sustaining the benefits of Digital Technology for the European economy and society.

[2] *Source: ITEA 3 Application documents*
[3] *Source: ITEA 2 Office*

1

CHAPTER 1

Seven areas of major change

1 Globalisation and demographic change

2 Management of scarce resources

3 Climate change

4 Urbanisation

5 Mobility

6 Healthcare

7 Digital society

1 GLOBALISATION AND DEMOGRAPHIC CHANGE

Globalisation means ever increasing interaction and interdependence between societies, economies, governments, companies, institutions for research and education, civil society organisations and individuals all over the world. According to the Future Management Group [FMG], important drivers for globalisation have been liberalisation of trade and services, international tourism, intercultural trends and technological developments in the fields of information and communication. In the years ahead two demographic developments will accelerate globalisation:

- The world population will grow from 7 billion people today to 8.3 billion in 2030. 95% of this growth will happen in developing and emerging countries
- The distribution of the world population will then be: Asia 58%, Africa 19%, the Americas 13% and Europe 9%
- Globally, the growth of the middle-class in these countries is even more impressive, from 1.8 billion people in 2009 to 4.9 billion people in 2030. Middle class means that they have an annual income of between US$ 6,000 and 30,000 measured in purchasing power parity. 80% of this middle-class will live outside Europe and North-America.

As a consequence, from 2010 to 2030 GDP growth in emerging and developing countries will be 70% as opposed to 30% in developed countries and, in less than two decades, the emerging markets will account for more than half of all global GDP.

Roland Berger Strategy Consultants [RB2011] have coined the slogan of "eight billion business opportunities" to describe their advice to European economic leaders.

Digital Technology will be a key technology to exploit these opportunities. As we announced at our Co-summit 2011, "mobile and cloud power are enabling massive scalability and opportunities for growth".

- The number of mobile-only broadband users is expected to grow from 14 million in 2010 to 5 billion in 2030, most being in Asia and Africa [RB2011]
- The applications for all these mobile users will be in the cloud, for example financial transactions, trade, healthcare, education, entertainment.

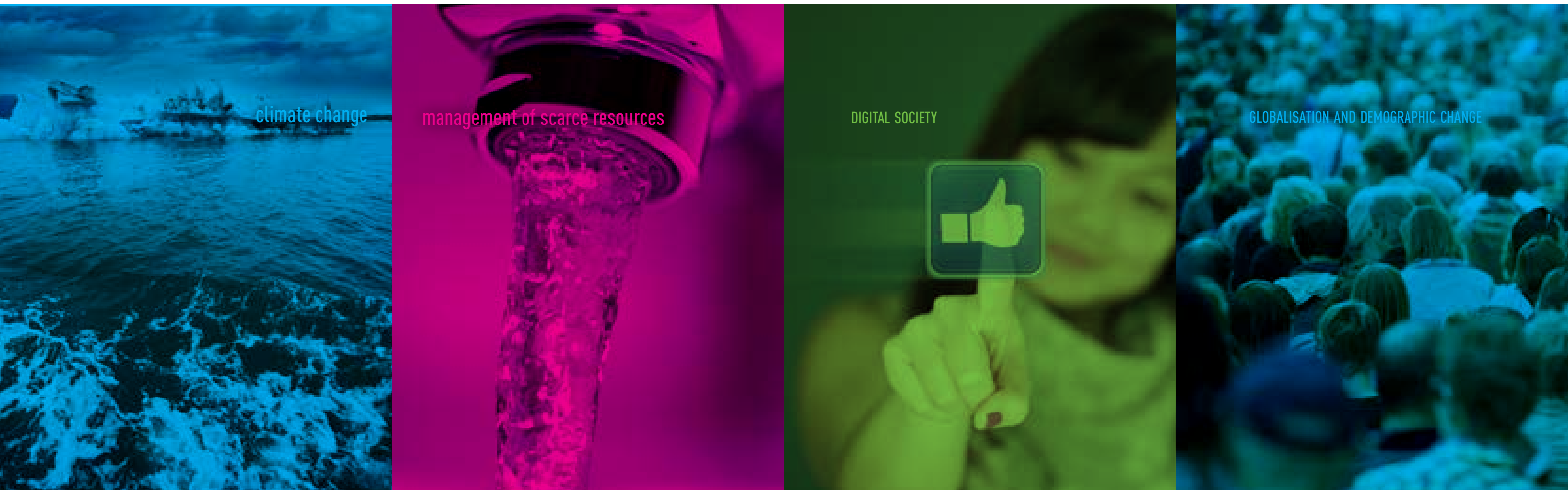
Another important aspect of demographic change is the rising proportion of the elderly population in many parts of the world over the next few decades. The population pyramid turns upside down and becomes a spindle. Working life will become longer and the pension entitlement age will be higher according to [FMG].

- The number of people in the world aged 60 and above will grow from 740 million today to 2 billion in 2050
- Age-appropriate products and services based on Digital Technology, especially in the sectors of health, security and assistance, will become increasingly important
- Worldwide revenue in the market segment covering those aged 60 and above ("Group 60+") will almost double from 6 billion euro in 2010 to 11 billion euro in 2020
- China's demographic profile is an outlier among most emerging markets. Due to its one-child policy, China is ageing at an extraordinary rate and, by 2030, is projected to be older than Europe [RB2011]. In 2010, 118 million of the 1.3 billion Chinese were over 65 years old. By 2040, this number will have grown to 329 million.

2 MANAGEMENT OF SCARCE RESOURCES

The consequence of the growing world population and growing wealth in emerging countries is that, irrespective of vision 2030, the way we live and we are doing business in 2030 will be radically different from today. If we continue with a business-as-usual approach, we will need 2.3 planets instead of the single planet Earth we do have is the conclusion drawn by the World Business Council for Sustainable Development in its Vision 2050 [WBCSD].

WBCSD developed a vision of a planet Earth well on the way to sustainability by 2050. This will be a world in which the global population is not just living on the planet, but living well and within the limits of the planet. By "living well", the report describes a standard of living where people have access to and the ability to afford education, healthcare, mobility,



the basics of food, water, energy and shelter, and consumer goods. By "living within the limits of the planet", the report means living in such a way that this standard of living can be sustained with the available natural resources and without further harm to biodiversity, climate and other ecosystems.

To achieve this goal, sustainable solutions are needed for the management of scarce resources, such as food, water, energy and materials, especially rare earth metals.

To develop sustainable solutions, the whole chain from source to user needs to be understood, covered and tackled, e.g.:

- Water – from source to tap
- Energy – energy production, smart grid, connecting many different sources and consumers
- Food – from farm to fork
- Materials – for example, rare earth metals.

Water

Today, drinking water is already very scarce in some regions of the world. Demand for drinking water continues to increase massively because of population growth and urbanisation. The Future Management Group [FMG] sees this problem being intensified by careless use, pollution, intense agricultural demand, damaged supply infrastructures and over-exploitation of natural reserves like groundwater.

Today's total demand is 4500 billion m^3. Demand in 2030 is projected to be 6900 billion m^3, whereas the existing sustainable supply is 4200 billion m^3.

Energy

Neither does the Future Management Group [FMG] see increasing global demand for energy in the course of the next few decades being curbed to any significant extent by higher energy efficiency and economisation.

- Global energy consumption will rise by 39% between 2010 and 2030
- Despite improved energy efficiency, energy consumption through electronic devices will triple until 2030 because of a massive rise in overall demand
- 19% of all electric energy is used for lighting, which is 2.5% of the global energy use, but intelligent lighting and controls can enable 70% of this energy to be saved. [Ph21].

Food

By 2050, agricultural production must increase by 70% in order to meet the nutritional needs of the growing world population.

- Innovative solutions are necessary, for example in the field of biological and genetic engineering or process automation in agriculture [FMG].
- Precision Farming, i.e. the large-scale use of IT in agriculture, will help save resources, reduce environmental impact and increase yields.
- All players in the domain of food are confronted with increasing customer demand for information and reassurance on the origin and content of their products. Since all these products contain ingredients from around the world, and the finished product is then distributed globally, demand for authenticity can only be satisfied with global information platforms based on Digital Technology.

Materials

By 2030, a shortage of high-tech metals will threaten the further development of future technologies such as photovoltaic cells, hybrid propulsion and energy-efficient flat screens.

In summary, consumption models need to be challenged in the coming decade, since the Earth's resources will fall short of meeting the needs of a growing world population and higher living standards in emerging countries. Business models and the management of scarce resources will need to adapt to this new situation. All these models and systems deal with the manipulation of physical entities and related information that spans many layers from networked sensors and actuators to high-level distributed and networked control, monitoring and information systems.

A combination of information systems and embedded systems will be needed to implement the "neural network of society" as coined in the ARTEMIS SRA [SRA].

3 CLIMATE CHANGE

Whether caused by human activity or by natural factors, the Future Management Group [FMG] regards global climate change as one of the major challenges of the 21st century. The main factor is the warming of the planet's atmosphere, or global warming. The years between 2001 and 2009 constitute the warmest unbroken period since measurements began in 1850.

- Between 2010 and 2030, the average sea level worldwide will increase by between six to eleven cm [RB2011]
- Until 2015, the number of people affected by disasters connected with global warming, such as droughts, storms or floods, will increase by more than 50% to 375 million
- The damage in dollars inflicted annually by climate change will rise from US$ 63 billion in 2010 to US$ 157 billion in 2030.

Many sectors are directly affected by the climate change:

- For agriculture, the expected climatic changes will affect crop yields, livestock and the location of production. The growing risk and severity of extreme weather events will increase the risk of crop failure. As has been seen in the recent past, flooding also impacts regional economy and production in all economic sectors
- But climate change will also pile pressure on the fisheries and aquaculture sectors as marine ecosystems are expected to be affected and coastal erosion rates increase. So, existing coastal defences may provide insufficient protection against the sea and will need huge investments to keep the risk at acceptable levels
- In the energy sector, climate change will have a direct effect on both the supply and demand of energy. The projected impact of climate change on precipitation and glacier melt indicates that hydropower production could increase by 5% or more in northern Europe and decrease by 25% or more in southern Europe
- Climate change will cause significant changes in the quality and availability of water resources, affecting many sectors including food production, where water plays a crucial role. More than 80% of agricultural land is rain-fed. Food

production also depends on available water resources for irrigation Limited water availability already poses a problem in many parts of Europe and the situation is likely to deteriorate further due to climate change, with Europe's high-water stress areas expected to increase from 19% today to 35% by the 2070s. Natural ecosystem services, such as the provision of drinking water, food production and building materials, will also be affected. [EC study Climate change]

On the other hand, environmental protection is increasingly taken into account in the development of products and processes, with natural resources being used efficiently and environmentally harmful effects minimised throughout the complete product life cycle. For instance, technologies are being used to conserve water and energy, for sophisticated waste disposal, recycling and filter systems as well as techniques for the efficient use of renewable energies.

- As a global mega-trend, "Going Green" is becoming increasingly important in mechanical engineering, driven by regulation, the necessity to reduce costs and the growing importance of an environment-friendly reputation [RB2011]
- The green technology share in the European industry will rise from 40% in 2010 to 60% in 2020.

The World Business Council for Sustainable Development's Vision 2050 [WBCSD] believes that information and communication technologies can make a major contribution to the global response to climate change by enabling energy and emissions savings in transportation, building, industrial, power and other systems.

4 URBANISATION

While in 1950 less than one third of the world's population lived in cities, the Future Management Group [FMG] puts this share at slightly more than half today and still growing. In 2007, for the first time in history, more people lived in cities than in rural areas (3.3 billion).

- The number of people living in cities will grow from 3.5 billion in 2011 (50% of the world's population) to 4.9 billion in 2030 (59%) [RB2011]
- Population numbers in economically remote areas will decrease significantly
- The number of mega-cities, i.e. cities with more than ten million inhabitants, will increase from 21 in 2009 to 29 in 2025.

Urbanisation - the increase in the urban share of the total population – is inevitable, posing both great challenges to and opportunities for society.

- No country in the industrial age has ever achieved significant economic growth without urbanis ation. Cities concentrate poverty, but they also represent the hope of people to escape it.
- Cities also embody the environmental and climate damage done by modern civilisation. However, experts and policymakers increasingly recognise the potential value of cities to long-term sustainability
- The potential benefits of urbanisation far outweigh the disadvantages. The challenge is in learning how to exploit the unique properties and possibilities of cities. Products and techniques for making efficient use of crowded living spaces will attract a ready market.

The administration of cities and mega-cities and the management of their infrastructures rely heavily on Digital Technology: energy, mobility, waste disposal, water and wastewater treatment, city lighting, safety and security.

5 MOBILITY

Transport is fundamental to our current economy and society. Mobility is vital to economic growth. The transport industry in Europe employs around 10 million people directly and accounts for about 5% of gross domestic product (GDP). Effective transport systems are key to European companies' ability to compete in the world economy. Logistics, such as transport and storage, account for 10–15% of the cost of a finished product for European companies. The quality of transport services has a major impact on people's quality of life. On average 13.2% of every household's budget is spent on transport goods and services. But congestion and fuel scarcity are important threats to mobility.

- Oil will become scarcer in future decades. Oil prices are projected to more than double between 2005 and 2050 levels. Current events show the extreme volatility of oil prices
- Transport has become more energy-efficient but still depends on oil for 96% of its energy needs.
- Congestion costs Europe about 1% of gross domestic product (GDP) each year
- There is a need to drastically reduce world greenhouse gas emissions, with the goal of limiting climate change to a 2ºC rise. The EU needs to reduce emissions by 80–95% in 2050 (compared to 1990 levels) to achieve this
- Congestion, both on the road and in the air, is a major concern. Freight transport activity is projected to increase, with respect to 2005, by around 40% in 2030 and by a little over 80% by 2050. Passenger traffic will grow slightly less than freight transport: 34% by 2030 and 51% by 2050.

Nevertheless, individual mobility will stay a major concern for the future. The strongly increasing traffic volumes demand a sustainable approach to society's mobility. This means that our transportation infrastructure must be efficient, safe, environmentally friendly and trustworthy. The transportation infrastructure is a combination of all mobility means, not only the road and rail infrastructures but also the vehicles, the communication possibilities, the services and the traffic management. To handle this increased traffic many technical issues need to be solved.

The Deutschland 2030 BDI report [BDI] expects smart and integrated mobility services to be offered in 2030 and the focus may even shift from owning a car to buying a transportation service or even avoiding the need to move.

Actors are entering the market: suppliers of post-fossil engines or batteries, energy and IT suppliers. Cities and regions take the lead and redefine the public transport as an integral part of international mobility.

Networked transportation services enable seamless, easy-to-use and price-efficient door-to-door mobility integrating all kinds of transport systems, cars, buses, railways, aeroplanes, bikes. These transportation services are based on global, comprehensive information systems including services like travel planning, selecting and providing the means of transportation including ticketing, real-time planning, traffic control, transportation means and the transitions between them.

So mobility is clearly an important area for the transport industry. However, mobility also has another dimension: making it easy for people to be mobile in their own home (or other places people choose to be). How can we create a seamless virtual environment and possibilities for people to work, meet or attend with others in different situations and feel they are actually part of the meeting without the needs of physical transportation? For instance a doctor may have patients in different parts of Europe and can carry out remote diagnostics or healthcare in a similar way as if he is present in the same room as the patient.

6 HEALTHCARE

The healthcare sector is becoming one of the most important future markets driven by a wider access to healthcare, wellbeing and the convergence of medicine, pharmacy and biotechnology.

Better access for more people to healthcare is achieved by making healthcare affordable for more people as well as introducing certain new offerings in emerging countries. More efficient and cost effective healthcare is being realised by:

- Reducing costs – based on patient specifics – by:
  - More precise and earlier diagnostic imaging
  - Image-guided interventions and therapy, ensuring the least invasive treatment for patients, and response prediction and assessment
- Moving from hospital treatment to home care where appropriate

There is a clear need to improve our fundamental understanding of health, disease, disability, development and ageing (including life expectancy). Medical imaging has changed from a tool for qualitative description of diagnostic findings towards a quantitative measurement tool for pathological changes in the body, with measurements extending from morphology to physiological functions and pharmacokinetic and metabolic process parameters. Hence, imaging has become crucial in interdisciplinary science for generating, understanding and using spatially resolved biological information [ZER], to be understood in the context of the "Four Ps" describing the future paradigms in medicine:

- Predictive (outcome prognosis based on "bio-informatics" and data bases)
- Personalised (treatment based on patient's genetic / metabolomic profile)
- Pre-emptive (e.g. being the vaccination against cervical cancer)
- Participatory (patients and care providers form a team in decision making)

In this context, the term "Imaging as a Biomarker" has been coined, which is now being considered a key not only in diagnostic imaging, but increasingly also in image-guided interventions and image-guided therapy delivery.

The convergence of Medicine, Pharmacy and Biotech is based on scientific and technological progress, according to the Deutschland 2030 BDI report [BDI]. Progress in molecular diagnostics and the cost efficient analysis of biomarkers (within the individual gene analysis) opens new possibilities for personalised therapy but also nutrition. The traditional classifications of patients according to age, gender and family history is extended by much more precise and efficient indicators now available on an individual genetic level. This is already being applied today in oncology and blood cancer treatment.

This requires new breakthroughs in medical imaging and healthcare IT, including more use of real time and 3D/4D visualisation as well as semi-autonomous workflow and decision support. The platform for cooperation among the Medicine, Pharmacy and Biotech actors is provided by Digital Technology, which includes the need for more precise imaging, contributing to the viability of personalised Medicine, starting with groups of patients for whose illnesses the genetic and other reasons are sufficiently explored.

With regard to supporting the trend from hospital care to home care, it is important to provide ICT solutions that enable efficient and reliable remote care, especially for people suffering from chronic diseases. For example, monitoring progress with patients at home from the hospital instead of repeated visits will help to drive costs down and provides more personal freedom for patients, who also are empowered for the control and management of their own medical needs. Patients and professional care providers should be offered standardized interfaces and a common IT backbone in order to avoid redundant, error-prone, multiple data entry from these remote networks. In addition, remote networks can contribute to support a healthy lifestyle. This applies to both patients and healthy people. Based on genetic and biomarker predictive profiling, healthy people can be supported in healthy behaviour that is customised to avoid personal health risks.

Other important challenges for the health sector are:

- To enable the extended full participation of more people in society, allowing care for their physical and mental well-being to enable them to work longer
- More focus on prevention is needed to reduce the care burden
- Most services for elderly people depend heavily on Digital Technology, for example teleworking, robots at home, future communication and entertainment.

7 DIGITAL SOCIETY

Digital society is a special aspect of "globalisation". We observe the emergence of two trends:

- A knowledge economy which is completely decoupled from geographies
- A virtualisation of communities and societies.

Knowledge economy

Globally, a structural change occurs from physical to intangible added value. In the 21st century, the production industry will experience the same fate as the agricultural industry in the 19th century: its contribution to the economic creation of value will decrease. The tertiary sector of services and the quaternary sector of knowledge work will become more important suggests the Future Management Group [FMG].

- More and more companies and complete industries will be based on production and exchange of knowledge and ideas instead of industrial goods.
- The management of available knowledge (=evaluated information) will become a strategic corporate factor
- In 2030, Internet penetration in the developed countries will be close to 100%. The Internet penetration rate has already grown from 51% in 2005 to 72% in 2010 [RB2011]
- The cross-linking of knowledge via the Internet will increase significantly up to 2030. Some experts predict that Internet users will consume an average of 3GB of data per day in 2030 [RB2011]. The Internet will become the global repository of knowledge.

Timely, easy and reliable access to knowledge is a prerequisite for the knowledge economy. Since Digital Technology provides the main store of information and networks add the capability to relate information to any other information in the world, Digital Technology has become essential for the evolution of existing knowledge and the creation of new knowledge.

Virtualisation of communities and societies

- In recent years the sheer amount of information and knowledge available has changed society. Individuals are no longer individuals only but they are part of social networks and entities. Web-based social and business networks serve as virtual communities in which individuals may even adopt a virtual identity
- Social media channels such as Facebook are also quite important for knowledge sharing. Facebook currently has more than 500 million active users, a number which is likely to increase. By 2030, social media could also replace many of the traditional types of media and will be firmly integrated into corporate IT [RB2011]
- There is a strong demand among the young generation to remain and stay connected to their communities in any circumstances. This will lead to a revision of all the legacy applications to integrate this collaborative way of living
- Of specific importance in Europe is the preservation of cultural heritage in a digitised society
- Security and safety, privacy and identity theft are important challenges for all future systems based on Digital Technology.


2

CHAPTER 2

The need for research and innovation in Digital Technology

Nowadays, no business department could function properly without Digital Technology, no bank, hospital or factory could operate effectively and no telephone would be operational any more. Digital Technology is crucial in many parts of our daily life today.

As a result Digital Technology will evolve in the basic infrastructure for all vital social, business and economic processes. Every commercial and public service will be provided through this e-Infrastructure. Therefore, ICT will continue to play a defining role by providing the critical infrastructure for the global economy.

These observations are supported by ISTAG in its report "Orientations for EU ICT R&D & Innovation beyond 2013" [ISTAG]. In this report ISTAG concludes that ICT (Information and Communication Technology) will play an even more central role in business and societal processes for the coming decades. A selection of the ISTAG statements:

- "ICTs will grow out to be the basic and critical infrastructure for all vital social and economic processes"
- "ICTs will be indispensable to address the key challenges that society is facing in, for instance, urban planning, transport and logistics, in crime prevention and risk management, in health care and in coping with scarce resources. And, last but not least, ICTs will continue to play a defining role in our economy by providing the critical infrastructure for the global economy"
- "From a societal perspective, guarantees for universal access to robust, trustworthy and secure infrastructure services, and standards and open interfaces will become crucially important"
- "ICT is not only a solution to existing problems, but also a disruptive force in itself, having a pervasive and transformative impact on society."

Today, the dominant view of Digital Technology is as an enabler technology that is used exclusively as an instrument to reach certain targets. However, recent history shows many examples in which Digital Technology has proven to be a disruptive force in itself: services like social media, Google maps and Skype, combined with innovative platforms such as smart phones and tablets capable or executing "apps" have opened completely new roads to information access, information sharing, individual communication and business opportunities, also for SMEs. The importance of the underlying communication infrastructure implies a clear need for continued research and development of the technology enablers behind it.

Many examples support the observation that Digital Technology has grown into a disruptive force in itself. The smart phone with all its apps makes its way not only into the consumer domain, but also more and more as mobile access to information and services in the business domain. Also access to many services is increasingly shifting to the internet, as for example banking, buying of goods by consumers and government services.

For business, cloud computing is at present creating radically new possibilities to roll-out global services at very low capital costs. New suppliers of cloud-based services have entered the Digital Technology field and rapidly established themselves as dominant competitors in different industry segments where they change the rules of the game. This impact of Digital Technology on daily life has most impact on the behaviour of younger generations that grow up with these developments.

Also the Delphi report [DELPHI] observes that Digital Technology has in many ways been a driver of social and economic change and will remain such a transformative force in the coming decades. Opportunities will emerge in an unpredictable way, as in the past, which requires the continuous evaluation of emerging innovation opportunities generated by new Digital Technology.

Experts believe that intelligent embedded systems will drive new applications that also affect sectors like manufacturing and energy. The results will be systems, technical processes and workflows that are continuously optimised from both an ecological and economic perspective. Developments in Digital Technology will continue to increase their influence on the manufacturing, energy and medical technology sectors.

The continued maturing and rapid growth in the use of Digital Technology through to 2030 implies that it will become the key infrastructure for the future European Knowledge Society.

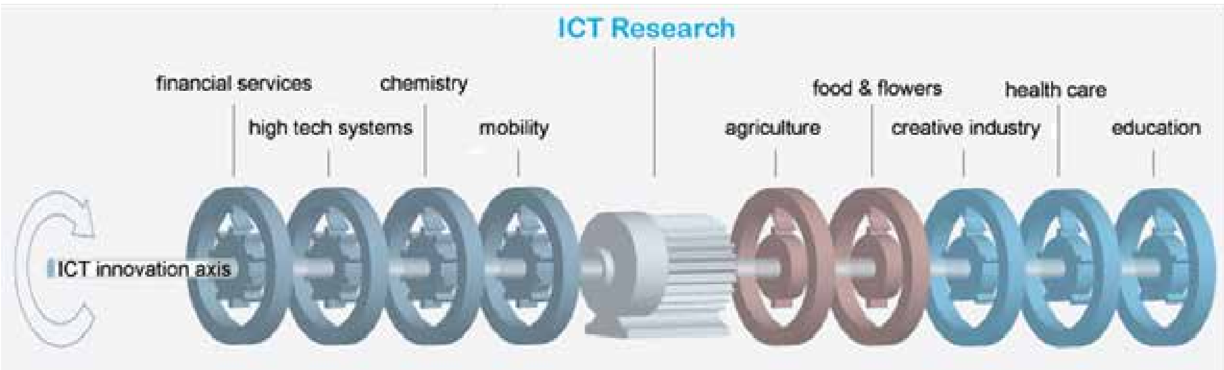
Many innovative companies have grasped the opportunities emerging from the convergence between Digital Technology and other sectors, building new businesses on adaptive consumer behaviour. Predicting the social and economic impact of Digital Technology is extremely difficult and recent history has often proven such predictions to be wrong. Examples can be found, especially in the mobile phone industry, where Apple and Android revolutionised the smartphone market with significant consequences, even for telecom network providers. The only way to keep up with this revolution is to continuously invest in research and development.

Another example of such transformations driven by Digital Technology is observed from the "Internet of Things" which implies that interaction will be strengthened between the physical world and the virtual worlds of Digital Technology. Physical entities will have digital intelligence and are also represented in the virtual world of internet. "Things" become context aware and will be able to sense, communicate, interact and exchange data, information and knowledge.

Through the use of intelligent software applications, appropriate rapid responses can be given to physical phenomena, based on the very latest information collected about physical entities and consideration of patterns in historical data, either for the same entity or for similar entities. These create new opportunities to meet business requirements, create new services based on real-time physical world data, gain insights into complex processes and relationships, handle incidents, address environmental degradation (pollution, disaster, global warming, etc), monitor human activities (health, movements, etc.), improve infrastructure integrity (energy, transport, etc.) and address energy efficiency issues (smart energy metering in buildings, efficient consumption by vehicles, etc.).

The future Knowledge Society will be a society in which massive amounts of information and data are processed and given meaning. The generation of information and data by sensors, machines and information-enhanced products requires progress in the basic technology needed to realise the computing power that has to process all the data into useful information. Multicore processing technologies are essential components in accelerating the day-to-day processing power needs according to the state-of-the-art technology of high-performance computing.

And ISTAG is not alone in its observations. ICTRegie in the Netherlands launched an agenda for the future of ICT in 2030 in the Netherlands [ICT2030.nl]. This agenda stresses the importance of research in ICT to propel innovation in many sectors of the economy as is depicted in the figure below.



Example: The Dutch ICT innovation axis driving Dutch application areas.

ICT 2030.nl describes how the axis of innovation is driven by ICT research. ICT creates new markets for established operators and opens up existing markets to new players. So ICT can be visualised as an axis of innovation running through all sectors of the economy. However, this axis of innovation is of little value without an engine to drive that axis. Another crucial element is the transfer between the axis and those parts (sectors) that must be set in motion.

Hence, to gain maximum benefit from all opportunities generated by ICT, both smarter applications of available ICT as well as good research are needed while the development of new opportunities must not be forgotten.

This is the only way to keep the axis turning. The connection between ICT and the application fields is essential, and leads to new challenges and ideas. This requires intensive interaction among all of those involved in the innovation process: researchers, end users, ICT companies, businesses and the users of ICT solutions. This innovation ecosystem forms the basis for successful ICT-fuelled innovations in products, services and processes.

Also the Delphi report [DELPHI], built on extensive research and questions to a wide and heterogeneous audience, reveals similar messages for the German economy. The main messages in the Delphi report are:

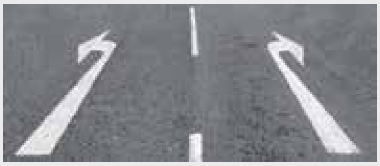
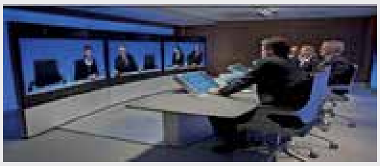
1. Digitisation and the on-going penetration of ICT into all areas of professional and private life will be even more all-embracing in moulding the information society in the future
2. Acceptance and trust in using ICT is the foundation for developing a modern and open information society
3. A high-performance communications infrastructure is a vital precondition and a strategic success factor for an open and competitive information society
4. The mobile use of the internet and its services will have a lasting impact on the information society and create independent new areas of application
5. Dynamism in ICT based technologies will drive innovation processes and have a serious impact on all key industries in the economy.

Since the dynamism in Digital Technology uptake and progress is huge, research and innovation remain essential in the coming decades to enable companies to identify and grasp business opportunities that realise economic growth in this sector for the coming decades.

By introducing the notion of Digital Technology we wish:

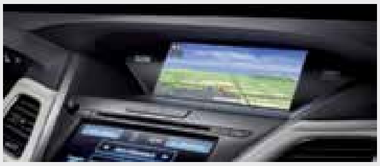
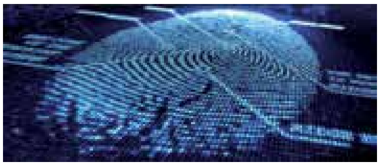
- to once more underline the inclusion of the job-intensive domains of IT services and internal IT in the scope of ARTEMIS and ITEA as described in the previous version of this Vision 2030 document.
- to supplement the previous version of this Vision 2030 document by adding the hardware to cover the totality of semiconductors, embedded software and general software in innovative solutions

Among the key trends identified for all these Digital Technology domains, the recently released report *"Global market for Digital Technology"* [RB2013], Roland Berger refers to flexibility, mobility, collaboration, ubiquity, cybersecurity and data-driven business. In summary, the report expresses the expectation that the importance of Digital Technology is set to increase further as technology becomes increasingly complex and gains a strong footprint outside of "traditional" areas of use. The demand for mobile solutions and unlimited connectivity will drive hardware spending, while Cloud Computing and Big Data are likely to have a strong positive impact on IT Services.

MEGATREND	KEY TREND	DESCRIPTION
Flexibility 	▪ Cloud Computing ▪ Flexible Sourcing	▪ Virtual infrastructure and services solutions offered through cloud increases flexibility and reduces fixed cost ▪ Virtual sourcing network enhances speed when sourcing products/ services
Mobility 	▪ Enterprise Mobility	▪ Smartphones and tablets increasing connectivity on the go and giving access to relevant data
Collaboration 	▪ Virtual Collaboration ▪ Open Innovation	▪ Virtual Collaboration enhances knowledge sharing and cooperation across countries or organizational boundaries ▪ Open Innovation to reduce time-to-market and R&D cost

Source: Deutsche Telekom; Roland Berger

Table 2.1 Key trends in Digital Technology impacting productivity (1/2)

MEGATREND	KEY TREND	DESCRIPTION
Ubiquity 	▪ Embedded technology ▪ Internet of Things	▪ Strong increase in the usage of embedded technology outside of typical ICT industries ▪ Growing importance especially in manufacturing, e.g. automotive and production in line with automation ▪ Internet of things enhances process efficiency
Cybersecurity 	▪ Chip security ▪ Network protection	▪ Increased dependency on IT infrastructure strengthens fear of espionage or terrorism ▪ Utilisation of tamper protection to avoid invasive attacks
Data-driven businesses 	▪ Real-time data ▪ Big data	▪ Growing need for real-time data in new markets (e.g. healthcare, transportation and logistics) ▪ Strong importance of mobile solutions ▪ Underlying big data solutions drive need for storage and bandwidth

Source: EDA; Gartner; iSuppli; University of Cambridge Computera Laboratory; Roland Berger

Table 2.2 Key trends in Digital Technology impacting productivity (2/2)

Conclusion

In summary, the main messages of this chapter are:

- Digital Technologies, spanning the entire scope of semiconductors, embedded systems and services, are set to increase even further as technology becomes increasingly complex and gains a strong footprint outside of "traditional" areas of use
- Digital Technologies provide a vital e-infrastructure and are a driver of innovation
- Digital Technology is both a solution to existing problems and a disruptive / intrusive force in itself


3

CHAPTER 3

Economic dimension of Digital Technology

The data and statistics presented in this chapter are based on the analyses made by Roland Berger in the report "Global market for Digital Technology", 2013 [RB2013].

Current public discussion does not always use the terms software, IT, ICT, semiconductors and embedded systems in a consistent way, so for the purpose of this document we have coined the term of "Digital Technology"[4], which encompasses all these notions. The scope of Digital Technology thereby covers the scope of the previous 2012 version of the Vision 2030, extended with the digital hardware on which the software-intensive systems and services and embedded systems are executed. Roland Berger segments the global Digital Technology sector into the following main clusters.

CLUSTER	SUB-CLUSTERS	REMARKS
Software	▪ Development Software ▪ Databases ▪ Packaged Software ▪ Embedded Software	▪ Packaged software includes enterprise application software, personal application software, system infrastructure software ▪ Only packaged embedded software included
Hardware	▪ Storage ▪ Peripherals ▪ Devices ▪ Semiconductors	▪ Devices include PCs, servers and tablets ▪ Semiconductors volume reduced by semiconductors built into devices
IT Services	▪ IT Consulting ▪ System Integration ▪ ITO ▪ BPO	▪ System Integration includes system integration, software support, hardware deployment & support ▪ ITO[1] includes ASP[2], application management, infrastructure outsourcing, desktop outsourcing and all cloud-based services
Internal IT	▪ Plan ▪ Build ▪ Run	▪ Internal IT is based on average global spend for IT specialists, segmented by key functions within IT organization
Embedded Software [3]		▪ Lifecycle effort/cost for customized (individual) software, which is part of embedded systems in automotive, healthcare etc.

[1] *IT Outsourcing* [2] *Application Service Provisioning* [3] *Lifecycle effort/cost for packaged software are included in the Software cluster*

Source: Roland Berger

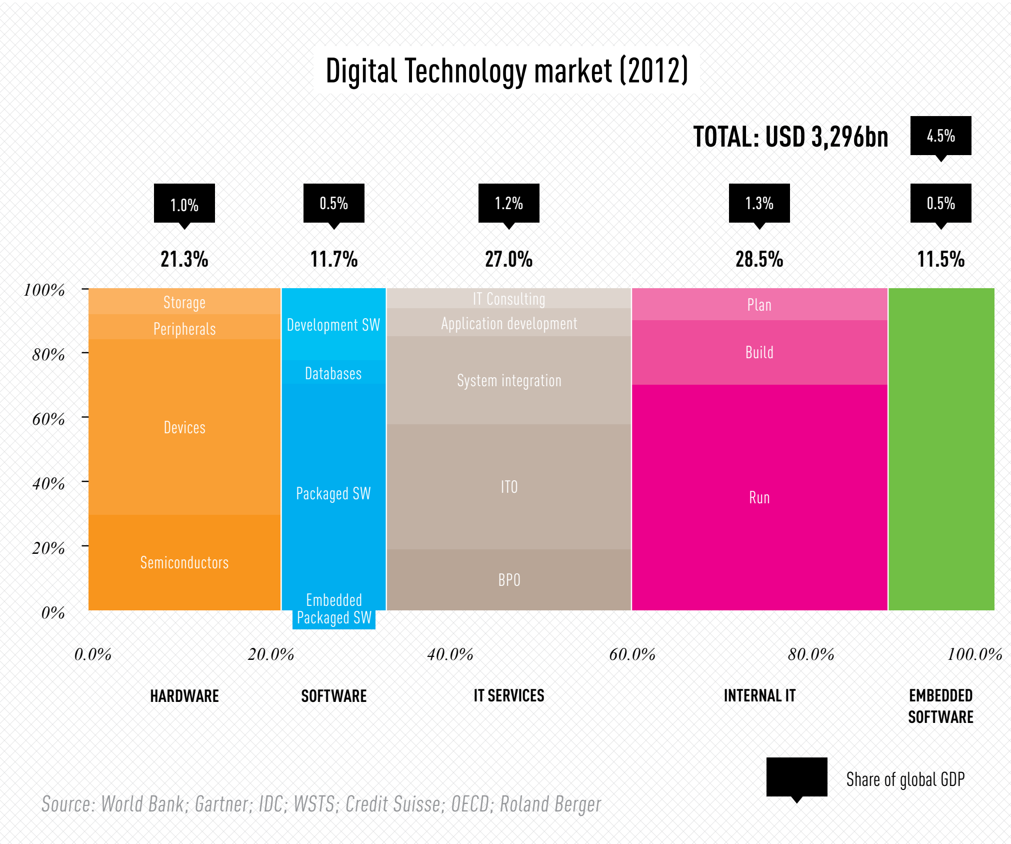
This encompassing notion of Digital Technology allows us to understand the full economic impact of all these areas for the total revenues and jobs involved.

The following paragraphs detail the revenues, jobs and growth rates of Digital Technology in the different segments.

[4] *Within the definition of Digital Technology as used only the technology-driven market is considered, excluding the "digital economy" sector with earnings from other sources like advertisements (e.g. Facebook, Google).*

3.1 GLOBAL MARKET OF DIGITAL TECHNOLOGY

It is estimated that global spending for Digital Technology is USD 3,296 billion. It thus represents 4.5% of global GDP in 2012.



IT Services and Internal IT account for the largest share, namely 27.0% and 28.5%. The Hardware (21.3%) and Software (11.7%) clusters represent the third and fourth-largest shares of Digital Technology, while Embedded Software has a share of 11.5%.

In the Hardware cluster, devices (USD 379,426 million), represent the largest sub-cluster, driven by increasing sales of Tablet PCs that are balancing weakening revenues from PCs and Notebooks. Producers of semiconductors (representing USD 212,560 million) have profited from the enhanced usage of embedded components in non-IT industries, which is leading to an increased demand for semiconductors, which are not built into classical IT devices.

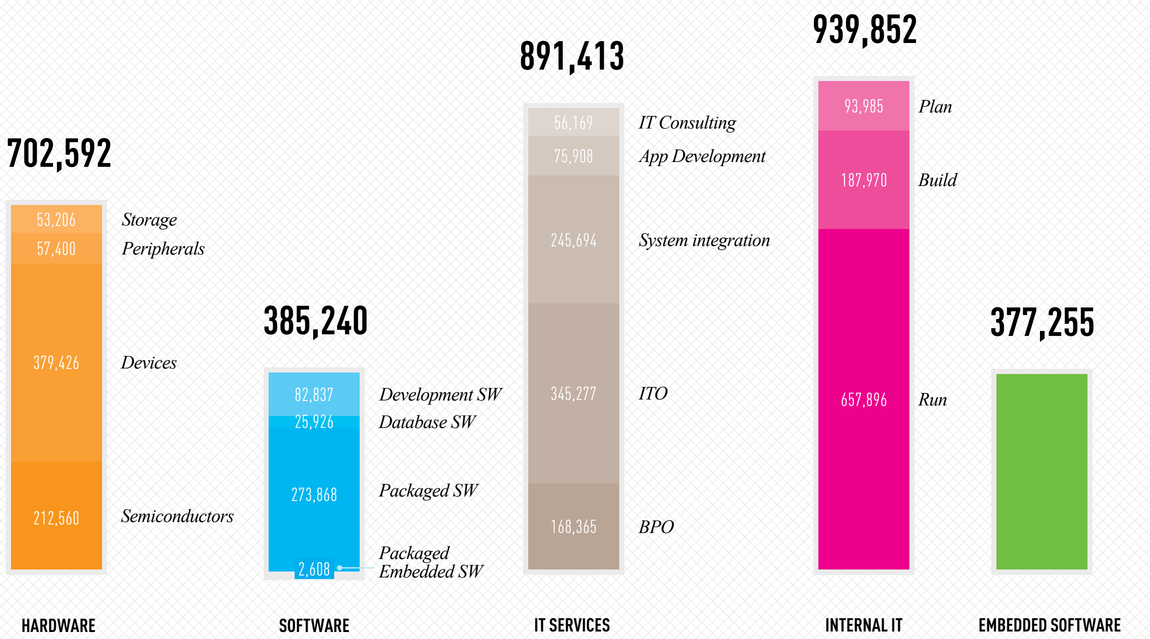
The Software cluster (USD 385,240 million in size) is dominated by packaged software, which accounts for 70% of the volume represented. This is mainly due to the large volumes included in the enterprise application software and system infrastructure software sub-clusters, which both exceed USD 100 billion. Although embedded components are on the rise, off-the-shelf or other packaged embedded software represents no significant share of Digital Technology yet (USD 2,608 million). The lion's share of embedded software (i.e. software built into components) comes from customised, non-standardised software.

IT Services (USD 891,413 million) play a significant role in Digital Technology, as companies are turning to outsourcing due to their need for increased flexibility and cost efficiency in IT. ITO thus represents the largest share of IT Services, accounting for USD 345,277 million. Infrastructure outsourcing thereby remains the dominant field, accounting for over two thirds (USD 225,991 million) of total volume in ITO. System Integration services are becoming increasingly important as well, now consisting of almost USD 250,000 million in annual volume.

Internal IT, i.e. expenses for IT specialists within organisations, represents the largest share among all clusters. We have estimated annual expenditure for Internal IT at USD 939,852 million. In order to classify spending, we assumed a split of 10% for employees in "plan" (e.g. IT management or IT controlling). "Build" (e.g. design, coding, deployment and testing) accounts for 20%, whereas "run" (e.g. maintenance, infrastructure, data centre operations) is estimated at 70%. Thus Internal IT still represents a larger cluster than IT Services. Due to increasing outsourcing volumes, however, IT Services are expected to outgrow Internal IT within the next five years.

Expenditure for Embedded Software accounts for USD 377,255 million annually. They are closely related to volumes in Internal IT and jointly represent expenditure for insourced value creation in Digital Technology.

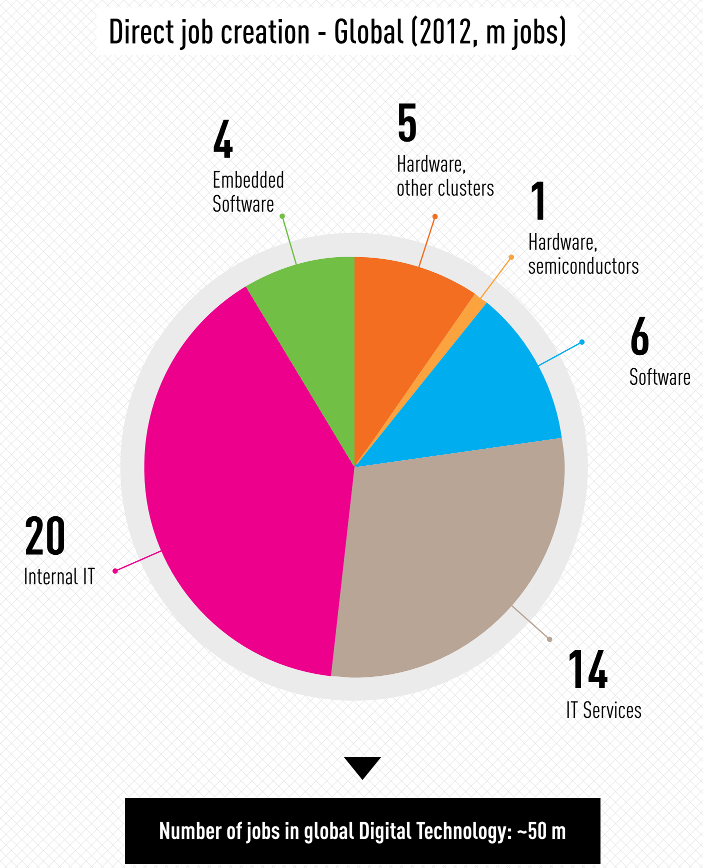
Market size by clusters (2012, USD m)



Source: Gartner; IDC; WSTS; Credit Suisse; OECD; Roland Berger

THE IMPACT OF DIGITAL TECHNOLOGY ON JOB CREATION

Based on a global volume of USD 3,296 billion, it is estimated that there are approximately 50 million jobs worldwide in Digital Technology. The analysis is based on average share of Digital Technology employees relative to the global workforce.



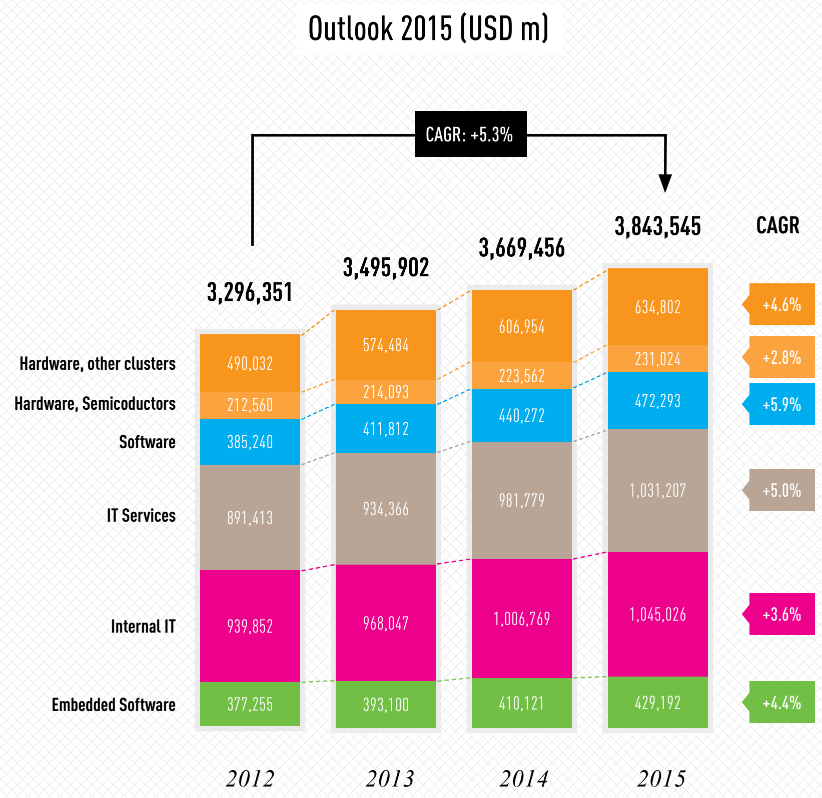
Source: OECD; Roland Berger

In more industrialised countries, such as the USA or Western Europe, we estimate a share of 3.8%, whereas countries such as China or India account for only 0.5-0.8%. The split by clusters is derived from the market share, as spending in Digital Technology is translated directly into jobs. The share for the hardware cluster is lower than the corresponding market share due to higher industry automation and corresponding lower labour-intensity. Data was validated through bottom-up analysis, mainly based on local labour statistics and reports by industry associations.

As a result, Internal IT thus represents the largest share of roles in Digital Technology, accounting for approx. 20 million jobs created, followed by IT Services employing an estimated 14 million people around the globe. A further 6 million are estimated to work in the software cluster, while 4 million people are involved in Embedded Software. In Hardware, the semiconductor industry accounts for 1 million jobs, while other Hardware sub-clusters provide 5 million jobs.

EXPECTED GLOBAL GROWTH RATE DIGITAL TECHNOLOGY

The global market for Digital Technology is expected to grow by 5.3% YoY until 2015 and reach a total volume of USD 3,843 billion. The strongest growth drivers are Software and IT Services.



Source: Gartner; IDC; WSTS; Credit Suisse; OECD; Roland Berger

In Software, which is expected to grow by 5.9% annually, the strongest sub-clusters are Enterprise Application and System Integration Software, with forecasted annual growth of 6.5% and 6.9% respectively. As digitisation in businesses is still on-going, related IT Services also profit from strong growth across all sub-clusters with annual growth totalling 5.0%. In Hardware, meanwhile, strong double-digit increase in tablet sales is expected to balance out weakened revenues in PC and Notebooks. CAGR for the cluster is estimated at 4.6%.

As Embedded Software expenditure has previously been strongly correlated with the development of global GDP, we expect this trend to continue. Annual Embedded Software spending is thus expected to increase by 4.4% annually, based on recent GDP forecasts provided by the World Bank. While current forecasts for Internal IT remain positive, organisations face a talent gap that might weaken future expenditure on personnel and growth opportunities for companies that rely heavily on a strong internal workforce or low degrees of automation and standardisation.

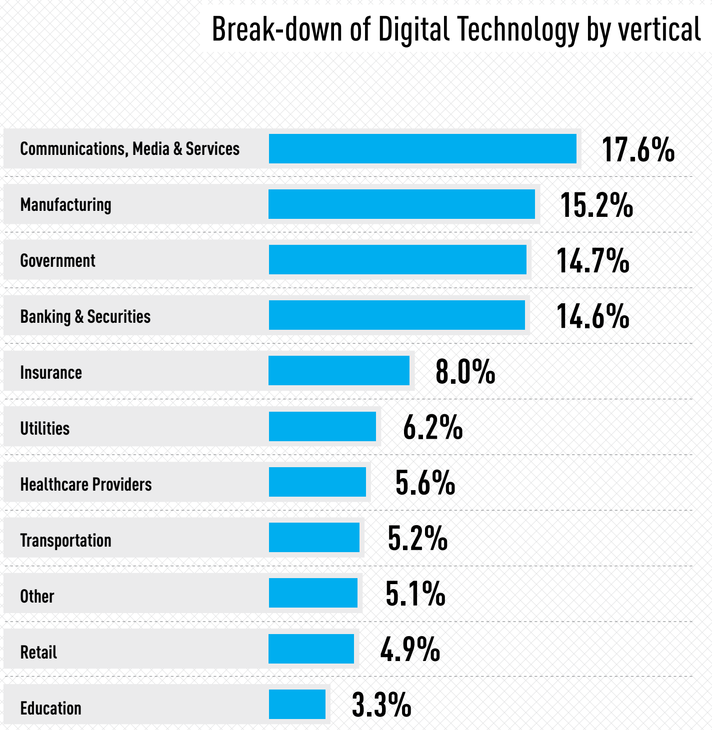
3.2
PENETRATION OF DIGITAL TECHNOLOGY IN VERTICAL MARKETS

In order to determine the market split by industry verticals, Roland Berger has applied the categorisation provided by Gartner.

VERTICAL	DEFINITION (EXTRACT)	EXAMPLES
Communications, Media & Services	Companies with revenues from broadcasting, publishing, professional services, telecommunications equipment and services, programming,	AT&T, BSkyB, Oracle, Vodafone, Bertelsmann
Manufacturing	Companies with revenues from production automation, shop floor, technical or industrial equipment, cars, aircrafts, military equipment, medical devices, pharmaceuticals, consumer goods, food	Bosch, Continental, Ericsson, BMW, Siemens, Boeing, Fresenius, Huawei
Government	Organizations from the national/local governments, organizations performing government services, government affiliated organizations.	Ministries, municipalities
Banking & Securities	Companies with revenues from commercial and investment banking, asset management, financial trading, consumer finance	BNP Paribas, JP Morgan, Commerzbank
Insurance	Companies with revenues from life insurances, health insurances, property and casualty insurances	Allianz, AXA, Generali
Utilities	Companies with revenues from electronic power generation and distribution, fossil fuels, water utilities, waste management	EDF Suez, RWE, E.on
Healthcare Providers	Companies with revenues from hospitals, nursing homes, retirement facilities, medical laboratory services, healthcare services	General Healthcare Group, Asklepios
Transportation	Companies with revenues from freight and logistics, passenger transportation, airport services	SNCF, Deutsche Bahn, Delta Airlines
Retail	Companies with revenues from online and brick-and-mortar stores, hotels, restaurants, hairdressers and beauty shops	Tesco, Metro, Carrefour, Walmart
Education	Companies with revenues from provision of higher education, elementary and secondary schools, driving schools, language schools	Universities, New Horizons

Source: Gartner; Roland Berger

Derived from the relative share of business IT spending per vertical provided by Gartner research, the Communications, Media and Services segment can be identified as the strongest vertical in Digital Technology. It accounts for 17.6% of the total market, followed by the Manufacturing sector with 15.2%.



Source: Gartner; OECD; Roland Berger

Overall, verticals with a stronger degree of automation or standardised processes account for larger market share compared to Education (3.3%) or Retail (4.9%). Industries in vertical manufacturing (e.g. pharmaceuticals, automotive) account for large share of R&D spending due to an increased use of embedded components.

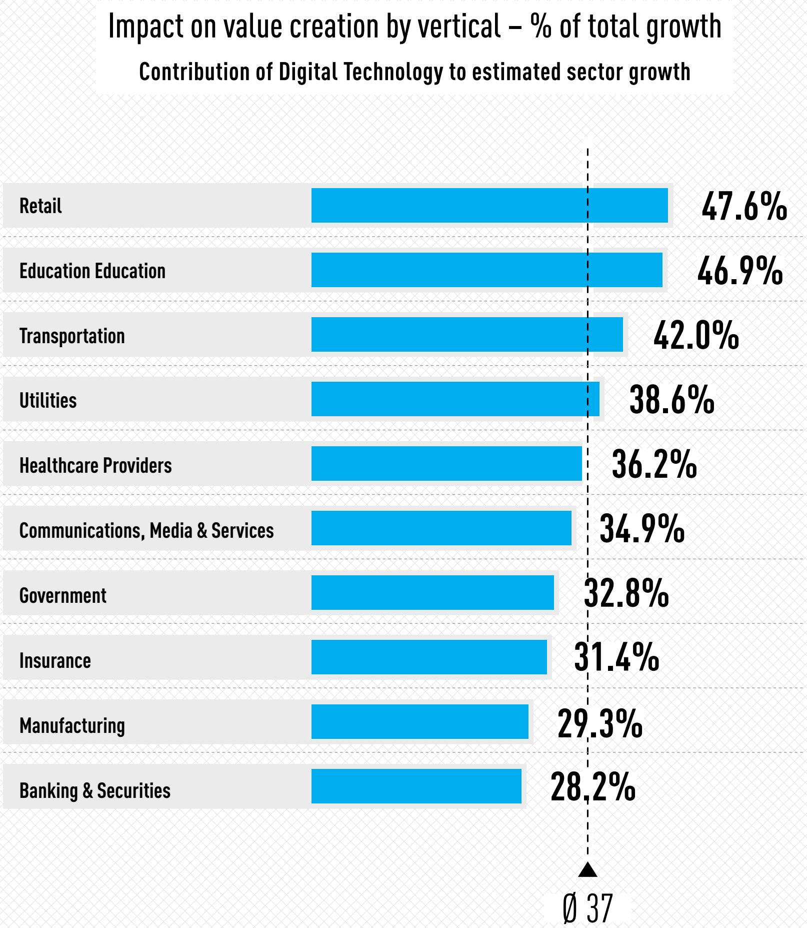
To provide a view on the absolute growth contribution of Digital Technology to these verticals, Roland Berger has analysed each vertical's share of total global GDP as well as expected growth over the coming five years. Retail leads this race, due to significant growth rates, followed by government (representing the largest vertical on global level) and healthcare providers.

Size and growth of verticals

VERTICAL	MARKET SIZE (USD BN)	GROWTH 2013-2018	GROWTH CONTRIBUTION OF DIGITAL TECHNOLOGY (USD BN)
Retail	28,400	21%	2,800
Government	63,500	13%	2,500
Healthcare Providers	35,600	15%	1,900
Banking & Securities	23,900	23%	1,500
Manufacturing	43,200	9%	1,300
Utilities	9,300	29%	1,000
Communications, Media & Services	20,300	11%	700
Transportation	14,000	12%	700
Education	5,500	16%	400
Insurance	12,500	10%	400

Source: Worldbank; Deutsche Telekom; Roland Berger

Survey-based analysis derived from estimates of experts in the relevant verticals shows that 60% of respondents consider Digital Technology to have a positive impact on their business, being highly relevant for development of new business models and revenue streams. Overall, Digital Technology is expected to account for 37% of industry growth across verticals in the next five years.

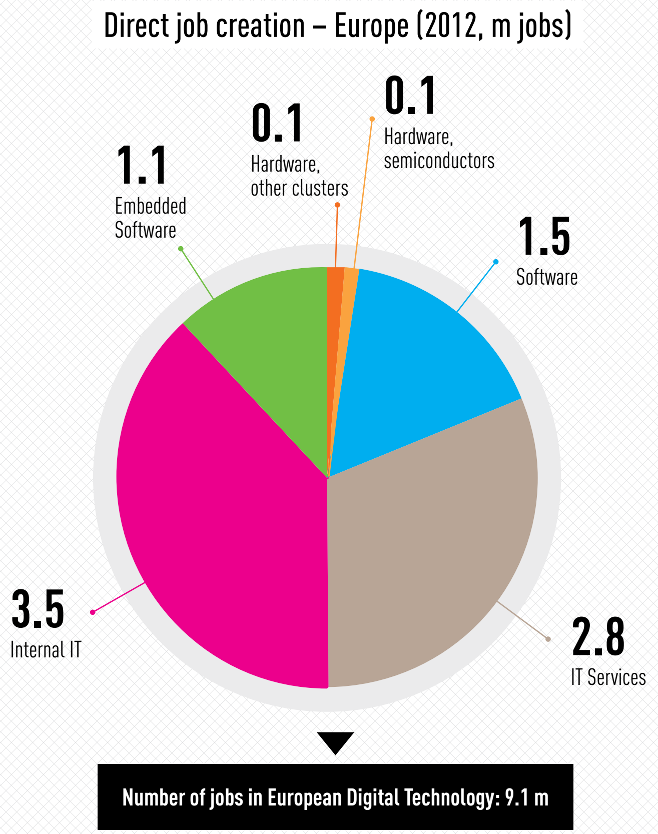


Source: Deutsche Telekom; Gartner; Roland Berger

The strongest impact on revenue growth is expected in verticals with low degrees of automation and large workforces. This is especially true for Retail, where RFID ("internet of things"), "Big Data" and improvements in processes related to e-commerce will drive future revenues. Digital Technology is thus expected to account for 47.6% of the total growth of this vertical. In the educational sector, e-learning and enhanced collaboration are among key industry trends that are expected to significantly contribute to value creation. The contribution of Digital Technology to sector growth is currently estimated at 46.9%. In verticals that are characterised by large investments in Digital Technology and high degrees of automation, future potential to create additional value from the increased use of IT are more limited, but still strong. The impact of Digital Technology on value creation in Manufacturing, Insurance, Government and Banking & Securities is consequently estimated at about 30% of total growth.

3.3 EUROPE'S POSITION IN GLOBAL SOFTWARE INNOVATION

Europe accounts for approx. 20 % share of global jobs in Digital Technology, which translates into approx. 9.1 jobs.



Source: EU; IDC; Destatis; Roland Berger

This figure has been derived from bottom-up EU estimations as well as the average share of Digital Technology employees[5] relative to the European workforce. The split by clusters is based on available bottom-up market size data on the European hardware and semiconductor industries as well as the global share of spending on Digital Technology.

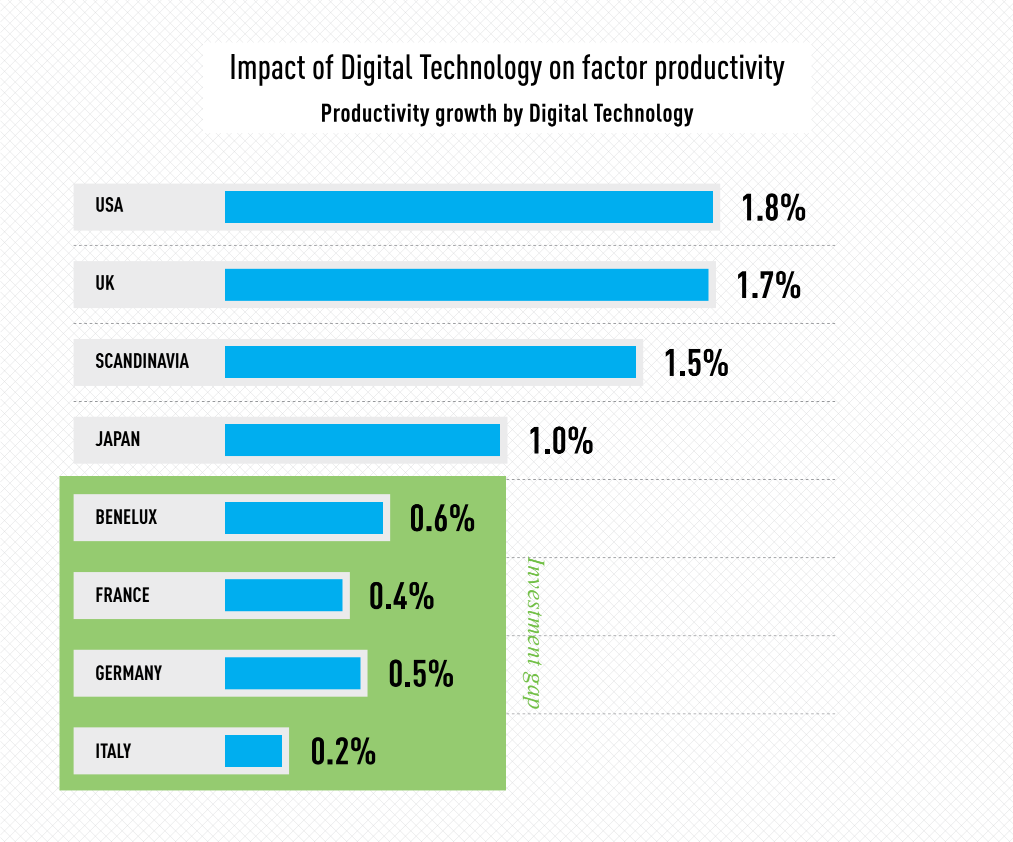
Internal IT, however, still represents the largest cluster, employing 3.5 million people, followed by IT Services with 2.8 million jobs created. Software and Embedded Software each account for 1.5 million and 1.1 million jobs respectively in Europe. The significance of the semiconductor industry is less than the global impact, providing approx. 100,000 jobs in Europe. The other hardware sub-clusters are similar in size.

[5] *A broad definition of IT specialists has been applied; excluding management overhead, sales and support functions*

3.4 IMPACT OF DIGITAL TECHNOLOGY ON FACTOR PRODUCTIVITY [6]

As research, especially performed by the GGDC (Groningen Growth and Development Centre), indicates, Digital Technology has a strong positive impact on overall factor productivity, namely labour productivity. Investments in Digital Technology allow the economy to realise a so-called "ICT Dividend" through an increase in factor productivity. Key drivers for productivity gains from Digital Technology are investments and intangible factors such as improved process design and easier access to information. Data show a strong investment gap between the USA, the UK and continental Europe, allowing the USA and the UK to realise significantly higher productivity gains from Digital Technology compared to continental Europe.

If European countries thus would increase their investments in Digital Technology to reach levels equal to the USA (as share of GDP), they could profit from annual productivity gains of up to 5%.



Source: Oxford Ecnomics; Roland Berger

[6] *In economics, total-factor productivity (TFP), also called multi-factor productivity, is a variable which accounts for effects in total output not caused by traditionally measured inputs of labour and capital. (http://en.wikipedia.org/wiki/Total_factor_productivity)*

3.5 CONCLUSIONS & RECOMMENDATIONS

From all these facts and figures on the global and European market of Digital Technology, the following conclusions[7] can be derived:

- The global market of Digital Technology is estimated at USD 3,300 billion, corresponding to around 50 million jobs
- The share of Europe in digital technologies is about 9.1 million jobs
- Europe's position is characterised by a strong presence in vertical markets
- In Europe we have 0.2 million jobs in hardware, including semiconductors, and 8.9 million jobs in software and services

Within Digital Technology, ARTEMIS and ITEA are addressing innovation in Software, IT Services, Internal IT and Embedded Software, collectively denoted as 'Software innovation', we can state that: ***Software innovation thus addresses a global market of around USD 2,600 billion, corresponding to 44 million jobs.***

The goal of software innovation in Europe is to get as many of these USD 2,600 billion and 44 million jobs into Europe

"If Europe would increase investments in Digital Technology to the same % of GDP as the USA, economies would grow by 5% per year" [RB2013].

This statement coincides exactly with the action statement no. 55 of the Digital Agenda for Europe, a Europe 2020 Initiative [DIG]:

Action 55: Member States to double annual public spending on ICT research and development

Member States should, by 2020, double annual total public spending on ICT (Information and Communication Technology) research and development spending from €5.5 billion to €11 billion (which includes EU programmes), in ways that leverage an equivalent increase in private spending from € 35 billion to € 70 billion.

Industry and Public Authorities should double the investment in software innovation in ITEA 3 and in the ARTEMIS successor programme

[7] *These facts are in line with the DECISION report, which has been used in the EURIPIDES[2] Vision, Mission and Strategy, June 2013* [EURIPIDES]

"The market for horizontal IT grows by 4 % per year, the market for vertical IT grows by 9 %.The vertical IT becomes an important competitive advantage for Siemens" Gerhard Kress, Siemens Corporate Development, in Pictures of the Future, Autumn 2012.

"The ICT industry and ICT-enabled innovation in non-ICT industries and services make an increasingly important contribution to the economic growth of advanced economies" in the 2011 report on R&D in ICT in the European Union, JRC Scientific and Technical Reports.

"Software and embedded systems are even more important for Barco's future networked visualisation and collaborations products" Jan Willem Brands, CTO Barco n.v., September 2013

"Today, the majority of the key features of our products already strongly depends on ICT technologies, esp. on SW and Embedded Systems. The influence is growing." A. Anderson, Head of Engineering and CTO, CASSIDIAN.


4

CHAPTER 4

One Mission, different instruments

In its 2011 report ISTAG already recommended that the transformation of the industrial society to the information society be supported by several policies [ISTAG]:

- "Stronger and better integration between the research and innovation dimensions but education should not be neglected; joint policymaking will be needed to achieve effective linkages between research and innovation, thereby shaping productivity, competitiveness and employment."
- "The mix of funding measures should strike a balance between bottom-up and top-down approaches to research."
- "A well-articulated innovation strategy needs to ensure that instruments and priorities encourage participation from a broad spectrum of small and large enterprises, universities and research and technology organisations; in fostering innovation, the role of industry as the bridge between research and 'commercialisation' has to be stressed and the fact that SMEs are consumers as well as performers of research better recognised."
- "Effective instruments are needed to achieve effective research coordination between the Member State and EU levels objectives, integrating the research base by overcoming fragmentation in research is vital, while simultaneously achieving a sharper division of labour between what is done at EU level and what is undertaken in national programmes; European research and innovation efforts must concentrate on themes where critical mass is vital for success and where breakthroughs require cross-border solutions, while also allocating sufficient resources to R&D topics which promise radical innovations."

Today's systems based on Digital Technology are so complex that no single organisation or company can oversee all the aspects or connections. With tomorrow's even more complex interacting systems-of-systems, the visibility of a single company will be reduced even further, highlighting the relevance of cross-border innovation eco-systems that foster open innovation. Both ARTEMIS and ITEA have built such innovation eco-systems of closely interacting companies and research organisations. These eco-systems are essential to enable European organisations, including SMEs, to keep up with the fast changing reality in Digital Technology, its increasing complexity and to remain at the forefront of innovation.

The common mission of the ITEA and ARTEMIS communities is to maintain European leadership in embedded systems and software-intensive systems and services. In this chapter the two programmes describe their roles and ambition for software innovation in Europe in the coming period, whereby this 2013 version contains a fuller examination of the economic impact in terms of revenues and jobs.

4.1
CYBER-PHYSICAL AND EMBEDDED SYSTEMS IN EUROPE

Already today, embedded systems assist and control important domains of our lives. They enable businesses to perform better and make citizen's lives more convenient and fulfilling. Some systems, especially for automotive and aircraft control, medical systems and nuclear power supply, are already critical to human life and their evolution will be so drastic that future generations will experience a pervasiveness of "embedded intelligence" that can hardly be imagined today. Embedded intelligent systems will literally be found; the lives and well-being of citizens will depend on these systems to an inconceivable extent.

4.1.1 ARTEMIS VISION

The vision driving ARTEMIS is of mankind benefiting from a major evolution in intelligent systems, a world in which all systems, machines and objects are 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. Digital convergence by the emancipation of data, building embedded intelligence into every aspect of life, and the internet revolution are the opportunities for Embedded Digital Technologies (EDT)[8] of our time. They will change the way we live as citizens and the way we do business in the new digital economy. It is a trend that is accelerating and its impact on our society will become deeper than ever.

In this context, the ARTEMIS-IA vision nurtures the ambition to strengthen the European position in Embedded Intelligence and Cyber-Physical Systems and to ensure its achievement of world-class leadership in this area by establishing an environment that supports innovation, stimulates the implementation of the latest achievements of Cyber Physical and Embedded Systems on European scale, and avoids the fragmentation of investments in R&D.

4.1.2 ECONOMIC RELEVANCE OF EMBEDDED DIGITAL TECHNOLOGIES

Embedded Digital Technologies enable high-tech industry product innovations. Substantial R&D efforts and investments related to Embedded Digital Technologies are made by industry. The AICC working group has made an estimation of the R&D investment in Embedded Digital Technologies of the applications industry in Europe in the period 2012-2020. The EU R&D Scoreboard for the Top1000 R&D companies in Europe, issued by JRC of the European Commission, is used as database for these estimations [EUSB2012]. These data were cross-checked by a survey of representatives in the related industries.

In the EU R&D Scoreboard [EUSB2012] a survey structured according to application areas is given for industrial achievements and efforts in R&D for the Top1000 R&D companies in Europe in 2012. We selected those application areas that are highly dependent on embedded systems.

[8] *EDT in this context comprises the hardware and software of the Embedded Systems as well as the natural extension towards Cyber Physical Systems.*

The application areas selected are:

- Aerospace & defence
- Alternative energy
- Automotive
- Electronic and electrical equipment
- Healthcare equipment and services
- Industrial engineering
- Software & computer services.

Application area	Turnover Billion euros of EU companies in 2012	Turnover growth/yr	R&D % overall	R&D in EU (2012) Billion euros	R&D growth/yr
Total	**1390**	**4.7**	**4.9**	**69**	**5.6**
Aerospace & defence	150	4.7	5.9	8.8	5.1
Aternative energy	13	3.9	5.9	0.8	34
Automotive	698	6.5	5.1	35	4.6
Electronic and electrical equipment	156	1	5	7.7	5.9
Healthcare equipment and services	65	6	4.1	2.7	5.9
Industrial engineering	236	1.8	3.1	7.4	7.5
Software & computer services	69	5	8.1	5.6	5.5

Table 4.1 European companies: Overview of turnover, turnover growth, R&D as percentage of turnover, the R&D amount spent and the R&D growth for each of the application areas [EUSB2012].

The average growth in turnover might rise with the increasing influence of Embedded Digital Technologies. For R&D the total investment was 4.9% of turnover, averaged over the last three years. The growth in R&D might suffer a slight decrease in the near future due to the economic crisis so this has to be counterbalanced by dedicated political measures and appropriate programmes!

In a survey of representatives from related European industries, the data were checked for each application area and completed with fraction of total R&D expenditure on Embedded Digital Technologies R&D, as estimated by these industry representatives.

Application area	WW turnover of EU companies in 2012	Overall R&D as % of turnover in 2012 [EUSB2012]	Overall R&D spending as % of turnover 2013	Overall R&D spending as % of turnover 2020	Fraction in % of total *R&D spent for EDT* 2013	Fraction in % of total *R&D spent for EDT* 2020
	Euros (billion)	%	%	%	%	%
Aerospace & defence	150	5.9	5.4	5.4	30	37
Automotive	698	5.1	6	5	27	38
Electronic and electrical equipment	156	5	8.4	8.4	70	75
Healthcare equipment and services	65	4.1	4	4	50	55
Industrial engineering	236	3.1	4.4	4.8	50	55

Table 4.2 Embedded Digital Technologies R&D investments per application area in Europe as given by experts

From this it is obvious that at least about 20% of the total R&D is spent on the Embedded and Cyber-Physical Systems R&D, or 1% of turnover, equivalent to annual investment of about €14 billion in 2012, increasing to €21 billion in 2020. Based on an annual growth of 5.6%, similar to overall R&D growth, the cumulative sum in the period from 2012 to 2020 of R&D on Embedded Digital Technologies amounts a total of €157 billion, €30 billion of which may be related to semiconductor R&D. This is listed in table 4.3.

Domain	Turnover Billion euros of EU companies in 2012	Turnover growth/yr	R&D % overall	R&D % EDT related	R&D growth/ yr	R&D on EDT in EU (2012) Billion euros	R&D on EDT in EU (2020) Billion euros	Cumulative R&D 2012-2020	Collaborative part	RDI OPEX
Applications domain	1390	4.7%	4.9%	1.00%	5.6%	14	21	157	10%	16

Table 4.3 Embedded Digital Technologies R&D spending in Europe estimated up to 2020.

Given an estimated 10% participation in cross-national collaborative R&D projects to improve European competitiveness, expenditure in collaborative R&D projects in Embedded Digital Technologies will be about €16 billion.

4.1.3 EMPLOYMENT IN EUROPE

The survey of the impact of Embedded Digital Technologies on the key features of all emerging products in the relevant industrial domains indicates that today already about 50% of the key selling features are directly impacted or even determined by Embedded Digital Technologies. This influence will increase to nearly 75% in 2020 and will have an enormous impact on the economy, and consequently, employment.

The following, fairly conservative, employment data are taken from the EU R&D Scoreboard 2012, for the given application domains.

Application area	Jobs (Million)	Growth % /year	Absolute growth / year (k)
Total	**5.7**	**2.7%**	**151**
Aerospace & defence	0.57	2.0%	11
Aternative energy	0.05	12.0%	6
Automotive	2.3	1.3%	30
Electronic and electrical equipment	0.9	2.5%	23
Healthcare equipment and services	0.47	4.3%	20
Industrial engineering	0.95	3.6%	34
Software & computer services	0.48	5.6%	27

Table 4.4 Employment in relevant domains in Europe [EUSB2012]

Based on annual growth of 2.7%, the period 2012-2020 can expect to see 1.3 million jobs accumulate in the applications areas.

In our survey, we also asked the industry representatives what percentage of their product features are likely to be based on or be enabled by Embedded Digital Technologies. The table below shows the result.

Application area	Estimated % of features based on EDT	
	2013	2020
Aerospace & defence	62	69
Automotive	50	75
Electronic and electrical equipment	70	80
Healthcare equipment and services	70	80
Industrial engineering	52	56

Table 4.5 Fraction of product features enabled by Embedded Digital Technologies

This table shows that the dominant part of the key selling features of our products are determined to a large degree by EDT. If the key selling features make the final "tick" on whether customers decide to buy the one or the other product, EDT is the key point to the competitiveness of the products. This has significant impact on competitiveness of European industry.

With an average of 60% of the features enabled by Embedded Digital Technologies, and thus also 60% of the jobs created, about 800k jobs in these application industries will be based on the Embedded Digital Technologies in their products. In conclusion, it can be estimated that the European applications industry will invest 150 billion euros in R&D in the domain of embedded Digital Technologies in the period 2013-2020, 15 bn of which is expected to be allocated to R&D&I projects in Embedded Digital Technologies. Based on [EUSB2012] we also estimate a growth of about 800k jobs in the application industries.

4.1.4 EMBEDDED AND CYBER-PHYSICAL SYSTEMS TECHNOLOGY

Embedded Digital Technologies, encompassing embedded software, Embedded and Cyber-Physical Systems will be part of all future products and services, providing intelligence on the spot and capabilities to cleverly connect to the abundance of systems in their environment, either physical or at cyber-space level, in real time. Internet has become the dominant connection medium for most communication and will remain so, especially for communication between the myriad of connected embedded systems. As a consequence, Embedded and Cyber-Physical Systems form the edges of the 'Internet of Things', linking cyber space and the physical world of real 'things'. They will be crucial in enabling the 'Internet of Things' to deliver on its promises. Yet with major benefits also come severe risks, including the impact of system failures or loss of privacy and security, putting ever more strain on the correct and timely development and deployment of increasingly complex systems.

Real-time connections between sensors, embedded systems and large information systems will create cyber-physical systems that open up new functionality and contribute to addressing the challenges imposed by the seven areas of major change.

Internet connected intelligent embedded systems will provide the core of solutions for the big societal challenges following from the seven areas of major change described in chapter 1. Embedded systems will raise expectations as well as concerns about potential failures and safety, privacy and security so the quality and dependability of embedded systems are key issues. In that context additional protocols and communication structures may be needed to guarantee the required **quality of service**.

The impact of networking will go far beyond that of today. Many emerging embedded applications now share networks and components in configurations whose conceptual structure no longer readily corresponds to their physical structure. In parallel, open networks of Embedded Systems applications from multiple domains are coupled: everything can, in principle, be connected to everything else. This 'bigger picture' for Embedded Systems implies change from local networks to open networks of embedded systems. This leads, in turn, to a change from single-system ownership to multiple-design processes and responsibilities involving many parties, multi-views, with conflicting objectives.

Networked Embedded and Cyber-Physical Systems will, in effect, become the neural system of the technical infrastructure of our society, as detailed in the ARTEMIS SRA [SRA].

Closer investigation of the applications has highlighted the importance of **interoperability**, system autonomy, networking - including use of the Internet or higher level **quality of service** protocols - and consideration of mixed criticality for more **dependable systems**. 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 and robust to compensate for the reduced real-time and reliability guarantees, operating dependably even in the presence of network degradation or temporary failure. The safe and secure operation of such increasing complexity will impose huge challenges on design, operation and interoperability of embedded systems, be it in software, electronics, sensors, actuators or a combination of those.

Embedded and Cyber-Physical Systems will be part of all future products and services providing intelligence on the spot and capabilities to cleverly connect to the abundance of systems in the environment; either physical or at the cyber space level, in real time or in distributed and heterogeneous systems, in open networks of embedded systems applications from multiple domains or in the Internet: everything can, in principle, be connected to everything else.

Cyber-Physical and embedded systems are, in effect, becoming **the Neural System of Society.**

The ubiquity and pervasiveness of embedded intelligence systems prompt expectations of constant availability and absolute zero risk of failure. In the past, design complexity was limited to that of single, dedicated systems in isolation. Networking such systems forces the design to embrace the behaviour of many interconnected systems, consequently with a manifold **multiplication of the complexity issues**.

The ARTEMIS SRA 2011 and its ADDENDUM 2013 point to a series of technical issues that should be resolved before 2030. First, those issues related to foundational science and technology; second, those related to the application contexts; and third, those encompassing societal challenges (see ARTEMIS SRA 2011 [SRA]).

Europe can address these challenges by using its sophisticated Embedded Systems Research and Development resources in industry and research institutes if well-coordinated and if adequately funded. In a global world **EMBEDDED SYSTEMS** are a crucial **KEY ENABLING TECHNOLOGY** for Europe's industrial and societal future, with sufficient effort to keep a leading position.

This key role of Embedded and Cyber-Physical Systems is increasingly penetrating European society as also indicated by the 2011 ISTAG Report [ISTAG]. The role envisioned for ICT by ISTAG underlines the importance of Embedded Systems as a 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.

4.1.5 ARTEMIS STRATEGY

ARTEMIS has developed an innovative strategy to follow this vision and achieve its objectives. This strategy mainly aims at overcoming the present 'fragmentation' in all areas of the innovation chain: in research, in development, in the supply chain and in the market. Cutting barriers between application sectors to facilitate cross-domain sharing of technologies and research is supported by a top-down strategic road map and an ambitious set of high-level key performance indicators.

The ARTEMIS SRA [SRA] has identified three main areas of research where the applications domains should share commonalities and synergies to overcome the fragmentation and create critical mass for investments.
The three areas of research are:

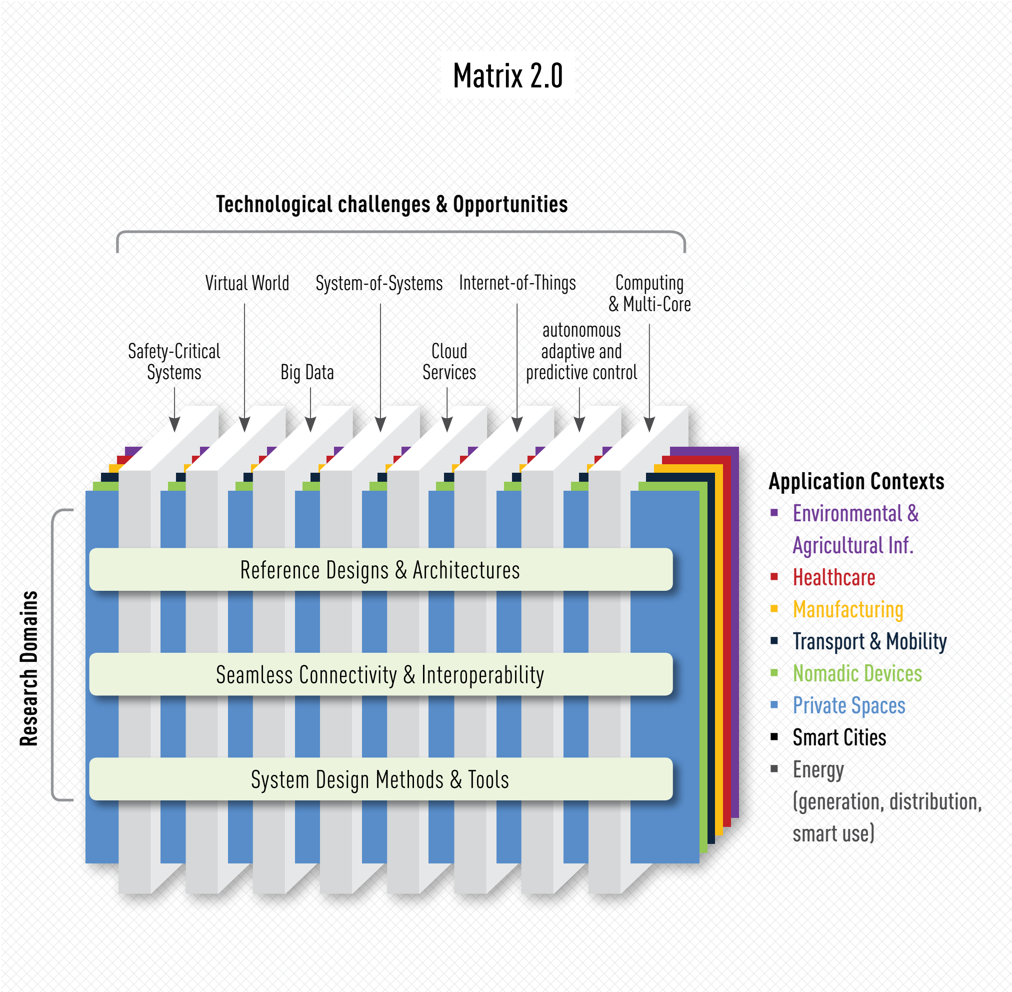
- Reference designs and architectures
- Seamless connectivity and interoperability
- Design methods and tools.

They are complemented by a fourth area that addresses foundational research, or the more up-stream research.

The technology challenges for 2030 for Embedded and Cyber-Physical Systems are such as:

- Architectural models and principles allowing new functionalities and performance
- Safe and secure by design, based on interoperability standards for systems and design tools
- Situation awareness for distributed real-time and highly certified operations
- Interconnection, to enable the development of new and smart applications and to create solutions to the areas of major change
- Autonomous, dynamic, adaptive, and self-organised systems
- Seamless interaction of the ES with their environment (CPS)
- Optimised and consistent processes and tools.

The relationship between the research domains, technology challenges and application contexts are depicted in the Matrix 2.0 [SRA].

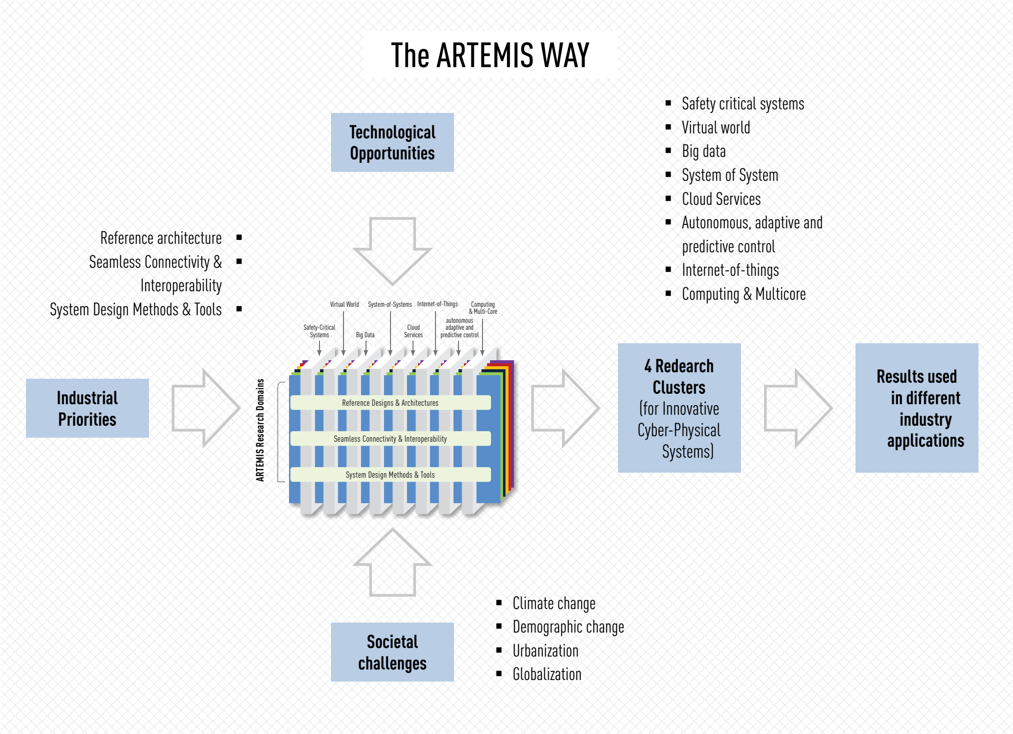


The road-mapping and prioritisation are guided by market prospects/ user needs /societal challenges (chapter 1) and also by the state of the art reached so far and results in a number of technological opportunities that fulfil the ARTEMIS strategy and support innovation (overcome the fragmentation, cross-domain application contexts and serving the high-level objectives and societal challenges).

These technological challenges and opportunities constitute the basis to tackle the identified societal challenges, cutting across the three ARTEMIS research domains and all targeted application contexts. They are the major ingredients for innovative, efficient and safe Cyber Physical Systems:

- Safety-critical Systems
- Virtual World
- Big Data
- Systems of Systems
- Cloud Services
- Internet of Things
- Autonomous, Adaptive and Predictive Control
- Computing & Multicore.

All these inputs come together in the ARTEMIS way:



"As the neural system of society, networked Embedded and Cyber-Physical systems should no longer be considered only in isolated application contexts but in relation to what they can offer in addressing today's and tomorrow's industrial and societal challenges."

This strategy is also based upon exploitation of European strengths and opportunities by:

- Building on the leading positions in specific technologies and in important application domains, such as highly reliable systems, professional and commercial applications, transportation and production.
- Creating opportunities for Europe to be positioned at the forefront of new or emerging markets with high potential growth rates to become among the world leaders in these domains.
- Using the new technologies to recover in areas, where Europe lost ground, e.g. by bringing back production to Europe, based on high degree of automation and societal compatibility.

To build a sustainable innovation eco-system for Embedded and Cyber-Physical Systems, the ARTEMIS strategy implementation will continue to be based on a strong, research-led innovation programme at its heart, combining the top-down strategic programming with a Europe-wide integration of the bottom-up priorities identified through its Centres of Innovation Excellence.

Product and service innovations are driven largely by developments in ICT, Embedded and Cyber-Physical Systems, where especially Embedded and Cyber-Physical System are increasingly crucial. Therefore ARTEMIS-ETP will continue, in addition to its R&D roadmap, to nurture activities supporting innovation such as education, standards and SME development... to boost the competitiveness of Europe's industry.

4.1.6 OPPORTUNITIES FOR EUROPEAN HIGH-TECH INDUSTRY

Chapters 2 and 3 presented the technical and economic relevance of Embedded Digital Technologies for the European high-tech industry. As argued in the previous sections of this chapter, Embedded and Cyber-Physical technologies play a very important role in keeping Europe at the forefront of high-tech product innovation, essential for its success in the world market. ARTEMIS has achieved a unique position to support European industry in its leading research and innovation activities.

4.1.6.1 THE ARTEMIS INNOVATION ECO-SYSTEM

The ARTEMIS projects cover a wide range of R&D activities, from basic R&D to large-scale demonstrators that validate R&D concepts within an innovation context in real-life settings.

A differentiator is the drive to influence worldwide standards, platforms and other structural conditions relevant for innovation. Impact requires a large EU footprint and ARTEMIS is active on several fronts to realise such impact:

- Exploiting the concept of **Artemis Innovation Pilot Projects** (AIPP), maximising impact by an unprecedented scale and focusing on combining project results and bringing them closer to market.
- Introducing the concept of **Reference Technology Platforms** (RTP) and tool platforms, supported by a defined set of labelling requirements and a nomination procedure for these Reference Technology Platforms and tool platforms.
- Establishing one **ARTEMIS Tool Platform**: CESAR. More are in the pipeline.
- Establishing a Working Group on **Standardisation** and a strategic agenda for standardisation that invoked the FP7 PROSE project.

The ARTEMIS Innovation Pilot Projects are expected to foster and sustain the ARTEMIS innovation environment through:

- Creating new business innovating eco-systems
- Aligning implementation of R&D&I (Research and Development and Innovation) priorities for Embedded Systems in Europe to turn European "diversity" into a strength
- Achieving a "European Dimension" by combining the R&D&I efforts across Europe for future proven application domains and technologies, while pooling resources in key areas, and involving relevant players with the ability to ensure successful valorisation and uptake of the results
- Establishing and sustaining a holistic approach to R&D&I, by undertaking projects of critical mass, reconciling the

market silos/ business-efficient approach with the cross-domain synergies
- Risk sharing to enable projects that otherwise would not be undertaken
- Building upon results from existing and previous projects to provide market-driven solutions based on prototypes and demonstrations
- Pooling industrial resources and "sharing" (e.g. standards and methods) to foster interoperability and synergies between various environments in order to maintain leadership in traditional markets, and gain worldwide positions and claim market share in new areas
- Setting and sharing of R&D&I infrastructures

In addition to the funded projects that are carried out under the umbrella of the ARTEMIS Joint Undertaking and that are R&D oriented, the **ARTEMIS Industry Association** has built a unique **Innovation Eco-system** by being active in the field of **Centres of Innovation Excellence**, **Design Environments** and **Tool Platforms**, **Standardisation** and **Education**, **Metrics** and **Projects** and a **Results Repository** through a number of very active working groups formed by voluntary members from Industry and Research Institutions.

Three transnational Centres of Innovation Excellences were already labelled:
- EICOSE
- ProcessIT.EU
- ES4IB (Embedded Systems 4 Intelligent Buildings)

The ARTEMIS innovation eco-systems span the whole value chain, including SMEs, research institutes and large companies. Innovation eco-systems are essential to master the immense complexity of future embedded systems, since no single company can master all the challenges involved. Some specific key activities are:
- Continuous open dialogue with the **EUREKA cluster ITEA** resulting in the co-organised Co-Summit events over five years, a high-level umbrella group with ITEA and this shared vision 2030.
- Supporting national mirror organisations such as ARTEMIS Austria and Prometeo in Spain, which are very active in organising national events.

ARTEMIS actively nurtures thematic inter-project cooperation, for example by means of special events such as the ARTEMIS Technology Conferences. ARTEMIS has also established a repository of project results. A prototype database tool has been implemented to capture the information of the project results that is publicly available.

4.1.6.2 STRENGTH AND IMPACT OF ARTEMIS

Another important activity in ARTEMIS is the **monitoring of impact and results** by the Working Group Metrics and Success Factors. In 2013, ARTEMIS published the results of this working group's second questionnaire that focused on the impact of ARTEMIS. The following statements from the executive summary of the Metrics report speak for themselves:
- ARTEMIS is growing and becoming a reference in Embedded Systems research and innovation in Europe
- The main motivator to work in ARTEMIS remains the industry-driven approach, including the scale and size of investment and impact
- The combination of scientific and industrial views is considered a key strength
- This business impact largely concerns reduced development costs, reduced time-to-market and higher re-usability.

From the report, the top three key strengths of ARTEMIS are:
- Industry-driven, industry relevance (55% of respondents)
- Partner alliances / consortium (40% of respondents)
- Cross-domain approach (30% of respondents).

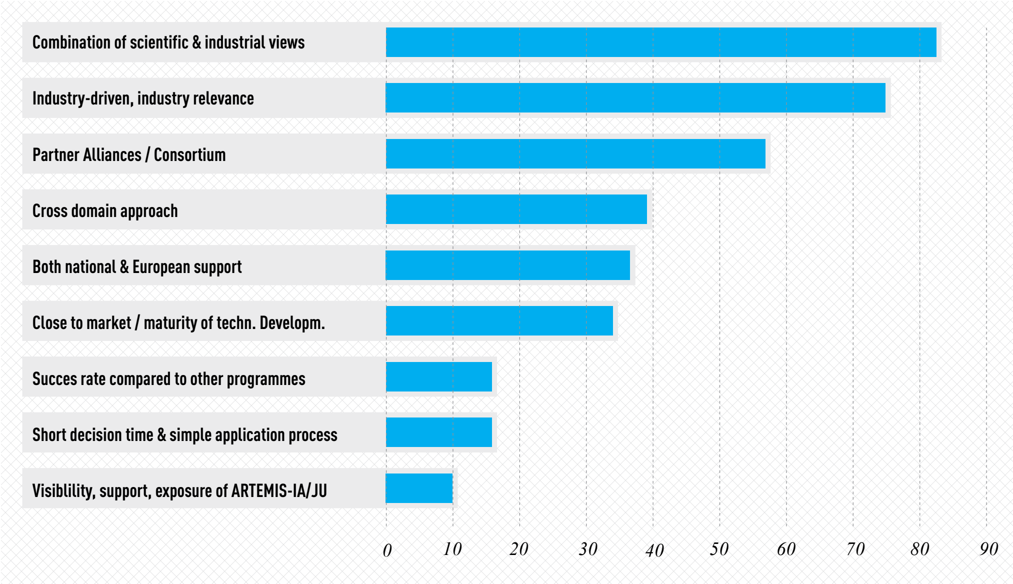


Table 4.6 Why join ARTEMIS: Impact on transnational cooperation [METRICS]

In terms of business impact, the top three answers are:

- Reduced development costs (60% of respondents)
- Reduced time-to-market (50% of respondents)
- Higher re-usability of component (50% of respondents).

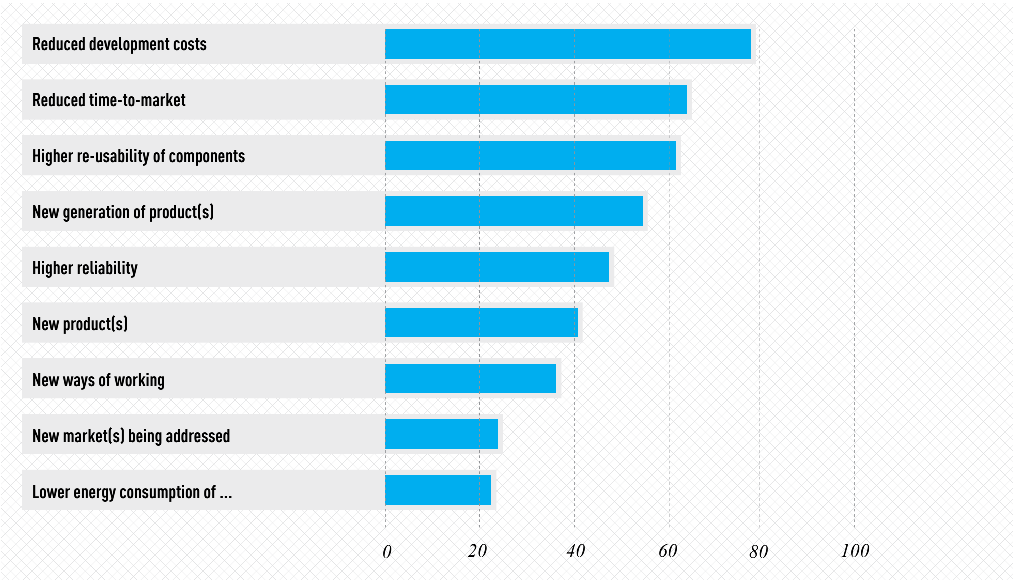


Table 4.7 Impact of ARTEMIS projects on business and commerce [METRICS]

From the conclusions of the report [METRICS], the key strengths and improvements reported are:

1. New partnerships and involvement of SMEs
2. Growth of awareness of and interaction with CoIEs.
3. Business impact on reduced development costs, reduced time-to-market and higher re-usability
4. ARTEMIS AWP targets are a living instrument
5. Societal challenges are addressed properly – "security and safety" being number 1. However, taking into account the security and safety focal area of in ARTEMIS (in comparison with the EU Policy), one can state that overall "Transport and Mobility" (including the security and safety aspects) remains the key focal area of ARTEMIS
6. Attention for prototypes and demonstrators is growing, including public trials and field tests.
7. More attention has been paid to press releases and press coverage. The publication of books and papers leads to higher quality dissemination (e.g. book on the Cesar project, to be published by Springer Verlag).

ARTEMIS contributes through all of its activities to strengthen the European innovation eco-system and thus improve the level of competitiveness of the European industry.

4.1.7 PRIORITIES FOR THE FUTURE

ARTEMIS has identified three main objectives that are essential to prepare the European high-tech ICT-based industry for the future and strengthen the competitive position of the European ICT-based industry through R&D&I in Cyber-Physical and Embedded Systems:

- Boost current EU strengths
    - In several professional and industrial applications especially, Europe is economically strong on the basis of early technology innovation. Good examples are the Automotive and Aerospace as well as Medical industries. These existing strengths need constant maintenance and reinforcement to remain at the technological forefront and sustain economic impact.

- Innovate to unlock new business potential
    - New business potential should be unlocked by bringing together existing and new technologies that have been implemented separately in products and services. New business potential may be expected especially from:
        - Smart spaces and systems, such as Smart Cities:
          Since 2008 cities have housed more than 50% of the world's population and this is expected to grow over the coming decades to 80%. The internet-of-Things will generate a new growth wave that will unlock the potential of smart mobility and smart buildings, especially to provide solutions for the densely populated and traffic-congested cities. This boost in connectivity will also pose security hazards that need solutions. Many technologies and applications will co-exist closely in cities, such as smart living, smart grid, e-Government, big data and integrated care. Especially at the interfaces where different technologies and applications meet, new opportunities for products and services will appear and be opportune for business success, if adequately supported by R&D&I in embedded and cyber-physical systems.
        - Food and agriculture systems: these are already making intensive use of ICT, but the challenge is now to establish links between these industries and the ARTEMIS eco-systems and centres of excellence to enhance their competitiveness.
        - Energy efficient and environmentally compatible products

- Opportunities to recover positions:
  - Make Europe attractive for manufacturing by intensifying automation. Manufacturing has been shifting to Asia, due to perceived cost benefits. This has weakened the European economies, painfully visible in times of economic crisis. Efficiency improvements and effective manufacturing processes need support from cyber-physical and embedded systems to buck this trend.
  - Strengthen semiconductor eco-system by cooperating on applications. Government and industry have recognised the need for a strong semiconductor eco-system in Europe since it is the basis for the whole electronics value chain in Europe. The electronics value chain can be strengthened if all the value-chain players cooperate along the axis of applications. Cyber-physical and embedded systems enable a systems perspective for the electronics value chain that opens up new options in respect of the semiconductor eco-system.

Europe, with its world-class automotive, aerospace, communication and medical equipment industries, still has an excellent position in the Embedded Systems field, which play a key role in enhancing the capabilities, availability and usefulness of these products. **Only through adequate coordination and collaboration and with the help of public funding can this position be maintained to help solve the enormous challenges emerging from the areas of major change rapidly enough and, at the same time, spur European competitiveness in many other areas.**

Pan-European action is and remains essential to keep Europe at the forefront of product innovation through research in embedding intelligence. ARTEMIS is a key player in achieving a pan-European approach to product innovation and maintaining the competitiveness of the European industry towards 2030.

4.2
ITEA 3

4.2.1. ITEA 3: SEIZING THE HIGH GROUND

ITEA stimulates and supports innovative, industry-driven, pre-competitive R&D projects which will contribute research excellence to Europe's competitive software-intensive systems and services sector. ITEA has a proven track record with major achievements in Europe's most competitive industries, such as automotive, communications, healthcare, aerospace and consumer electronics. In the future, with the transition to a service economy, ITEA will continue to play a key role in innovation and mastering economic and societal challenges in the period to 2030.

In a nutshell, ITEA stands for innovation, business impact and fast exploitation. Its projects are of concrete relevance for every participating company and country. In addition, in ITEA 3 our ambition will be to seize the high ground to ensure that European industry continues to be at the leading edge worldwide

4.2.2. ITEA 3 ADDRESSING ALL THE CATEGORIES OF SOFTWARE INNOVATION NEEDED TO MASTER THE CHANGES

There is a wide consensus that the period from now to 2030 will be one of permanent change and disruption. Chapter 1 described in some detail the major areas of these changes and disruptions.

In each of these areas, Digital Technology plays a major role in mastering the changes. For the leaders in economy and society, Digital Technology appears in seven categories:
1. Industrialised non-differentiating services
2. Customised services
3. Smart products
4. Smart services
5. Innovative engineering
6. Smart infrastructure
7. Security of systems and services.

ITEA is addressing software innovation in each of these seven categories.

1 INDUSTRIALISED NON-DIFFERENTIATING SERVICES

Non-differentiating services can often be outsourced, performed in low-cost countries or moved into the cloud.

Examples are:
- Outsourced application management: e.g. maintenance of existing applications, migration to new platforms
- Outsourced business processes: e.g. accounting, call centres, salary administration, ERP, CRM
- IT outsourcing: e.g. desktop software support.

The challenge for Europe is to get this back through smart automation. The development of such kind of services is in the scope of ITEA 3, e.g. in cloud projects or with companies in Business Information Systems as a key partner.

2 CUSTOMISED SERVICES

Differentiating services often remain in-house and are provided in a customised way.

Examples are:
- Ticketing
- Dealer systems
- Customer-facing services
- Maintenance services in the hospital.

Other customised services are:
- Security services like access control and video surveillance
- Services like hardware desktop support.

Also these services tend to remain in-house.

There are many projects in ITEA that address customised services, like:
- Security policies in multi-domain environments
- Multimedia content analysis
- Service infrastructure for technical hospital facilities.

3 SMART PRODUCTS

Product intelligence comes from embedded software. From the very beginning, ITEA had projects addressing smart products and embedded software.

Examples are:
- Automotive open system architecture
- Horizontal standard for machine-to-machine communication
- Web of Objects
- Wireless sensor networks
- Digital cinema
- High-performance medical imaging.

The intelligence of a smart product is generally shown through its interactions with the environment.

- A smart car is connected to its maintenance service operator that provides information on its status, the need for maintenance and communicates with roadside units sending alerts in the case of an emergency
- Smartphones are connected to information databases via internet. They can download from among a huge selection of apps, allowing household devices to be controlled and payments to be effected, for example.

4 SMART SERVICES

When do we call a service smart?
In general, the notion of smart service is based on the distinction between passive versus active behaviour; in the latter case, actions are taken and additional information is gathered to deduce correct solutions. In many cases sensors are involved in getting this information.

Some examples:

- Video surveillance is not smart in itself but it provides face recognition and automatic alerts concerning dangerous persons, then we would call it smart
- Smart systems avoid false alarms and false manoeuvring in medical contexts
- Autonomous aeroplane flying and automated landing are smart services in the same way autonomous car driving is.

There are many ITEA projects in this area addressing, for example:

- Smart urban spaces
- Do-it-Yourself smart experiences
- Maritime surveillance
- Smart rehabilitation of patients after heart surgery
- Smart navigation for heart surgery.

In ITEA 3, we expect to have projects on:

- Global service platforms for smart energy, water, food management, mobility services, smart city lighting
- Clinical decision support systems
- Smart building services, monitoring and controlling elevators, heating, security systems, blinds, window cleaning (robotised), energy supply.

5 INNOVATIVE ENGINEERING

Innovative Engineering is an on-going challenge for the R&I community to deal with software intensive systems and services as well as embedded systems. The drivers for these challenges are:

- New technologies, like multicore architectures
- New standards, like ISO 26262
- New development paradigms, like agile methods
- Time-to-market and development costs.

Permanent challenges are:

- The extremely different lifetimes of software and the products in which software constitutes a vital embedded element
- The ever-increasing demand for safety, security and reliability of software intensive systems and services
- The permanently growing number of "multi-X" dimensions of software and systems engineering: multi-disciplinary, multi-site, multi-company, multi-cultural.

Innovative engineering has been an important R&I domain since the beginning of ITEA. One of the first success stories was the launch of AUTOSAR, the automotive open-system architecture. Like a string of pearls, the engineering success stories continued throughout ITEA and ITEA 2.

Examples are:
- Multicore architectures in the automotive domain
- Sustainable engineering ecosystem in the aerospace domain
- Open engineering standards for train control systems
- Integrating safety standards into AUTOSAR processes.

We are convinced that innovative engineering will also constitute a lively part of ITEA 3.

6 SMART INFRASTRUCTURE

A smart infrastructure is, in many cases, just a different view of smart services.

For companies, the following examples are smart services; for political leaders they are smart infrastructures:
- Global service platforms for smart energy, water, food management, mobility services, smart city lighting
- Smart building services, monitoring and controlling elevators, heating, security systems, blinds, window cleaning (robotised), energy supply
- Internet infrastructure and cloud computing.

In ITEA, we have already had some projects addressing these topics and we expect many more to come.

7 SECURITY OF SYSTEMS AND SERVICES

Security of systems and services appears in two different subcategories. Security and reliability of systems should be carefully distinguished from security and safety of people and infrastructures:
- Security and reliability:
  - Security of systems against external attacks
  - Reliability of systems i.e. the system delivers what has been promised, under all circumstances.

System security and reliability are key subjects for ITEA because they concern the protection of the digital society from external attacks and poor design.

Examples of ITEA projects are:
- Access control security
- Advanced test automation, model-based testing and test-driven development,
- Multi-domain security testing technologies.

- Security and safety
  - Protecting people from criminal acts, and products or services that make people's lives safer, including Babywatch and airbags
  - Safety is specific to people and may be a systems behaviour requirement.

Furthermore the security of the flow of physical goods and information as well as of infrastructures such as Internet, smart grids, railways and airports is of major importance. A safe, stable and reliable infrastructure is a key enabler for economic prosperity.

ITEA projects in this area are addressing, for example:
- Safety systems in the home environment
- Surveillance and rescue framework for mobile environments
- Maritime surveillance framework
- Disaster control management

4.2.3. IMPACT OF ITEA 3

4.2.3.1 IMPACT OF ITEA 3 ON JOBS AND REVENUE

The importance of EUREKA clusters is demonstrated by positive results in evaluations of the impact of EUREKA. Results of the EUREKA Impact Assessment working groups of the Israeli and Hungarian Chairmanships (2010–2012) and some of the econometric impact studies [EUREKA] during that time show that the average additional turnover generated by €1 million of public funds invested in a EUREKA Individual Project is €9.5 million, and that the same €1 million of public funds helps create or save 37 jobs.

Taking the overall planned costs of ITEA 3[9] of €3 billion and using an estimated 40% rate of public funding for ITEA Projects[10] give an estimated total of €1.2 billion of public funds invested in ITEA 3 projects. Extrapolating the effects of €1 million public funds to this total gives approximate impacts for ITEA 3 projects of over 44,400 jobs created and €11.4 billion additional turnover generated.

[9] *Source: ITEA 3 Application documents*
[10] *Source: ITEA 2 Office*

Example of economic impact

Barco – Digital Cinema project

- From January 2001 until June 2003, Barco, with the support of the Flemish Government Agency IWT, headed the ITEA project Digital Cinema to develop the key components for the transition from analogue 35mm film to digital technology. The shift in the film industry to enable digital distribution was a major and risky step to produce change in a century-old industry that required a universal, long-term digital cinema standard meeting the needs of exhibitors, studios, equipment manufacturers and others involved in this effort.
- The completion of this project kicked-off 10 years of Digital Cinema pioneering for Barco, resulting today in an undisputed global market leadership for Barco in Digital Cinema.
- Barco's project budget was €2.7 million and 18 person years (PY). The project duration was 2.5 years and the funding is estimated at €1 million.
- In 2012, Barco employed 3725 people and realised a revenue of €1.156 billion.
- We estimate that close to 10% of Barco's workforce in Europe is active in the area of Digital Cinema (direct and indirect).

Conclusion: €1 million of funding contributed to generating and supporting approximately 350 jobs compared to the average of 37 jobs as mentioned in the EUREKA impact figures

Example of economic impact

KE-Works – 3DTestbench project

- In the Netherlands, the SME KE-Works was founded in 2008 as a spin-out of Delft University of Technology with Fokker Elmo as a launching customer in 2009. KE-Works was set up to exploit the innovations in the field of design automation resulting out of the ITEA 2 3D-Testbench project.
- Delft University of Technology's project budget was €396 k and 5.7 PY. The duration was 3.5 years (2007-2010) and the funding is estimated at €200 k.
- In 2013, KE-Works employs 7 people (FTE) and has a revenue of €0.5 million[11].

Conclusion: Within less than 3 years, €0.2 million of funding already generated 7 jobs corresponding to the average mentioned in the EUREKA impact figures.

[11] *Source: private communications, Jochem Berends, CEO of KE-works*

Example of economic impact
ParMa project

- The ITEA 2 ParMA project, which ran from 2007 to 2010, brought together leading European high-performance computing players, led by major French computer manufacturer Bull. ParMA produced a unified package of tools for parallel programming for multicore architectures. The application fields in which these results are being used include foundry combustion, iron casting and metal-forming simulation. In all three domains, ParMA resulted in a drastic reduction of the overall run-time of complete simulations. As a result, impressive competitive advantages have been achieved for users in the German metal industry among others, which created additional business for all ParMa partners.
- The total project budget was €13.7 million and 137 PY. The project budget of the industrial partners was €8.8 million and 74 PY. The project duration was about 3 years and the total public funding is estimated at €5.5 million.
- ParMa achieved its main goals of creating an eco-system of business partners in High Performance Computing and improving customer intimacy for Bull.
- Up to 2013, the ParMa project has generated additional economic benefits of €30 million among the industrial ParMa partners.

Conclusion: €5.5 million of funding generated €30 million of additional economic benefits among the ParMa partners. Thus, in less than 3 years, the total additional economic benefits including other customers should be close to the EUREKA average at least.

4.2.3.2. IMPACT OF ITEA 3 ON TAX REVENUE – ROI FOR MEMBER STATES

The goal of this section is to compare the costs of the ITEA programme with its return in the form of tax revenue from the perspective of the member states.

To this end, we consider the €3 billion ITEA 3 budget to be spent equally over 10 years, taking into account the 8 annual Calls plus an extension for running projects of the final call. This means the annual budget is €300 million. Based on the average funding rate of 40%[12] the annual public spending is €120 million.

Applying the EUREKA impact figures, we multiply the total public spending of €1200 million by 37 jobs, which results in 44,400 jobs.

Furthermore, we can assume that the average wage of these jobs is at least €30 k and that the average tax rate for these wages is at least 20%. These assumptions are quite modest: in the ITEA application documents we used a cost per PY of €150 k, which we assume to correspond to an annual wage of €75 k.

The annual tax revenue generated by personal income tax is now at least 44,400 x €30 k x 20% = €266 million (company income tax excepted)

Conclusion: annual public spending of €120 million generates annual public tax revenue of €266 million

[12] *Source: ITEA 2 Office*

Example of Barco for Belgium

- From the previous example on Barco we know that the Belgian government has spent, during 2.5 years, €0.4 million per year on the Digital Cinema project.
- Of the 3725 Barco employees we assume approximately 320 employees (direct and indirect) to work in Belgium in the area of Digital Cinema.
- We can assume that the average wage for these employees is at least €35 k, which corresponds to the overall average wage in Belgium. We can also assume a taxation rate of at least 38 %. This results in an annual income for the Belgian government of at least 320 * €35 k * 38 % = €4.26 million per year.
- Even more contribution was generated through income taxation, with Digital Cinema being part of the most profitable division of Barco.

Example of KE-Works for the Netherlands

- From the previous example on KE-Works we know that the Dutch government has spent ~€50 k per year on the 3D-Testbench project.
- KE-Works has 7 employees in 2013.
- We can assume that the average wage for these employees is at least €35 k, which corresponds to the overall average wage in the Netherlands assume a taxation rate of at least 30%. This results in annual income for the Dutch government of at least 7 x €35 k x 30% = €73 k per year

Example of the ParMa project for all participating countries

- From the previous example on the ParMa project we know that public authorities in the participating countries have spent €1.8 million per year on the ParMa project
- Up to 2013, the ParMa project has generated additional economic benefits of €30 million among the industrial ParMa partners.
- Based on these additional economic benefits of €30 million and an assumed VAT level of 20%, the participating countries now have a VAT income of 30 * 20% = €6 million.

4.2.4. WHAT DO WE NEED TO MAKE THIS HAPPEN? - GROWING TOWARDS THE ITEA 3 AMBITIONS

As mentioned earlier, total ITEA 3 funding of €1.2 billion will generate 44,400 jobs. This figure corresponds nicely to the announcement of AENEAS and CATRENE in their position paper on *Innovation for the Future of Europe: Nanoelectronics Beyond 2020* (November 2012) to create 250,000 jobs based on total public funding of €7 billion [NANO].

In the section on ROI considerations we calculated that out of annual public investment of €120 million, we generate annual tax revenue of €266 million. However, the ambitious plans for ITEA 3 are based on the assumption of doubling the investment by industry and Public Authorities compared to ITEA 2. This is fully in line with the statement at the end of Chapter 3 where a significant increase of investment in Digital Technology is recommended.

The target domain of ITEA 3 offers plenty of opportunities for high-quality proposals. ITEA 3 is addressing all verticals and all categories of Digital Technology that are relevant for leaders in economy and society:

- Industrialised non-differentiating services
- Customised services
- Smart products
- Smart services
- Innovative engineering
- Smart infrastructure
- Security of systems and services

In the ITEA quality management system (QMS), we defined the Call Funded Industrial (CFI) budget as one of ITEA's key performance indicators (KPI). The CFI budget is the total cost of all industrial partners in all projects in an ITEA Call. At present the average CFI budget of an ITEA Call is €160 million, the total budget of a Call including non-industrial partners is €190 million. This corresponds to a public funding of €76 million per Call or €608 million for ITEA 3 in total. In order to achieve the ambition of €1.2 billion total public funding for ITEA 3, the average CFI budget in ITEA 3 should be at €320 million, double the current size.

Based on the importance of software innovation and open innovation in general, we see plenty of opportunities to increase the value of this KPI in the coming years. This increase will be managed on the basis of focused initiatives towards "Seizing the high ground". The QMS processes of customer satisfaction and continuous adaptation are the right instruments to do this in a managed way.

4.3 COMMON CONCLUSION

In Chapter 3 we gave macro-economic arguments for the doubling of the investments in software innovation, including strong statements from Roland Berger and from the Digital Agenda for Europe.

In Chapter 4 we made this more specific and concrete for ARTEMIS and ITEA.

- For ARTEMIS the R&D investments in Digital Technology by the vertical industries justify at least a doubling of the industry and PA investment in Embedded and Cyber Physical Systems R&D&I.
- The ARTEMIS industry priorities target not only reinforcing the strength of the EU industries but also targeting the recovery of EU industry positions.
- For ITEA the high-level ambition of seizing the high ground is a strong argument for doubling the investment in software innovation.
- Finally, an economic impact analysis on job creation and ROI through tax revenue fully justifies the doubling of industry and PA investment in ITEA. The playground of business in systems and services based on software innovation provides a plenitude of promising investment opportunities.

With the arguments presented in this updated Vision 2030, ARTEMIS Industry Association and ITEA collectively request a doubling of the investment in software innovation to keep Europe on par with the rest of the world in sustaining the benefits of Digital Technology for the European economy and society.

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