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ADVANCED ICT UNDER THE 7TH EU R&D FRAMEWORK PROGRAMME: OPPORTUNITIES FOR THE AEC/FM INDUSTRY

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SUMMARY: *The 7th EU framework programme for research (FP7) aims to provide new impetus to Europe's growth and competitiveness, in realising that knowledge is Europe's greatest resource. The programme places greater emphasis than in the past on research that is relevant to the needs of European industry, to help it compete internationally, and develop its role as a world leader in certain sectors. For the first time the framework programme provides support for the best in European investigator-driven research, with the creation of a European Research Council. The FP7 budget is 50% higher compared with its predecessor. The paper focuses on advances in information and communication technologies (ICT) under FP7 and on how the architecture, engineering and construction (AEC) industry and facility management (FM) can benefit through a systematic involvement. The technologies under development, ranging from wireless sensor networks, cooperative smart objects, plug-and-play control architectures, technologies supporting the "Internet of Things", to ICT services supporting energy efficiency can benefit not only this sector, but the economy as a whole.*

Significant near-market research will be carried out in the two ICT Joint Technology Initiatives (JTI) which are launched in 2008. They address nanoelectronics and embedded computing systems applications. In international cooperation, the Intelligent Manufacturing Systems (IMS) initiative is focusing its strategy on building Manufacturing Technology Platforms in areas such as standardisation, education, sustainable manufacturing, energy efficiency and key technologies. All these activities aim to link R&D efforts of research groups across sectors, countries and regions.

KEYWORDS: *Research, ICT, FP7*

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1. INTRODUCTION

The 7th research framework programme, from 2007-2013, was designed to respond to the competitiveness and employment needs of the EU. Its budget is higher by 60 % compared to FP6, rising to EUR 54 billion (FP7, 2006). FP7 activities consist of four specific programmes (fig. 1). The new 'Ideas' programme aims to foster scientific excellence. An independent European Research Council has been created to support "frontier research" carried out by research teams competing at European level either individually or through partnerships, in all scientific and technological fields, including the social and economic sciences and the humanities. The 'People' programme supports scientific careers of researchers through training and mobility activities. The objective of the 'Capacities' programme is to develop the best possible research capacities for the European science community.

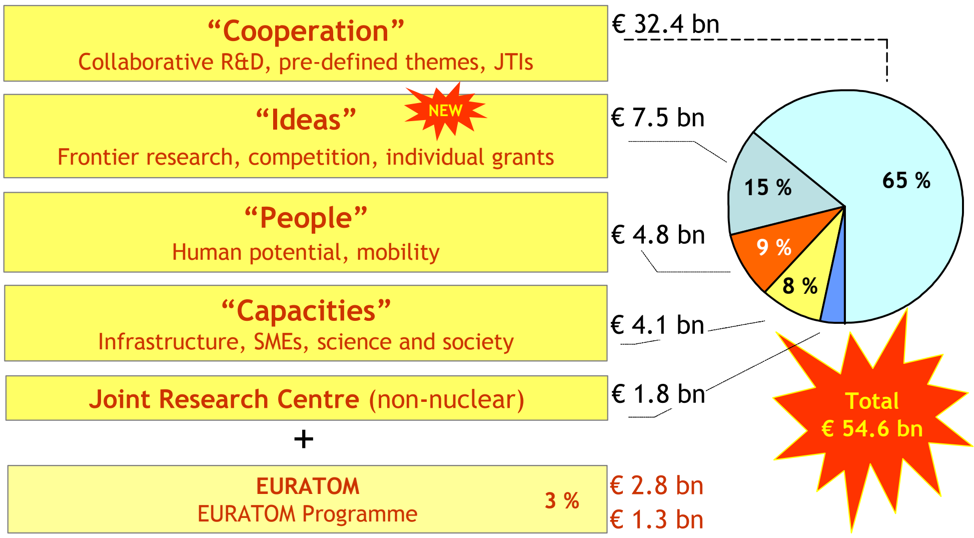

FIG. 1: Elements of the 7th EU Framework Programme for Research (FP7, 2006)

Activities of this programme aim to enhance research and innovation capacity in Europe, e.g. via research infrastructures and the building up of regional research clusters ('regions of knowledge'), by engaging in research for and by SMEs, through 'science in society' activities and international cooperation. The 'Cooperation' programme is the largest specific programme with a budget of EUR 32.3 billion. It promotes Europe's technology leadership in specific areas mainly through collaborative industry-academia partnerships. The programme is subdivided into ten themes (fig. 2) which are operating autonomously, allowing for joint, cross-thematic approaches on research subjects of common interest.

	2007-2013 Budget [mn €]
Health	6,100
Food, Agriculture & Biotechnology	1,935
Information & Communication Technologies	9,050
Nanosciences, Nanotechnologies, Materials & New Production Technologies	3,475
Energy	2,350
Environment (including Climate Change)	1,890
Transport (including Aeronautics)	4,160
Socio-Economic Sciences & the Humanities	623
Space	1,430
Security	1,400
	32,413

… including

- *Joint Technology Initiatives*
- *ERA-Nets*
- *International Co-operation*

FIG. 2: The 10 Themes of the Specific Programme "Cooperation" (FP7, 2006)

2. EUROPEAN INDUSTRY-ACADEMIA COLLABORATIONS FOSTERED BY SUCCESSIVE FRAMEWORK PROGRAMMES

Collaboration is key in the knowledge age. Europe, after centuries of war, has become a peaceful and prosperous area, also due to a spirit of collaboration that has successfully been built up in the past fifty years and the successful implementation of research cooperations.

2.1 'Cooperation culture' – A European asset

For centuries, Europe had been the scene of frequent and bloody wars. In the period 1870 to 1945, France and Germany fought each other three times, with a terrible loss of life. European leaders gradually became convinced that the only way to secure lasting peace between their countries was to unite them economically and politically. So, in 1950, in a speech inspired by Jean Monnet, the French Foreign Minister Robert Schuman proposed to integrate the coal and steel industries of Western Europe. As a result, in 1951, the European Coal and Steel Community (ECSC) was set up, with six members: Belgium, West Germany, Luxembourg, France, Italy and The Netherlands. The power to take decisions about the coal and steel industry in these countries was placed in the hands of an independent, supranational body called the "High Authority". Jean Monnet was its first President. The ECSC was such a success that, within a few years, these same six countries decided to go further and integrate other sectors of their economies. In 1957 they signed the Treaties of Rome, creating the European Atomic Energy Community (EURATOM) and the European Economic Community (EEC). The member states set about removing trade barriers between them and forming a "common market". In 1967 the institutions of these three European communities were merged. From this point on, there was a single Commission and a single Council of Ministers as well as the European Parliament. Originally, the members of the European Parliament were chosen by the national parliaments, but in 1979 the first direct elections were held, allowing the citizens of the member states to vote for a candidate of their choice. Since then, direct elections have been held every five years. The Treaty of Maastricht (1992) introduced new forms of co-operation between the member state governments - for example on defence, and in the area of "justice and home affairs". By adding this inter-governmental co-operation to the existing "Community" system, the Maastricht Treaty created the European Union (EU). Economic and political integration between the member states of the European Union means that these countries have to take joint decisions on many matters. So they have developed common policies in a very wide range of fields - from agriculture to culture, from consumer affairs to competition, from environment and energy to transport, trade and research. In the early days the focus was on a common commercial policy for coal and steel and a common agricultural policy. Other policies were added as time went by, and as the need arose. Some key policy aims have changed in the light of changing circumstances. For example, the aim of the agricultural policy is no longer to produce as much food as cheaply as possible but to support farming methods that produce healthy, high-quality food and protect the environment. The need for environmental protection is now taken into account across the whole range of EU policies.

It took some time for the member states to remove all barriers to trade between them and to turn their "common market" into a genuine single market in which goods, services, people and capital could move around freely. The Single Market was formally completed at the end of 1992, although there is still work to be done in some areas - for example, to create a genuine single market in financial services. During the 1990s it became increasingly easy for people to move around in Europe, as passport and customs checks were abolished at most of the EU's internal borders. One consequence is greater mobility for EU citizens. Since 1987, for example, more than a million young Europeans have taken study courses abroad, with support from the EU.The EU has grown in size with successive waves of enlargement. Denmark, Ireland and the United Kingdom joined the six founding members in 1973, followed by Greece in 1981, Spain and Portugal in 1986 and Austria, Finland and Sweden in 1995. The European Union welcomed ten new countries in 2004: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia. Bulgaria and Romania followed in 2007; Croatia and Turkey have begun membership negotiations. To ensure that the enlarged EU can continue functioning efficiently, it needs a more streamlined system for taking decisions. That is why the agreement reached in Lisbon in October 2007 lays down new rules governing the size of the EU institutions and the way they work (Filos, 2008).

2.2 More than 20 years of European collaborative research

In many cases it can be more advantageous to collaborate than to “go it alone”. Some research activities are of such a scale that no single country can provide the necessary resources and expertise. In these cases, collaborative R&D projects under the European framework programme for research can allow research to achieve the required “critical mass”, while lowering commercial risk and producing a leverage effect on private investment (FP7, 2005). These projects establish international consortia that bring together resources and expertise from many EU member states and research actors. An average EU shared-cost project has a budget of EUR 4.5 million and involves on average 14 participants from 6 countries, bringing together universities, public research centres, SMEs and large enterprises. European-scale actions also play an important role in transferring skills and knowledge across frontiers. This helps to foster R&D excellence by enhancing the capability, quality and Europe-wide competition, as well as by improving human capacity in science and technology through training, mobility and career development. The increasing number of participants and rates of oversubscription provide convincing evidence that participation appeals to Europe’s research community. One significant explanation for this interest is the fact that participation in collaborative research offers access to a wider network of knowledge. It enables participants to increase their know-how by being exposed to different methods, and to develop new or improved tools. Being part of an international consortium of highly qualified researchers offers spill-over effects that are more important than the monetary investment. The experience of six European framework programmes shows that while all participating countries enjoy knowledge multiplier effects, the size of these effects is roughly inversely related to the country’s total number of participations in the programme. Another feature of collaborative research is that public R&D funding carried out by enterprises leads to what is called a “crowding-in” effect on investment. In other words, it stimulates firms to invest more of their own money in R&D than they would otherwise have done. A recent study estimated that an increase of EUR 1 in public R&D investment induced EUR 0.93 of additional private sector investment. In the case of the framework programme, there is evidence that many projects would not have been carried out at all without EU funding. The consistent picture is that in approximately 60-70% of the cases the programme enables research activities to take place that would otherwise not have occurred. EU support for R&D encourages a particular type of research project, in which private companies can collaborate with foreign partners at a scale not possible at national level, in projects tested for excellence, and gain valuable access to complementary skills and knowledge. It is therefore reasonable to conclude that the attractiveness of EU schemes induces firms to invest more of their own funds than they would under national funding programmes.

Large-scale European projects enable participants to access a much wider pool of firms in a certain industry domain than would be possible at purely national level. This mechanism offers clear advantages to enterprises compared with national level schemes. It broadens the scope of research, and allows for a division of work according to each participant’s field of specialisation. It also considerably reduces the commercial risk, because involving key industry players helps ensure that research results and solutions are applicable across Europe and beyond, and enables the development of EU- and world-wide standards and interoperable solutions, and thus offers the potential for exploitation in a market of nearly 500 million people. Many projects lead to patents, pointing to an intention to exploit research results commercially. While the propensity to patent seems to be the same for the different types of research actors, industrial participants are more likely to be involved in projects with an applied research focus than pure basic research projects. In addition to the new knowledge described in a patent, participation in European collaborative research enhances the development and use of new tools and techniques; the design and testing of models and simulations; the production of prototypes, demonstrators, and pilots; and other forms of technological development. Firms that participate in this type of research, irrespective of their size, tend to be more innovative than those that do not participate. Participating enterprises are also more likely to apply for patents than non-participants. In Germany, for example, firms funded under the framework programme make three times as many patent applications as non-participating firms. Participating enterprises are also more likely to engage in innovation cooperation with other partners in the innovation system, such as other firms and universities. Although no causal links can be ‘proven’ by these results, they nevertheless provide a strong indication that public funding for research strengthens innovation performance (SEC, 2004). A wide range of ex-post evaluation studies (FP7, 2005) show that as a result of framework programme participation firms are able to realise increased turnover and profitability, enhanced productivity, improved market shares, access to new markets, reorientation of a company's commercial strategy, enhanced competitiveness, enhanced reputation and image, and reduced commercial risks. Results of econometric modelling indicate that the framework programme generates strong benefits for private industry in the EU. A recent study in the UK, commissioned by the Office for Science and Technology, used an econometric model developed at the OECD to predict framework programmer effects on total factor productivity. It was found that the framework programme "generates an estimated annual contribution to UK industrial output of over GBP 3 billion, a manifold return on UK framework (programme) activity in economic terms" (OST, 2004).

3. ICT AND AEC/FM

Today we are witnessing the next phase of a technological revolution that started more than fifty years ago with the miniaturisation of electronic components, leading to the widespread use of computers and then their linking up to form the Internet. The overall size of the world market in electronics was around EUR 1,050 billion in 2004 (IFS, 2005), not counting the microelectronics chips themselves, which were worth another EUR 210 billion. But even more striking is the growing share accounted for by electronics in the value of the final product: for example, 20% of the value of each car today is due to embedded electronics and this is expected to increase to 36% by 2009. Likewise, 22% of the value of industrial automation systems, 41% of consumer electronics and 33% of medical equipment will be due to embedded electronics and software.

Several areas, as described below, supply the basic components of the ICT sector and are considered a strategic part of Europe's industrial competence. Microelectronics currently represents 1% of global gross domestic product. While Intel leads the worldwide chip market, the three major European manufacturers, ST Microelectronics, Infineon Technologies and NXP (formerly Philips Semiconductors), have figured among the global top ten for the past ten years. On the chip manufacturing equipment side, ASM Lithography has become a true European success story by gaining world leadership in lithography – the technology used in chip fabrication (ENIAC, 2004).

Organic (or "printed") electronics offers new opportunities for integrating electronic, optical and sensing functions in a cost-effective way through conventional printing. First products such as electronic paper and intelligent displays printed directly onto product packages are expected to reach the market in the next two years. Organic light-emitting diodes (OLED), also based on this technology, are already in use in mobile phones. Printed electronics could revolutionise many industries as they do not require billion-Euro production facilities and so electronics manufacturing can be moved to where the customers are, thus creating new opportunities for local employment. Large-area lighting and signage applications, of utmost importance to AEC, become feasible and affordable through OLED technology. The market is forecast to have an annual growth rate of 40% over the next five years. By 2025, the business is expected to account for EUR 200 billion, almost the size of today's microelectronics industry.

Integrated micro/nanosystems draw together a broad variety of technological disciplines (electronics, mechanics, fluidics, magnetism, optics, biotechnology). It involves multiple materials and manufacturing processes. Europe leads the field in systems integration technologies in terms of knowledge generation and the challenge now is to convert this into industrial leadership. New business opportunities are emerging, both for technology suppliers and system developers. For example, in the specific area of micro-electromechanical systems (MEMS), the market is expected to double within five years, from EUR 12 billion in 2004 to EUR 25 billion in 2009 (NEXUS, 2006). The market for electronic equipment is characterised by a constant need to bring to the users innovative products and services with increasing functional capabilities at an ever diminishing price. Embedded computing systems are of strategic importance because they underpin the competitiveness of key areas of European industry, including automotive technology, avionics, consumer electronics, telecommunications, and manufacturing automation. Intelligent functions embedded in components and systems will also be a key factor in revolutionising facility management and industrial production processes, adding intelligence to process control and to the shop floor, helping improve logistics and distribution – and so increasing productivity. The capability to deliver systems with new functional capabilities or improved quality within a competitive timeframe has ensured substantial market shares for Europe's economy in various domains. The share of embedded electronics in the value of the final product is expected to reach significant levels in the next five years: in industrial automation (22%), telecommunications (37%), consumer electronics and intelligent home equipment (41%) and applications related to health/medical equipment (33%) (MMC, 2006). The value added to the final product by embedded software is much higher than the cost of the embedded device itself.

To stay competitive Europe must increase and bundle its R&D efforts to stimulate synergies in advanced technological areas by favouring knowledge transfer from academia to industry and across industrial sectors and by encouraging the formation of new industrial clusters. It can only succeed if it acts jointly and in a coherent way.

3.1. Electronics – Key to the future of AEC

The last twelve years have shown that Europe can achieve a lot. Consecutive European R&D framework programmes and Eureka initiatives (Eureka, 2008) have supported major research efforts and managed to bring Europe's electronics research and manufacturing, and the related materials science and equipment research, on equal level with competitors worldwide. But the efforts need to continue and even to increase if Europe wants to keep up. Consensus has grown amongst European policy makers on the added value of 'clustering' competent players around technology objectives. Some countries and regions are making significant investment in electronics by building up and sustaining research and innovation eco-zones, termed 'competitiveness poles'. These networks could lead to additional synergies if they are linked up at European level (FIG. 3).

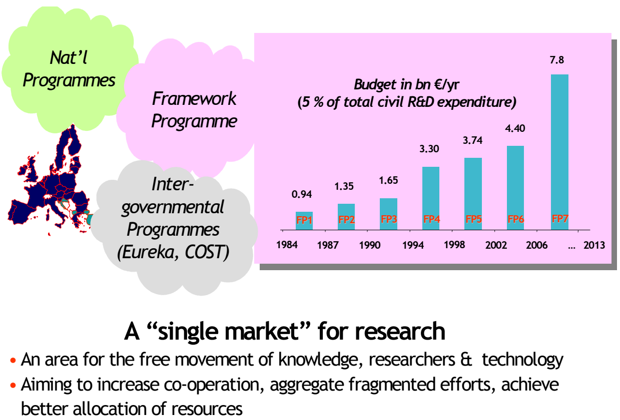

FIG. 3: The European R&D Landscape (Filos, 2008)

Three European technology platforms relating to electronics have been set up by industry: ENIAC (ENIAC, 2008) on nanoelectronics, EPoSS on smart systems integration (EPOSS, 2008), and ARTEMIS on embedded systems (ARTEMIS, 2008). These platforms have so far been successful in bringing together key industrial and academic research players and in reaching consensus on a long-term vision and agenda for research, delivered in the form of a strategic research agenda. Recognising this need, the European Commission began promoting the concept of European technology platforms in 2003. European technology platforms (fig. 4) involve stakeholders, led by industry, getting together to define a strategic research agenda on a number of important issues with high societal relevance where achieving growth, competitiveness and sustainability objectives is dependent on major research and technological advances in the medium to long term (ETP, 2005).

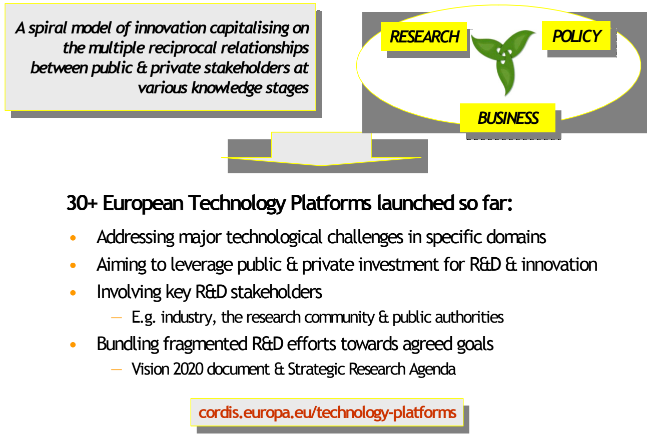

FIG. 4: European Technology Platforms (Filos, 2008)

Implementing strategic research agendas of European technology platforms (fig. 5) requires an effective combination of funding sources, including public funding at member state level and private investment in addition to European support, e.g. through the framework programmes. With regard to the European funding element, use of the regular instruments of collaborative research is likely to be the most effective way of providing Community support for the implementation of the EU-relevant parts of the majority of strategic research agendas developed by the European technology platforms. There are a limited number of technology platforms in areas that offer the opportunity for significant technological advances which have achieved such a scale and scope that implementation of important elements of their strategic research agendas requires the setting up of long-term public-private partnerships. In these cases, support through the regular instruments of collaborative research is not sufficient. For such cases the European Commission has proposed the launching of Joint Technology Initiatives (COM, 2004, 2005; SEC 2005).

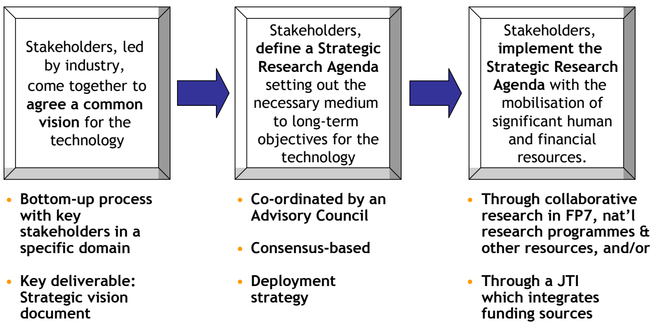

FIG. 5: Implementing the Strategic Research Agendae of European Technology Platforms

The key advantage of these activities is that they help focus efforts and align activities by bringing all the relevant private and public players in Europe together. The platforms thus aim to catalyse a critical mass of competences and resources (from industry and the public sector) to undertake research following a jointly agreed strategic research agenda and to agree on other relevant issues of importance to business success, especially standards (e.g. common platforms and architectures, environment – health – security issues, SME involvement) and also skills profiles.

The European Nanoelectronics Initiative Advisory Council – ENIAC

A far-sighted strategy for the European nanoelectronics industry, aimed at securing global leadership, creating competitive products, sustaining high levels of innovation and maintaining world class skills within the European Union is outlined in 'Vision 2020 – nanoelectronics at the Centre of Change' (ENIAC, 2004). In addition to identifying the technological, economic and social advantages of strengthening nanoelectronics R&D in Europe, the 'Vision 2020' document highlights the importance of creating effective partnerships in order to achieve this goal. Its rationale is that Europe must not only have access to leading-edge technologies for nanoelectronics. It must also have an efficient means of knowledge transfer between R&D and manufacturing centres in order to turn this technology into leading-edge value-added products and services. Such partnerships will need to include all stakeholders in the value chain, from service providers at one end to research scientists at the other, so that research in nanoelectronics can remain strongly innovative, and, at the same time, result in technological and economic progress.

To create an environment in which these partnerships can flourish, 'Vision 2020' proposes the development of a strategic research agenda for nanoelectronics that will enable industry, research organisations, universities, financial organisations, regional and EU member state authorities and the European Commission to interact and thus provide the resources required, within a visionary programme that fosters collaboration and makes best use of European talent and infrastructures. ENIAC has been set up to define this technology platform and develop strategic research agenda. The latter describes a comprehensive suite of hardware and silicon-centric technologies that firmly underpin the semiconductor sector.

While the nanoelectronics technology platform covers the physical integration of electronic systems-on-chip or systems-in-package, the technology platform on embedded systems covers the software- and architecture-centric group of technologies in ICT. The technology platform on smart systems integration covers the technology for the physical integration of subsystems and systems for different applications. Together, these three platforms bear the potential to become key enablers for providing the underlying technologies for virtually all other major European technology platforms. Taking into account the short-, medium- and long-term challenges faced by Europe, the ENIAC strategic research agenda identifies and quantifies the performance parameters needed to measure the progress of nanoelectronics research, development and industrialisation. By setting these out as a series of application-driven technology roadmaps it provides guidance in the coordination of local, national and EU wide resources in the form of research, development, manufacturing, and educational governance, infrastructures and programmes. By matching technology push from the scientific community with the innovation of SMEs and the market pull of large industrial partners and end-users, the strategic research agenda aims to ensure that research coordinated under it will be relevant to industry, the economy and society as a whole.

The European Platform on Smart Systems Integration - EPoSS

Strong market competition calls for rapid product change, higher quality, lower cost and shorter time-to-markets. 'Smaller' and 'smarter' will be key requirements for systems in the future, therefore trans-disciplinarity is a challenge. The miniaturisation of technologies down to the nano-scale, together with the application of the molecular-level behaviour of matter may open new opportunities for achieving groundbreaking solutions in many booming fields such as bioengineering, energy monitoring, and healthcare. In particular the ability to miniaturise and to integrate functions such as sensing, information processing and actuating into smart systems may prove crucial to many industrial applications. Perceptive and cognitive smart systems – will thus increasingly be offered in miniature and implantable devices with features such as high reliability and energy-autonomy.

The EPoSS strategic research agenda (EPOSS, 2007) has been produced by expert working groups. It lays down a shared view of medium-to-long-term research needs of industry in sectors such as automotive, aerospace, medical, telecommunications and logistics. It reflects the trend towards miniaturised multifunctional, connected and interactive solutions. Multidisciplinary approaches featuring simple devices for complex solutions and making use of shared and, increasingly, self-organising resources are among the most ambitious challenges. EPoSS therefore proposes a multilevel approach that incorporates various technologies, functions and methodologies to support the development of visionary new products. Rather than solving problems in a piece-meal approach, e.g. at the component level, it advocates a systems approach that offers comprehensive solutions. EPoSS is therefore neither dedicated to a specific research discipline, nor does it aim to restrict its activities to a certain scale or size of devices. Its goal is smart systems that are able to take over complex human perceptive and cognitive functions; devices that can act unnoticeably in the background and that intervene only when the human capability to act or to react is reduced or ceases to exist. Examples for such systems are, object recognition devices for automated production systems; devices that can monitor the physical and mental condition of a vehicle's driver; integrated polymer-based RFIDs for logistics applications etc. The target application domains of smart systems R&D - in a horizon of ten to fifteen years – are outlined in this document: (a) automotive; (b) aeronautics; (c) information technology and telecommunications; (d) medical applications; (e) logistics/RFID; (f) other cross-cutting applications.

Advanced Research & Technology for Embedded Intelligence and Systems – ARTEMIS

Embedded technologies are becoming dominant in many industrial sectors, such as communications, aerospace, defence, building and construction, manufacturing and process control, medical equipment, automotive, and consumer electronics. This trend is likely to continue, given the ever-increasing possibilities for new applications offered by advanced communications, embedded computing devices, and reliable storage technologies. Industries using and developing embedded systems differ significantly in business and technical requirements and constraints. Development cycles of complex industrial equipment, such as airplanes, industrial machines and medical imaging equipment, but also cars, are much longer than the development cycles of other high-volume, cost-dominated devices for private customers, such as DVD players, mobile phones, ADSL modems and home gateways. Safety requirements are different for an airplane, for a car and for a mobile phone. Security, privacy and data integrity pose specific requirements in various environments. Hence, industry is increasingly requested to integrate conflicting requirements.

In construction, there are not only the traditional safety requirements, but also the requirements of facility management and equipment, with an ever increasing integration of sensing, actuating and communications capabilities into the total system of a building. However, little cross-fertilization and re-use of technologies and methodologies is happening across industrial domains, since the segmentation of markets with their specific requirements leads to a fragmentation of supply chains and R&D efforts. One of the main ambitions of the ARTEMIS technology platform is to overcome this fragmentation by cutting barriers between application sectors leading to a diversification of industry, and by enabling a cross-sectorial sharing of tools and technology.
Embedded systems do not operate in isolation, but rather in combination with other systems with the aim to realise an overarching function. Examples are: digital television integrated into the 'digital' home; medical diagnostic devices embedded in hospital environments; infrastructure such as bridges, tunnels, roads that exchange information with cars to avoid accidents. These systems are often characterised by a large-scale networked integration of heterogeneous intelligent components. Sensor networks, and even aggregations of ‘smart dust’, may pose, in addition to these, requirements such as operation at low power, energy harvesting, miniaturisation, data fusion, reliability and quality-of-service.

In addition to these requirements, there is also a need to undertake new and unexplored approaches to safeguard the safety, security, reliability and robustness of the embedded systems in the future. The use and integration of off-the-shelf components certainly poses an additional challenge, as these components usually are not designed from the perspective of the decomposition of the system at hand. A transition from design by decomposition to design by composition raises some of the most challenging research and development questions in the embedded systems domain today. These changes, as well as the ambition for cross-sectorial commonality, inspire much of the specific research proposed in the ARTEMIS strategic research agenda (ARTEMIS, 2006). It outlines the objectives and the research topics that need to be addressed in the domain of embedded systems. This current strategic research agenda consists of three documents addressing issues such as (a) Reference Designs and Architectures; (b) Seamless Connectivity & Middleware; and (c) System Design Methods & Tools.

The Reference Designs and Architectures part of the strategic research agenda establishes common requirements and constraints that should be taken into account for future embedded systems when establishing generic reference designs and architectures for embedded systems that can be tailored optimally to their specific application context. The Seamless Connectivity & Middleware part addresses the needs for communication at the physical level (networks); at the logical level (data); and at the semantic level (information and knowledge). Middleware must enable the safe, secure and reliable organisation - even self-organisation - of embedded systems under a wide range of constraints.

The Systems Design Methods & Tools part of the research agenda sets out the priorities for research as to how these systems will be designed in future to accommodate and optimise the balance to achieve a number of conflicting goals: system adequacy to requirements, customer satisfaction, design productivity, absolute cost, and time-to-market. Each part of this research agenda has been produced by a group of experts that devised their own method of working. While the three expert groups liaised to achieve coverage and avoid inconsistencies, each of the three documents has its own structure and style. All three parts are 'living' documents that will be continuously refined and updated as research results arrive over the coming years.

3.2. Towards an "Internet of Things"?

With more than two billion mobile terminals in commercial operation world-wide and about one billion Internet connections, wireless, mobile and Internet technologies have enabled a first wave of pervasive communication systems and applications of significant impact.

Whilst this networking trend has acquired an irreversible dimension, there is undoubtedly a new networked technology dimension emerging with the deployment of trillions of RFID tags. Today's simple tags are evolving towards smarter networked objects with better storage, processing and sensing capabilities. This is leading to new and widespread applications in many sectors. The vision of the “Internet of Things", promoted by the International Telecommunications Union (ITU), foresees billions of objects "reporting" their location, identity, and history over wireless connections in application such as building environments and logistics (ITU, 2005). Flexibility is expected to become a key driver, enabling networks to reconfigure more easily and to dynamically adapt to variable loads and use conditions implied by an ever growing number of components and applications. New classes of networking technologies are emerging, such as self organised networks with dynamically varying node topologies, dynamic routing and service advertisement capability. Under such dynamic operational constraints, network management tools require increased adaptability and self-organisation/-configuration capability of network and service resources.

The resulting network and service architectures will need to support fully converged environments, such as extended home networks, with myriads of intelligent devices in homes, offices, or on the move providing an extensive set of applications and multimedia contents, tailored to the device, the network, and the application requirements. Networked objects equipped with sensing and processing capability will become capable of autonomous decision-making and will collaborate to better serve user preferences and management requirements such as energy efficiency. Future intelligent buildings may engage in collaborating across domains to dynamically control energy consumption on the basis of use patterns and knowledge about deviations from standard use patterns, for example, when the heating in the home is to be turned on only when the user is in physical proximity and is not stuck in traffic.

4. CONCLUSIONS

This paper aimed to draw a picture of the changing R&D landscape in Europe. European research policy, aiming to build strong industry-academia R&D partnerships and to increase levels of R&D investment, is a proof for Europe's determination to achieve leadership in ever-competitive world markets. The 7th framework programme for research supports this goal with its objective to strengthen research excellence and to forge strong collaborative research partnerships across Europe and with international partners (IMS, 2008).

The paper aimed to provide in particular a non-exhaustive overview of the new programme's advanced ICT objectives and how these may impact the AEC/FM sector and industry as a whole. What will be essential for the success of industry-academia cross-fertilisation is the cross-sectorial interlinking and cooperation between technology-oriented platforms, such as those discussed above, with more sectorial platforms, such as the European Construction Technology Platform (ECTP, 2008). This requires trans-disciplinary thinking and certainly an open-handed approach.

5. ACKNOWLEDGEMENTS

The views expressed in this paper are those of the author and do not necessarily reflect the official view of the European Commission on the subject.

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