DECISION OF THE PUBLIC AUTHORITIES BOARD OF THE ENIAC JOINT UNDERTAKING APPROVING THE ANNUAL WORK PROGRAMME OF THE JOINT UNDERTAKING FOR YEAR 2013

THE PUBLIC AUTHORITIES BOARD OF THE ENIAC JOINT UNDERTAKING,

HAVING REGARD TO THE Statutes annexed to Council Regulation (EC) No 72/2008 of 20 December 2007 setting up the ENIAC Joint Undertaking[1], and in particular Article 8.2(b), 9.2.(b) and 19.2 thereof,

WHEREAS:

(1) The Public Authorities Board should approve the Annual Work Programme of the Joint Undertaking upon proposal from the Industry and Research Committee,

HAS ADOPTED THIS DECISION:

Article 1

The Annual Work Programme of the ENIAC Joint Undertaking for 2013, including the scope and budget of Call for Proposals, as annexed to this Decision, is hereby approved.

Article 2

The Executive Director of the Joint Undertaking is invited to take all appropriate measures to comply with article 19.5 of the Statutes and make a publishable version of the Annual Work Programme of the Joint Undertaking available, included on the Joint Undertaking's website.

Article 3

This Decision shall enter into force on the date of its adoption.

Done at Brussels, on 30 November 2012

For the Public Authorities Board,

Ben Ruck
Chairperson of the Public Authorities Board

[1] OJ L 30, 4.2.2008, p. 21, corrected by OJ L 219. 14.08.2008, p.72

Annual Work Programme 2013

Elaborated by the Industry and Research Committee

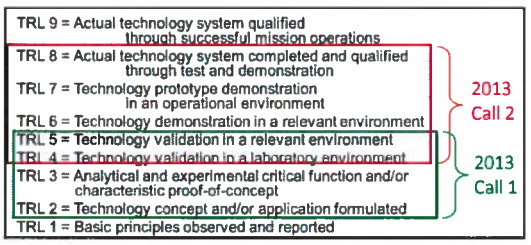
1. Introduction

Nanoelectronics create the essential hardware enabler for innovative electronic products and services in key growth markets for the European industry. The Multi-Annual Strategic Plan (MASP) defines the strategy that the JU will follow to ensure that the Research Agenda (RA) can be executed under the most favourable conditions.

The MASP identifies focussed and strategically decisive application driven key areas of research, development and innovation in nanoelectronics that have the potential to strengthen the European industry. To this effect, the MASP identifies the most important challenges to address from the economic, societal and political viewpoints and selects the most promising ones in terms of market success and lasting impact. The selected topics ensure a broad participation of the Member States. The identified activities encompass the complete project life cycle from technology concept formulation to complete system qualification. They also encompass the complete value chain, from technology development to applications that would yield commercially successful products. In line with the objectives of a Joint Technology Initiative, offering the potential for larger Europe-wide initiatives, with more flexibility, increased efficiency, no restriction in duration or size, it is expected that large, integrated projects are launched having a significant industrial impact.

The MASP 2010, which underpins the AWP 2013, has been adopted by the ENIAC JU Governing Board; it has been written together with CATRENE and contains a Vision, Mission and Strategy for nanoelectronics in Europe, with emphasis on the Research, Development and Innovation aspects. It provides furthermore information about the roles of the various actors and the funding tools. It analyses the current status of the industry and backs this up with relevant data. It concludes about desired innovations, which are important from commercial, societal and/or technological perspective. It is a comprehensive document, which will be referred to in this work plan on several locations[1]. The MASP has a scope of several years. This 2013 Annual Work Plan (AWP) will be the last one during the lifetime of the actual ENIAC JU and will have at the same time the largest budget. Therefore it will allow to open calls for all 8 key areas as defined in the MASP and also for all ~3 Grand Challenges as part of each of them.

Large efforts are needed by the R&D&I actors and Public Authorities in the European Nanoelectronics industry in order to reverse the trend of a declining market share. Part of these efforts focus on industrial investments and fall outside the scope of the AWP. However, it has an important impact on the Research, Development and Innovation efforts presented here, because execution and intimate connection of both efforts is condition for success. On Research, Development and Innovation the R&D actors estimate that an effort on R&D&I will be needed of about 100 B€ in the period 2013-2020. When consistency with the accompanying industrial effort is reached, the R&D actors are prepared to step up to these levels of R&D&I. This AWP reflects a first step on this route. Not surprisingly and like in the previous year, focus on higher TRL's is pivotal. But also cooperative European efforts targeting lower TRL's remain of utmost importance. It is proposed to handle lower and higher TRL's in separate calls.

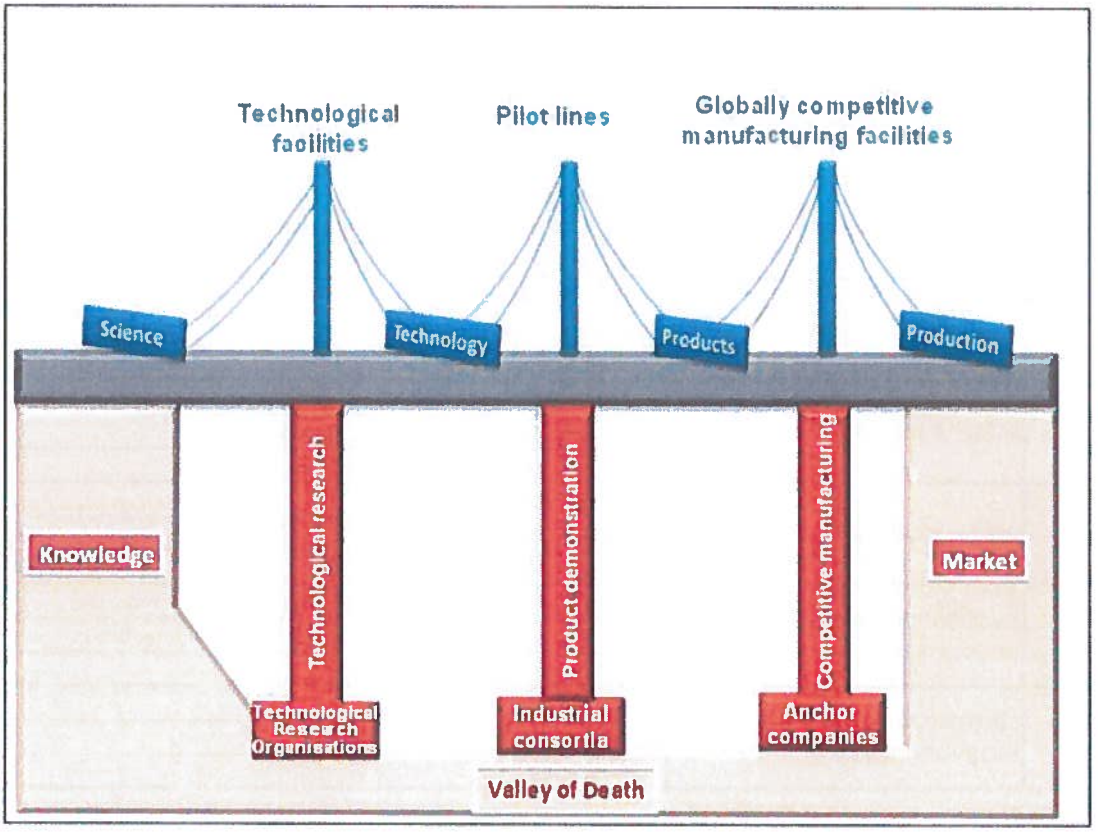


[1] In order to make this AWP a self-contained document, all references to the MASP have been copied in Annex 1.

2. From Technology to Product demonstration via Pilot Lines

On initiative of the European Commission a High-Level Expert Group (HLG) reported[2] on Key Enabling Technologies (KET) and introduced the metaphor of a bridge that crosses a "valley of death" to describe the project life cycle. Technology Readiness Levels (TRL's, see table) were grouped into pillars underpinning this metaphorical bridge. Specifically the second pillar, which deals with pilot projects, was emphasized (TRL 5-8). The High-Level Experts Group recognized the "Micro- and nanoelectronics, including semiconductors" as a Key Enabling Technology[3] and recommended in its final report "that the EU and its policy makers ... urgently engage in a radical rebalancing of resources and objectives in order to retain critical capability and capacity in these domains of vital European importance".

Like in 2012 ENIAC will be the tool of choice to implement this policy.



[2] HIGH-LEVEL EXPERT GROUP ON Key Enabling Technologies, **Final Report**, June 2011, http://ec.europa.eu/enterprise/sectors/ict/files/kets/hlg_report_final_en.pdf

[3] Commission communication "Preparing for our future: Developing a common strategy for key enabling technologies in the EU, Brussels, 30.09.2009" COM(2009) 512

3. Research, Development and Innovation priorities for 2013

The Work Plan

The 2010 MASP, which constitutes of the VMS (Vision Mission Strategy) document augmented with its annexes 2 and 3, sets the scope of the AWP-2013. Goals in 8 domains, corresponding to the 8 chapters of part C of the MASP need to be tackled in order to fulfil the mission of ENIAC. Within these 8 selected domains 25 Grand Challenges have been identified. They have been described, analysed and road-mapped in terms of expected achievements and foreseen innovation in chapters X.3 of part C of the VMS document, where X is the chapter number. They are reproduced in the table below.

Chapter #	Chapter	Grand Challenge
1	AUTOMOTIVE AND TRANSPORT	Intelligent Electric Vehicle
		Safety in traffic
		Co-operative Traffic Management
2	COMMUNICATIONS & DIGITAL LIFESTYLES	Internet Multimedia Services
		Evolution to a Digital Lifestyle
		Self-Organizing Network
		Short range convergence
3	ENERGY EFFICIENCY	Sustainable and Efficient Energy Generation
		Energy Distribution and Management - Smart Grid
		Reduction of Energy Consumption
4	HEALTH AND THE AGEING SOCIETY	Home Healthcare
		Hospital Healthcare
		Heuristic Healthcare
5	SAFETY & SECURITY	Consumer and Citizens Security
		Securing the European Challenging Applications
		Enabling Technologies for Trust, Security and Safety
6	DESIGN TECHNOLOGIES	Managing Complexity
		Managing Diversity
		Design for Reliability and Yield
7	SEMICONDUCTOR PROCESS AND INTEGRATION	Know-how on Advanced and Emerging Semiconductor Processes
		Competitiveness through Semiconductor Process Differentiation
		Opportunities in System in Package
8	EQUIPEMENT, MATERIALS AND MANUFACTURING	Advanced CMOS - 1Xnm & 450mm
		More than Moore
		Manufacturing

Scope:

This AWP calls for projects that address one or more of the above mentioned Grand Challenges as their primary target. The reader is referred to the MASP to get a more detailed description about the Grand Challenges and the goals that should be reached. Where applicable the synergies with other domains (as defined in the MASP, part C, chapter X.6) and relations to results obtained in earlier projects must be identified respectively used.

Project Constituency:

Within each integrated project, a realistic representation should be found for the underlying nanoelectronics R&D ecosystem in Europe, including large corporations, SME's, institutes, and universities. The mechanisms to accommodate smaller partners, SME's, institutes or universities in larger integrated projects shall be kept flexible e.g. by allowing direct participation in the project, special links with one of the direct project partners, or a set of linked smaller projects. SME's are an important consideration when shaping new consortia and proposing projects. Part of the Mission in the MASP is to"....set up and support mechanisms to integrate the strength

and capabilities of small and medium-sized enterprises (SMEs) ……". References to the role that SME's play in ENIAC and CATRENE projects are especially given in chapter 6.4 of part B of the MASP. Past experience, with 13% to 20% person years participation of SME's in MEDEA+/CATRENE and ENIAC projects till now shows the efficiency of these two programs in involving SME's.

Guidance:
Guidance for projects will be published in the 2013 Guide for Applicants.

Relation to running projects:
The table at the end of this chapter indicates the Grand Challenges within the ENIAC JU running and envisaged projects of calls 1-7. New projects, within the same Grand Challenge, should indicate to what extent (if any) they relate to the running projects, how they will use the results of running projects and –if applicable– what mechanisms have been installed to guarantee complementarity. New proposals should ensure that their contribution to a Grand Challenge is not overlapping with running or envisaged projects.

Projects are called that fulfil the before mentioned conditions to scope, constituency, guidance and relation to running projects. In order to differentiate between projects of different natures, two calls[4] are foreseen for 2013. The first call will focus on projects addressing TRL's 2-5; the second call will focus on projects addressing TRL's 4-8.

2013 call 1
The first call will focus on projects dealing with technological research and development activities meaning in TRL terms levels 2 to 5, i.e. formulation of technology concepts, experimental proofs and validation in laboratory conditions. A valorisation and deployment plan must be included in the project proposal. The eligible costs foreseen in this call are ~350 M€

2013 call 2
The second call will focus on activities leading up to Pilot Lines, corresponding to TRL levels 4 to 8. These activities comprise the work necessary to prepare innovation in the market with focus on validation and demonstration in relevant and operational environments to be established within the project. Also system completion and qualification must be part of the project focus. On the other hand, minor parts of the planned projects may need to address also lower TRLs in order to prepare the scientific and engineering ground for the pilot activities. The second call will implement the recommendations of the before mentioned report on Key Enabling Technologies, as far as these fit into the constraints of the ENIAC funding tool. Total eligible costs foreseen for the second call are ~750 M€. This is under the assumption of usual funding levels and of allowance to start on time with large (above state aid threshold) projects.

Each "ENIAC KET Pilot Line Project" within the second ENIAC call of 2013 will be characterised by:

a. Execution by an industrial[5] consortium including at least three non-affiliated partners from three different ENIAC member States of the European Union
b. Use of innovative technology
c. Development of innovative products, meeting social challenges, within the scope as set by the Grand Challenges of the MASP-2010

[4] A third call by the very end of 2013 is not excluded, if following conditions are met: 1) availability of funding and 2) H2020 based funding tools are judged to have too low maturity to launch calls early 2014.

[5] "Industrial" to be interpreted as "part of the Industrial Eco-system" and therefore including Universities, Research Institutes, SME's and large companies.

d. Establishment of a new, realistic R&D environment, a facility ("Pilot Line") capable to manufacture
e. Demonstrators in small volume in order to establish their value and potential
f. A deployment plan to a real life European manufacturing site.

The MASP, being a multi-annual strategic document, covers all contents, which will be focused on in these specific Pilot Line activities. This way these activities will not only contribute to Europe's manufacturing capabilities but also support the solutions to the formulated societal challenges.

"P" indicates a primary project target, "S" a secondary project target.

N°	Chapter	Grand Challenge	CALL 1	CALL 2	CALL 3	CALL 4 (2011-1)	CALL 5 (2011-2)	Call 6* (2012-1)	Call 7* (2012-2)
1	AUTOMOTIVE AND TRANSPORT	Intelligent Electric Vehicle	E3Car (P) SE2A (P)		MotorBrain (P)		IDEAS (P)	E2COGaN (S)	
		Safety in trafic							
		Co-operative Traffic Management							
2	COMMUNICATIONS & DIGITAL LIFESTYLES	Internet Multimedia Services		MERCURE (P) MIRANDELA (P)	ARTEMOS (P) EPAMO (P)				
		Evolution to a Digital Lifestyle							
		Self Organizing Network							
		Short range convergence							
3	ENERGY EFFICIENCY	Sustainable and Efficient Energy Generation							AGATE (S)
		Energy Distribution and Management - Smart Grid	SmartPM (P)	CSSL (P) END (P)	Enlight (P) ERG (P) HEECS (P)	E2SG(P)		E2COGaN (P) ESEE (S)	
		Reduction of Energy Consumption				SILVER (P) DCC+G (P)	MIRTIC (P) BattMan (P)	ESEE (P) OPERA (P)	EPPL (P) PLACES2BE (S)
4	HEALTH AND THE AGING SOCIETY	Home Healthcare		CAJAL4EU (P) CSI (P) MAS (P)				DeNeCor (P)	
		Hospital Healthcare		CAJAL4EU (S)		PANORAMA (P)		DeNeCor (S)	
		Heuristic Healthcare							
5	SAFETY & SECURITY	Consumer and Citizens Security							
		Securing the European Challenging Applications		SMART (P)	TOISE (P)				
		Enabling Technologies for Trust, Security and Safety							
6	DESIGN TECHNOLOGIES	Manging Complexity				ELESIS (P)			
		Managing Diversity		END (S)		ELESIS (S)			
		Design for Reliability and Yield	MODERN (P)			ELESIS (S)			
7	SEMICONDUCTOR PROCESS AND INTEGRATION	Know-how on Advanced abd Emering Semiconductor Processes		MIRANDELA (S)	ARTEMOS (S)				E450DL (S) PLACES2BE (P)
		Competitivness through Semiconductor Process Differentiation		LAST POWER (P) MERCURE (S) SMART (S)			HIPER3 (P)		
		Opportunities in System in Package	JEMSiP (P)	CSSL (S) ESiP (P) MERCURE (S)	EPAMO (S) NanoTEG (S) NANOCOM (S) PARSIMO (P)				Lab4MEMS (S)
8	EQUIPEMENT, MATERIALS AND MANUFACTURING	Advanced CMOS - 1Xnm & 450mm	LENS (S)	EEMI450 (P)			EEM450PR (P)		E450DL (P)
		More than Moore	LENS (P)		NanoTEG (P) NANOCOM (P)		EPT300 (P)	PROMINENT (P)	AGATE (P) EPPL (S) Lab4MEMS (P)
		Manufacturing	IMPROVE (P)			GreenElec (P)		PROMINENT (S)	

Note:*: the projects arising from Call 6 and 7 are pending the successful closure of the negotiations.

4. Conclusion

This AWP-2013 calls for projects to implement the strategy of the MASP. A first call for projects will focus on activities in laboratory conditions with projects that deal with one or more "Grand Challenges" as their primary target. A second call will focus within the context of the MASP strategy on activities that aim to create a pilot industrial environment. This environment may be an extension of an existing production line in order to enable new products or applications or may be a new line that is limited in capacity.

ANNEX 1:

Copy of all quoted and referred chapters and/or paragraphs of the VMS/MASP

VMS, Part B, chapter 6.4:

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

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

Similarly, the presence of large industries in a region or ecosystem often depends on SME suppliers. The customer-supplier intimacy within the ecosystem greatly contributes to the stability of the industrial activity in a region. A focus on SMEs in public-private partnerships will therefore also be beneficial for universities and large companies.

VMS, Part C, chapter 1.3 (Automotive and transport):

1.3.1 Grand Challenge 1 'Intelligent Electric Vehicle'

Description:

Grand Challenge 1 'Intelligent Electric Vehicle' should be considered as the refinement of the previous Grand Challenge 'Full Electric Vehicle'. The Intelligent Electric Vehicle should be embedded in complex traffic management and logistic systems and should cover all available electric drive concepts especially the full electric drive but also hybrid technologies (e.g. parallel hybrid, plug-in hybrid, serial hybrid, and range-extender).

High Priority Research Areas:

- overall concepts for EVs covering cruising range, energy management, reliability and safety enabled by nanoelectronics
- energy efficient power electronics for the electric drive train (new voltage classes)
- electronics to control advanced storage technologies (innovative battery cells, hybrid batteries, fuel cell)
- introduction of multi-core technology for real-time control
- heterogeneous system integration inclusive thermal management
- advanced reliability research (e.g. EMC)

The identified areas request fundamental research on semiconductor technology, device level and assembly/packaging technology.

Competitive Situation:

At present European companies are at market position 1 in conventional cars and position 3 in electric cars. In Automotive, Europe has three players in the top five: *ST*, *NXP* and *Infineon*. There is a realistic potential to become number 1 also for electric vehicles, especially in integrated e-mobility systems (vehicle and infrastructure integration for (H)EV). Full market penetration will stabilise employment and has potential to even increase it.
The full electric vehicle will create an estimated world-wide market in the multi-billion Euro range. For 2015, it could be around 50 Billion Euros , and in 2020 around 100 Billion Euros.
Recent market trends show a fast introduction of e-bikes and e-cycles in order to get fast on the e-mobility learning curve and to pave the way for mass introduction of e-cars.

Expected Achievements / Innovation Foreseen:

The well-known economic and ecologic reasons will push the introduction of the full electric vehicle. A significant CO_2 emission reduction from today >120g/km to around 45g/km is expected, proving that electric energy is generated from low carbon resources.
Nanoelectronics based solutions will be expected for a significant progress in the fields of energy efficiency, reliability and lifetime at reasonable costs.

Therefore innovative application systems are expected like:

- interconnection systems for secure connection of the electric vehicle to the grid for remote identification, diagnostics, charging and metering,

- intelligent on-board traffic management and navigation in order to achieve maximum efficiency and driving range,
- innovative advanced driver assistance systems.

This should be accomplished by new innovative components (sensors, multi-cores,...), system-in-package technologies and design and verification methodologies.

1.3.2 Grand Challenge 2 'Safety in Traffic'

Description:

The Grand Challenge 2 'Safety in Traffic' should cover the different layers from vehicle up to complete management systems in terms of safety.
The importance of improved safety inside and outside the vehicles and in complex traffic infrastructures is self-explanatory. The public and legislative demand for safer cars and safety in traffic is increasing. Safety in vehicles will become a key condition for market penetration. The same holds for security if networking increases. In urban traffic especially, 50 % of the fatal accidents shall be avoided.
The estimated global market for the safety in traffic challenge is the total vehicle market and the complex traffic infrastructure like traffic management systems, vehicle-2-vehicle, vehicle-2-X, logistic systems etc.

High Priority Research Areas:

- innovative active safety systems
- reliability and safety from component (e.g. sensor) up to complex traffic safety management systems
- reliability and safety in operation and control and communication
- initiation of European standardisation for deployed technologies, safe communication protocols, certification and test
- European introduction of automatic emergency calls (e-call)

Competitive situation:

Especially in the European countries, the automotive industry plays a central role for the internal market as well as for export. Concerning conventional vehicles and the safety of vehicles, European companies are currently in a clear leading position. In addition to this, there is also a very strong aeronautic industry (*Airbus*) and railway industry. The success of Europe in these transportation domains is strongly dependent on the latest technology – especially for improving energy efficiency, safety and comfort.
If Europe safeguards its good market position by including innovative and effective safety features, many jobs in the automotive industry will be conserved.

Expected Achievements / Innovation Foreseen:

New innovative traffic safety management concepts and systems with a holistic view on all kind of transportations are expected as well as new active safety and driver assistant system in electric vehicles driven by safe components like sensors, actuators and multi-core

processors. The expected progress in the overall safety system will strongly support the European target of decreasing fatal accidents by 50%.

1.3.3 Grand Challenge 3 'Co-operative Traffic Management'

Description:

The Grand Challenge 3 'Co-operative Traffic Management' should be considered as multi-modal and also covering trustworthy communication systems. This grand challenge aims to introduce at a higher level efficiency, prediction and reliability in traffic and transportation by using data from different sources as GSM, UMTS, GPS, WLAN, DSRC, navigation systems, vehicle-to-vehicle communication and others. Distributed sensor networks, communicating through RF and broadband info-busses have to be analysed according to their deployment in Automotive & Transport. Appropriate multi-access / multi standard gateways for seamless interaction with other domains have to be developed. Of particular interest will be the standardisation across Europe of interfaces between components from different suppliers.

High Priority Research Areas:

- intelligent traffic flow management covering efficient use of energy resources and time
- real-time-traffic-information by using the cars as moving sensors
- appropriate multi-access/ multi standard communication gateways
- intelligent high performance data processing
- intelligent electronics for security and privacy protection
- concepts and introduction of pro-active communication (e.g. for e-cars: accidents, road blocks, dangerous situations, availability of charging stations, active route planning)

Competitive Situation:

The European industry is in a clear leadership position in terms of complex embedded systems. New standards for electronic vehicle architecture (AUTOSAR), communication (V2VC) and co-operative traffic management concepts (e.g. EU projects Safespot, CVIS, Coopers) have been developed. This is leading to a holistic approach on Intelligent Traffic Systems for improved safety, for vehicles and vulnerable road users, efficient traffic flow and low energy consumption (incl. EV and grid management).
The strong position of the European industry in nanoelectronics and embedded technology will be a major enabler for the breakthrough of this technology.
The implementation of multiple bus systems and distributed ECUs war driven by European OEMs, such as CAN, LIN, Flexray and MOST. Future requirements will lead to partial networking (distributed intelligence and stand-by of transceivers and processors). These car networks will interact with the environment in the future.

Expected Achievements / Innovation Foreseen:

New innovative concepts and prototypes of co-operative traffic management interacting with systems in other application domains like Internet or logistics are expected. Such systems will strongly support the improvement of the efficiency of the traffic by reducing traffic jams, reducing average time needed for public transport and multi-modal goods transport. Extending the car network to the road community will offer new features. Intelligent traffic management systems, automatic emergency calls and road tax systems for all vehicles will require safe, interactive telematic modules, which will become part of the automotive architecture, including smart driver interfaces. These innovations will set the ground for saving

time, energy and CO2 emissions due to traffic jams and road congestions, while saving additional lives.

1.6 Synergies With Other Domains

The general ubiquitous expectation of our modern information and communication society is to take advantage of all existing services regardless where we are – in the office, at home or on the way.

This strong request leads on the one hand to the multi-domain deployment of various applications, basic technologies, methodologies, architectures and on the other hand to new cross-domain applications. Seamless connectivity and interoperability becomes more and more important.

This should be supported by cross-domain use of *Design Technologies, Semiconductor process and integration and Communications.*

In contrast to other domains *Automotive & Transport* is characterised by its harsh real-time environment and very limited energy resources available for applications. To meet these requirements robust technologies and domain-specific implementations of the same functionality are requested.

Another specific characteristic of *Automotive & Transport* is the different significance of non-functional aspects like *Safety and Security* or *Energy Efficiency* in comparison to other application domains.

The challenge for nanoelectronics is to develop solutions with almost no degradation in performance and comfort.

VMS, Part C, chapter 2.3 (Communication and Digital Lifestyles):

2.3 Grand Challenges

In the context of convergence and in order to address all the technical issues in the most efficient way, the R&D activities will be organized around Four Grand Challenges with a long range planning effort and close cooperation along the whole value chain. The objective is to spur development of innovative and cost effective technologies enabling designing and manufacturing in high volume silicon systems solutions for the communication and digital life style market. The Four Grand Challenges are namely: INTERNET MULTIMEDIA SERVICES, EVOLUTION TO A USER DIGITAL LIFESTYLE, SELF ORGANIZING NETWORK and SHORT RANGE CONVERGENCE.

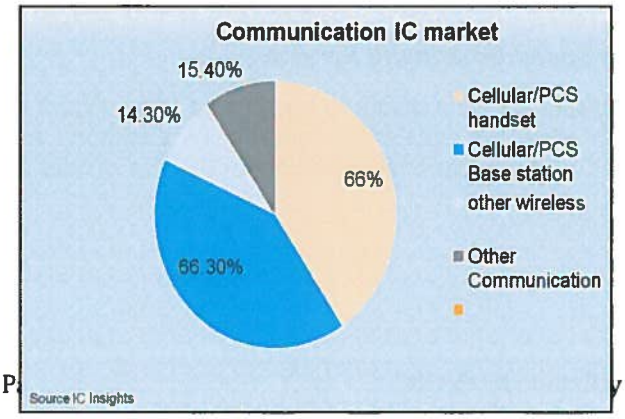
2.3.1 Grand Challenge 1: "Internet Multimedia Services"

Vision:
Towards the convergence of application devices and networks , the Internet Multimedia Services challenge aims at developing innovative silicon solutions offering the possibility to manage in the most effective way the amount of data requested by the implementation of broadband services.

Description:
The convergence scenario of consumer, computer and communication electronic systems drives an exponential growth of code and data in all electronic systems. At high level "convergent" electronic system performances are measured in term of bandwidth, in order to speed up Internet connection, and in term of reduction of the power consumption, in order to enhance the portable use. Power reduction also has a strong impact on consumer-grade devices (STB, tablets...) because of new power usage standards and cost aspect. The continuous introduction of new multimedia formats impact the processing capabilities because of the decoding / encoding requirements (access to any content requires spatial and temporal transcoding). Ease of use also has a strong impact on the processing capabilities and memory requirements, as "making it simple" for the user is not at all simple on the design side.

Competitive Situation:
After dropping 12% in 2009; IC insights forecasts that the Telecommunication market will register a 9% growth in 2010 to reach $370 billion. For the period 2009-2013 we should register a CAGR of 8%. This market includes cellular mobile phones, cordless telephones, cellular base station equipment and switching equipment (BS&SE), pagers and two way radios. Other communications systems include wireline systems. The figure shows that cellular phones will be the largest market for communication ICs. Growth for the IC communication market should continue well beyond 2010 to reach a total of $77,9 billion. The former n°1 is *Qualcomm* (US); the other major suppliers are *Samsung*, *ST-Ericsson*, *Texas Instruments*, *Mediatek*, *Broadcom*, *Infineon*, *Renesas* and *Numonyx*.

Worldwide Communication MKT by product type ($B) 2007-2013 (Fcst)		
Logic	27.8	42.5
Analog	11.6	13.2
Memory	10	16.9
Micro	7.2	5.2
TOT	56.5	77.9



As part of the telecommunications market, the global silicon photonics market is expected to reach $1,950 million in 2014 from $10 million in 2007 with a CAGR of 105.3% from 2009 to 2014. In 2008, the wavelength division multiplex filters contributed $7 million or 30.4% to the global silicon photonics market.

P[illegible]y the IRC

Photo detector is the second-highest market and it contributed 21.3% and then comes optical interconnect with 18% and optical modulators with 17%. In 2014, due to the high growth rate in telecommunications and sensing markets most of the silicon photonics products are expected to attain full integration and commercialization. The key players in the silicon photonics market are in Europe: *Alcatel-Lucent*, *STMicroelectronics* and *Innolume* and in the US: *Luxtera*, *Hewlett-Packard*, *IBM*, *Intel* and *Infinera*. (Source: MarketsandMarkets).

Expected Achievements/Innovation Foreseen:

- ***System Memories***

The memory system design has to support the increasing requirements in terms of bandwidth and power consumption reduction, and to that respect non volatility solid state is the best way for reducing power consumption. Multimedia and Data Storage integration require to secure European leadership and competitiveness also in the memory-field both from architectural and technology point of view. Memory Systems will have to offer the bandwidth needs of the final device, cache structures and the use of different memory technologies being the forecasted solutions. Due to the limit reached in the scalability model which was up to now the driving solution to achieve more powerful and less expensive memory systems; in the next decade it will become impossible to continue to shrink actual NVM Flash. **New memory technologies are needed like PCM (Phase Change Memories), which will offer further scalability, low cost per bit, and improved performance.**

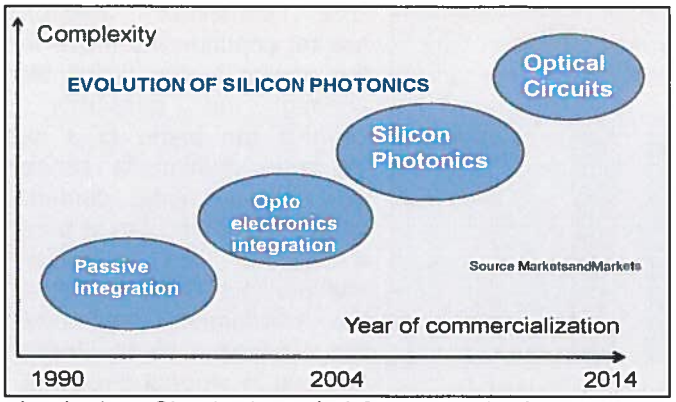
Since critical computing applications are becoming more data-centric than compute-centric high-performance, high-density, and low-cost NVM technology with access time much lower than hard Disk Drives and close to the order of magnitude of DRAM Memories are indentified to offer the memory system solution for the new computing applications.
So the challenge for solid-state memory technology is also to meet the demand of future storage server systems, modifying actual storage-memory hierarchy.

- ***Implementing New Computing Approach***

Multimedia broadband services are moving from pure voice connection to audio, video imaging and graphic. In particular video content for real time or streaming applications are growing fast with more and more demand for higher quality driven by HDTV. The challenge is to develop advanced video compression techniques optimising the amount of bandwidth. The emergence of HDMI output for a mobile device brings as well new features and new problems to address as it connects it to a TV set. This has the side effect of introducing in a mobile device some issues existing only in the digital TV domain like user interfaces on a wide screen. The support of new HD format in the device brings very complex problems related to processing power as the amount of data to process is dramatically increasing **leading to solutions integrating more and more processors cores** making the programming tasks even more challenging than ever.
To make the situation even more complex, the new solution will have to manage efficiently a big part of the software legacy already existing in order to have silicon systems solutions compatible with aggressive time to market constraints. The integration of very heterogeneous blocks of IP makes interconnection issues very critical as it has a strong impact on viability and performance of a solution. Today due to the size of the chips it is clear that integration can happen only in connecting asynchronously synchronous islands. In such conditions the **solutions like NoC** (Network on Chip) are very important.

- ***Photonics, At The Heart Of High Speed Broadband Services***

The enormous performance of today's communication network is based to a large extent on optical communication technologies which allow for highest bit rates in it's backbone and increasingly as well in it's fine ramifications of the access network connecting the residential areas.



The ever-growing demand for higher traffic in the communication network involves higher bit rates in future WDM optical transport backbone surpassing bit rates of 100 Gbit/s per optical channel. Electronic circuits dealing with such high data rates will be highly sophisticated designs based on most advanced Silicon On Insulator (SOI) CMOS or even high performing SiGe BICMOS technologies. Circuits intended for usage in the passive optical (access) network (PON) will face lower speed performance requirements ranging up to several Gbit/s in PON, but face extremely challenging low cost targets. Similar requirements hold for optical backhaul systems solutions for base stations in wireless access network. The conflicting needs for performance increasing and reduction of energy dissipation are demanding for high efficient system solutions. As a consequence **future high performing systems will increasingly be based on photonic system concepts, which promise a significant higher performance at reduced energy budget.**

Integrated optics and CMOS circuits, based on Silicon On Insulator (SOI) wafer technology is going to become the new process mainstream opening the road for a pervasive high speed communication at low cost and low power: such a process technology is well known as "Silicon Photonics". The possibility to merge, on the same substrate and package, optics with the most advanced CMOS / BiCMOS offers a unique possibility to miniaturize the today high speed applications by reducing cost and power by a scaling factor of two decades with respect to the interconnections based on copper. In fact it is now possible to envisage solutions where electrical interconnect can be replaced by very high-speed link on silicon. Such technologies are already emerging in server markets for die-to-die connection but will soon be a mandatory solution in SoC on SiP. Such a very high bandwidth link will have an important impact on architecture and system partitioning and for sure will become a gating factor to new high end multimedia system in the future.

The Silicon Photonic can therefore be seen as a disruptive process technology that will remove the bottlenecks in high-speed intensive computing, data communication, telecom and high-end storage applications.

2.3.2 Grand Challenge 2: "Evolution To A Digital Life Style"

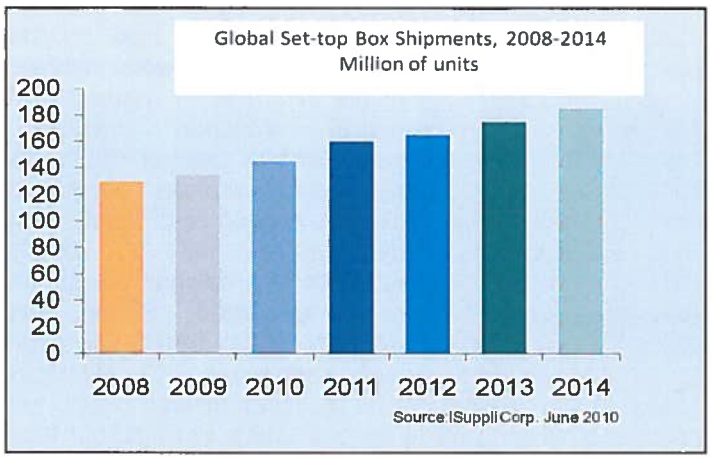
Vision:

The new "Digital TV User lifestyles" aims to bring an easy, ubiquitous and fun access to media, information and knowledge to European Citizens.

Description:

Consumer Electronics devices are becoming more and more complex. The number of features they embed is growing exponentially. The large number of possible interfaces to the outside world, the new applications and the list of standards they have to support are adding to this usage complexity. **Keeping complex devices easy to use is very challenging but it has a strong societal impact**. This must help less-technological friendly European Citizens accessing to the digital world and to the associated knowledge. The "lamda" user wants to have an easy and seamless access to these advanced features. The consumer must be able to move its screen/tablet/TV without noticing the way the content is transmitted. The switching from a digital wired network to a wireless link should be transparent for the user with an efficient management of the associated bandwidth constraints. The easy access to the contents leads to an increase of data exchange and data computing that must accomplish with latency in line with the user expectations.

Competitive Situation:



The consumer electronics market continues to move from the analog to the digital world offering the possibility to connect the home to a large range of multimedia services. Towards a digital connected home, the set-top box is playing a central role in offering multimedia services and despite the economical environment, this market driven by the demand in emerging regions, is showing solid strength. The total shipment should be in the range of 180 Million Units in 2014, representing large opportunities for the semiconductors industry including audio/video processor, memories, demodulator and tuner ICs. *Pace*, *Motorola* and *Technicolor* are the top three set-top box suppliers. As far as the digital market is concerned, IC Insights forecasts the market for DTV semiconductors will reach $8.25 billion in 2010. Chip revenue for DTVs is expected to increase from $7.25 billion in 2009 to $13.0 billion in 2013, representing an average annual growth rate of 16%.

Expected Achievements/Innovation Foreseen:

New Video Sources and Content Management:

The next 5 years will see the deployment of the 3DTV, the emergence of the Ultra High Definition, the generation of new content with immersive video in which virtual content and reality are merged together. The management of all these new content and video formats, on various devices (TV, set top box, mobile phone, tablet), represents a real technical new challenge.

Ubiquitous Access to The Content

This means, "access to my content anywhere, anytime, on any device". The user is not interested in format transcoding, content rights protection or bandwidth issues; he/she only wants to watch/listen to his/her content. As a consequence there will be a need for high bandwidth multiple entertainment streams that have both the DRM content and the individuals' privacy protected. Also fast video search engine to search a video sequence in a huge video data bank will be needed.

2.3.3 Grand Challenge 3: "Self Organizing Network"

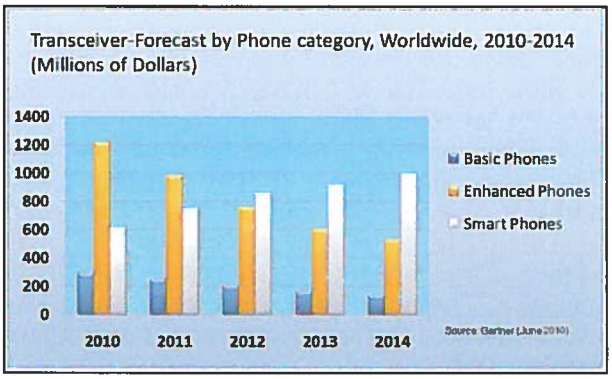
Vision:

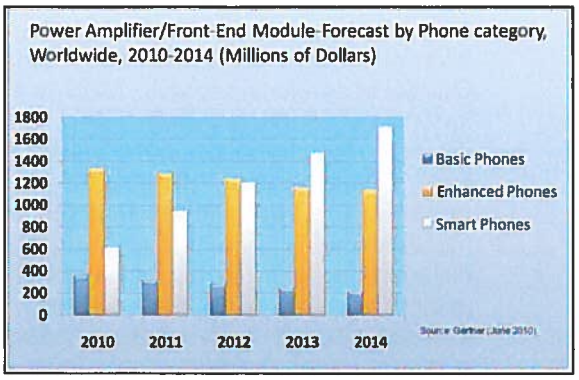
"self organizing network" aims to introduce new flexible and energy efficiency design architectures able to support multi-band and multi-mode cognitive applications.

Description:

In the past 10 years the wireless connectivity has really exploded as devices are now connected to a large number of systems and networks that were previously separate. Different technical worlds are going to merge and this will apply to fixed and mobile networks, for public and for private networks, for telecom and information technology. In this converging world, the main driving factors are the mobility, continuity/quality of service. The data exchanged Convergence requires that connectivity links, targeted originally for fixed or pedestrian terminals (WiFi standard 802.11 a/b/g), can be extended to mobility, (introduction of mobility in WiFi standard e.g. 802.11p). The associated increased demand for data traffic is driving the need for high data rate, high spectral efficient and low power consumption. Latest Connectivity technology is moving toward the exploitation of new spectrum region, in the range of mmWave (i.e. across 60GHz, actual WiFi systems being in the range of 2.4 or 5 GHz), as recently addressed by the standard IEEE 802.11ad or other consortia (Multi-Gigabits Wireless system, ...).

Competitive situation:
The rapidly growing broad band communications market and the development of advanced RF CMOS and Si/SiGe technologies are driving the development of new generations of transceivers and Power amplifiers requested by the cellular phone market. The enclosed





figures show that the total both markets are estimated at $ 2.7 Billion in 2014.Power amplifiers and transceivers are expected to perform very differently during the forecast period. Power amplifiers are benefiting from the transition from 2/2.5G to 3G/3.5G and the move to multimode baseband processors, and are expected to grow at a CAGR of 8.5% from 2009 to 2014. The transceiver market is expected to decline over the forecast period with a projected CAGR of -6.4%. After transitioning from separate transmitters and receivers into integrated transceivers, transceivers are increasingly being integrated into the baseband processor system-on-chip (SoC) for low-end and midrange mobile phones.

Expected achievements/Innovation foreseen:
Towards the convergence of fixed and mobile networks, the first k**ey challenge is to develop RF components capable to handle 2GHz bandwidth** (today WiFi RFs have to handle up to 200 MHz if compatible with 802.11 n Standard) that could be allocated to each single link. Further consolidated trend is the adoption of Multiple Antennas Transmitting and Receiving (MIMO = Multiple Inputs Multiple Outputs) with the aim of increasing robustness and or throughput of the link such as recently addressed by IEEE W-LAN 802.11n. Due to the number of interfaces to integrate in a low volume device, the RF problem is becoming a real headache in mobile systems. The increasing data throughput linked to multimedia and Internet browsing is making the situation even worst. New solutions are absolutely needed. Fully flexible Tx/Rx chain with regard to protocol, modulation and spectrum and highly programmable Rx/Tx chain have to be developed. Agile radios are very important, as it is a way to manage diversity in term of radio interfaces while maximizing hardware and software resources. Agile radio solutions while being able to monitor the radio spectrum utilisation will adapt dynamically the transmitted data rate according to the available radio resources and will offer the best usage of the spectrum. The complete system knowhow (agile radio solution associated with specific algorithms and protocols) s then crucial, as it is a way to sense the environment and to optimize the quality of service parameters in a crowdie RF spectrum. **The convergence scenario of consumer, computer and communication systems requires more communication protocols to be supported by a single device, with more multimedia operations executed in embedded processors**, more security checks should be offered, etc. The paradox is that in order to cope with a green policy, the required power dissipation for operating these devices represent the most challenging design constraints and will require the best in technological solutions (Deep architecture analysis with focus on ultra low power solutions, best in low power technologies, most advanced power management solutions, 3D packaging…)

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2.3.4 Grand Challenge 4: "Short-range convergence"

Vision:
The ubiquity of mobile devices and the deployment of wireless network open large scope for innovation. The aim of "short range convergence" is to develop new class of energy efficient single-chip system able to sense, communicate, reason and actuate.

Description:
Recent advancement in wireless communications and electronics has enabled the development of low-cost low-power, multi-functional sensor nodes that communicating over a short distance. Tiny sensor nodes, consisting of sensing, data processing, and communicating components, carry this out. Sensors are to detect sense information, and to recognize signs expressed by human and to monitor environments. For example, biometric information sensor monitors body temperature, pulse, perspiration, and detects emergency. On top of wireless sensors, M2M is said to grow fast. This is actually a sector where the knowledge of the application field is essential to succeed, allowing the creation of many different niches and business opportunities. In other hand, in a **mobile terminal,** the Near Field Communication (**NFC**) and Radio Frequency Identification (**RFID**) capabilities **are boosting the applications that the can perform**. The intuitive nature of the NFC enabled mobile phone is prone to a large acceptance in the public, for all ages in particular. The small distance between the tag and the RFID reader is allowing some confidentiality. The SIM is adding the security for the commercial transaction. The potential applications are endless: Transportation (Navigo on the phone), Travel (Ticketing, Car and Hotel room reservation), and Dependant people (services to for drug prescription).

Competitive situation:
Global shipments of short-range wireless ICs (Bluetooth, NFC, UWB, 802.15.4, Wi-Fi) **are expected to surpass two billion units this year**, increasing approximately 20 percent compared to 2009. Shipments are forecast to total five billion in 2014, according to new market data from ABI Research. In fact, driven by the development of smart autonomous wireless sensors and "Machine to Machine" communication, radio devices are increasingly in demand for short range wireless applications like building application, home systems, and industrial control, medical and commercial transaction.

Expected achievements/Innovation foreseen:
All these applications have a specific profile but all face common challenges when it comes to a large deployment and acceptance.
For all these applications, **a paradigm shift is needed in energy management domain**. Further research is needed for ultra low power analogue interfaces and radios as well as the digital part and harvesting energy from the environment should substantially enhance the autonomy of the systems to reduce the battery requirement. The second area to consider is linked to the necessity to increase the functionality of sensors nodes and their **capability to work in harsh environment** and with limited energy resources. Low complexity and real time algorithm have to be developed to improve the performances of smart autonomous systems and new network protocols need to be developed and implemented to operate in specific harsh environment like car or industrial with the best efficiency in order to save energy requirement. This also means that sensor network protocols and algorithms must possess self-organizing capabilities Therefore, the design of the sensor network is influenced by many factors, including fault tolerance, scalability, production costs, operating environment, sensor network topology, hardware constraints, and power consumption. Other important aspects are higher data rates with the networks and between the base station/routers as well as connectivity with the public network, the Internet

VMS, Part c, chapter 2.6:

2.6 Synergies with Other Domains

The synergies with the other chapters are as follows:

- Low Power and RF design can find synergies with design technologies and specific cooperation with the semiconductors process integration domain.

- Heterogeneous 3D integration requested to perform the next generation of cellular phone and sensors networks will be an issue at design technologies level as well at process level.

- Silicon photonics solutions are requesting specific silicon technology improvement and have to be developed in strong relation with the semiconductor process domain.

- "Self organizing network" and "short range convergence" will be essential for "Health and aging" as well as "Energy efficiency" projects.
- "Internet Multimedia services" will be also an issue for "Automotive and Transport" projects, especially in the light of car to car communication.

VMS, Part c, chapter 3.3 (Energy efficiency):

3.3 Grand Challenges

A consequent strategy for reduction of energy loss and for most efficient use of energy must define actions along the whole energy cycle (generation, transport and consumption). Therefore, the "Grand Challenges" for Energy Efficiency have been identified as described below.

3.3.1 Grand Challenge 1 "Sustainable and Efficient Energy Generation"

Description:
The topic of Energy Generation can be divided in two main application fields, one being the traditional energy generation (e.g. coal or nuclear power plants) and the energy generation based on renewable sources. In both cases, "raw energy" is produced in a form, which cannot be transmitted or used without conversion. Examples are non-continuous energy sources like wind-mills and like solar cells. Using old-fashioned electronics for rectifying, transforming or converting (AC/DC or DC/AC) the currents, only about half of the energy could be used. New, much more dedicated and efficient components have to be used, which partially will be based on new materials.

Competitive Situation:
The relevance of a high efficient energy conversion for new energy sources can be demonstrated by the example of wind-energy. The actual trend, that wind capacity doubles every three years, still continues (Source: World Wind Energy Report 2009). All wind turbines installed by the end of 2009 worldwide are generating 340 TWh per year, corresponding to 2% of global electricity consumption. A few impressive numbers: The wind sector in 2009 had a turnover of 50 billion € and employed 550'000 persons worldwide. In the year 2012, the wind industry is expected for the first time to offer 1 million jobs. European discussions about a super-grid connecting offshore wind farms of the countries around the North Sea seem to offer promising prospects for this technology opening a large field of research in efficient energy conversion, distribution and management.

Expected achievements / innovation foreseen:

- Energy conversion with efficiencies of 90% and more will allow an even better use of renewable resources. Industrial research has to be done, to find solutions to make these efficiencies affordable. Once demonstrated, it's still a long way to achieve "higher efficiencies at lower system cost".
- Another aspect is research in terms of reliability and long lifetime. This market needs lifetimes of power electronic solutions of 20-30 years. The combination of new materials like silicon carbide (SiC) or Gallium Nitride (GaN) which enables highest efficiencies and extreme long lifetime is challenging.

Developing and integrating semiconductors-based solar energy technologies with solid state lighting applications will enable not only sustainable energy resources but also energy efficient lighting applications.

3.3.2 Grand Challenge 2 "Energy Distribution and Management – Smart Grid"

Description:
An enormous potential for energy saving is the management, storage and distribution of (electrical) energy. The existence of European wide energy distribution networks is today only visible in case of problems producing large area "black-outs". The challenge is to bring

intelligence into the power distribution system. The power grid of the future is one of the most challenging visions. Gigantic wind farms in the sea and enormous solar fields in the desert are to generate the bulk of our power in the years to come. But consumers and companies are also producing energy with mini-power plants in their own basements and solar panels on the roof. And intelligent and efficient appliances are saving energy in our homes: washers, dryers and refrigerators that communicate with each other wash, dry or cool when electricity is cheapest.

The "smart energy grid" will combine management of incoming power, of distribution of power and of outgoing power. This could include also a network of (at this moment) un-used batteries of millions of electrical cars. But, the "smart energy grid" will only work "smartly", if it is not only a power-network, but at the same time a communication network, which contains security features, grid monitoring and payment features. This "smart energy grid" should be constructed at the building, district and city levels, to ensure maximum energy efficiency of the overall systems.

Competitive Situation:
As the discussion about energy supply and about its environmental aspects is conducted all over the world, the competition is very hard and indeed there is a world-wide race for the first real smart energy grids. Europe is in a rather good starting position as all necessary elements are available and Europe has a leading in research and in market penetration of most of the needed elements. European companies have acknowledged strengths in power electronics and in communication, and the respective R&D is very active.

Expected achievements / innovation foreseen:

- Energy conversion with efficiencies of 90% and more will allow a transformation of the produced electricity into currents/voltages, which are adequate for the respective type and length of the power lines.
- For efficient energy transmission over long distances, very high voltage (HVDC) lines will be installed (e.g. 800 kV). Similarly, for integration of renewable energy systems (such as solar or wind) with DC-based lighting technologies, low voltage lines in buildings are required. Highly effective AC/DC/AC conversion will be needed for entry and exit of energy.
- To effectively measure and communicate energy consumption in buildings, cities and districts, user profiles or future needs, dedicated sensors and communication networks have to be developed.

3.3.3 Grand Challenge 3 "Reduction of Energy Consumption"

Description:
A first, but not negligible, contribution is the reduction of power consumption of the electronic components and systems themselves. Well-known examples are the limitations by heat development of microprocessors as used in computers or the demands for mobile electronic equipment.
A more important – indirect - contribution is the energy savings on system/applications level. Research on advanced semiconductor technologies and energy efficient systems and solutions will enable industry to provide technologies and products to drive energy saving of end-equipment and the social system. Some examples are: intelligent lighting, motor control for home appliances, industrial applications and automotive, mobile applications. These areas feature healthy growth while being conscious that energy efficient systems and solutions are key factors for the Green society.

Competitive Situation:
Having the whole value chain present and in world-wide leading positions, Europe has a rather good chance to build up a healthy "green industry" around tools and goods for reduced energy consumption. European companies have acknowledged strengths in power electronics and in nearly all of its applications. Market studies show strong positions of Europe in the whole field of power electronics, but even dominance in power semiconductor modules for renewable energies. Also, the related R&D is very active.

Expected achievements / innovation foreseen:

- Lighting: In the near future, incandescent and fluorescent lighting will be replaced by LED technology, which is still being improved by remarkable R&D efforts. Two essential innovations are needed: One is focusing on high performance (>150 lm/W efficacy), reliable and low-cost LED system integration, wherein LED devices, optics, drivers, controllers, sensors, cooling solutions, and other essential components should be seamlessly integrated into a compact and smart opto-electronics sub-system. Another focus is to create and add intelligence to the LED light engines and sub-systems to provide optimal lighting solutions for a much large lighting system (such as buildings and outdoor spaces), to maximise energy saving and user needs. Supported by adequate sensors, algorithms and software systems an efficient and smart lighting control system will enable important energy saving in the private, industrial and public domains, and be able to be integrated with other systems and environments.
- Intelligent drive control: Technology, components and miniaturized (sub) systems will be developed addressing the challenges at system and device level for highly efficient controlled engines and electrical actuation in industrial applications. The need for R&D includes new systems architectures and circuit designs; new components and power electronic technologies; innovative module, interconnect and assembly.
- Efficient ("in-situ") power supplies and power management solutions: They will be supported by an efficient voltage conversion and an ultra-low power stand-by. The need for R&D includes new systems architectures and innovative circuit and package design concepts and specific driver ICs and power components for lighting and industrial equipments. Examples for the application of highly efficient "in-situ" power supplies are portable computers and mobile phones and stand-by switches for TV, recorders and computers.
- Medical applications: They will show very good energy efficiency - guaranteeing a long lifetime and low weight for the portable units. Improved energy management is also key for cost-effective imaging systems in medicine.

VMS, Part c, chapter 3.6:

3.6 Synergies with Other Domains

There are many synergies with "Automotive and Transport" (Drive Control), with "Communications" (Smart Grid and Mobile Applications), with "Equipment, Materials and Manufacturing" and "Design" (Design and production of specific components for energy saving applications), "Healthcare" (Mobile Applications)

VMS, Part c, chapter 4.3 (Health and the aging society):

4.3 Grand Challenges

The overwhelming societal challenge of keeping the cost of Healthcare and the Aging Society manageable can be split in three grand challenges:

1. Prevent institutionalization of elderly, impaired and sick people: "**Home Healthcare**";
2. Reduce time and cost of hospitalization: "**Hospital Healthcare**";
3. Increase the speed of pharmaceutical development and body fluid sample analysis: "**Heuristic Healthcare**".

These challenges are shown in Figure 1, which also visualizes the trend towards people centric healthcare. The key requirements per grand challenge are shown in Table 1.

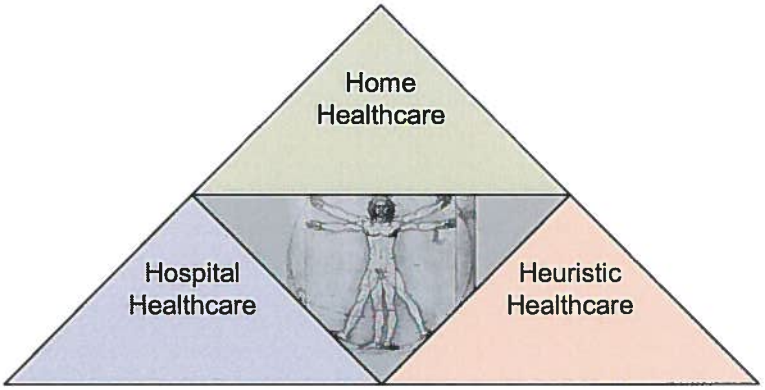

Figure 1 The three grand challenges for patient centric health in the aging society

	Home Healthcare	Hospital Healthcare	Heuristic Healthcare
Low-cost	X	X	
Accurate		X	X
Efficient		X	X
Easy-to-use	X	X	

Table 1 Key requirements for the Grand Challenges

4.3.1 Grand Challenge 1 "Home Healthcare"

Description:
Highest quality of life and lowest cost for society are obtained if elderly, impaired and ill people can fully function, independently from human support, in society without being institutionalized ("Independent living"). Electronics will assist people with limited mobility, sight or hearing abilities and with limited cognitive abilities, like elderly people suffering from dementia or people with mental health issues. Next to wellness at home, home care and home treatment will be an essential part of modern, integrated and patient-centric healthcare. Instead of a traveling patient, his data will travel on a secure basis and full attention by healthcare services is guaranteed (Figure 2).

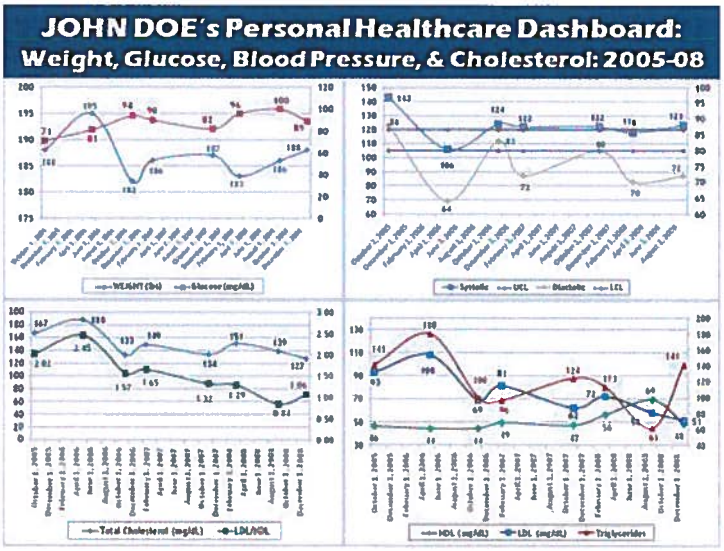

Figure 2 Continuous tracking of important patient health parameters

Competitive Situation:
The primary driver for a health related monitoring of vital signs is the demographic change, due to the increased prevalence of chronic diseases in an aging society. A study published in 2008 estimates the number of potential end-users of telecare solutions aged 65+ for the year 2020 in the 25 countries of the EU as ranging between 3 and over 15 million, depending on the development of the market penetration.

ICT-based therapy for mental health management improves healthcare productivity and access to care as it provides therapy with 80% savings in therapist time compared to conventional therapy (Marks & Cavanagh, 2009). As mental health problems are largely under-diagnosed (Katon, 2003) and few are able to obtain expert consultation, there is a clear need for improvements.

If only we consider the people suffering from chronic conditions, which should maintain a healthy life and monitor continuously their condition, the market size is huge. Accounting for 59% of the 57 million deaths annually and 46% of the global burden of disease, chronic diseases are the major cause of death and disability in Europe and worldwide. As the population is ageing, the number of people suffering from one and, very often, multiple chronic conditions increases. This poses an increasing burden on health care and social service systems and affects the quality of life by inducing both physical disabilities with frequent hospitalizations and social impairment.

As a result of the enormous economical impact that the increasingly ageing population will have in Europe and the rest of the world in the next decades, there is a potentially growing world-wide market in the area of Independent Living services and ICT for healthcare.

Expected achievements / innovation foreseen:
The introduction of Remote Sensing applications into the Public Health systems will contribute to the workload reduction and diminished waiting lists thanks to its improved features: rapid parameter analysis, multiple analyses assessment and ICT-related features. This fact will bring to physicians (anytime, anywhere) more information than current and dispersed analytical equipments about their patients. As a consequence, improved monitoring and diagnosing practices will be established. Therefore, patients will be more confident with public health systems due to several factors:
a. Individualized information on his/her disease progress
b. Reduced time to treatment and disease-oriented decision making
c. Optimized health resources and government taxes employed.

Of course this requires the development of cheap screening solutions for early diagnostics, biosensors and cheap mobile monitoring of biologic samples and parameters ("The doctor in your pocket"), as indicated in "Heuristic Healthcare". One of the ways this can be done efficiently is to integrate the tests into a mobile phone application linking to a patient centric

database. Testing in real time individual response to drugs will help to tune the therapeutic protocol and reduce side effects in conjunction with telemedicine for a better patient coaching.

These Remote Observations systems also include fall prevention and fall detection electronics for the elderly and impaired. For people with limited mobility, sight or hearing abilities electronic assistants will be developed. In general the wellness of the elderly and impaired will be increased.

Smart devices will also help to monitor the healing process (e.g. e-Inhalers for rapid and accurate dosage of drugs, also using smart band-aid with impedance changes for wound healing). In the same way smart automated drug-delivery systems, based on MEMS actuators coupled with low power control logic and energy scavenging, will help to apply therapy where and when it is needed.

The efficient use of health technology embraces several key areas in every country health system. From the social perspective, it influences to the informal care-givers or family caregivers which can be overloaded due to its emotional link and for its lack of health specialization. From the economical side, this initiative permits health care attention at home which discharges assistential pressure at the hospitals as well as it improves the satisfaction of older persons to increase the degree of "independent living", even in cases of dependency on long-term care. Finally, the remote supervision keeps track of key clinical parameters close to real-time providing the basis for decision making and even, if necessary, immediate intervention. For the latter fast localization will be implemented.

4.3.2 Grand Challenge 2 "Hospital Healthcare"

Description:
Hospital effectiveness can be increased by early and improved diagnostics. Efficiency can be increased with targeted therapy, where image diagnostics is combined with therapy in Image Guided Intervention Therapy (IGIT), see Figure 3 for an impression.

Figure 3 Research setup for interactive and interventional procedures

Competitive Situation:
The global market for medical imaging (diagnostic and interventional imaging) is estimated to be 20.1 B$. (2007 TriMark study). The European market is about a quarter of this total and the US market almost half. The medical imaging market records solid growth percentages. Depending on the modality, the average compound annual growth rate (CAGR) is about 4% (for interventional imaging this is 8%). There a few specific areas where growth is markedly higher than average:

- Image-based software applications that support intervention processes in healthcare.

To illustrate these growth opportunities:

- The European market for 3D/4D imaging software has a CAGR of 14% from 2004-2014
- The global market of CDSS (Clinical Decision Support Systems) grows from 159 M€ to 289 M€ during 2006-2012 (Frost & Sullivan)

- The integration of medical imaging with delivery systems (e.g. robotics) and therapy devices. This trend alone creates an entire new market space for IGIT procedure solutions. Ultimately this market will unify the market of interventional imaging, delivery systems and devices and therapy solutions. It is expected to be 10 times the size of the interventional imaging market today and it also enjoys higher growth figures and gross margins (based on US market data).

The global competitive players in the medical imaging industry providing both hardware and software are General Electric (GE) Healthcare (US based), Philips Healthcare, Siemens Healthcare (both Europe based) and Toshiba Medical Systems (Asia based). Emerging are Chinese suppliers, which now focus on the local market, but can be expect to expand internationally in the future. The market shows also innovative technologies developed by companies focused on specific segments such as EEG and represented by Nihon Kohden in Japan and GTech in Europe.

Expected achievements / innovation foreseen:
Improved and combined image detectors lead to efficient, more precise and earlier detection of diseases. These improvements incorporate increasing the resolution, supporting larger data rates, and being more precise in the properties of the signals that are detected. In addition, the detection of other kinds of signals can lead to earlier detection of symptoms, and/or reduce the harm to the patient. In this context, more precise and earlier detection also allow for significant dose reduction for a patient. For screening purposes, imaging systems without radiation have to become cheaper, faster and more accurate.

More targeted therapy will be achieved by combining imaging with therapy. Image guided intervention will help in medical diagnosis, planning and treatment of patients by minimally invasive placement of diagnostic and therapeutic devices such as catheters, stents, but also heart valves inside the human body, enabled by medical image analysis and navigation methods. Testing in real time individual response to drugs will help to tune the therapeutic protocol and reduce side effects in conjunction with telemedicine for a better patient coaching. Specific techniques like deep brain stimulation and neuronal communication will particularly benefit from miniaturization of control logic and real-time patient specific protocols.

Localisation techniques support the freedom of to be supervised persons and the management in large hospitals in knowing where the nearest experts and expensive equipment is located.

4.3.3 Grand Challenge 3 "Heuristic Healthcare"

Description:
"Heuristic healthcare" focuses on parallelization of analysis tools. On one hand it considers (educated) trial-and-error methods used in screening chemical compounds for drugs. On the other hand it involves (multi-parameter) bio-sensors, Figure 4, for early diagnostics ("the doctor in the pocket") and in the real-time response measurements to drug delivery.

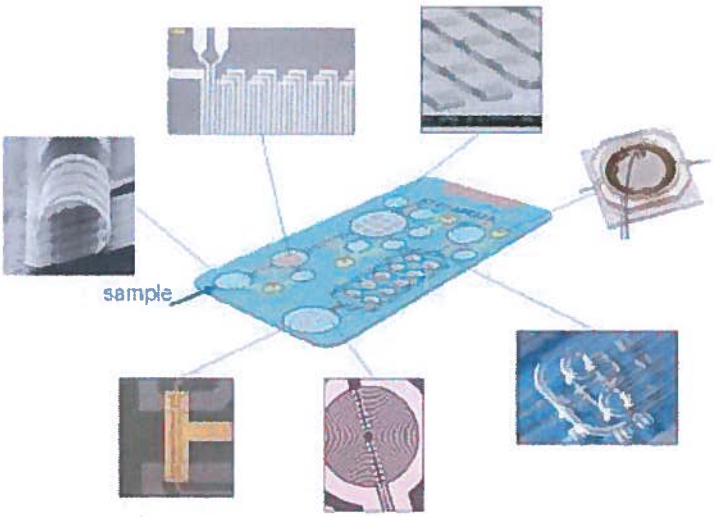

Figure 4 Illustration of a diagnostic cartridge based on heterogeneously integrated MEMS-based modules on a common breadboard

Competitive Situation:
Three markets are approached, the pharmaceutical industry (compound screening), the home healthcare market ("the doctor in the pocket") and the hospital with minimal invasive real-time response to drug delivery via bio-sensors.

The potential for parallelization and performance of the nanoelectronics is huge and will directly benefit the analytical and research laboratories in providing tools which are order of magnitude more efficient. This status will enable rapid progress in healthcare techniques thanks to a more efficient screening of potential drug compounds using bio-electronic devices, creating synergy between high volume laboratory-based systems for advanced treatments, and more cost effective home based systems.

Estimations are that the total in-vitro diagnostics market will grow from EUR 3.3 billion in 2007 to EUR 17.7 billion in 2018. Traditionally, the European molecular diagnostics industry is strong, but increasingly threatened by Asian and especially American companies. While still leading in the traditional markets, Europe is behind in new, upcoming diagnostics markets, American governments and companies have done major investments in next generation integrated diagnostic platforms due to the bioterrorism defence programs as well as in next generation biomarkers and assays which in some cases is driven by the 'never event' healthcare policies in the majority of American states as well as by the strong US Life Sciences R&D. The US is therefore currently leading in this field with companies like Cepheid, Life Technologies, Illumina, HandyLab, Caliper, Celera and Rosetta (MSD). Europe however has the broad (nano)technology base and the clinical application knowhow to become a leading player in the next generation genomic assays, especially when forces are bundled

Expected achievements / innovation foreseen:
The exams to determine real-time response to drugs and for quasi-continuous health monitoring ("The doctor in your pocket") must be minimally invasive to avoid repeated traumas inducing non compliance. This goal requires the screening of the most promising fluids starting from saliva and sweat, arriving to peripheral blood. For the development of biosensors this means: (1) finding new, and more reliable panels of disease markers, (2) finding specific receptors for these markers (3) integration of the testing components in a cost-effective testing package, which enables quantitative results in a short time (a few minutes) for the whole panel in question (e.g. micro-fluidics and polymeric packaging) and (4) evaluation of the results and (5) wireless interlinking with a patient-oriented database system.

Highly reliable tests will identify those pre-disposed to certain diseases, allowing them to enter preventive programs that will identify early onset of the disease.

High-throughput platforms addressing the discovery of new drugs through screening procedures play a role in the segments with higher economic growth, such as immunotherapies and other biological drugs. Detecting toxicities on as many classes of cells as possible, while supporting the required therapeutic effect requires the implementation in parallel of many thousands of assays. This task includes the handling of delicate cells to detect the desired effects. It has to be explored if quantum effects can give a further boost to this field.

VMS, Part c, chapter 4.6:

4.6 Synergies with Other Domains

From this work area on "Healthcare and the Aging Society" there are possible synergies with:

- "Automotive and transport" as car safety can be improved by enabling wellness applications in an automotive environment (such as a sensor network that can monitor the driver's vital signs and act accordingly). Also, imaging systems can benefit from new power electronic devices developed for electrical and hybrid vehicles;
- "Communication and Digital Lifestyle" as the availability of cheap and wireless communication links can be essential in the realization of home patient monitoring and for improvements in advanced imaging systems for screening. Additionally, there can be synergy on the technology for LTE terminals to support safety on the road and safety at home. Additionally, exchange of high resolution life images and data may require optical broadband access technologies.
- "Energy Efficiency" as low-power techniques can be essential for monitoring systems that use portable or on-body devices, and new materials, devices and equipment for solar energy conversion can be beneficial to develop new radiation conversion detectors and efficient power converters for imaging systems;
- "Design Technologies" as integration of heterogeneous technologies, low levels of acceptable energy consumption and high levels of reliability are required for the complex heterogeneous systems for Healthcare applications;
- "Silicon process and integration" and "Equipment materials and manufacturing" to create the best solution as a More than Moore spearhead for low-cost cartridges and platforms for microfluidics and gas sensors to monitor the body and environment
- "Safety and Security" as drug deliveries and operation become automated intrinsic safety has to be guaranteed. The large amount of patient (and non-patient) data has to be collected, transmitted and stored securely. Privacy needs to be supported.

Figure 5 Source: www.seppo.net/e

VMS, Part c, chapter 5.3 (Safety & security):

5.3 Grand Challenges

5.3.1 Grand Challenge 1 "Consumer and Citizens Security"

Vision: Maintain and Develop the European leadership in security enabling nanoelectronics for Consumers and Citizens

Description:

European Citizens are living in a technological society where most of the communications and transactions are done electronically. People are living in a society which depends from the errorless operation of embedded computing systems in transportation, wireless, industrial plant and of some critical infrastructures (airports, public transportations, utilities, networks, distribution,..). Both electronic systems, goods, and critical infrastructure are highly vulnerable to various threats. Europeans citizens are acting in an open society with very high mobility of people in both their personal and professional activities. The final end-users and the society as a whole need to be protected against fraud and information attacks, deficits in modern highly complex installations and endangerment of critical infrastructure. In addition privacy of the end user's data needs to be ensured .As a consequence we have to provide systems which protect from vulnerability in an cost/effective manner and we need to target security without restriction to mobility of the people and without disturbance of their daily life.

Competitive Situation:

Europe strategic independence in key security technologies serving citizens is essential. Europe has always been leader in our evolving digital society in order to provide secure personal devices such as SIM , credit cards , electronic passports but also secured servers and associated infrastructure & services .

Considering the growing demand for mobile connectivity, identity and data protection of citizens, health & transport services, e-banking & e-government and moreover for global security as a whole, it is essential that Europe maintains and enhances its technical leadership and continues to provide for millions of people means to communicate, travel, buy and work everywhere in an enjoyable and secure environment using key, but also to make available products which convince their users of their quality, functionality and resistance against external and internal errors and influences.

Expected achievements / innovation foreseen:

Communication technologies

- Secure spontaneous networking
- New architectures:P2P, M2M, Cloud Computing, IoT
- Security of wireless protocols (IEEE 802.X,... UWB, RFID,..)
- Trust and integrity

Secure servers and personal devices

- Very high-cryptography bandwidth
- Multi-level security
- Trusted virtualization and compartmented operation systems
- *Smart personal devices*
- Smart-cards and secure tokens
- Privacy-enabled Trusted Personal Devices (Fixed, mobile)
- Integrated trust and security hardware and firmware features for embedded computing platforms

Smart-sensors and actuators

- Integrated authentication against fraud
- Wireless enabled
- Adjustable local intelligence/remote monitoring
- Data fusion algorithms

Privacy-enabling technologies
- Anonymisation
- P3P (Platform for Privacy preferences..)
- Digital signatures

Identity management technologies
- Federation
- Biometry (Multimodal)
- Authentication
- Digital signatures

Embedded SW agents
- Configuration , profile management
- Privacy, security
- Integrity and reliability

5.3.2 Grand Challenge 2 "Securing the European challenging Applications"

***Vision:* Take advantage of European leadership and expertise in electronic security to define, develop and implement the needed security in European new challenging application domains and stay ahead of world competition.**

Description:

In all new fields of application, electronic control and data exchange show an obvious need for more security. Protection like simple guarantee that software program integrity is preserved during product life, solid mutual authentication of communicating parties, data confidentiality are key targets. What ever the application domains, similar concerns are appearing, but the overall definition and implementation may change significantly according to the ecosystems, regulatory environment (may be very different in transport and health care…) and targeted cost and budgets.

Energy Efficiency and smart energy grids
In that field, key application will be the definition and use of the smart grid system so that the overall distribution network is managed and protected from undue external control. Liked with that customer usage profile data collection, distribution and usage has to be severely protected in order to protect privacy, avoid massive fraud. Remote control by users or by the overall management systems has to show resilience to many threats or associated risks covering security (wrong access, billing fraud…) but also safety (people at risk if home equipments are incorrectly driven either by fraud or failure). Energy networks are also a matter of critical infrastructure (the prosperity and existence of our communities depend on them at a large scale); they need protection against foreign emissaries as well as natural system deficits due to e.g. design and software errors.

Health & Ageing Society
Keeping elderly or dependant people at home, or minimizing the level of institutionalization will require permanent monitoring of activity, vital functions and others useful parameters. Collecting this information, communicating and filtering the contents will require highly trusted chain of systems with fully dependable electronics and strong data protection.

When life sustaining equipments are to be used control (local or remote) of such equipment will be highly critical and the highest level of security has to be achieved. In that domain the ecosystem include both medical professional and insurances (either private or public). They will be key in defining the proper requirements and setting budgets, but European, nation or even local regulation may contribute to solution definition.

Automotive & Transport
In transportation – automotive, city transportation, railways and airplanes - safety is critical. Security now combines with trust and safety requirements. System integrity and traceability are also mandatory. The increasing mobility and traffic require more safety in traffic. Electronics are the enabling technologies to develop smooth access control when traveling, more safety in traffic and co-operative Traffic Management. New and increased use of protective technologies is necessary to protect todays complex systems against bad internal and external influences and errors. New DSM technologies bring new technical challenges, such in signal integrity, reliability, trust and safety/security compliance.

Communication
A new security paradigm is requested by more and more communicating applications, more mobile users and more distributed data. Thus securing services or data and providing proper protection evidences is becoming increasingly important and difficult in advanced, open wireless and fully mobile devices. End-users, OEMs, ISVs, content owners, service providers and operators have different, sometimes diverging needs and should have differentiated privileges towards terminal resources. Robust stakeholders' segregation, security policy enforcement and mutual assets isolation is a challenge in increasingly open "computing" devices exposed and vulnerable to everyday new malware, software and hardware attacks. Increasing interoperability, trust and flexibility requirements are bringing standardization and security evaluation challenges. Finally the ever-increasing security complexity should remain transparent to the end-user, which is stressing the security performance and efficiency dimensions.

Other leading applications
Other new applications for trusted Future Internet, new e-Payment, e-ID ... are also developed at European level. Security is a core technology for these applications.

Competitive Situation:
Europe has always been a leader in developing new large applications at European level, based on their industrial OEM and system industries such in automotive, energy management, transportation, health, and security. However new applications such as security and smart energy grid have shown early initiatives and starts in US and Asia in the same growth or even faster than in Europe. However the involved industries start recognizing the absolute need for trust and security, which is an opportunity to be developed by European actors if we are fast enough.

Expected achievements / innovation foreseen:
- Identity and secure authentication as part of new applications
- Trusted execution and trusted computing for embedded systems and complex netted information and computing systems
- Validation, verification and proof of safe and secure devices
- Tagging and tracking goods, Counterfeiting protection techniques
- Secure execution, management, personal privacy in new European wide applications.

5.3.3 Grand Challenge 3 "Enabling Technologies for Trust, Security and Safety"

***Vision:* together with the European semiconductor actors and the security experts, develop the Building blocks and Technology trust, security and safety add-ons to provide secure and safe enabling devices.**

Description:

Semiconductor technologies and nano-electronics have direct relevance to security and safety capability as part of Information Technologies, Consumer goods and citizens practises, Payment, Wireless Communication, Energy distribution, Health individual information, Transportation, complex Machinery and equipment and Secure access.

While at the same time, the semiconductor process and integration and the design technology are contributing to the advancement of the core capabilities (sensing, data & signal processing, computation and communications) needed for IT and embedded systems, some critical features and building blocks are required for the foundation of secure and safe nano-electronics devices.

Security and Safety being generalized in any applications, a methodology for integrating basic security bricks in more complex systems (microsystems such as SoC or macrosystems) with capabilities of proof, early validation, simulation, etc has to be developed; Secure by Design approaches are generic terms for these developments.

Trust has to be achieved by measuring the integrity of hardware and software of processing platforms and thus constructing trusted platforms, where the integrity can be preserved during operation also in a networked environment. Trust is necessary to protect secure systems also against advanced attacks and report their integrity status to the companioning system parts. Trusted implementations are coming up to protect PCs, mobile communication and servers but also e.g. embedded systems like car control or industrial control systems against attacks from the outside as well as to protect against error propagation from the own error sources (like residual software implementation errors).

Because any product is produced by assembling subcomponents from various sources, trusted or not, controlled or not, subcomponents authentication and integrity checking is a key elements to fight against piracy. The subcontracting of part of the systems or the fabless companies, are sometimes used for fraudulent modification of the products (troyan like).

Competitive Situation:

Semiconductors companies in Europe are worldwide leaders in providing secure and industrial devices in line with the European OEM leaders. With the globalisation, it is important for European actors and stakeholders to maintain a technology mainstream and to develop the security and safety add-ons.

The European industrial machinery, production systems, transportation, security, healthcare and automotive industries develop solutions with a continuing increase in complexity to full fill customers expectation and users needs worldwide, which results in a continuing worldwide market share. For continuing enhancement of such systems we need integrated trust and safety to give our industry a differentiating advantage against other economic regions.

Expected achievements / innovation foreseen:

Enablers to be developed on top of the baseline semiconductor technologies

- Attack and probing resistant silicon cells and design processes
- Silicon ageing of DSM technologies to be examined versus duration of life required by industrial applications
- New generation, large and secure NVM memories to protect the confidentiality and integrity of information during storage. Include extensions from multiple-key management to public-key encryptions
- Tamper resistant packaging

Building functions

- Embedded Sensors technologies for security and safety

- Very small area integrable security algorithms e.g. for authentication and digital signing
- Component authentication such as PUF technologies (Physically Unclonable Functions)
- Secure new high data rate interfaces for MtoM and RFID
- Internal architectures for intrinsically resistant components (resistance to fault injection, flat signals emission, etc)

Design techniques

- Security CAD,
- Tamper resistant design
- Trust and security protocols and algorithms. And influence the related standardization
- Configurable and integrable Trusted Modules (TPM) for embedded systems
- Design for Reliability DFR
- EMC protection

VMS, Part c, chapter 5.6

5.6 Synergies with Other Domains

Safety and security domain is transversal to all application domains and the related technologies need to be developed together with the semiconductor process and integration and design technology domains.

VMS, Part c, chapter 6.3 (Design technologies):

6.3 Grand Challenges

6.3.1 Grand Challenge 1 "Managing complexity"

Description:

"Managing Complexity" aims at developing solution for managing the design of complex chips including billion of transistors and different types of I.P.'s, coming from different sources, with a large software component.

The trend towards the integration of more and more complex systems on chip or in package, made possible by the Moore's Law is becoming the main challenge for design, both in terms of system complexity related to the integration on chip of different logic functions (logic, multi-core processors, memories, dedicated functions) and in terms of silicon complexity, related to parasitic effects and variability in advanced CMOS. The insertion of programmable component to increase flexibility is adding a further level of complexity, introducing embedded software, and hardware-dependent software components as critical elements of design.
Architectural level design, and the possibility to evaluate different options and make choices at the highest level of abstraction, is becoming a critical issue in defining the performances of the final device. Since several large I.P.'s are required to compose the system, the possibility of I.P. reuse plays and the definition of open standards also play an important role in overall design cost and time.

Competitive Situation:
Large EDA companies are providing standard tools essentially for logic synthesis and layout optimization. Higher design levels are not well covered even if some initiatives exist to try to move design at higher abstraction levels:
The most critical issues to be covered are:

- Capture and verification of specifications;
- Tools and methodologies to handle multi-core design, taking into account both hardware and software and operating systems;
- Tools to verify hardware dependent software;
- Standard languages for high level design;
- Open standards for I.P. exchange and interfacing;
- Tools and flows to interface design cores coming from different sources and to handle communications among them;
- Tools and model to perform basic design evaluation for performances and power dissipation at the highest abstraction levels.

Expected achievements / innovation foreseen:
The main achievement that the projects should target is the establishment of a standard language for the high level design. A non-exhaustive list of required innovation is:

- Standardized description language;
- Flows and tools for model generation at high abstraction levels;
- Tools able to handle at the same level hardware and software;
- Tools for the formal verification of the design at different abstraction levels;
- Tools for generating interfaces among heterogeneous IPs.
- establish an OPEN standard ecosystem

6.3.2 Grand Challenge 2 "Managing Diversity"

Description:
"Managing diversity" aims at the development of design technologies to enable the design of complex system-in-package incorporating heterogeneous devices and functions.

The drive towards higher integration levels for semiconductor components, coming from considerations of cost, form-factor, connection speed/overhead, and reliability, has pushed towards the tighter integration also of heterogeneous non-logic functions, like power,

communication (RF or optical) and sensors. System integration in package and 3D stacking of different devices are becoming mandatory to achieve the desired targets in terms of size and performances and to interface non-logic functions to data processing devices, when cost and reliability considerations limit the full integration of heterogeneous functions on a single chip, even if technically feasible. The total combination must be designed as a single system and tools and methodology are lacking. At the moment three main challenges exist:

- Standardized modelling tools also for non-logic components compatible with the design of the system at higher abstraction levels;
- An integrated design environments for PCB, package and chip design;
- Tools take into account parasitic effects like heat generation and propagation, related to the close proximity of components in the package and an efficient A/MS simulation capability on the large scale.

Competitive Situation:
At the moment major EDA companies are focusing mainly on tools and design flows for logic devices, which make up 75% of the world market. Specific tools exist for board design and package design, but they are not integrated with chip design, and nothing is available for System-in-Package integrated design. Support for non purely logical functions is also poor and limited to RF design and analogue/mixed mode design, with severe limitations for complex devices. Big companies normally use in-house developed partial solutions, which present standardization and support problems. The most important bottlenecks are:

- missing standards for bare-die-IP (e.g. interfaces electrical and mechanical)
- models of bare die IP and their integration into system simulation
- 3D floor-planning, place and route
- 3D-parasitic extraction methods (concerning stacked dies and/or bond wires)
- standardized design rule description (3D) on package level (enabling die and package DRC)
- test approaches on die and system level, especially for analogue and RF, with links to testing equipment.

The lack of a 3D design-flow for heterogeneous applications prevents the broad application of SiP and stacking technologies in domains as e.g. medical and automation.

Expected achievements / innovation foreseen:
A non-exhaustive list of expected achievements is:

- Initiation of standardization process for bare die I.P.'s;
- EDA compatible design kits for sensors, actuators and other heterogeneous system components;
- Creation of models for non-electrical components and interfaces for SiP design;
- Creation of intermediate, digital/mixed analog and RF levels of abstraction for EDA improvement and making most use of existing levels for verification, validation, testability and repair.
- Development of a platform that enables the delivery of reusable IP for microsystems and other heterogeneous systems and is compatible to existing EDA environments;
- Creation of a design flow for Heterogeneous functions;
- Technologies for chip, package and board co-design with multi-scale simulation tools.
- Technologies for implementation of heterogeneous SiP and 3D-stacks (3D parasitic extraction, 3D-DRC)
- Testing approaches for non-logic functions.
- Test strategy for SiP and 3D integration, considering also the interface to testing equipment.

6.3.3 Grand Challenge 3 "Design for Reliability and Yield"

Description:

"Design for Reliability and Yield" aims at the development of design technologies to compensate the effect of parameter variability, parasitics and aging effect on yield and reliability of semiconductor devices.

Following CMOS scaling to deep submicron regions, intrinsic device reliability of transistors cannot be any longer guaranteed due to the increase in electric fields and local power densities, and the large number of elements. At the same time critical applications in the field of Automotive and Aerospace, Security and Health require very high levels of reliability, often for limited production volumes. Yield, which is determined by the device functionality at time zero over the entire range of application and reliability, which is understood as the extrapolation of this functionality over lifetime, are becoming closely related and cannot be any longer guaranteed by process and design only. Testability, yield and reliability must be inserted by design, starting from the architectural level, and going down to cover parameter spread in the line and parasitic and reliability effects at device level. Therefore models and procedures are required to migrate reliability modelling from transistor level up to system/architectural level.

Competitive Situation:
At the moment variability in circuit design is handled mainly with Monte Carlo simulations, which are quite expensive and extremely time consuming, and some first approaches to include reliability and variability in compact models. Further progress is needed in moving to compact model-based simulation flows and to cover analogue and mixed-signal circuits in the presence of parametric degradations are directly influencing the performance of the block. Tools and flows should cover the interactions among components (EMC, thermal management) and allow interfacing reliability issues among the blocks that form the complete system. New design approaches must be developed to increase and verify device testability, also for non-logic functions, interfacing testing equipment.
Europe is quite innovative in the Design Technology and EDA area. CATRENE released in 2009 a new version of the EDA roadmap, which is internationally recognised. The innovations often are coming out of IDM companies and from SMEs. Some of these EDA companies have achieved unique breakthroughs. They are focussing on supplementary solutions to large EDA tools in the area of design support in face of varying parameters, changing technologies, and parasitic effects. More approaches are available throughout Europe in academia, which are not covered by the mainstream tools from the big USA based EDA companies. These efforts should be strengthened in order to meet the special European needs (heterogeneous system integration and safety relevant applications) and to keep some independence of the large mainly US-based EDA companies.

Expected achievements / innovation foreseen:
A non-exhaustive list of main expected achievements:

- Methods to extract independent, uniform distributions out of device characterization data for e.g. Monte Carlo simulations;
- Faster simulations to handle complex circuits and large number of influencing parameters as well as methods to handle non-uniform distributions;
- Methods to transfer variability and reliability information over different levels of abstraction;
- Tools and flows to handle simultaneously in the design optimization both process variability and lifetime related parametric degradation;
- Design and testing approaches for failure detection, localisation and repair during application (and tools to verify them);
- Design and testing tools for fast and efficient yield learning

VMS, Part c, chapter 6.6:

6.6 Synergies with Other Domains

Possible synergy areas with other priorities are (not exhaustive):

- Design for Safety and Reliability with application projects in "Automotive and Transport" and "Health and Aging Society".

- Design for complexity includes tools for reducing power dissipation, which is essential for "Communications" and Health and Aging Society"

- Design for diversity includes sensor integration 3D and SiP design, essential for "Communications", "Automotive and Transport" and "Health anf Aging Society"

- Failure analysis and reliability procedures related to high temperature, high current/voltage operation will also be an issue for Sub-programme: "Automotive and Transport" and "Energy Efficiency"

- TCAD and modelling of device reliability and variability will be synergic to "Silicon Processes and Integration"

- Design for diversity implies strong cooperation with "equipment, Materials and manufacturing" especially on package modelling.

- Testing development, especially for 3D and heterogeneous components requires synergy with testing equipment development.

VMS, Part c, chapter 7.3 (Semiconductor process and integration):

7.3 Grand Challenges

7.3.1 Grand Challenge 1 "Know-how on Advanced and Emerging Semiconductor Processes"

Vision: Develop a European know-how on semiconductor process technologies for mastering future applications.

Description:

Mastering in advance the knowledge of emerging semiconductor processes is a key asset for developing new products with the right time-to-market.

This is especially true for **advanced CMOS** process where the pace of progress is staggering. Considering that:

- a technology push in advanced CMOS enables and drives high value-added applications
- there is a need to maintain R&D and expertise in Europe to specify and access the latest CMOS and memory technologies
- a critical size is obtained at the European level through the cooperation of the few leading excellence clusters in Europe
- in US and Asia there is a strong involvement of PA's for supporting this industry

it is appropriate to propose a major Europe-wide public initiative on core CMOS technologies in support of a more comprehensive European industrial policy targeting microelectronics. The technical program should be in line with the pace of the technology generations expressed by the ITRS.

Though the process development is mostly independent of the wafer size, the historical trend towards using wafers of **larger diameters** for cost efficiency should be acknowledged. Though the transition in wafer size is mainly equipment and material related (and thus included in the "*Equipment materials and manufacturing*" chapter) it is important to leverage the enhanced capability of the semiconductor processes on larger diameter wafers. More specifically many differentiated technologies are presently produced on 150mm to 200mm: a transition to 200 / 300mm wafers should enable new process integration schemes through more capable equipments. For leading-edge CMOS technologies a transition to 450mm should be taken into account.

A key capability for acquiring advanced knowledge is the availability of leading expertise in **characterization, modelling and simulation** of state-of-the-art semiconductor technologies and devices. This should be addressed not only for advanced CMOS but also for differentiated processes where added challenges appear like multiphysics, multiscale approaches.

Competitive Situation:

In the **advanced CMOS** domain major changes are taking place worldwide and were accelerated by the economical crisis. For Europe it is characterized by opportunities which need to be capitalized upon and trends which should be addressed to benefit to Europe:

- early research in this area is increasingly done in a multi-partner, consortia-level structure, because of cost and risk considerations (IMEC, Albany...). In addition, owing to the cost of developing the latest CMOS generation, some European companies which preserve in-house manufacturing capability in advanced CMOS execute the early R&D for these

CMOS generations in clusters, such as the IBM cluster (one of the few major consortia worldwide developing the full CMOS process by gathering many US and non-US partners together). Still the preindustrial development and qualification are made in their European facilities: there is thus a need to *support the CMOS R&D in Europe for accelerating the technology appropriation in Europe*

- some European companies are going fablite or fabless: for them there is a need to *understand the next generation CMOS in order to specify according to their needs the technology nodes which will be implemented in foundries*
- while most of the foundries of advanced CMOS are presently located in Asia one observes the emergence of a state-of-the-art Western foundry producing in Europe: there is a new *opportunity for Europe to compete with Asia in the foundry business*
- at each new technology generation there is a risk that more production moves outside of Europe: it is thus important to *enhance the CMOS pool of expertises to attract more semiconductor production activities in Europe*
- best in class R&D centres are present in Europe which don't exist elsewhere in the world: there is a need to *maintain the viability and expertise of these R&D centres*
- in geographical terms and contrary to other nanoelectronic technology fields (see below) there are few leading regions / clusters in Europe where advanced CMOS technologies are developed. Owing to the cost and time needed to establish such excellence clusters, European programs and calls should acknowledge this situation and *encourage projects to form around the few excellence regions to benefit from the critical mass of expertise*. At the same time it should be a clear channel to link with and benefit from the smaller research providers especially for exploring disruptive concepts. These clusters will thus induce an efficient spill-over effect benefiting the other European regions.

Characterization, modelling and simulation are a stronghold especially of the European research organization. Commercial activities[6]s are less developed in Europe.

Expected achievements / innovation foreseen:

Innovations in electronics-enhanced systems and applications are enabled by advanced knowledge in technologies.

A strong European R&D program on **advanced CMOS** is a prerequisite to specify and access the latest technologies and thus secure further growth in European lead markets. Supporting this major program will allow staying state-of-the-art[7] and having a prescription power in the development of miniaturized technologies. It will allow creating value through differentiation in specific process steps and building blocks (see below) whose integration into a CMOS platform requires needs an in-depth knowledge of the development of the MOS transistors. More specifically funded programs should demonstrate advanced CMOS prototyping in line with or ahead of the ITRS roadmap (e.g. 12nm logic CMOS in 2016 or earlier, see Table below).

Equally important one should ensure that **no research gap** builds up between the shorter term projects considered in this document and the more disruptive approaches explored in the "classical" FP projects or other programs. A clear process should be set up to connect with the outputs of these programs such that we can extrapolate from the best projects in stretching "Moore's Law" while preparing a path to the "beyond CMOS" era. More specifically process modules applicable to the next two CMOS generation (i.e. modules for 10 and 8nm

[6] We are not considering here the equipment industry which is addressed in the relevant chapter.

[7] GlobalFoundries and STMicroelectronics announced the availability of a 28nm process in the late 2010, showing that fabs operating in Europe have the potential to stay in the leading pack.

logic CMOS in 2016, see Table xx) should be demonstrated as an outcome of the funded projects.

Table: CMOS logic "nodes" according to the ITRS

	2012	2016	2020
CMOS prototyping	**22 nm**	**12 nm**	**10 nm**
CMOS process modules	18 nm	10 nm	8 nm
	12 nm	8 nm	6 – 7 nm

Programs in **characterization, modelling and simulation** should lead to a worldwide recognized leadership of the European R&D players. More specifically some of the techniques developed through funded projects should become strong candidate for (de facto) standards[8].

7.3.2 Grand Challenge 2 "Competitiveness through Semiconductor Process Differentiation"

Vision: ***Develop European competitiveness through semiconductor process differentiation permitting different European business models and supply chains to succeed.***

Description:

Advanced memories are critical components in most systems (communication, automotive, consumer...). There is an opportunity for Europe to take the leadership in **disruptive technology approaches** bringing differentiation with respect to the mainstream technologies (Flash and DRAM). **Technology – system co-development** is another way to bring differentiation in taking into consideration the technology impact of system constraints (e.g. system bandwidth, power / energy consumption, etc.

It is not by chance that the ITRS didn't formalize a full-blown roadmap on **differentiating technologies** (dubbed as **"More than Moore" technologies**) which includes all the non-digital components of an electronic system. In contrast to the development of generic digital CMOS and memories, these technologies are much diversified and represent a strategic field for Europe. Their performance metrics are multifold, they are often driven by dedicated application domains and the target markets operate through different business models and supply chains. It is thus more difficult to give a simple and unified view of the many and often disruptive technologies which are likely to enable new applications and markets.

Most of these technologies are strongly linked to a given application which drives their development: those technologies will be addressed in the relevant application chapters of this document. Here will only be considered technologies:

- generic enough to leverage the high development cost and time on a broad range of applications
- prone to European cooperation among R&D players
- not enough supported in the "classical" Framework Programme

Following these guidelines this chapter suggests to promote a pan-European effort on generic technologies in the following (non-exhaustive) fields:

- enhanced process genericity for **sensors and actuators**
- **analogue / mixed signal technologies** (e.g. BiCMOS)
- **rf devices** (including passives, rf interfaces, antennas, tunable filters...)

[8] As an example the present compact model chosen by the Compact Model Council was partially developed by Europe.

- possibly **power / high voltage devices** and **smart power** though most of the projects are likely to fit within the "Energy efficiency" and "Automotive and transport" chapters
- and **mixed technologies** integrating e.g. analogue / mixed signal with rf and/or power

Competitive Situation:

The industrial landscape on **advanced memories** is evolving fast. It stands for 25% of overall semiconductor market, almost equally divided between DRAM and Flash and there is a strong trend for consolidation. Stand-alone DRAM industrial R&D disappeared from Europe, but innovative NVM companies are active in Europe. Furthermore embedded memories are critical parts in a CMOS chip. Finally Europe has significant assets in this field through world-class R&D centres which don't exist elsewhere in the world.

Europe has key competitive advantages in **differentiating technologies**:

- there is a historical synergy in Europe between system / application companies and component suppliers (incl. SME's)
- a strong R&D and manufacturing base exist and is widely distributed all over Europe

Expected achievements / innovation foreseen:

For **memories**, European industry can profit from the presence in Europe of major application drivers (smart cards, automotive, medical), and from an existing large competence base to further extend its market position, especially through new technologies (e.g. PCM, RRAM) and architectures (e.g. 3D stacking). The funded projects should demonstrate the industrial viability of the disruptive approaches.

By setting worldwide the pace of R&D in **differentiating technologies**, Europe can expect the same benefit as US (and recently Asia) did in aligning the world R&D efforts in the digital technology domain. By developing industrial differentiating technologies all over Europe and by maintaining the synergy between technology and applications one can expect to develop further existing and new markets. The applicability of the developed technologies to a wide set of applications should be one of the results of the funded projects.

7.3.3 Grand Challenge 3 "Opportunities in System-in Package"

Vision: develop a European SiP supply chain for innovative systems integrating advanced CMOS and European differentiating technologies through 3D and heterogeneous integration.

Description:
Integrated complex systems need more and more to combine high performance computing and information storage with dedicated devices for interfaces and energy / power in a single package. While integrating on a single chip different technologies (the so-called "System-on-Chip" or SoC approach) can be useful in some applications, in other cases SoC doesn't bring any competitive advantage in terms of cost and size (e.g. integrating in a single die advanced CMOS having a high cost / mm² with large area sensors). Furthermore integrating heterogeneous part gives an added degree of flexibility in bringing in time new system solutions to the market and in adapting to evolving standards.

Considering the complex interplay between IDM, fables companies and foundries, it is expected that for a given system solution components will be supplied from many sources, part of them outside of Europe, enhancing the need to find cost effective solutions to integrate heterogeneous technologies in a single package.

In order to develop generic processes and 3D / SiP[9] standards applicable to many applications domains, Europe should address many technologies in a holistic approach, including:

- methodology and tools system-level co-design[10]
- advanced substrates (incl. embedded devices technologies, innovative antennas, printable wiring also on organic substrates, thick copper power lines, etc.)
- wafer-level integration
- module integration
- 3D integration (incl. TSV, thin wafer technologies, bonding, etc.)
- interconnection (electrical, rf and/or optical) & interposers
- assembly & packaging (incl. wafer dicing and encapsulation technologies)
- characterization and modelling (rf, optical, mechanical…depending on the application)
- test (incl. KGD)
- thermal management
- signal integrity, EMC and reliability

Competitive Situation:
There is a clear opportunity for Europe to develop a European SiP supply chain and take a significant leadership worldwide:

- the supply chain of 3D/SiP is not firmly established yet worldwide
- standards for SiP are underdeveloped
- there is a historical synergy in Europe between system / application companies and technology suppliers (incl. SME's). As the technological solutions for heterogeneous integration will be driven by classes of applications a strong interaction between technology development and application domains is mandatory
- there are leading R&D centres in Europe

Expected achievements / innovation foreseen:

3D/SiP heterogeneous integration is expected to act as a key differentiating factor of complex integrated systems: in mastering its supply chain Europe secure its future in many application domains.

Classical assembly and packaging has moved mostly to the Far-East. Innovative technologies for complex packages are partly derived from IC manufacturing techniques and could benefit from the geographical proximity of R&D competence centres in SiP and from IC manufacturing lines: there is an opportunity for Europe to relocate part of the worldwide "back-end" supply chain by setting its leadership in the heterogeneous integration of complex systems.

VMS, Part c, chapter 7.6:

7.6 Synergies with Other Domains

[9] 3D means three-dimensional integration of electronics components. SiP stands for "System-in-Package".
[10] addressed in the chapter on "Design, methods and tools"

Addressing generic technologies this chapter is synergetic to the application-driven chapters ("*Automotive and transport*"; "*Wireless communications*"; "*Energy efficiency*"; "*Health and aging society*"; "*Safety and security*") in enabling innovative systems and applications.

Semiconductor process development and integration rely critically on the availability of equipments and materials. It is also fully consistent with the development of a competitive European manufacturing. As such it interacts strongly with the chapter on "*Equipment, materials and manufacturing*".

Interaction between design and technology is more and more central for successful products. Characterization, modelling and simulation are classical interfaces between the two domains, but growing interaction is expected between this chapter (especially in differentiating technologies and heterogeneous integration) and the "*Design methods and tools*" chapter.

VMS, Part c, chapter 8.3:

8.3 Grand Challenges

8.3.1 Grand Challenge 1 "Advanced CMOS – 1X nm & 450mm"

Description:
This Grand Challenge targets to find new E&M solutions for advanced CMOS that shall enable (i) the nano-structuring of electronic devices with 1X nm resolution in high-volume manufacturing, and in fast prototyping, and (ii) to set common standards and strategies for 450mm E&M. The overarching goal of 1Xnm is to lead the world in shrinking by providing nano-structuring equipment ~2y ahead of the corresponding volume production as scheduled by the ITRS roadmap. Accordingly, research and development is needed to facilitate innovations among others in:

- lithography systems, in particular EUV technology for high-volume manufacturing including tools, optics, and source; as well as NGL technologies including e.g. e-beam and maskless lithography;
- mask technology including infrastructure, metrology, CoO issues, holistic optimization sustaining multiple mask technologies (Immersion, EUV, Mix&Match);
- infrastructure for the new nano-structuring technologies including e.g. materials, wafer, resist, and cleaning;
- metrology including e.g. mask & wafer inspection tools, litho metrology, and data handling;
- yield aspects in e.g. manufacturing science, defect engineering, test, and CAD;
- 300mm equipment & materials;
- nanometer process development including thin film deposition, and ALD processing, specific enabling materials such as copper sources, ALD precursors as well as specific etching and cleaning gases;
- wafer preparation: equipment and processes for polishing, cleaning, wafer thinning and laser marking; and finally
- materials as e.g. substrate materials, chemicals, gases and precursors for next generation processes.
- The overarching goal in 450mm is to create the ability to have European competitive 450mm E&M available when needed by the market. Accordingly, research and development is needed to facilitate innovations as for example in
- open platform technologies, including automation, handling, software, interfaces (hardware and software) and standards;
- SOI ;
- substrates, materials, and facilities ; as well as
- process and metrology equipment.

Competitive Situation:
In E&M for advanced CMOS – 1Xnm and 450mm, Europe has a world leading position in several areas, foremost in lithography, metrology and silicon substrates. The annual market size for 1Xnm is according to ASML at least 5 b€ where EUV lithography alone addresses a large market with an estimated annual volume of ~3 B€ in 2015. The substantial markets for metrology, EUV infrastructure and complementary 1Xnm patterning technologies are additional.
Also for 450mm a potential multi B€ annual market size can be expected as 450mm E&M may become a dominant segment in the world wide E&M market indicated in Figure 2. Forefront R&D for 450mm creates new opportunities to increase the European market share in this competitive domain.

Expected achievements / innovation foreseen:
The key achievements targeted in E&M for Advanced CMOS is to lead the world in shrinking ~2y ahead of ITRS volume production schedule, and to provide competitive 450mm E&M when needed by the market. In a timeframe of five years, European lithography systems shall provide solutions for 1Xnm patterning in high-yield, high-volume manufacturing, and the corresponding mask technology, processes and process control, infrastructure and metrology

tools. Furthermore, first European E&M solutions and prototypes for 450mm chip manufacturing shall be available

8.3.2 Grand Challenge 2 "More than Moore"

Description:

More than Moore technologies will create opportunities and demands new skills and know-how, e.g. in 3D heterogeneous integration, new system on chip solutions by synergizing electronic- and biological- (medical) skills enabling aging society and carbon dioxide aware society. The over-arching goal of Grand Challenge 2 More than Moore is to enable European E&M companies to provide sensors, power electronics, rf-, and bio-technology according to market needs. Furthermore, the transition to larger wafer diameters (200, 300mm) is a challenge, and should enable new process integration schemes through more capable equipments.

Among others, More than Moore will address challenges in the fields of:

- back-end equipment: in particular for 3D packaging (wafer level and chip level) and novel approaches in die separation;
- advanced substrates;
- wafer bonding;
- alternative approaches for patterning, such as imprint or roll-to-roll;
- innovative control techniques and data handling based on different statistical basis and different requirements of the customers (e.g. automotive);
- process characterization tools, in-line and in situ metrology and sensors;
- advanced process control capabilities (APC) for high-mix low-volume environments;
- test tools;
- equipment for wafer size transitions;
- 3D high aspect ratio metrology; and
- new materials for packaging, thermal interface materials, and for added functionalities at reduced scales and associated enabling materials (precursors, gases).

Competitive Situation:

More than Moore can be partially sourced from past generation CMOS infrastructures, however new technology generations[11] require new capabilities which are still unsolved manufacturing challenges with large impact to energy efficient electronic systems and not available in advanced CMOS fabs. Furthermore, the constant trend in More than Moore solutions to decreasing feature sizes, with ever more features and interconnects packed on each IC, puts big demands on product validation and verification methodology and, to test equipment. Since to-days equipment is designed for high volume and endless lot production and is therefore less efficient for small lot production, the performance of More than Moore production tools must be enhanced to provide low CoO. This requires in general major modifications or even new design of the equipment.

Expected achievements / innovation foreseen:

More than Moore is creating future opportunity by addressing the increased request for new functionalities. Product volumes per function will be relatively small compared to classical semiconductor production, but in a much larger variety. This provides the European industry with the opportunity to creatively develop More than Moore solutions and so further exploit the wide experience in agile and market sensitive production. Furthermore, the production means must also be adjusted to this kind of market, asking the equipment suppliers to continue the tradition of highly sophisticated but cost-effective equipment. In addition, European E&M companies target to provide sensors, power electronics, rf, bio tech according to market needs. Finally, in order to create an industry wide basis for technology developments, a common More than Moore technology roadmap will be defined, and common standards shall be established.

8.3.3 Grand Challenge 3 "Manufacturing"

[11] e.g. based on Silicon Carbide SiC or Gallium Nitride GaN or new metallization technologies based on thick copper

Description:
The Grand Challenge Manufacturing focuses on research and development of E&M to enable highly flexible, cost competitive, and "green" manufacturing of semiconductor products within the European environment. The over-arching goal is to develop new E&M solutions that support flexible and competitive semiconductor manufacturing in Europe, and supply world wide market including innovations for resource saving, energy efficiency, sustainability without loss of productivity, cycle time, quality and yield performance; to allow for cost reduction; and to invest in people competency in Europe. To achieve this, new E&M solutions are required in several fields, as for example:

- small and variable size lot manufacturing;
- automation robotics ;
- efficient solutions for data handling and analysis;
- high-performance computing platforms for process control systems and metrology tools;
- fab process control software;
- quality and process robustness ;
- world class yield and defectivity;
- manufacturing robustness (tools and facilities reliability); and
- production environment (people, tool, process).
- These innovative solutions for E&M might address new materials (e.g. quality, defectivity, functionality), new designs (e.g. functionality, robustness, reliability, running cost), new software and automation, new "environmental" solutions (e.g. energy consumption, chemical usage) and innovative human to tool interfaces.

The target is to develop new E&M solutions that support flexible, agile and competitive semiconductor manufacturing in Europe, and supply the worldwide market. Thus, innovations for resource and energy efficiency, sustainability, enhancement of yield and reliability without loss of productivity, cycle time and performance are required to allow for cost reduction and to invest in people competency and IP in Europe.

Competitive Situation:
The topics addressed in the Grand Challenge Manufacturing are of key importance for several fields in European semiconductor manufacturing. They consider both, the strengths, and the challenges of the European semiconductor environment. On the one hand, E&M developments should capitalize on the European strengths, as e.g. the world class level of R&D and engineering expertise, the large technology portfolio, the high expertise level, creativity and stability of human resources, the multitude of SME's operating on very narrow but highly technical fields, and, in particular, the world class level of some E&M suppliers who are creating ecosystem within their activity field. On the other hand, the European E&M developments should consider the European challenges, as e.g. the high cost environment (labour, logistics, services) mainly with regards to Asia, the lack of flexibility (e.g. regulations, employment), the lack of dimension of scale in many small operations, the global character of the E&M market, and the lack of incentive environment for manufacturing.
Substantial market potential is given in e.g. in advanced CMOS high-volume manufacturing solutions that have to be provided according to the ITRS roadmap, and market needs; in More than Moore manufacturing requiring high flexibility in usage of resources, material and equipment; in existing semiconductor manufacturing plants that still exhibit a high potential for energy conservation; and, finally, in new methodologies and information and control tools to enable IC production lines to efficiently manufacture small and variable size lots with the vision down to wafer level manufacturing for already existing fabs.

Expected achievements / innovation foreseen:
The new E&M developments shall support flexible and competitive semiconductor manufacturing in Europe, and be competitive to supply the world wide market. Accordingly, the innovations foreseen must enable solutions for productivity improvement (even at low production volume), resource saving, energy efficiency, and world class performances in quality, yield, and cycle time in all kinds of semiconductor fabs. In addition, cost reduction potentials shall be generated compensating some cost disadvantages of European environment. Therefore, the challenge is to develop generic solutions for current and future fabs which allow, both, the production of variable size lots at high productivity figures, and energy efficient, sustainable and resource saving production of advanced CMOS under high-volume conditions. For example, a successful outcome will be the creation of a high-

performance, local hardware and software computing system for process control systems that are useful for multiple European companies. Accordingly, focus topics include among others factory operation methodologies, data acquisition and analysis concepts, factory information and control system, material transport as well as local storage and fully automated equipment loading/unloading.

VMS, Part c, chapter 8.6:

8.6 Synergies with Other Domains

All Grand Challenges clearly exhibit synergies to the domain of "Silicon Process and Integration". Furthermore, synergies exist to the domain of "Design", in particular between More than Moore and package modelling, but also in the areas of design for test, and design for test tools.