PART D
(ANNEX 3 about Smart Systems)

of the

2014 ECSEL MASRIA

2014 MultiAnnual Strategic Research and Innovation Agenda for the ECSEL Joint Undertaking

Elaborated for the Private Members Board of the ECSEL Joint Undertaking

by the EPoSS Industry Association

Smart Systems in the Multi-Annual Strategic Research and Innovation Agenda of the JTI ECSEL

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1 Introduction

Smart Systems combine data processing with sensing, actuating and communication and are able to analyse complex situations and to take autonomous decisions. They take advantage of miniaturisation, and are often invisible to the consumer. They are highly energy efficient or even energy autonomous and can communicate with their environment. Smart Systems recognise each other and enable the product in which they are integrated to interact with the environment and with other "intelligent" systems. Their application may lead to improved safety in cars or to reduce emissions in transport, they can be used to help disabled people in their familiar environment by providing cognitive assistance or they can make buildings and manufacturing equipment more energy-efficient by orders of magnitude. Often the incorporation of Smart Systems will provide the key technical features for the competitiveness of products in all these sectors and more.

Smart Systems will provide solutions to address grand challenges and risks for mankind in social, economic and environmental terms. Examples of the threats we face are as follows:

- Pollution of the environment and depletion of energy and materials ressources
- Aging populations and demographic change
- Fictitious value creation threatening real value creation
- Higher vulnerability of economies accompanying globalisation
- Risk of industrial decline and mass unemployment
- Destabilisation of entire world regions and the increase of extremism and terrorism
- Increased needs for the mobility of people and goods
- Demand for fresh water and safe food
- Health risks resulting from lifestyle
- Limited access to energy sources and scarce materials

Information technology companies such as IBM, Cisco and Hewlett-Packard have identified up-coming "Smart Systems" as fundamental to their "Smarter Planet" campaign which is aiming at providing smart technologies for intelligent resource-saving energy, sustainable transport and traffic, energy efficient buildings and intelligently managed municipalities. Major electrical engineering companies such as Siemens and General Electric are building upon Smart Systems for solutions in the healthcare and advanced manufacturing sector.

Europe - currently the global market leader in the field of Smart Systems - has both an excellent knowledge base as well as solid industrial structures and highly skilled workforce in this field – reason enough to further expand Europe's competitive advantages and to strengthen its position in global terms. The excellence of European Smart Systems research is represented by a number of strong big players as Bosch, Siemens, Thales and EADS forming a powerful technological backbone. High class public research structures (MPI, CEA LETI, FhG, CNM, CNRS), medium size private and public research entities as well as thousands of high-tech SMEs are forming a powerful backbone of excellence and creativity.

Therefore Smart Systems research has to be considered as one of the technology areas of primary importance for Europe, not least because:

In all competing world regions the importance of smart systems integration (SSI) as a fundamental cross-cutting technology has been recognised. U.S. companies as well the policy makers, also in China or Japan, consider smart system integration technologies as a condition for creating competitive advantages in a highly developed industrial environment. Powerful industrial competitors able to move with a high innovation speed are also able to exercise a significant price pressure. Competitive advantages go hand in hand with high investments of the public sector in these regions for both, R&D as well as manufacturing infrastructure. The technical requirements for complexity and diversity of functionalities for innovative product solutions powered by Smart Systems Integration are huge. They require an efficient and dynamic research and manufacturing infrastructure and a comprehensive collaborative approach of the public and private side. Europe has reached an outstanding level in mastering Smart Systems Integration Technologies, in companies as well as in research organisations. This is the basis to build upon for further developments in order to remain competitive with innovative products competitive in global markets.

1.1 Smart Systems Addressing Societal Challenges

Global markets with their changing dynamics have created an environment of worldwide competition. A series of social, economic and environmental factors concerning every nation, company or entity have become primary driving forces. Global competition for scarce resources, changing consumer and business behaviour, new technologies and changes of the institutional framework all lead to an increased innovation pressure on industry and also on the research community.

As recognised by most governments, technological development and innovation in the next few decades will be determined by major pace-setting challenges termed the “Big Five”:

- Climate change and the environment
- Energy and resource conservation
- Health and an ageing population
- Transport and efficient mobility
- Safety and security

Smart Systems provide decisive solutions for current and emerging problems in all the above categories. They have enormous potential to benefit people’s everyday lives and tackle society-wide challenges, not only in developed countries but also for less infrastructure intensive societies where the low cost adaptability and autonomous distributed intelligence featured by Smart Systems could provide affordable and readily-deployed solutions.

The Digital Agenda of the COM focuses already on technological capabilities to treat environment with respect, and to minimize GHG emissions, to reduce the energy consumption of processes, machines and buildings, to support ageing citizens' lives, to revolutionise health services and to deliver better public services at large. Smart Systems technologies can feature in all this, and furthermore drive forward concepts for sustainable mobility and measures for securing the integrity of data and the privacy of individuals.

The ability to adapt to and exploit change is pivotal for the competitiveness of the European economy and for achieving the EU's overall growth and job objectives. Policy measures can have significant impact on technology developments, and hence, have to support and stimulate restructuring processes and continuous adjustments to changing conditions. Through process and service innovations, totally new manufacturing processes or business models will be implemented: from new forms of energy storage to intelligent billing of the cost of medical services. The backbones of this coping strategy, however, are primarily products, innovative products manufactured in Europe which are able to revolutionise existing markets and open up new ones in multiple application fields.

As an important pool of cross-cutting technologies, smart system integration is core to Europe 2020: “To achieve a sustainable future, a mid-term perspective has to be developed. Europe needs to get back on track. Then it must stay on track. That is the purpose of Europe 2020. It's about more jobs and better living. It shows how Europe has the capability to deliver smart, sustainable and inclusive growth, to find the path to create new jobs and to offer a sense of direction to our societies.”1

Smart Systems will provide answers and solutions to these challenges by supplying the enabling functionalities for innovative products and services in a timely, cost effective manner, and by serving user requirements beyond today’s expectations. The following overview shows, functionalities, technological and innovation aspects of Smart System Integration and their interrelations at various levels in view of their contribution to societal challenges.

Smart Systems developments are driven by the user-level needs of individuals and society. Foresight and futures have, in different ways, been used to anticipate social changes. During the last 2-3 years, the term ‘Grand Societal Challenges’ has emerged (and has been promoted) as an appropriate phrase to capture some of the major issues facing people around the world during the next decades. 'Grand Societal

[1] José Manuel Durão Barroso, President of the European Commission, Communication from the commission: EUROPE 2020 - A strategy for smart, sustainable and inclusive growth, Preface, Brussels, 3.3.2010, COM(2010)2020

Challenges' may be regarded as a significant discursive formation and infiltrated the discussions, at least in relevant policy communities as well as R&D and industry. This discourse tends to convey the scale and depth of challenges, a sense of interdependency of problems and the need for a concerted, strategic response. To be responsible involved in this discourse, it seems to be necessary to analyse some recent developments, to find out, how European research and innovation systems can offer responses to emerging global challenges and opportunities.

Global challenges signal unprecedented change. This will take place at economic, social, political, ethical, regional as well as individual levels. It is the task of research and industry alike to analyse, based on their skills and potential, the problems arising from these challenges and changes, then to provide the functionalities needed for addressing these problems and to improve or develop the technologies for implementing these functionalities in marketable, affordable and competitive products. Smart Systems technologies are capable of providing the necessary solutions and opportunities. Some examples of this potential follow:

Example Climate: Governance of and influence upon the processes causing climate changes and stressing the environment require firstly a pool of excellent, scientifically exact and non-contradictory data. These have to be acquired using extensive in-situ and remote monitoring providing locally-relevant information and highly specific pollution sensing, possibly with automated counter-measures. Equipped with enhanced functionalities based on smart system solutions, these monitors will provide unique performance, with, for example, resilience to user errors and ability for de-skilled operation, autonomous intelligence, system-wide networking, evaluation of local conditions and contextually optimising the system-efficiency without the need for external control.

Example Energy: The increasing difficulties to economically access irreplaceable resources necessitate a conceptual rethinking of energy and resource use. Europe's dependencies upon energy sources such as gas or oil, or special materials such as platinum for catalysts or lithium for high-performance batteries or rare earths for high-efficiency electrical drives or high-performance wind power generators must be seen as the primary driver for a number of strategically necessary developments in Europe. Sophisticated usage of energy and conservation of resources, supplemented by seeking alternatives, is the order of the day. We expect intelligence to be introduced to assist users to reach the goals of efficient energy consumption. Smart system based solutions provide opportunities to use renewable energies as a pillar in a pan-European concept of secure energy supply by solving problems of safe, adaptive electricity storage at product, domestic and regional levels due to an interdisciplinary combination of properties of tailored materials with innovative seamless sensing, processing and actuation approaches to power management and distribution. Smart system integration is also a basic technology for a low waste, high efficiency production, for sophisticated facility management and a starting point for shrinking the use of scarce materials due to a holistic system integration approach.

Example Health: Population ageing, progressing rapidly in nearly all industrialised countries, is expected to be among the most prominent global demographic trends of the 21st century. This process is expected to continue over the next few decades, affecting one way or the other the entire world. Population ageing generates severe consequences for socio-economic development and public health, for example shrinking and ageing of the labour force, losses in innovative ability and the possible bankruptcy of social security systems.

Smart Systems integration is the basic technology promising solutions for advanced personalised point-of-care diagnosis and treatment to avoid enormous ramps in the cost of the social security and health system. With multiple sensing and an in-built facility to make deductions, Smart Systems have the potential to self-test, to self-calibrate and to shut down, reconfigure or self-heal in the case of fault or unexpected operating conditions. They can build a technological basis for advanced solutions for urgently needed ambient assisted living and mobility approaches. This will make it possible for millions of people to live in their home environment independently as long as possible, from social, economic, well being and health points of view. Smart Systems solutions can provide higher performance from common and also new materials, by exploiting nano-, micro- and bio-technology to enable new adaptive prosthetics or artificial organs for vital replacements, acting as a bridging technology and adjunct to tissue engineering and other purely medical treatments.

Example Mobility: Individual mobility and public transportation systems will face many challenging issues in the future. Critical among these are the fuel and energy sources that will drive the vehicles, and the concomitant air pollutant and greenhouse gas emissions. There are several promising options: improving mainstream internal combustion engines and the gasoline and diesel fuels they utilise; propulsion system electrification using hybrid internal combustion engines, batteries, and electric motors, combinations in charge-sustaining and plug-in versions that draw electricity from the power grid; pure battery/motor electric drive systems; natural gas fuelled vehicles; and fuel-cell powered vehicles operating on hydrogen. Another area of concern is road safety and the losses in productivity by time wasted in congestion. A promising path to overcome these issues is provided by the networking and automation of the vehicle, which at the same time would serve the need for energy efficient traffic solutions. The enabling technologies for automation are driver assistance systems, environment perception, as well as control and communication systems based on smart systems integration

For all of these examples, Smart Systems provide basis technologies to solve the challenges which these techniques bring with them.

1.2 Smart Systems: a Chance for Europe

In the last decade, Smart Systems Integration has undoubtedly matured into one of the most important enabling technologies, now guaranteeing the world market success of innovative products in numerous and different application fields. These cover a wide range of opportunities, from intelligent implants and pacemakers in medical technology to Smart Systems in the automotive industry, where they add to the efficiency of propulsion technologies while also increasing the safety of occupants. Smart Systems in intelligent industrial control systems help reduce the CO2 emissions enormously. They make aviation safer, and allow for the detection of hazardous and harmful substances in safety and security applications.

Many of these applications have their origin in Europe. European industry has achieved a market leading position in many fields - not least because of the continued support at national and European level.

Due to their technological and innovation capabilities, as well as their customer focus, Europe's Smart Systems manufacturers currently enjoy a good competitive position in many Smart Systems segments. Process knowledge and application know-how ensure that, worldwide, customers can expect the best fitting technology tailored to their specific needs. The European Smart Systems sector is characterised by representing nearly all the necessary technologies and disciplines. The very specialised sensor sector alone consists of more than 6,000 innovative companies in EU27. Total employment in the Smart Systems sector amounts to 827,600 empoyees in 2012 of which 8%, i.e. 66,200 are employed in R&D activities. R&D expenditures are 9.6 B€.2

The Smart Systems sector in Europe is also characterised by high value creation and a highly-skilled workforce. It is an excellent example of a competitive European value chain. Despite a high degree of automation, human system know-how is still essential to make the best connections between devices and the applications environment they are incorporated in. Moreover, the legal and environmental conditions under which products are made are becoming increasingly important to the customer. European manufacturers enjoy also an excellent reputation in both these matters.

In recent years the speed of development has increased significantly because of the immediate and expected economic benefits and the great potential of the technology. However, along the way new questions for the direction and focus of future research efforts have come in view. The interdisciplinary nature of Smart

[2] Sources: Prognos AG: Analyse zur ökonomischen Bedeutung der Mikrosystemtechnik, Studiums about the Smart Systems economy in Baden-Württemberg and Germany; European Competitiveness Report; EU Industrial Structure 2011; Figures provided by major industry associations.

Systems development and integration is a weighty issue. New tailor-made and multi-functional materials promise the provision of entirely new properties, the integration of bio-components are beginning to blur the barriers between living and dead matter. The design, manufacture, testing and assurance of the smooth running of these systems will engender methods and tools with not yet foreseeable challenges. This leads to a need of highly sophisticated R&D, as well as a need of bringing different disciplines together and for the matching and the advantageous usage of different scientific and technological approaches; including advanced manufacturing capabilities as a base for commercialisation of the results.

The tackling of all these tasks will increasingly over-strain the performance of individual economies. The U.S. was, due to the generous support of DoD, DoE, NSF, or DARPA, a leader in the use of SSI technology in military and security technology. The resulting developments demonstrated to have an enormous potential for civilian applications. Dual use constitutes for the U.S. economy a significant competition factor. Stakeholders in Japan, China and Korea focus their efforts on the other hand on the use of Smart Systems technology to strengthen their already claimed application fields, such as the consumer sector, and continue to set themselves apart from the competition with innovative developments.

Thus it is of high importance to favour every initiative, which can help Europe to maintain industrial leadership at all stages of the value added chain in the smart system domain.

1.3 Smart Systems and Key Enabling Technologies

Smart Systems bridge the gap from the component to the product.

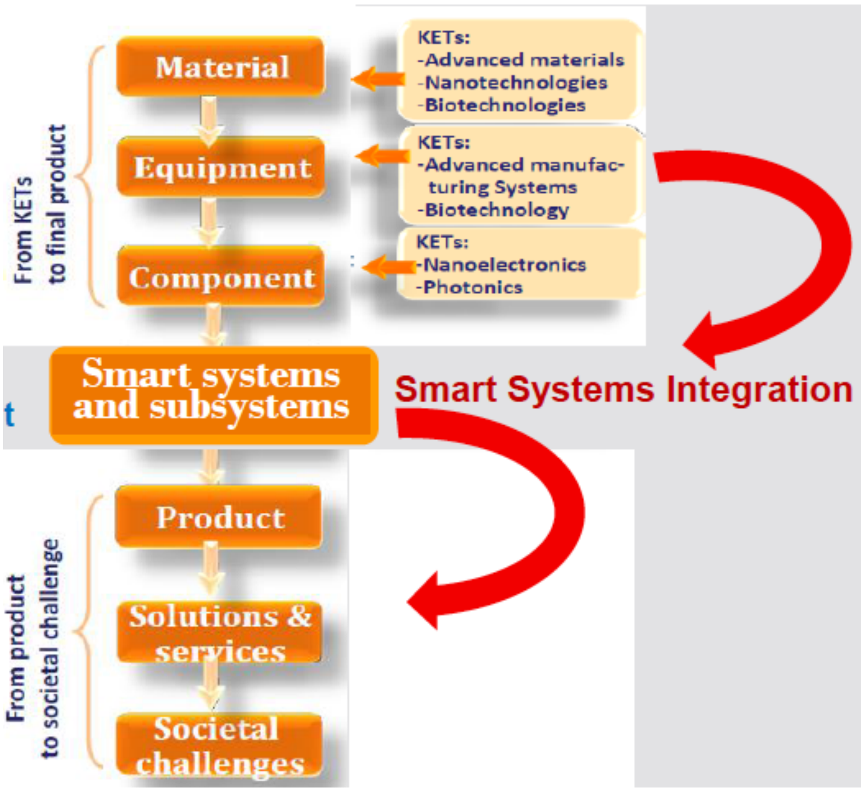


Figure: Smart Systems in the context of KET

2 Strategic Research Agenda

2.1 Structure of the EPoSS SRA

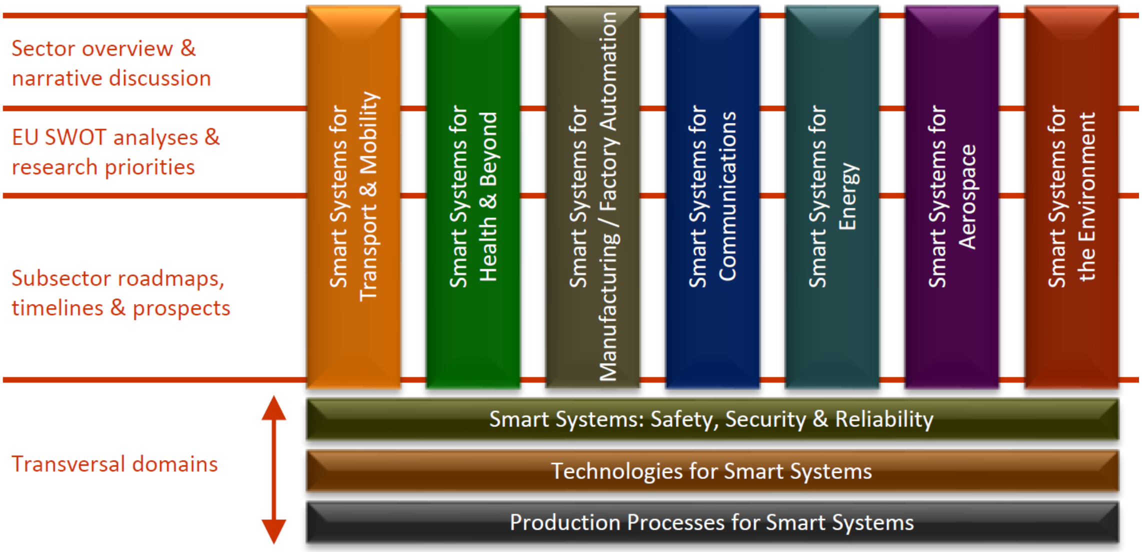


Figure: The Structure oft he Strategic Research Agenda of EPoSS

2.2 Implementation in FP7 Work Programs

2.3 Previous and current EPoSS Projects

3 Smart Systems: Functions and Technologies

3.1 Smart Systems Building Blocks

Smart Systems are self-sufficient intelligent technical (sub-)systems with advanced functionality. They sense, diagnose, describe, qualify and manage a given situation in order to perceive complex circumstances, be predictive, and take autonomous decisions. Their operation is further enhanced by their ability to mutually address, identify and work in consort with each other. They are able to interface, interact and communicate with users, their environment and with other Smart Systems, and to manage their energy consumption.

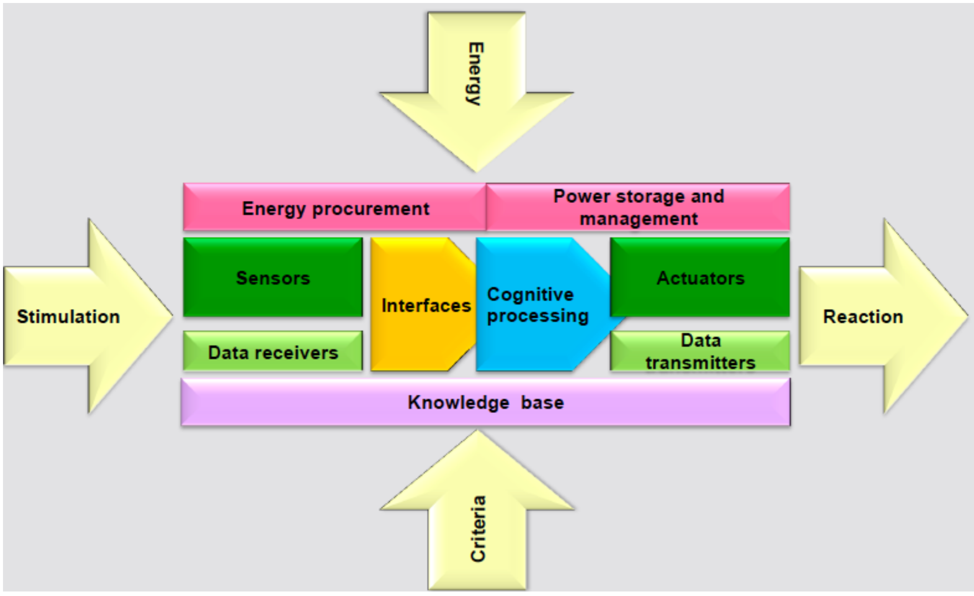


Figure: Building blocks of smart systems

Smart Systems can be standalone, networked, or embedded into larger systems; they comprise heterogeneous devices combining data processing with sensing, actuating, energy scavenging, and communication (see figure) and they excel in self-reliance and adaptability. What distinguishes smart systems from systems which are purely reactive is the knowledge base.

The development of Smart Systems requires the integration of inter-disciplinary knowledge from a manifold of enabling principles including nanoelectronics, micro-electro-mechanics, biosystems technologies, magnetism, photonics, chemistry, radiation and a multitude of other physical or chemical principles.

3.2 Development Process : Focus on Functionalities

Smart Systems developments are ultimately driven by the application to user-level needs of individuals and society. They identify the key systems functionalities to address those needs and marshal the most appropriate technologies in combinations to enable those functionalities (see Figure). By emphasizing functionalities, this development process is quite distinct from the alternative and typical route in non-smart development, which drives upwards from component level, often testing and conflicting with technology boundaries.

The major application fields for Smart Systems are in (e)wellness, (e)health and medicine, automotive and land/sea transportation, aerospace, safety and security, agriculture and food supply, energy conversion and management, storage and distribution, manufacturing, logistics and ICT. Smart Systems will enable and bring forward the technology breakthroughs needed to address the developing issues of public health and an aging population, environmental protection and climate change, the conservation of energy and scarce materials, enhancements to safety and security and the continuation and growth of economic prosperity.

The “smartness” of systems is expressed in autonomous and transparent operation based on closed loop control, predictive capabilities, energy efficiency and wider networking. Further typical functionalities of Smart Systems are e.g. reliable, intelligent, self-managed, expert and adaptable principles which are attentive to the needs, habits and capabilities of the user. Thus, the ever improving performance of signal processing technologies is transferred into smart systems, and the smart functionality is embedded into the very fabric of products, the built environment and its infrastructure. Eventually, the interaction between mankind and technology is improved through establishing smart human-machine interfaces.

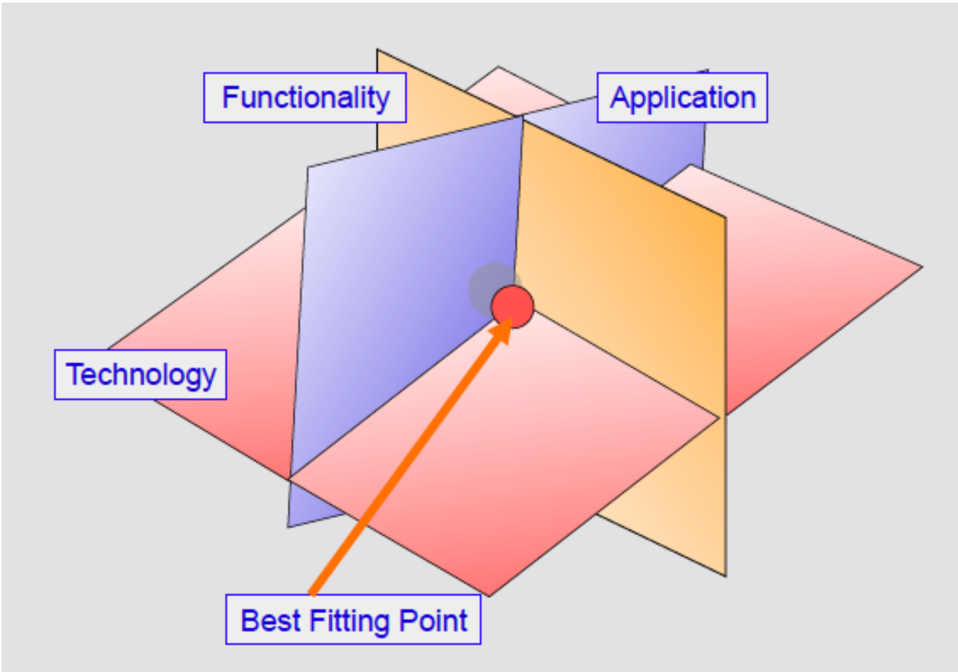


Figure: Smart Systems Development Process

In terms of the technology base Smart Systems can be considered as the consequent further development and future path of microsystem technology – including specialties such as MEMS, NEMS or MOEMS and RF MEMS. While microsystems are defined as miniaturised systems combining the sensing of physical, chemical or biological parameters, signal processing and actuators, Smart Systems are advanced technical systems with additional and highly advanced functionalities as described. Therefore, to enable the functionalities of Smart Systems one has to unlock the immense potential of new materials, effects and developments in combinations, across disciplines and magnitudes of scale bridging from nano- through micro- to macro-, to include multi-functional and composite materials, micro-, nano- and bio- technologies, multi-domain communications, signal processing and machine cognition. Linking technology between the nano-, micro- and macro-world systems integration is the key challenge. In this context, a particular relevance is to be attributed to Micro-Nano Bio Systems (MNBS) given their growing importance for various application sectors. MNBS are understood as Smart Systems combining microsensing and microactuation, microelectronics, nano-materials, molecular biology, biochemistry, measurement technology and ICT.

Ultimately, Smart Systems Integration will provide the functional connection of devices and subsystems at the component level (manufacturing), at the system level (integration into a macro system, or “handling level“), at the application level (integration into the overall system, or “product level “) and at the process level (integration of manufacturing processes including design, simulation, verification and testing). Systems integration may be based on monolithic, hybrid, multi-chip module or other techniques spanning several scales ranging in size from nano to micro to macro. These developments include also an impetus of electronic components development leading to smart components which demonstrate enhanced performance and functionality enabled by the re-use of nanoelectronics processes and building blocks offering very advanced performance, high voltage and high power operation or operating under special conditions.

3.3 The Evolution of Smart Systems

The progressive development of Smart Systems is characterised by their increasing autonomy through the twin effects of becoming increasingly self-sufficient in energy requirements and becoming less reliant upon external supervision and control. Advancements in the „smartness“ of a system are determined by the degree to which the key functionalities are implemented. The EPoSS community has defined the evolution of smart systems as follows:

Figure: Evolution of smart systems: gyro mouse (1st generation), continuous glucose monitoring system (2nd generatzion), fully automated car (3rd generation)

1st Generation Smart Systems integrate sensing and or actuation as well as signal processing to enable actions. Such Smart Systems are already routinely and successfully deployed in many sectors. One simple example is a gyro mouse translating 2 axis hand movements into cursor positioning (see figure). Other examples are systems able to monitor the health status of persons and to initiate necessary actions, pacemakers and safety systems in automotive applications, as exemplified by airbag systems and electronic stability techniques for chassis frames.

2nd Generation Smart Systems are built on multifunctional perception and are predictive and adaptive systems with self test capabilities that are able to match critical environments. Moreover they are equipped with network facilities and advanced energy scavenging and management capabilities. Systems of this generation are able to measure and deal with variability and uncertainty, yet generate an informed suggestion in the decision-preparing process regarding the original sample and the multitude of answers required by the detection objective. They will be more and more featured with the ability to learn and adapt, to change environmental conditions, and to respond accordingly. A striking example of a 2nd generation Smart System is a continuous glucose monitoring system for patients with diabetes which is measuring subcutaneous fluid parameters, predicting the blood sugar trends and warning the user to take action. Cross disciplinary development of 2nd generation Smart Systems will furthermore bring about simple artificial organs and in-body implants that work with the body chemistry rather than guarding themselves against it as is the case with conventional heart pacemakers. Other examples of such systems include smart RFID labels with measurement of multiple parameters like temperature, inclination and shock for transport monitoring have already been introduced into market.

3rd Generation Smart Systems perform human-like perception and autonomy and generate energy. The Smart Systems of this generation act independently and do not require any human control or decision. They may also be able to establish self-organizing communication networks and develop from self-test to self-calibration and self-healing. A prominent example of a 3rd generation Smart System is a highly or fully automated car which is executing steering, acceleration and deceleration autonomously, monitoring the driving environment by itself, and either needs the driver not at all or just as a backup. Other free-ranging systems e.g., autonomous bio-robots and swarming agents interacting between the physical and virtual world, are at the far end of this vision.

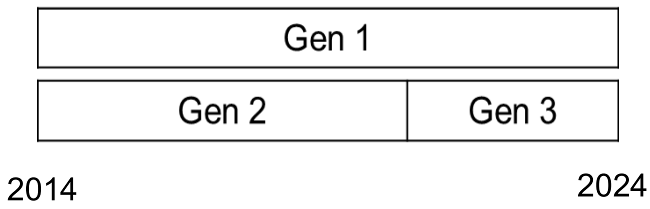
It is important to understand that the generations of smart systems develop at different speed depending on the functionality considered. In many cases, the further optimization of 1st generation Smart Systems still requires serious research and development efforts. Overcoming the scientific, materials and manufacturing hurdles presented by 2nd and 3rd generation Smart Systems, however, will give Europe a critical technology lead. Generating a comprehensive approach to their design will ensure not just a single range of competitive products, but the ability and agility to maintain that competitive edge into the future.

4 Smart Systems Research Fields

4.1 Sensing/Actuating

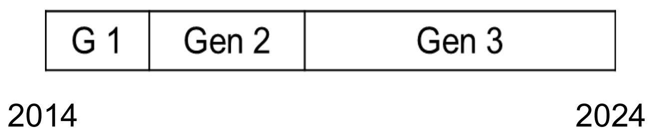
Research Area	Application Fields
Environment Monitoring and Recognition	**environment:** air/water/soil pollution monitoring and disruption and disaster prediction
	aeronautics: enhanced air diagnostics and collision avoidance, air traffic control, automated flying
	manufacturing: human activity interaction of robots
	automotive: Advanced Driver Assistance and highly automated driving
Monitoring of body parameters and Health / Usage Monitoring	**environment:** access control systems
	aeronautics: structural health monitoring, pilot health status monitoring
	automotive: driver's status monitoring
	manufacturing: process control for quality assurance
Multiple-Parameter sensing	**health:** integrated sensor for multiple biomarkers or molecules
	manufacturing: robotic perception
	environment: real-time weather information for precision agriculture
Remote Sensing	**environment:** separation systems in recycling; hazard security: detection of presence, age, gender, mood of individuals
	aeronautics: turbulence detection
Nomadic/ autonomous sensing	**health:** Point of Care home devices
Functionalised sensing	**health:** scalpel with force feedback **automotive:** thermal management of EV
Drive-by-wire/wireless	**health:** micro-implants, percutaneous/implantable drug delivery systems
	aeronautics: fly-by-wire
Motion control	**manufacturing:** robotic manipulation and grasping **aeronautics:** adaptive avionics **automotive:** smart wheel

Surface Actuation + Adaption	**aeronautics**: adaptive avionics
Transmission of touch + smell	**manufacturing**: approximation of human quality perspective
Precise Positioning	**health**: surgery robots



4.2 Signal and Cognitive Processing

Research Area	Application Fields
Pattern recognition	**health**: recognition of healthy/malignant tissues **aeronautics**: air traffic control
Closed-loop-control	**environment**: industrial emissions control & hazard safety **aeronautics**: autonomous navigation
Data Fusion	**aeronautics**: advanced weather forecast **automotive**: highly automated driving; trajectory prediction
Self-learning	**manufacturing**: autonomous navigation in human environments **aeronautics**: adaptive avionics **automotive**: smart wheel
Life time prediction	**automotive**: battery value assessment
Behavior prediction	**health**: neuro interface, pacemakers



4.3 Energy Procurement, Storage, Management

Research Area	Application Fields

Energy scavenging	**health**: micro-implants
Energy management	**aeronautics**: adaptive jet engine
	automotive: thermal management and conditioning of EV

G 1	Gen 2	Gen 3

2014 2024

4.4 Networking (Data Receivers/Transmitters)

Research Area	Application Fields
Integration of Nomadic Devices	**automotive**: user adaptable EV
Sensor Networks	**environment**: real-time weather information, ultra local weather forecasts
	aeronautics: redundant distributed black box recorders
	automotive: Battery Cell balancing
Body area Networks	**aeronautics**: structural health monitoring

Gen 2	Gen 3

2014 2024

4.5 Interfaces

Research Area	Application Fields
Managing the organic/ inorganic Interface	**health**: biocompatibility, Lab-on-chip
Challenging environments (pressure, temperature, vibration, radiation)	**aeronautics**: high speed Internet connectivity during flight
Implantables	**health:** artificial tissue, organs, implants
Augmented reality	**aeronautics**: augmented flight deck, UAV operator interface **automotive**: repair assisstant

Gen 1	Gen 2

2014 2024

4.6 Knowledge Base

Research Area	Application Fields
Mapping	**aeronautics**: automated flying
Access to references/ knowledge bases	**health**: wiki/communication with experts during surgery, live guidance
Positioning & Targeting	**aeronautics**: air traffic control, collision avoidance system

G 1	Gen 2	Gen 3

2014 2024

5 Applications-specific Developments

5.1 Health

A specific and promising application of Smart Systems in the health domain can be expected from the use of current and future ICT-products to improve health e.g. smart watches that can sense pulse, smart phones with front camera can monitor eyes movements, touch screens can give feedback on neurological disturbances

Generally, the smart operating room is another example built on a unique combination of smart systems functionalities for specific applications. This applies to the area of implants, where predictive and adaptive components and organs as well as optimized bioreactors are needed. Another application domain in this field is minimal invasion. Smart functionalities here relate to robots for precision and remote surgery as well as tot he combinations of imaging/diagnostics and therapy, e.g. in an endoscope or a smart pill. Also assistance systems for the doctor greatly benefit from smartness, e.g. functionalised surgery tools building on real time analysis and guidance by imaging, and the interactive access to information provided by augmented reality, knowledge, and monitoring data.

5.2 Manufacturing

In the field of manufacturing, robotic co-workers that can work with, or in the presence of humans are an important application domain for specific smart systems functionalities including environment recognition and monitoring, Motion Control, Human Robot Collaboration.

Another significant area are smart process lines that can analyse variations in raw materials and rapidly change parameters based upon prior experience. They combine functionalities like the monitoring of body parameters, multiple-parameter sensing and adaptive capabilities

5.3 Environment

In the environment field advanced smart systems for efficient use of irrigation resources to create or maintain micro climates for agriculture can be considered applications with specific functionalities, as well as functionalised products to detect and allow specific treatment of recoverable materials, e.g. RFID-based.

5.4 Automotive

An exciting example of a Smart System from the automotive domain is the smart wheel which aims to integrate braking as well as suspension functions and active torque vectoring, thus offering additional features in vehicle stability. The specific functionalities it requires include Multi-Parameter Sensing, Motion Control, Power Control, Thermal Management, and Closed Loop Control.

Of particular interest also is the highway pilot which enables highly automateddriving without the driver in the loop, including autonomous overtaking, but allowing the driver to intervene. This requires a sophisticated combination of functionalities like e.g. Environment Recognition, Data Fusion, Positioning/Mapping, and Monitoring of Body Parameters.

6 Horizontal technologies

6.1 Multi Disciplinary Approaches

a) Improvement of existing smart systems particularly for health applications, food quality and environmental monitoring in order to make them more robust, autonomous and better networked.

b) Interdisciplinary Smart System: Micro-Nano-Bio-Systems (see also pt. a)

c) Sensor/Actor systems for autonomous robotics,

d) Printed functionality: Large area Smart Systems: walls, facades, roofs, panels, floors, System-on-product: smart interfaces, smart packaging

e) Advanced manufacturing concepts (including self-assembling) in order to improve the cost-performance relation of smart systems

6.2 Multi Functionality

a) Multi-faceted sensing and inference, very large sensor arrays: building-wide, region-wide

b) Single-device combinational sensing, multi-device polling and referral

c) Predictive and reactive systems able to match critical environments and with network facilities, advanced energy scavenging and management capabilities.

d) Multifunctional structures: Merging structure with function, avoiding the need for mechanical support, seamless sensing, processing, energy supply and actuation

e) Artificial organs and in-body implants that work with the body chemistry

f) Smart systems as part of IoT solutions contributing to the vision of an accident free traffic

g) Self-adaptive electro-optical systems for efficient production, nano-scale mechanical actuators

6.3 Self Assembling

a) Smart energy storage and management

b) Smart materials and composits for intelligent storage

c) Free-ranging energy-autonomous systems, e.g., autonomous bio-robots and swarming agents interacting between the physical and virtual world

d) Self-monitoring of usage and health embedded into distribution network components

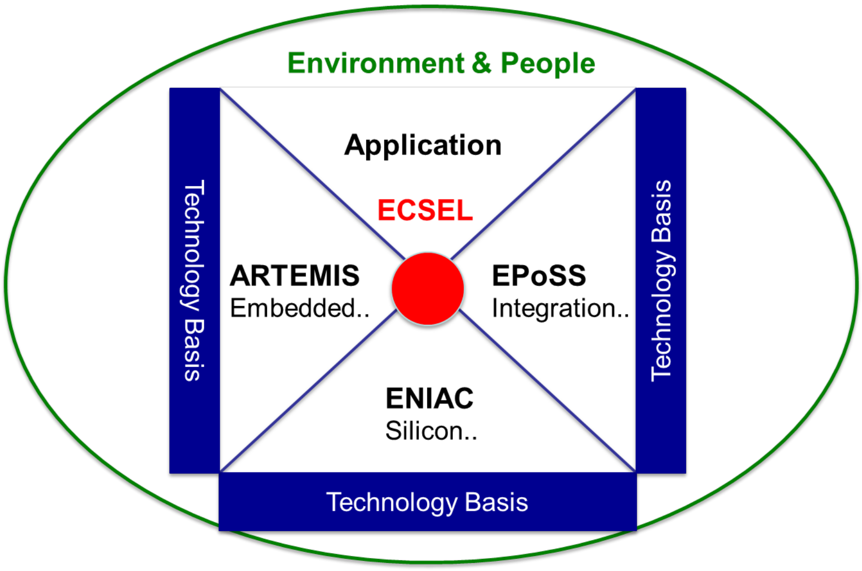
e) Self-testing, self-calibration and self-healing Smart Systems technology, Innovative concepts for energy scavenging or network design

f) Self-fabricated and self-assembled smart systems, incl. self-assembly technologies for labs-on-a-chip or efficient sensor arrays for high-throughput screening in genomics and drug discovery, new superior materials using molecular self-assembly

g) New approaches in design, modelling and assurance (multi-scale, multi-disciplinary), risk mitigation

7 Synergies

7.1 EPoSS expectations from and contributions to EGVIA



7.2 Topics for potential joint projects

1. Plug-in capable car
   (data fusion)
2. ADAS and autonomous vehicles
   (sensor / actuator and testing)
3. Energy consumption / environment impact characterization
   (sensor fusion, integration in harsh environments)
4. Analytical Instruments
   (system integration)
5. Smart home appliances
   (inclusion of human factor)