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Challenge 3: Alternative Paths to Components and Systems

Challenge 3 covers nanoelectronics and photonics, the heterogeneous integration of these key enabling technologies with related components and systems, as well as advanced computing and control systems at a higher level. Energy-, resource- and cost efficiency as well as recycling/end of life issues are major drivers across the Challenge. Its overall aims are:

- to reinforce European industrial leadership in these key enabling technologies through miniaturisation, energy-efficiency, performance increase and manufacturability, for information and communication systems and other applications in 2020 and beyond;
- to enable further integration and cross-fertilisation of key enabling technologies towards building energy- and resource-efficient components and systems through the convergence of nanoelectronics, nano-materials, biochemistry, measurement technology and ICT;
- to expand Europe's industrial leadership in embedded and mobile computing systems towards powering the cloud with cost and energy efficient servers, and towards exploring new paradigms for control in systems with mixed criticalities where the embedded world meets the internet world, and systems of autonomous systems with emergent behaviour.
- to promote inter-disciplinary R&I activities by bringing together different research domains and constituencies with the aim of increasing impact and of bridging to Horizon 2020;
- to stimulate the innovation of European industry by well-targeted take-up actions, with special emphasis on SMEs – either as users or as technology suppliers.

In those areas related to the ENIAC[1] and ARTEMIS[2] JTIs, Challenge 3 focuses on research on new paradigms which are applicable across several application domains. Related to Photonics and to the integration of components and systems, work is aligned with the strategic research agendas of Photonics21[3] and EPoSS[4].

Stimulating innovation through take-up

The objectives under this challenge include actions for technology take-up and innovation, which aim at creating an innovation ecosystem where industry is introduced to new technologies and markets. They focus on emerging innovative technologies and processes, which need to be validated and tailored for customer needs before being able to compete on the market. Special emphasis is on strengthening the participation of European SMEs, both on the supply-side and on the demand-side.

Two types of take-up activities are supported at **technology-domain level,** each of which brings together all relevant actors from the use and supply side supported by competence centres:

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[1] http://www.eniac.eu

[2] http://www.artemis-ju.eu

[3] http://www.photonics21.org

[4] http://www.smart-systems-integration.org

a) **Assessment experiments** assess new or enhanced equipment, tools, processes, or methodologies, and their use. The objective is to support suppliers, in particular SMEs, in crossing the "valley of death" from research prototypes to successful market adoption (objective 3.3).

b) **Access services** provide fast access to knowledge, training, prototyping, manufacturing, design or engineering services for first users and early adopters, in particular SMEs, through experiments. The objective is to reinforce the competitiveness of users by enabling them to exploit innovative technologies (objectives 3.2, 3.3, and 3.4).

For both types, activities are expected to be clustered in larger projects to achieve critical mass and to better exploit EU-added value. Common tasks include: targeted dissemination; management of calls for new actions; exploitation of synergies across actions. To better cope with the speed of innovation in ICT, implementation must be flexible and fast. Part of the actions and partnership are to be defined from the outset, while additional experiments or users, may be identified through open calls during the action (max. 50% of the total budget).

To facilitate the emergence of a European **innovation-ecosystem,** a network of innovation multipliers will be established across all take-up projects and disciplines to achieve broader coverage thereby maximising impact and better addressing the needs of SMEs. Tasks include establishing a single innovation portal allowing one-stop-shopping for newcomers; sharing of best practices and experiences; dissemination; and brokering between users and suppliers in light of open calls. The participation of actors traditionally not participating in research projects or programmes is encouraged, e.g. regional innovation clusters, chambers of commerce, societal actors, industrial associations, technology transfer departments of large research labs. This cross-objective action is included under Objective 3.3.

Objective ICT-2013.3.1 Nanoelectronics

This objective addresses overcoming serious barriers, which are currently slowing down the expected evolution of CMOS, including the fundamental limits of devices and materials, system level limits, energy-efficiency, power density issues, design complexity issues, and cost. It is in line with the ITRS roadmap. It complements FET, and the more application driven and closer to market activities carried out under the ENIAC JU. Take-up actions in nanoelectronics, including Europractice-type actions, are addressed under Objective 3.3.

<u>Target Outcomes</u>

a) Integration of advanced nanoelectronics devices and technologies (16nm and below)

- New solutions to boost performance in More Moore. This includes Ge, III-V compound semiconductors, graphene, CNT or nanowires.
- Innovative solutions to boost functionality in More than Moore.
- New switches for Beyond CMOS and beyond silicon, charge-based or non-charge-based with a sufficient level of technological maturity.
- Interconnects and 3D integration at device, chip and wafer level.

b) Advanced nanoelectronics manufacturing processes.

- More Moore IC Manufacturing: efficiency and productivity enhancement
- Manufacturing approaches to Beyond-CMOS and advanced More-than-Moore, and to their integration with nano-CMOS including 3D integration.

c) Design, modelling and simulation for advanced nano-electronics technologies

- Circuit- and system-level modelling and simulation: e.g. quantum and atomic scale effects; electro-thermo- mechanical effects; modelling for new materials, processes and devices.
- Design technologies for "Si complexity" challenges addressing non-ideal scaling of device parasitics and supply/threshold voltages; manufacturing variability; thermal effects; decreased reliability; ageing effects; coupled high-frequency devices and interconnects.
- Innovating with nanoelectronics - designing heterogeneous SOC integration, re-using IP.

d) International Co-operation

One support action to develop a European strategy which addresses the challenges in manufacturing for 450 mm in dialogue with G450C and with the US, Korea, and Taiwan.

Expected impact:

- Secured European **industrial competence** in advanced nanoelectronic technologies, and strengthened European **capacity to manufacture** nanoelectronic products.
- **Improved performance at lower cost**: improvements boosting performance and functionality at all levels (device, circuit, system), and in particular in relation to a few critical parameters which drive integration and miniaturisation such as operating frequency, switching time, throughput, device or circuit complexity;
- **Higher energy efficiency**: reduction of device/circuit/system power consumption through improved energy per operation, efficiency of basic components, and control of leakage currents;
- **Higher levels of integration and miniaturisation**: improvement in component/functions per chip, cost per function, compactness, design productivity exploring new materials, architectures, and design - going beyond just an extension of known practices;
- **Improved structuring**: improvement in coordination of European research priorities and their industrial relevance, exploitation perspectives for Europe in terms of competitiveness and, jobs.

Funding schemes

a) – c): STREP

d): CSA

Indicative budget distribution

EUR 31.5 million for STREPs
EUR 0.5 million for one SA

Call: FP7-ICT-2013-11

Objective ICT-2013.3.2 Photonics

The aim is to advance the state-of-the-art of photonic devices (i.e. components and sub-systems such as transmitters and receivers, lasers and light sources) in application fields where Europe is strong[5] and to develop advanced products with a view to industrialisation. Research actions should demonstrate strong industrial commitment and be driven by user requirements. They should include validation of results for the target applications and address the supply chain as appropriate.

Target Outcomes

a) Application-specific photonic devices

Focus is on new device technologies and architectures, including as appropriate the related materials, processing and device integration issues. Research actions should address:

i) Optical data communications[6]: Photonic devices enabling future networks with increased flexibility, bandwidth, energy efficiency and cost effectiveness. Specific emphasis is on devices for fully converged optical networks allowing several bitrates, modulation formats and/or radio standards on the same infrastructure; and on devices for flexible, dynamic optical networks coping with varying traffic demands, possibly including quality of service management at the optical layer. Device manufacturers, suppliers of communication equipment and network operators should be involved.

ii) Solid-State Lighting (SSL):

- Large-area, large uniformity OLEDs for general lighting applications with increased lifetime and brightness enabling an effective market introduction.
- High performance, reliable and low-cost SSL lamps and modules with added intelligence to provide optimal lighting systems.

Research actions should also address end-of-life/disposal/recyclability issues and involve SSL manufacturers and/or suppliers.

iii) Lasers for industrial processing: Short and ultra-short (below 10 ps) pulsed laser sources with average output power above 200 W, high conversion efficiency and repetition rate for high speed surface processing or cutting at micro/nanometre precision. Activities may include the necessary optical elements for beam delivery, guiding and shaping. Laser device and equipment manufacturers and end users should be involved.

b) Cross-cutting technologies for a wide range of applications

Focus is on technologies for automated, low-cost volume manufacturing of highly integrated, complex photonic devices:

i) Integration technologies for photonic integrated circuits offering enhanced capabilities (e.g. integration density, functionality, performance) through the use of innovative materials, nanophotonics or other new functional structures. This may include also heterogeneous integration based on wafer processing technologies. Photonic device manufacturers should be involved.

ii) Cost-effective assembly (including in particular hybrid optical integration) and packaging technology. Actions should also address the related thermal, electrical and mechanical challenges and fabrication technology. Photonic device manufacturers and fabrication tool suppliers should be involved.

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[5] Due to synergies, biophotonics is addressed together with micro-nano-bio systems under objective 3.3

[6] Photonic devices for communication networks support the overall vision and requirements of Objective 1.1 "Future networks"

c) Technology take-up and Innovation Support

i) Access services enabling the wider adoption and deployment of photonic technologies in innovative products, in particular by SMEs and driven by their business needs[7]. Proposers are referred to the description of take-up actions in the introduction to this Challenge.

ii) Coordination and support actions fostering innovation in SSL[8]: a) Bringing together actors along the value chain to promote innovative design and new business models through open innovation. b) Promoting the cooperation of lighting industry and end users (e.g. architects, designers, installers) to accelerate the wide deployment of SSL. c) Promoting SSL and analysing its effects in applications where there are benefits for people's health and well-being. d) Addressing scarcity of materials, use of hazardous materials and recyclability & disposability of SSL products.

iii) Coordination and support actions: a) Cooperation of photonic clusters and national technology platforms to stimulate the innovation potential of SMEs, based on business cases demonstrating a clear potential for sales and employment growth. b) Raising the interest of European citizens, young people and entrepreneurs in photonics. Actions should be driven by the relevant stakeholders.

d) ERANET-plus action

A joint call for proposals on a photonics topic of strategic interest, to be funded through an ERANET-Plus action between national and regional grant programmes.

Expected Impact

- Secured European **industrial leadership** in photonic applications and technologies, and safeguarded European capacity to manufacture innovative products.
- Broader and faster **take-up** of photonics in innovative products, in particular by SMEs.
- Accelerated innovation and deployment of SSL;
- Improved **innovation** effectiveness of photonics clusters in particular towards SMEs;
- Increased **awareness and interest** in photonics amongst the general public, youngsters and entrepreneurs.
- Closer cooperation and greater alignment between the participating regional, national and EU-wide research programmes through an ERANET+ action.

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Funding schemes

a), b): STREP; c) (i) IP; c) (ii),(iii) CSA; d) ERANET-Plus

Indicative budget distribution

IP and STREP: EUR 50 million, maximum EUR 8 million for IP.
CSA: EUR 7 million
ERANET-Plus: EUR 4 million (any remaining funds will be transferred to target outcomes a) and b)).

Call:
FP7-ICT-2013-11

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[7] This action should cooperate with others in key enabling technologies in Challenge 3 – see Objective 3.3 b) ii)
[8] These actions are in line with the Green Paper "Lighting the Future", COM(2011) 889 final.

Objective ICT-2013.3.3 Heterogeneous Integration and take-up of Key Enabling Technologies for Components and Systems

Building energy and resource efficient systems for competitive, highly performing products, applications and services requires further integration of key enabling technologies, components and subsystems. It also needs a functioning ecosystem of actors, in which the research, design, and take-up of innovative technologies is stimulated. Strong industrial participation along the value chain is a must as well as focusing not only on research but also on deployment driven by concrete business cases. End-of-life/disposal and recyclability issues should be addressed as appropriate.

Target outcomes

a) Integrating heterogeneous technologies

This target outcome addresses the integration of Key Enabling Technologies for Components and Systems across multiple research fields (nano-systems. organic electronics, micro-nano-bio systems, bio-photonics), materials (organic and inorganic) and functions (sensing, actuating, communicating, processing, energy harvesting) with emphasis given to supporting the semiconductor heterogeneous integration (hardware, software, photonics, MEMs). The major challenges include mastering interactions and underlying complexity; design, prototyping, manufacturability and recyclability; biocompatibility, safety, security, reliability, miniaturisation; low energy use and resource-efficiency. Focus is on:

i) **Miniaturised smart systems** based on the integration of different key enabling technologies and functions, which have the ability to sense, describe, predict, decide, and to interact with their environment. Being standalone, networked, or embedded into larger systems, smart distributed environments or smart spaces; they use highly sophisticated interfaces between systems and users and can address and identify each other.

ii) **Hybrid integration of organic electronics and micro/nano electronics** on flexible, large area and/or stretchable substrates, combining different materials, components and subsystems, creating opportunities for application driven integrated systems. Focus is on interfacing different types of material, different types of components and subsystems, different design styles or production processes and dealing with process variations, multi-layers, packaging and encapsulation.

iii) **Further development and validation in real settings of micro-nano-bio and bio-photonics systems** addressing key societal challenges, in particular in the health (for early or fast diagnosis and monitoring or surgery) and the food sectors (quality and safety), with involvement of relevant industrial stakeholders and driven by users.

b) Technology take-up and innovation support

Technology take-up is stimulated by a set of supply- and demand-side measures, supported by a network of innovation multipliers. Proposers are referred to the general description of take-up actions in the introduction to this Challenge.

(i) Assessment experiments in nano-electronics and smart systems for technology suppliers and integrators to evaluate their novel equipment, processes and building blocks with potential customers.

(ii) Access services for new users of nano-electronics design and smart systems spanning the full innovation cycle and ranging from consultation, assistance in conception and design, access to tools and equipment, and training; to feasibility studies, prototyping, pilot runs, and advanced flexible manufacturing – including Europractice-type actions.

(iii) A **network of innovation multipliers** established across all take-up projects of this Challenge taking an interdisciplinary approach to achieve broader technological, applications, innovation, and regional coverage thereby maximising impact and better addressing the needs of SMEs.

(iv) Supporting the development of an **eco-system for smart systems integration** in Europe, including activities such as co-ordinating regional clusters; developing training material and services; international cooperation related to road-mapping, manufacturing and standardisation; and reaching out to attract the interest of citizens, young talents and young entrepreneurs.

(v) Cooperation of scientists, technology developers and providers, and end users for accelerating the deployment of bio-photonics and micro-nano-bio solutions.

(vi) International co-operation with Africa on roadmapping and constituency building towards the development and deployment of point-of-care diagnosis and treatment of human and animal diseases in rural areas.

Expected impact

- Increased **industrial competitiveness**, in particular of SMEs, through strengthened capabilities in systems and innovative products and services.
- **Improved system characteristics**: higher performance and functionality; physical features; economics/cost; environmental, in the context of the final application.
- More **autonomous** smart systems which are aware of and adaptive to their environment, ubiquitously connected, with cognitive abilities.
- Improvements in **innovation capacity and competitiveness** of European industry measured through indicators such as an increased number of SMEs and other newcomers taking up novel technologies.

Funding schemes

a): IP and STREP;
b) (i), (ii): IP;
b) (iii), (iv), (v), (vi): CSA.

Indicative budget distribution

- IP and STREP: EUR 61 million with a minimum of 25% to IPs and 25% to STREP. It is expected that a minimum of one IP each for a)(i), a)(ii), b)(i), and b(ii) is supported;
- CSA: EUR 3 million.

Call:

FP7-ICT-2012-10

Objective ICT-2013.3.4 Advanced computing, embedded and control systems

Driven by use cases addressing the grand societal challenges in Europe, the objective is to combine and expand Europe's industrial strengths in embedded and mobile computing and in control of networked embedded systems along two dimensions: (1) designing the next generation of cost- and energy-efficient computing systems to power the future "cloud", and (2) expanding the functionality of embedded systems architectures towards controlling their behaviour within a system of systems (SoS) and towards seamlessly integrating safety- and time-critical with non-critical functionalities sharing common computing resources and evolving from the convergence of the embedded and the internet worlds.

Addressing novel paradigms applicable across different applications, work is complementary to what is addressed under the Joint Undertaking ARTEMIS. While computing is addressed under several challenges, work in this objective focuses on computing systems for embedded systems and for data centres, and generic technologies and tools applicable across computing segments. Thereby it is complementary to the work under Objective 1.2 related to computing architectures for future cloud services, and Objective 9.10 related to exa-scale computing, and Objective 6.2 focusing on energy and environmental performance of data centres.

<u>Target outcomes:</u>

a) Next generation of energy- and cost-efficient servers for data-centres

System design addressing the full server eco-system: processor, chip, board, rack, storage, network, data-centre, system software, applications. Research challenges include: taming the data deluge; holistic integration of hardware and software in future servers including 3D-stacked server chips or optical interconnects; operation and load-balancing over a collection of physically distributed sites. Being highly ambitious with strong industrial participation and a clear path to commercialisation, projects should deliver a full prototype and validate it under real-life workloads from various application areas including clouds.

b) Control in embedded systems with mixed criticalities sharing computing resources

Innovative solutions capable to manage design, modelling, verification, validation and certification of networked complex systems featuring an extended functionality through seamless integration of mixed criticalities. Focus is on data, energy and system integrity in addition to security, safety and performance when exploiting multi-core chips or heterogeneous distributed systems. An integrated approach is expected on the one hand addressing fundamentally new perspectives of control and computing and on the other hand building on existing or emerging approaches for standardisation and certification. Work should encompass prototyping and validation of the developed methods and architectures in minimum two application domains.

c) Exploiting synergies and strengths between computing segments

Bringing together teams from embedded computing and high-performance computing to jointly address challenges that are common in these two areas and are magnified by the ubiquity of many-cores and heterogeneity across the whole computing spectrum. Examples of challenges include: low-power and energy efficiency, performance analysis, dependability, time-criticality, hybrid programming, parallelisation, compilation, debugging, co-design, customisation, virtualisation, reconfigurability. Projects should focus on one specific and credible common challenge and prove a real cross-fertilisation of expertise.

d) From analysing to controlling behaviour of Systems of Systems (SoS)

Analysing and modelling SoS with possibly emergent behaviour and their control, and validating new SoS engineering approaches in industry-driven case studies of real applications, such as distributed energy systems and grids, multi-site industrial production, or automated transportation. Generic aspects of the approaches should be stressed, basic concepts elaborated and open research issues identified.

e) Access to novel computing technologies for industry

Access services for technology transfer from academia to industry in computing including activities to strengthen links to venture capital and promoting entrepreneurship. The aim is to facilitate the transformation of research prototypes to products and services and to introduce lead customers to technologies and tools for multi-core and hybrid systems across the computing spectrum. Proposers are referred to the general description of take-up actions in the introduction to this Challenge.

f) Constituency building and road-mapping

Co-ordinating SoS-related projects towards deriving common concepts and research challenges and building constituencies for a European R&I agenda on SoS. Building constituency and developing a R&I agenda towards radical improvements in software development for advanced computing systems.

Expected Impacts

- Reinforced **competitiveness** of European technology suppliers across the computing spectrum; in particular for data-centre servers with two orders of magnitude improvements in total cost of ownership and energy efficiency.
- Reinforced European **technological leadership and industrial competitiveness** in the design, operations, and control of embedded systems with mixed criticalities and SoS.
- **Improved systems characteristics:** energy/cost efficiency, controlling dynamic and emergent behaviour, managing different criticality levels, security, safety, degree of integration in generic architectures and platforms.
- Increased **take-up** of European computing technologies in industry, in particular SMEs.
- More **efficient application software development** by breaking the dependence on dual expertise for application development and customisation for advanced computing systems.

Funding schemes:

a), b): IP – it is expected that a minimum of one IP is supported for each target outcome.
c), d): STREP
e), f): CSA

Indicative budget distribution

- IPs and STREPs: EUR 69 million with a minimum of 40% to IPs and 30% to STREPs
- CSAs: EUR 3.5 million

Calls:

FP7-ICT-2013-10