FP7 ICT Work Programme 2009-10 Orientations
Annex: Detailed orientations per Challenge and FET

This paper presents the orientations for WP2009-10 of ICT in FP7. It takes into account the input received so far from ISTAG, from the ETPs, from various consultations with external experts in workshops and meetings, studies and analysis as well as the results of the first two Calls of ICT in FP7. The overview part (main document) summarises the main findings from the input received and the proposed priorities, features and structure. The chapters in this annex identify the objectives to be achieved in the various parts of the WP.

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Challenge 1: Pervasive and Trusted Network and Service Infrastructures

Analysis

The "Future Internet" emerges as a federating research theme globally, as the ever growing number of networked applications and business models - especially those supported by the Internet and increasingly connected to other communication infrastructures - bring novel challenges in terms of scalability, mobility, flexibility, security, trust and robustness of networks and services. With the emergence of a multiplicity of “digital” players at all levels of the networked value chain, no particular stakeholder can claim to be in control of complete end-to-end services or systems. Crossover value between different IT/telecom/software/media technologies and environments has become the norm, imposing flexible and adaptive technologies to handle increasing levels of complexity and heterogeneity with customisation and personalisation being key differentiators of competing offerings.

Future sophisticated networked services will be established around the aggregation of multiple building blocks available from multiple sources and vendors. Clear emphasis must hence be placed on ensuring interoperability through agreed interfaces eventually leading to industry standards. Technical interoperability must be complemented by semantic interoperability, enabling the integration of business or social processes stemming from heterogeneous environments at enterprise or consumer level.

Within these networked environments, consumer and enterprise usages are also bringing new demands for the management and retrieval of unprecedented volumes of digital content and data streams, notably in the form of collaborative usages, which open new perspectives beyond the current Web 2.0 paradigm.

From the ***network*** perspective, broadband and mobility will remain key research drivers. The introduction of High Speed Packet Access technology in 3G networks has prompted a 40% increase of mobile data usage. Still, current mobile technology does not meet the ambitious targets set in the global context of 4G systems. For fixed access, a four fold increase beyond current state of the art represents an imperative. Cognitive/reconfigurable radio and networks are essential technologies capable of meeting the objectives of the EU spectrum policy whilst bringing down networks' capital and operational expenditure.

Sensor networks and machine-to-machine communication systems emerging at the edge of networks bring about important architectural perspectives for the underlying network and service infrastructure. User-controlled (home) networks notably based on femtocells (and community networks) bring new architectural and management challenges.

Altogether, the proliferation of end-user devices, the heterogeneity of network types, the range of mobile and broadband demands, and the imperative for stronger security call for a reappraisal of the current Internet protocols and architecture.

From the ***software/service*** perspective, an Internet of dynamically combined services fully reflects the requirements of IT/telecom/media industries. They seek to deploy worldwide service delivery platforms and flexible infrastructure allowing for the creation of new opportunities for new market entrants seeking to establish themselves as providers of innovative services. This trend towards “third party generated service” mirrors at business level the trend of “user generated content”. These developments also respond to the move towards user-centric services, a trend illustrated by the advances in Service-Oriented-Architectures and in service front-ends as the interface to users and communities. This trend is also supported by novel technologies and business models, such as Software-as-a-Service (SW delivered on line only when needed) or open source.

In this context, virtualisation of resources remains an important research driver enabling the delivery of networked services independently from the underlying platform. This trend is also of particular relevance to network operators, as it enables them to move up the value chain with innovative service offers beyond network management/customer care applications. It also paves the way towards flexible deployment of dynamically composed services, which will in turn give rise to advanced collaborative environments.

The realisation of these objectives, which will open up new industrial opportunities, requires major breakthroughs in software engineering methods and architectures addressing complexity in distributed, heterogeneous and dynamically composed environments, as well as non-functional requirements.

From the ***networked enterprise*** perspective, network/IT industries target the development of integrated/interoperable service platforms matching the outsourcing requirements of businesses. Such platforms have specific functionality, performance and collaborative usage requirements as they have to be integrated with enterprise software tools. Efficient and flexible management of inter-business relations including knowledge, trust, reputation, and identities as well as interoperability notably at semantic level are key research drivers.

Integration of evolved RFID tags and of sensors, in particular in portable devices, result in the emergence of new business processes as well as highly effective payment and billing systems calling for major changes in the ICT architectures of enterprises, in particular SMEs. This in turn gives rise to new demands being placed on the underlying service/network platforms. Information processing/filtering at the network periphery (middleware), integration with the enterprise business application and management, service discovery and object management architectures emerge as key research drivers.

From the ***networked media*** perspective, user-generated/centric content over the Internet as well as community networks and the use of peer-to-peer systems are generating new business opportunities. It is anticipated that by 2012 a quarter of all content will be user-generated and passed between centralised as well as peer to peer networks. Interaction with content, media-to-network dynamic adaptation, search capabilities across distributed repositories and P2P network (including mobile devices) and dynamic adaptation to memory characteristics of multiple terminals remain solid research drivers.

Advances in 3D processing give rise to innovative applications notably in gaming technologies and in virtual worlds which place new types of traffic demands and constraints on network architectures. 3D collaborative platforms create new requirements in terms of information representation, filtering, aggregation and networking. They also drive demand towards more sophisticated search tools and raise issues of identity management, ownership and trading of virtual digital objects, right of use, and personalised advertisements. These environments coupled with their usage rules hold the promise of a "3D Media Internet" which will form the basis of tomorrow's networked and collaborative platforms in the residential and professional domains, in virtual/gaming applications, and in digital and electronic cinema.

From the perspective of ***secure, trustworthy and resilient*** ICT infrastructures and services, the future networked society will depend on massive data collection for security surveillance, creation of Web communities and personalised services. Data collectors are in an uphill battle to protect their data and ensure compliance with data protection regulation and increasing societal demands for privacy and trustworthiness. At the same time, hackers, organized crime and terrorists are quick to use new technology in an efficiently organised underground e-market.

Despite significant efforts of industry, networked infrastructures become more vulnerable. Current ICT developments lead to more complex large-scale polymorphic networks with massive distributed data storage and management capacity. Research is needed for new and more effective security, trust and privacy, coherently addressing technological, societal and legal issues, in an effort to ensure a society based on freedom, creativity and innovation, whilst providing security for its citizens and critical infrastructures.

There is an increasing demand from academia and industry to bridge the gap between long-term research and large-scale experimentation, through ***experimentally-driven research*** consisting of iterative cycles of research, design and experimentation of new networking and service architectures and paradigms addressing all levels, including horizontal research on issues such as system complexity and security.

A fundamental need in this approach is the set-up of ***large-scale experimentation facilities***, going beyond individual project testbeds, which are also needed as validation tools, including for interoperability issues. They would help anticipating possible migration paths for technological developments which may be potentially disruptive, discovering new and emerging behaviours and use patterns in an open innovation context, as well as assessing at an early stage the socio-economic implications of new technological solutions.

There is a clear need for putting together different research communities in an interdisciplinary approach, which would be stimulated and enabled by flexible experimentally-driven research approaches that cut across layers, in a large systems perspective, for instance from network connectivity and service architectures to security solutions and beyond, i.e. not limited to a few levels of the value chain or to a single objective.

Orientations

There is today no unified view of the stakeholders as to what a "Future Internet" may or should look like, especially in terms of architecture. It is hence useful to provide a common thread whilst enabling various players to research different approaches.

The “Future Internet” would appear as a federating theme across the activities of the Challenge, with a more visible focus on Internet issues and pushing towards longer term research and very innovative approaches:

- The “*Network of the Future*” will have a focus on solutions to cope with the issues of capacity, mobility, scalability and flexibility of the ICT infrastructure;
- The "*Internet of Services, Software and Virtualisation of resources* " in relation to software and services will have a focus on issues such as virtualisation, dynamically composed service overlay over (or intricate with) a modified network structure and service joint execution environments;
- The *"Internet of Things for Entreprise Environments”* relates primarily to the object management and associated service and data discovery architectures, with integration in generic business environments.
- The *"Security of ICT infrastructures and services"* will have a focus on secure, resilient and trusted networks and service architectures and composite end-to-end services, as well as identity management and business and personal data protection and privacy;
- The *"Networked Media and 3D Internet"* will research the architectural and related technological implications of 3D virtual environments over networked platforms.
- The "*Experimental Facility*" will be able to do experimentally-driven research projects, which cut across several layers from connectivity via service architectures to applications, thereby addressing the "Future Internet" from a broad system perspective.

Whilst "Future Internet" may provide a common thread, it is also important to ensure that opportunities are created for objective level issues that may be more loosely coupled to this thematic. Each objective would also include specific technologies that have a European dimension whilst being, at the same time, more standalone. 4G in the context of networks, advanced digital and electronic cinema in the media context, trusted computing are typical examples. Work on experimental facilities will include integrating existing and emerging testbeds and maturing the concept of federations of testbeds cutting across all layers including service architectures at middleware and application level. This includes setting up and carrying out the management and operations of the resources as a coherent prototype experimental facility.

Challenge 2: Cognitive Systems, Interaction, Robotics

Analysis

Cheap, miniaturised sensors and abundant computing power have enabled industry to exploit the ability of machines to extract information from their environment and use it to achieve their tasks. These trends allow companies to further extend the autonomy of systems such as robots, smart cameras, autonomous vehicles and sensor networks as well as human-machine interfaces, speech recognition and translation systems, thus broadening their applicability.

European industrial ***robot*** manufacturers are diversifying their product offerings to enter new markets beyond traditional production environments, and with time the industrial robot market will converge with the burgeoning market for professional service robots. Both types of robots now require advanced visual and pressure sensing techniques to enable all sorts of tasks involving positioning, manipulation and navigation. Markets are diverse and standards not well developed.

Smart cameras have reached widespread use not just in lending autonomy to manufacturing processes (eg in inspection and handling), but also to non-manufacturing applications in particular high-end surveillance, monitoring and analysis. These growing markets combined with the upsurge of manufacturing in China bode well for the strong EU supply industry.

Scientific and other endeavours are generating a growing demand for data-gathering, analysis and action in remote and hostile environments, which in turn drive autonomy requirements for underwater vehicles, unmanned air and ground vehicles. Spatially ***distributed sensing*** and acting elements can operate collectively towards overall goals such as identifying objects of interest, search & rescue, situation awareness and efficient resource usage.

Industries are recognising the importance of taking user needs and human factors as starting points in product design and development. This requires further advances in multimodal ***interaction*** technologies.

Given that ***language*** (in all its modalities) is one of the most important means of human communication, and given Europe's linguistic diversity, technologies for language based interaction (human-machine and human-human) keep ranking high on the priority lists of relevant industries.

Machines and other systems operating in unstructured environments (most non-manufacturing environments are unstructured), and close to people, will regularly be confronted with novelty, uncertainty and change. If their operation is to be robust and adaptive, they will not only have to be able to extract information from their environment but also reason and learn about it. There is a growing recognition that artificial systems will have to be endowed with many different 'cognitive' capabilities, including perception, recognition, learning, reasoning, planning, motivation, communication and self-understanding. The growing body of knowledge about how natural cognitive systems work is helping to fuel developments in this domain.

<u>Orientations</u>

[***Cognitive Systems, Interaction and Robotics***]

Research will

- measurably progress towards solving (also informed by the neuro- and behavioural sciences) key issues related to the engineering of artificial systems that can robustly sense and understand their environment, act in it in useful ways with an appropriate degree of autonomy, and (where applicable) interact naturally with their human users; this includes determining the requirements basic technologies have to meet in order to enable creating such systems;
- significantly broaden the remit of machine learning, putting stronger emphasis on various forms of reinforcement learning and "intelligent" process control in real-time;
- analyse and meet requirements for robotic systems linked to different types and scales of operating environments (including individual vehicles, transportation networks, shop floors, power plants and other technical infrastructures), and different tasks, ensuring a high degree of flexibility, robustness, safety, dependability and autonomy of the systems in question; robots may employ new sensor and sensor networking technologies with a view to enhancing their functionality, performance and resource usage; "intelligent" materials may bring new functionalities, like self-configuration and self-repair, within reach of industrial realisation;
- facilitate the cross-fertilisation between research / academia and development / industry, through the joint realisation of a family of configurable industry-strength robotic platforms that are equally suited to experimenting in real-life contexts and to setting and advancing industrial de facto standards and benchmarks.

[***Language-based interaction***]

Research and development will

- advance our understanding of the specific capabilities required of technical systems that call for or mediate language-based interaction and communication;
- enable the design and implementation of interpersonal communication facilitators and automatic translation systems capable of learning translation preferences and autonomously inferring and representing relevant world knowledge and linguistic and semantic rules from imperfect and unstructured data.

Challenge 3: Components, systems, engineering

Analysis

The component and systems business in Europe concentrates on added value operations, on systems integration and on enabling the end user industry to offer new technologies and total product/service solutions. The trends in miniaturisation, diversification and increasing software content remain valid and increasing emphasis on a systems approach requires significant improvements in chip design tools and methods. At the same time new opportunities are emerging in new technologies beyond CMOS, photonics, organic and large-area electronics, 3D acquisition and visualisation. Increased multi-disciplinarity, integrated software/hardware systems, heterogeneous microsystems and the use of widely distributed systems for monitoring and control are growing challenges. In computing, mastering multi-cores and programming for ever-higher performance systems becomes essential. Cross-cutting issues such as efficient energy management have become a new desirable development objective and are no longer seen as just an obstacle to performance.

Private equity capital, the increasing cost of manufacturing and research for the next generation of basic ***nanoelectronics*** technologies have been instrumental in the development of a few major global strategic R&D alliances close to manufacturing capabilities. Industrial R&D executed in Europe is shifting towards adding extra functionalities to the basic nanoelectronics technology and to design innovative products. Institutional research is concentrating on long term or higher risk topics; on exploring multi-disciplinarity and on applied research into understanding and controlling new and complex systems.

Organic and large area electronics have very high market growth expectations with about half of the market for cheap and even disposable electronics, including RFID-tags and sensors. The EU has excellent R&D infrastructures and EU companies came early on the market with e-paper and e-tags products. It is also a leader in large area compound material photovoltaic cell manufacturing and in signage and lighting, expected to account for 20% of the market. The current trends are going beyond organic materials by including inorganic material. The technology is characterised by large area processing, by flexible products, and by the ability to create circuitry with modest upfront investment and could be the pathway to digital/3D manufacturing and molecular electronics.

Photonics in core as well as in access networks, is gradually replacing electronics. Photonics is also an enabling technology that exploits advances in lasers, light sources, fibres, detectors, in materials (e.g. nanocrystals, organics, nanotubes) and in architectures / manufacturing processes (hybrid integration, silicon photonics and CMOS compatibility). It promises to play a major role in new areas such as energy saving (e.g. by improving photovoltaic and lighting efficiency), medicine, biology, environment and safety. The possibility to manufacture structures at the nanoscale - far below the wavelength - will radically change the traditional approaches by exploiting physical effects not accessible before. Europe has strong and recognized R&D capabilities in photonics including SMEs.

Microsystems integrates and interfaces multiple core technologies (including micro/nanoelectronics, microfluidics, chemistry, bioengineering, magnetism, micromechanics and optics) and related materials to implement a variety of functions. Microsystems are implemented through scalable homogeneous or heterogeneous hardware integration technologies, including multi-level/3-dimensional interfacing, to advance miniaturisation, functionality and reliability of the sensing, processing, actuating and communicating functions. Power autonomy (consumption and supply is a common issue. Integration of multiple functions (sensing, logic, energy collection, wireless communication) into traditional materials, in particular textile, is one of the priorities. In the medium term, there is growing industrial interest to integrate nanosensors in microsystems, mainly due to an increase in sensitivity, a device simplification and the cost reduction associated.

Embedded systems, computing and control: Inexpensive networking, sensing and sophisticated control is moving decision-making to the point-of-action, and value-added functions in software are driving the diffusion of embedded systems in an ever broader range of applications. Recent trends in embedded systems design include enhanced components and model-based methodologies for high-confidence systems able to overcome the challenge of complexity and the resulting low productivity. Computing systems are moving to multi-core and polymorphic architectures where radical rethinking of systems software, programming paradigms and abstractions is needed to overcome complexity. Engineering large distributed systems increasingly requires cooperative networked control systems, and optimisation and decision support methods and tools which are used to modernise physical infrastructures, to control complex processes in manufacturing, or to monitor and control systems performance.

Orientations

Miniaturisation and diversification of ICT components, systems and devices will involve increasing efforts in nanoelectronics, microsystems, photonics and organic and large-area electronics. At a higher level, exploding system complexity will be addressed through advances in the theoretical framework and methodology of system design, radical innovations in computer architecture, new embedded systems and distributed control. Holistic approaches, including design and manufacturing engineering, end-user driven integration and cross-disciplinary activities will be coordinated across domains and will also target cooperation with other FP7 themes (eg. theme 4 NMP) and international cooperation (e.g. IMS).

The imminent launch of the ***Joint Technology Initiatives*** ENIAC (nanoelectronics) and ARTEMIS (embedded systems) implies a re-focussing of the topics covered in nanoelectronics and embedded systems. The JTIs will address mainly application-guided and mid-term technology development whereas the ICT WP will target longer term research activities. The focus of the ***ENIAC*** JTI will be industrial developments in the *'More Moore'* and the *'More than Moore'* domains, executed with a clear application focus. The ***ENIAC*** JTI will also cover design, equipment and material research activities, but will not target the 'beyond CMOS' domain. The ***ARTEMIS*** JTI will address embedded systems in a number of application domains with emphasis on the cross-cutting challenges of *design tool integration*, *middleware* and *reference designs and platforms*.

Nanoelectronic technology covers process development and multi-function high density integration activities with a high risk factor or an industrialisation perspective beyond 2013, and has a generic development focus. The activities will also target the *'beyond CMOS'* area, as well as new manufacturing approaches, equipment research and assessment and energy efficiency of components and integrated systems, including e.g. power supplies and mm-wave components.

Design of semiconductor components and electronic based miniaturised systems will be oriented towards design and modelling platforms, architectures and generic approaches, including very high density integration on large chips using deep submicron technology and heterogeneous integration of different functions or different technologies in very compact systems and subsystems. 'Systems on a Chip' and 'Systems in a Package' concepts and their implementation, including the hardware dependent software integration, will be covered. The WP will specifically address the needs of smaller and fab-less design houses, and system developers requiring access to different technologies and suppliers, and the design of energy efficient electronic systems.

Through breakthroughs in ***embedded system design*** and development of associated integrated tool chains, the aim is to map application requirements onto embedded platforms with the confidence and efficiency of a mature engineering discipline. This covers software, hw/sw and system design methods and tools for holistic design from applications down to component and platform level. Predictability of properties such as power consumption, timing, and self-configuration will be a priority.

Computing systems will aim at breakthroughs in performance, power efficiency and reliability of multicore computing systems through advances in computer architecture, system software and parallel programming models and languages. The emphasis is on programmability, customisation, virtualisation, system modelling, simulation and run-time optimisation of embedded, reconfigurable and high performance computing.

Engineering complex distributed systems will address integration platforms and methods for engineering large distributed systems, composed of heterogeneous networked components such as controllers, sensors, actuators and embedded processors, e.g. in manufacturing, process plants and large scale infrastructures for safety, security, dependability, energy efficiency and low cost maintenance. A key aim is to develop unified plug & play system architectures for pervasive sensing, computing and control systems including wireless sensor networks, which enable autonomous and self-sustained behaviour as well as real-time decision making, leading to efficiency and productivity improvements.

Photonics R&D will be driven by key applications, particularly energy efficiency (lighting and photovoltaics); communications and interfaces; biomedical (diagnosis and treatment); and safety/security (including sensing and imaging systems). This will be accompanied by cutting-edge research exploring technological opportunities, enabling photonic technologies crossing different industrial sectors, and by support to SMEs in accessing advanced photonics technology and in transitioning from concept to prototype.

Organic and large area electronics R&D will contribute to overcoming the main technical challenges of manufacturing, performance and reliability of devices. The research will focus on: device architecture, performance and stability; low voltage, small feature size with highly productive processes; complementary logic for low power; compatibility with sensors, actuators, imagers and energy scavenging and storage devices; expandability to 3D functional foil integration, with emphasis on heterogeneous (organic/inorganic) material integration.

Nano/micro-systems R&D will address the scalable integration of core hardware technologies (electronics, mechanics, fluidics, biotechnology, etc.) into a heterogeneous nano/microsystem. It will draw on the combination of multiple materials and/or processes to provide high levels of miniaturisation, functionality and autonomy. The work will cover relevant elements of the value chain (design, fabrication, packaging, testing), with special emphasis on smart manufacturing issues, resulting in stand-alone micro/nanosystems or integrated intelligence in traditional materials and objects (eg. wearables) Advanced nanosensor and nanoactuator concepts with industrial viability will also be covered.

Research into ***advanced visualisation technologies and systems*** will include: high-definition, extended colour gamut and dynamic range systems, supporting multi-viewer, unaided and unrestricted 3D viewing and natural interaction modalities; imaging systems and techniques for fast 2D/3D data acquisition and processing.

Challenge 4: Digital Libraries and Content

Analysis

Digital content is today being produced in quantities that are deeply transforming the enterprise and the creative media industries. Conditions for production and consumption are also rapidly changing as more and more content is produced by users. Most of this new content has no analogue surrogate. Organisations, public and private, are faced today with managing, exploiting and keeping increasing amounts of data and knowledge, in environments that are continually changing.

New ways of expressing and representing cultural and scientific content in digital form are creating new opportunities for people to experience and share assets. But the transformation extends beyond new patterns for creation and use of content to understanding how humans work with the technologies to master the content, understand it and transform it into learning resources for individuals and into knowledge for use by others.

In the past few years, progress in ***knowledge modelling and processing*** has enabled the creation of innovative commercial and community services and is starting to transform scientific discovery. New communities that produce and consume content can now also benefit from better structured content. An emerging example is 3D content for games and virtual reality environments.

Conceptualising and producing digital content as a container of rich objects that can be individually addressed, manipulated and imported/exported and scenes that can be freely navigated is emerging as a trend. Greater sophistication in the structuring of content enables more immersive experiences supporting richer interaction with digital information.

This increasingly complex content needs to be safeguarded for future access. ***Preservation*** needs to be intelligently planned, capturing and selection of content need to be automated and hardware and software dependencies must be overcome. Keeping the associated semantics as well as the digital objects, should guarantee the integrity and authenticity of the information as originally recorded.

If these challenges are met, richer content can bring new opportunities to the exploitation and ***sharing of Europe's rich cultural and scientific resources***. New services will engage users in new ways of experiencing and understanding cultural resources. They will enable the aggregation and annotation of objects available in digital libraries. 3D and visualisation will provide access, mainly through virtual re-creations of cultural and scientific artefacts.

More abundant, accessible, interactive and usable content and knowledge, coupled with shifts in demands (future of education and training systems, higher productivity, time-to-competency and focus on intangible assets) contribute to reshaping the world of ***education and training***. Teaching methods are increasingly focusing on inquiry-based, problem-solving approaches, with ICT being used to provide advances in learning, and within that, to support innovation and creativity. Business processes, corporate knowledge management and human resource systems are integrating learning functionalities. Technologies such as game-based learning, immersive environments, virtual characters and storytelling are suggesting new ways to generate affective engagement and motivation. The research is getting intrinsically cross disciplinary, requiring input from cognitive and social sciences, pedagogy, computer and neurosciences.

Orientations

[Intelligent Information Management]

Research and development will seek advances in making large amounts of digital content of disparate types (traditional and "social" media, enterprise as well as scientific, newly created or legacy) more manageable, accessible and usable. This will require principled methods (involving machines as well as humans) of integrating (for instance in terms of 3D composite models) the intelligence that is needed to work with content in ways that exceed the abilities of people (professionals, talented amateurs, or consumers) in terms of coverage, speed and contextually meaningful analysis and synthesis. Such methods should enable sophisticated and trusted forms of privacy-preserving analysis and reasoning about digital content. They should also facilitate the visualisation of, and navigation in, complex digital content spaces through (mobile) personal appliances, and based on a deep understanding of the psychology of human memory, reasoning, perception and attention.

[Digital Libraries and Preservation]

Research will focus on expanding and improving the use of digital collections of cultural resources through advances for instance in knowledge technologies, visualisation and interaction techniques, that take account of the specificities of these resources. It will for instance enable: i) new services for assembling, on-the-fly, digital libraries for online communities; ii) new ways of experiencing cultural heritage, e.g through virtual re-creations, and new cultural expressions, also accomodating individual narrative tendencies.

The increasing use of digital (collections of) objects in business, science and culture requires: i) intelligent systems for preservation planning, automation of core preservation tasks (capture, selection, annotation, curation, evolving semantics); ii) hard- and software independent preservation environments; iii) ways of ensuring the authenticity and integrity of original context of use; iv) scalable methods for preserving the context of data and for modelling the knowledge development processes so that knowledge can be captured and made accessible for future use. This includes capturing the behaviour - in addition to the form of digital objects.

[Technology Enhanced Learning]

Research will focus on new ways of mediating, through appropriate ICT systems and tools effective learning experiences within learning institutions and communities, for the independent learner, as well as at the workplace (integrating learning in workflows and business processes), leading to learning outcomes that improve organisational and individual performance and which can be re-used over time. The aim is to enable the design of conducive, highly motivating and flexible learning places, empowering both learners and teachers, and tailored to individual learning needs (e.g., what people learn, where and how they learn it, taking into account why they need to learn and with whom, as well as their cognitive capabilities).

Challenge 5: Towards sustainable and personalised healthcare

Analysis

[Socio-economic background]

The health sector and its three main industries, pharmaceuticals, medical devices and eHealth are dominant economic sectors with respect to employment creation and growth. Sustainable delivery of quality healthcare at affordable cost is a major challenge for European healthcare systems for a variety of reasons like: (a) demographic change and increasing prevalence of chronic diseases; (b) waste and inefficiencies, inadequate safety standards and quality control; (c) demanding citizens who require best-quality care including the use of latest diagnostic and treatment technologies and (d) current focus is on treatment rather than on prevention.

The growth of healthcare expenditure in Europe is faster than the economic growth. ICT for Health (eHealth) solutions have been proven to contribute to greater quality, efficiency and safety in healthcare and have great potential for a sustainable market.

[Trends in healthcare and ICT domains]

Advances in basic ICT components and the convergence of ICT-nano-bio technologies allow for the development of life saving applications with great business opportunities.

The major shift in the R&D scope of ICT for Health has taken place at the end of FP6 and beginning of FP7. The new targets are now disease prevention and personalised care, better management of chronic diseases, patient safety through minimisation of medical errors and support to a new generation of molecular medicine through better understanding of diseases.

The current trends include more emphasis on technological development such as more precise instrumentation for early diagnosis, prevention, disease management and treatment. Addressing challenging problems in biology and medicine is also expected to push the boundaries of technologies like grid computing, modelling and simulation.

[A changing constituency]

The strong response to the first two FP7 calls for Challenge 5 activities demonstrates the large interest from both research community and industry - including SMEs - in all areas addressed by the Challenge and the emergence of a new, wider constituency both at EU and global level.

New industrial groups are being formed in areas close to Challenge 5 like: 1) Continua Health Alliance, a group of technology, medical device and health and fitness industry leaders, which aims to help establish a market of connected personal health and fitness products and services; 2) eHealth group of the Brussels Round Table of major Telecom operators; 3) special subgroups of Joint Technology Initiatives and European Technology Platforms (EPoSS, NESSI, Photonics 21, Nanomedicine, IMI) and 4) subgroups of National Trade associations focusing on Health and Telemedicine such as Intellect in the UK or Lesis in France.

These new interest groups are formed in addition to established industrial subgroups such as COCIR (representing Radiological, Electromedical and Healthcare IT Industry), EUROREC (working on certification of electronic health records), IHE (integrating the healthcare enterprises) and EFPIA (the pharmaceutical industry association operating in Europe).

Furthermore, several related research initiatives have been launched recently in various regions of the world, such as the Virtual Human in China and "in silico Medicine" in Japan. The US and these countries have recently initiated programmes that are similar to the Virtual Physiological Human initiative of the ICT Programme, taking also into account recommendations of the existing EC roadmap. Finally, there is strong support for the concept and activities around HealthGrid. The European Conference "HealthGrid" will take place in the US in 2008, aiming at developing a strong transatlantic relationship.

<u>Orientations</u>

Taking into account the above trends and the general policy targets, Challenge 5 will address the same 3 main R&D areas in the next Work programme namely, *Personal Health Systems* (PHS), *ICT for Patient Safety* and *Virtual Physiological Human* (VPH), but with different R&D topics. In response to recommendations for more emphasis on clinical validation, newly developed solutions in all three domains will be tested and validated within selected clinical environments.

[Personal Health Systems]

The major shift will be introduced in the PHS area where the focus will be on three topics, all responding to an increasing demand: (a) Minimally invasive systems and ICT-enabled artificial organs for early diagnosis, management and treatment of major diseases; (b) Management and early diagnosis of mental diseases. The focus will be on technological development taking into account the latest microsystems and nanotechnology components.

As a concrete example, the envisaged R&D activities will lead to development of prototype artificial organs, which are tailored to the individual’s needs, operate within an ICT environment and communicate with healthcare professionals as and when required. These developments will facilitate remote monitoring and management of the patient's health status as well as monitoring and control of the artificial organ's operation by healthcare experts.

[ICT for Patient Safety]

The area of Patient Safety will continue to support decision making processes and tools for health professionals. The main changes are in the extension of the decision support across the full continuum of care, from clinical research to ambulatory to inpatient practice. The focus will be on concrete applications that combine a strong advanced-technology focus and that bring together closer the clinical research and medical practice, and in this way improve the quality and safety of patient care. As an example, R&D activities will develop new simulation and visualisation tools, including elements like augmented reality, for safer surgical interventions in clinical practice.

[Virtual Physiological Human]

VPH will consider new generation models and simulators for non-conventional medicinal approaches to understand diseases from early onset, to support the creation of a medical research library and to develop specialised tools for the biomedical research community. Research will address the development of ICT based tools for patient specific computational modelling and simulation of human organs physiology. The models will integrate multi-level aspects of the organs from molecular, cellular, to tissue. The simulation requirements are expected to provide challenges and applications for the emerging petaflops computing facilities. The use and benefits of the models must be demonstrated on specific clinical needs as prediction of disease or early diagnosis. There will also be focus on R&D infrastructure and ICT specialised tools and services for the researchers to share and develop new knowledge in this multidisciplinary field. These specific tools and services will provide mechanisms to provide the access, integration, management and clinical use of different VPH models and bio-medical data used or generated by these models. Special focus will be given to international cooperation in this field with US and Japan.

Challenge 6: ICT for Mobility, Environmental Sustainability and Energy Efficiency

Analysis

Economic growth is increasing demand for energy in Europe. In order to maintain its prosperity and competitiveness on global markets, Europe has to focus on energy efficiency in the most energy-intensive sectors[1]. Society at large is increasingly aware and sensitive to climate change impact and to the importance of a safe, clean and healthy environment to sustain quality of life. On the occasion of the European Council of 8-9 March 2007, EU leaders have pleaded in favour of an integrated climate and energy policy[2].

The recent liberalisation of the energy market has stimulated the offer of eco-innovative solutions (e.g. active networks including renewable energy) and new economic models at service supply level, at local level (cities, neighbourhoods) and at large. At the same time, new concepts for eco-management of urban areas are gaining ground involving interrelated infrastructures (e.g. energy, transport, water, waste management, crisis management).

Transport accounts for ~30% of total energy consumption in the EU and its growth represents a pervasive socio-economic challenge. While EU is currently negotiating with the automotive industry on how to reach an average CO_2 emission of 120g/km for the new cars fleet by 2012, ICTs offer a new, complementary way of improving energy efficiency and thus reducing CO_2 emissions of the whole transportation system, including vehicles. Safety on European roads has improved considerably in the past few years but it remains the least safe mode of transport. With increasing demand, there is a strong need for ever more intelligent vehicles and infrastructures that will further increase safety and energy efficiency in transport.

[ICT for safe, clean and smart mobility]

ICT continues to provide new intelligent systems that assist the driver to avoid accidents, provide drivers with real time information to avoid congestion, and that optimise a journey or the engine performance to improve energy efficiency. Autonomous on-board systems are complemented with vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) co-operative technologies and improved traffic network management. The future transportation system needs to provide access to all and to be capable of enduring uncertainties and shocks. Research efforts in the area of safety also need to be maintained, and a stronger emphasis on clean and more efficient vehicles and energy-efficient intelligent infrastructure is needed, including traffic control and management systems and new mobility concepts.

[ICT for energy efficiency]

ICT plays an increasing role in reducing the energy intensity of the economy, thus helping to decouple growth from energy consumption and creating new opportunities. Innovative ICT-based energy saving tools and techniques will help the European products and services to become more competitive and will foster the emergency of a new category of jobs and energy efficiency services. ICT for monitoring and control of power grids faces new challenges with the growing complexity and distribution of the energy grid, and ICT tools and platforms to support energy services are still scarce.

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[1] Buildings ~40 %, transport ~30% and industry ~30%.

[2] They have set the combined targets of (i) reducing greenhouse gas emissions by 20% by 2020 (compared to 1990), (ii) increasing to 20 % the share of renewable energy sources by 2020 (compared to the present 6,5%) and (iii) saving 20 % of the EU's energy consumption (compared to projections for 2020).

[ICT for environmental sustainability and crises management]

Improved connectivity of environmental systems is increasingly required as a result of the multiplication of international environmental commitments. Policy formulation and environmental management increasingly rely on distributed monitoring and management systems able to interact with common protocols and semantics and to cope with higher complexity at various scales. ICT offer an enormous potential for bridging information spaces and stimulate environmental services in Europe. Moreover, adapting to climate change and the related more frequent and extreme weather events, requires a strong effort to raise the European capacity to mitigate impacts of natural disasters. Real-time informed decision support is an essential feature for effective crisis management that will in the future need faster access to unprecedented volumes of geospatial information. ICT-based modelling, simulation and visualisation will need to be fully integrated with rapidly deployable sensor networks taking full advantage of recent advances in miniaturisation of sensors coupled to the emerging wireless revolution.

[ICT and urban infrastructures]

Cities represent a particularly complex environment with acute sustainability challenges. Four out of five Europeans live in urban areas which consume about 80% of the energy in Europe. Cities import huge amount of resources through large infrastructures to consume them in various processes creating air, water and land pollutions. Urban transport accounts for up to 70% of pollutants from transport, and congestion problems are concentrated in and around cities. Optimal management of urban complexity requires full integration of a wide range of technologies.

Orientations

[ICT for Intelligent Vehicle Systems]

This is a key research area for further improving road safety. Research needs to take an integrated approach to safety, considering together the infrastructure, vehicles, drivers and other transport users. Research topics include development of integrated in-vehicle safety systems, systems supporting autonomous driving (first in restricted environments and later on open environments), new approaches on network-wide mobility management and technologies for addressing digital footprint, data security and privacy.

[ICT for Clean and Efficient Mobility]

By addressing transportation systems as a whole, ICTs can contribute significantly to the Community's climate change objectives. Research topics include new tools and systems supporting energy-efficient driving, energy-optimized traffic control and management systems, ICTs for optimizing in-vehicle energy use and energy-optimized multi-modal traffic and travel information and route planning tools.

[Field Operational Tests for Integrated Safety Systems and Co-operative Systems]

Co-operative Systems based on V2V and V2I communications hold the promise of major improvements in the efficiency of the transport system, in the safety of all road users, and in making individual mobility more comfortable. Field Operational Tests are the next step towards their deployment in Europe, collecting data on user acceptance, performance and benefits.

[ICT for Smart Urban Mobility]

Urban mobility can greatly benefit from the development and deployment of ICT based systems and services, which address the environmental footprint and safety of mobility, while fostering economic growth. Research topics include new tools and methods for demand management, ICT tools for logistics optimized for urban environments and research in new, multi-modal urban mobility concepts.

[ICT for efficient distribution of electricity]

The transition towards *active networks for distribution of electricity* calls for R&D on generic platforms for monitoring and control of distributed energy resources, that can be tailored to specific requirements, that support new user-oriented energy trading facilities, that adapt to the actual demand/response and that manage fine-grained input from micro-grids or virtual power plants.

[ICT services and tools for energy efficiency]

ICT support to *energy positive buildings and neighbourhoods* needs further R&D in monitoring and control systems able to optimize, in near-real time, the local production-demand matching. Such smart metering systems should be built on adaptive service platforms connected to the energy grids and providing information to decision makers. These systems should also interact with end-users helping them to save energy. ICT research is also needed to foster *energy efficient services* such as remotely operated command and control platforms for energy efficiency management including for industrial and manufacturing processes. Further research efforts have to be devoted to incorporate *energy efficiency parameters into conventional ICT tools* (e.g. CAD, simulation or assets management) in order to assess the full life-cycle energy associated to new products and services before their realisation.

[Discovery and chaining of distributed environmental services]

Research on automated *discovery and chaining of distributed environmental services* on the Web is a key element to allow an open market for environmental service providers. There is need for a dynamic management of heterogeneous networks to allow breakthrough in new environmental services. The resulting platforms are expected to allow user communities to plug in their own use cases and to take benefit of all available environmental resources. This involves research on tools for the chaining of models, for predictions support, coupled with collaborative environment for on-demand distributed geo-processing. This also requires research on agent reasoning methods and protocols, on semantics and ontology services, and on services for automatic data and service quality control.

[ICT for crisis management]

Crisis management require effective ICT solutions based on: *real-time smart decision support, deployment of infrastructures, integration with simulation and prediction models coming form a large number of sources*. In particular, this will involve R&D on ICT-based modelling, simulation and visualisation tools, intelligent decision support systems, collaborative ICT environments for all stakeholders involved and advanced 3D geospatial information development and visualisation from multiple sources to deliver better quality information to responders, to inform decision support, and to give better prediction and training.

Support will also be provided to ***integrate, demonstrate and validate ICT research for urban environments***. The research activities should opt for a holistic approach that takes into account interrelated and mutually reinforcing problems of urban infrastructures. The cross-sectorial approach will allow the identification of the interrelations/interdependencies and help preparing the design of efficient solutions for infrastructure and resources management that fully address sustainable development objectives and minimize rebound effects.

Challenge 7: ICT for Independent Living, Inclusion and Participatory Governance

[ICT for independent living and inclusion]

A number of societal trends will strongly influence the future markets of ICT for independent living, inclusion and participation. Firstly, ageing is beginning to change the shape of labour markets and is already exploding the needs for care and 'lifelong participation' in society. The ICT literacy of the above-65 age group will improve significantly in the next decade. This will create mass commodity markets for well-being products and services – and unlock markets for assistive technologies-, fuelled by an estimated 3000 B€ of wealth and revenues of the above-65 population. Secondly, citizens have increasing expectations in terms of full inclusion in society and economy, quality of life and exercising of rights. Driven by productivity increase, job creation, new services and new markets for inclusive ICT, the shorter-term impacts of e-Inclusion on the GDP in Europe will be of the order of 100 B€ (for the next 5 years alone).

The increasing political and commercial interests in the field combined with the disruptive potential of ICT are starting to change the constituency and value chains of e-Inclusion RTD. The presence of mainstream ICT companies in the field is growing rapidly and new value chains are emerging, integrating users, formal and informal health and social care providers, technology and service providers as well as local/regional authorities, building and insurance companies. Elderly people and people with disabilities are increasingly recognised as posing the most challenging requirements for also mainstream usage (safety, reliability, ease of use, versatility, personalisation, integration, etc). Successfully meeting these needs translates into building key competitive strengths in global mass markets.

Several major technological developments underpin future R&D for e-Inclusion, ICT for Ageing. Sensing, computing and communication power combined with decreasing size and cost enables the monitoring of essential vital signs, presence, emotional and health parameters. New non invasive sensors with low power consumption are combined with sophisticated signal analysis to react intelligently to human conditions and behaviour. The emergence of new types of human computer interfaces (e.g. natural language processing, augmented reality, brain computer interaction) contributes to enhancing the accessibility of ICT resources for elderly and disabled.

The ability to be connected anytime, anywhere, with wireless communication, sensor networks, location and RFID technologies provides new opportunities for independent living of cognitively or physically disabled persons – and, in fact, for anyone in a temporary impairment, e.g. in an emergency situation. Other important evolutions include progress in cognition and intelligent systems able to learn from experience and adapt themselves to context and user states as well as the emerging maturity and viability of service robotics as a promising new basis for independent living solutions.

[ICT for Participatory Governance]

It is now recognised that on-line collaborations have the potential to trigger and shape significant changes in the way future (e)societies will function. Extrapolation of the present exponential growth leads to scenarios where very large percentages of populations could, if equipped with the right tools, simultaneously voice opinions and views on major and minor societal challenges, and thereby herald the transition to a different form of dynamically participative "eSociety". While such scenarios are readily imaginable, we also recognise that we currently do not have appropriate governance models, process flows, or analytical tools with which to properly understand, interpret, visualise and harness the forces that can be unleashed.

By 2020 there will be no barriers any more for citizens and businesses to participate in decision making at all levels, hence overcoming the present democratic deficit. Advanced tools – possibly building on gaming and virtual reality technologies will enable citizens to track the totality of decision making processes and see how their contributions have been (or are being) taken into account. Current linguistic and cultural barriers will have been largely overcome through use of semantic-based cooperation platforms. Opinion mining, visualisation and modelling into virtual reality based outcomes and scenarios will help to both shape, guide and form public opinion. The processes and tools will have to demonstrate transparency and trust and be devoid of manipulation. The outcomes of such consultative processes should be faster, more efficient in terms of revising policy and making decisions.

Orientations

Between 2010 and 2015, the research is expected to provide a substantial contribution towards the objective of an inclusive society by delivering ICT solutions that, in line with the i2010 Ageing Well in the Information Society action plan and the European e-Inclusion initiative, can help substantially reduce the 30% of the European population currently not fully benefiting from ICT for their social and economic participation.

EU-level activities under this challenge will be complemented by the 'Ambient Assisted Living' (AAL) applied RTD initiative based on Article 169. The AAL programme will cover shorter term applied R&D on ICT & Ageing by developing concrete ICT based solutions for ageing well. Challenges in FP7 will mainly address longer term research (5-10 years to market) as well as essential research requiring large scale projects (IPs).

[ICT and Ageing]

New opportunities for ageing well solutions offered by emerging ICTs will be exploited to provide the largest possible benefits by significantly prolonging independent living, by improving social interactions, and by facilitating the productivity of an ageing workforce.

- *Advanced prototypes of systemic solutions* for Ageing Well: focus will be on operational verification in real user environments, in particular, introducing the integration and usage of service robotics for independent living,
- *Open Systems Reference Architectures, Standards and ICT Platforms for Ageing Well:* should facilitate cost-effectiveness, systems integration and easy personalization to provide seamless end-to-end care services for independent living, smart workplaces and mobility of elderly people as well as providing support for their carers. The wider potential of the open platforms should enable integration with other home based applications related to personal health and energy efficiency.
- *Emotionally aware social interaction and support of elderly people* ICT mediated/stimulated social interaction and support of elderly people in order to *stimulate and facilitate social interaction, to provide cognitive support and increased* independence – building on advanced ICT in areas such as emotionally aware and cyber-physical computing, multi-modal human-computer interfaces, gaming and immersive environments..

[Accessible and Assistive ICT]

There are now major opportunities arising from a) Mainstream ICT industry realising the market potential, b) the sector is shaping up new user-centered innovation value chains across large and smaller ICT industries, service providers and user organizations and c) advanced ICT developments opening up new possibilities for responding to user needs related to e-Inclusion. The objective of R&D is to respond to these trends by mainstreaming and radically improving the accessibility, usability and cost-efficiency of new converging ICT products and services.

- *Embedded Accessibility of Future ICT:*
  *S*olutions for deeply embedding generalized accessibility support within future mainstream ICT-based products and services. Emphasis will be on the use of virtual environments and realistic user modelling and interaction on the basis of the "virtual user" concept.

- *ICT-Restoring and augmenting human capabilities for inclusion:*
  Radically new ICT-enabled approaches to restore and augment the ability of people in their daily life in order to help overcoming hearing, vision, cognitive or motor disabilities,. The research should target advances in brain computer interaction, and advanced sensor and actuator concepts including smart bio-sensors and signal processing. ;

- *Innovative ICT for societal inclusion of young people*
  Emphasis is put on user-driven innovation and technology development (e.g. on the basis of gaming or other creative environments), design of intuitive, highly personalised services and validation in a real context to improve motivation, education, employability and social participation of young people at risk of exclusion.

- *Improving social capital through use of new ICT)*
  A new action building on user driven innovation in experimental settings based on emerging and highly innovative ICT developments. Specific target areas will be: participation of people at risk of social exclusion; improving ICT skills for groups, e.g. excluded due to cultural diversity or lacking capabilities.

[ICT for Participatory Governance]

- *Governance Toolbox:* Technologies and tools to embody structural, organisational and new governance models and associated procedures to enable groups to form, engage, create, learn and share and track group knowledge

- *Policy Modelling, Tracking and Visualisation*: to manipulate and exploit the vast reserves of Europe's public sector collective data and knowledge resources. Semantic web applications to access and visualise background knowledge repositories to the public. Tools include; translation, process modelling, data mining, pattern recognition and visualisation and other gaming-based simulation, forecasting and back-casting, and goal-based optimisation techniques. The research also includes support to Real-time Opinion Visualisation through simulation, visualisation and mixed reality technologies, data and opinion mining, filtering and consolidation.

- *Policy Simulations:* Tools and technologies to animate large-scale societal simulations that forecast potential outcomes and impacts of proposed policy measures. Parameters include impacts on movements of people, commuters, goods and services, jobs, costs, benefits, social impact and resulting social burdens. Research will include the use of systems dynamics methodology to analyse and modelling complex systems, cooperative vs competitive systems, etc.

Future and Emerging Technologies

Analysis

Future and Emerging Technologies aims at finding new avenues for ICT research by challenging its foundations, exploring non-conventional solutions, and venturing into uncharted areas and new ways of performing research. As "pathfinder", FET feeds the ICT research community with fresh ideas and new long-term perspectives for future research and innovation. With some mainstream ICT objectives taking on more upstream research, FET foundational research ensures the full coverage of the R&D spectrum, from new ideas and emerging trends, to addressing fundamental roadblocks at the horizon of industry-driven technology roadmaps. In addition, the questioning and trend-setting nature of visionary ICT research has short- and medium term socio/economic relevance and impact as well.

[*FET and ERC*]

FET and ERC are complementary ways to fostering foundational research and building excellence. ERC funds curiosity-driven research carried out by individual researchers or small teams, whereas FET (i) supports purpose-driven collaboration among academic and industrial organisations, (ii) improves EU excellence and long-term competitiveness in ICT, and (iii) bridges science and technology, thus providing the foundations for future research agendas, kicking them off in research collaborations with industry or with high-tech SMEs.

[*ICT in collaboration with other sciences*]

Radical breakthroughs in ICT increasingly rely on "cross-pollination" and convergence with different scientific disciplines (e.g., biology, chemistry, nanoscience, neuro- and cognitive science, ethology, sociology, economics) and with the arts and humanities. New synergies are required to overcome the foundational roadblocks that can not be tackled incrementally or by relying on conventional approaches. Such trans-disciplinary and high-risk research requires new attitudes and research practices which FET needs to stimulate in order to remain effective as well as attractive for the top-level scientists and the young researchers alike.

[*FET Proactive Initiatives & FET-Open*]

Experience from FP6 and first calls in FP7 shows that the two-pronged 'open' and 'proactive' FET approach is very successful. FET PIs aim to create critical mass in selected emerging directions of research that may take up to 10 years before maturing to mainstream research. They are elaborated through open consultations with researchers from various disciplines and selected to balance continuity with renewal. Complementary to this, the bottom-up, light and deadline-free FET-Open scheme detects new long-term perspectives for ICT by providing first funding for a proof-of-concept, or to achieve a key breakthrough that turns a new scientific finding into a new technological option.

Orientations

The challenge for FET is the timely identification of new paradigms and research directions that have the potential to become the bases for ICT developments beyond 2020.

New visions for ICT research are inspired by unprecedented scientific discoveries concerning how information is captured, processed and communicated and how intelligence and self-organisation is built in nature and society. This includes the capability to manipulate physical properties at the atomic scale, as well as the search for new materials and structures beyond silicon. It also involves achieving a sustainable evolution by being able to predict the properties of large, complex techno-social systems. Information systems are being integrated in their environment in a way that allows new approaches to sensing, reasoning and action.

Key technologies and concepts, such as CMOS, Boolean logic, von Neumann architectures that prevail in present ICTs are pushed to their limits by recent advances, for example, in quantum science or emerging from the confluence of synthetic biology and ICTs. FET will exploit these emerging approaches to further expand the foundational basis of ICT.

FET will continue its two complementary schemes. FET-Open captures new ideas with long-term impact, as they arise from new scientific findings or in response to emerging drivers. Proactive Initiatives (PIs) complement the mainstream ICT agendas by exploring alternative research directions bringing in contributions from several disciplines.

The PIs outlined in the previous work programme are re-confirmed, although their description may be updated at a later stage:

- Massive ICT Systems
- Human Computer Confluence
- QIPC and other Quantum Technologies

The broad areas of possible later PIs are provided below. The FET objectives to be reached within these areas will be defined with more precision in the final texts of the Work Programme. These will take into account the progress achieved so far and the research that is mature enough to be addressed in other parts of the WP:

- New physical implementations of computing, storage, communication and sensing, from atomic and molecular information systems to those inspired by reverse-engineering information processing and communications in living systems. These should form the foundations of reliable and adaptable systems with new functionalities.
- Reverse engineer biology for new information processing paradigms, e.g. perception-action systems, event-driven information processing systems, self–maintaining and self-protecting systems, learning and memory, or ICT artefacts tightly coupled within living organisms, or addressing confluence of ICTs with living technologies.
- Develop closely integrated energy-harvesting capabilities in ICT systems
- Exploring the convergence between ephemeral overlay computing, distributed resources and communications.
- New programming paradigms driven by simplicity and intuitive semantics
- Promoting adaptation at all levels of ICT systems, from hardware components to distributed pervasive systems, to ensure dependability and quality of service in face of changes in availability and reliability of resources and evolution of service requirements.
- Distributed intelligence adapting to distributed knowledge and supporting multi-level decision making and social structures, as well as policy development.
- Modelling and data-driven validation for complex techno-social systems that involve closely tied users and ICT. Developing means to encourage desired behaviours and to suppress unwanted behaviours in such contexts.
- Semantic reasoning for long-lasting management of massive amounts of data and services
- Abstract and develop new ICT concepts employing computational neuroscience to mimic neurobiology of asynchronous, event-driven low power brain processes.
- Explore and exploit scientific foundations of sensory processing, perception, emotions and behaviour for enhancing creativity in people, including community-level creativity.

FET also targets a wide range of activities aimed at achieving the best conditions for new ideas to emerge, for stimulating adventurous research across disciplines, for involving young as well as experienced researchers, and for catalysing the emergence of new research communities. Through these activities, new research practices and methodologies will be explored, as well as new ways of achieving impact, for instance by early take-up of results by decision makers in society and industry, by artists or by high-tech SMEs. FET will also support multidisciplinary groups of researchers to debate and elaborate new research directions, in preparation of new future Proactive Initiatives.

International Cooperation

International cooperation will be implemented through:

– The *general opening* of the ICT programme objectives to the participation of third country organisations from International Cooperation Partner Countries and high income countries.

– *Encouraging the participation* of third country partners in several objectives of the work programme.

– *Specific International Cooperation Actions* (SICAs) consisting of collaborative research projects with ICPC countries in areas of mutual interest and dedicated to cooperation on topics selected on the basis of their scientific and technological competences and needs. Political dialogues with third countries and regions as well as international support projects have allowed the identification of potential cooperation priorities that are of mutual interest and benefit. SICAs will have specific rules for participation and specific evaluation criteria.

– *Horizontal support actions* for international cooperation, with a focus on supporting established policy dialogues, as well as diffusing adoption of ICT research results in emerging and developing economies.

In order to support coherence at the Framework Programme level, coordination will be sought with ICT-related international cooperation activities launched under the *Capacities* and *People* Specific Programmes.

Three levels of international co-operation have been identified:

– Co-operation at *project/partner level*, with mutual interest restricted to a group of companies or entities. This is primarily left to proposal bidders to identify their target country/partner;

– Co-operation *at initiative level*, in fields where initiative can be identified in other regions of the world (e.g. Future Internet with GENI/FIND, AKARI, Korea Future Internet Forum…). In this case, support actions (CSA) are the most appropriate instrument.

– Co-operation at *governmental level*, in fields where we have been informed on the occasion of dialogues that third country governments would welcome more visible R&D actions with Europe (example of India or of the US in the context of the Transatlantic Economic Council).

Orientations

[Responding to major global technological challenges]

Topic	Intervention scheme	Target countries/region
Future Internet	Participation in RTD projects, support measures	North America, Japan, Korea, Australia
ICT trust and security	SICA, participation in RTD projects, support measures	All third countries
Search Engines	Support measures	Japan
RFID	SICA, participation in RTD projects, support measures	North America, China, Japan, Korea
Next generation nano-electronics and microsystems manufacturing	SICA, IMS, participation in RTD projects; equipment assessment, support measures	US, Japan, Korea, China, Australia, India, Russia, Brazil, other emerging economies

[Developing ICT solutions to major global societal challenges]

Topic	Intervention scheme	Target countries/region
Semantic-based environmental data interoperability	Support measures	Industrialised countries (mainly North America)
ICT for mobility	Participation in RTD projects, support measures	US, Japan, emerging economies
ICT for complex urban management	SICA, participation in RTD projects	Emerging economies
Low-cost internet technologies, applications and tools	SICA, participation in RTD projects, support measures	India, China, Africa, Latin America
ICT for Health	Participation in RTD projects, support measures	US, Japan
ICT and Ageing, e Accessibility	Participation in RTD projects, support measures	North America, Japan
EHS (Environment-Health-Safety) for sustainable manufacturing of components and miniaturised systems	SICA, IMS, participation in RTD projects, support measures	US, Japan, China, Korea, emerging economies

[Improving scientific and technological cooperation for mutual benefit]

Topic	Intervention scheme	Target countries/region
Digital Cinema and 3D media entertainment	SICA, participation in RTD projects	India
Digital TV	SICA, participation in RTD	Latin America

	projects, support measures	
Components, miniaturised systems and ICT for power systems and hostile environments	SICA, IMS, participation in RTD projects, support measures	IMS countries (US, Japan, Korea); Russia, Brazil
Micro and nano-electronics design, modelling and simulation	Participation in RTD projects, support measures	Industrialised countries, China, India, Russia, Brazil
Embedded Systems	Participation in RTD projects, support measures	US, Japan, Russia, Western Balkans
Organic and large-area electronics	Support measures	Industrialised countries
Photonics	Participation in RTD projects, support measures	North America, emerging economies, South-America, Africa
Quantum Information Processing and Communications	SICA, participation in RTD projects, support measures	North America, Australia, Japan, Singapore
Neuro-Engineering	Participation in RTD projects, support measures	US
Complex systems research	SICA, participation in RTD projects, support measures	All third countries, building on FP6 with China an India in particular
Long-term research for future long-term partnerships (FET-Open)	Participation in RTD projects, support measures	Emerging economies and developing countries

[Horizontal support actions for international cooperation]

Support actions for:

- Support to information society policy dialogues
- Promotion of ICT research results take-up in emerging and developing economies
- Support for technology forecasting, roadmapping and benchmarking exercises