Orientations for EU ICT R&D & Innovation beyond 2013

10 KEY RECOMMENDATIONS

Vision and Needs, Impacts and Instruments

Report from the Information Society Technologies Advisory Group (ISTAG)

July 2011

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Objectives, rationale and content

Introduction

The European knowledge society is entering a new phase of development where ICT is providing the key basic infrastructures for all vital social and economic processes and is the most influential key technology in most innovations across all industries. All private and public services are being provided through and shaped by these infrastructures. ICT is becoming indispensable to address key social challenges and continues to play a defining role in our economy, providing a critical infrastructure for the global economy. The ICT infrastructure thus becomes an issue of the highest social concern. Therefore, in this new phase social innovation will be a key driver for ICT development.

Social innovation refers to new strategies, concepts, ideas and organizations that meet social needs of all kinds. Technological innovation can inspire social innovation, for example e-health, distance learning and the use of texting on mobile phones, but technological innovation is also driven by our desire to build systems to meet social needs, for example the Google search engine was developed to enable people to find things on the Web. The two processes are becoming increasingly inter-connected.

The shift towards social innovation also implies that the dynamics of ICT-innovation has changed. Innovation has shifted downstream and is becoming increasingly distributed; new stakeholder groups are joining the party, and combinatorial innovation is becoming an important source for rapid growth and commercial success. Continuous learning, exploration, co-creation, experimentation, collaborative demand articulation, and user contexts are becoming critical sources of knowledge for all actors in R&D & Innovation.

The rapid deployment of the Internet as a global infrastructure available practically anywhere anytime has led to a new dimension of integration across time and distance. Never before in history could global distributed systems be connected like today. Thus, a new era for systems and service integration, where ICT will be functioning as a ''systems-of-systems', is about to take off in the next decade.

Recommendations

1. Strengthen Europe‘s competitiveness by investment in ICT as an enabling technology – keep ICT as a free standing area in the CSF with sufficient budget allocation

The last two decades have shown that ICT is THE key innovation enabler in almost any technology domain as well as has changed the social behaviour of most of the people in Europe. Europe must continue to focus on ICT as a key technology area by having a dedicated R&D&I programme for ICT with special emphasis on how to apply ICT inventions in mission critical application domains both in societal as well as in industry domains.

European investment in collaborative ICT research in the CSF must continue to ensure that research results, needed as the basis of the next generation of global technologies and services for ICT, are available on time. ICT must be kept as a free standing area of collaborative research efforts in the CSF, with sufficient budget allocation, to ensure that future generations of technologies can be researched while, at the same time, the work of implementing new solutions to societal challenges can be undertaken using the latest available ICT products and services based on previous cycles of investment in research.

2. Aim at global leadership in Social Innovation and create a 'Balanced Progress' framework

In the next stage of our knowledge society the social dimension of technical innovation becomes increasingly visible and important, as the ICT infrastructure is now an issue of the highest societal concern. The key importance of ICT for society implies that ICT is not only a key enabler, but also a transformative force that redefines both challenges and solutions. Economic growth, social cohesion and the wellbeing and empowerment of European citizens will fully depend on the further development of ICT. This requires a continuous balancing of sometimes contradictory individual, social, societal, entrepreneurial, and ecological needs. Action is needed to embed technological innovation in social, cultural, political, material, and cognitive contexts. It also requires the development of multidisciplinary research contexts in which this balance is reflected. By focusing on social innovation, Europe can take leadership in developing solutions to worldwide challenges

Different stages of development in ICT also imply different systems of evaluation and impact assessment. In a product-centric phase, the technology developer community to a large extent defines what constitutes ‘’progress”. In a user-centric phase, consumption and market forces play a similar evaluative role. Users signal their preferences, which can be highly varied, but which are typically grounded in the underlying social practices and communities of practice. In the phase that we are entering now, progress is predominantly defined in *social* terms, which implies that intrinsically different and often conflicting interests need to be balanced. This also means that the definition of ‘’progress’’ is fundamentally political and value driven.

In this stage, research areas such as Trustworthy Digital Societies or Smart Cities gain importance and European Innovation Partnerships aiming to join up research, innovation and policy are encouraged in these areas.

3. Enlarge the stakeholder community as new, non-conventional actors become increasingly important

The increasing importance of the social dimension of technical innovation also requires the involvement of new stakeholders. Policy needs to include new, non-traditional stakeholders who become increasingly important to articulate both technological opportunities and social concerns. As the collective interest in technology development and its usage becomes more crucial, political and ethical research gains importance for ICT research.

New institutional and regulatory approaches should be created that enables the participation of non-conventional actors, including individual persons, informal networks, and researchers from non-ICT disciplines.

Simplification of rules and procedures and streamlining of instruments is important to ease the participation in the EU programme in particular for new actors.

4. Focus on Europe’s strategic strength to manage complex systems and environments

Priorities for ICT research in Europe should be placed in areas where ICT technological progress meets European research and industrial strengths. These intersection points, from components to the capability to manage large interconnected ICT systems, will be essential technical enablers of new solutions to complex societal challenges, like green and safe transport, smart energy, smart communities, and affordable healthcare.

Europe by nature has to deal with a very complex environment. Furthermore, European industry leaders, including SME, are capable of building and managing the most complex ICT systems in the world. Internet, ICT and services are more and more connected and integrated in complex, distributed systems. Europe should make sure that it owns the key system technology and know-how in this development and takes leadership in developing a ‘system of systems’ approach’. The Internet of Things and Services mentioned in previous ISTAG reports (ref. http://cordis.europa.eu/fp7/ict/istag/reports_en.html) provides the profound sound base for what is called System-of-Systems, where e.g. car-to-car and car-to-infrastructure communication, cyber-physical systems, autonomous robots, and real time analysis & prediction will be among them.

5. Ensure the dependability of ICT with next generation of infrastructures

The dependence of European business, society, public sector and defence on ICT and large infrastructures – such as power grids, water supply, roads and railway systems, the Internet – poses a high risk and should be countered with sufficient and timely countermeasures.

These include the issuing of international, binding policies and the definition, implementation and enforcement of effective, preventive, responsive and forensic defence mechanisms against intentional (= attacks) and accidental (= faults and failures) impacts on all layers of the ICT infrastructure. This has implications on the next generation smart networks that shall be developed in order to face new challenges like scarcity of resources (both energy and spectrum) while at the same time face the growing demand for more bandwidth and services offered by the underlying infrastructure.

Means of implementation

Introduction

The CSF should build on the success of previous FP initiatives and the related activities of the CIP, EIT and e.g. the Eureka Programmes. The CSF can bring all of these activities together in a single framework supporting the transformation of both curiosity- and agenda-based research results into market and society oriented field trials and innovations, which will help to bridge the gaps between current initiatives.

In a world of Open Innovation it is imperative that European funding instruments facilitate effective cross-border collaboration. Open Innovation in Europe will often involve bringing the research results, obtained in one country, into the industrial sites located in another European country.

Recommendations

6. Unleash the potential of the full value chain in ICT R&D & Innovation by bridging the gap between pre-competitive R&D and products

Current focus of EU-funded ICT projects is mostly on research and development. Innovation and exploitation is often not pursued with the effort and focus required to deliver a sufficient or sustainable impact on market value and society. Often the overall ambition of initiatives and projects fails to connect world class ICT research with various industries and SMEs. The result can be an opportunity lost in leveraging the results by efficient knowledge transfer and turning invention into innovation, i.e. successfully bringing products and services to the market. The recently established "ICT Labs" Knowledge Innovation Community of the EIT is an essential first step in addressing this question. Given the significance of ICT in Europe’s wealth, initiatives like EIT "ICT Labs" must be provided with adequate resources and position within the CSF in order to achieve its goals.

What is needed is a comprehensive view of the value chain from basic research to industrial and applied research including support to market entrance going beyond current CIP-like measures and also including large-scale 'European Lighthouse Pilots'. Innovation actions should also comprise pilot lines for fabrication, innovative process technology, and user centred pilots to validate technology developments and new business models. Such actions (cf. Recommendations from the High Level Expert Group on Key Enabling Technologies (KET)) are very important to develop and prove technology and show feasibility in real life environments, to allow users to participate and co-create in the development of applications and services and to evaluate end-user value. In public markets these research and innovation activities should be followed by public procurement where procurers consider the life cycle cost of the product/service they will procure and use.

In order to fully unleash the potential of the full value chain in R&D & innovation in ICT, an adequate regime for handling of the intellectual property generated by the projects needs to be developed. Finally, adequate instruments are needed for supporting start-ups and ventures exploiting project results.

7. Create open fast-track schemes for innovation detection, amplification, and acceleration

Innovation is rarely predictable. Many important uses of ICT have come as surprises to technology developers and policymakers. Yet, chance favours the prepared mind. We may not be able to predict innovation, but we can detect it when it emerges. When the locus of innovation continues to shift downstream, and will feed the rise of many more unexpected and disruptive innovations, the early detection of important new developments becomes very important. Innovation and growth are facilitated by systemic amplification of promising new lines of development. This requires agility, fast strategic sense-making, and instruments that can boost growth.

Open, rapid and light-weight explorations are often needed to check the viability and practical potential of new ideas that emerge during research. Such exploration can lead to a redefinition of the original project objectives. Successful ICT companies often have good plans, which they discard several times before finding the right formula for success. R&D&I projects need flexibility and openness to creative thinking and non conventional stakeholders and partners. R&D&I portfolios, in turn, need amplification and selection mechanisms that flexibly re-allocate resources to promising new opportunities.

Action is needed to create project extension and spin-out instruments and open fast-track project pipelines and processes for rapid exploitation, innovation and commercial exploitation. Such investments could be evolutions from current CIP instruments. Processes should include two-step project submission models (as today's FET-Open scheme), with a low-effort first proposal stage that focuses on detecting promising new lines of research. EU-level funding instruments should be developed to facilitate ICT breakthroughs also when they occur locally, at small scale, and before EU-level co-operation is established.

8. Continue and strengthen the Future and Emerging Technologies (FET) scheme with new initiatives

The Future and Emerging Technologies (FET) scheme should continue as a nursery for new ideas and for funding high-risk research promising major advances with the potential for societal and industrial impact. The FET Flagships initiative is welcomed as a new model for large-scale scientific partnerships. The level for the FET open programme should be maintained at least at the current level. If the overall funding level for FET activities is increased, funding should be sought for a complementary FET Proactive scheme, running alongside the Flagships. Assuming that the FET Proactive scheme continues, the Commission should consider engaging the FET community on a more regular basis to identify potential themes with ground-breaking potential for societal and industrial impact and requiring concerted action and resources beyond the reach of individual organisations. The FET scheme should also have a stronger focus on the quick diffusion of its ideas to 'non-FET communities', societal stakeholders etc, in order to detect the potential for innovation in the FET work as soon as possible and to translate that into new ideas for more innovation-oriented research.

The mixing of people between academia, research institutes and industrial R&D should be encouraged and facilitated as promoted under the EIT. Researchers who wish to work in collaboration with a commercial partner to turn their research into an industrial application or get involved in the main part of the programme should be supported. Short-term industry-based fellowships should be set up for established researchers who have developed exploitable ideas through the FET scheme. An "industrial uncle" scheme should be established to ensure that projects have appropriate industrial or societal impact.

9. Develop common EU-wide services and platforms in cross-border, co-funded initiatives and partnerships, and re-think the set-up of schemes involving Member State funds

Future funding of cross-border, co-funded initiatives and partnerships should focus on areas and activities where EU-wide action, services and systems-of-systems are needed. This notably includes development and support to common platforms and reference architectures as binding sets of structures, processes, interfaces, and data exchange standards and documentation standards. It also includes formalisation of sets of best practices and support to ICT solutions to be implemented and tested in actual environments in the public sector.

For co-funding schemes that require matching funds from the Member States (like today's ENIAC and ARTEMIS Joint Technology Initiatives and the AAL joint programme) improvements in implementation must be found to create efficient cross-border collaboration, balancing EU-wide and Member State interests. When research in one Member State can strengthen product generation and manufacturing in another Member State, European funding should come in as the glue that enables this. Part of the EU budget should be reserved for true cross border cooperation, by supporting those partners that can contribute, but have not sufficient regional budgets to do so.

10. Embrace ambiguity and unpredictability and enable a dynamic agenda

The CSF should allow for changes in priorities of European organisations' for both curiosity- and agenda-based research. Enabling a dynamic agenda, including cross-sector programs, the CSF can support a continued leadership of European based organisations in key segments of the global ICT markets for the coming decade and beyond.

Conventional planning and management approaches have an inherent tendency to make complex realities manageable by clustering, consolidating and simplifying reality. Emergent domains of innovation, however, imply unclear focus, vague objectives and inherent managerial complexity. Conventional control-oriented management approaches and systems are common in bureaucratic contexts, but often dysfunctional for innovation management.

Action is needed to embrace ambiguity and unpredictability, instead of managing them away. Portfolio-approaches should be used to reduce risk and to manage uncertainty.

Towards balanced progress: a social innovation perspective

Report of ISTAG's Working Group

on Vision and Needs

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Executive Summary

Context: a new phase of development

The European knowledge society is entering a new stage of development. Many ICTs will mature in the next decade, leading to a disruptive transformation of society. The wide use of ICTs implies that in the coming decade ICTs will grow out to be a basic infrastructure for all vital social and economic processes. All commercial and public services will be delivered through and shaped by this e-Infrastructure. ICTs will be indispensable to address key social challenges and will continue to play a defining role in our economy, providing the critical infrastructure for the global economy. As a result, the eInfrastructure becomes an issue of the highest societal concern and *social innovation* will be a key driver for ICT-development.

In this new stage, the dynamics of innovation will change as well. European actors will be even more deeply integrated in global networks of research and innovation than they are now. It will be increasingly difficult to speak of 'European' firms and industries. Regional innovation needs to be linked to global networks of research and innovation, thus creating local innovation hotspots operating on a global scale. At the same time, the maturation of the e-Infrastructure and wide use of ICTs, facilitates a downstream shift in the dynamics of innovation. Innovation processes will be increasingly distributed and based on local knowledge of innovative technology users, users who are connected in dynamic networks and ecosystems. Innovation moves out of corporate R&D centres and labs to real life environments and to more or less open networks of innovation. New stakeholders and new cultures of creativity will become more important, and companies will need to manage knowledge and innovation far beyond their traditional domain of control. As the e-Infrastructure matures, the speed of new product and service introduction accelerates. Increasing differences between the time horizons of industry, academia and policy-making will create new challenges. First-mover advantages and network effects may generate temporary monopolies that may need to be regulated.

New phase of development requires a value shift: towards balanced progress

As ICTs will provide the vital e-Infrastructure for the future knowledge society, a value shift in policy is needed. ICT can not be understood only as a means to achieve growth or competitiveness; it has to be understood primarily in terms of what fundamental societal needs we want to address. Technical advancement cannot be evaluated only using criteria and values that are internal to technology expert communities. The social dimension of technical innovation becomes increasingly visible and important.

A *balanced progress* perspective is needed here: the future requires a continuous balancing of often contradictory individual, social, societal, entrepreneurial, and ecological needs. We cannot simply assume that technical developments in ICTs will lead to socio-economic progress. We need to ask ourselves why and when we need more transistors, faster clock speeds, and more bits. More than ever we need to put human beings in their social environment in the centre. We need to articulate and communicate what social objectives publicly funded innovation aims at. This requires both the involvement of new stakeholders and a stronger focus on *social innovation*. Social innovation refers to new strategies, concepts, ideas and organisations that meet social and societal needs. In our view technological innovation and social innovation are inextricably linked and inter-connected in the near future, as the eInfrastructure is growing out to be a basic and vital societal infrastructure. This *mutual shaping* process implies an understanding of ICTs as a *transformative* force that redefines both problems and solutions. This not only involves a new approach towards R&D&I, but also requires new indicators to measure productivity, growth, development, and progress.

Implications for research and innovation policy

- As ICTs will grow out to be the basic and critical infrastructure for all vital social and economic processes, ICT is more than ever an area of research that deserves substantial and free standing public funding;
- Within ICT research, more than before *social innovation* needs to be a key driver for public funding. Although *curiosity-driven basic research* and exploration will remain important, there is a shift in balance towards ICT-research which connects technical development with the new strategies, concepts and organizations that are needed to meet social needs.
- Particularly knowledge building with a strong *multidisciplinary* character is needed to create a balanced link between technical change and social and individual progress.
- The emerging new dynamics of innovation requires a policy that focuses on the *early detection and amplification* of promising new lines of development. One way of doing this is to provide more space for c*ombinatorial innovation* and *system innovation.* In this new phase of development, technically and scientifically relatively simple modifications and additions can lead to major breakthroughs. Similarly, the simple re-framing of existing technical possibilities in new contexts of use can lead to new value propositions and rapid uptake. Open standards and open interfaces to the underlying key infrastructure services are increasingly important enablers for rapid experimentation and innovation.
- Policy needs to include *new, non-traditional stakeholders* who become increasingly important to articulate both technological opportunities and social concerns. For instance, *political and ethical perpectives* gain importance for ICT research.
- Focused initiatives on key enabling technologies are important. They need to be complemented with *open bottom-up initiatives* which focus not only on radical scientific breakthroughs but also on *rapid experimentation, 'ecological' probing and co-creation in real-world settings.*
- As both ICT firms and research institutions will be *globally networked*, policy needs to be formulated in a global context, with focus on *impact* on the local and regional level.
- Qualitatively new domains of innovation and 'systemic unpredictability' require experimentation and trial and error. To a certain degree this implies lack of focus, concentration and efficiency. New procedures, management attitudes and incentive structures are needed to make this possible. Work programmes may adapt a *portfolio approach* that creates competition among *alternative solutions* within the Framework Programme. Reallocation of funds in the portfolio should be facilitated to enable rapid scaling of promising initiatives.
- The shift towards balanced progress also implies the development of *new indicators* to measure growth and progress (e.g. the 'beyond GDP paradigm' of the Paradiso consortium). ICTs are not only tools that make economies more productive and generate more outputs from given inputs; their pervasive social and economic use requires *rethinking the concepts of productivity, growth and development* and the indicators to measure them. A shift towards societal challenges is needed.

1. Information Society 2011-2025: a new phase of development

For the last decade the European Commission has stressed that its ICT strategy is of key importance to realize broader European policy goals. This was the case in the Lisbon Agenda, and now is again the case in the Europe 2020 strategy. ICT is believed to be one of the main drivers behind the recovery of the European economy and for turning Europe into 'a *smart, sustainable and inclusive* economy".

ISTAG's specific task is to provide detailed feedback on the Framework Program and related work programs and to set the agenda for the future European ICT related R&D (specifically the CSF). ISTAG's role is to 'frame' the R&D agenda in such a way that this leads to focused priorities, investments and actions in R&D. The ambition of ISTAG is to create the best possible conditions for European leadership in ICT development and use in and beyond 2020, and to do so by thinking out of the box. In order to come up with such a 'frame', a *vision* is needed on where we are heading with the European information society, where we want to go, and what are the emerging needs that should be addressed by policy.

In the next two sections, the ISTAG-vision on the European knowledge society in 2020 and beyond is presented. First, we outline important new developments that characterize the next phase of the European knowledge society. More specifically we position future ICTs as the driver of Social Innovation. Then we describe our approach based on a vision of Balanced Progress.

Definition: Social Innovation refers to the development, implementation, and deployment of innovative solutions that impact society by addressing societal needs or by supporting societal opportunities.

Definition: Balanced Progress refers to the synergy that can be achieved by stimulating those social innovation solutions that benefit society in more than one dimension.

2. ICT as a driver of Social Innovation

There are many different ways to describe the ongoing transformation of society, driven and mediated by ICTs. It has been labelled Information Society, Network Society, Data Society, and Digital Society. We will speak of the Knowledge Society, because this concept focuses on human communication and knowledge production, whereas the other concepts seem to focus more on technological dimensions. Furthermore, the concept more adequately reflects a process of development and social transformation. In the years behind us the European model has been strong in linking the social and technical dimensions of ICT; in the future this linkage needs to be even stronger than today.

2.1 The changing context: ICT as a vital e-Infrastructure

During the period under consideration (2011-2025), the Knowledge Society will enter a new phase of development. Many ICTs will have matured, and ICTs will be widely used and inextricably linked to everything we do. As a result their transformative impact will be visible in every area of life. ICTs will provide the basic infrastructure for *all* vital social and economic processes. Every commercial and public service will be provided through and shaped by this e-Infrastructure. ICTs will be indispensable to address the key challenges that society is facing, in for instance urban planning, transport and logistics, in crime prevention and risk management, in health care and in coping with scarce resources. And, last but not least, ICTs will continue to play a defining role in our economy by providing the critical infrastructure for the global economy. It will function more and more as a 'system of systems'.

With the maturation of silicon technology new emerging trends will shift into the focus such as:

- The development of new concepts and architectures for computing;
- The utilitization of advanced ICTs for “non-computing’’ purposes;
- The search for non-silicon processing and memory technologies;
- The increasing role of photonics (the use of light will enable new disruptive innovations in the field of healthcare, manufacturing and security, and may reduce dependency on energy).

The current convergence of information, communication and media technology and services is at the basis of this highly integrated e-Infrastructure that will shape the future of the knowledge society. The future e-Infrastructure will be the key platform for the development and deployment of innovative, efficient and attractive knowledge society services. The development of this infrastructure poses us with important challenges. It is more than network connectivity; it also includes basic application services. Development and deployment need to be better integrated, particularly from the perspective of users. It also calls for regulatory frameworks covering issues such as ownership of personal data, open standards, sustainable IPR and competitiveness in the market. The successful development of this e-Infrastructure requires alignment of public and private interests. It brings about complex coordination and governance issues. R&D efforts both need to address critical e-Infrastructure technology components and focus on the development and deployment of applications and services. Furthermore, convergence also underlies the growing importance of media and content in the ICT-field.

The pervasive impact of ICTs will also change the drivers for innovation. Historical research on technological disruptions suggests that general-purpose technologies often develop through three qualitatively different phases. The first *concept-centric* phase kicks-off when radically new technical opportunities emerge, resulting first in a large variety of product concepts and then in a dominant design. In the next *product-centric* phase, the dominant design and its production processes are optimized using the performance criteria implicit in the dominant design. When product performance starts to exceed the requirements of many users, a *user-centric* phase of development emerges, with an increasing focus on users, their differentiated needs, and on the convenience of use.[1]

We have seen this sequence of stages in many industries such as electrical lighting, automobiles, and consumer electronics and it may now also be observed in ICT innovation. A substantial part of the ICT industry is currently moving *beyond* the user-centric phase, towards what we may label the *infra-centric* or *society-centric* phase[2]. In this phase, technology becomes a vital infrastructure that is of critical importance to society. In this stage, the drivers for innovation, improvement and progress are foremost *socially defined.* The infrastructure becomes an issue of the highest societal concern and *social innovation* a main driver for ICT development. Evidently, this does not mean that there is no longer any product- or user-oriented technology development: what we imply here is that a shift is taking place towards innovation that is primarily society-driven.

In this phase, progress can no longer be measured by merely using technical criteria. Let us take the computing industry as an example: progress is no longer defined by faster processor clock-speeds and more bits. Instead, the criteria for measuring development are now more society oriented and are consequently more and more defined *outside* the technical developer community. In this cycle of innovation, challenges are rephrased: “more power” may first be

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1 See, for example, Utterback, J.M., and W.J. Abernathy. 1976. A dynamic model of process and product innovation. *Omega* 3, no. 6: 639-656; and Bass, M.J., and C.M. Christensen. 2002. The future of the microprocessor business. *IEEE Spectrum* 39, no. 4: 34-39.

described as “longer battery life”, next as “greater usability” and then as “less battery power and carbon emissions.”

2.2 A new phase in technological development

Even without further technical development, the wide deployment of ICTs will have disruptive societal implications, as ICTs are more and more inextricably interwoven with every aspect of our lives. But technical innovation in the ICT-field will not at all slow down. New ICT-paradigms will come up, with new opportunities for high-impact research, technology development and innovation. The extremely fast incremental improvements that we have seen in the past (based on continuous miniaturization of components on integrated circuits), will probably slow down. But alternative technical developments will come to the fore - for instance when highly detailed contextual data will be more and more connected to biological and neural information on human beings - introducing new disruptive transformations.

Let us illustrate this by describing developments in the basic semiconductor technology. At present, integrated circuit technology is entering a new disruptive phase. For almost five decades now, integrated circuit technology has progressed at a speed probably outpacing any other known technology in the human history. The extremely fast incremental improvements in the basic integrated circuit technology that we have seen in the last decades, were based on continuous miniaturization of components on integrated circuits. This improvement will now slow down and hit physical and economic boundaries.This can be overcome only by disruptive innovation. Alternative basic computing technologies and programming models will become increasingly attractive. In the society-centric phase of development that we are entering now, “more of the same” will not be enough. More than before questions such as *why and when* we need more transistors, faster clock speeds, and more bits, will be asked.

In this new stage of development, new technologies are needed, such as self-organizing, reconfigurable, bio-inspired, non-deterministic, and cyber-physical processing architectures. ICT will move beyond the Silicon-age of the 20th century. Photonic technologies utilizing light will gain importance. Silicon-based high-performance computing will no longer be a dominant driver for technology development, but instead technologies such as opto-electronic and extremely low-energy devices, including self-powered devices, will gain visibility.

The future Knowledge Society is a society in which massive amounts of information and data are being processed and given meaning to. Information and data are generated by sensors, machines and information-enhanced products. This enables action at a distance, which will become common place, whether it means reacting to video and monitor streams from our homes, conducting scientific experiments in international e-collaboratories, making nano-scale devices, having a health check or driving a car in intelligent traffic. Robotics, sensors and autonomous agents will therefore be important elements of this emerging e-Infrastructure. Technological progress will be more than before based on the ability to take human beings in the loop in their social environment, but also including their biological, and neural information.

2.3 Regional hotspots and global networks of innovation

In this new stage, the dynamics of innovation is changing as well. As these e-Infrastructures for science and society mature, European actors will be even more deeply integrated in global networks of research and innovation than they are now. Regional policies will be increasingly formulated in a global context, aiming at intensifying regional activity by creating regionally and globally linked hot-spots of innovation. It will be increasingly difficult to speak of ‘European’ firms and industries. SMEs and knowledge-intensive start-ups aim at globally competitive business models, which allow them to participate in internationally distributed ecosystems. In some cases, local manufacturing capabilities and infrastructures remain important sources of new knowledge, innovation, and critical mass. Policies that facilitate the development of locally networked and embedded subsystems of larger innovation ecosystems will be important in creating local innovation hotspots operating on a global scale.

2.4 New industrial and innovation dynamics

The global consolidation of industries will occur at an unprecedented pace and scale. New natural monopolies will emerge, although they will often be transient. Large first-mover and network effects may lead to winner-take-all dynamics in some sectors of the converging ICT and media industry, whereas in other segments the long tail of niche markets may push supplier power either towards small value creators or consolidate it to service aggregators and intermediaries. In this highly turbulent environment, some fixed points of control will appear, and businesses will compete to access and dominate those control points. In some cases, new cloud infrastructures and application platforms will enable extremely rapid scaling of successful ICT-based business models at low cost. Policy-makers will struggle to keep up with the ongoing change and to understand what new policy approaches will be needed in this turbulent and highly uncertain environment.

The maturation and wide use of ICTs will strengthen the downstream shift in the dynamics of innovation that is already clearly visible today. This shift is currently deeply transforming the traditional models of value creation and the speed of innovation. Innovation processes are increasingly distributed and based on local knowledge of innovative technology users, connected in dynamic and fluid networks and ecosystems. As the eInfrastructure matures, the speed of new product and service introduction will accelerate. This will sharpen the differences between the time horizons and modes of innovation of industry, academia and policy-making and thus create new challenges. Firms will need to manage knowledge and innovation far beyond their traditional domain of control. Innovation will increasingly move out of corporate R&D labs to real life environments and to more or less open social networks of innovation. New stakeholders and new cultures of creativity will gain importance. A ‘combinatorial’ mode of innovation, recombining and complementing existing system components, and using available infrastructures and service components to produce new solutions and value propositions, will become more important.

From a societal perspective, guarantees for universal access to robust, trustworthy and secure infrastructure services, and standards and open interfaces will become crucially important. Furthermore, this new dynamics of innovation urges an active search for new intellectual property regimes and policies that reduce and control the anti-competitive effects of IPR.

2.5 Systemic unpredictability

In this highly dynamic context, predicting the future will be even more difficult than it was before. Many key ICT applications and technologies will continue to come as surprises to ICT and industry experts. We cannot simply solve this challenge by collecting more information or by using more intricate planning efforts, as we often only retrospectively know what types of information would have been relevant. What is needed is an approach that facilitates the rapid uptake, amplification, and growth of promising emerging technologies and applications. Furthermore, new, more lean and mean and agile methodological approaches for foresight, planning, and project management need to be developed. Future research needs a balanced combination of top-down and bottom-up approaches; the role of bottom-up initiatives, however, increases when the world becomes increasingly unpredictable and the speed of innovation accelerates.

3. Towards balanced progress

The previous section highlights some trends that will shape the policy context in the 2011-2025 period. An important claim in that section was that we are moving from a technology- and user-oriented stage of development towards an *infra- or society-centric* phase. In this phase, new criteria for progress and development become important. We need to define – not only *where* we are heading – but also where we *want* to go: what choices are in order when addressing the grand challenges that European society is facing. This means that there is also a more *normative* dimension to our vision. In the next section we first assess the current way of articulating ICT-related policy objectives and then present a new way of framing the issues.

3.1 Need for change

Today the world is confronted with profound and fast changes, in which ICT-related developments play a major role. The maturing and wide use of ICTs in the next stage of development implies that ICTs will become the key infrastructure for the future European Knowledge Society.

The dominant policy perspective towards ICT is to see ICT as an *instrument*, as an *enabler* of desirable outcomes. In our view, such an instrumental approach is too simplified. ICT is not only a *solution* to existing problems, but also a *disruptive force* in itself, having a pervasive and transformative impact on society. In recent decades, ICT has in many ways been a driver of social and economic change and it will remain such a transformative force in the coming decades. The maturation of many ICTs, as described above, will bring with it radically new models of production, social organisation and value creation. In many cases the outcomes of these transformations are unpredictable and therefore difficult to steer. This calls for a flexible and agile approach towards innovation that enables the continuous identification and valorization of emerging opportunities. An instrumental approach in this context is too limited.

ICTs do not provide straightforward solutions to specific social, economic or individual problems. ICTs evolve in a complex non-linear way, and in the process they generate unintended consequences and rebound effects. Instead of simply providing solutions to existing problems or addressing given needs, the advancement of ICT consists of both solving and creating problems at the same time.

An example of the transformative capacity of ICTs is the user empowerment resulting from the mostly unforeseen explosive uptake of social computing. In recent years, user empowerment has had an important impact on technical, economic and social innovation. This is illustrated, for example, by an explosion of new software developments, user interfaces and (open) standards), but also by growing patient empowerment in the health sector, and emerging new business models based on the based on extraction of value from networks of users. These shifts embody a potentially radical transformation in the ways value is created. They have made it clear that we need to rethink traditional user/producer relations, business models and production and innovation processes in the future Knowledge Society.

The transformative force of ICTs can also be seen in the ICT industry itself. A large majority of the now highly influential Internet platforms were launched after 2002. These include MySpace (2003), Skype (2003), YouTube (2005), Google Maps (2005) and Street View (2007), Twitter (2006), and, for example, Spotify (2008). Industrial revolutions are today occurring at speeds that increasingly outpace policy-making and research project cycles. Using technology-centric criteria, these platforms may seem quite trivial. Yet they have fundamentally shaped the future of industries and ICT use. New generic platforms, such as the iPhone, have rapidly created vast business ecosystems, and smart phones and mobile internet devices are now accelerating the convergence of traditional content industries, profoundly shaping the world of communication. Cloud computing is at present creating radically new possibilities to roll-out global services with very low capital costs. New players have entered the ICT field and rapidly established themselves as dominant competitors in the industry segments they define, at the same time changing the rules of the game. Many innovative start ups have grasped the opportunities emerging from the convergence between the ICT sector, the telecom sector and the media sector, building new businesses on rapidly changing consumer behaviour. As a result, the models that we use to forecast and predict future impacts often become outdated faster than we can formulate them.

In the emerging context, we cannot simply assume that technical developments in ICTs lead to straightforward socio-economic development. ICT use can both increase and decrease micro- and macro-level productivity. It can lead to increased energy consumption and it can reduce it. It can provide better access to knowledge, and at the same time increase information overload and information obesity. The instrumental view on ICT, therefore, is not only inadequate, but also often misleading. Instrumental, impact oriented, and evidence-based policies need to be reconsidered in this new context. We need to be less predictive about the future and more open to it. We need new impact indicators which measure, for instance, both intended and unintended consequences. We also need a framework that allows us to describe what growth or progress means in this emerging context.

3.2 A balanced progress perspective

Different stages of development in ICT also imply different systems of evaluation and impact assessment. In the product-centric phase, the technology developer community to a large extent defines what constitutes ‘’progress”. In the user-centric phase, consumption and market forces play a similar evaluative role. In the society-centric phase that we are entering now, progress needs to be defined in predominantly social terms. This implies that intrinsically different and often conflicting interests need to be balanced.

In this sense a *value shift* is in order. We no longer approach ICTs merely in terms of technical progress or ongoing economic growth, but in terms of a balancing of often contradictory societal and individual needs and impacts. This need for a value shift was also highlighted by Aarts & Grotenhuis (2009)[3] in their critical evaluation of the earlier ISTAG Ambient Intelligence vision: “Brave new world scenarios will no longer be desirable: we need a more balanced approach in which technology should serve people instead of driving them to the max.” The infra-centric phase of Knowledge Society is therefore fundamentally a value-based phase. It requires a foundation that allows different stakeholder groups to participate within a shared value frame. Value definition fundamentally requires negotiation among stakeholders.

In the future, investments in technology development can not, in general, be justified by technical advancement as it is understood by technical expert communities. Neither can it be justified by ‘global competitiveness’, if competitiveness is merely understood as forging ahead and catching up with global “leaders”. Both technical and economical development has to be linked with social development. When we perceive ICT as a vital e-Infrastructure for society, the policy agenda needs to be driven primarily by social concerns. This also means that the context in which technology developers and businesses operate and innovate will change. They will increasingly have to operate in an networked ecosystem where various stakeholders are connected to each other and have to find and define their common interest and path of action. R&D&I policies need to connect to this variety of stakeholders and facilitate these processes of negotiation and articulation of common interests.

A perspective of balanced progress thus requires:

- a balanced concern across the various spheres of life, including environment, society, economy, and individual development;
- an open and forward-looking view to emerging societal challenges, transformative impacts and related opportunities;
- an agile, open and participatory process for formulating and negotiating choices;
- an open approach towards disruptive innovations that may emerge in these networks of stakeholders.

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3 Aarts, E.H.L. & Grotenhuis, F. (2009). Ambient intelligence 2.0: towards synergetic properity. In M. Tscheligi et al (Ed.), *Proceedings of Ambient Intelligence, European Conference, AmI2009. (pp. 1-13).*

3.3 Leadership in social innovation

Until now, European policy has strongly emphasized the key role of ICTs in turning Europe into the most competitive economy in the world, realizing sustainable economic growth. In the proposed vision, Europe is taking leadership in the next phase of socio-economic development, by focusing on *social innovation* and creating a *balanced progress* framework. ICT is not only a key enabler, but also a transformative force that redefines both challenges and solutions. Economic growth, social cohesion and the wellbeing and empowerment of European citizens will fully depend on the further development of ICT. This requires a continuous balancing of sometimes contradictory and often unpredictable individual, social, societal, entrepreneurial and ecological needs. This will often require a true multidisciplinary approach that casts new light on the capabilities, functionality and potential uses of ICTs. It also means that in problem articulation we need to involve a variety of stakeholders and expertise that exists beyond the traditional ICT domain.

3.4 New indicators to measure progress

The perspective proposed above aims at balanced and sustainable progress. This shift also implies that we need new indicators to measure growth and progress. In this context, the FP7-Paradiso consortium states that we need a ‘beyond GDP paradigm’. Studies of GPI in various countries—which includes some of the effects of unsustainable resource use, social costs of economic differences, and economic losses generated by environmental degradation—indicate that GDP growth has been accompanied with a decline in economic development in many leading industrialised countries in the last two decades. GDP has been optimized to measure industrial and primary production in the Industrial Age context. In the network economy, value creation is increasingly based on non-material services, globally disaggregated and dynamically configured production networks, and on the constant innovation and redefinition of business models, industries, and product categories. We thus need *new indicators for socio-economic progress* that are able to capture value creation in the next phase of development. ICTs are not only tools that make economies more productive and generate more outputs from given inputs; their pervasive social and economic use will also require that we *rethink the concepts of productivity, growth and development*, and the indicators to measure them. This change in focus is not about turning our backs to growth; instead, it is about taking it seriously and rephrasing growth.

Impact on Economy, Society and Ecology from EU ICT Research and Innovation

Report of ISTAG's Working Group

on Impacts

Final version, May 2011

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Table of Contents

Executive summary

This document reports the results of the ISTAG WG 2 workshops. It is a continuously growing document with material added after each meeting and after each review. The document contains the consensus of all ISTAG WG 2 members[4].

„Research leads to innovation; innovation leads to jobs; jobs leads to more taxes, which then pay for more research.

There are approximately 7 billion people in the world, and half of those who are working make less than $2 a day. So unless we continue to innovate and unless we have a skilled workforce, we are going to see our standard of living decrease"

Bart Gordon, Chairman of the US Committe on Science and Technology [NATURE, Vol. 469, No. 7328, 6 January 2011, p. 10]

ISTAG WG 2 delivers four *recommendations*. The first recommendation is to use the conceptual model of *system-of-systems* to organize the structure and implementation of some elements of the *information society*[5]. The second recommendation requests a shift of focus in FP8 from research/development to *innovation* and *exploitation*, i.e. to the commercial usage of the results elaborated in the respective instruments of FP8. The third recommendation addresses the very high dependence of the information society on its *information and communication technology infrastructure* (ICT infrastructure) and suggests massive improvements in its defence against intentional attacks, such as *cybercrime*, *cyberterrorism* and *cyberwar* and also against accidental negative impacts, such as hardware and software *faults*. Key concepts here are the engineering and implementation of *dependable systems*. Finally, the fourth recommendation addresses the *human element* (use by humans and empowerment) of the ICT in order to enable as many *information society stakeholders* as possible to benefit from the information society offerings, both as *consumers* and as *providers*.

The essence of the document is contained in the chapters 2 and 3. In order to present an easily readable document it is organized as follows:

- Chapter 1: Management Summary.
- Chapter 2: Introduction (including mission and objectives)
- Chapter 3: Recommendations – Statements
- Chapter 4: Conclusions

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4 Consensus of meeting attendees (see table on page 1), as well as non-attendees (by e-mail review)

5 In today's globalized information society, ISTAG has to include also the interaction with and the impact of non-European information societies, such as USA and far East

1. Introduction

1.1 Mission and objectives

The WG2 mission is defined as follows:

> The mission of ISTAG WG2/2011 is to propose measures to get more quantifiable value for positive impact on economy, society and ecology from the money invested through EC-projects and instruments

This includes observations, recommendations and models which help to argue how actions allocating resources or the use of instruments will have a desired, measurable impact[6].

The term „*impact*“ has the following meaning in the ISTAG-WG2 FP8 context:

„The consequence of an idea or action, resulting in the move of an organization, a structure or an endeavor towards one or more, preferably measurable, objectives“

ISTAG takes into account 3 areas of impact (see figure 1)

- The *economy*,
- The *society*,
- The *ecology*.

Figure 1: Areas of impact (Courtesy of WG 1)

[6] Interestingly, the US research establishment intensively deals with the same questions. See: „Daniel Sarewitz: *US Science Agencies must bit Innovation Bullet*. NATURE, Vol. 471, 10 March 2011, p. 137“

On economy:

- Generation of new, protected, exploitable IP (Intellectual Property)
- Successful, global commercialization of IP, technology, applications
- Contribution to the European GNP and to the wellness and well-being of the citizens
- Creation of sustainable jobs and business opportunities, especially start-up's, SME's and innovative sectors within the established industry
- Contributions towards the evolution of the worldwide leading European ICT infrastructure
- Exploitation of the creativity of the European ICT people ("We cannot be the largest, we must be the brightest")
- … (Note: List not exhaustive, but intended as examples – For full information see [Aho_06][7], [CybEU_10], [DigAg_10], [E2020_10], [ERAB_10], [GreenP_11], [Inno_10], [PBook_10])

On society:

- Contribute to a better quality of life, health, aging etc. for all citizens
- Improve the efficiency and quality of the societal processes (such as health care, child care, education, …)
- Positively and adequately engage all stakeholders in the evolution and use of the Information Society, both as consumers and as providers of Information Society
- ICT shall support (not drive) the evolution the Information Society
- … (Note: List not exhaustive, but intended as examples – For full information see [Aho_06], [CybEU_10], [DigAg_10], [E2020_10], [ERAB_10], [GreenP_11], [Inno_10], [PBook_10])

On ecology:

- Sustainable use of resources, such as energy, other natural resources (minerals), minimize adverse effects to the biosphere (such as CO2)
- Green ICT
- Future ICT capabilities should enable society to make better use of resources (Enabler for efficient user resource management and saving) in all sectors of human activity (transportation, energy distribution, communications, …)
    - Note: has to be balanced with the resource consumption of the ICT used for these achievements
- … this list is not exhaustive, but intended as examples – For full information see [Aho_06], [CybEU_10], [DigAg_10], [E2020_10], [ERAB_10], [GreenP_11], [Inno_10], [PBook_10])

It is worth noting that "impact" may have a positive and / or a negative effect as illustrated in table 1.

Clearly the intention of EC-funded projects is to support positive impact and to try to make the use of ICT for negative impact as difficult as possible. However, here a significant lack of appropriate laws and regulations is visible[8].

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[7] [xxx] = see references in Annex 4.

Positive ICT Impact	Negative ICT Impact
• Better and safer products, e.g. through the use of embedded systems • Job creation through ICT-based innovation • Improvement of societal processes, leading to better and safer lives of the citizens • Improved applications that are more attuned to human needs, practices and contexts • Better health management tools, such as monitoring and prevention, early diagnosis, better cures etc. • More efficient education system with more information availability • Advanced e-systems for more citizens engagement, such as e-government, e-voting • User-centric applications for social contacts and personal intercommunication • …	• Possible destabilization of the economy and society by the power of ICT, such as the financial industry (via ICT-based structured products, high volumes, algorithmic [automated] trading), see e.g. [FT_02022011] and [Sorkin_09] • Threats to privacy and human rights via the use of ICT • Instability and lower availability of critical infrastructures, such as the power grid[9], the telecom infrastructure, rescue support etc. due to unreliable ICT components and emerging properties of complex SoS • Substantial danger from cybercrime, cyber terrorism and cyber war through attacks via and to ICT systems • Possible threats to personal health from the permanent ICT usage (long term PC/Tablet usage, radiation etc.) • Loss of social skills and personal relationships because of the extensive use of electronic social networks ([Turkle_11]) • Ethical issues • ...

Table 1: Positive and negative ICT impact (Examples)

1.2 Constraints

The following constraints hold for the work of the WG 2:

- Compliance to the document "Digital Agenda for Europe 2010-2020" ([DigAg_10]),
- Compliance to the Europe 2020 Flagship Initiative "Innovation Union" ([Inno_10]),
- Compliance to the strategy "Europe 2020 – *A European Strategy for smart, sustainable and inclusive growth*" ([E2020_10]).

Adherence to the current instruments, processes and procedures for calling, evaluating, negotiating and executing projects is not a constraint.

Valuable input to this report came from the "Interim Evaluation of the Seventh Framework Programme – *Report of the Expert Group* ([FP7Eval_10])" and "OECD Information Technology Outlook 2010 ([OECD_10])".

8 In order to keep the negative impacts at bay, the law and applicable regulations need to make a big step forward. With respect to ICT-based misuse the laws and regulations are at least 10 years behind the technical possibilities and highly inconsistent between nations. Here an important field of activity is wide open.

9 See [Blumsack_10], [Spectrum_11]

2. Recommendations: Statements

2.1 Base the emerging Information Society on the "System-Of-Systems" paradigm

Context

The elements of the *information society*, such as the ICT infrastructure, the societal structure (EU, nations, regions, ethnic groups etc.), the processes to develop and operate the information society, the ways of cooperation, and the financing schemes have in many cases become highly complex, monolithic structures relying on a certain amount of centralized control. Such large, complex, monolithic structures are inflexible and show a considerable *resistance to change*, i.e. they are difficult and slow to change, evolve, and operate. This fact is a serious obstacle in enabling the desired information society.

Challenge

Reduce the resistance to change of the structures, processes, and bodies which enable the information society. Change the paradigm from large, monolithic structures under centralized control to distributed, autonomous subsystems which collaborate together based on trust and use agreed interfaces. By doing so, reduce the complexity, the time-to-market and the cost of using the elements which enable and evolve the information society.

Solution Approach

ISTAG WG 2 proposes to use a proven approach as the overall architecture of the elements of the information society and its instruments: The distributed, collaborating systems paradigm ([Maier_09]). Such architectures consist of individual systems with their specific properties and characteristics which are collaborating with other systems via specific *interfaces*. This is a promising, in some applications proven architecture for the design, implementation, evolution and operation of very large and ultra large systems and is known as "*System-of-Systems*" (SoS) paradigm ([Fisher_06], [Kopetz_11]). The SoS concept is explained in Annex 1 of this document including a number of examples. Note that the SoS concept is not only applicable to technical systems, but also to societal structures, to complex processes etc[10]. As such, this recommendation is an overarching principle to be applied also to the other recommendations.

Justification

Long standing experience and best practices have shown that *architectural monoliths* in any domain are extremely difficult to evolve maintain and operate. Today's proven engineering approach for large, complex systems is therefore to partition the monolith, to implement it as separate parts and to couple the separate parts as loosely as possible – i.e. to build a system-of-systems. This also facilitates the handling of possible conflicts, because a federated ownership can be used.

The massive reduction of complexity results from the fact that only the interfaces between the systems have to be defined, specified, implemented and enforced. The individual internal complexities of the constituent systems are hidden behind the interfaces – a property know as "encapsulation".

Recommendation 1: Use the concept of system-of-systems as the *architecture* of the elements which enable the information society and its instruments for FP8. Leave sufficient autonomy to the individual constituent systems and centrally define and enforce the interfaces.

[10] Although the term „system-of-systems" has technical roots, its application to other domains is increasingly accepted. WG 2 has therefore decided, to keep this term

2.2 Shift focus from Research and Development to Innovation and Exploitation

Context

The desired impact of the past European ICT funding has been limited, due to several reasons. Therefore this recommendation focuses on how to commercialize quickly European ICT technical developments, ensuring competitiveness and profitability, i.e. to provide an effective and efficient environment for the commercial exploitation of results generated by EC-funded projects.

Challenge

Experience from FP6 and FP7 have shown that dissemination done by EC-funded projects is in most cases excellent. Many projects produce outstanding and ground-breaking papers and conference contributions and also make their results freely available on their project websites. Contrary to this positive point, innovation and exploitation – i.e. the transfer of the results into profitable companies – must be considerably improved. Experience has shown, for instance, that innovation often comes from small companies which experience a higher risk of failure.

> **Research** = transforming money into knowledge (intellectual property);
>
> **Innovation** = transforming knowledge (intellectual property) into money

In addition, the current EC instruments are risk-averse: Project proposals with a high risk or without very clearly stated objectives are in most cases rejected during evaluation. This is very detrimental to innovation and adapted instruments should be created.

Solution Approach

Current focus of the EC-funded ICT projects is mostly on research and development. Innovation and exploitation is often not handled with sufficient, sustainable impact[11]. Unfortunately, the current set-up for calling, evaluating, negotiating and reviewing projects is not focused on innovation and exploitation. Some key elements missing, such as a strategy for handling of intellectual property generated by the projects and the financing of emerging companies. In the course of FP8 therefore also laws and policies (such as exit-strategies for VC-funded startup companies, protection laws (such as punitive damages) to protect new players in a technology or application field should be introduced. Also required is an adaptation of the current EC project call, evaluation and execution procedures, especially a simplification and speed-up.

> „Intellectual property (IP) protection has emerged as an important component of national economic policies. Governments face choices on how to design an IP system that best serves their policy objectives. They also need to respond to changes in technology and in business models that may challenge the status quo"
>
> (from: http://www.wipo.int/econ_stat/en/economics/)

Justification

If the emphasis is not considerably shifted to innovation/exploitation – but <u>not</u> reducing efforts for research and development at the same time! – the fruits of the intellectual property gained from the EC-funded ICT-projects cannot be harvested in Europe[12]. More explanations and examples are given in Annex 2. Note also the supporting evidence in [IUSB_10], [ERA_10], [WIPO] and [Qiu_11].

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[11] Which can be seen from some relatively poor „exploitation plans" delivered by the projects

[12] But will be used by non-European competitors!

Recommendation 2: Shift the focus from research/development to innovation/exploitation. Do this by defining adequate FP8 instruments, by protecting and managing intellectual property and key technologies, by generating entrepreneur-awareness, and by supporting start-ups and ventures. Create adequate instruments to evaluate and fund projects with high risks (⇒ potential high gain) and with evolving objectives

ISTAG WG2 proposes an Impact Model to trace the flow of money, the flow of knowledge and the flow of risk in the future FP8 instruments (= separate document)

2.3 Ensure the Dependability of the Information and Communication Systems

Context

ICT discussions and endeavours tend to strongly focus on the positive aspects of ICT, such as enabling business and growth, driving innovation etc. Unfortunately, ICT has two dark sides: The *cyber-crime* and potential failures in hardware and software. Cyber-crime (including cyber-terrorism, cyber-espionage and other illegal activities, see e.g. [Kshetri_10], [Winkler_05] and *cyber-warfare* [Carr_10]) could become a devastating "show-stopper" for ICT applications and severely harm the world economy[13]. In addition to offensive measures – resulting in the progress of ICT – also effective *defensive mechanisms* must be developed and implemented. Such mechanisms must ensure not only the confidentiality, integrity and availability, but also the dependability (including reliability, safety, security, survivability and maintainability ([Aviziensis_01]) of the ICT infrastructure, data and applications. Dependability protection mechanisms must therefore become a key initiative of FP 8. Focus should not only be on security (response to cyber-crime), but also on robustness with respect to *hardware and software faults*. The upcoming submicron chips will have a larger transient failure rate that must be handled at the system level. Many applications do not require (absolute) correctness, but robustness, i.e., an adequate level of service in the face of unforeseen disturbances (hardware, software, users, intrusions, etc.). The wide impact of computer system failures on the safety of humans and the environment (such as robots that interact with humans, transpiration systems etc.) requires appropriate design strategies.

It is important to see that "dependability" is defined here in a much broader sense as the technical dependability. It also includes all form of societal dependability, i.e. dependability of services, transportation, financial systems etc.

Challenge

Dependability of ICT is impacted by two forces: Deliberate attacks (such as cyber-crime) and faults in hardware or software. Cyber-criminality has become a global, successful and highly profitable industry (see [Kshetri_10]). Large profits are made from fraud, industrial espionage, extortion and all sorts of illegal activities through ICT. Fighting against cyber-crime is a very difficult endeavour, because on one hand the ICT systems are highly complex and offer a large attack surface and on the other hand the opponents have "unlimited" resources at their disposal to stage all sorts of attacks, even using ICT as a warfare weapon[14]. In addition ,very often it is impossible to identify attackers, and so deterrence capability may be severely constrained. Hardware and software faults are inevitable in today's complex systems (an even more so in the

[13] The impacts of an ICT breakdown on the European Economy has been studied in [Bisogni_10]

[14] Example: The targeted malware „StuxNet" was successfully used to delay the start of operations of an Iranian power plant (see: http://en.wikipedia.org/wiki/Stuxnet)

future systems) and must be dealt with by adequate measures on the system level (such as fault containment and fault-tolerant designs).

Solution Approach

Methods, processes and technologies for the design and implementation of dependability must be developed and installed. This includes fight against all types of cybercrime (intentional impacts), requiring a major, concerted effort with a large financial investment. Many fragmented ideas, tools and procedures are available today, but they are insufficient for the protection of the ICT infrastructure against today's and future threats. Note that preventive, responsive and forensic protection measures must be defined and implemented. However, technical measures alone are not sufficient – effective laws, regulations and law enforcement governing cyber-XXX also need to be in place. The second area of dependability covers the hardening of ICT systems against hardware and software faults (non-intentional impacts), i.e. to make them resilient against unintentional and unplanned faults and failures.

Justification

The dependence of European business, society, public sector and defence on ICT and *large infrastructures* – such as power grids, water supply, roads and railway systems, the Internet – poses a high risk and should be countered with sufficient and timely countermeasures. A targeted blackout or disruption of such infrastructures could have catastrophic consequences for the European information society[15] and European economy. A holistic approach is needed, which cannot be provided and sustained by individual companies or organizations in Europe.

Recommendation 3: Ensure the Dependability of Information and Communications Technology Systems. Do that by issuing international, binding policies and by defining, implementing and enforcing effective preventive, responsive and forensic defense mechanisms against intentional (= attacks) and accidental (= faults and failures) impacts on all layers of the ICT infrastructure.

The SoS approach strongly facilitates the implementation and operation of dependable systems due to its inherent fault contention capability, avoiding fault propagation through the interfaces.

2.4 Engage all stakeholders in enabling the Information Society

Context

Enabling and building a sustainable, valuable Information Society requires the involvement of all stakeholders, such as citizens (of varying skills and education levels). .The stakeholders must be engaged both as consumers and as providers of ICT and applications. The objectives should be to provide equal possibilities in all areas, a rich life, the possibility to grow and to reach the full potential (see e.g.: http://www.europractice.com/). An important enabler is human empowerment, including education, training, support etc.

Challenge

Involve all areas, such as technology, social sciences, ecologists, and psychologists etc. to provide solutions which "bridge the silos" and to define FP8 instruments to do so. Define, engineer and implement user-centric, comprehensive and consistent user-interfaces for the ICT services. Reduce the vendor-generated infinity of user interface concepts to few (hopefully) standardized, comprehensive way of interacting between human users and ICT services. Provide adequate education, training and support for the different groups of stakeholders.

[15] Unfortunately, the awareness of this danger and its serious consequences is not sufficiently accepted

Solution Approach

Involve all areas, such as technology, social sciences, ecologists, and psychologists etc. to provide solutions which “bridge the silos” and to define adequate FP8 instruments.

Justification

Evolution, efficiency, and social acceptance of the information society should not be limited to privileged groups of stakeholders or specific areas of science. All stakeholders – possibly to a varying degree – need to be involved, both as consumers and as providers.

Recommendation 4: Engage all Stakeholders in enabling the Information Society. Do that by involvement of all areas, such as technology, social sciences, ecologists, and psychologists etc. to provide solutions which “bridge the silos” and to define FP8 instruments to do so and by providing adequate education, training and support.

This recommendation also suggests the need to reflect more deeply about the future of the information society and its intertwined relationship with the evolution of ICT. [Torrieri_10] and the Intelligent Community Forum[16] provide an interesting discussion of this topic.

2.5 A First set of recommended vertical topics

The following recommended vertical topics (table 2) were identified in a first brainstorming of WG2 as possible investment targets in FP8. The list is by far not exhaustive or complete, but provides offers a good point of departure for the discussion. The first column ("general lines") identifies either an existing competitive advantage or a weakness of Europe currently. The next column lists the research topics that are likely to enhance the advantage or to correct the weakness. The third column ("justification") explains why the recommended action is likely to produce the impact mentioned in the first column.

General Lines	Recommended Topic (Illustrative Examples)	Justification
First mover advantage	Intensify research, development and production of **Power Semiconductors** • Understanding and extending basic architectures of power semiconductors and their control algorithms in different areas of application • Setting up and evolving embedded algorithm and code factories for the intelligen, networked control of power semiconductors • Developing and implementing production facilities for the small to medium capacity production	Europe is currently leading in the development and production of **power semiconductors**. This field is important – even decisive – for the future (such as sustainable energy production, intelligent grid management, electric vehicles etc) The technology is manageable in „reasonable“ foundries, i.e. does not need submicron production facilities Much of the intelligence of power semiconductors is implemented in the form of „software“ – mostly as „invisible code“ in embedded systems of as SoC (= System on a Chip), a field where Europe is strong and leading

[16] https://www.intelligentcommunity.org/index.php?src=blog&srctype=detail&refno=222&category=Digital+Inclusion&blogid=222

General Lines	Recommended Topic (Illustrative Examples)	Justification
	Embedded systems: • Develop and standardize efficient embedded systems (ES) architectures, such as high dependent architectures, high performance architectures, low power architectures etc.	Embedded systems (ES) are already today at the core of the key functionality of cars, airplanes, railways, medical systems etc. In fact, most of the innovation in these areas comes from ES. Developing and operating high-dependability, complex ES is an emerging, highly active research field. European industry is successfully leading the effort and should maintain its advantage The significant value in ES stems from software where Europe has been traditionally strong
Basic competitive requirement	Formal research into **System-of-Systems** (SoS)[17] • Understanding and defining the structure (architecture), interaction (interfaces) and emerging properties of SoS's • Application of SoS to technological and societal challenges and solutions	The **SoS paradigm** is believed by many system architects to be the only way which enables the management and evolution of highly complex, heterogenous systems. It will therefore evolve into a foundation of research, development and implementation of most future systems – both in the technological and societal field – thus acting as a very strong driver for progress (see WG2 recommendation #1 above)
	Advance theory and application of **Dependability** • Continue to research and develop theories and foundations (both technological and operational) for highly dependable, scalable SoS and their components • Continue to research and develop theories and methods/standards (both technological and operational) for the verification and validation of SoS and their individual constituent systems • Continue to research and develop theories and methods/standards (both technological and operational) for the implementation of SoS and their individual constituent systems, based on fault tolerance, controlled degradation, self-healing (e.g. autonomous computing paradigms)	Dependability of technical and societal systems is becoming a key issue for the future. More and more systems become dependent on ICT, such as cars, airplanes, power grid, telecommunications etc. The increasing complexity must be understood, managed and compensated by highly dependent SoS components (Hardware and software). Failures may have grave consequences Europe has currently a significant advantage in this field which enables many industries, such as advanced cars, airplanes, railway systems and medical/industrial equipment (see WG2 recommendation #3 above)

[17] In the US SoS research has become a strategic research priority for 2010+ (strongly supported e.g. by NSF)

General Lines	Recommended Topic (Illustrative Examples)	Justification
	Change the focus of the current <u>tele</u>communications to <u>information</u> communications • Intensify research in semantics, interoperability, intelligent agent systems etc. • Develop methods and standards for semantic interoperability, including bridging different semantic domains (currently done by ontology transformations)	Many (all) important applications in the future will be based on semantic interoperability of applications. Europe has long been clearly leading the research in semantics and should try to rebuild its advantage. Semantic technology is a very important field underlying many new concepts of the future
Improving essential weaknesses	Research in understanding **people's true needs** • Such research is a combination of societal science and cognitive science, allows to "break the silos" and to specify truly open, useful systems •	Up to today much of the innovation was technology-push driven, i.e. a technological innovation was pushed into the market and "forced" on the society. Truly useful systems really supporting the societal evolution should be based on people's and communities true, sustained needs (see WG2 recommendation #4 above)
Removing show-stoppers		

Table 2: First set of recommended vertical topics

3. Conclusions

As pointed out by WG 1, the challenges of the future in ICT are disruptive change, raising complexity of all systems, globalization, fierce competition and "grand challenges", such as societal changes, danger to the climate and energy utilization.

The pressure to make best usage of the resources available from EC-funding to improve the quality of life of the European citizens and other objectives (see see [Aho_06], [CybEU_10], [DigAg_10], [E2020_10], [ERAB_10], [GreenP_11], [Inno_10], [PBook_10]), requires the *targetted improvement of the impact* of the EC-instruments.

This WG2 document presents 4 recommendations which will measurably create more desired impact. However, the recommendations overarch not only DG INFSO, but touch als other DG's which need to be involved.

ANNEX I - SYSTEM-OF-SYSTEMS

A1.1 SoS Introduction

The concept of a "*system-of-systems*" (SoS) is a model for the management of the complexity of very large systems and of ultra large systems, especially ICT systems ([Murer_11], [Northrop_06]) or socio-ecological systems ([Walker_04]). The SoS model consists of a number of *constituent systems* which share a common goal. To reach this goal, they cooperate as a larger entity – the system-of-systems – with clearly defined cooperation rules ([DSoS_03], [Avizienis_01], [Kopetz_11]).

The system-of-systems approach allows each constituent system to have specific properties, rules and constraints, which may be different or partially different from the other constituent systems. The constituent systems collaborate via clearly defined *interfaces*, often called linking interfaces. The result of this coordinated cooperation is the achievement of the common goal, which would not have been possible for any individual constituent system alone. The massive reduction of complexity results from the fact, that only the interfaces between the systems have to be defined, specified, implemented and enforced. The individual internal complexities of the constituent systems is hidden behind the interfaces – a property know as "encapsulation".

A system-of-systems need some kind of centralized coordination. The central coordination authority defines, specifies and enforces the interfaces. Below two tutorial examples are described.

Example 1: A nice (simplified) example for a system-of-systems is an airport (Figure 3). The two constituent systems are the airplane system and the passenger system. The airplane system is internally highly complex and includes the planes, the runways, the maintenance hangars, the fuel providers, the air traffic control etc. The passenger system is also complex and includes the car parks, the passenger zones, check-ins, restaurants, shops etc. The interface between the two systems, however, is quite simple: It is the boarding gate. Through the boarding gate – as an interface – the two highly complex systems are connected. The interface contract is the boarding card and the central coordination authority ist he IATA[18] – which regulates the airport operations.

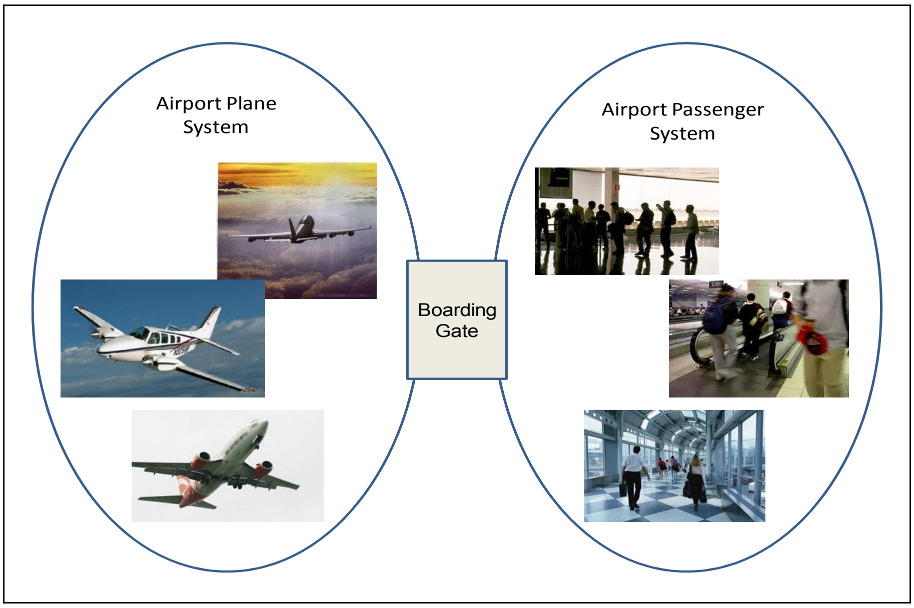

Figure 3: The SoS „airport"

[18] The Air Transport Association (**IATA**) represents, leads and serves the airline industry. Its members comprise all major passenger and cargo airlines (see: http://www.iata.org/Pages/default.aspx)

Example 2: A second example for a large scale SoS is the payment exchange system of the worldwide financial system (Figure 4). Worldwide many then-thousands of banks in more than 170 countries, i.e. in different jurisdictions are active. Each jurisdiction constitutes an individual system with its own banking and privacy laws, data export and reporting regulations. All these laws and regulations are constantly changing. It is not feasible for any authority or user to keep track of this vast and continuously changing set of laws and regulations.

However, the financial institutions need to be able to exchange payments between each other, irrespective of the difficulties of differing laws and regulations in the different jurisdictions.

The solution is a SoS: Each jurisdiction is regarded as a constituent system and is in its own right responsible for complying with all local laws and regulations, both for import and for export of data. The system-of-systems consists of the interconnected local systems (jurisdictions). The central coordination authority in this case is SWIFT[19]: SWIFT defines, specifies, enforces and operates a world-wide secure messaging system for the exchange of financial transactions and assures security and non-repudiation.

Here also, the interface between the individual, complex constituent systems is quite simple: A messaging standard which "only" provides the means to execute secure financial transactions, but leaves the full responsibility for compliance with local laws and regulations to the constituent system.

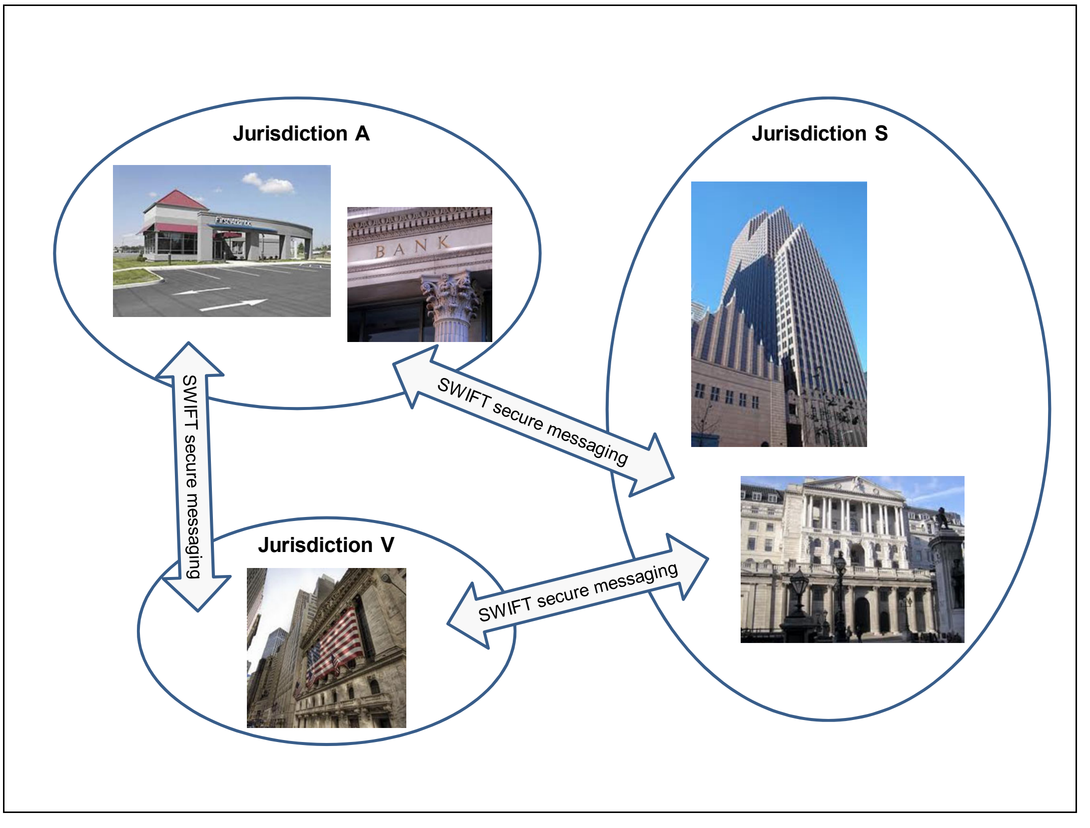

Figure 4: Payment exchange system of the worldwide financial system

Note that the SoS-approach can be applied to different levels, such as *nations* (jurisdictions, see Example 2), large systems – such as traffic systems (see Example 1) – and down to the *person level*.

[19] Society for Worldwide Interbank Financial Telecommunication (SWIFT) supplies secure messaging services and interface software to wholesale financial entities (see: http://www.swift.com/)

A1.2 SoS Application: FEV (Fully Electric Vehicle)

A larger, interesting example where the application of the SoS concept would be highly beneficial is the Fully Electrical Vehicle Ecosystem (FEV, see http://www.ict4fev.eu/public). It is worth noting that activities in FEV research have a wider scope of application including notably today's vehicles.

Example 3: A (simplified) FEV ecosystem as a SoS is shown in Figure 4. The constituent systems are: the battery, the power grid, the FEV, The driver, the community, the environment, other cars, the traffic infrastructure. The interfaces are shown as broad arrows. Remember, that the interface specification not only includes technical specifications, but also a contract for the usage of the interface.

A concept is the interface between the battery of the FEV and the power grid (power provider). Technically, only a few details, such as the plug, the voltage etc. need to be standardized. However, the usage contract for the interface contains a tremendous potential: Once a sufficient number of FEVs are in use, a massive electric storage capacity is available. This could be actively used to store electrical energy generated through the day and thus enable efficient solar energy utilization. The contract would stipulate, that the smart power grid can load my car battery when it is optimum for him, subject to certain conditions, such as a time window.

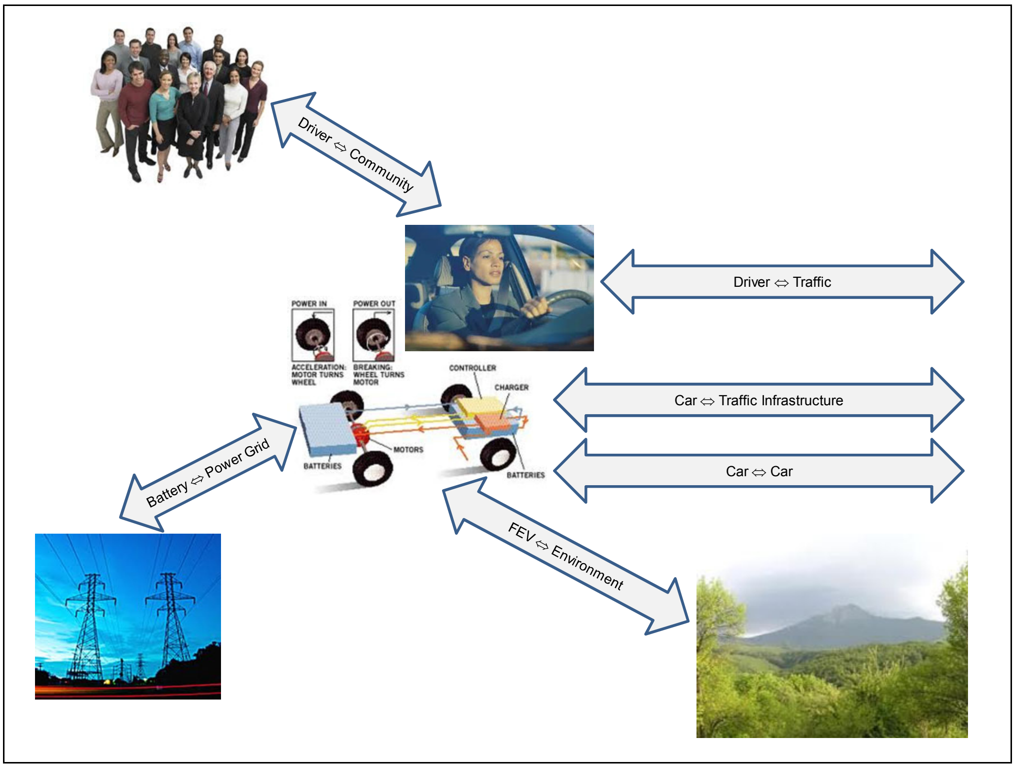

Figure 4: FEV ecosystem as SoS

A1.3 SoS Applications in future Framework Programmes

Possibilities (brainstormed during Nov 17):

- European energy trading system
- Cross-national regulations for the financing of start-up companies
- Cross-national electronic invoicing

ANNEX 2 - IPR AND INNOVATION

A2.1 Innovation Models

An impressive number of innovation models have been published – and more are added every year, creating a growing body of literature. ISTAG WG2 explicitly did not aim at adding another new innovation model to the list, but to create "only" an impact model. The impact model assumes that innovative ideas have been generated (in some way) and tries to provide the instruments to develop these innovative ideas with the highest efficiency into commercial successes. The ISTAG WG2 impact model is documented in a separate document.

One common factor for all successful innovation models (see e.g. Finland, Sweden and Germany) is *collaboration*. This means collaboration between universities, research institutes and industry should be close and well organized. As an example, the Open Innovation model ([Chesbrough_06], [http://www.openinnovation.eu]) may be listed here.

A2.2 IPR-Loss Example

A typical example[20] for the inability of current FP7 instruments to protect and commercially exploit intellectual property generated during a project is GENESYS (GENESYS = GENeric Embedded SYStem Platform, see http://www.genesys-platform.eu, FP7-213322 from January 2008 to June 2009).

The objective of GENESYS was to develop a *cross-domain architecture* for embedded systems. GENESYS is currently the sole candidate for the ARTEMIS *European Reference Architecture* for *embedded systems*. ARTEMIS is a European joint technology initiative (JTI) that bundles the efforts of European players from industry, academia and governments in the domain of embedded systems in order to develop a cross-domain approach to Embedded System Design. Such a cross-domain approach is needed to support the coming Internet of Things, to take full advantage of the economies of scale of the semiconductor industry, and to improve the productivity of the human resources. In a two year effort, before the start of the GENESYS project, an expert group from ARTEMIS has captured the detailed requirements and constraints for such a European cross-domain embedded system architecture. GENESYS has taken these requirements and constraints as a starting point.

In the course of the GENESYS project, the following *patent application* was written and submitted

- "Cross-Domain SoC (System-on-Chip) Architecture for Dependable Embedded Applications"
- International Publication Number: WO 2009/140707 A1
- International Filing Date: 20.5.2009

It is a fairly basic patent which covers an important aspect of dependable, distributed system implementation. Unfortunately, neither the ARTEMIS organization, nor any of the project members wanted to provide the funds to pay the way to granting the patent. Therefore the patent application had to be dropped.

At the end of the GENESYS project the main results were published as a book[21] ([Obermaisser_09]) in which the full knowledge was divulged, including the material from the patent application. The download statistics for the period 1.2.2010 to 29.2.2011 of the GENESYS book[22] are as follows: EU-countries: 520 (57%) downloads, **Non**-EU-countries: 395 (43%) downloads. The "top 20" (= more than 10 downloads/country) are shown in Table3.

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[20] Courtesy of Prof. H. Kopetz, 2010

[21] Downloadable from: http://www.genesys-platform.eu/genesys_book.pdf

[22] http://genesys-platform.eu/genesys_book.pdf

Country	# of Downloads	EU
United States	165	no
Germany	139	yes
India	97	no
France	80	yes
Spain	60	yes
Austria	46	yes
United Kingdom	43	yes
China	39	no
Japan	36	no
Finland	31	yes
Italy	30	yes
Luxembourg	24	yes
Canada	21	no
Korea, Republic of	20	no
Sweden	18	yes
Belgium	17	yes
Israel	17	no
Hungary	12	yes
Greece	10	yes
Portugal	10	yes
Total EU	520 (57%)	
Total non-EU	395 (43%)	

Table 3: „Top 20" download statistics fort he GENESYS book

The download statistics – showing the successful dissemination and the know-how drain – show clearly a deficit in the handling of EC-project generated IPR. The following main issues exist:

- No policy and no support from the EC is available to guide IPR protection in projects,
- No contract framework to handle the rights on the IP within the project and for external parties,
- No central body[23] to manage the IPR generated by the projects.

A2.3 The importance of IPR

Intellectual property can be protected by patents, trademarks, copyrights etc. This provides the owner of the IPR with the power to restrict or license the use of the IP and thus gain and secure some market advantage.

- The „old" way of using IPR was to fight off (or at least delay) competition (= Offensive use). This use of IPR is still to be encountered e.g. in the pharmaceutical industry.
- The „modern" use of IPR includes in addition:
  - Protection of own IPR in such a way that nobody can restrict my usage (defensive),
  - Trading of IPR to avoid litigation (Note: Whenever a system of a certain technical complexity – such as a car or an airplane – is built today, infringement of 3rd party patents cannot be avoided. This is usually mutual (because both parties hold patents) and therefore mutual IPR usage is granted instead of litigation),

[23] Note that GENESYS should have become the ARTEMIS reference architecture

– Licensing of IPR as a business model (Note: Some companies, such as ARM (www.**arm**.com) and IBM (www.**ibm**.com/patents) have very successful IPR licensing businesses),

– IPR as a foundation for venture capital (Note: Venture capitalists are very reluctant to invest into a company or venture if the underlying IP is not sufficiently protected),

– IPRs can be a decisive input for the standardization process (Note: An organization can trade free access to its IPRs with the worldwide strandarization of its technology)

– *Correct IPR handling does not restrict Open Innovation (see IMEC-model)*

It is therefore of key importance for a successful commercial exploitation of innovation that IP is sufficiently protected. The foundation for this would be a set of pre-defined IPR-policies which the innovator can choose from[24].

A2.4. Research and Innovation Framework

The production and exploitation of IPR needs a framework. Such a framework has been proposed by H. Kopetz ([Kopetz_11]). The separation of *basic research*, *technology research*, and *product research* is fundamental. The characteristics of each phase are shown in **Figure 5**. If the 3 phases are not clearly separated, generation and exploitation of IPR is difficult. Note that in the technology research, publications must be kept to a minimum as long as the IPR is not protected (by patent applications, trademarks, copyrights etc.).

Research: Basic vs. Technology vs. Product

	Basic Research (BR)	Technology Research (TR)	Product Research and Development (PR)
Topic	New insights into the basic mechanisms of nature and society	New insights into the construction of new products and production processes	Design and Development of Concrete Products
Market Orientation	No	Yes	Yes
Time Horizon	> 10 years	3 - 10 years	< 3 years
Results	Scientific Publications which are open to the public	Patents, Know how (secret) and Prototypes Publications are counter productive.	Concrete Products, including the relevant marketing information

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Figure 5: Basic vs. Technology vs. Product research

Figure 6 shows the important relationship between basic research, technology research and product research and the timescales. Basic research is enabling technology research, and technology research is enabling product research, finally leading to the commercial exploitation through new products or services.

[24] As an example, the IMEC IPR-policy could be cited

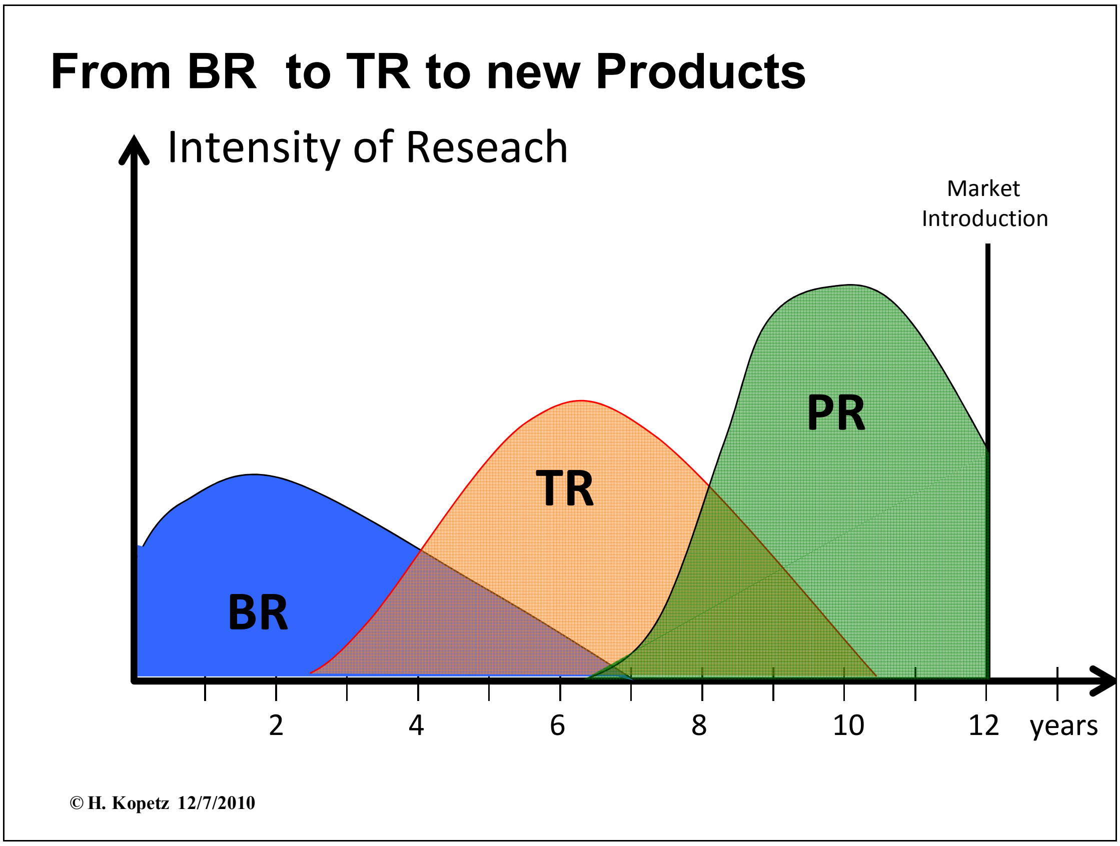

Figure 6: From BR to TR to new products

Figure 7 shows the highly dangerous effect of missing technology research TR – which should generate exploitable IPR ! – because product research and product development become very difficult.

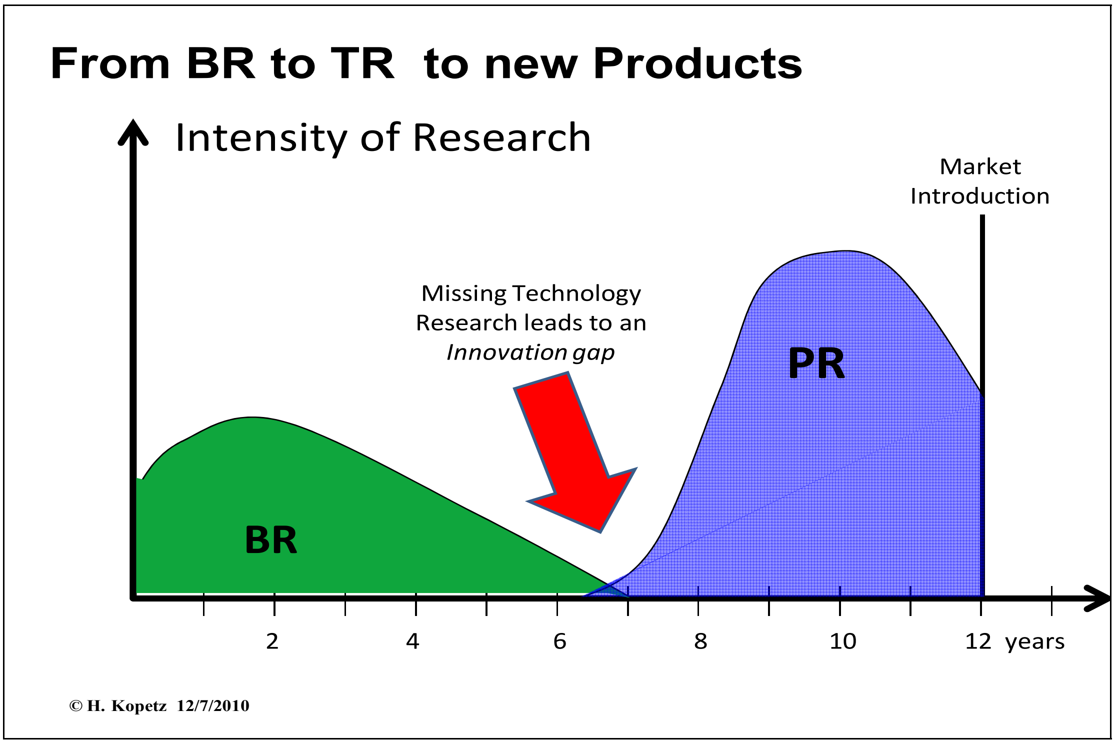

Figure 7: Effect of missing technology research

A2.5 Key technology protection

Interestingly, Europe's industry commissioner Antonio Tajani urged Monday (December 27, 2010 in an interview with the German Handelsblatt, that European key technologies should be better protected in order to allow exploitation in Europe. The following is an extract from http://www.eubusiness.com/news-eu/china-business.7tt (28 December 2010, 10:14 CET): Commissioner moots takeover protection for key sectors

> *(**FRANKFURT**) - Europe's industry commissioner Antonio Tajani urged Monday in an interview that strategic sectors be protected against foreign takeovers, in particular by China.*
>
> *Europe should establish "an authority tasked with examining foreign investments in Europe" using the the Committee on Foreign Investment in the United States (CFIUS) as a model, Tajani told the German business daily Handelsblatt.*
>
> *"Chinese companies have the means to buy more and more European enterprises with key technologies in important sectors," Tajani noted.*
>
> *"It is a question of investments but behind that there is also a strategic policy, to which Europe should respond politically," the Italian added.*
>
> *A European authority would determine "if the acquisition (of a company) with European know-how by a private or public foreign company represented a danger or not," the commissioner said.*
>
> *China said last week that it could invest in European sovereign debt to help the eurozone come through a crisis, and Chinese companies are keen on buying others in Europe, one example being the purchase of the Swedish carmaker Volvo by Geely.*
>
> *But German Economy Minister Rainer Bruederle warned European countries against taking "hasty actions" in placing controls on foreign investment.*
>
> *"Of course one can have an evaluation procedure taking into account security and public order concerns. But we shouldn't take hasty actions," Bruederle was quoted as saying by Handelsblatt.*
>
> *"Europe profits from the openness of its markets and offers attractive conditions for foreign investors," he added in comments to be published in Tuesday's edition of the newspaper.*

In fact, Commissioner Antonio Tajani asks for even more than IPR protection. Provocatively, he suggests handling the key technology protection by a new European authority, modeled according to the CFIUS (American Committee of Foreign Investments)[25].

[25] CFIUS is an inter-agency committee authorized to review transactions that could result in control of a U.S. business by a foreign person ("covered transactions"), in order to determine the effect of such transactions on the national security of the United States (see: https://ustreas.gov/offices/international-affairs/cfius/)

ANNEX 3 - INFORMATION SOCIETY STAKEHOLDERS

A3.1 Roles

The transformation of the *industrial society* to an *information society* has a profound impact on the different roles humans take up in society. We distinguish between four important roles: Humans as users, Humans as IT professionals, Humans as decision makers, Applications as users.

Humans as users

As a technology matures, the emphasis shifts from functionality to dependability and in the next step to *usability*. Usability is determined by the simplicity, intuitiveness and coherence of the interface model that governs the man-machine communication. Ideally, this *interface model* should be designed such that a new system can be used on an intuitive basis without any reference to lengthy documentation. Putting more computational power and intelligence into the user interface is cost effective: it cuts the time needed for training, reduces the number of human errors during operation, and opens up applications to new user groups. User-friendly interface design is a cross-domain endeavor, based on insight from the cognitive science and the capabilities of the available software/hardware technologies.

Humans as IT professionals

The further development of the ICT sector is limited by the availability of competent IT professionals at all levels in the fields of system design, hardware development, software development, operation and maintenance. Additionally, the IT professionals must have a thorough understanding of the targeted application domain. Since the pace of hardware development is slowing down, the focus of innovation shifts towards the knowledge-intensive design activities that require a well-educated work force. Starting from kindergarten and continuing up to PhD level research at the universities, the educational system has thus a most important role to play in this transformation form the industrial society to the information society. Since the IT industry is a global knowledge-based industry, competence development must be embedded in this global context. A proper investment in the education and empowerment of our young talented people will have the most profound impact in establishing European leadership in the important area of ICT.

> „Research in universities requires solid undergraduate and graduate learning and teaching. It is foolhardy to weaken this foundation, because the modern research university is built on the energy and ideas of students. Students are not customers of a university; they are its very soul. The idea that research will prosper while teaching and learning decay is a dangerous fallacy“
>
> Colin Macilwain,
> [NATURE, Vol. 469, No. 7329, 13 January 2011, p. 133]

Humans as decisions makers

The transformation of the industrial society to an information society poses novel demanding challenges to decision makers. Professionals in the economic, legal, political, educational, and the social fields must be properly educated to grasp the societal and economic potential and hazards of the widespread adoption of information technology. At present, the models, methods and tools used to govern our society are not properly considering the peculiarities of the information sector.

Applications as users

In the Information Society not only human-machine interactions exist, but more and more also machine-to-machine (i.e. application-to-application, A2A) interactions become important. Typical examples are business-to-business (B2B) scenarios, where business is executed between applications with no – or very little – human intervention, automated search and compare activities, human delegation to specialized *agents* etc.

Enabling the ICT infrastructure to support application-to-application interactions is an important part of the Information Society. Such support requires new technologies, especially in the field of formalized semantics (Ontologies, taxonomies, ...).

We need to establish meaningful KPIs that measure the impact of FP8 instruments in the mentioned fields.

A3.2. Rules

Information Society – especially the World Wide Web – poses a number of serious and significant *threats* – to security, dignity, privacy and to the rights of its users, including human rights (see: [Menn_10], [Kshetri_10], [Wall_07], [Clough_10], [Winkler_05]).

It is mandatory, to set up policies, laws and rules of conduct as well as the necessary monitoring and enforcement mechanisms to define, supervise and enforce such rules. The Information Society must not become a “lawless” space where “outlaws” can be active without consequences[26].

[26] Which – unfortunately - is currently the case for some activities, such as gambling, spam, hacking etc.

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Abbreviations

Abbreviation	Meaning
FEV	Fully Electrical Vehicle
GNP	Gross National Product
ICT	Information and Communication Technologies
IP	Intellectual Property
IPR	Intellectual Property Rights
NFC	Near field communications
RFID	Radio frequency identification
ROW	rest of the world (In this context: Non-EU)
SoS	System-of-systems

Funding Instruments in the future Framework Programme

Report of ISTAG's Working Group

on Instruments

Final version, May 2011

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1. Introduction

The currently existing instruments for the funding of research and the stimulation of innovation are the Framework Programme, the Competitiveness and Innovation Programme, and the Structural Funds. Under the 7th Framework Programme for Research and Technological Development (FP7), there are 4 main funding programmes: Cooperation, Ideas, People and Capacities.

The main focus has been on the Cooperation programme, receiving 64% of the total (non-nuclear) budget available within FP7, with instruments like Collaborative Projects, Networks of Excellence, the Coordination and Support Actions and there are currently 5 Joint Technology Initiatives (JTI´s). The European Parliament and the Council have, on adopting FP7 in 2006[i], also decided that an evidence-based Interim Evaluation of FP7 was to be carried out no later than 2010. It was stipulated that this evaluation shall cover the quality of the research activities under way, as well as the quality of implementation and management, and progress towards the objectives set. A group of experts, chaired by Mr Rolf Annerberg was appointed to carry out the evaluation and submitted its report in November 2010[ii].

One overarching criticism that applies to many of the FP7 instruments is that they are overly and needlessly bureaucratic. The main aspects that are adjudged to be unsatisfactory and require attention are:

- Too much focus on the avoidance of risk, rather than adopting a trust-based approach;
- Overly complex administrative and financial procedures;
- Inconsistency in the application of rules or implementation of procedures;
- Excessive time to contract and unexplained variations between different themes.

In April 2010 a Communication on possibilities for simplification[iii] was issued, which proposes the amendment of the EU's Financial Regulation and the framework programme rules, in order to address these aspects. The results of this debate will be introduced in the FP7 rules as far as feasible, in the shaping of the next framework programmes, and in the Commission proposals for the "Innovation Union" flagship.

Based on the evaluation that the group conducted, covering the first 3 years of FP7, the expert group sets out key recommendations for the second half of FP7 and a new FP after 2013. Some of the most relevant points within the scope of this report are:

- Stronger and better connections need to be established within the knowledge triangle; there needs to be a better integration between the research and innovation dimensions in light of the new research and innovation strategy being developed by the Commission, but education as the third arm of the Knowledge Triangle should not be neglected; joined-up policy-making will be needed to achieve effective linkages between research and innovation, thereby shaping productivity, competitiveness and employment.
- The mix of funding measures in FP7 and successor programmes should strike a different balance between bottom-up and top-down approaches to research, with greater emphasis in the specific programme Cooperation during 2011-2013 on more open calls.
- A well-articulated innovation strategy needs to ensure that instruments and priorities encourage participation from a broad spectrum of small and large enterprises, universities and research and technology organisations; in fostering innovation, the role of industry as the bridge between research and 'commercialisation' has to be stressed and the fact that SMEs are consumers as well as performers of research better recognized;
- More effective instruments are needed to achieve effective coordination of research between the Member State and EU levels; to advance ERA and Innovation Union

objectives, integrating the research base by overcoming fragmentation in research is vital, while simultaneously achieving a sharper division of labour between what is done at EU level and what is undertaken in national programmes; European research and innovation efforts must concentrate on themes where critical mass is vital for success and where breakthroughs require cross-border solutions, while also allocating sufficient resources to R&D topics which promise radical innovations.

- At the same time as identifying the need for certain instruments, the expert group also recommends that a moratorium on new instruments should be considered until the existing ones have been sufficiently developed and adequately evaluated, and care should be taken to avoid a confusing proliferation of instruments.

The Commission has responded to the recommendations in the various evaluations through a Communication of February 2011[iv], outlining which actions the Commission intends to take or has already taken. The issues addressed in this Communication that are most relevant within the framework of this report are listed here:

- Three immediate wins were identified to address simplification: I) a re-definition of the criteria for the acceptance of average personnel cost methodologies; II) provision of a possibility for owners of SMEs and natural persons to reimburse the value of their work brought into FP7; and III) establishment of a clearing committee in order to achieve a uniform interpretation and application of rules and procedures between the Directorates-General. The Commission adopted the required implementing decision in January 2011. The revision of the Financial Regulation, essential for achieving more radical simplification in future programmes, is also being addressed[v].
- In order to establish a better integration of the Knowledge Triangle, the 'university-industry' forum and the 'knowledge alliances' announced in the Innovation Union Communication, as well as the development of appropriate skills for researchers to innovate as provided by the Marie Curie Actions, are considered to be important.
- Currently, a bottom-up approach to research is considered to be provided by the Marie Curie Actions, the European Research Council, and also the Future and Emerging Technology (FET) Scheme that is supporting exploratory research in ICT. The Commission has proposed further open, challenge-driven calls for proposals in the final years of FP7, and the issue of bottom-up versus top-down approaches is set to feature strongly in the orientation debate on the next FP.
- The approach to align FP funding priorities with the technology needs of industry is to be strengthened in future EU programmes, as set out in the Innovation Union, along with stronger knowledge transfer mechanisms and the launch of European Innovation Partnerships. The innovation impact of remainder of FP7 is to be achieved through funding projects that take research results closer to market, additional emphasis on innovation impacts in evaluating proposals and funding for SME specific projects and topics.
- In order to advance the ERA and Innovation Union objectives, EU research programmes must provide a clearer focus on the major research items and the large societal challenges. Areas of common or convergent interest must be identified, while ensuring better alignment of research capacities. Furthermore, in February a Green Paper was issued on “A Common Strategic Framework for EU Research and Innovation Funding”[vi], which will aim to ensure that all EU research and innovation funding works towards common goals and according to a shared strategy.
- In order to avoid a proliferation of instruments, the Commission will examine the current portfolio of instruments to identify areas for simplification, possible redundancy and potential gaps. Novel approaches such as prizes or innovative procurement schemes should also be considered. The adaptation of a Common Strategic Framework will necessitate a development of a coherent and streamlined portfolio of instruments.

The explicit assignment for this Working Group has been to identify which instruments should be desirable to propose for the purpose of optimally fostering ICT Research and Innovation under FP8. On the basis of plenary discussion within ISTAG and personal experience, the Working Group has concluded that there are a number of overarching themes within ICT research that require further attention:

- Implementing simplification measures and creating more flexible conditions;
- Creating an environment in which innovation can prosper;
- Enhancing the impact of the instruments for Future and Emerging Technologies;
- Filling the gap between pre-competitive funding and products;
- Increasing the functionality of cross border public-private collaboration.

The simplification measures and the moving to more flexible conditions is seen as an extremely important development. The view of this working group is that:

- The open call procedure adopted in FET-Open, which involves a 2-stage application process, is recognised as an example of good practice that encourages new proposers to engage with the programme;
- Whilst recognising the need for Commission procedures to be simplified, it is also important that the process as seen from the proposers´ perspective is made simpler and less bureaucratic;
- Emphasis should be given to supporting accelerated routes to market for innovations coming out of the Framework Programme;
- In initiatives that are aimed at creating cross-border cooperation, such as the JTI scheme, the Commission needs to work with national governments to ensure better alignment of national regulations relating to such activities.

Taking into account the considerable amount of attention currently being paid to the scope for simplification, it will not be any further addressed in this report. The other 4 issues will subsequently be discussed in the Chapters 2, 3, 4 and 5 and resulting recommendations are collated in Chapter 6.

2. Creating the right environment

The societal impacts of the 8th Framework Programme are expected to be the generation of wealth, the creation of employment and a sustainable society of high human values. However, one could question whether or not it should also have concrete products and services as desired impacts. Currently a weakness of Europe in the area of innovation is that it is not getting sufficient benefits from the investment in research, and it does not have support for practice-oriented innovation models, which generate 96% of innovations.

The impact can only be achieved through holistic development of the innovation system of Europe. Education, research, development and innovation are just partial solutions. Funding, legal issues, and culture, are also part of it. Meta-level innovation on a societal system is required, as silo management is not capable to develop society in a cross-functional manner. The sublevel goals can only be achieved partially if this top-level innovation ecosystem is not managed. Therefore, we recommend the creation of a strategic framework that extends beyond the knowledge triangle to incorporate further legal, societal, and cultural dimensions. The strategic framework should promote a horizontal approach to vertical domains to overcome potential fragmentation; work in the vertical domains should not be focused on a single societal challenge, but should be designed for re-use in other areas.

Europe now offers an exceptional market for investments into high-tech companies. At the same time, the boundaries of our industry are diminishing as venture capital and Business Angel investing becomes an increasingly global business. For Venture Capital funds to flourish in this increasingly competitive market they need a strong value proposition that attracts the best prospects and provides value to a company beyond initial cash investment. Also technology companies now address global markets, and must compete around the world. Growth within a single country is now not enough to drive the value of a company.

A new ‘EU Ventures’ fund is needed to offer companies a Europe-wide platform of knowledge and investment, allowing companies to grow rapidly and achieve a significant market share. The Commission could also explore mechanisms, such as demonstration projects, to maintain a manufacturing base in Europe.

We welcome the launch of the European Innovation Partnerships (EIP’s) pilot on “Active and Healthy Aging” as part of the Innovation Union Communication[vii]. We strongly support DG INFSO in its ambitions to participate in further ICT related EIP’s in the areas of “Smart Cities” and “Trustworthy Digital Society”. The strong alignment between these proposed areas and the strategic agenda of the EIT ICT Labs[viii] should be particularly beneficial for achieving a strong synergy between research and innovation.

We hope that the EIP initiative will serve as a strong paradigm for creating the kind environment foreseen in the foregoing paragraphs. Taking such long-term views of the research and innovation agenda is encouraged, but it is important that these schemes remain sufficiently flexible to maintain the alignment with national agendas, which tend to align more strongly with shorter-term, electoral time scales.

We recognise that international cooperation is likely to become essential in order to achieve our full ambitions in the future. The Working Group did not have appropriate expertise to make specific recommendations about the INCO instruments. These should be reviewed in the next stage of the development of the recommendations in this report.

3. FET Impact

Future and Emerging Technologies (FET), currently about 10% of the ICT Programme, is intended as a nursery for new ideas and should be funding high-risk research promising major advances with the potential for societal and industrial impact. There is evidence of the high scientific quality of FET-funded work both through prestigious awards (Nobel Prize in Physics 2005) and high impact publications. Areas such as Quantum Cryptography, Advanced Microelectronics and Nanotechnologies, which are becoming more mainstream, are topics that started in the FET programme.

The Commission has initiated an activity to assess the impact of FET research activities. The consortium conducting the study have developed a methodology for assessing the impact of FET research initiatives and applied their framework to two areas: Bio-inspired ICT and Quantum Information Processing and Communication. The team have developed a set of 12 questions that can be used to assess the results of the initiative and its impact on human capital. The empirical approach is based on desk research, interviews, bibliometrics and patent analysis. The final report from the study should be available before the final version of this report is produced.

The team caution against attributing specific contributions to FET by itself but recognises that FET projects are usually embedded in a broader programme and therefore it may be more appropriate to measure the added value of FET. Previous impact assessments of FET OPEN, covering the period 1994-2004, found that “the FET-OPEN scheme proved to be particularly successful in opening new S&T possibilities, setting the agenda for future ICT research programmes, providing/exploring alternative technology solutions for industry, and confirming the path-finding role that FET has in IST"[ix].

The FP6 Impact Analysis study "Watching IST Innovation and knowledge"[x] has a single paragraph devoted to FET and likens it to the US Department of Defence very-high-speed integrated circuits programme of the 1980s, which the Pentagon described as "lunatic fringe" research. Despite this pejorative terminology the report recognises that FET must be evaluated on different timescales than the rest of the programme and observes that the effectiveness of FET's "change agent" role should be subjected to closer examination (which it may receive through the current impact study).

DG INFSO's internal document on participation, positioning and impact of the ICT Programme[xi] also says very little about the FET but does show that 90% of FET participants in FP7 have already been involved in FET projects in FP5 and FP6. It would be interesting to understand how such involvement has changed across the programmes. Anecdotally, at least within the software technologies area, projects have become more application-focussed with increasing involvement of both large companies and SMEs as project partners, but it would be interesting to capture the evidence to support this assertion.

Despite these observations, which apparently point to a relatively healthy positioning of FET research, there does seem to be a perception that there is lack of connection between FET research and the main programme/European industry. This view of the "valley of death" between longer-term research and exploitation is not unique to the Framework Programme. The UK Research Council's recent emphasis on proposers being required to identify detailed pathways to impact reflects the UK Treasury's concerns about the exploitation of publicly funded research. Assuming that there is a problem, the question arises as to whether new instruments could be developed to address it.

One possible instrument is suggested by the UK's Engineering and Physical Sciences Research Council (EPSRC) Collaboration Fund. This is currently in a pilot phase. It is a £2M fund offering funding and practical support to researchers who wish to work in collaboration with a commercial partner to turn their research into an industrial application. Grants are limited to £100K but offer additional mentoring and commercial advice.

A similar scheme could be used to incentivise successful FET researchers to engage in pre-competitive activities in the main programme. In addition to supporting researchers who wish to work in industry, industry-based R&D engineers should be offered the opportunity to spend a period in academia. The exchange of people between academia, research institutes and industrial R&D is vital for fostering innovation and should be a main focus point.

The Aho report[xii] calls for a step-change in mobility of researchers from academia into limited-term appointments in industry. It has an aspiration of 10% of the workforce moving in each year with as high a proportion as is feasible engaged in movement between academia and industry. A different way of achieving the transfer from academics to industry, as described in the previous paragraph, may be to establish short-term fellowships for researchers who have developed exploitable ideas through the FET programme. It is equally desirable to encourage mobility of more experienced researchers between countries although this need not be a prerequisite for this scheme.

A further suggestion is inspired by the "industrial uncle" scheme pioneered in the UK Alvey programme in the 1980s; industrial uncles were charged with steering projects to ensure that they had appropriate industrial or societal impact. They had a more frequent interaction with projects than the reviewers, often acting as uncle for a number of projects and playing a role as project champion.

The FET Flagships initiative is welcomed as a new model for large-scale scientific partnerships. At the same time, the Commission communication[iv] in response to the Expert Group on the Interim Evaluation of FP7 highlights the success of the FET scheme in supporting a mix of top-down and bottom-up research. We strongly recommend that the FET Flagships should be adequately supported at the levels of funding foreseen in the original proposal but that this should not be at the expense of FET Open; the budget for the latter should be maintained at current levels (at least).

If additional funding is available to support the FET Flagships, the Commission should consider retaining a FET Proactive scheme that could be aligned to topics which have emerged from the Flagship discussions but which are not selected as Flagships.

Assuming that the FET Proactive scheme continues, the Commission should consider engaging the FET community on a more regular basis to identify potential themes. This did happen during the early years of FP7 but does not seem to have happened recently. The mechanism ensures that fast emerging areas can be integrated into the scheme and FET maintains its position as a pathfinder programme rather than a follower or, worse still, missing new areas altogether.

4. Filling the gap from pre-competitive R&D to products

One fundamental issue of innovation is to fill the gap from pre-competitive research and development (R&D) to products. It is the classical issue of technology transfer, which is basically common to academic research laboratories and industrial research laboratories, even if the conditions/landscapes are quite different.

Over the past few decades, the worldwide innovation landscape has changed. Before, most innovation took place through internal R&D by large corporations, whereas academia carried out fundamental research that benefited the general advancement of science. Today, in many industries, the logic that supports an internally oriented, centralized approach to R&D has become obsolete. Useful knowledge has become widespread and ideas must be used with alacrity. Such factors create a new logic of Open Innovation that embraces external ideas and knowledge in conjunction with internal R&D.

By Open Innovation we here refer to “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively; this paradigm assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology”[xiii]

Since the start of the last decade, organisations adopting this approach have demonstrated that Open Innovation can be an effective way to bring academia, institutional researchers and industrial engineers together to create commercially exploitable IP. Several European research institutes have built a worldwide reputation in implementing an Open Innovation scheme in which resources, costs and results are shared.

It needs to be considered if Open Innovation can play a wider role within Europe in fostering technology transfer from the R&D teams into the products. Within the concept of Open Innovation, all actors along the trajectory from research to commercialisation work together on technology development and transfer. This ensures practice-oriented innovation where both demands from the user-side as well as issues that can hamper successful industrialisation are taken into account at an early stage, leading to a more effective technology transfer process.

An added advantage in the European context is that Open Innovation will often be an international endeavour, as the required strengths in the areas of research, development and industrialisation are seldom found in one country.

In addition to the more paradigm-shift requiring concept of Open Innovation, there are three pragmatic easy-to-implement recommendations that can foster technology transfer: the first recommendation deals with culture, the second with innovation expertise, the third with seed funding of technology transfer.

The first recommendation concerns the use of “clean words” in order to win the battle of ideas. It is necessary to clearly state the fact that pre-competitive R&D and innovation are different as to their goals and processes.

The severe drawback of the innovation-driven ideology concerning R&D projects funding, is that there are a lot of “weasel words” in many proposals, when the projects only consist in pre-competitive R&D and do not at all target product design. It implies that a common awareness of the gap between R&D and products is missing.

It is recommended to define and use the appropriate words, accept that it is not mandatory to claim an innovation-driven future for *each* R&D project and launch awareness-raising campaigns for R&D scientists (academia and industry) explaining the gap between R&D and products (what, who, why, when, how).

Secondly, the follow-up for R&D projects should be challenged with the appropriate expertise. A dedicated strategy for transferring the results of R&D pre-competitive project should be designed and challenged as regards the potential business applications and the ways to reach the market. Such investigations, meant at bringing help to the project members through external views and appropriate expertise, shall be performed by a panel of market-oriented experts (including VC, CEO of innovative SME, CIO of large companies, business developers, but no scientists).

It is recommended to define and build a dedicated process for transferring R&D results to the market, based on challenging the related technology transfer strategies. Set up a market-oriented panel of experts. This is in line with one of the conclusions of the Aho report [xii], which calls for the creation of an innovation-friendly market and the establishment of an independent high-level coordinator to orchestrate European action. Filling the gap from pre-competitive R&D to products has been identified as a key issue by the EIT KIC ICT Labs and is the aim of the Technology Transfer Program (led by INRIA) that ICT Labs will launch in 2011.

Lastly, technology transfer should be supported at an early stage. Appropriate funding tools (similar to seed money) should be available in order to initiate a *technology transfer project* as such (i.e. filling the gap from pre-competitive R&D to products).

It is recommended to build an Innovation Accelerator/Seed Money Fund (with an amount defined as a percentage of the whole R&D expenses) with the purpose of increasing spin-out activities and supporting start-up SME´s. The KPIs of such a program should include numbers of awareness-raising actions, R&D projects to be investigated, technology transfer projects funded and “success stories” resulting from these projects.

5. Cross Border Cooperation

In recent years, Member States and the European Union have taken many initiatives to boost the relevance, impact and efficiency of R&D programmes in Europe. However, the fragmentation of public research programming leads to sub-optimal returns at increasing costs. This chapter points to some of the present problems and suggests improvements.

The European Research Area and the Framework Programme for Research and Technological Development are of high importance for collaborative research contributing to the development of the innovation-based economy and to tackle societal challenges. The Innovation Union is stressing the need for more cross border cooperation in Europe.

Centres of excellence located in Europe are encountering specific challenges and problems due to recent evolutions within the European research and innovation policy. In the past the European Commission supported directly the European partners willing to cooperate in accordance to their capabilities and expertise.

Today the European Commission sees a shift in its role within the science and innovation policy to a role as a coordinator and facilitator where the real implementation will belong to external organisations. The adoption of the Lisbon Treaty last year promotes the set-up of new legal structures to do this job. Within the external organisations national/regional programmes will be lined up and budgets of publicly funded research programmes will be pooled.

The aim was to establish cross-border cooperation by setting up instruments based on co-funding schemes: schemes where the funding is partially provided by the national/regional governments and partially by the European Commission (mostly proportionally to the national participation), supplemented with participation of the industry (in cash or in kind). Examples of such schemes are the public-private partnerships (article 171 initiatives - JTI's like ENIAC and ARTEMIS), the public-public partnerships (art. 169 initiatives) and the upcoming Joint Programming and Innovation Partnerships.

These initiatives within the co-funding schemes have proven that it is very difficult to convince Member States to support part of the costs made by research centres outside their borders although the results from the collaboration would flow mainly to the industrial participants in their country.

This issue leads to a more restricted participation by centres of excellence located in Member States in which the related industry is not strongly present or not participating in the project while other industrial partners located in Europe would benefit from their participation. One of the consequences is that these centres of excellence are forced to seek cooperation and funding outside the European collaboration schemes. This leads to a reduced interaction with European companies, which is a missed opportunity.

Centres of excellence located in a Member State or region, not having the specific local industry participating, are not always able to participate in the European programs, which means that the full creativity and innovation potential existing in the EU is not used.

It is clear however that in order to compete at a global level, Europe has to bring its strengths together and this without being hindered by the borders of the different European Member States. This cannot be achieved without a fair European Cross Border funding instrument. European Cross Border funding is interpreted here as European funding available for structural collaboration between centres of excellence (universities, research centres, and industry) located in different Member States or Associated Member States.

Smaller Member States encounter bigger problems with these initiatives based on co-funding schemes since their financial funding capabilities are smaller in comparison with large Member States. For instance, the allocated 2008 budgets for ENIAC respectively ARTEMIS by Germany are 15 and 8,8 m€, Italy 10 and 8 m€, The Netherlands 8,65 and 5,8 m€, France 8 and 5 m€, Austria 3,9 and 3,7 m€, Belgium 1,6 and 1,5 m€ and Ireland 0,97 and 0,64 m€.

In conclusion it can be stated that for research institutes in general, but especially when located in small Member States, the European funded public-private and public-public partnerships are not working well - and as a consequence - Europe is not making use of the full research potential that is available.

It is therefore important that the European Commission gives attention to this point when reviewing the impact of these public-private and public-public partnerships. The present funding rules within these instruments induce inefficiencies and should be reconsidered in order to facilitate cross border cooperation. In view of the ongoing discussions on the Key Enabling Technologies (KETs), an appropriate European funding scheme for true cross border collaboration becomes even more important.

Also in the framework of Open Innovation, as discussed in the previous chapter, it is imperative that funding instruments facilitate effective cross border collaboration. Open Innovation in Europe will often involve bringing the research results, obtained in one country into the industrial sites located in another European country.

The pre-competitive work, to some extent covered by the European research programmes, may lead to excellent results that are not exploited because the innovation part has to take place in another country with Member State funding. When research done in one Member State is strengthening the product generation and manufacturing in another Member State, European funding should come in as glue in order to promote this transition from research into innovation.

A practical suggestion to solve the situation with respect to the JTIs (ENIAC and ARTEMIS) is to reserve part of the European budget in these projects for true cross border cooperation, by supporting those partners (academia and research institutes) that can contribute to the project but have not sufficient national/regional budgets to do so. The same will apply to Joint Programming and to the Innovation Partnerships.

A more general and probably easier to implement approach could be to provide 75% European funding for all institutes and academia involved in these projects as is the case in the Framework Program. However in order to promote the spirit of European cooperation, it may be more appropriate to restrict the 75 % European funding to those institutes and academia having industrial partners in other Member States and/or producing results that are used cross border.

It is highly desirable to implement a different financing structure already in 2012 in order to obtain more European cohesion, especially in the JTI's but also in other initiatives like Joint Programming and Innovation Partnerships.

6. Summary of recommendations

Creating the right environment:

- Create a strategic framework with a meta-level focus that extends beyond the knowledge triangle to incorporate further legal, societal, and cultural dimensions.
- Establish European Innovation Partnerships (EIP's) with as aim to join up research, innovation and policy. Especially the creation of EIP's in the areas "Smart Cities" and "Trustworthy Digital Society" is encouraged.

FET impact:

- Establish a Collaboration Fund for researchers who wish to work in collaboration with a commercial partner to turn their research into an industrial application or get involved in the main part of the programme. More generally, the mixing of people between academia, research institutes and industrial R&D should be encouraged and facilitated.
- Establish short-term industry-based fellowships for established researchers who have developed exploitable ideas through the FET programme.

- Establish an “industrial uncle” scheme to ensure that projects have appropriate industrial or societal impact.
- The FET Flagships initiative is welcomed as a new model for large-scale scientific partnerships. The commission is urged to maintain the level for the FET open programme at least at the current level. If the overall funding level for the FET programme is increased, the Commission should seek to have funding for a complementary FET pro-active programme, running alongside the Flagships.
- Assuming that the FET Proactive scheme continues, the Commission should consider engaging the FET community on a more regular basis to identify potential themes.

Filling the gap from pre-competitive R&D to products:

- Facilitate and play an active role in the wider implementation of Open Innovation in Europe.
- Define and use the appropriate words, accept that it is not mandatory to claim an innovation-driven future for each R&D project, and launch awareness-raising campaigns for R&D scientists (academia and industry) explaining the gap between R&D and products.
- Define and build a dedicated process for transferring R&D results to the market, based on challenging the related technology transfer strategies. Set up a market-oriented panel of experts.
- Build an Innovation Accelerator/Seed Money Fund (with an amount defined as a percentage of the whole R&D expenses) with the purpose of increasing spin-out activities and supporting start-up SME´s.

European Funding for Cross Border Cooperation:

- When research in one Member State can strengthen product generation and manufacturing in another Member State, European funding should come in as the glue that enables this.
- Reserve part of the European budget within the JTIs and Joint Programming for true cross border cooperation, by supporting those partners that can contribute, but have not sufficient regional budgets to do so.
- Provide 75% European funding for institutes and academia involved in JTI´s having industrial partners in other Member States and/or producing results that are used cross border.
- Implement a different financing structure already in 2012, rather than under FP8.

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Orientations for **EU ICT R&D & Innovation beyond 2013**

10 KEY RECOMMENDATIONS

Vision and Needs, Impacts and Instruments

••• Directorate-General for the Information Society and Media

Unit C2 – Strategy for ICT Research and Innovation

http://cordis.europa.eu/fp7/ict/istag

European Commission
Information Society and Media