REVISING EUROPE'S ICT STRATEGY

Report from the Information Society Technologies Advisory Group (ISTAG)

Final version

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FOREWORD

The European ICT strategy has become one of the most important issues that the European Union and its member states have to address. Given the influence of ICT on practically any new innovation in any industry sector, sustainable wealth in Europe will rely on a successful European ICT strategy.

The ISTAG (Information Society Technology Advisory Group) is a think-tank of leading researchers and technology officers established by the European Commission to provide recommendations to the Commission on how to address upcoming trends in ICT and its adoption. In particular, ISTAG provides detailed feedback on the Framework Program and related work programs.

ISTAG has played an influential role in the evolution of European ICT Strategy.

In 1999, at the start of the 5th EU Research Framework Programme, ISTAG promoted the concept of 'Ambient Intelligence' and also that of 'Seamless Connectivity' to enable Ambient Intelligence. Ambient Intelligence continues to focus ICT research and product development in Europe, and the notion of Seamless Connectivity has transformed attitudes to communications that were traditionally closed within sectoral islands - even between wired and wireless worlds.

Prior to the launch of the 6th Framework Program in 2002, the advisors recommended *"mechanisms for co-operation across the European Research Area so as to achieve a common vision of 'strategic domains', and associated road-maps, shared between the Framework Program, other European programs - especially Eureka, and national programs"*. Today we have the Joint Technology Initiatives which fulfil exactly that function. In particular, ISTAG recommended that initiatives should be established to develop the next generation of embedded systems. The leading JTIs - and now the first 'Joint Undertakings' (apart from the very different Galileo Satellite Navigation) under Article 171 of the Treaty of the European Union, are the Artemis JU for Embedded Systems and the ENIAC[1] JU for Nano-electronics.[2]

In 2003 ISTAG proposed that European governments should be at the forefront of ICT adoption - not only applying established technologies and solutions but actively encouraging innovation and facilitating the establishment of new markets. Today, the ICT Policy Support Program that was launched at the end of 2007 is bringing together Member States in large scale pilot projects and networks to share experience in ICT uptake in the public sector.

The ISTAG report "Shaping our Future through ICT – A vision for ICT research and innovation in Europe" recommended the development of lead markets for innovative ICT solutions addressing Europe's key societal challenges. The report was a major inspiration for the 2006 Aho Group that called for a focus on the creation of innovation-friendly markets in Europe. This has shaped the targets, approaches and actions of recent EU and national initiatives in this field.

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1 ENIAC: The European Nanoelectronics Initiative Advisory Council.

2 The call-1 of both ARTEMIS and ENIAC has been successfully closed on last September 3rd 2008. A total of 27 projects have been submitted to ARTEMIS and 11 projects to ENIAC.

EXECUTIVE SUMMARY

"Products with totally new capabilities will become available for general use, dreams such as intelligent cars, non-invasive health monitoring and disease prevention, homes sensitive and responsive to the needs of the persons living in it will become available to everybody., We will get better control of our health and environment, and over the quality of our food and our air, ensure better utilization of energy and other basic resources, we will be able to recognise diseases even before symptoms appear, and we will be able to be fully mobile and at the same stay constantly in touch with everybody."[3] These dreams will be realised, primarily, through ICT.

With the economic downturn and as policy and decision makers tend to focus on short term reactive measures, it is essential that Europe keeps mobilising resources to shape and exploit ICT innovations. We are on the doorstep of a new era -- the Future Internet will be a new infrastructure that will dramatically affect the way individuals, businesses, public services, and government and society as a whole operate. Europe must be a serious player within this development and if we do not act now, we may sleep away the future. This new infrastructure will provide the 'information ether' for imaginative new intelligent products and services - both hardware and software, as well as robotic devices - which can engage with the real world.

Progress towards the Future Internet and towards more adaptive and interactive devices and artefacts is also fuelled by further miniaturisation and integration and by the emergence of new alternative paths to future electronic components and systems. ICTs are becoming today essential constituents of an increasingly wide range of products and services across the economy and society.

The ISTAG approach is to ensure that Europe develops and sustains:

- the knowledge and the technical capabilities to develop and to frame the Future Internet infrastructure, services, access devices and systems.;
- the applications & solutions for the user, in terms of new intelligent products/services – or 'end systems', benefiting notably from the Future Internet.
- the (e-)skills, to be capable to use these new capabilities;

Future ICTs must:

- respond to the need for greater sustainability, efficient use of scarce resources and a lower carbon emission economy.;
- have a high impact on productivity to ensure economic growth and jobs creation in Europe;
- help us address key societal challenges from health to ageing and inclusion.

ISTAG believes that it is important to recognise that in today's society, and even more in tomorrow's society, ICT and the related network and service infrastructure, is a fundamental contributor to the survival and well-being of society.

At a time of economic downturn like the present, there is a tendency to lean toward Keynesian policies of public procurement to support the development of infrastructure.

[3] Ref: ENIAC web page: http://www.eniac.eu/web/about/local_index.php

But infrastructure is not just bridges and roads: *the* infrastructure of the future is the ICT infrastructure. This is the time to invest in it - to upgrade public services, and to provide a motor for innovation to accelerate societal, environmental, industrial and technological progress.

The infrastructure is a vital enabler but, as our report indicates, ICT underpins capability and competitiveness in *every* sector, and Europe has particular strengths in 'embedded systems' - that are to be found in aircraft, cars, and before very long in the human body - and in 'end systems' - that is to say 'applications' in domains such as manufacturing, medical, energy and transport. So in addition to building the infrastructure for the future, we must build on and exploit our existing strengths while helping these sectors move into the future, *sustainable*, era.

CONTENTS

1 *INTRODUCTION*

In this report, the Information Society Technologies Advisory Group, ISTAG, sets out the updated strategy for ICT in Europe for the decade 2010 to 2020.[4]

Following an overview of societal and economic trends, we indicate ways in which the 'mega-trends' in ICT can help people to stimulate and support these trends. This sets the context for the recommendations for a European response to these trends: this is the ISTAG strategy for the next decade. The strategy has four tiers:

- maintain and develop European strengths in underlying science and technology;
- maintain and develop European skills and knowledge to use ICT to good effect ;
- establish a European infrastructure for innovation - not just a technological infrastructure but infrastructural processes necessary to take ideas from dreams to market;
- support the development of applications and solutions that exploit the innovation infrastructure to the benefit of the European citizen and European society in a sustainable way.

2 *SOCIETAL AND ECONOMIC TRENDS*

The trends influencing and changing our society and economy over the next years and decades are here structured around the interests of *Individuals*, *Society* and *Businesses*. We then focus on those trends which will have significant impact on the way that each of these groups will behave and develop.

2.1 The Individual

Rising standards of living and ever-improving healthcare are increasing both the length and quality of life. The individual can expect a richer, more fulfilling life, with a range of experiences undreamed of for most people half a century ago. We can play a longer and more active role in society - indeed, in many societies. We can have multiple careers. We can expect the boundaries between employment, voluntary work, hobby and recreation to become more and more diffuse. Society, as a consequence, can expect ever greater, richer and longer engagement of citizens in the economy, in social activity, and in democracy itself.

This enhanced engagement of the older citizen is being facilitated by political, cultural, and technological changes to enable inclusion of all citizens in society throughout their life. The European Ambient Assisted Living initiative joint program is a flagship initiative in this field.

[4] Note that earlier recommendations of ISTAG have been accommodated in the prioritisation of ICT actions within the 7th Framework Program. The updated strategy in the present report takes into account that projects launched during FP7 in response to earlier ISTAG recommendations will be running until 2013.

2.1.1 From *isolation* towards *integration*

Our citizens are living longer and better. Society is becoming more inclusive. Advances in the standard of living, in medical care, and in technological support enable more citizens to participate more fully in society.

People increasingly expect to move around. Unlike travellers of old, many are not prepared to accept being remote. Increasingly they expect to remain connected - not just electronically, but emotionally, and societally. ICT enabled eMobility enables the individual to roam where they will yet stay connected to the extent that they wish.

But much of today's transport potential is consumed in unpleasant and what will become largely unnecessary movement, such as commuting. ePresence, together with sophisticated travel-pricing building on our early steps in road-pricing, will encourage a shift from unnecessary to desired transportation, at a cost that takes account of both personal needs and societal impact.

Through greater exposure to other cultures, greater mobility, and electronic communication, the individual no longer feels bound to one place and one culture. The individual is liberated to be truly an individual, and to choose their own place, culture, friends, career and colleagues. This has implications for society and even democracy.

2.1.2 From *local citizens* towards *the global village*

Individuals experience themselves as members of social entities, normally linked to their local area. Web applications like *Facebook*, *MySpace* or business networks like XING or alternative worlds like Second Life offer virtual communities for individuals who can adopt new identities and become part of the global village.

News travels fast in the global village. We can - if we wish - be aware of and even influence societal developments, scientific advances, and technological innovations wherever they occur in the world.

The global economy in the global village requires all individuals to care about global trends as much as local ones. In times of growth, people can easily benefit but they can also be affected by a global crisis through, for instance, personal pension plans that are based on global trading funds - as many have seen in recent times.

2.1.3 From the *consumer* towards the *prosumer*

Most individuals experience ICT as *consumers*. TV, personal computers, mobile phones, mp3 players and navigation systems shape our daily life as well as numerous ICT solutions invisibly integrated into the products surrounding us.

With new web platforms like *YouTube*, *Wikipedia*, *eBay* and blogs we are seeing the emergence of the ***prosumer***, whereby the individual, formerly a consumer of content, takes an active part in the production and delivery of content. Individuals thereby play a proactive and creative part in the next generation of services. People have always been able to contribute their views to society, but today's technologies and applications provide a much easier way of doing it. *"Yesterday it was Speakers Corner, today it is*

YouTube". Nevertheless, these new platforms challenge data confidentiality, as e.g. recruiters can check out *XING* or *Facebook* to see what someone's personality is like, and anyone can easily upload compromising pictures or statements via *YouTube* to harm other individuals (teachers, neighbours, ...). Therefore, issues of personal integrity and identity management need to be addressed and ensured.

Becoming an active producer allows an individual to reveal themselves to the global village and to participate in its activities in a way never experienced before, whether they publish their own essays and music or become semi-professional traders on auction platforms.

2.2 Society

Increasing communication and integration have broadened the scope of computing systems from individual use – be it a professional solving a technical problem or a private citizen seeking entertainment - to the management of enterprises. We are now on the verge of an era of ***societal computing***, in which all facets of society will be managed with ICT support to optimise societal and economic outcomes.

Societies benefit greatly from ICT solutions. At the same time, the dependence of our society on the correct functioning of many technical systems - energy infrastructure, telecommunication infrastructure, transportation - is becoming increasingly significant. As a consequence, society expects these systems to be ever more safe, secure and reliable - as instanced by the EU's goal of zero traffic fatalities by 2020. This is evident in the new regulations and certification rules that are being put in place in many domains to increase the degree of confidence we can have in the flawless operation of these systems.

We identify three major trends in society: a move to more transparency in government and corporate management, a growing emphasis on sustainability, and a shift from geographically located societies to virtual communities.

2.2.1 From *government* to *governance*

Recent corporate crises, political crises, and especially the most recent financial crisis have highlighted the increasing expectation of the citizen for more transparency in corporate and governmental management and for a greater say in that management. Governance, defined as a continuously coordinated and balanced set of regulations and agreements within and between states, as well as in the private and the tertiary sector, is the foundation that ensures the wealth and benefit of societies. ICT can enable us to manage, control and develop those regulation processes to master their complexity.

Through the modelling, predicting, sensing, and monitoring offered by ICT, we can be better informed, make better decisions, and exercise better control.

ICT is also enabling the citizen to *participate* rather than be just a passive subject. *e-Government* and *e-Administration* not only make government more efficient, they enable and encourage inclusion and *involvement* - of not just those who have difficulty participating in the 'old' way, but everybody. ICT enables *e-Democracy and eGovernance.*

2.2.2 From *resource-intensive living* to a *sustainable lifecycle*

We are at long last beginning to care for our planet. It has sustained us for around 30,000 years: we are beginning to realise that if it is to continue to do so, then we must help it to sustain itself as well. Increasingly our society is demanding that we manage better our exploitation of natural resources - both materials and energy - while reducing carbon emissions and pollution of all kinds. Indeed, the evidence is that CO_2 concentration in the atmosphere is increasing even faster than predicted[5].

Moreover, this trend is not just a 'problem': it is also an economic opportunity - not just to save money but to make money. Sustainability is set to become big business[6].

ICT plays a double role. As the use of ICT keeps growing in both professional and private lives, ICT itself is adopting sustainable developments and technologies. In other domains, ICT is already increasing the energy-efficiency of many products and production processes through better planning, monitoring, and control. The introduction of computer-controlled automotive engines has resulted in engines with a significantly higher fuel-efficiency and significant lower emission of pollutants, while improving overall engine performance. Also in transport, highways are being built with multi-sensorial networks incorporated to help manage traffic flows, reduce pollution, and reduce energy consumption. Logistics are being optimized with ICT to enable more efficient distributed production and distribution. Even energy production and management is undergoing innovation enabled by ICT to achieve decentralisation and optimized distribution.[7]

2.2.3 From *geographically based economies* to *virtual communities*

For ages, societies have been linked to their original geographical location, e.g. a home town or a homeland. Through web applications, as aforementioned, cyber societies are emerging in which individuals prefer selection-based services to the services available in established 'real' societies.

The change from geographical to virtual communities has already taken place in our ways of communicating with each other: SMS, e-mail (newsletters), VoIP, instant messengers and now virtual worlds like Second Life have opened new ways to get in touch with other people or have even substituted the old ways of transmitting information.

In the virtual community – as in real life – success depends on a few engaged people who move things forward, but without the constraints of geography. Virtual communities offer the ability to combine the needed knowledge (or services) to offer a complete new

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[5] See Global Carbon Project: Carbon Budget and Trends Report 2007: *"All these changes have led to an acceleration of atmospheric CO2 growth 33% faster since 2000 than in the previous two decades, implying a stronger climate forcing and sooner than expected"*", in: http://www.globalcarbonproject.org/carbontrends/index.htm

[6] See, for example, the proposal of US president-elect Obama to spend $150 billion on climate-friendly energy development and deployment. (http://obama.3cdn.net/780e0e91ccb6cdbf6e_6udymvin7.pdf)

[7] See for example *"SMART 2020: Enabling the Low Carbon Economy in the Information Age"* available from the Global e-Sustainability Initiative (GeSI): www.gesi.org. This report indicates that there is a potential to reduce CO_2 emission by 15% through the use of ICT. A more recent US addendum to this report indicates that 24% is achievable.

service. Web 2.0 is a good example of how manifold the combined services can be which are "used" and "generated" by the virtual communities. If you combine price-search engines with online maps and rating communities you gain completely new knowledge for the customer. Ordering the cheapest desired product by mail is then only one mouse click away.

But also the dependency between members of the virtual community differs from geographical communities. Looking at newsletters, the bond between the people on the distribution list might not necessarily be strong, but all might share the same interest.

Real, physical societies now compete with virtual communities for the individual's attention. This raises questions of identity and support. A major challenge is the use of the ability of virtual communities to overcome loneliness in two ways: firstly, to offer a community for senior citizens who cannot move around anymore due to their physical condition; secondly, to include the younger generation which spends hours and hours on "virtual games", some of them leading to serious mental problems of isolation. In this case the "ambient society" has to make sure that people do not get lost or left out in a merely virtual community, as another form of a "digital divide" where people are not virtual community savvy.

2.3 Business

Society is becoming distributed, and so are industry and commerce. There are still international industrial giants, but even they are moving away from rigid vertical integration to becoming more flexible and agile. In the context of this transformation, businesses are facing two major trends: the change of their role as local players to players in a global competition, and the shift from purely selling products to providing complete solutions addressing costumer needs in a much fuller way.

2.3.1 From *local players* towards *global competition*

With few exceptions, all industry and commerce is becoming internationalised. Once consumers, and particularly commercial consumers, buy online, they can and will buy anywhere. Manufacturers buy parts from wherever in the world they can get the optimum quality-price-delivery advantage. The supply chain is becoming the supply web. And within this web, players are not only becoming more flexible themselves, they are forming more flexible relationships with each other in 'business webs'[8]. Competitors trade subsidiaries and form shifting alliances with their suppliers and with each other in cooperative competition ('co-opetition'): sometimes cooperating to share reduced costs without jeopardising their competitive position while, at other times, fiercely fighting each other.

With real-time information and shorter feedback-loops, management is becoming able to react faster to changing customer behaviour. With more detailed data, products can be more individualized for specific customers (*the "segment-of-one" strategy*). Usage-based and performance-based pricing are becoming possible. By gathering more information regarding individual customer behaviour companies are becoming able to

[8] Christian Janiesch, Rainer Ruggaber and York Sure: Eine Infrastruktur für das Internet der Dienste. In: HMD – Praxis der Wirtschaftsinformatik, 45(261), 2008.

offer specific product and service bundles. 'High resolution management systems' make real-time target-performance comparisons and continuously adjust companies' processes to increase efficiency. [9]

Better information is leading to better decisions but much more data requires much more efficient management of data. So the high resolution management system operates more or less autonomously, with data gathered automatically, and only exceptional cases being escalated, following the principle of 'management-by-exception'. Some sectors have already started fragmenting their products and services to give full transparency during the lifetime of a product, enabling both more efficient and effective logistics and greater flexibility. This in turn facilitates better products and services, mass customization and ultimately personalization.

Open collaborative innovation changes the make-up of who the competitors are and who the partners. Open innovation increasingly takes place across national borders and some of the larger global enterprises have a turnover larger than a number of countries. But innovation is done largely by SMEs whereas big global enterprises find it difficult to enter new tracks successfully. And SMEs need state support programs on innovation because they lack the resources to properly develop their solutions. The EU has to take into account this duality as the big players give directions to whole sector, whereas SMEs often employ the majority of employees in these sectors. Thus, SMEs need to follow the big players in terms of globalization but on their own conditions, within their own boundaries and at their own pace. International collaboration of governments and regional markets like the European Internal Market is the key to the success of SMEs as well as of public procurement.

2.3.2 From *piecemeal products* to *end-to-end solutions*

We are moving from a product-based society, in which we *'give something to somebody',* to a service-based society, in which we *'do something for somebody'*[10]. Aerospace engines and telecom infrastructures alike are being sold as 'power by the hour'. Rail companies do not buy train carriages but 'passenger capacity miles'.

Sometimes the suppliers of these new user-oriented services are the original product manufacturers, but often they are not. There is a new breed of entrepreneur emerging who aggregates component products and services into *'end-to-end'* solutions. Their business models are different. Where product quality was once concerned primarily with the delivery of specified technical functionality, it is now the total *'through life' 'doorstep to doorstep'* user experience that matters. It is unlikely that there will be no products, but the trend will foster "products embedded in solutions", as people expect a set of services surrounding the products to receive a complete solution for the "problem described".

A consequence of the move to end-to-end solutions is that *dependability* of the services provided is now intrinsic to the contract. Instead of buying a product and hoping it will keep working, users are coming to expect a 'service level agreement' that includes not

[9] Fleisch, E., Müller-Stewens, G. (2008). High-Resolution-Management – Konsequenzen des „Internet der Dinge" auf die Unternehmensführung. Zeitschrift für Führung + Organisation (zfo), 05/2008, 272-281.

[10] See Spohrer, Jim (IBM); presentation on SSME.

just the raw functionality of the services required, but response time, reliability, availability, and safety.

The new, more open, business models that enable aggregation of services also, as a by-product, open up the market for provision of component services. Web-based services are becoming tradable goods, and the entry barrier for the web-based service industry is very low, with a very large potential scope[11]. The first shoots of such new business models can be seen in the content industry in the form of mash-ups and user-generated content (often user-generated mash-ups!). The need to be able to work with a collection of services, many of which are of unknown origin, is creating demand for new forms of certification to guarantee interoperability and, again, dependability.

3 *ICT 'MEGA-TRENDS' & THEIR IMPACT*

Information and Communication Technologies have already transformed modern life. We are all familiar with the explosion of affordable ICT-based consumer electronics, from mobile phones to DVD players on which you can watch films on the bus from work. But ICT underpins capability and competitiveness in every sector.

ICT-based engine management systems in cars have halved their fuel consumption in two decades. Body scanning, robot-assisted surgery, bio-informatics in drug design, and a multitude of other applications have revolutionised healthcare. Design tools, planning, management and control systems, manufacturing systems, and information systems in *every* sector are *all* ICT-based.

ICT is also a key enabler for the natural sciences. The LHC experiments and the nuclear fusion research and development of ITER and HiPER would not be possible without extremely advanced ICT. Weather prediction, disaster prevention and recovery and risk assessment all rely on ever more sophisticated computer modelling.

ICT innovation is the driver for innovation in every other sector. And in the ICT sector itself there are major innovative trends in infrastructure, devices, user-interaction, under-pinning technologies, and services. By exploiting these ICT trends Europe can gain maximum advantage from the social and economic trends highlighted in the previous section.

All these examples show how ICT has already had significant impact on the amelioration of living conditions, economical wealth and successful innovations across all application areas. The next decade will be dedicated to the Future Internet in order to interconnect all of these innovations in a seamless and efficient manner. Moreover, the Internet will become the dominant infrastructure of the future with respect to contributions to the GDP. It will provide tremendous opportunities to sustain our business world and our environment. Thus we need to discuss the various mega-trends in ICT and their impact on infrastructure, but equally important is the discussion about Smart Things, user interaction, systems and applications.

[11] See report of ISTAG Working Group on 'Web-based Service Industry', Feb. 2008

3.1 Infrastructure

From an incompatible loosely coupled infrastructure to the "Future Internet"

With its several billion users worldwide, the present Internet is a world-wide success in terms of connecting people and supporting communities in general. It is a global integrated communications network and service platform underpinning the fabric of the European economy and European society. Even though today we experience a vast number of daily life applications being run on Internet, tomorrow's applications will attract even more users to new services needing greater mobility, wider bandwidth, higher speeds and enhanced interactivity. These demands will put the underlying architecture under greater stress and we need a more secure, reliable, and scalable Internet architecture for the future in order to meet with these requirements.

Since the beginnings of the Internet almost 40 years ago, we have witnessed a number of changes in the application of communications technologies. Today, the Internet is a ubiquitous infrastructure: it is always on. And after this first era of connecting *places* and connecting *people*, the Future Internet will also connect *things*.

The next generation network architecture will fix the shortcomings of the current Internet, including Security, Privacy, Trust and Identity Management. It will have hooks for business and incentive models, support for semantics, support for mobility, and it will be resilient. This architecture will be flexible enough to support a range of application visions and business models in a dynamic way, ensuring convergence between technology, business and regulatory concerns.

New communication technology will enable increasing connectivity, through both wired and wireless communication, both near-range and far-range. Enhanced communication services will open many possibilities for innovative applications that are not even envisioned today.

Through the Internet of Services, barriers for accessing services will be removed, giving way to a level "playing field" for service supply and access. The Internet has already demonstrated how highly commoditized services such as ordering books, querying maps, booking flights, can empower consumers and generate revenue. Expectations are growing for "long tail" services from mainstream industries to be as seamlessly accessed, repurposed and operational through new business models as it has for Amazon, eBay and the growing ventures of software-as-a-service, service marketplaces and business process outsourcing on-demand.

New software development paradigms such as software-as-a-service are emerging that free developers from the need to develop software monoliths that are almost impossible to change with changing circumstance. The huge amounts of data that will be gathered, coupled with the market pressures arising from both business and entertainment use of augmented reality, will create demand for new forms of content analysis.

The goal of the Internet of Services is to weave the different developments of global service provisioning into a harmonious fabric for consumers and businesses alike. In the European setting, the Internet of Services will foster:

- new revenue growth for EU service industries by enabling services to be repurposed and tradable in new settings;
- service partnerships across EU trade boundaries, drawing cost savings from resources from member states;
- the transformation of businesses into business networks, in particular with SMEs engaged with larger enterprises for revenue sharing operations and Industry-wide resources for global service provisioning, e.g. cloud computing environments (virtualized IT hosting) compliant with EU privacy and trust regulation.

3.2 Smart things, devices and systems

From one device to interconnected intelligent Embedded Systems and artefacts

Business studies indicate that RFID technologies could lead to efficiency enhancements of 40% in the luxury goods industry or even 100% in the food sector. But 'smart things' are not just products in shops with RFID tags: they are the components of the aeroplanes that we fly in, the smart surface of the roads that we drive on, the clothes that we wear, the equipment that we operate, the pills that we take, even our own 'wet components'.

Looking into the future, we will go beyond utilizing technologies like RFID for business process optimization. We will embed sensors, actuators and miniature computer systems directly into our products. By using concepts developed in the Embedded Systems and Robotics field, businesses and their customers, including the end-consumers, will have much more information, and more accurate information, about the state of the objects in their world (self-aware capabilities) and about their environment (context aware capabilities).[12]

Autonomous self-organizing systems are beginning to emerge. Such systems can adapt autonomously to changing requirements and reduce the reliance on centrally planned services. Self-organizing traffic lights, for instance, have their own sensors and communication links to their neighbours and autonomously smooth the flow of traffic, without relying on commands from a remote traffic control centre.

Furthermore, 'smart' devices within systems and systems themselves will benefit from a communication and control 'ether' – the Internet of Things. Self-monitoring automatic traffic control systems will exploit the capability of automobile and infrastructure sensing systems to engage in a dialogue with decentralised and central computing systems and then engage in processing which impact on the control of cars, buses etc.

Smart devices, and indeed ICT in general, will play a very important role also in energy savings and emissions reduction (smart industry motors and industrial automation, smart buildings, smart grids, smart logistics) as convincingly advocated in GeSI sponsored study "SMART 2020"[13]: the biggest role ICT could play is in helping to improve energy efficiency in power transmission and distribution, in buildings and factories that demand power and in the use of transportation to deliver goods.

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[12] The ARTEMIS JU is now the European reference for Embedded Systems (ARTEMIS – Embedded Computing Systems Initiative; http://www.artemis-ju.eu)

[13] http://www.gesi.org/files/20081212_smart2020_pt_ingles.pdf

Things will record their own life-history. The consumer will be able to know which field the cow that provided her milk grazed in; what the cow ate; and how the temperature was controlled as the milk travelled across Europe. More likely, it will be her automated personal shopper that shows such interest as things negotiate with other things. The establishment of the Internet of Things will require the development of an infrastructure meeting a rich set of service parameters, supporting in particular real time interactions, with a high degree of availability, integrity and trust.

Interoperating with the Internet of Services, the Internet of Things will enable us to monitor our own well-being; to manage our movements safely, economically, and in an environmentally friendly way; to optimise our use of energy; and to enable optimal access to resources for work and play. Particularly important will also be the "smart things" systems whose performances can strongly augment the ability of Future Internet to provide useful services to the end-users, such as micro-systems for sensing, mechatronic systems and robots to act.

In the future, there will be a continuum of the network proper and "end systems": passive and intelligent sensing devices, sensorimotor devices and pure actuators. Sensing devices (e.g. mobile cameras) will provide information about their environment and their user (e.g. live video streams). Sensorimotor devices (e.g. cognitive robots) will act based on their perception of the environment, on behalf of their user, and actuators (e.g. decentralised power stations, robots, traffic lights) will perform actions based on information gathered by some other device and/or background knowledge.

The level of "autonomy" of the individual system will vary along a continuum of self-determination. In other words: there will be a plethora of semi-autonomous "cyber-physical" systems (which all rely on embedded ICT) with different local intelligence, but they will all be connected to the "information ether". This ever-growing set of devices will actually constitute a new kind of *physical intelligence*.

Clearly, these developments will have drastic consequences for areas like robotics and for embedded system design. Even today, large parts of European industry are crucially dependent on keeping a competitive edge in various types of embedded physical systems. Europe has been able to maintain leadership in this area up to now, but with embedded systems becoming increasingly networked and complex, the challenges for staying "on top" will reach a new dimension.

3.3 User

From a computer-focused to a computer-served perspective

The use of ICT in businesses is not a goal in itself. ICT has to support end users in a world where technology and work practises change at an ever-increasing rate, while at the same time a constant improvement in productivity and quality is expected.

Users are becoming more and more reluctant to give their attention to the use of computer systems. Drawing on the concepts and technology of the highly successful European games industry, innovative solutions are emerging to support people-centric work and business processes. The empowerment if the user has to come through

intelligent services, which deliver within the context of the user, e.g. a user who is currently on the move needs different support than somebody who is at the office or at home. The blur between business and private life will foster the integration and interoperability of services, to be applied in the different contexts appropriately.

The immersive 3D virtual world is already with us. These worlds are populated by avatars – virtual replicas of the humans as they desire to look, never tired, and always ready to work. An avatar is made to best fit the medium in which the user is immersed – the office, the home, the school, the park, the shopping mall etc.

3D worlds are not just for simple social interactions. Companies and other organisations are holding management meetings, press conferences, product launches and user forums in the virtual 3D World[14]. In a virtual workspace, exploration and experiments beyond thinking in a real environment can take place unhindered. All activities will be recordable for interaction and exchange. Recorded artefacts and the ability to manage them at a fine, granular level will enable us to learn from other peoples experiences.

Additionally, new patterns of interaction such as "pen centric computing"[15] or "wearable computing" are anticipating the Future, when augmented User Interfaces will be taking the natural interaction pattern in their centre.

3.4 Systems

From dedicated computing facilities to Computing-as-a-service (Cloud)

Cloud Computing is emerging to offer storage, compute infrastructure, and foundational infrastructural services as a service over the Internet. The 'cloud' is a metaphor for the concealed, complex infrastructure that enables this (based on how it is depicted in computer network diagrams). It is a style of computing in which IT-related capabilities are provided "as a service", allowing users to access services from the Internet ("in the cloud") without knowledge of, expertise with, or control over the technology infrastructure that supports them[16].

The revenue potential of such infrastructural services will be very significant and 'Clouds' may prove to be a sustainable business model both for new players as well as the established Telecom operators. There are significant unaddressed issues around managing both the design and operational phases of service deployments on clouds.

From centralised and hierarchical to distributed autonomous systems

The trend in building dependable real life systems and smart infrastructures today is to move from monolithic, centralised and strictly hierarchical systems to highly distributed networked systems with local and global autonomy. When they are deployed in complex processes and services, these new systems exhibit promising features and capabilities such as modularity and scalability, low cost, robustness and adaptability. Examples of

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[14] IBM, Sun Microsystems and Reuters all have 'offices' in Second Life.

[15] See Jürgen Steimle, Oliver Brdiczka , Max Mühlhäuser, (outstanding full paper award): CoScribe: Using Paper for Collaborative Annotations in Lectures. In: The 8th IEEE International Conference on Advanced Learning Technologies (ICALT'08). pp. 306-310, IEEE Press, New York, NY, 2008.

[16] http://en.wikipedia.org/wiki/Cloud_computing - cite_note-3

such systems may include mission critical systems like power generation, nuclear and chemical plants, air traffic control or robots operating in space or deep waters; and more consumer-oriented systems such as the *ad hoc* cooperation of devices in a smart building to minimise energy consumption.

This trend is enabled by powerful and programmable multi-core chip platforms; dependable communication networks and protocols of industrial grade; engineering technologies for integrated networked sensing, monitoring, control and automation systems; and distributed software architectures based on service orientation. Cloud Computing allows for professional compute provisioning, also known as professionally managed large data centres (of SMEs). Thus it facilitates the consolidation of IT services for those companies whose provisioning is key to them, while operating them is not. Given its industrial strengths in networks, embedded systems and system engineering, it is essential for Europe to also lead the design and engineering of future generations of such large-scale systems.

3.5 Applications

From stand-alone to end-to-end

Today companies are organized in flexible business value networks that operate on a global scale. Production adapts quickly to changing market situations. Logistic chains and distribution channels are continually reorganised and re-optimized to be more efficient. Flexibility and agility are *sine qua non* for companies. Flexible and agile information system architectures are becoming the key enablers for companies to execute better and faster than their competitors.

Following the successes of Amazon and eBay, software-as-a-service marketplaces have emerged. Salesforce.com, Employease, Reardon Commerce and others are leveraging the existing web services and service creation capabilities to expand their offerings of hosted business applications. In turn, mainstream industries are capitalizing on service-enablement investments by turning to the private sector for value-added service partnerships[17]. Meanwhile, in telecommunications, services are being pushed to "experience" as content and, increasingly, enterprise services are becoming crucial differentiators for slim-margin mobile services.

Driven by the demand for flexibility and agility, the trend is to flexible and dynamic composition of services, processes, interfaces, reports and electronic forms so as to quickly assemble customised solutions. Companies are increasingly linking stand-alone processes to quickly compose new end-to-end processes, selectively redesign existing processes to make changes faster, and facilitate seamless process design and execution across company boundaries in order to leverage the core competencies and best practices of business partners. The days of the monolithic corporate application suite are over.

Simultaneously becoming even more complex, another trend leads to "applications consuming applications of other services". Through Service-oriented Architecture (SOA), the application development industry will be able to provide lean applications –

[17] In the Singapore Government's 'TradeExchange', regulatory trade services are being aggregated with services such as logistics and the goods tracking, through third parties.

even by providing end-user development infrastructures – in a fast and cost effective manner to react quickly on business trends and new business models.

Research will be important to close the gaps between the general wish for sustainable environments and efficient resource utilization on one side, and the need of Corporate Social Responsibility and the implementation of those capabilities in a highly pressured financial set-up on the other side. The ability to achieve more with fewer resources will set apart successful companies from unsuccessful ones. Europe has the great advantage of a high recognition in terms of considering sustainability and anticipated impact on the environment as being for the public benefit. The US culture is currently trying to catch up. New concepts in ICT can leverage Europe's strategic advantage, e.g. when it comes to energy, traffic and transportation management and the application of "green" supply chains and product designs with little CO2 footprint.

3.6 Underlying components, nano-electronics and -systems

The opportunities that ICT will offer to the future society will be underpinned by innovation in the basic technologies.

Thanks to Moore's Law, during the last 30 years the semiconductor industry has been a key enabler to ICT and it will continue to be. Ten years ago a Digital Video Encoding System was huge and bulky equipment lying in a TV studio, incorporating many integrated circuits as large as a few square centimetres each. The TV industry was developing contents and business through broadcasting. Today, even more complex encoders can be implemented into a single chip of a few square millimetres that can fit into each 3G mobile phone, allowing the YouTube model to become reality. It is not just technological capability that drives change: dramatic reductions in cost trigger fundamental changes in business models and markets[18].

Nanoelectronics shows no signs of slowing down as new technologies based on different physical properties continue to appear, yielding an ever greater performance, lower energy consumption and larger memory capacity in a smaller die, for a lower price (The European Nanoelectronics Initiative Advisory Council (ENIAC)[19] is now the European reference on this topic).

YouTube would not have been possible without the capacity provided by the nanoelectronics industry to pursue and enforce the Moore's law. Europe should continue to leverage on such a strategic technology capabilities, which will enable the creation of new added-value on top of it. New software algorithms will be discovered to utilise this technology in new applications.

And despite frequent warnings of diminishing productivity of design and manufacturing with increasing complexity, we will continue to find new ways of doing things - new ways to manage and utilize that complexity.

New technological developments bring new research needs:

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[18] According to the ITRS Roadmap, 1MB of DRAM cost 0.96 cents in 2007, and is predicted to cost just 0.06 cents by 2015.

[19] http://www.enaic.eu

From simple and safe to complex and critical

Where, for instance, automotive and aircraft systems have previously been a collection of stand-alone, independent devices and sub-systems, they are now being integrated more closely with the potential for many more interactions, necessitating new techniques for security and error containment. Guaranteeing safe service provision by autonomous systems poses interesting technical and even philosophical challenges.

From Systems-in-a-Box to Systems-on-a-Chip

With lithography features getting smaller and smaller, statistical approaches are now incorporated in the chip design methodology and the way the architectural blocks are interconnected within a chip are closer to the internet protocol than ever.

From Technology Paradise to the Real World

Deep nano-scale features will require new tools and methods to guarantee automatic recovery from stochastic errors generated by real-world physics and the capabilities of production equipment. This is driving new approaches to design methods so as to guarantee *predictability and robustness* – i.e. an acceptable quality of service despite the occurrence of hardware and software faults.

From Ad-hoc Design to Model-Based Design

A trend toward design methods based on the composition of models for components and whole systems to manage the design from a set of separate viewpoints, such as behaviour, reliability, energy consumption, mechanical shape, and cost. The concept is simple: its realisation is a major research challenge.

4 *A STRATEGY FOR EUROPE*

– a virtuous circle of innovation

ISTAG recommends that ICT research be systematically presented in the larger scope of a more human-oriented and sustainable society in order to establish a critical amount of success stories by 2020 that will demonstrate to all how new services and products can increase sustainability and social values that in turn stimulate the emergence of yet more innovative services and products.

Based upon our analysis of trends above, we propose a strategy to exploit the 'ICT mega trends' to the advantage of society, the environment and the economy and put Europe in a leading position for the coming decades.

Our report places great emphasis on the impact that is to be expected with the Future Internet. However, while the infrastructure is a vital enabler for new services and systems, ICT underpins capability and competitiveness in every sector, and Europe has particular strengths in underlying technology components and systems, notably in 'embedded systems' – that are to be found in aircraft, cars, and before very long in the human body – and in 'end systems' in domains such as manufacturing, medical, energy and transport. So in addition to building the infrastructure for the future, our strategy is to build on and exploit these existing strengths and to help these application sectors to become more sustainable.

Most of the activities that we propose in order to achieve our goals impact more than any single goal. They also affect and require engagement with areas of industry, education and government that go beyond those traditionally associated with research and technology development. However, the programs of different public agencies – whether national or European – are frequently not 'joined up' and often cannot be co-ordinated tightly for reasons of policy and subsidiarity. However, by promoting, encouraging and facilitating a set of overlapping activities, ISTAG aims, during the coming decade, to achieve greater synergy and coherence of action than hitherto, leading to a richer, more dynamic innovation environment.

4.1 Goals

The goals of our strategy are aimed at putting the citizen, companies, research organisations and public administrations in a position to take maximum advantage of the social, environmental and economic trends that are foreseen. To do this, citizens, companies, research organisations, and public administrations must be ***informed, enabled*** and ***capable***.

Specific goals of the ISTAG ICT strategy are:

- ***Enable European companies to provide ICT-enabled innovation in all sectors of industry and public services for a global market in a sustainable future.***

- ***Enable European ICT inventions to be commercialized quickly and competitively.***

- ***Enable European citizens, from childhood to old age, to both use and contribute to the evolution of ICT-enabled services and products.***

- ***Engage consumers, businesses and the public sector in the innovation process so that their experiments and experiences become part of the innovation process itself.***

- ***Establish a world class ICT knowledge and skill base.***

- ***Establish theories, science, and technology - for both physical and social domains - to give rigorous underpinning for ICT developments in the coming decades.***

4.2 Approach

To achieve these goals, ISTAG recommends a ***tiered strategy*** for Europe.

The first, fundamental tier is to continue to develop European strengths in the underlying ***science and technology*** that will be necessary for the future evolution of the upper tiers.

On the second tier, ISTAG proposes a concerted effort to encourage the development of the ***skills and knowledge*** to *use* ICT to good effect in personal and social life in society; to *develop and apply* ICT to derive economic benefit in both the ICT sector itself and in all other industrial, commercial and public sectors; and to *evolve* ICT through scientific and technological research and development.

The third tier is to establish in Europe a major, and novel, ICT ***infrastructure for innovation***. This is not just a technological infrastructure, though it is underpinned by technology. It will include as well the processes and communities necessary to take ideas from dreams to market. ISTAG encourages user-involvement and experimentation as integral parts of the innovation process, support to deployment of innovation and measures to speed up commercialisation.

The uppermost tier is that of ***applications and solutions***. The rapid development of the Internet, both in speed and in capabilities, will enable a re-engineering of the service industry. Its applications of the future will enable embedded products as well as business services. Coevally, business models will develop towards usage-dependent price models or leasing models. ISTAG proposes the creation of focus areas for application research, such as the combination of core areas like transport and utilities with sustainability and effectiveness. A strategic proposal would be to develop technology out of applications, not the other way around.

4.2.1 Science and Technology

EU member states have already committed €9.1 billion of funding for ICT research over the duration of FP7 as a result of increasing awareness about the importance of information and communication technology industries for the wealth and competitiveness of Europe. Successive Framework Programs have established a cross-sectoral, cross-disciplinary, cross-cultural hot bed of ideas. Research and technology

development in Europe is now being enriched with focused trans-national programs and through integration of EU, national and transnational programs in JTIs such as ARTEMIS for Embedded Systems and ENIAC for Nanotechnology. These JTIs will concretely contribute to reduce the fragmentation of both the industry and the scientific research base, where there are many small, isolated research groups and specialised SMEs.

4.2.1.1 Develop knowledge and technical capabilities in priority ICT fields

Europe has to focus on setting up the infrastructure to allow for maximum benefit of all these joint initiatives during the next decade. This will be the full scope of the Future Internet comprising the Internet of Services, the Internet of Things and the broadband Internet network.

Future Internet

While we have said that the proposed infrastructure for innovation extends well beyond traditional ideas of ICT infrastructure, we nevertheless need to ensure that Europe is at the forefront of the development and implementation of technological infrastructure. To enable European companies to provide ICT-enabled innovation for a global market we must promote and develop the ***Future Internet***, with its component ***Internet of Services*** and ***Internet of Things***.

We believe Europe is well-placed to take a leading role in defining and developing the network and service infrastructures for the future to provide connectivity everywhere and always for everyone and everything, together with services and applications being able to adapt to needs and conditions of tomorrow.

We must ensure that continuous and long term support is given to the design of the Future Internet as a key element of the future networked society. It is of crucial importance for Europe to fully engage in the support, development and conception of new Web-based industry and public services, and their underlying infrastructure, especially as there are strong indicators that their development is at present driven predominantly in the USA and Asia.

Internet of Services

In future, companies will run solutions composed of a multitude of services which are highly customised to the needs at hand and adaptable and expandable on-the-fly to meet new requirements. A new global infrastructure is needed in order to bring together offering and demand for such ever-changing services. The infrastructure will bring together key players to innovate, provide, broker and consume services. In contrast to today's monolithic offerings, services will be composed by seamlessly integrating new component services from a wide range of service suppliers to meet the ever-changing demand.

Support for managing concerns such as ***security, reliability and regulatory constraints*** need to be added to the nascent Cloud Computing offerings in order to be able to engineer services and be able to offers services in accordance with Service Level Agreements. However, while it is important that the Internet has properties that *enable* the provision of secure services over the Internet, it must not be thought that

security can be 'built in' to the Future Internet. What good is a 'secure Internet' if the end-to-end services cannot be authenticated?

Internet of Things

Creation of a smart Internet of Things, linked to an Internet of Services, will require technology for context aware, reliable, embedded, energy efficient and secure distributed networks of cooperating sensors and actuators, as well as the energy provision for this technology. This requires a *"total system" solution*, starting from *systems theory of massive distributed networks* through *embedded software platforms* to the development of *More than Moore nano-system design*, based on the application of advanced nano-materials to devices and subsystems compatible with ultimate CMOS computational power at the 10nm scale, becoming possible by 2020. The development of new materials with unique properties will fuel the innovation in many ICT applications and lead to important breakthroughs in advanced devices. The use of these new materials will allow the creation of completely new products in communication, health, environment, energy and many consumer applications.

The fields of ***Embedded Systems*****,** ***Wireless Autonomous Transducer Systems*** **and** ***Robotics*** are expected to make significant contributions to the development of the Internet of Things. In particular ISTAG believes that the Artemis JTI, amongst other ETPs, within the federating concept of the Future Internet, can make essential contributions to the development and support of research objectives and the improvement of innovation capabilities in the area of the Internet of Things. This approach will benefit the many industrial sectors that depend on ICT innovation for their progress (automotive, aerospace, health, smart buildings, telecommunications, energy efficiency, security …) and which participate in the Artemis JTI. The technologies will also make significant contributions to a plethora of semi-autonomous "cyber-physical" systems with different local intelligence. ISTAG believes that keeping a competitive edge in design methodology for such networked systems is vital to the success of European industry.

Underlying components, nano-electronics and –systems are essential constituents of a huge range of products and services. Nanoelectronics shows no signs of slowing down as new technologies based on different physical properties continue to appear, yielding an ever greater performance, lower energy consumption and larger memory capacity in a smaller die, for a lower price. Europe should continue to leverage on a strategic technology capabilities in these fields.

Europe's dominating experience in *micro-systems*, flexible/stretchable and disposable electronics, *MEMS* and *NEMS* need to be combined with system level design principles. A "global system level approach" is required as major progress will come from convergence rather than from single domains.

New ICT systems need to be embedded in their environment. In particular, the computing system must not interfere with the user's ability to perform complex tasks in the real physical world. This requires breaking with current design principles and requires *new models of interaction* that reach beyond the desktop metaphor, supported by new design and development practices that enable the development of solutions and services that fulfil the requirement of simplicity and go beyond user centred design and end-user development.

Recommendation 1

ISTAG advises to continue to develop European strengths in the underlying science and technology that will be necessary for the future evolution of ICT skills, innovation and applications.

- The **Future Internet** - with its component **Internet of Services** and **Internet of Things** - is a priority ICT field, given the fact that during the next decade the value of products and services distributed over this infrastructure will significantly exceed the value of products provided via traditional infrastructures;
- **Networking technologies, embedded systems and robotics** are priority ICT fields, because large parts of European industry are crucially dependent on keeping a competitive edge in various types of embedded physical systems, in their underlying technology as well as in their development processes;
- **Underlying components, nano-electronics and -systems** are priority ICT fields, as essential constituents of a huge range of products and services, where Europe must stay in the race in terms of research, design, applications and manufacturing needs.
- The *Commission* should propose to make the Future Internet a key priority when it gets to future infrastructure-planning in the EU.
- Networking technologies, embedded systems and robotics should also remain key priorities, as well as underlying components, nano-electronics and micro-systems, including continued backing of the ARTEMIS and ENIAC JTIs;
- The *Member States* and the *Commission* should strengthen and coordinate national R&D efforts and initiatives towards the Future Internet, and strengthen cross border cooperation in this field;
- The *Member States* should establish dedicated national R&D programs on ICT such as IKT 2020 in Germany to complement the FP7 programme;
- *Industry* should spearhead the global initiative of the Future Internet by providing best available knowledge, skills and inventions. Industry should continue their strategic research and innovation agenda-setting in key ICT fields such as network and service infrastructures, robotics, and micro-systems.

4.2.2 Skills and knowledge

4.2.2.1 Ensure the skills and knowledge to develop and to use new ICT

Ensure the e-Skills to be capable to use new ICT

European citizens must be skilled for life. But this is not a one-off exercise at school. With growing life expectancy, and a rapidly changing business environment, people may expect to live until they are 100 years old and professionals might have two or three careers rather than one. We must promote familiarity with latest tools, technology and infrastructure throughout life. Traditional teaching environments are part of the

solution, but we look to Living Labs and similar initiatives to better engage the citizen in a life-long learning environment that is more productive, more educational, more useful and above all more enjoyable than conventional 'chalk and talk'.

The promotion of eSkills as one of the foundations of a knowledge-based society has been a top EU priority since the meeting of the European Council in Lisbon, March 2000. This has led to a series of programs and initiatives designed to promote ICT and eSkills in Europe. However Europe still lags far behind its main competitors in the use of ICT.

Ensure a skilled workforce to progress ICT

Apart from helping the man on the street to be familiar with ICT and ICT-enabled services, we also need to develop a skilled workforce to drive the ICT sector itself. We must, urgently, attract young people into ICT, even involving them in ICT-research projects at an early age.

The global dimension of knowledge development should not be interpreted as a threat. Competition should coexist with efforts aimed at contribution to the global public good. Policies should be established to maintain or achieve diversity in order to demonstrate the openness of European higher education systems to the world. It is expected that institutions at supra-national level will emerge allowing for a Europe wide coordination of skill development in ICT and thus avoiding another wave of "digital divide" to occur.

Schools should be involved in ICT research projects within the 8th Framework program to allow for early on experience. As children typically decide (implicitly) early about their future education path, the ICT has to demonstrate its value as early as possible. In this context also the Living Lab concept with its interdisciplinary approach and its real-life scenarios offers the possibility to "experience" ICT and in doing so attract young kids, pupils and students to get involved.

There is an urgent need to create a new breed of system architects, overlooking the overall systems challenges and the art of smart integration, with a special attention for cost of functionality, energy for given functionality, data integrity and heterogeneous system design aspects and architectural optimization schemes.

Europe has always had a strong tradition in this art of integration and should play all its cards to maintain and strengthen such position. It should keep expertise (talent-wise, research-wise and industrially speaking) in the entire value chain of HW, SW, MW, services, content and experiences: one cannot dissociate those functions any longer. They are all increasingly intermingled and very interdependent from each other. Europe must grasp the opportunities offered by the need for smart integration!

Recommendation 2

ISTAG proposes a concerted effort to encourage the development of the skills and knowledge to use ICT to good effect and to develop and apply ICT to derive economic benefit.

- *The Commission* should continue to support the development of ***eSkills*** among all EU-citizens to enhance the effective usage of ICT, to close the ***digital divide*** and build a strong European ***workforce in the development and use*** of ICT in the emerging digital economy.
- *Member States* should develop ***national ICT curricula*** at schools and universities to improve e-Skills among all citizens and increase the availability of qualified skills in ICT R&D.
- *Industry* should educate and train the European workforce and empower them for ***highly skilled work profiles in ICT***.

4.2.3 An infrastructure for innovation

The ISTAG-proposed ***infrastructure for innovation*** will extend well beyond conventional, technological concepts of ICT infrastructure. It will enable a rapid process from formulation of new ideas, through research and development, to evaluation for commercial viability, individual acceptability, societal acceptability, and sustainability. And, as we indicated earlier in the sections on trends, ideas for new products and services are as likely to come from citizens as from researchers or corporate think-tanks. In this way we envisage the proposed infrastructure enabling a virtuous circle of innovation.

4.2.3.1 Encourage user-involvement and experimentation as part of the innovation process

Create application- and user-driven research clusters

Building on the JTIs, ISTAG proposes the formation of *Application-driven Research Clusters* in the ICT sector to bring together leading companies of sectors applying ICT, independent software vendors, system integrators, technology vendors, and academic institutions in a network of groups focused on turning inventions much faster into innovations successful in the global market.

These user communities should form a collaborative environment to stimulate co-innovation and the development of high-impact business solutions. Such clusters capitalize on the knowledge, products, and services of all members, gather user requirements and feedback, provide governance to the ICT sector to finally offer the "right" commercially viable and user-friendly solutions, and facilitate take-up within their sector. They facilitate applying the results even during the course of projects, to accelerate adoption of results.

Experimentation

It is not enough to provide an infrastructure and stand back. We need to encourage its *use* and listen carefully to feedback. ISTAG proposes a range of measures.

To enable European inventions to be explored in a quick, easy, non-discriminating way and to reach out to consumers and businesses in the broadest possible way, infrastructures such as ***Living Labs*** and ***Industry Value Networks*** should be created

and promoted to establish a sustainable European ICT-research-infrastructure for the integration of all involved stakeholders.

Living Labs are designed to boost open innovation by ensuring that all relevant stakeholders, including end users, are closely involved throughout the research and development process of new products and services. The value of the Living Labs lies in their function as a secured test environment for technical validation and development of "proof of concepts" for innovative scenarios. Thus they help to gain user/consumer /market acceptance before the actual launch of new technologies or products and moreover help to collect feedback from users and raise acceptance within society for new ways of working. The Living Labs provide a bridge from research into business and an environment to showcase technology, raise awareness for possibilities, limitations and threats of technology.

A major development of the Living Labs concept is 'T-City', in which a whole city becomes a 'Living Lab', using the latest information and communication technologies to enhance the quality of life and attractiveness of the city[20].

Industry Value Networks bring together customers, system integrators, and independent software vendors to develop and evolve business solutions for specific sectors. They facilitate 'co-evolution' of new end-to-end solutions, in which users get early exposure to new ICT possibilities, and suppliers get earlier exposure to user feedback.[21]

The ***ICT Policy Support Program*** offer other opportunities to engage potential users in exploration of the possibilities offered by new technology, as well as providing the research community with demand-led requirements and validation.

Open platforms and ***large-scale test-beds*** should be created to develop and test new services and to use ***large scale experiments*** to explore the impact of possible new services in near-to-live scenarios and in 'real' pilot scenarios like those of the Living Labs and the ICT-PSP.

While experiments and trials in initiatives like those we propose are typically focussed on high-level applications and services of interest to potential users, they also test the underlying infrastructure and services, and their properties such as dependability, security and privacy, in ways that requirements elicitation and focus groups could never do.

Recommendation 3

ISTAG encourages user-involvement and experimentation as integral parts of the innovation process.

[20] See e.g. http://www.deutschetelekom.com/dtag/cms/content/dt/en/395380

[21] See e.g. *Industry Value Network for Chemicals*, https://www.sdn.sap.com/irj/bpx/bpx-chemicals. Partners from Chemical Industry: Celanese, Dow Corning, DuPont, Eastman Chemical Company, Hexion Specialty Chemicals, Nova Chemicals / Technology partners: IBM Global Business Services, Invensys, LogicTools, Meridium, NRX, OR Soft, OSIsoft, Pavilion Technologies, SmartOps Corporation, TATA Consultancy Services, TechniData, Vendavo

- The *Commission* and the *Member States* should promote ***application- and user-driven research clusters***, to stimulate co-innovation and the development of high-impact business solutions.
- The *Commission* should encourage the ***active involvement of user industries*** in ICT FP7 projects.
- The *Commission* should stimulate ***open platforms and large-scale test-beds*** to develop and test new services and to use ***large-scale experiments*** to simulate the impact of possible new services in near-to-live scenarios and in 'real' pilot scenarios like those of the Living Labs, Industry Value Networks and the ICT-PSP.
- *Member States* should ***open existing national infrastructures*** such as electronic toll systems to test new web-based applications and solutions e.g. in the field of logistics and transport.

4.2.3.2 Support deployment of innovation

It is not enough to *design* the best infrastructure: ISTAG recommends that Member States be made aware of the huge advantage that *implementing* a modern ICT infrastructure, *starting with* broadband to the home, can bring to their citizens and their society. But it is not enough for some individual Member States to provide just their citizens with ICT infrastructure. The networking benefits for European society, citizens and companies will only be fully realised if all Member States roll out a modern infrastructure, interoperable and with harmonised regulation, throughout the Union. Therefore an internal market is essential to achieve an equally available Future Internet based on global standards.

Promotion of innovation in the provision of public services is also essential. This not only raises the quality and effectiveness of these services; it also creates opportunities for companies in Europe to take the lead in new public markets. *Pre-commercial procurement* empowers public authorities to stimulate industrial product development from its early R&D stages to test series in order to best fit its needs.

Recommendation 4

ISTAG recommends the support to deployment of innovation.

- The *Commission* should raise awareness among political leaders and the public about the role of ***ICT as a key enabler*** for achieving all major policy objectives of the EU in the next decade, including enhancing competitiveness, addressing the climate change and the demographic challenges.
- The *Member States* should encourage public administrations to act as "early buyers" of innovative ICT for enhancing public services (incl. healthcare services) by using measures such as ***pre-commercial procurement***.

4.2.3.3 Enable quick and competitive commercialisation of ICT inventions

Commercialisation

To allow ICT inventions to be commercialized it is essential to foster and promote ***entrepreneurship and start-up businesses*** in education and SME. Why are the Google, eBay, Facebook and others American? One possible answer is that all these small company or individual entrepreneurs found venture capital to provide them with the means of their ambitions and the ability to deploy their service up to a critical level where the proof is finally there. In Europe, we also have venture funds and investment money, but the way they calculate risk is clearly different.

For example, in the eHealth domain many successful pilots exist but the time between a successful pilot and mainstream adoption can be up to 15 years caused by increasing evidence requirements and a lack of value-based reimbursement systems. Hence it is very difficult for the industry to justify the required investments. More communication and earlier agreement between policy makers and solution providers across Europe is required to turn this tide. It is likely that similar barriers will hinder the uptake of new promising technologies like personalized medicine.

We believe that if Europe wants to be coherent, take-up actions and collaborations with private capital to push the most successful and promising research project up to the market would be needed as well.

Recommendation 5

To speed up commercialisation, ISTAG recommends intensifying collaborations between ICT innovators and private equity firms.

- The *Commission* and the *Member States* should promote the uptake and effective ***usage of ICT*** within European key industries (like automotive, logistics, pharmaceutical, chemicals, health, professional services etc) to secure European competitiveness.
- The *Commission* should support more intensive dialogues between innovative ICT firms and ***Venture Capitalists/Business Angels***.
- *Industry* should facilitate a stronger alignment with the ***user industries*** to ensure that future ICT products and services better meet user demands.

4.2.4 Applications and Solutions

4.2.4.1 Exploit the emergence of new a Web-based services industry

The rapid development of the Future Internet, both in speed and in capabilities, will enable the service industry to be re-engineered. The future web-based service industry will be better able to address the requirements of our society like health, aging, environment and mobility and our core industries like manufacturing, finance and

telecommunications. The rich "horizontal services" offered as infrastructural services will foster an interoperability and trust framework for service integration, authentication, privacy and security. These "horizontal services" will be discovered, ordered, negotiated for pricing, composed, settled/fulfilled, rated and consumed by "vertical services". This framework will enable the Web-based service industry to more efficiently and more flexibly procure, extend and repurpose services to new markets.

A rich array of web-based content and social services will be used to enhance more traditional services in new channels such as the growing world of handheld devices. This integration with new generation Internet services will present complex integration challenges for established vertical services, which are typical in government, healthcare, banking, and telecommunications. Also we see a shift from professional users to casual users in the consumption of these services, requiring ***significant adaptations*** in the user interaction and in ***legal and regulatory requirements such as safety and privacy***.

There will not be a single universal model for service enterprises. There will be different configurations of partnering structures, policies and interactions of different types of service provisioning enterprises. Hence different service provisioning enterprises and a rich variety of business models will appear for different service types such as business services, societal services, etc.

Through the Future Internet, it is envisaged that proprietary barriers will be removed to create a "level playing field" for service development, deployment and access. Beyond ordering books, renting downloaded movies, booking flights and the like, commoditized business transactions from mainstream industries are set to take off as the next wave of consumable services. Property conveyance, business formation and life events (e.g. births and marriage) are examples and they all entail complex integration challenges. These services require long-running transactions and are implemented through legacy applications hosted by multiple providers. Access to these services requires interactions with backend applications and several agencies may be involved. Navigation of such services therefore needs to be as seamless for consumers as linking to pages, facilitated by semantic descriptions of services and their interactions.

Industrialisation of Services through Informatisation

By 'informatisation' of the complete supply chain of traditional industries and business, from design & manufacture through to marketing & distribution, ICT is already improving productivity, enhancing competitiveness, sustaining economical growth and creating new jobs. Moreover, the boundaries between manufacturing and services provision industries are becoming more and more blurred as traditional manufacturing processes are becoming disaggregated to be organised and delivered as services according to Service Level Agreements between parties.

The next step in the industrialisation of services is 'digital informatisation' through the creation of new digital platforms for integrated service provision of sophisticated services to increase accessibility and functionality and simultaneously reduce complexity and the skills required. This may represent a breakthrough in the current economical crisis. Two main challenges have to be addressed:

- a radical cost reduction in the production and provision of services and more specifically in the provision of public services related with education, health and government administration;
- development of service provision platforms enabling the incorporation of less qualified task forces to areas of sophisticated services provision.

Achievements in these areas will stimulate the migration of low qualified workers to higher value added areas and will help to reduce unemployment.

Recommendation 6

To ***increase the impact of a new Web-based services industry***, ISTAG recommends that:

- a ***holistic approach be taken for the Future Internet*** considering the interaction of Technology, Business Models and Service Content; this should include forums and dialogues with all the stakeholders in the Future Internet on technology, business, society and regulation;
- ***existing technology baselines*** for business enterprises should not be displaced but ***should be harnessed and extended to consolidate the underpinning of the Future Internet***. In particular Enterprise Service-Oriented Architecture should be enriched and extended by semantic service descriptions, next generation service delivery capability, and community-driven service innovation and engineering;
- ***both a medium and a long term trajectory be taken for the Future Internet***, securing successful "quick win" ventures on the one hand, but increasing in service provisioning sophistication, notably for B2B and the coupling of Internet of Services and Internet of Things, on the other.

The Commission should also help establish a ***truly functioning internal market for ICT*** and especially for the emerging Internet of Things and Services, which is a pre-requisite for the development of globally competitive web-based industries "made in Europe".

4.2.4.2 Create focus areas for application research

ISTAG proposes the creation of focus areas for application research, such as the combination of core areas like transport and utilities with sustainability and effectiveness. A strategic proposal would be to develop technology out of applications, not the other way around.

Emphasis should be on the end systems, the services they provide and their interaction with the ICT network and service infrastructures. The research efforts should be embedded in the societal and economic trends and signals relevant to the end systems in question.

Examples of challenges for which breakthroughs in terms of advanced and qualitatively new networked end systems are needed include:

- *From resource-intensive living to a sustainable lifecycle*: The self-organising, decentralised power grid with electric cars as temporary storages; Climate-friendly energy development and deployment;

- *From isolation towards integration*: The physically adaptable, cognitive robotic system embedded within a smart infrastructure for extensive care for the infirm or elderly to enhance and extend the quality of independence at home;

- *From the consumer towards the prosumer*: The private factory of the pro-sumer, with devices producing all kinds of goods in small quantities;

Through more dynamic exchanges between public authorities, innovative businesses, and world-class universities, Europe should lead the way and demonstrate competitive solutions to today's pressing socio-economic challenges.

Recommendation 7

ISTAG proposes the creation of focus areas for application research driven by key societal and economic challenges.

- The *Commission* should continue to facilitate the ***collaboration between all stakeholders*** – Community, Member States, industry and academia – to ensure European leadership in the ICT transformations needed to address Europe's socio-economic challenges.

- The *Commission* and the *Member States* should ***mainstream ICT innovation in all other relevant policies*** in Europe's responses to major socio-economic challenges.

A call for action

The need for large-scale cooperation between all actors in Europe – be they small or large countries – is obvious and will continue to represent a key political action in the years to come. Towards a European ICT strategy for 2010 to 2020 to ensure the competitiveness and the wealth of the European Economic Area and its citizens within the effects of social, economic and technological trends, we call on the European Commission, the Member States, industry and academia:

Recommendation 1: *ISTAG advises to continue to develop European strengths in the underlying **science and technology** that will be necessary for the future evolution of ICT skills, innovation and applications.*

***Recommendation 2**: ISTAG proposes a concerted effort to encourage the development of the **skills and knowledge** to use ICT to good effect and to develop and apply ICT to derive economic benefit.*

***Recommendation 3**: ISTAG encourages **user-involvement and experimentation** as integral parts of the innovation process.*

Recommendation 4**: ISTAG recommends the support to **deployment of innovation.

***Recommendation 5**: To **speed up commercialisation**, ISTAG recommends intensifying collaborations between ICT innovators and private equity firms.*

***Recommendation 6:** To increase the impact of a new **Web-based services industry**, ISTAG recommends taking a mid-to-long term holistic approach for the Future Internet considering the interaction of technology, business models and service content, and harnessing and extending existing technology baselines.*

***Recommendation 7**: ISTAG proposes the creation of **focus areas for application research** driven by key societal and economic challenges.*