ISTAG_060313 15/03/06 07:21 Page 1

ISTAG Report on

Shaping Europe's Future Through ICT

Further information is available from:

European Commission
Directorate-General Information Society and Media
Unit C2-Strategy for ICT Research and Development
e-mail: INFSO-C2@cec.eu.int
Tel: +32 2 296 20 51
Fax: + 32 2 296 62 72
Web: http://www.cordis.lu/ist/istag.htm

Printed by OIB

© European Communities, 2006
Reproduction is authorised provided the source is acknowledged.

Printed in Belgium.

March 2006

European Commission
Information Society and Media

SHAPING EUROPE'S FUTURE THROUGH ICT

Report from the Information Society Technologies Advisory Group (ISTAG)

http://www.cordis.lu/ist/istag.htm

March 2006

CONTENTS

EXECUTIVE SUMMARY

ICT shaping Europe's future

The purpose of this report is to present a vision for the role of Information and Communications Technology (ICT) in European society and economy. In particular we focus on the key role of ICT research in unlocking the transformational effects of ICT for Europe's future growth, welfare and sustainability.

Transforming Europe through ICT

Europe urgently needs to reshape its economy and society

Europe today faces an added sense of urgency in reshaping its economy and society to meet the challenges of the 21st Century. We must realise higher economic growth through improved competitiveness and productivity, whilst ensuring a sustainable future. We have to adjust to the changing economic realities brought about by the globalisation of markets and the ever-faster pace of technological change. At the same time, we have to modernise our public services and tackle emerging challenges in areas such as security, ageing and inclusion.

The opportunity: transformation through ICT

ICT offers a means to respond to these challenges. **It is the "constitutive technology" of the first half of this century**, much like electricity or combustion engines have been in the last. ICT does not just enable us to *do* new things; it *shapes* how we do them. It transforms, enriches and becomes an integral part of almost everything we do.

As ICT becomes more deeply embedded into the fabric of European society it is starting to unleash massive and far-reaching social and economic change. ICT is essential for increasing productivity, for bringing more advanced solutions for societal problems, and for providing new services to consumers. These constitutive effects amount to a paradigm shift in how our economy and society function.

Shaping specific long-term solutions to Europe's societal challenges

At the same time, further advances in ICT will allow us to address Europe's socio-economic challenges - in areas such as health, inclusion, transport, manufacturing, environment, security and education - in ways that were impossible, and in many cases not even conceivable, even a few years ago. ICT has now reached a stage of development that enables us – in this generation – to shape the answers to Europe's specific needs for many years ahead.

Only by enthusiastically embracing digital technologies in all areas of our economy and society will Europe and Europeans achieve their true potential. The future is knowledge-based and we have to allow ICT to shape it. To do this we need to be able to "think ICT from the outset" and to better accommodate the user perspective in future developments of the technology.

Closing the Gap in ICT Research

A step-change in Europe's ICT research effort

Europe's leading competitors (the US and Japan) have understood this constitutive nature of digital technologies and spend 30% of their research effort on ICT. Europe only spends 18% and its per capita expenditure will soon be surpassed by China and Korea.

Our key message therefore is that Europe urgently needs to step up its research and development effort in ICT. It is inconceivable for any economic area of the world to be a major actor in terms of value creation if it is not one of the major

actors in ICT research. Similarly, no society can ensure the security of its citizens and improve their quality of life if it cannot shape progress in ICT.

Europe must be the location of choice for ICT investment and researchers

The increasing competition at a global scale gives Europe no other choice than to mobilise its resources to attract both investment in ICT research and the best researchers to its public and private labs. Europe has great knowledge and industrial assets. It has one of the world's largest markets. It should lead and be a first choice for ICT development and it has the capacity to do so.

Research to Shape Innovative ICT Solutions

Research is essential to realising these constitutive effects. Research in ICT will enable us to knit together the technology developments to achieve a step-change in the capabilities of the resulting applications and systems. Research is also required to bridge between ICT and other disciplines (bio-/nano-/cogno- sciences), from where many radical innovations will come.

The next generation of ICT

Building on and extending the ambient intelligence vision, technology developments are proceeding along well characterised paths. We note four main trajectories for this next generation of ICT. Systems and services that are:

1) **Networked, mobile, seamless** and **scalable**, offering the capability to be always best connected any time, anywhere and to anything;
2) **Embedded** into the things of everyday life in a way that is either **invisible** to the user or brings new **form-fitting** solutions;
3) **Intelligent** and **personalised**, and therefore more centred on the user and their needs;
4) Rich in **content and experiences** and in **visual** and **multimodal** interaction.

Orientations for ICT research

These trajectories, in turn, have implications for the nature of ICT research. In particular, ISTAG identifies five key orientations: the need for a systems approach to master increasingly complex technology chains; fostering interdisciplinarity and synergies in ICT research; creating an open engagement with users; the growing importance of services and content; and the need for research to address the whole business value chain.

Conclusions and Recommendations

In order to step up and improve Europe's research effort in ICT, ISTAG proposes a set of concrete measures aimed at mobilising resources in the private and public sectors to invest more and better in ICT research:

Stimulate lead markets for ICT solutions

- ISTAG invites the EU Member States to use all possible means to support and attract investment in ICT research. To make it attractive for companies to invest in ICT research in Europe it is essential **to stimulate the development of lead markets for innovative ICT solutions addressing Europe's key societal challenges**. This includes initiatives in areas such as health, ageing, transport & mobility, manufacturing, energy, environment, security and digital content. These initiatives should use a combination of measures attracting and facilitating investment in ICT research and the deployment of innovative ICT solutions. Measures range from public procurement of innovative solutions, tax incentives, the use of structural funds and the investment in ICT research centres of

excellence. This recommendation is in line with the conclusions of the recent report by the Aho Group[1].

Define common strategies and research agendas

- ISTAG proposes for industry and the academic research community to **work together to define strategies and agendas for research** from which all actors can benefit. European Technology Platforms provide a good framework for these agendas to develop. The implementation of these agendas should be based upon excellence and sufficient market acceptance and they should leave space for technology discontinuities and breakthroughs. As the number of Platforms in ICT grows, ISTAG sees a danger of fragmentation, however.

Better coordination of ICT programmes and policies

- ISTAG sees **an important role for the Commission in facilitating the further coordination between national programmes and policies in ICT research**. It sees the Framework Programme as a means to strengthen cooperation between industry and academia across Europe. To be efficient, ICT in FP7 needs to be steered towards the achievement of challenging goals preparing Europe for the next wave of technology innovations. ICT in FP7 needs simpler instruments and procedures than FP6.

Focus research in areas of European expertise

- In terms of priorities for research investment, ISTAG's strategic approach is to exploit "centres of gravity" – **focus areas where the natural development paths of ICT ("technology trajectories") in providing new solutions intersect with areas of European expertise and industrial capacity**. The societal challenges provide the opportunity to set concrete goals for European research within these focus areas that build on Europe's specific needs, values, priorities and strengths.

In addition, we note that research is only one part of the overall equation. Mastering the next wave of ICT development and its use will require research to go hand-in-hand with regulation and policy. Specifically, we highlight the need for Europe:

A joined up approach: research, regulation and policy

- *To maintain leadership in standards* in order to attain global leadership in tomorrow's ICT markets.
- *To be more flexible and responsive in the EU regulatory framework*, so as not to hold back the innovation emerging from ICT research.

The future is ours to shape

ISTAG believes that if Europe's future is not to be one of managing decline then it must rebuild its economy and society to meet the challenges of the 21st century. We must grasp the opportunities ICT presents us to shape the answers to Europe's specific needs and to remain one of the world's most competitive regions. A renewed effort in research and innovation in ICT is essential to this task.

The future is ours to shape; Europe must rise to the challenge.

[1] *Creating an Innovative Europe:* Report of the Independent Expert Group on R&D and Innovation appointed following the Hampton Court Summit, January 2006. See: http://europa.eu.int/invest-in-research/

CHAPTER 1: INTRODUCTION

1.1 Reshaping Europe's Economy and Society: An Added Sense of Urgency

Europe at the crossroads

Europe is at a crossroads. Global competition is accelerating, value chains are breaking up and new technologies are having profound impacts. Ageing puts more and more pressure on health and social care systems, transport systems get saturated and the education system needs updating. Europe's assets of a high quality of life and social protection are at stake. How can we keep them affordable? How can we generate enough added value to pay for them?

In the past decade productivity growth in Europe has lagged that in competing economic zones mainly because of insufficient usage of ICT[2]. This gap in productivity growth of about 1% per year is further compounded by the ageing of the population which will reduce the active population by about 0.5% per year. Only a dramatic increase in the use of ICT will allow us to bridge this gap.

The path to sustainable growth

Europe must realise higher economic growth through improved competitiveness and productivity, whilst ensuring a sustainable future. We have to adjust to the changing economic realities brought about by the globalisation of markets and the ever-faster pace of technological change. At the same time, we have to modernise our public services to meet the needs of our changing societies and lifestyles. And we have to tackle emerging challenges in areas such as security, ageing and inclusion.

Lisbon objectives now more urgent

All this requires a greater anticipation and mobilization from Europe. In its communication to the October 2005 Meeting of Heads of State and Government, the Commission warns that Europe can no longer afford to wait: five years on from the Lisbon Summit in 2000 there is an **added sense of urgency** in reshaping Europe's economy and society to meet the challenges of the 21st Century.

A dramatically changing world

Yes, Europe has been able to change: the internal market, the Euro, and EU enlargement are all steps in the right direction. But the world around it has changed even more dramatically. Asia's rapid economic growth continues; India is now a major player in software and is targeting other knowledge industries. China is emerging as a major manufacturing hub, with the electronics sector as one of the main beneficiaries. Meanwhile, the US economy continues to reap the highest benefits from the production and the use of ICT and from global trade. All these competing economic zones are more homogeneous than Europe from a standards and regulatory point of view, while Europe continues to suffer from fragmentation of its markets.

[2] For further background on the general scenario see: *Creating an Innovative Europe; Report of the Independent Expert Group on R&D and Innovation,* 2006; and *Going for Growth,* OECD, 2006

1.2 ICT: A Constitutive Technology

1.2.1 A Step Change in ICT's Impacts

ICT a tool for higher growth

Undoubtedly, information and communication technology (ICT) is a key tool for adjusting to the changes in the global context and realising higher growth. Virtually every facet of industry, commerce and government is touched by ICT and several depend heavily on it. Innovation in and through ICT is essential for improving productivity and economic growth; for developing new products and services for global markets; for modernising public services and meeting societal challenges, and for enabling every citizen to realise their potential.

The ICT revolution continues to bring new waves of technologies

Despite these advances, we are still only at the early stages of the ICT revolution. Progress and technological breakthroughs continue to bring new uses of ICT from which unexpected benefits will come. This next wave of technologies following from the ambient intelligence vision will make systems "smaller, cheaper, smarter, friendlier, "form fitting" and "always best connected", and their applications ever-more wide ranging. Digital convergence is increasingly opening up new opportunities and is accelerating the speed of economic and social change.

These developments add up to more than the sum of their parts. Steady progress in the underlying technologies amounts to a step change in performance at system level. In addition, new waves of ICT enable us to do things that are impossible with today's technology and create innovative applications, products and services. The net effect is a step-change in what ICT is able to deliver for users.

1.2.2 More Than an Enabler: Constitutive Effects of ICT

Much more than just a tool

ICT is often described as an "enabling technology". While this is true, the term fails to capture the transformational effects brought by the new generations of ICT. **ICT is now much more than just a tool. ICT is a "constitutive technology"**: that is, it constitutes – becomes part of - the things to which it is applied. Digital technologies don't just enable us to *do* new things, they *shape* how we do them.

New approaches necessary to realise the full potential of ICT

This is a major departure from the past where ICT was often viewed as simply a digital implementation of an analogue process; as a black box that functions irrespective of user or organisational context. In this sense, we have failed to fully exploit the potential of ICT as a driver of innovation. We have to go further and faster than in the past and understand that ICT offers a different way of doing things. We have to learn to **"think ICT from the outset"** and to **better accommodate the user perspective** in the development of ICT. Only then will the full transformational effects of the next digital waves be unleashed.

1.2.3 Building on Ambient Intelligence

Broadening and extending AmI

This vision of ICT as a constitutive technology builds on and complements the ambient intelligence (AmI) vision, for which ISTAG has been a vocal champion. A degree of socio-economic change has always been present in AmI scenarios. Viewing ICT as a constitutive technology essentially represents a widening and deepening of AmI-type approaches at the level of societal applications and value chains.

ICT research (including under FP6) has provided many of the building blocks for AmI-type approaches. But we are still missing important parts of the jigsaw and –

even more importantly – we are missing much of the glue, in terms of business models, service enablers, standards, etc, to knit the different parts together into a viable digital ecosystem. This drive will come primarily from the demand side: from capturing further the market/application demand for the types of solutions that ICT can offer.

1.3 ICT Research: Mastering and Shaping ICT for Europe's Specific Needs

Research is essential to mastering the next wave

Research is essential to mastering this next wave of ICT developments. Research will enable us to integrate the various technology building blocks to achieve a step-change in the capabilities of the resulting applications and systems. Research can bring domain expertise and a strong user perspective into the development of ICT systems. And research will allow us to bridge between ICT and other disciplines (bio-/nano-/cogno- sciences), from where many radical innovations will come.

Shaping the next generation of ICT systems

Investment in ICT research will allow us to develop the more holistic approach needed to unlock the transformational and constitutive effects of ICT, and also to shape ICT developments in ways that meet Europe's specific needs. These investments will also help push us towards a path of more sustainable development.

If Europe is not able to be creative and master the ICT technological developments and to innovate and shape their use, then it will not be the first to exploit and benefit from the new technologies. And, in many cases the solutions will not fit the specific needs of Europe's citizens and businesses.

Time for a step change in Europe's ICT R&D effort

Stepping-up the ICT R&D effort in Europe is essential to be able to master and shape ICT and its use. **A radical step – both in the scale of the R&D effort and in the efficiency of the innovation system – has become urgent**.

Furthermore, the constitutive character of ICT requires a new research offering, one that combines perspectives from technology, business models and user needs without sacrificing the deep knowledge within each area. This applies as much to specifying which societal challenges should be solved as to developing the solutions.

1.4 The Report

Structure of the report

This report presents ISTAG's vision for the role of information and communication technologies (ICT) in shaping Europe's future society and economy. After this short Introduction:

Chapter 2 sets out the societal and economic challenges and opportunities facing Europe and outlines what new generations of ICT can do to meet these.

Chapter 3 summarises the position of Europe in the global ICT market and briefly surveys EU ICT industry structure and market trends. It then characterises in some detail the development trajectories of the next generation of ICT and the implications for the nature of ICT research.

Finally, Chapter 4 presents ISTAG's vision and strategy for addressing European challenges in ICT. This covers: concrete proposals for stepping up Europe's ICT research effort; orientations for future ICT research in Europe; and specific priorities which align future societal and economic needs with European expertise and industrial capacity.

CHAPTER 2: ICT CHALLENGES AND OPPORTUNITIES

Europe faces a number of major challenges in areas such as health, inclusion, energy, environment, transport, education and security. These aspects have been analysed in some depth in previous work by ISTAG, and by other commentators. Rather than reiterate this analysis, here we present snapshots on selected issues focusing on how new generations of ICT can have transformational effects.

2.1 European Values and Priorities for ICT

Europeans appreciate the European model, based on values such as equality, solidarity, inclusiveness, tolerance, and sustainability. In reality, there is not one model but several: a Nordic/Scandinavian, an Anglo-Saxon, and a Continental model. Each has slightly different nuances. Nevertheless, there is a consensus that social justice contributes to economic efficiency and progress, and there is no contradiction between competitiveness and social cohesion.

ICT can serve socio-economic policy goals

With ICT, Europe's efforts to promote economic competitiveness can be done by respecting the underlying principles and values of the European integration process and the European socio-economic model. ICT can serve as a means of achieving both social and economic policy goals and the best possible degree of inclusion, even though ICT's prime objective is certainly not to bridge social divides.

Often in the past ICT systems were developed with no reference to the social or organisational context in which they would be used. More recently, greater efforts have been made to accommodate user requirements, including drawing on inputs from the social and behavioural sciences. If we are to unlock the transformational effects of ICT we need to move further and faster in accommodating the user perspective.

As technology becomes ever more closely entwined in our daily lives, so it becomes more closely related with our political and moral values. We should welcome this and make the most of the opportunities it brings. How can ICT be used to prevent harm to others, to improve the quality of life, to establish a just and fair society and to help solve some of our most difficult societal problems? We need new approaches that allow values to be expressed as part of technological design, research and development[3].

Values as drivers of innovation

Values are by no means obstacles to innovation; they may serve as important drivers of innovation. In countries such as Germany, Denmark, Sweden and the Netherlands, for instance, a strong commitment to environmental values has helped business establish a lead in environmental technologies. In ICT, we can anticipate similar effects in areas such as privacy, identity management and digital rights management provided that consumer rights are clearly defined in the digital environment. Values are also a key parameter for reading social patterns, an important characteristic of many successful innovators.

[3] Value Sensitive Design is one such approach. See for instance: www.designforvalues.org, www.ischool.washington.edu/vsd/index.html, and www.nyu.edu/projects/valuesindesign/index.html

In the search for a distinctively European approach, our values can serve as an important differentiator and offer a means of responding together to the major societal challenges we face in the 21st century.

2.2 The ICT Landscape

Next generations of ICT will bring further advances …

Today's state-of-the art in ICT is impressive and the continuously increasing level of research into the next generations of ICT is bound to yield further remarkable advances.

We are in a technology race for smaller, cheaper and faster processors, for terabit memories, and ever greater communication bandwidths. At the same time, advances in sensor technologies, microsystems, displays and software, are paving the way for new systems and applications characterised by intuitive, flexible and more-autonomous behaviour. Breakthroughs are also expected by pursuing ICT research in combination with other disciplines, for example those related to new materials, bio- and life sciences and from the knowledge base of the cognitive, biological and social sciences.

Convergence, in particular, is rapidly changing the ICT landscape. Over the next 5-10 years virtually every European home and enterprise will have access to broadband, and at speeds much greater than those available today. Interactive digital TV will be widespread, 3G services will be mature, and context-aware, especially location-based, services will be widely available. All of this will make possible a plethora of new, accessible and affordable mobile and networked services and experiences for consumers which will further embed ICT within their daily lives.

Convergence will deeply modify the business models currently adopted in the telecommunications, audio-visual/content and IT industries. As a consequence, new opportunities and challenges are emerging for European ICT enterprises, reinforced by the trend towards an increasing concentration of demand at a global scale.

Soon seamless broadband communication networks will be spanning from the personal area to the regional and global area. The distinct processes of communication and computation are being linked together within miniature artefacts and objects that are embedded in the environment and communicate with each other. Because these artefacts have sensing and computational capabilities, their linked communications will underlie the creation of distributed and self-organising systems that are adapted to human and organisational needs.

…offering radical new solutions

This progress allows us to address socio-economic problems in ways that were impossible, and in many cases not even conceivable, even a few years ago. At the same time, many of today's challenges of our societies require completely new, creative and innovative solutions.

2.3 Responding to Europe's Challenges through ICT

2.3.1 Today's Society

ICT accounts for an increasing share of the household budget

Europe is already embracing ICT. Since 1990, despite diminishing costs, communication expenditure by households has grown more than any other area of household expenditure (Figure 2.1). In addition, ICT is playing a more and more important role in other items such as health, transportation, entertainment, energy, and education. In total these represent about 45% of the European household budget.

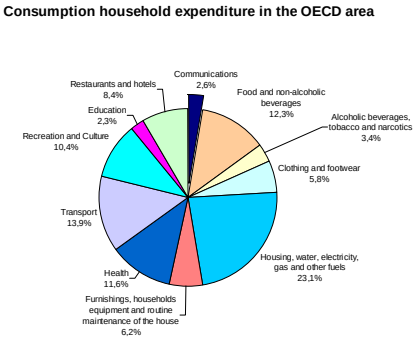


Figure 2.1a Consumption Household Expenditure in the OECD, 2003 (OECD):

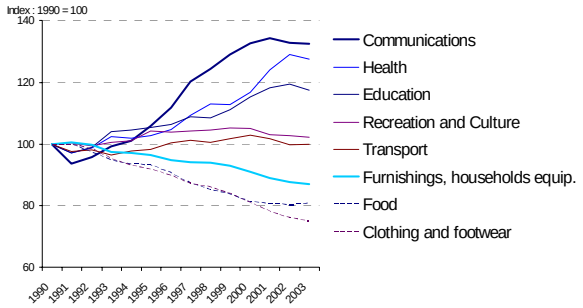


Figure 2.1b: Change in Household Expenditure in OECD, 1990-2003 (OECD)

Europe's enterprises and public organisations too have invested heavily in ICT and have used it to derive economic and service advantage (Figure 2.2). However, the efficiency of public services still varies significantly between the Member States, and overall the productivity of government services is stable or decreasing. ICT is a key tool to improve the productivity of public services and studies show that countries with the best performing public sectors are those that invest most inICT.

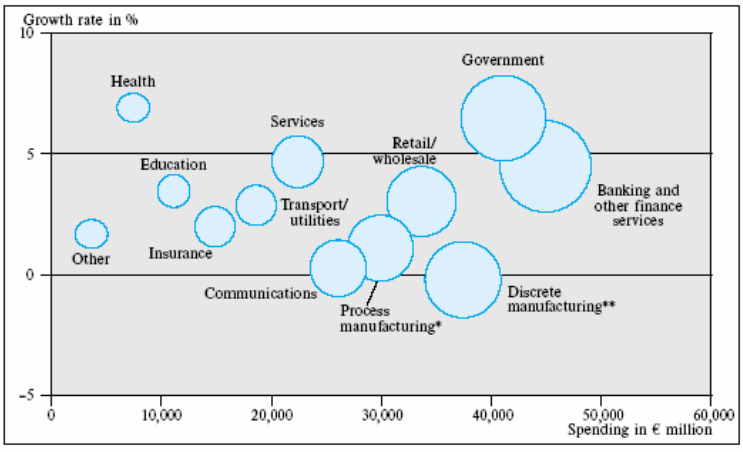


Figure 2.2: European IT Expenditure in Key Areas (EITO 2005)

2.3.2 Tomorrow's Society

Virtual meets Real: Bridging the Real and Cyber Worlds

Seamless integration of physical and online activities

One of the most exciting possibilities for tomorrow's society is the opportunity to use ICT to bridge the real and virtual worlds. Reflecting the fact that ICT is no longer seen as a bolt-on, organisations in many fields are capitalising on digital technologies to customise their products, access wider markets and exploit cross-synergies between physical and online activities. These include industrial design, manufacturing, logistics, information services, entertainment and games.

In industrial design, for instance, clay models are being replaced by 'digital factories' in which products are only built physically when all constituting elements and the full manufacturing process have been simulated and optimised with virtual reality techniques. In transport and logistics, the real-time monitoring of shipments leads to leaner supply chains, lower costs and happier customers. Similar paybacks can be expected for mobility in general once cars, trucks and roads are linked to tracking, monitoring and visualisation software through sensors and cameras.

The entertainment industry increasingly makes use of simulation and 'mixed-reality' techniques that bridge the real world of scenes and actors with the flexible and limitless space of virtual reality where everything is possible. At the other end of the chain, the virtual world of films and games is extended to the real world of toys and various gadgets creating huge leverage. New virtual-communities reduce the need for mobility and offer new opportunities for community building.

Clearly, we are only seeing the very first benefits in terms of enhanced creativity, lower costs and diversity. Much more is ahead of us. In health, for example, there is the prospect of the *in-silico* human and the associated vision of a much more efficient healthcare system seamlessly connecting patient, doctors and hospitals with simulation, databases, health monitoring software and embedded actuators to provide us with permanent monitoring, full accessibility of record and customisation of treatment.

Creativity in Products, Services and Digital Media

New paradigms for digital media and content

New media and content will be in digital formats and 'network friendly'. They will deliver new multimedia and multimodal "experiences" based not only on text, photos, audio, animations and video, but also on systems that evoke the sense of touch and smell in association with sights and sounds. Experiences with new media and its creation/consumption will involve a blend of local data and remote (network-based) data and will frequently involve other people or devices. Media will be scalable across the range, from low bandwidth and small screen environments to high bandwidth and macro screen/experience settings.

Entertainment is the largest market for 'new media' at present and will continue to be so in the future. However, the characteristics of the market are changing. The media consumer will no longer be just a passive viewer. S/he will become an active creator, mixer, promoter and collaborator, and 'hot spots' will enable context-sensitive interactions. Instead of media being managed and sold in big chunks by "big outlets", it will be created and made available online by smaller entities, even individuals. In these peer-to-peer networks, in principle everyone can be a content provider and many associated services can be developed.

From a Mass Society to a Networked Society

ICT fostering social interaction and community-building

Increasingly, many people live at considerable distances from family, friends and feel little connection with community organisations or local and national democratic structures. There is a feeling that face-to-face communication, social gatherings and 'neighbourliness' are in decline. This has led a number of commentators to warn that our stock of 'social capital' – the very fabric of our connections with each other - has plummeted, impoverishing our lives and communities.

ICT can play a prominent role in ameliorating the negative effects of physically fragmented communities and can reinforce/extend existing social networks and communities, from the family level, through local communities up to nations and cultures. ICT increasingly provides us with the capability to share information and to communicate through e-mail, mobile phones, iDTV, video/audio conferencing, etc.

Community-based knowledge building environments facilitate the development of a 'collective', 'living' or 'community memory'; multimedia environments enable people to share their thoughts and communicate informally from any location; and dynamic knowledge exchange systems provide intelligent references to the people holding this knowledge as well as to more static databases of information.

From Healthcare to Well-Being

New approaches to healthcare

In health, the general picture is one where healthcare is being delivered better, quicker and earlier, with a consequent knock-on effect in ever-higher healthcare costs. Patients are better informed and have high expectations of healthcare systems. New technologies are extending life and improving health and well-being and are opening the way to more personalised treatments. As health issues move closer to our daily lives, we are seeing a paradigm shift from traditional healthcare towards "well-being for all".

ICT has a major role to play here. Demands for new treatments and therapies, better monitoring, more personalised care, and preventative health management will all make intensive use of ICT, in close combination with medicine and genomics. However, in Europe ICT use in the health sector lags behind other sectors. It is one of the least connected sectors, with great disparities between countries.

The Age Pyramid

Europe's ageing population presents challenges and opportunities

Europe's population is ageing rapidly. Between 1998 and 2025 the proportion of the population classified as elderly will increase from 20% to 28%, and by 2050 the old-age dependency ratio will have risen by over 160% from the 1985 level. The fastest growing group of the elderly population is the very old, that is those aged over 80.

This new age pyramid has enormous socio-economic implications. It demands a paradigm shift in health and social care; it creates new requirements for inclusion and access to public services; and it presents a challenge to education and business to embrace lifelong learning, so that older people can remain both socially and economically active.

ICT will provide a basis for new inclusive products and services in areas such as eHealth, eGovernment, eLearning and eCulture. Such systems will not only address a societal need, they also offer a major economic opportunity for European industry.

Box 2.1: E-care Services: An Opportunity for Europe

The increasing number of elderly people in society is creating demand for new types of care provision. Older people value the ability to live independently in their own homes despite the increasing dependence, and in some cases disability, that is a "normal" part of ageing.

These changes are leading to new eCare models based on combined support for social, health and personal care. They constitute a novel approach for efficient integrated care delivery which will improve both the quality of services and resource allocation. The development of effective e-care services requires a blending of technology and health/social expertise and can be considered as a new market sector where European E-care Service Providers will co-exist with traditional health services.

This new e-care economy should lead to the development of innovative products like home service robots, always-on portable devices, the use of RFID to locate objects, new applications for home and personal monitoring, and the creation of tele-care centres.

The Energy/Environment Imperative

Energy and environmental issues demand new solutions

Having slipped down the agenda during the 1980s and 90s, energy has once again emerged as a major policy issue. This prominent position is driven by recognition of a number of energy-related challenges, including instability in fossil fuel prices, with a potentially negative effect on economic growth, and geo-political aspects raising concerns about security of supply. Several issues are intimately coupled with environmental concerns, such as depletion of fossil fuels and an increasing urgency to reduce CO_2 emissions as a means of tackling climate change.

ICT will contribute to much-needed technology breakthroughs in the energy and environmental sphere. These will improve the efficiency of energy production and use; modernise energy networks, including utilisation of renewable energy and small-scale generation; optimise the workings of energy markets; underpin the breakthroughs in hybrid cars; and improve the quality and security of energy and environmental services.

The Transport Bottleneck

More sustainable approaches to transport

While Europeans value their mobility, they are also aware of the increasingly negative impacts of transport on society and the environment. Transport networks are saturated and congestion is endemic, with costs estimated to reach 1% of the Community GDP by 2010. Economic growth and Community enlargement will further drive demand for mobility. Unless we are able to curb this demand, there is a real prospect that transport will become a brake both on Europe's economic growth and on improving its environment.

ICT offers a means of managing demand for mobility, with an optimum balance between social and productivity benefits and environmental sustainability. Examples include: on-board navigation and control systems that allow better use of existing infrastructure; real-time information systems that allow people to choose between different transport modes; and road pricing and tolling mechanisms that help to internalise the costs of travel for each vehicle and journey. At the same time, ICT can provide alternative solutions to transport through "virtual mobility" (e.g. making possible highly realistic virtual meetings).

Box 2.2: ICT and the Future of European Rail Infrastructure

Rail represents an energy-efficient alternative to road transport for moving freight. Despite this advantage, rail's share of freight movements is declining, mainly because the average speed of freight transport over long distances is only 16 km/hour. This is mainly due to i) capacity of the railway network; ii) weaknesses in logistics; and iii) differences in signalling and communication systems.

ICT is key to solving these problems. ETCS, a new European standard for control of rail transport systems, could significantly reduce the problems and increase capacity of European railway networks by as much as 40%. Meanwhile, developments such as the Galileo satellite system will bring even more benefits. The improvement over existing GPS systems in terms of coverage, precision, security and services will make it possible to track vehicles and goods in even greater detail. In railways, as elsewhere, applications of ICT hold the key to better services.

Learning as a Foundation for the Knowledge Society

Equipping Europeans for lifelong learning

Education and learning are key to Europe's competitiveness and underpin most other economic and social policy goals. They have the most to contribute to achieving the Lisbon goals in the period up to 2010 and beyond, and will allow the EU to position itself in the global context. To succeed in tomorrow's knowledge-based economy and society, we have to equip people of all ages with the knowledge and skills necessary to cope with continuous change in their private and professional lives.

ICT will make a reality of lifelong learning for all. New eLearning technologies and tools offer learners greater flexibility, easier access to information and the opportunity to match learning to their specific needs and circumstances. Yet, while most learners now have access to ICT at school and at work, they utilise it less than our international competitors. The younger generation is adopting a new way of learning not being matched by traditional teaching methods in the school systems of Europe. Faster introduction of ICT is required to modernise the educational process. Such a move requires a major change in Member States' educational systems.

Embracing Digital Culture

Culture as a social and economic asset

In a globalised world, there is increasing recognition of the social and economic value of culture. Citizens have an awakened interest in their own cultural identity – local, regional, national and European. Preserving this cultural heritage for future generations, while enriching it with contributions from our own time, constitutes one of society's most important tasks. In the European context, this means a particular emphasis on linguistic diversity, which is a key European asset.

But digital technologies also offer new means of creative, artistic and social expression and will also drive new industries in the creative, media and tourism sectors. In addition, ICT will play a fundamental role in facilitating inter-lingual comprehension and interactions.

Security: The New Global Concern

Balancing security and freedom

Security-related issues are coming to the fore in a number of policy areas. Border security, protection against terrorism and crime, transportation security, protection of critical infrastructure, disaster management, and information network security are all areas demanding new security-focused solutions. At the same time, in the search for higher levels of protection for its citizens, Europe must defend its commitment to a

democratic, pluralist, open and liberal society. Striking the right balance between security and freedom will be a permanent challenge.

ICT is crucial to these developments, in particular in providing the interoperability and connectivity to enable systems to work across different authorities and countries. Europe needs to act quickly if it is to remain at the forefront of technology research, and for industry to meet the rapidly emerging needs for sophisticated security-related products and services.

All of this underlines the vision of ICT as a constitutive technology that reshapes societal and economic practices and behaviours. Most of the necessary changes become feasible not only due to the progress of technology: also social and economical conjunctures are creating favourable conditions for these changes to become profitable and sustainable.

2.3.3 Europe in Today's Global Economy

Europe must achieve higher growth

For the EU to realise the economic and social advances to which its citizens aspire, it has to find a path to higher economic growth. At present, the EU's growth lags that of its international competitors, productivity growth has plummeted, and unemployment remains high with marked differences between countries and between regions.

Whereas average annual labour productivity growth in the US accelerated from 1.1% during the period 1987-1995 to 2.5% during 1995-2004, EU-15 productivity growth declined from 2.3% to 1.4%. For the first time in the post war period, Europe now has a trend productivity growth rate which is lower than that of the US, despite the fact that the EU's productivity levels are still lower than those of the US.

Part of the downturn in the EU's productivity growth rate over this period reflects an outdated and inflexible industrial structure which has proved slow to adapt to the intensifying pressures of globalisation and the associated acceleration in technological progress.

In non-European markets, especially in Asian markets, customers tend to be more technology savvy in their consuming behaviour. European industries are handicapped to some extent by having a somewhat more prudent (in terms of adopting the latest technologies) customer base in their home markets.

2.3.4 Towards a More Competitive Europe

ICT is a major factor in economic growth

A consensus has emerged that faster growth can be traced at least in part to the effects of the ICT revolution. Capital investment in ICT, strong productivity effects from ICT-producing industries, and a more productive use of ICT in the rest of the economy all contribute to economic growth.

The productivity gains come from the use of ICT across all industrial and business sectors, as well as from production of ICT products and services.

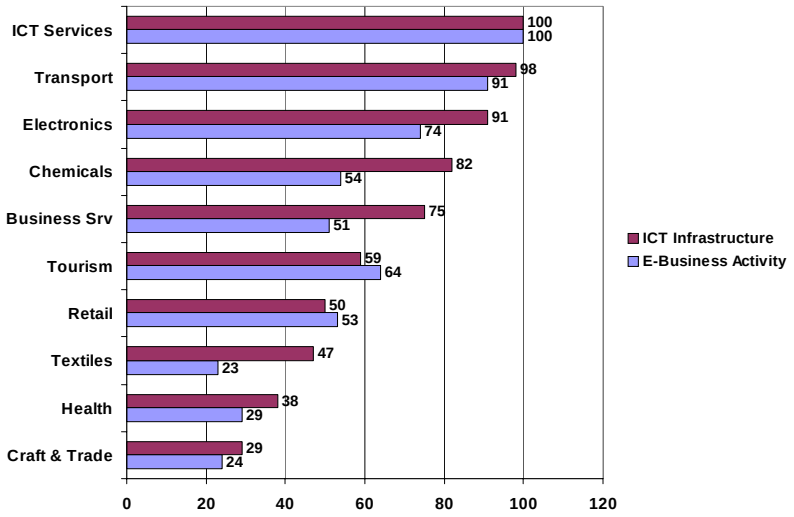
Higher Value Products and Services

Added value in products and services

ICT represents a substantial - and increasing - part of the added value of products & services in key European sectors (automotive, aerospace, pharmaceuticals, medical

equipment, financial services, etc). In automotive, for instance, an estimated 70% of innovations over the last 20 years are ICT-related gains.

Figure 2.3: The 2004 eBusiness Index For 10 Sectors



Source: eBusinessWatch 2004. The eBusiness Index is a composite measure that takes account of both ICT infrastructure and e-business activity.

Business Transformation

In the digital networked economy enterprises have to move with agility and speed. ICT provides a vehicle for organisational change and for re-engineering business processes and models. Benefits reported by firms as a result of increased use of ICT include: faster product development, cost and overhead reductions, faster and more reliable transactions, better relationships with customers and suppliers, improved levels of customer service and support, and enhanced collaboration opportunities.

Disruptive change in the service industries

To date the most disruptive change from ICT has come in manufacturing (ERP, supply chains) and retailing. The next disruption will most likely be in service industries, including public services such as healthcare and education. We can expect to see radical improvements in the automatic creation and personalisation of e-services and of e-services support for physical services. Providers will also be looking to increase the productivity of assets and resources through ICT support (the service equivalent of a lean supply chain). In production sectors the impact of ICT will be further intensified by the move to agile manufacturing (see Box 2.3).

Here again we see the constitutive nature of ICT. The new digital technologies not only change the way we do business, they change the nature of business itself.

Box 2.3: Agile Manufacturing in Europe

In manufacturing, the outsourcing of key business processes to low-cost economies has been a major trend over recent years. Proximity to new and potentially large markets, cheaper material costs, and cheaper labour costs are usually offered as the main justifications.

This situation is changing, however. Labour costs in developing countries are increasing, while in many product categories labour costs as a proportion of final product cost are falling. Add to this the cost of logistics – with an oil price of $100 per barrel a real possibility – and the risk of disruption to supply chains, and the rationale for outsourcing no longer looks so clear cut. Furthermore, many European plants still have the potential to yield substantial productivity gains – in some cases by as much as 10-30%.

An alternative strategy is for European manufacturers to embrace agile manufacturing based on small and flexible manufacturing units. These make extensive use of ICT to support rapid and frequent product introduction, and help balance demand and supply in dynamic market segments. They also provide a local production capability to handle variations in demand, reduce supply chain risks and lower logistic costs.

Better Performing Public Services

Re-engineering public services

Considering the share of services of public interest in the European economy, exploitation of advanced ICT solutions is bound to have a large impact – both in societal and economic terms. Exploiting the full potential of ICT in public services will simultaneously (i) stimulate private sector investment for the creation of new markets and services based on innovative ICT solutions; and (ii) deliver services with better value and lower cost for society.

Experience has shown that a simple translation of paperwork to computer system has provided relatively little benefit. As in the private sector, we have to rethink the whole business process, so that technology goes hand-in-hand with other issues such as organisational change, skills, and the implementation of rules and regulations. Then the benefits from the "re-engineering" of public services can be huge.

We need a new generation of public sector and social entrepreneurs in Europe who are ready and willing to use the new technologies to create innovative, accessible and affordable services that respond to the challenges citizens face. Such services will require a successful blending of technology and domain expertise.

CHAPTER 3: EU POSITIONING AND ICT TRENDS

3.1 ICT Market and Investment Overview

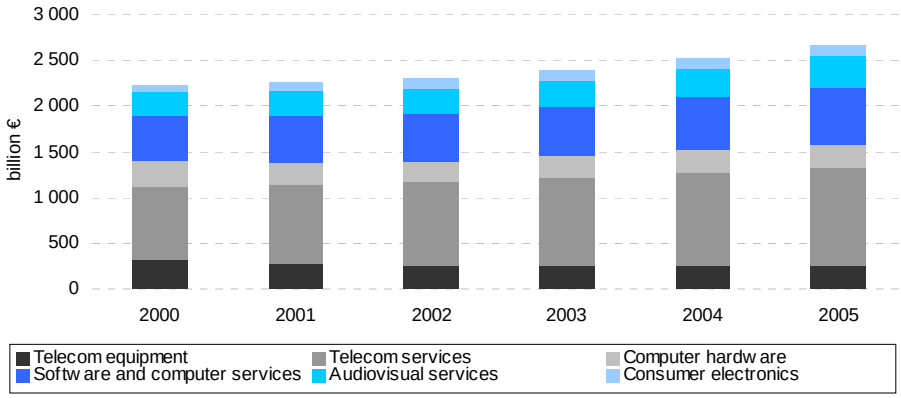
3.1.1 Europe in the Global ICT Market

Global ICT markets are recovering

After a few tough years, due to the internet bubble and the general economic climate, ICT markets are increasing again and at a more rapid rate than the economy as a whole.

The global ICT[4] market increased by around 6% in 2004, to an estimated €2,530 billion (Figure 3.1). IT was the most dynamic segment (+7% for hardware and +8.5% for software and services) and now accounts for approximately 32% of the global market. Telecommunication accounts for 48% with a 5.8% growth in 2004. Overall, there is a reduced gap in growth between equipment (+6.6%) and services (+6.4%).

Figure 3.1: World ICT Markets by Sector



Source: iDATE, 2005

In Western Europe, ICT market growth in 2004 was 2.9%. This was below North America, which grew by 3.9% and still accounts for more than one-third of the global market. At 10%, growth in Asia Pacific accounts for around half of all growth of the world market, with demand particularly strong in telecoms equipment and services.

Europe's ICT industry is a major economic sector in its own right. The telecoms, IT and audio-visual markets make up 6-8% (depending on definition) of EU GDP, and 4-6% of employment. The ICT-producing sectors record very high productivity increases, an average of 9% over the period 1995-2002[5].

Worldwide industrial output experienced very high growth between mid-2002 and mid-2004 but has now dropped back slightly. In the US, investment in ICT is already

[4] ICT here is defined as covering six key segments: computer hardware; software and computer services; telecom equipment; telecom services; consumer electronics; and audiovisual services.

[5] Van Ark, 2005: The study looked at the average annual growth of GDP per hour worked for three industry groups: ICT-producing, ICT-using and non-ICT industries in the European Union, Japan and the US. Average productivity growth rates in the EU, 1995-2002, were 16.2% for ICT Manufacturing and 5.9% for ICT Services. Although productivity growth rates in ICT-producing industries were similar in the EU and US, the study shows productivity growth in ICT-using industries much higher in the US than in the EU (approximately double), emphasizing the under-utilisation of ICT in Europe.

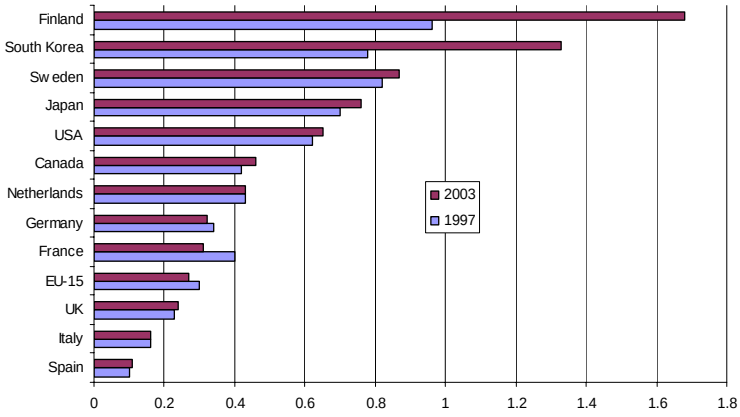
higher than 1999-2000 and accounts for half of tangible private sector investments: a key warning sign for Europe.

The share of ICT equipment in international trade has increased substantially over recent years and now accounts for around 15% of global trade. China is experiencing spectacular growth (ICT market up 24% in 2004) and has become a major exporter of consumer electronics products and mobile devices.

3.1.2 Research and Development in ICT

Europe lags far behind its international competitors in expenditure on research and development in ICT. In 2003, the EU spent around 0.3% of GDP on ICT R&D, compared to 0.55% in US, 0.75% in Japan and 1.35% in South Korea[6]. The strongest performance was in Finland, Sweden, Netherlands and Germany.

Figure 2.4: ICT R&D Expenditure as a Proportion of GDP



There are marked differences in public financing of ICT research between regions. The public sector accounts for around 18% of ICT R&D investments in the EU and US but less than 10% in Japan and Korea.

Europe's research performance in ICT versus other industrial sectors is more positive. Studies show the top-500 European ICT companies have the highest R&D/sales ratio[7] of any European sector at 15.6% – higher even than pharmaceuticals. Furthermore, average innovation performance – a composite measure of the efficiency of R&D investments – in ICT is the highest of any sector[8].

Expenditure on ICT – the fruits of ICT research – is an increasing factor in explaining the innovation gap between the EU and its major international competitors. For instance, levels of ICT expenditure are attributed as the third most significant factor in the innovation gap between the EU and the US, and the fourth most significant in the gap between the EU and Japan[9].

---

[6] *Information Technology Outlook 2004,* OECD

[7] *Monitoring Industrial Research: the 2004 EU industrial R&D investment scoreboard,* Directorate-General Joint Research Centre, European Commission. The term "R&D/sales ratio" here means the ratio of a company's R&D investment to its net sales.

[8] *Sectoral Innovation Scoreboards,* European Innovation Scoreboard, 2005. See: www.trendchart.org

[9] *2005 European Innovation Scoreboard: Comparative Analysis of Innovation Performance*, European Commission, 2006. The most significant factors were: for the US, USPTO patents, tertiary education and ICT expenditures; and for Japan, USPTO patents, triad patents, tertiary education, and ICT expenditures.

3.2 European ICT Industry Structure and Trends

3.2.1 Sector Strengths and Weaknesses

Europe is a major player in ICT

The EU represents approximately 20% of world ICT supply. This is comparable to Japan and less than the US which accounts for 30%.

Telecommunications, embedded computing, micro- and nano-electronics, micro-systems, 'smart' integrated systems and rich audiovisual content are Europe's main industrial and technology strengths. Computers and packaged software are Europe's main industrial weaknesses. The main threats for the EU originate in ongoing industrial investments in emerging economies, in expansion of US dominance in computing, and in a lack of user acceptance and uptake of new technology.

The position and trends in each of the main segments are summarised below. These are expanded on in greater detail in Table 3.1.

- ***Telecoms:*** Telecom services account for 38% of the ICT market and telecom equipment and services a further 9%. Telcos have recovered financially from the slow growth of the recent past but still face slow revenue growth. Digital convergence is bringing major changes to the communications sector, as the telecoms world collides head on with the IT and media industries. The success of broadband and the migration to an all-IP infrastructure for both fixed and mobile networks are key features impacting market growth. European industry is in a strong position in both services and equipment, and also has world-leading academic research.

- ***Hardware and components:*** accounts for around 12% of the ICT market. Three distinct segments are emerging in the semiconductor market: "Watt applications" for very high performance systems such as PCs and servers; "mWatt applications" for portable (battery powered), high bit-rate devices – mobile phones, PDAs, GPS; and "µWatt applications" for low bitrate, low power systems such as wireless sensors and actuators. The segments have very different characteristics but are closely interlinked. Europe enjoys relatively strong positions in electronic design for high growth applications such as mobile phones and automotive electronics. Signal processing, smartcards and microsystems are also key strengths.

- ***Software and services:*** IT software and services account for around 20% of the ICT market. Several major breakthroughs in software have been generated in Europe in the last 10-15 years. Examples include the Web, mpeg2 and mp3 encoding, and the Linux operating system with its influence on the open source software movement. Key European strengths include: enterprise software; embedded and distributed software; hard real-time design and dependable/fault-tolerant systems; software engineering; and high-end computing and GRID architectures.

- ***Consumer electronics:*** Consumer electronics amounts to around 9% of the ICT market. It is a diverse and highly competitive sector and is profoundly affected by convergence which carries strong potential. Despite booming sales, firms face tough competitive conditions: prices are decreasing dramatically and new competitors (e.g. Apple, HP, Dell) are entering the market as the digitisation process creates bridges with the computer world. China has emerged as a major player in the production of electronic goods

over recent years, with Chinese firms increasingly active in international markets. Europe's strength in mobile devices presents a major opportunity to open up new areas within the converged consumer marketplace.

- ***Content and media:*** Audio-visual services make up 12% of the ICT market. Europe's online content sector is still in an embryonic phase, representing less than 3% of total revenues from music, video and games content. Nevertheless, it is still a €10.2 billion market. EU markets are dominated by US companies and content: for instance, only 20% of the DVDs sold in Europe have European content and over 70% of the films shown in Europe are American or are co-produced with the US. Europe has key strengths in media technologies such as image processing and related fields; semantics and knowledge management; computer vision; virtual and augmented reality. European groups have a strong record in contributing to standards (e.g. MPEG, DVB).

3.2.2 The Growth of a Borderless Digital Ecosystem

One global digital market …

Digital convergence – the coming together of computing, communications, content and consumer electronics - is the over-riding influence on Europe's ICT industry today. The coalescence of these technologies is unleashing a wealth of opportunities, blurring the boundaries between market sectors, and proving a powerful driver for innovation and change. As a consequence, we are seeing the emergence of one global market for all digital services covering communications, IT and media.

…and a borderless digital industry

Driven along by the convergence wave, the structure of the global ICT industry is changing fundamentally. The industry is less and less identifiable as a discrete sector but is becoming part of a **borderless digital ecosystem.** In this ecosystem firms are increasingly defined by their role within the converged value chain – as system developer, content provider, equipment manufacturer, aggregator, access/network operator, etc - rather than by traditional market segments.

The manifestations of this digital ecosystem are seen in a number of trends:

1) *Increasing competition between the traditional market segments:* Convergence continues to transform and restructure the three traditional market segments – IT, telecoms, and media. Separate, vertically integrated "silo" networks (fixed, mobile, broadcast, business and residential) are being transformed into horizontally interconnected functional layers. In this new scenario, network operators, IT and CE players as well as the big media conglomerates are all competing for market share.

2) *Increasing share of content and services within the overall ICT market:* Digital content and services are the main beneficiaries of the convergence revolution. The growth of network infrastructure and access platforms has given rise to a proliferation of content-based products and services for both consumer and business markets. In this new ecosystem all sorts of actors will be able to generate and transact digital content and services over global networks. Content/service providers will be as diverse as small businesses, professional football clubs, local/specialist libraries & museums, writers & artists, and individual hobbyists and enthusiasts.

3) *Increasing share of ICT in applications:* ICT is emerging as a key driver of technology development and innovation in major professional and

application sectors, such as health, automotive and security. Some of these applications will start to cross-over into consumer systems as applications move closer to the consumer marketplace. The strong growth of in-car satellite navigation is an early example of this; markets such as personal healthcare monitors and home security systems are likely to be the next growth areas. Future progress in these sectors depends not just on the ability to integrate ICT building blocks into systems, but to tailor technology development to meet the specific needs of the final applications.

Europe's ICT firms need to be increasingly aware of these shifting global value chains and to orientate themselves within them to derive the greatest competitive advantage.

TABLE 3.1: CURRENT EU INDUSTRIAL POSITION AND TRENDS IN KEY ICT MARKET SEGMENTS

Segment	EU's Global Position	EU Industry Strengths	EU Industry Weaknesses	Key Market Features
Telecoms	Telecom services: Six EU companies in the world top-10 revenues in 2003: Deutsche Telekom (DE), Vodafone (UK), France Telecom (FR), TelecomItalia (IT), Telefónica (ES) and BT (UK). Telecom equipment and systems: Four EU companies in the world top-10 with a combined share of 45% of revenues: Nokia (FI), Siemens (DE), Ericsson (SE) and Alcatel (FR).	• Telecoms equipment & systems, especially optical systems; • Telecom services, especially mobile & networked services • World-leading communications research in academia		• Success of broadband in the European market. • Migration to an all-IP infrastructure for both fixed and mobile networks. • Connectivity being built in to an increasing range of devices and applications. • Emergence of multiple radio access techniques in the mobile segment.
Computer Hardware and Components	Three European companies are ranked among the world's top-ten for semiconductor manufacture: STMicro (FR/IT), Infineon (DE) and Philips (NL) Europe's main microelectronics research labs (e.g. IMEC, LETI , FhG, CNR and NMRC) have worldwide recognised know-how that is attracting private investments from across the world	• Electronic design, for sectors such as telecoms, consumer electronics, automotive systems and smartcards. • Signal processing and low-power chips. • Microsystems and related nano-technologies • Microelectronics research labs	• Microprocessors and memory chips	• Continuing strong growth rates worldwide (~10% p.a) • Emergence of distinct but interlinked market segments.
Software and Computer Services	Europe has world leaders in some key areas such as: SAP (DE) in enterprise software; and Dassault (FR) and BAE Systems (UK) in embedded systems.	• Enterprise software • Embedded and distributed software; • Hard real-time design, • Dependable and fault-tolerant computing systems. • Software agent technologies • Software engineering. • High-end computing and	• Packaged software market is dominated by US companies such as Microsoft, Oracle, Adobe, IBM and Sun	• Increasing pervasiveness and complexity of software • Growth of embedded and distributed software systems • Open source as a new model for software development

		GRID architectures		
Consumer Electronics	Three EU companies in the world top-ten: Thomson-Multimedia (FR), Philips (NL), and Siemens (DE). Thomson-Multimedia & Philips are number 1 and 2 in the US CE market. Strong competition from new Chinese manufacturers	• High-end audio & video systems	• Low-cost devices such as mp3 players and cameras.	• Broadband take-up is helping to drive market growth • Digital devices displacing analogue equivalents • Convergence bringing new functionalities & blurring device categories
Content and Media	Strong European players in companies such as Vivendi Universal and Bertlesmann, but these lack the global reach of the big US media conglomerates. In addition, Europe has strong creative SMEs	• Digital interactive TV • Image processing, representation and coding • Semantics and knowledge management • Computer vision • Virtual and augmented reality • Games, animation, and special effects	• Packaging & delivery of content and services	• Dominance of US media companies in EU markets • Positive knock-on effects for other ICT industry segments (e.g. PCs, digital cameras, telecoms) • Content value chains are increasingly complex
Automation	Automation of discrete manufacturing including industrial robotics is led by European companies such as ABB, Kuka, Siemens. Automation of the process industry including drives is globally led by European companies such as ABB, Invensys, Siemens	• Automation products such as PLC, DCS, Robotics, drives • Industrial real time solutions • Vertical and horizontal integration of software applications	• Japanese companies are often cost leaders especially in the less complex product areas	• Global solutions with high services content • Trend towards more customization drives demand for automation and innovative solutions
Security	European companies lag US suppliers, who are benefiting from strong domestic market & investment in security research. US companies benefiting from first-mover advantage as US standards are being adopted worldwide.	• CII • Information network security • Civil disaster management • Biometrics		• Emerging & fragmented market • Lack of coordination between national & European efforts • Separation of defence & civil research in Europe a key barrier

3.3 Technology Trajectories: Development Paths in ICT

3.3.1 On the Verge of a Step Change in ICT Applications

New opportunities from a step-change in ICT applications

ICT is neither stable nor static. While there is a need to improve the technology at hand, a world of new opportunities is emerging. This will have tremendous consequences for the way we do science, technology and business, the way we learn and work, and the way we live our daily lives.

Technological progress is continuous but progress in applications proceeds in successive 'quantum leaps' that are made possible by a combination of technological, human and economical factors. There are strong signs that we are on the verge of such a leap today.

Technological, societal and market conditions are right for major growth

In technological terms, it will be made possible by factors such as the availability of broadband, the booming of wireless devices for communication and entertainment, the progress in integration and embedded technologies, the increasing intelligence of information systems and the omnipresence of visual information.

In society, teenagers and children are leading the way to a broad take-up of trendy high-tech devices - often seen as 'status-symbols' – that help social interaction. All generations have embraced the web and mobile phones, and other applications are increasingly popular. There is little doubt that the market is ripe for much greater use of ICT, once more attractive content and services become available.

Finally, in market terms, the second wave of internet developments, the availability of ubiquitous digital communication networks and the falling hardware prices have now put in place the right conditions for a much wider roll-out of ICT across all sectors.

3.3.2 The Next Generation of ICT

Tomorrow's ICT will be defined by its function

The convergence of technologies; the deeper embedding and wider integration of technology into products, services and processes; and the tighter links between technology and its use are all orientations shaping the future development of ICT. As noted in section 3.2.2, this is having major impacts on the ICT industry making it less and less identifiable as a discrete sector.

The next generation of ICT will be characterised by its functionalities rather than by traditional product or service categories. In particular, we note four main trajectories. Systems and services are increasingly:

1) **Networked, mobile, seamless** and **scalable**, offering the capability to be always best connected any time, anywhere and to anything;
2) **Embedded** into the things of everyday life in a way that is **invisible** to the user or brings new **form-fitting** solutions;
3) **Intelligent** and **personalised**, and therefore more centred on the user and their needs;
4) Rich in **content and experiences** and in **visual** and **multimodal** interaction.

These trajectories are explored further in the following sections.

3.3.3 Networked, Mobile, Seamless and Scalable

New levels of networking and mobility

The next generation of ICT will take networking and mobility to new levels and will continue to benefit from digital convergence – the fusing of computing, communications and content. Specifically, within the next decade we can anticipate:

- *Internet everywhere,* with universal and multimodal access to broadband and all-IP networks *at any time, anywhere* and to *anything.*
- *Convergence,* with all communication services, media and content migrating increasingly to an all-IP infrastructure. IP networks become application- and service-centric;
- *Faster, fatter and scalable networks*: with 20 Mb/s available to all homes & offices, leading to more use of bandwidth by both humans and machines;
- *Ubiquitous and always-on connectivity*, with users no longer required or able to make a distinction between fixed and mobile network access and availability;
- *True mobility,* with seamless roaming between different access technologies and platforms;
- *Secure communications*, with security- and privacy-enhancing features built into the ICT infrastructure and applications layers;
- *New architectures,* such as peer-to-peer (P2P), ad-hoc networks and interactive broadcast/multicast, offering new communication paradigms.
- *Basic service enablers,* such as presence, location, billing, and authentication, providing building blocks for the rapid creation of all sorts of value-added services.

The overall picture will be one where seamless broadband communication networks span from the personal area to the regional and global area. This will be made possible by meshing all sorts of different computing and communication networks, whether these are fixed wired and wireless networks, third or higher generation mobile networks, wireless personal and local area networks, satellites or whatsoever. Ever higher bandwidth communication networks and the integration of fixed and mobile, all-IP, communication infrastructures and their interconnection and interoperability will permit the seamless delivery of ever higher volumes of data and services anywhere, anytime.

Convergence will continue to redefine devices and give them new functionalities. Already today we see that mobile phones are not just for talking but are able to receive e-mail, pictures and even video. As well as word processing and databases, PCs are used to store and manipulate all types of media and are becoming the hubs of our digital world. Consumer equipment, such as hi-fi and cameras, and even kitchen appliances, are able to communicate with each other and with computing devices. And content of all forms – music, video, images – is being generated, or converted into, digital form.

What this will enable

Implications of this more networked and mobile world include:

- Connectivity accelerates the process of globalisation and community interaction (with the interconnected home as a key example) which in turn will

facilitate innovative services and applications and drive evolution/disruption in other sectors: eHealth, eCare, eLearning, etc.

- ICT as an enabler of co-operative processes between different players to achieve common economical or service objectives.
- New converged services bridging across devices and between entertainment, information access and communications (e.g. IP TV services).
- New communications business models, exploiting the full potential of the new architectures (P2P, ad-hoc, broadcast/multicast, etc) to deliver value-added services (e.g. online gaming, P2P sharing).

Convergence is a powerful force for innovation and competition. With many potential configurations of access platforms, applications, services and market players, conditions are ripe for the 'creative destruction' necessary for successful innovations to emerge. In particular, deeper levels of service integration will increase both the value for the end-user and the potential revenue for the service provider. Service convergence has its own dynamics and the strategic business case will vary depending on type of services, network operator and market conditions.

3.3.4 Embedded and Invisible

The Internet of things

Another important characteristic of future systems will be that they will be integrated in the things of everyday life. The systems will be embedded into our everyday environments, so that they are invisible to the user. Such functionalities are made possible by developments in miniaturisation, embedded systems, networks and the convergence of ICT with other fields.

Sensing, communication, storage and computation capabilities are being linked together within miniature artefacts and objects that are embedded in the environment and communicate with each other. Such smart artefacts can be joined together to create distributed and self-regulating systems that are adapted to human needs. These massively distributed systems will form dynamic ecosystems that are able to grow and adapt to the evolving needs of individual users and communities.

The cost of communications is insignificant relative to the potential convenience and value obtained by connecting nearly all devices with a processor to the net and each other. We can think, for example, in terms of the €1 device and the 10 cent network. The result will be a vast increase in the number of communicating objects: the birth of "the Internet of things".

Such a scenario would offer:

- *The environment as the interface:* People will be surrounded by easy-to-use interfaces that are embedded in all kinds of objects and settings. Technology "disappears" into the background as the visual form factor of the PC is replaced by widely embedded systems that are easier to use. Developments such as agents, natural interaction and natural language, as well as sensors and actuators integrated into personal devices and wearable computing, open the way to new applications.
- *Embedded components and embedded control*: Intelligence is embedded in all kinds of products (textiles, buildings, cards, furniture, roads and traffic systems). Technologies such as low-cost sensors, sensor and actuator networks, and RFID enable data collection and control across massively

distributed systems. Devices are more durable and consume less power, while also benefiting from developments in energy storage.

- *Processing power and storage on demand and as a commodity*: Higher power and lower cost processors will be ubiquitous and always connected to the networks. Real-time Grid computing will become a reality. Data storage too will become a commodity, with unlimited capacity available at little or no cost. These developments will permit tasks of ever higher computational complexity, such as large-scale simulation, knowledge mining and pattern recognition.
- *Interfacing living and artificial world:* The convergence of ICT/nano/bio/cogno technologies and pioneering developments at so-called "wet-hard interfaces" will lead to radically new solutions. Such systems will offer totally new ways of interfacing and feedback with/from the real world. Examples include: new interfaces, implants and treatments for healthcare; enhancements in human capabilities (e.g. night vision, memory improvements); and even implants for identification and security purposes.

The complexity of such systems presents profound technical challenges. They will need to "know" themselves, their environment and the context surrounding their use and act accordingly. System entities will need to be able to find and generate their own rules on how best to interact with their neighbours, while always looking to optimise their own workings and their own relations with the environment. Systems must be dynamic, able to configure and reconfigure themselves under varying, and even unpredictable, conditions. They must be reliable and secure and protect the privacy of the users. And they must be able to store and make sense of the vast amounts of data and information generated.

What this would enable

Embedded intelligence and embedded control will be found in a wide range of products and processes. Integration of RFID in mobile phones and other consumer devices will allow smart access to information, authentication, electronic payments, etc across a wide range of scenarios. Real-time enterprises will be able to make immediate use of information about assets, processes and people, leading to improved competitiveness. Specific examples include:

- *Lifecycle tracking:* By giving each item an identity, products and components can be tracked throughout their lifecycle – from source to end-of-life. Products can be linked with marketing and support information; foodstuffs can be linked with the original farm or producer; components can be linked to their original manufacturer. This will bring radical changes to logistics and distribution chains.
- *Intelligent infrastructure:* Smarter solutions to the management of scarce resources (traffic, energy, water, etc) through intelligent infrastructure. In energy, for example, sensors could be used in user equipment to better manage demand through real-time energy pricing; and in the electricity supply network to enable the effective integration of renewable energy and small-scale generation.
- *Better management of the environment*, with higher granularity environmental data helping us to deal with the Earth's environmental stresses.

- *Effective crisis management,* through better assessment of the incident and priority requirements, fast intervention, containment of negative effects and rapid restoring of the functionality of critical infrastructures.
- *Adaptive structures:* Materials with integrated actuators and sensors that are able to change their structure and adapt to external conditions. Examples could include: active suspension in motor vehicles to reduce vibration, more precise positioning of robots; and adaptive artificial limbs.
- *Personal health management systems and tools* for health professionals, combined with wearable, implantable and portable devices for monitoring, diagnosis and therapy.

Many legal, social and ethical issues remain to be addressed here. For instance, what are/should be the user's rights to data collected over sensor nets? How can we safeguard privacy and security in such massively distributed networks?

3.3.5 Intelligent and Personalised

Putting user-needs centre stage

The next generation of ICT will enable the creation of systems that are more intelligent and personalised, and therefore more centred on the user.

Key developments in this direction include:

- *Autonomous sensing and decision-making,* based on functionalities such as context-awareness, and system learning and adaptation.
- *Semantic Web*: allows the transformation of information to knowledge. New approaches based on indexing and linguistic methods lead to new search machines for precise access to content in the internet. Massive networked archives benefit from the new search systems.
- *New service enablers*: a variety of factors leading to the emergence of new services, business models and processes. Location, presence, authentication and ubiquitous all-IP communications are key enablers for personalised and context-aware services and applications.

These semi-intelligent and highly adaptive networks will augment the physical environment with new properties, enhancing the way people interact with it while keeping the underlying system out of sight. They will hide the overall system complexity and provide stable functionality, with functions being revealed only "on demand". Human attention will be preserved by delivering us only information which is rich with meanings and contexts. Together with situated and cooperating smart artefacts, these network resources will boost the creation of new ambient environments that are tailored to individual needs and will increasingly link the real and the virtual worlds.

Smart ambient environments could revolutionise many sectors in terms of control and monitoring and give rise to "invisible intelligence". With less central infrastructure devices will have the capability to act as terminals and access points in their own right.

What this would enable

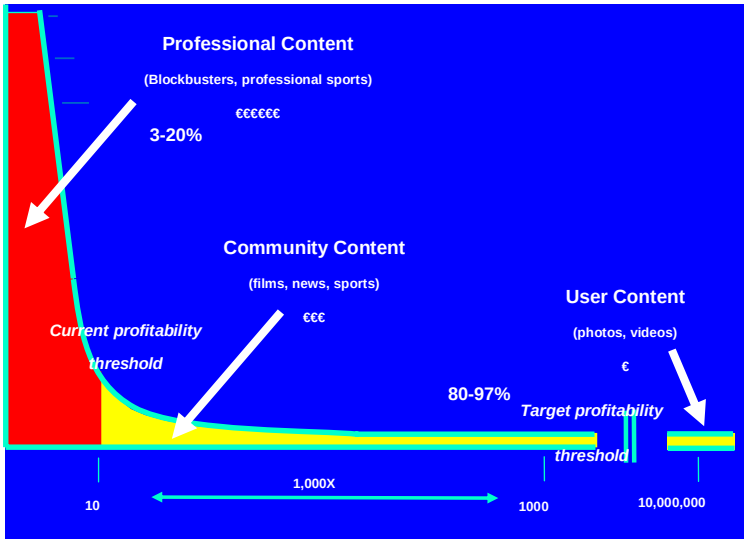
Offerings tailored to the needs of the user are in demand in all sectors including media, consumer and industrial products. We can envisage a scenario where all

Box 3.1: The Long Tail – The Shift to Personalised Content and Services

One of the consequences of convergence has been an explosion in digital content, much of which is generated by users themselves.

With connectivity and storage capacity being incorporated into all ICT equipment (TVs, mobiles, computers, music players) and opportunities for more interactive content (e.g. interactive TV, digital camera phones, etc), we are entering a new era where any organisation or even individual can become a content/service provider. Thus, alongside mass consumer content & services, there will be a "long tail" of personalised content and services tailored to the needs of the individual user.

Some content/services will be produced and distributed by users themselves, whereas others will be generated on a professional or community basis. Often cultural or artistic content will be generated at the local level. Leveraging the distribution and personalisation capabilities of broadband networks, this "long tail" of personalised content/services could dwarf consumer content/services in terms of volume and value.



The challenge is to move the profitability threshold to make this long-tail of niche and personalised content and services more exploitable by individuals and businesses (especially SMEs). Instead of selling the same high value content/services to large audiences, providers accrue revenues from a huge number of small or micro content/service transactions. Successful innovators such as Amazon and eBay already exploit this model.

sorts of products, content and services are produced or manufactured according to the individual user's own requirements and specifications. With personalised offerings no more expensive to produce than standard ones, the niche becomes the norm.

One example of this is in the so-called "long-tail" of user-generated content, which is an increasingly important aspect of content provision over the global networks (see Box 3.1). Other instances include:

- *Batch-of-one manufacturing*, a new production paradigm allowing personalised products to be custom-designed and built within a flexible production environment. Achieving this will require integration of diverse ICT applications.
- *Location-based services* for transport and logistics.

- *Control of complex processes* like: co-operative applications; self-configuring and self-organising networks; control of the networked configurations necessary for the social service requirements.

Here as well there are many legal and business issues. What are the right business models to exploit the long-tail? With increasing personal data being stored, how can we safeguard privacy?

3.3.6 Content-rich, Interactive and Experiential

Engaging systems for the PlayStation generation

Future ICT systems will be visual, interactive and content-rich. The 'PlayStation generation' is used to the world being highly visual and fast-moving: they will expect to have interfaces and content as rich, fluid and reactive as games.

Key features of these future systems will be:

- *Rich visualisation:* Systems will be visual and content-rich. High definition broadcasting will be an enabler for converged entertainment and information services. New visual techniques for search and retrieval will allow users to make sense of the explosion of digital content and data. Simulation and visualisation will be widely used to analyse, understand and exploit very large and complex datasets. 3-dimensional interfaces and content will be found in a wide range of environments, including the home.
- *Tele-presence and experience:* Future ICT systems will be much more experiential. Experiences will be "all inclusive", combining the real world with enhanced reality. Highly realistic and interactive mixed reality environments will create presence: a sense of "being there". Rich use of multimedia and content, based on live and stored media archives, will enable us to interact with content in new ways. Customised, personalised multimedia experiences will be accessible on demand in a seamless way over all network types.
- *Multimodal interaction:* Developments in haptics, speech and other sensory interfaces will bring new capabilities and allow us to interact with systems in new ways. ICT systems will be able to "see", "talk", "smell", "feel" and even sense our emotions. We will be able to interact with systems more naturally and intuitively. There will be the possibility to enhance or augment the human body's natural capabilities (e.g. to restore loss of sight, hearing or dexterity).

What this will enable

- *Intuitive man-machine co-operation:* the interaction of humans with machines will change to more human ways of communication. For instance, new multimodal interfaces will be able to identify gestures and voices or to use touch-sensitive displays. Humans and robots will work directly together in a common environment.
- *Simulated reality - modelling of processes and products:* Simulation can be used to model the behaviour of a wide range of complex materials, processes and systems. With powerful simulation techniques, engineers will be able to develop materials, to plan their processing and to design their final structure. Similarly, doctors will be able to combine clinical, medical and genetics knowledge to simulate personalised medical interventions on virtual humans.
- *Virtual presence:* Mixed reality mediation environments will create virtual presence, offering highly realistic face-to-face interactions between remote

sites. Virtual face-to-face meetings could be held in which participants share and exchange information and knowledge. Similar scenarios can be envisaged for other settings: a theatre stage, a city square, a stadium or our home living room.

- *Virtual learning:* One instance of virtual presence with a potentially significant impact is virtual learning. Students would be able to share the same educational experience (a university class, a debate or a seminar) with teachers and fellow students, irrespective of space and time constraints. Global communities will appear with common goals and needs, and European content will be accessible across the global networks. Such developments will have a profound positive impact on the organisation and the overall quality of educational processes.
- *Widespread applications of robotics:* Robotics will be a key beneficiary of developments in actuators, sensors and interfaces. With enhanced capabilities, robots will "break out" of manufacturing and permeate into many areas of modern life e.g. health, home chores, homecare, maintenance, etc.
- *Assistive aids for those with special needs:* New classes of assistive aids will be developed that will help to compensate for functional limitations. Such systems will be able to enhance, augment or replace the individuals' functional capabilities, including cognitive and sensory impairments.

CHAPTER 4: A VISION AND STRATEGY FOR ADDRESSING EUROPEAN CHALLENGES IN ICT

4.1 ICT as a New Societal Paradigm: A Vision for Europe

4.1.1 Transformation through ICT

ICT is the key to competitiveness and sustainability

Europe is embarked on a race to become more innovative, competitive and sustainable. The outcome of this race will depend on our ability to embrace digital technologies in all areas of the European economy and society.

It is clear that the societal challenges facing Europe today - in health, inclusion, transport, education, etc - demand completely new, creative and innovative solutions. Similarly in the economic sphere, developments such as globalisation and convergence demand creativity and innovation. Europe must marshal ICT to address these societal challenges and find a path to higher and sustainable economic growth.

At the same time, the nature of ICT is changing. ICT today is unlike any other technology field: it is the constitutive technology of the first half of the 21st century, moulding and becoming part of the things to which it is applied. ICT does not just enable us to *do* new things; it *shapes* how we do them.

Embedding ICT into the fabric of European society

As ICT becomes more deeply embedded into the fabric of European society it starts to unleash massive and far-reaching social change. It also create opportunities for innovation, creativity and progress that lead to growth and new jobs. The next waves of the digital transition, on which we are just engaging, are likely to have an even bigger transformational impact than the first.

ICT as the basis of a new societal paradigm

These constitutive effects amount to a paradigm shift in how our economy and society function. Like the railways, electricity and the internal combustion engine in previous generations, innovation in ICT shapes our societies in fundamental – and often unexpected - ways. Who at the time could have predicted, for instance, that the railways would lead to the growth of manufacturing clusters; or that motor cars would shape the growth of our cities?

Shaping the answers to Europe's specific needs

Further advances in ICT will allow us to address Europe's socio-economic problems in ways that were impossible, and in many cases not even conceivable, even a few years ago**. ICT has now reached a stage of development that enables <u>us</u> – in this generation - to shape the answers to Europe's <u>specific</u> needs for many years to come**.

4.1.2 Research to Shape Innovative ICT Solutions

Europe has no choice but to be a key player in ICT research

To capture this "constitutive" nature of ICT Europe has no choice but to be a key player in ICT research. An economy that wants to grow and create jobs cannot only "consume" ICT products and services. It has to master their progress so that it is able to sustain the development of all its economic sectors. A society that wants to ensure the security of its citizens and improve their standard of living can only do so if it can shape the progress of ICT so that it fits its societal needs.

To achieve this requires a substantial improvement in both the level and the quality of Europe's investments in ICT research and development. With competition increasing at a global scale, even in research and development, we need to improve

significantly Europe's attractiveness to business investment in ICT research that has been weakening gradually since the late nineties. We need also to attract the world's best ICT researchers to our labs.

Stepping up the ICT research effort

To be a first choice for business investment and for researchers, Europe should lead ICT progress. It has the capacity to lead, but **needs to step up significantly its effort in ICT research.** This requires both higher public investment, that pushes further the excellence of our knowledge and skills, as well as the development of a better framework for attracting private investment.

4.2 Stepping Up Europe's ICT Research Effort: ISTAG's Proposals

ICT research in Europe represents 18% of the total research effort against more than 30% for all its major competitors. The ICT research effort in Europe is less than 40% of the US effort and is less than the Japanese effort. Europe's ICT research effort per capita is sliding below the Chinese and Korean effort. There is therefore no time to wait.

To reverse these trends, ISTAG proposes below a set of concrete measures that should be undertaken both by public authorities, in the Member States and at Community level, and by industry and the private sector.

4.2.1 Developing Lead Markets for ICT Innovations

Lead projects play a key role in the uptake of innovative technologies

The successful introduction of new technologies or systems is highly dependent on successful lead projects or early users. In the US, in addition to the defence sector which often plays the role of experimenters or early users of ICT, large initiatives are now being launched in areas like health and energy. In a number of Asian countries this early usage is part of an overall industrial policy. In Europe, Member States have largely abandoned this kind of industrial policy in the context of introducing a market-driven economy. At the same time European defence efforts do not lend themselves to this kind of early usage.

Nevertheless, experience clearly shows the importance for industry of having these lead customers. The stimulating effect of the Galileo project, for instance, in creating a market for mobile and location-based services is one example of this. It is essential for Europe to find a way to have lead projects particularly in the fields responding to major societal needs.

Acting globally with a European accent

Europe must master the new value chains emerging from convergence so as to produce the best returns both at home and internationally – what we might call "acting globally with a European accent". Strong lead projects would enable Europe to develop common solutions that are recognised across the EU-25 and so create a true European market. They would also allow European companies to compete effectively in global markets. We should focus on critical parts of the value chain in well selected areas, concentrating on generating knowledge-intensive added value from inside Europe.

Working together in focused initiatives

ISTAG therefore invites the public and private sectors at the national and EU level to work together **in focused initiatives for the development of lead markets for innovative ICT solutions** addressing Europe's key societal challenges. This includes initiatives in areas such as health, ageing, education, transport, manufacturing, energy, environment, security or digital content. Urgent actions

should be taken to identify these 'lead customers' and 'lead markets' for ICT innovation.

These initiatives **should mobilise all necessary resources** to achieve well defined and challenging socio-economic goals. **They should involve a wide range of stake holders and should combine a set of measures** attracting and facilitating investment in ICT research and the deployment of ICT innovative solutions. They should also address the whole development cycle from the short term deployment of existing innovative technologies to the more ambitious development in the medium to longer term of new solutions.

4.2.2 Support Measures to Step Up the Research Effort

A diversified effort

Lead projects alone will not be enough to strengthen Europe's ICT research and its impact. A variety of measures to support these initiatives will also be required. These include public procurement of innovative solutions, focused support to public research, tax incentives, the use of structural funds, and the investment in ICT research centres of excellence:

- **Public procurement of innovative ICT based solutions:** Several barriers prevent European national and regional authorities today from procuring innovative solutions in order to improve their applications and services. The new European directives on public procurement and on State aids provide means to alleviate some of these barriers. It is important though that national and regional authorities across the EU work together to ensure sharing of best practices and to achieve clearer understanding of the various possibilities.

  The Commission should also provide guidance on the implementation of its directives. In cases like eHealth, for example, most Member States have planned for large investments in ICT solutions. In general, though, these investments target the incremental improvements of existing solutions. They do not aim at procuring completely new innovative solutions that could substantially improve the services. Such higher risk-higher reward procurement can be extremely effective, as shown by the US and Asian experiences.

- **Public funding to strengthen Europe's centres of excellence in the target fields**: Although the Member States have recently launched several national initiatives aimed at reinforcing or creating new centres of excellence in ICT platforms, ISTAG believes that coordination between these initiatives per domain at the European level is essential. It will enable optimisation of the use of resources and the creation of the necessary critical mass to boost innovation and excellence. The experience of coordination between Europe's microelectronics research centres illustrates the added value of such an approach.

- **Public funding through grants to highly innovative research** preparing the ground for future solutions: This should range from basic research providing the necessary fundamental understandings to progress a technology through to the more application-driven research and pilot implementations. Support to research through public grants, be it at national or European level, has its limits though and is often not sufficient to "pull through" a set of technologies into innovative products and services.

- **Tax incentives** have been the subject of many Communications from the Commission, but it is important that Member States share experiences in this

field. The example of Finland, which has shifted its tax systems to support research and innovation in the late 80's and early 90's, illustrates the extreme importance of such measures. The same applies to Ireland and other regions.

- **The use of structural funds**: Investing in research and development is one of the main pillars of the new guidelines for Structural Funds that have been agreed upon by the EU Member States. By focussing the research investments on ICT fields that help address key societal challenges, the regions will be able to build leadership in emerging areas that have direct impact on their developments and that contribute to EU policy goals.

  By creating centres of excellence, for example addressing ICT for education or ICT for health, under-developed regions can rapidly get worldwide recognition and attract private investments in high growth ICT fields. Such investments could be especially important in the context of the new Member States (EU-10). Efforts should also be made to benefit from the latest concepts of research, for example "experience research centres in ICT" involving users at the earliest stages.

- **Venture and seed capital**: SMEs can be the first beneficiaries from such initiatives that open up new markets. The initiatives, if well targeted, will naturally draw investors that see the emergence of new businesses. However, the present fragmentation of markets and the lack of a single European stock exchange for technology companies create an under funding of European start-ups. It is urgent to take necessary measures to remedy this situation.

4.2.3 Better Coordination of the EU ICT Research Effort

Better coordination of ICT programmes and policies

ISTAG sees an important value in facilitating the further coordination between national programmes and policies in ICT research. It sees, though, that this should be done whilst enabling competition and taking into account the specificities of each Member State and region. **The ambition is to avoid fragmentation of the research effort whilst at the same time pushing for excellence**.

The Framework Programme is an important means to strengthen cooperation between industry and academia across Europe. To be efficient, ICT in FP7 needs to be steered towards the achievement of challenging goals preparing Europe for the next wave of technology innovations. ICT in FP7 needs simpler instruments and procedures than FP6. ISTAG has issued a specific report on ICT in FP7.

4.2.4 The Role of European Technology Platforms

ETPs are a key means to translate research into innovation

ISTAG welcomes the European Technology Platforms (ETPs), with their common European visions and research agendas, as a means of building consensus around technology development strategies and other measures needed to turn research results into marketable products and services. ETP's should be an excellent way to organise work on standards which are essential for putting European technologies at the forefront of the world scene.

There is certainly an important value for industry and the academic research community to work together and define strategies and agendas for research that all actors can benefit from. To bring real value, though, these Platforms should not be perceived by their members as mere lobby groups to get additional public funding. Neither should the ETPs' research agendas be just the mere juxtaposition of short term development agendas of the influential members. The implementation of the

Strategic Research Agendas (SRAs) should be based upon excellence (quality and critical mass) and sufficient market acceptance.

ETPs should not fall therefore into the trap of simply extrapolating existing technology bases but should leave space for technology discontinuities and breakthroughs.

As the number of Platforms in ICT grows, ISTAG sees a danger of fragmentation and the risk that this would have on developing coherent strategies for ICT research in the context of a converging ICT field.

ETPs should strive for ambitious goals

The value of ETPs is in providing clearer insights on the means to achieve vision-driven ambitious goals in Europe and on ensuring the best implementation of these means. This applies equally to the development of Europe's skills and knowledge in the key ICT technology fields and to the establishment of lead markets for innovative ICT solutions.

4.3 Orientations for ICT Research in Europe

The technology trajectories in ICT development identified in Chapter 3 have significant knock-on effects for Europe's product and service offerings, and hence for the nature of ICT research. They suggest five main orientations in Europe's ICT research effort:

New approaches for massively complex systems

1) **Addressing complexity and the need for a systems approach:** The growing pervasiveness of ICT and its intensive interactivity bring a step change in complexity. Technology chains are becoming more and more complex, spanning across a range of components, devices, infrastructures and services. The successful exploitation of these technologies requires their integration in managed services and solutions to be applied across a broadening range of sectors and markets. Thus, increasingly research needs to follow a systems approach.

Innovation at the boundaries with applications and other research domains

2) **Fostering interdisciplinarity and synergies:** Europe should foster and stimulate a more interdisciplinary approach to ICT research. Research should draw ICT researchers into interactions with a much wider range of disciplines. There are two dimensions to this.

   a. Firstly, there is a need for stronger involvement of domain expertise, since more and more innovation comes from the use of ICT in a broadening range of application domains.

   b. Secondly, there is a need for greater interaction with other science and technology disciplines, since further advances rely increasingly on exploration at the frontiers between ICT and other fields.

   Thus, the range of interactions around ICT research must be both wider and deeper.

Exploit users as drivers of innovation

3) **Creating an open engagement with users:** The critical role of users as drivers of innovation is increasingly apparent. New and open means of engagement need to be found between those that develop new ICT and those that use it. Users should be integrated into the processes of research and development, and new product creation and introduction. Users should

be at the centre of the innovation process, a source of ideas, and not just a resource to evaluate ideas generated by professionals.

A virtuous circle from investment in content and services

4) **Stimulating the consumption side (services and content):** As infrastructure investments mature and the capabilities of networks and devices increase, services and content becomes a more important part of the overall picture. Properties such as mobility, connectivity, embedded intelligence, personalisation, and interactivity offer the prospect of a new generation of service delivery platforms, managed applications and support services with much enhanced capabilities. Networks become service- and application-centric and will be invisible for the user.

   From the economic perspective, through serious investment here there is the potential to create a virtuous circle: growth on the *consumption side* (content and services) should boost user demand, which will automatically create growth on the *investment* side (infrastructure upgrades).

Addressing the whole value chain

5) **Focus on value chains and ecosystems:** Markets, too, are becoming more complex, with increasing interdependencies between technology, products and services. Successful exploitation of ICT research results requires not just innovative technology but also innovative business models. While keeping user needs centre-stage, we need to shift the user focus from discrete systems to the value chains of which they are a part and the societal challenges to which they are applied. What do European users – at a societal level – *really* want and need? Thus, research must take account of at least the value chain, and increasingly the whole business/service ecosystem.

These trends lead us to a series of strategic priorities on how Europe can best utilise its industrial strengths and research assets in ICT in a way that is aligned with both the technology trajectories and the societal challenges.

4.4 Setting Priorities: Centres of Gravity for ICT Research

Where socio-economic needs meet European expertise

Europe has the best chance of developing leadership positions if it concentrates on areas where future societal and economic needs intersect with European expertise and industrial capacity. We call these points of intersection "centres of gravity" and a major part of ICT research in Europe should be centred around them.

The vision of ICT as a constitutive technology shaping solutions to major societal problems presents many new challenges in ICT research. In addition to work at the network and systems levels and on embedded technologies, there will be a substantial emphasis on application-drivers, services, content and experiences. Indeed, while a number of application-drivers can and should be considered as generic, in many cases the local environment and changing laws and social systems will require a continuous adaptation of these applications. This will constitute a major challenge for application development in terms of timing, flexibility, adaptability, productivity, and reliability.

4.4.1 Omni-present Communication and Applications

Innovation at the boundaries of future networks

The ability to communicate and to become context-aware will be an inherent feature of virtually all future systems. All sorts of systems are being inter-networked, plus communication capabilities are being added to everyday objects and devices which will be able to communicate amongst themselves. The present internet, designed originally with totally different objectives, will have to evolve to meet these more exacting requirements.

Innovation will be concentrated around the edge of these networks. There are substantial opportunities for value creation on the boundaries between the communications network and other application fields (e.g. in health, environment, entertainment, etc).

Although it has not been a pioneer of the internet, Europe with its strength in telecommunications services and network supply can be a leader in defining future network evolution. Specifically, to exploit the new communication paradigms, Europe should:

- *Develop application layers and service enablers* that make use of the underlying infrastructure. Key aspects include network management, security, billing, context-rich search, etc. Approaches also need to be found for reliability and quality-of-service which strike the right balance between cost and benefit.
- *Focus a major effort on integration,* aiming to bring together technologies and related services to tackle societal needs. The emphasis is on innovation and value creation.
- *Tackle privacy and security,* which are emerging as major issues for the massively inter-networked world and require new solutions.

Business models will be essential to the success of future applications and services and should be a key focus of attention. Fertile areas are likely to include: gaming, music/video, P2P communication with legal safeguards, plus context-aware and location-based services. Self-organising wireless applications, as we might expect in next generation mobile networks, would have huge advantages but would also circumvent the business models of current network operators.

4.4.2 Embedded Intelligence

Embedded intelligent systems present key challenges

Embedded intelligence is becoming a feature of many ICT systems and applications. It will be the basis for innovation in all future products and services, while the emergence of massive networked intelligence, acting more and more independently from human intervention, will add new levels of system complexity. The reliability, transparency and adaptability of such intelligent systems present key challenges.

Further research should allow Europe to consolidate its leadership position in embedded intelligence in a number of key industrial sectors. In particular, European experience in building large networks and systems should be an opportunity to build a leading position in systems applied to our pressing societal needs. Specific priorities here should include:

1) *Systems integration:* Progress requires a massive effort on the integration of processors, software, sensors, etc, into systems, together with a continuing

effort on new component technologies. Low power (mW applications) and ultra-low power (µW applications) are key requirements.

2) *System architectures:* The way we build, distribute and network intelligence should be a continuous subject of research in itself. Many of the requirements mentioned previously can only be met if we basically rethink architectures. The ability to control complex systems by using self-configuring and semantic network concepts, as well as context-aware mechanisms, has to be developed and consolidated.

3) *Boundaries with other fields:* For the longer term, major challenges for intelligence are also to be found in the overlap between ICT and research in bio-/nano-/cogno- systems.

4.4.3 Networked, User-friendly Systems

Exploit the hotspots from digital convergence

Although many systems will become "full function", communications with and between humans remains a major challenge in a lot of cases. As systems (terminals, applications, interfaces, etc) become more intelligent and capable, making them user-friendly is more than ever a priority. This is essential not only in communications and entertainment, but also in other areas like transportation, manufacturing, healthcare and education.

Major opportunities are opening up in consumer systems markets as convergence leads product and market segments to overlap and converge. These intersections are innovation hotspots. Areas of most interest to Europe are those that play to our established strengths in telecoms and network services.

Europe should aim to develop these next generation consumer markets. This could be achieved by concentrating efforts on the boundaries between devices, networking and communications, following a systems approach. Personal and home-environments and networks will be key areas. In addition, there are major opportunities in specialist and societal applications (e.g. health, automotive, etc.) as products from these sectors start to permeate mainstream consumer markets. Satellite navigation and personal "well-being" monitors are early examples of this. The advent of wireless creates the opportunity to create completely new types of consumer devices.

Prescriptions for future success here are:

- *Think ICT; think convergence*: Overcome conventional notions to develop new product and service concepts for consumer and professional applications.
- *Move quicker on standards and regulations*: Standards and regulation are essential to systems interoperability, and hence to user take-up. Europe should target standards through R&D efforts; embrace open standards and interfaces; and move faster in the regulatory arena.

4.4.4 Rich Content and Experiences

Capitalising on rich-content and related services

Content is essential to realising the potential of converged networks and services. But the content explosion brings new challenges both in terms of scale (e.g. search & retrieval, etc within massive datasets) and depth (rich-content interaction and experiences). Furthermore, ICT accounts for an increasingly important part of the

content value chain, as more and more of the added value is created in the transformation of the creative idea into some form of virtual reality.

Europe has to take advantage of the paradigm shift brought by broadband networks to put Europe on the map in terms of digital media. It has major technology assets here: a strong broadband infrastructure, leadership in mobile communications, and a good position in broadcast-multicast convergence are all key building blocks through which to capitalise on the potential of rich-content and related services.

These building blocks need to be integrated into innovative, high-value solutions and applications. In addition, research efforts should focus on:

- *Innovative service creation and delivery tools* which exploit the possibilities of the all-IP infrastructure (including the long-tail of personalised content and services);
- *New service concepts and business models* which leverage the power of the digital networks (e.g. micro-payments, DRM, business models for P2P services), transforming telecom networks into the most efficient window for content delivery;
- *New approaches to knowledge discovery and interaction* which lead to new paradigms of media usage (e.g. richer experiences, collaborative systems).
- *New multimedia search & classification tools* for friendly content retrieval.

4.4.5 Software and Services

Playing to Europe's strengths in software & services

Software and services has become a strategic capability, underpinning virtually every field of ICT and innovation in many industrial sectors. It will become even more important in the future, as we move towards intelligent ambient environments.

A competitive European software & service industry reinforces Europe's strengths in many other industrial sectors, and hence it is essential that Europe stays at the forefront of this strategic technology.

Europe has a significant position only in certain segments of the software field. Building a position in these other segments will be difficult, but the increasing importance of managed services, embedded software/intelligence and the growth of open source are all factors that play to Europe's strengths.

The rising complexity of systems and networks and requirements for higher dependability and reliability will necessitate new methodologies for software development and testing. Leadership positions will more and more be built on the capacity to pioneer in this field.

4.4.6 Next Generation Components

Major challenges remain in components

Silicon technologies are expected to continue their progress in terms of performance and density and will remain the basis of systems and networks for the foreseeable future. Nanoelectronics will address further scaling, new materials and new device concepts to further push miniaturization, improve performance and lower costs/function ("More Moore"). At the same time it will also add functionality to the systems by combining different forms of logic, interaction and sensor capabilities with the outside world ("More than Moore"). Indeed, components are becoming ever more

complex as they converge with developments in photonics, nanotechnology and, ultimately, biotechnology.

In addition, more integrated value chains, distinct but inter-linked application segments (W, mW, µW), and the need for new process and system design technologies for nano-scale systems all present challenges for Europe's semiconductor industry.

It is essential for Europe to remain at the forefront of this next generation of components technology covering both the "More Moore" and the "More than Moore" challenges simultaneously. To achieve further success in this field Europe should:

- *Exploit skilled researchers and system designers:* Europe should build on its strong position in both process technology and design technologies and direct these towards a range of high-growth applications. It should exploit both mWatt applications (mobile phones, PDAs, etc) and also the emerging micro-Watt applications (sensors, RFID, etc). It should focus on markets where European industry can play an important and sustained role and where the most talented professionals can be attracted.
- *Maintain control of the whole value chain:* Concentrate on generating knowledge-intensive added value from inside Europe. In particular, this requires merging hardware and software capabilities in areas that will create reconfigurable platforms for services, content and experiences.
- *Exploit "technology aware design":* At the process level, the prospect of the end of "fabless design" represents a major challenge for the semiconductor industry worldwide. Europe has the opportunity to take the lead here in the new processes needed to master nano-scale systems (sub 45nm).

4.5 Essential Horizontal Issues

4.5.1 Standards and Interoperability – towards homogeneous markets

Fragmentation remains a barrier to growth in European ICT markets

As noted in the recent report by the Aho Group[10], one of the main barriers to innovation in Europe is that the European market is still too fragmented. Although major steps have been taken in European integration (elimination of tariff barriers, the Euro, etc) firms still face many barriers in operating effectively at European scale.

This is a major obstacle to the growth of new European companies, particularly in areas related to societal needs. In fields like health, transportation, and security, the Member States continue to define solutions with "a national-only approach", and therefore create an extremely fragmented market even for 21st century technologies. This situation contrasts markedly not only with Europe's traditional competitors, the US and Japan, but also its new competitors like China and India, where companies work in large, homogeneous markets.

Standards are essential in overcoming fragmentation

Standards are an essential feature of the market landscape and will be important in enabling Europe to overcome this handicap. This is particularly the case in the fast moving world of ICT where worldwide leadership positions (nearly monopoly positions) have been built by the early introduction of "*de facto*" industrial standards.

[10] *Creating an Innovative Europe:* Report of the Independent Expert Group on R&D and Innovation appointed following the Hampton Court Summit, January 2006. See: http://europa.eu.int/invest-in-research/

At the same time, experience shows that Europe has been most successful in building industrial leadership in areas where European companies have created or made major contributions to ICT standards (GSM, ADSL, DVB, MPEG)

For global leadership in tomorrow's ICT markets Europe must have leadership in standards as well. Standards must be a priority in the co-operative research at the European level. At the same time Europe must improve the functioning of its standardisation bodies and create a new political determination to reinforce Europe's position in global standardisation.

We must ensure that research outcomes are aligned to and well represented in European and international standards bodies. We must move quickly to ensure the standards adoption cycle is as short as possible. And we should foster openness in the standardisation environment, so to enable open tailored business models whilst avoiding consumer lock-ins.

The pace of technological change and aggressive market strategies are threatening the traditional standards-making process. Developments such as software re-configurability, borderless networks, and the increasing complexity of service value chains challenge the conventional views of standardisation.

Europe has a tendency to procrastinate on standardisation issues, for instance over HDTV, and licensing for WiMax and mobile spectrum. This uncertainty is not conductive to innovation and hinders Europe's manufacturers and research community.

4.5.2 The Regulatory Environment

A joined up approach: research, regulation and policy

It is clear that the regulatory environment can be both a stimulant and a roadblock for the introduction of new technologies and systems. At present, major regulatory and legal reviews are necessary in Europe - at both the Community and Member State levels - to remove roadblocks to the deployment of ICT and avoid creating new ones.

The merger between the network world and the content world poses major questions in areas such as: access to networks, access to content, digital rights management, electronic payment, loop unbundling, privacy and security, cyber-crime, etc. Health is governed by laws and regulations dating from a time when digital imaging did not play any role in diagnosis. The field of e-learning is confronting an education system based on a social model of the mid 20th century. And so on.

It is imperative that initiatives are taken at the European level to set guidelines for removing these roadblocks, reflecting the fact that technology is outpacing our regulatory systems. The EU regulatory framework should better anticipate the pace and scale of technology evolution, so as not to hold back the innovations emerging from ICT research. Regulation and policy should also provide greater scope for research and innovation around new business models.

4.6 Conclusion

ISTAG believes that if Europe's future is not to be one of managing decline then it must rebuild its economy and society to meet the challenges of the 21st century.

Only by enthusiastically embracing the constitutive effects of ICT in all areas of our economy and society will Europe and Europeans achieve their true potential. Only ICT can deliver productivity increases across all economic sectors; only ICT allows us to find radically new solutions to Europe's major societal problems; and only ICT enables citizens and businesses to unlock creativity and innovation.

We must grasp the opportunities ICT presents us to shape the answers to Europe's specific needs and to remain one of the world's most competitive regions. A renewed effort in research and innovation in ICT is essential to this task.

The future is ours to shape; Europe must rise to the challenge.

ISTAG_060313 15/03/06 07:21 Page 3

LEGAL NOTICE

By the Commission of the European Communities, Information Society and Media DG.

Neither the European Commission nor any person acting on its behalf is responsible for the use which might be made of the information contained in the present publication. The European Commission is not responsible for the external web sites referred to in the present publication.

The views expressed in this publication are those of the authors and do not necessarily reflect the official European Commission's view on the subject.