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ICT Research
The policy perspective

ICT and telecoms
Seamless communication strategies

European Commission
Information Society and Media

This brochure has been produced for the Information Society Policy Link (ISPL) by the ICT Results editorial service. ISPL is an important part of the Information Society and Media Directorate-General's goal to draw clear lines between policy, policy-making and European research in the field of information and communications technology (ICT).

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ICT Results is an online editorial service established on behalf of the Information Society and Media Directorate-General.

The service's main aim is to:
- raise the visibility of ICT-funded research results
- support projects' access to markets and encourage uptake of innovations
- raise awareness of European ICT programmes and activities

ICT Results website: http://cordis.europa.eu/ictresults

Crucial connections

In this report produced for the publication series ICT Research: The policy perspective, we examine how information and communications technology, or ICT, is at the heart of Europe's global leadership in telecommunications.

Digital communications networks are the bedrock of modern European society and industrial development. We expect access to information and entertainment, seamless contact with friends, family and colleagues, and we usually get it any time and anywhere.

Wireless technologies, broadband internet connectivity and satellite systems have transformed Europe into one of the best-connected regions of the world – and a breeding ground for advanced systems and services.

In recent years, Europe has witnessed a rapid roll out of broadband internet and, according to OECD figures in 2007, the top five countries worldwide in terms of broadband subscriptions per 100 inhabitants are European (Denmark, the Netherlands, Switzerland, Britain and France).

Subscriptions to mobile phone networks, meanwhile, now average more than one per citizen in Europe, yet annual growth remains healthy. In economic terms, the telecoms sector is one of Europe's most important, with annual turnover of around €290 billion, representing around 4% of the jobs in the Union.

Europe undeniably dominates the telecoms sector and is a world leader at exploiting the technology for innovative business models, improving competitive advantage and raising the quality of life for its citizens.

Yet none of this would have been possible without pan-European legislation and regulation. Liberalisation in the telecoms sector in the EU, launched in the mid-1980s, has brought significant benefits for consumers. The price of telecoms services has fallen, on average, by around 30% in the past decade. Moreover, the introduction of competition has raised standards of service all round, making former monopolies much more respondent to the needs of consumers.

However, there is still work to be done, especially as the rapid advances in ICT now make the regulatory framework adopted in 2002 outdated. In particular, pan-European services are still uncommon, as the internal market remains fragmented. This fragmentation is hindering effective cross-border consolidation, often blocking or delaying the entry of new competitors to the market.

Unbundling policy loop for telecoms

The i2010 initiative, the EU policy framework for the information society and media, describes its vision for a Single European Information Space, offering "affordable and secure high-bandwidth communications, rich and diverse content and digital services."

An important step towards this goal was made in November 2007 when the European Commission agreed proposals to reform the European telecoms market. The changes aim to strengthen consumer rights; give consumers more choice by reinforcing competition between telecoms operators; promote investment into new communication infrastructures, in particular by freeing radio spectrum for wireless broadband services; and make communication networks more reliable and more secure, especially against viruses and other cyber-attacks.

A report by the i2010 High Level Group foresees three features of this single European telecoms market of 500 million consumers. First, the mobile device will take over and be the primary communication gateway for accessing broadcast TV, browsing the Web or playing music.

Second, people will shift to a "syncing" culture where they download content to various devices at high-speed access points. This change in behaviour could radically alter typical broadcasting and advertising models. Thirdly, homes and offices will become more connected, with their own networks and connections to intelligent appliances with embedded microprocessing power or radio frequency identification tags (RFID).

This "connected future" of pervasive ICT relies on major convergence between different telecoms and ICT networks and technologies. The proposed changes to the EU telecoms rules should provide an enabling regulatory framework to smooth the road to multi-channel and multi-national convergence. In particular, the new rules aim to create market conditions in which telecoms operators – incumbents and new entrants – can compete fairly.

Competition drives investment, innovation and, thereby, greater uptake of innovative services to enhance Europe's knowledge-based society and improve citizens' quality of life.

The second pillar of i2010 – to strengthen innovation and investment in ICT research – is an essential complement to the creation of a Single European Information Space as companies try to grow their customer base with novel applications and improvements in their level of service.

Europe's innovation in telecoms stems from significant investment in research and development (R&D). The Seventh Research Framework Programme (FP7), with a budget of over €9 billion for ICT R&D projects, is the largest publicly-funded programme for telecoms research.

Telecoms issues cut across all of the seven ICT challenges outlined in the FP7 ICT Work Programme. A wide variety of projects will, therefore, look to solve problems of network convergence and interoperability, wireless technology evolution, the management of radio frequency spectrum, and miniaturisation of telecoms components and microelectronics.

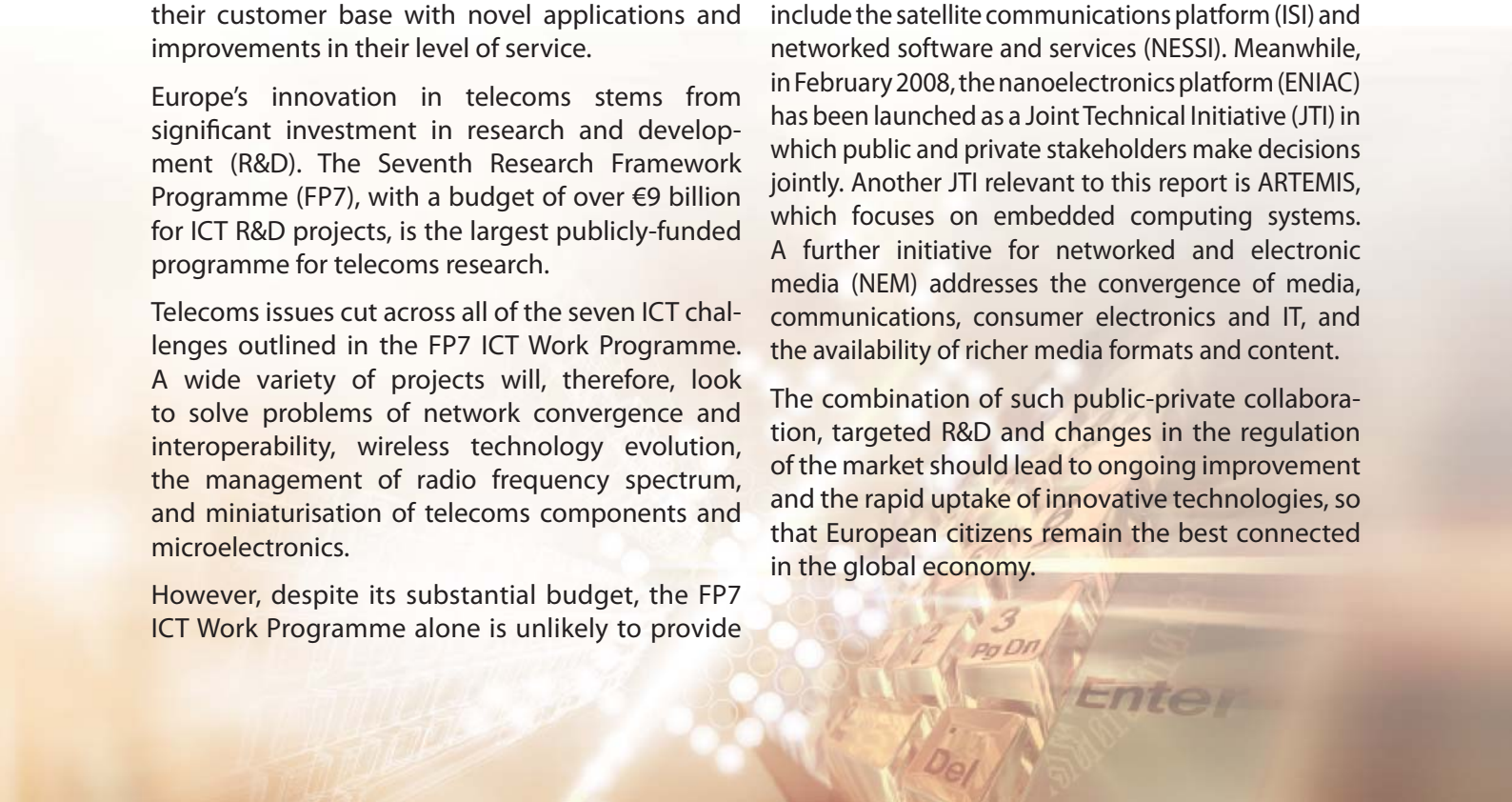
However, despite its substantial budget, the FP7 ICT Work Programme alone is unlikely to provide Europe with sufficient technological innovation to maintain its lead in global telecommunications. Private funding for telecoms research is absolutely critical. The i2010 initiative also supports a number of European Technology Platforms (ETPs) to encourage private investment in ICT and telecoms R&D.

ETPs bring together representatives from industry, research organisations and national or regional bodies to explore how to coordinate their research and tailor it to a common "strategic research agenda" (SRA). The SRA sets out R&D goals, time frames and action plans for technological advances, mobilising a critical mass of national and European public and private resources.

The eMobility ETP, for example, aims to "reinforce Europe's leadership in mobile and wireless communications and services, and to master the future development of this technology, so that it best serves Europe's citizens and the European economy." It advocates a user-focused approach to research so that European telecoms operators develop products and services that consumers demand rather than exploring technically advanced white elephants.

Other ETPs of note in relation to telecommunications include the satellite communications platform (ISI) and networked software and services (NESSI). Meanwhile, in February 2008, the nanoelectronics platform (ENIAC) has been launched as a Joint Technical Initiative (JTI) in which public and private stakeholders make decisions jointly. Another JTI relevant to this report is ARTEMIS, which focuses on embedded computing systems. A further initiative for networked and electronic media (NEM) addresses the convergence of media, communications, consumer electronics and IT, and the availability of richer media formats and content.

The combination of such public-private collaboration, targeted R&D and changes in the regulation of the market should lead to ongoing improvement and the rapid uptake of innovative technologies, so that European citizens remain the best connected in the global economy.



Meeting the challenges

Traditionally, telecommunications have taken place over dedicated and distinct networks. Fixed, copper landlines have been used for carrying voice calls, and more recently dial-up and broadband internet access. Mobile phones have offered wireless connectivity for voice call and text messages. Televisions have received broadcast content principally via cable, satellite and radio frequency transmission.

But all this is changing. ICT is blurring the boundaries between these different networks. Indeed, the internet has become the network architecture of choice and almost every telephone call, text message, satellite broadcast, or TV programme will have travelled the internet at some point in its journey between sender and receiver.

Telecommunications is not a distinct market sector, but just one aspect of converged ICT networking that is increasingly important as ICT becomes pervasive in society. European research must work at delivering "a converged communication and service infrastructure…" the European Commission states. This is one of the most important challenges that European industry must overcome to retain its leadership in ICT over the next decade.

Other challenges that have been identified by the various European Technology Platforms in their published strategic research agendas, and subsequently incorporated into the FP7 ICT Work Programme 2007-2008, include the development of more complex systems and components, new radio technology for wireless systems (including RFID applications), the efficient and coordinated management of the radio spectrum, and the development of industry standards.

Communication systems

The telecommunications of tomorrow depend on the development of new devices, networks and architecture. Converged telecoms will, for example, require mobile devices that can receive broadcast TV or terminals capable of sending data to, as well as receiving it from, satellites.

"The challenge is to deliver the next generation of ubiquitous and converged network and service infrastructures for communication, computing and media," notes the ICT Work Programme, including overcoming the scalability, flexibility, dependability and security bottlenecks.

Radio frequencies: adaptive technologies and spectrum management

As the wireless network expands, the growth in mobile digital services will place increasing pressure on the radio frequency spectrum – a limited resource. European R&D must develop innovative approaches and new standards that optimise how networks and devices use radio frequency. The spectrum must be managed well and shared fairly between operators and technologies.

Research in this area must look at industry standards and new techniques that can "squeeze" more and more data into the airwaves

Miniaturised components

Microelectronics are at the heart of telecommunications systems. Convergence requires components to become smaller, less power hungry and cheaper to manufacture. Systems today and in the future must deliver the kinds of services and functionality that consumers and businesses demand, but at a competitive price.

Many EU-funded projects are trying to pack ever-more power into microchips. Researchers are developing new microelectronic design and fabrication technologies, along with entirely new approaches to electronics. Advances in optoelectronics, for example, will make use of light as a medium for faster, more power-efficient data transfer, whilst the development of nanoelectronics will allow the electronics industry to continue its unrelenting quest for miniaturisation.

Radio frequency identification

Radio frequency identification (RFID) has been around for a few years, but as radio transmission chips get cheaper and smaller, the wider application of RFID becomes possible. Europe has been at the forefront of developments in first-generation RFID for tracking applications in a number of industry sectors. EU research and work on the development of industry standards in this area will continue to drive growth in this market.

RFID could soon be embedded in everyday items, with opportunities for improved security, "smart thinking" between household goods and the beginning of "the internet of things" connecting items without any human interaction.

All systems go for mobile services

Consumers and business are demanding wireless services that use increasingly more bandwidth. Even the most advanced third-generation (3G) technologies are struggling to cope with the load on the network. A large number of EU-funded research projects are developing systems to keep Europe at the forefront of innovative mobile telecoms and services.

The mobile phone is a ubiquitous device in Europe – almost everyone has at least one. And the "I-can-contact-you-wherever-you-are" culture is changing dramatically how we conduct ourselves in business, at home and on the move. More than ever, we expect information or entertainment on demand, delivered fast into the palm of our hand.

Consumers and businesses, now relying on wireless technology, continue to demand innovative communications systems and services. The telecoms operators, content providers and regulatory bodies increasingly are working together to keep Europe well ahead of the game and ensure that subscribers will get the levels of service and functionality they expect.

Much of Europe's current dominance in telecommunications stems from the significant public and private investment that has been ploughed into developing innovative systems and services.

More than a decade of R&D is paying dividends today.

The i2010 initiative recognises how important it is to maintain high levels of investment for R&D into communication systems. This is documented in published strategic research agendas (SRA) of several European Technology Platforms (ETP) – groupings of companies, research organisations and other public and private bodies.

The eMobility ETP states in its SRA that, by 2020: "mobile and wireless communications will play a central role in all aspects of European citizens' lives, not just telephony, and will be a major influence on [the] European economy, wirelessly enabling every conceivable business endeavour and personal lifestyle."

Communications systems at a glance

We now rely on wireless telecommunications to conduct business and organise our social lives. But as demand for mobile services continues to grow – putting strain on existing technologies – new ICT will enable Europe to move its networks "beyond 3G".

The document says that improvements in our quality of life can be achieved "through the availability of an environment for instant provision and access to meaningful, multi-sensory information and content."

Wireless devices will be central to how we access information and entertainment in the future. Wherever we are, we will "expect to connect". Challenge 1 of the FP7 ICT Work Programme identifies the importance of mobile communications calls for more research into pervasive and trusted network and service infrastructures. In particular, it recognises that converged telecommunications will depend on interoperable networks and adaptive devices.

Almost 30% of the 2007-2008 FP7 ICT budget will be invested in this challenge. Projects will look to develop extremely high-capacity and fully flexible networks that can be adapted for and adopted by many business models.

It is here that we will see the evolution of the internet and innovations in its architecture and underlying technologies overcome some of the current usage limitations, not least by providing affordable, high-speed, wireless access to remote communities.

Along with developments in hardware and architecture, other research projects will explore novel services and how they are delivered. In particular, it is believed that mobile TV will soon become popular, but this will dramatically change the current model of "push" broadcasting. Users will expect personalised and interactive media delivery along with the possibility of greater collaboration between "end-users" and "producers".

Projects in action

MobiLife
SPICE
Ambient Networks
MAESTRO
INSTINCT
MOCCA

We already expect to text, make calls, receive email and surf the Web on our mobile phones. And soon we will be able to access many more mobile services, such as mobile TV and location-based services.

FP7 and industrial R&D, along with the latest European telecoms regulatory reforms will create better conditions for operators and service providers to provide creative wireless applications. But what do people want?

The EU-funded **MobiLife** project has shown how recent advances in wireless technologies – using 3G systems and beyond – could be developed into services to support people's everyday lives. Taking a user-centric R&D approach, MobiLife matched innovative applications and services with enabling technologies and service components and frameworks. Extensive user and industry evaluations made sure the services were fit for purpose, and that the main hurdles between service development and deployment were removed.

The project's main results have been collated in a recently published 'MobiLife Book' which outlines such basics as how to define service architecture/infrastructure with interoperable, user-centred components in mind; the importance of context awareness, privacy and trust; personalisation; and the sort of services needed to support all this.

MobiLife is part of the **Wireless World Initiative** (WWI) a set of five coordinated research projects looking at the technologies needed for communications systems beyond the 3G era. The projects span the entire communications "stack" from future wireless air interfaces, through ambient networking, adaptive radio systems, service provisioning frameworks, and distributed application architecture. The initiative represents the collaborative work of over 100 organisations from Europe, North America, Asia and Australia, more than 700 researchers and in excess of €80 million of investment thus far.

Another WWI project, **SPICE**, has looked at ways to thread together the vast array of existing and mobile platforms, for example GPRS and 3G, in such a way as to provide users with a homogenous and seamless experience in the post-3G era of mobile technology. The SPICE partners prototyped middleware systems which help different platforms to communicate and work with one another. They also created intelligent service enablers which manage user profiles and context information to proactively and invisibly adapt their service network connections.

The **Ambient Networks** project, meanwhile, focuses on how mobile devices switch between different networks and wireless technologies. Your mobile phone, bluetooth headset and laptop effectively make up your personal area network (PAN). The Ambient Networks project is looking at how a PAN could switch automatically from a pay-for GPRS network and "merge" with a free wireless hotspot, for instance. The partners want to establish an open framework for network control functionality, which can be extended with new capabilities as well as operating over existing connectivity infrastructures.

Mobile technologies can be combined with satellite systems to deliver interactive digital services to

mobile users. Launched in January 2004, **MAESTRO** set out to use Satellite Digital Multimedia Broadcasting (S-DMB) technology to provide mobile broadcast services, such as mobile TV and video service delivery, to 3G handsets with minimum cost impact on 3G handset terminals. The satellite component is designed to reuse current 3G technology, thereby minimising the development of new products and technologies.

Mobile TV is receiving a lot of attention in the EU's telecoms reforms programme, and research projects are looking at how to make sure consumers get the pictures they want on the move. DVB-SH is a standard, partly developed and tested by the MAESTRO project, that is able to deliver IP-based media content and data to handheld terminals via satellite or terrestrial transmission. A single satellite could provide cost-effective mobile TV coverage to the whole of Europe, urban and rural.

Further, the EU's **INSTINCT** project has validated the related DVB-H standard. This standard is intended to support digital transmission of multimedia content for handheld devices. To reduce the amount of power required to receive the content, DVB-H uses time slicing, which requires the handheld device to be ready to receive data only during certain time intervals. It also optimises the use of broadband bandwidth by devices. INSTINCT has conducted trials on small-scale DVB-H services and attracted interest from some of Europe's largest mobile operators, hardware manufacturers and content providers.

Europe is working hard to minimise the wireless divide between itself and the developing world. Mobile services can help developing countries leap ahead in technology. The **MOCCA** project is addressing challenges and requirements related to the usage, technology, regulations and policies of wireless technologies in emerging markets, especially those which face shortages – or a complete lack – of electricity.

More information

MobiLife: www.ist-mobilife.org/

SPICE: www.ist-spice.org/

Ambient Networks: www.ambient-networks.org/

MAESTRO (fact sheet on CORDIS): http://cordis.europa.eu/fetch?ACTION=D&CALLER=PROJ_IST&QM_EP_RCN_A=71246

INSTINCT: www.ist-instinct.org/

MOCCA: http://mocca.objectweb.org/

Wireless World Initiative (WWI): www.wireless-world-initiative.org

FP7 ICT Work Programme: http://cordis.europa.eu/fp7/ict/

i2010: http://ec.europa.eu/information_society/eeurope/i2010/

ICT and telecoms stories on ICT Results: http://cordis.europa.eu/ictresults/ (enter search terms 'telecommunications', 'Telecoms and regulations' and 'spectrum management')

A spectrum of opportunity

The rising demand for wireless connectivity is placing immense pressure on the management of the radio frequency spectrum. By 2012, the switchover to digital TV should release frequencies for new wireless technologies. Europe is driving the development of adaptive hardware and intelligent spectrum management systems so that precious bandwidth is optimally used.

In the wireless world of today, we move through an invisible sea of radio signals. Every wireless device – mobile phone, PDA, bluetooth headphones – connects to other devices and networks using radio frequency signals.

The radio frequency spectrum is a precious resource and, as more telecommunication systems use wireless technologies, the pressure on the spectrum will become intense. It is essential that the spectrum is managed fairly so that incumbent network operators and new entrants will be able to offer new mobile products and services and openly compete.

The development of radio spectrum policy in the Community is currently based on the Radio Spectrum Decision 676/2002/EC. However, rapid expansion of wireless services means that reforms in the way the spectrum is regulated have become essential.

The most important move in the EU to free up valuable bandwidth is the switch from analogue to digital broadcasting. This switchover, due to be completed by 2012, will allow some of the most valuable bandwidth, previously reserved for traditional TV, to be used much more efficiently and innovatively for other services.

Apart from the benefits of digital TV itself, other exciting new opportunities include the greater possibility of wireless access to broadband communications and mobile multimedia services, including mobile TV.

Adaptive radio and spectrum sharing and management at a glance

A combination of smart ICT and regulatory reforms will allow Europe to effectively and fairly manage the use of the radio frequency spectrum.

However, only an EU coordinated approach will unlock its full and rich potential. Airwaves do not stop at national borders, so 27 national systems for one resource cannot work. Consequently, investment in new wireless technologies is now mostly conducted at a European or global scale.

The telecoms reform package would expect Member States to set aside airwaves for EU-wide services and share spectrum on an EU-wide basis by clustering similar types of services into common spectrum zones. Clustering would also help to tackle possible interference between the main networks that support the services.

However, alongside such regulatory reforms, the wireless technologies themselves have an important part to play. They must evolve and become smarter in how they receive and make radio transmissions. For example, wireless devices could switch between networks depending on their location and bandwidth demands. New microelectronics could improve data transfer rates or intelligently manage the connection "up-time" for mobile devices.

The FP7 ICT Work Programme 2007-2008 summarises this critical research objective succinctly: the network of the future must support "flexible and spectrum-efficient radio access enabling ubiquitous access to broadband mobile services for short-range to wide-area networking."

Projects in action

E2R
PLUTO
EVEREST
AROMA
PULSERS
WINNER

Wireless communication beyond 3G will offer an unprecedented variety of innovative services. However, incompatible equipment, networks and configurations might inconvenience mobile users who want to access many different services. To solve this, European researchers are looking at "reconfigurability".

The **End-to-End Reconfigurability (E2R)** project aims to develop technology that provides users with seamless communication across heterogeneous wireless networks and environments, while allowing networks to deploy and provide services faster and at lower cost. "We are working to build bridges between technologies, so users can roam freely between services and environments they want to access, anywhere, anytime," says Didier Bourse of Motorola, the project manager. "Reconfigurable systems will allow users of wireless communications to access differently configured services, for example using GPRS, IEEE.11, IEEE.16; WiFi, WiMax, GSM or 3G, without changing telephones or configurations."

With E2R technology, networks will be able to reconfigure equipment without changing infrastructure, making it possible to lessen the cost of hardware and deployment over a longer lifetime. "The consortium is working to optimise networks' use of resources through advanced radio resource and flexible spectrum management. For example, they could move GSM or UMTS access to another frequency band, to improve efficiency, a goal that could take 10 to 15 years to achieve," says Bourse.

Of course, new technology has to appeal to consumers to be viable. "So, for example, you could use the same telephone to simultaneously talk and browse the internet," says Bourse.

In a typical broadcast transmission, radio signals bounce off objects in the environment, reaching the receiver over multiple paths. Distortion from 'multi-path' signals can produce fading, resulting in temporary failure of reception. This distortion could seriously compromise connectivity to modern wireless broadband networks. Researchers in the **PLUTO** project have shown that splitting the transmit power of a signal between multiple antennas can provide substantially more effective coverage than using a single antenna.

The transmission-splitting technique particularly improves reception in indoor and urban environments and could help mobile networks save on costs by using fewer transmitters and less power. "This technique does not require revision of any WiMAX, DVB or DAB standards," says Maurice Bard of UK company Broadreach Systems, the technical leader of PLUTO. "The great advantage is that it can be exploited by existing in-service receivers without modification. All you need is an additional box that can split the signal."

With so much data traffic whizzing through the airwaves, it is important to manage how the spectrum radio frequencies are used. The **EVEREST** project developed and tested advanced algorithms to provide mobile operators with enhanced Radio Resource Management (RRM) techniques aimed at reducing the risk of communications bottlenecks. EVEREST's approach addressed heterogeneous networks, in particular, where operators can allocate traffic to different generations of communications systems (from GSM and GPRS to UMTS and, eventually, beyond 3G systems), as well as Wireless Local Area Networks (WLANs) depending on the types of services being used.

"Clients who only want to make a phone call can be switched over to GSM, thereby keeping UMTS bandwidth free for people who are holding a video conference, while automatic handover to

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high-bandwidth WLANs in a building cuts pressure on other networks," says project coordinator Fernando Casadevall. "This balancing of resources is essential as more and more applications with different bandwidth needs are run over mobile devices."

A follow-up project, **AROMA**, is building on EVEREST's success to provide tangible resource management for all-IP heterogeneous wireless systems for the 2010-2015 time frame.

Ultra Wide Band (UWB) is another way of providing high-speed, high-bandwidth connectivity within the limited radio frequencies available. Using very-short-duration pulses (down to nanoseconds or picoseconds) UWB can deliver data rates of up to 1 gigabit over short distances. It uses little power and can operate in the same bands as existing communications without producing significant interference. The implications and potential applications are enormous, and the market could become a multi-billion euro business by 2010.

The partners of the **PULSERS** project see UWB as nothing less than a new commercial communications technology. The project's work runs from basic science through regulation to definition of scenarios for final consumer products. Obvious markets are Personal Area Networks (PAN) linking one person's devices together and local area networks (LAN), or wireless connectivity between devices in a room. Besides wireless short-range communications, UWB technology also enables precise real-time location tracking.

Partners in the **WINNER** project are developing what project coordinator Werner Mohr describes as "a totally new concept in radio access". They are investigating advanced radio technologies based on predictions of user requirement throughput, latency and spectral efficiency.

"We are developing a system to provide wireless access for a wide range of services and applications across all environments, from short range to wide area," Mohr explains. "A single adaptive system concept for all radio environments will provide significant improvements in peak data rate, mobile speed, spectrum efficiency, coverage, cost per bit and supported environments, taking into account quality of service requirements." Recently completed, WINNER II has produced a detailed systems definition for a radio interface that supports the challenging requirements of systems beyond 3G. The system is scalable in terms of carrier bandwidth and frequency range, and allows deployment in newly identified and 're-farmed' frequency bands.

More information

E2R: http://e2r.motlabs.com/

PLUTO: http://dea.brunel.ac.uk/pluto/ (formerly www.ist-pluto.org/)

EVEREST: www.everest-ist.upc.es/

AROMA: www.aroma-ist.upc.edu/

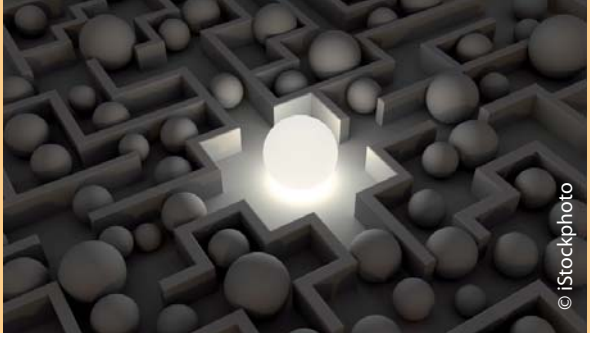
PULSERS: www.pulsers.net/

WINNER: www.ist-winner.org/

FP7 ICT Work Programme: http://cordis.europa.eu/fp7/ict/

i2010: http://ec.europa.eu/information_society/eeurope/i2010/

ICT and telecoms stories on ICT Results: http://cordis.europa.eu/ictresults/ (enter search terms 'telecommunications', 'Telecoms and regulations' and 'spectrum management')



Microchips go 'nano'

Electronics are heading for the nanoscale thanks to new fabrication techniques for silicon-based integrated circuits. Europe is poised to break into this strange new world and take full advantage of the many benefits of miniaturisation.

We like to think of mobile telecoms as a modern phenomenon. Yet the feasibility of wireless communications using radio frequency signals was first demonstrated over a century ago.

But there is a simple reason why mobile phones only caught on in the last decade or so: miniaturisation. Without microelectronics and the miniaturisation of transmission technology a "mobile" phone might require a 10m antenna and a small generator.

Nevertheless, with their lightweight, pocket-sized phones and PDAs, consumers are demanding increasingly interactive services, more device functionality, and on-demand content such as mobile TV. These resource-hungry applications make the ongoing quest for miniaturised components evermore important. Devices must do more, without any increase in weight or size.

Europe has long played an important role in chip design and manufacturing, pushing the boundaries of fabrication techniques and packing more and more transistors onto a silicon wafer. But to stay ahead of global competition in the telecoms sector, Europe must maintain this innovative edge.

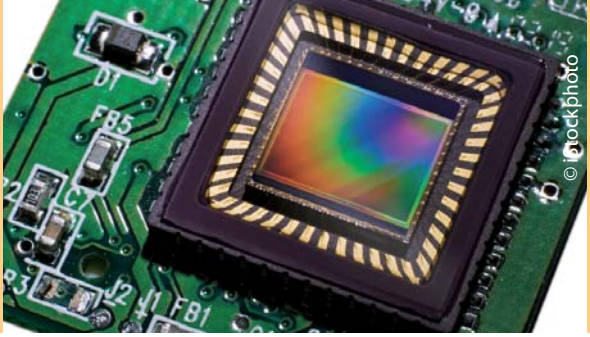
The EU's framework funding instruments, such as FP6 and FP7, play an important role in pushing the boundaries of component design and manufacturing, not least by funding projects that explore the burgeoning fields of nanoelectronics and photonics. This R&D strategy fully supports the International Technology Roadmap for Semiconductors (ITRS) and the strategic research agendas drawn up by several European technology platforms.

Accordingly, the ICT Work Programme 2007-2008 states that "industry [is] at the centre of a number of projects that will target R&D into new manufacturing technologies, chip design technologies and the integration of different materials and microtechnologies into packaged, microscale systems. The Joint Technology Initiative ENIAC, with an estimated budget of €3 billion, will target the next level of miniaturisation required to cross the threshold from micro- to nanoelectronics, as more and more functions are integrated into simple commercial products."

With such significant public and private investment, Europe is in a good position to fully embrace the economic and innovation potential of nanoelectronics. Mobile telecommunications could be one of the first areas of application; you could soon be carrying nanochips around in your pocket.

Chip miniaturisation at a glance

Smaller microelectronic components mean that future mobile devices should offer more functionality and "smart connectivity" without getting bigger or heavier. Innovative manufacturing is shrinking electronics down to the nanoscale.



Projects in action

NanoCMOS
Pullnano
PICCO
PICMOS
WADIMOS
GAWAIN

Over the last four decades, computer chips have found their way into virtually every electronic device in the world. During that time, they have become smaller, cheaper and more powerful, but European researchers believe there is plenty of scope for still more miniaturisation. The chips in most products in use today have features with dimensions of just 65nm. That may be small, but in the competitive semiconductor industry, where size is of high importance, it is not small enough.

A reduction in minimum feature size means more transistors per chip, more transistors means more computing power, and more power means electronic systems – mobile phones, PCs, satellites – will gain in functionality and performance. "The semiconductor industry is in the business of selling square millimetres of silicon. So, by cramming more transistors into a chip you're delivering more capacity, more functionality and more computing power for the same price," notes Gilles Thomas, the director of R&D Cooperative Programs at STMicroelectronics in Crolles, France, Europe's largest semiconductor supplier.

Over the last three and a half years, STMicroelectronics has coordinated two large EU-funded projects to push back the limits of miniaturisation in the semiconductor industry. The **NanoCMOS** initiative, which concluded in June 2006, developed the technology to create a 45nm generation of chips, which could be in consumers' hands by 2009. A follow-up project, called **Pullnano**, is currently working on developing nodes as small as 32nm and even 22nm.

At the 32nm scale, in particular, quantum mechanical effects enter the picture. One major problem Pullnano's researchers have solved is reducing current leakage at the logic gate by using a hafnium compound-based insulator with higher dielectric strength than traditional silicon dioxide. "We've achieved a 100-fold reduction in gate leakage," Thomas says, noting that it is the first time the oxide – the 'O' in CMOS – has been replaced with a different material.

Another important advance in nanoelectronics could be the incorporation of photonics – in simple terms, using light instead of electricity – into electronic components. The work of the **PICCO** project has provided evidence that functional photonic circuits can be created using state-of-the-art, deep UV lithography. This technology is at the very forefront of wafer-scale processing, and appears to be a promising approach for high-volume device production. The development has moved photonic crystals from a previous position as scientific curiosities to being serious contenders in the future manufacture of microphotonic circuitry.

"We've established a design process for deep UV lithography that enables us to produce photonic crystals on an eight inch CMOS line," says project coordinator Thomas Krauss of St Andrews University. "To date, all photonics manufacturing has been done using e-beam lithography – we can now produce photonic circuits using deep UV lithography on an eight inch wafer (just like a vinyl disk) in one shot!"

According to Krauss, the results of PICCO are a significant contributor to maintaining European research at the forefront of this field, as microphotonics will play a key role in the telecoms backbone in the longer term. Japanese research in the field predicts that circuits with 10,000 components will be deployed inside the next ten years; photonic circuitry is the only means of achieving this goal.

The **PICMOS** project is also helping to usher in the age of microphotonics. The project partners developed a method to etch indium-phosphate lasers with a diameter of just 7µm, sufficiently small enough to integrate several thousand onto

a 2cm x 2cm silicon chip. This is the first time that such compact lasers have been produced in a very practical, cost-efficient way.

But the biggest breakthrough in the project was the development of a bonding technology that joins the silicon and iridium-phosphate materials together. The bonding process effectively 'glues' silicon-based wave guides and semiconducting indium-phosphate in layers. It is possible to etch out the microlasers and the wave guides and produce an optical interconnecting layer on a microchip which could prevent bottlenecks in data transfer between different areas of a chip.

The production cost of the prototype optical interconnect layer is still too high for mass production, although the results from the demonstrator 'chip' have been extremely encouraging. A follow-up project, **WADIMOS**, will continue to drive the PICMOS platform towards commercialisation.

Satellite navigation or 'satnav' systems are a mobile technology enjoying growing popularity, especially as unit prices have dropped rapidly. The global market is already estimated to be worth some €8 billion. Now the partners in the **GAWAIN** project hope to prompt further growth by combining satnav and 3G telephony facilities within one device. They hope to combine the world's two most important global positioning systems, Europe's Galileo and the American GPS, within a 3G mobile telephone on a single chip.

"An integrated chip like this reduces the components a manufacturer needs to use, and reduces power consumption. It will make it very attractive for handset manufacturers to include navigation as standard with their mobile phones," notes Günter Heinrichs, coordinator of the GAWAIN project. "Combining European and US satnav systems will also double the availability of navigation, and should help combat problems like urban canyons where one satellite system might not reach."

This is the first time a UMTS (Universal Mobile Telephone Services) receiver has been combined with Galileo/GPS. The advent of such an integrated chip could finally unlock the future potential for location-based services (LBS). Once the functionality is installed within a large number of devices, it could facilitate the growth of such services for the mass market, simply because the additional cost of entry for users will not be as high and providers will have a ready market based on devices that are easily upgradeable.

GAWAIN has explored some intriguing LBS applications. For example, in smart transport the devices could be used to tell commuters when the next bus will arrive at a particular stop. Such a service could make using the bus much more competitive with train travel, helping to popularise bus transport.

More information

NanoCMOS: www.nanocmos-eu.com/

Pullnano: www.pullnano.eu/

PICCO: www.intec.rug.ac.be/picco

PICMOS: http://picmos.intec.ugent.be/

WADIMOS: www.photonics.intec.ugent.be/projects.asp?ID=144

GAWAIN: www.gawain-receivers.com/

FP7 ICT Work Programme: http://cordis.europa.eu/fp7/ict/

i2010: http://ec.europa.eu/information_society/eeurope/i2010/

ICT and telecoms stories on ICT Results: http://cordis.europa.eu/ictresults/ (enter search terms 'telecommunications', 'Telecoms and regulations' and 'spectrum management')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A radio frequency fingerprint

Chip miniaturisation and the mass production of radio transmission microelectronics has opened the door to a technology that could soon change how we pay our train fares, track goods in transit or obtain security clearance. Radio frequency identification is becoming an affordable option for many industrial purposes, and could soon appear in mass market applications, too.

Radio frequency identity (RFID) tags are small chips that send out relatively weak, localised radio frequency "fingerprint" signals. They are generally used to identify people or products within a specific area or as they pass a specific checkpoint. RFID is commonly used by logistics or large-scale warehousing operators, in swipe-free security passes and modern central locking systems on cars.

But these kinds of applications are just the beginning. As manufacturers embed advanced RFID chips into products, objects will have the potential to connect with each other, interact and respond intelligently to other items around them.

This widespread item-level tagging of products is likely to progress as costs go down and standards for RFID signals are defined. Technical problems, such as reader accuracy and interference from external sources, must also be overcome. Nevertheless, even if not imminent the "internet of things" – a network of objects interacting independently from any human input – is likely to develop in the next decade.

Around 600 million RFID tags were sold in 2005 alone, and the value of the market, including hardware, systems and services, is expected to be multiplied by 10 between 2006 and 2016. The number of tags delivered in ten years will be over 450 times the quantity delivered at present.

The European Commission has conducted wide-ranging public debate on the opportunities and challenges posed by Radio Frequency Identification technology for government, industry and society at large. RFID is of policy concern because of its potential to become a new motor of growth and jobs, and thus a powerful contributor to the Lisbon Strategy, if the barriers to innovation can be overcome. With wider use, it becomes essential that the implementation of RFID takes place under a legal framework that affords citizens effective safeguards for fundamental values, health, data protection and privacy.

According to a Commission communication (COM(2007)96 final): "The policy issues raised by RFID are generally seen as including standards, intellectual property rights and associated licensing regimes. Citizens are concerned about the openness and neutrality of the databases that will register the unique identifiers that lie at the heart of the RFID system, and the storage and handling of the collected data, including its use by third parties."

Thus, the EU is monitoring the development and deployment of RFID technologies and is expected to formulate specific policy as the technology becomes more commonplace.

In the meantime, the technology is an active area of R&D. No less that four of the ICT Challenges covered in the 2007-2008 ICT Work Programme of FP7 mention RFID applications (in healthcare, intelligent vehicle and mobility systems, micro- and nanosystems, organic electronics, and future networks, for example large-area networking scenarios). The eMobility ETP also has RFID technologies and applications within its scope.

RFID at a glance

Many logistics and warehousing operators already use radio frequency identification, or RFID, systems. European research could help to bring this short-distance wireless telecommunication technology to a wider audience.

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Projects in action

CoBIs
WINGS
TENUTA
POLYAPPLY
PROMISE
Cold-Trace

The IST-funded **CoBIs** project is going a step beyond the passive smart tags used to identify goods, pets and even people. Collaborative Business Items (CoBIs), containing smart RFID chips, can shift a substantial part of business processes from resource-intensive back-end systems to those embedded in the products themselves. With sensors, wireless communication and computing components attached, the goods or equipment become "intelligent" – chemical drums will warn operators when the storage limit in a warehouse is reached, if a leak occurs or if one is placed in the wrong location.

"What we are doing is making sensor network technology useful to businesses by creating a system that responds to the need for real-time information. It allows goods to act and react automatically to changes at the local level, and warn operators of the change," CoBIs coordinator Stephan Haller at SAP Research in Germany explains. The petrochemical industry is a likely early adopter.

Another European research collaboration has come up with what it calls an "intelligent choice in sea crossing". Using accurate marine weather forecasts and "now-casts", as well as customised route optimisation, shipmasters can make vital routing decisions which ensure safer, more efficient maritime transport with improvements in fuel saving, transit management and navigation.

The **WINGS** service uses satellite link-ups between on- and offshore data providers/receivers to provide critical decision-support to shipping companies and authorities. The software and system make dynamic computations using ship- and sea-area models which optimise onboard decision-making while taking into consideration all the necessary parameters, including the probability of seasickness, pitch and roll, wave height, wind and pressure.

To smooth WINGS' path from prototype to market conditions, the service has undergone some modifications, taking into account lessons learned from its predecessor – the WINGS-FOR-SHIPS project – and trial data in the current project. This has basically meant simplifying and reducing the cost of the IT architecture in order to have a more commercially viable system with an easy-to-use interface. WINGS' user interface was also put through its paces by partners from the eTEN project **TENUTA** which assesses usability and accessibility. Apart from some suggestions for minor improvements, the results were very positive.

The extension of RFID applications depends considerably on reductions in the cost of RFID chip manufacturing. The small UK firm Plastic Logic is working with partners on the €23 million **POLYAPPLY** project to develop manufacturing technologies for the production of printed plastic electronic circuits. The company utilises a low-temperature process – which avoids the need for vacuum deposition or mask alignment – to fabricate low-cost, large-area, high-resolution transistor arrays on plastic substrates. These kinds of circuits could have important applications in RFID, for example in a new generation of low-cost "thinking" devices that interact with their environment and communicate with people, perhaps to tell you when food has perished or stop you taking the wrong medicine.

Next time you contemplate the bill after collecting your car from its annual service you might wonder, was it really necessary to replace all those spark plugs? Surely that air filter would have lasted

another year? And why did they replace the wiper blades when the old ones seemed to be working perfectly well?

One novel RFID, anticipated by the **PROMISE** project, is a PEID, or "product-embedded information device". This electronic package gathers information about the state of the components in a product and the environment it operates in. It can help to optimise preventative maintenance and get the most out of vehicle parts. The project led to the publication of specifications and standards to ensure that PEIDs collect data and analyse it in a standard way.

The benefits go wider than maintenance, though. By returning information about the performance of a product to the manufacturer, the system can help designers to improve later versions of the product. Another benefit comes when the product is finally scrapped. Evidence from a PROMISE system can be used to evaluate the state of various components to decide whether some, such as a starter motor or an alternator, have sufficient life left in them to be immediately reused as spares, to be sent for refurbishment or remanufacturing, or broken down for recycling.

An innovative RFID system that allows transport managers to track the status of their haulage fleet at all times has recently been implemented by three European companies, thanks to the **Cold-Trace** project co-funded under the European eTEN programme for market validation. The technology was originally developed under the two-year IST project **ColdRoad.**

In addition to tracking the movements of vehicles, the Cold-Trace system also monitors temperatures inside the trailers, to ensure that produce reaches its destination in the optimum condition. "It may seem surprising, but although systems to monitor the temperature inside trucks and GPS systems to track their location have long been on the market, there has been no integrated solution combining those applications with work-order management," explains Yolanda Ursa, the manager of the Cold-Trace project at INMARK in Spain.

Where, in the past, fleet managers have relied on calling drivers to find out where they are or to check if a pick-up or drop-off went okay, the Cold-Trace system gives them the information for the whole fleet on a PC screen. A 'black box' in each truck is connected to a server in the fleet manager's office via a GPRS connection, while each driver has a standard PDA. GPS location data and information from sensors placed around the vehicle are all fed into the black box, and from there fed back to fleet headquarters.

If any temperature increase above set parameters is detected, an alarm sounds, alerting both the driver (who receives the information on his PDA) and the fleet manager. A remote-control system even allows the fleet manager or driver to set refrigeration levels in the truck remotely. "That feature alone saves the driver half an hour every morning, which is the time it takes on average to cool off a truck before it can be loaded," says Ursa.

More information

CoBIs: www.cobis-online.de/

WINGS: www.wingseten.mettle.org/

TENUTA: www.etenuta.org/us_projects.php

POLYAPPLY: www.polyapply.org/

PROMISE: www.promise-plm.com/

Cold-Trace: www.cold-trace.com/

FP7 ICT Work Programme: http://cordis.europa.eu/fp7/ict/

i2010: http://ec.europa.eu/information_society/eeurope/i2010/

Read about RFID policy: http://ec.europa.eu/information_society/policy/rfid/doc/rfid_en.pdf

ICT and telecoms stories on ICT Results: http://cordis.europa.eu/ictresults/ (enter search terms 'telecommunications', 'Telecoms and regulations' and 'spectrum management')

What's inside?

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Information Society and Media: Linking European Policies

Further information:

FP7 ICT Work Programme
http://cordis.europa.eu/fp7/ict/

Information Society Policy Link initiative:
http://ec.europa.eu/information_society/activities/policy_link

Europe's Information Society: Thematic Portal
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