COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 20.4.2009
COM(2009) 184 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Moving the ICT frontiers – a strategy for research on future and emerging technologies in Europe

TABLE OF CONTENTS

1. CONTEXT AND OBJECTIVES

In line with the objectives of the Commission's European Economic Recovery Plan[1], this Communication proposes bolstering Europe's competitiveness and the innovation ecosystem in the long term by means of greater investment in higher risk research in the strategically important area of information and communication technologies (ICT).

It emphasises the success and strategic importance of research on Future and Emerging Technologies (FET[2]) in laying the foundations for future ICT and sowing the seeds for innovation[3]. *A longer-term strategy and specific actions to be implemented under the 7th Framework Programme (FP7) are outlined to enable Europe to take the lead* in FET research by strengthening its European and global dimension. They complement and reinforce the action outlined in the Commission Communication on the strategy for ICT R&D and Innovation in Europe[4], in particular on raising investment in research, prioritising efforts and reducing fragmentation. The findings of the 2006 Aho Report on R&D and Innovation[5] regarding the role of leading-edge science in attracting world-class industry and the need for centres of excellence to build up a critical mass of activity in strategic areas are also addressed.

The Commission is issuing this Communication at a time when the world economy is in turmoil. Especially when prevailing paradigms show their limitations, investment in new foundations is needed to put Europe in a strong position in innovation in future.

2. FET RESEARCH IS ESSENTIAL FOR FOSTERING EXCELLENCE AND SEEDING INNOVATION

2.1. The FET scheme, a pathfinder to radically new information technologies

Since European FET research was launched in 1989, it has served as a *pathfinder* for identifying and shaping radically new information technologies. With a present funding of around € 100 million a year, it supports scientists and engineers venturing into uncharted areas beyond the frontiers of traditional ICT by fostering *multidisciplinary research* collaboration at the highest level around novel research ideas and themes. This research radically transforms ICT research agendas and fosters major technological, industrial and societal innovations in Europe. It produces new practices that change the way research is conducted.

Understanding and harnessing self-organisation and evolution of social and biological systems, for example, opens the way to develop novel capabilities for the next-generation software and network technologies. Understanding how the human brain works is not only leading to innovations in medicine but also providing new paradigms for low-power, fault-tolerant and adaptive computing technologies.

---

1 COM(2008) 800: A European Economic Recovery Plan.
2 Refers to FET in ICT.
3 As specified in the ISTAG Report on FET, November 2008.
4 COM(2009)116: A Strategy for ICT R&D and Innovation in Europe: Raising the Game.
5 http://ec.europa.eu/invest-in-research/action/2006_ahogroup_en.htm.

The European FET research scheme is unique in the way it *combines* the following characteristics:

– *Foundational.* It lays new foundations for future ICT by exploring new unconventional ideas and scientific paradigms that are too long-term or risky for industrial research.

– *Transformative.* It is driven by ideas that challenge and can radically change our understanding of the scientific concepts behind existing information technologies.

– *High-risk.* But it balances these risks against high potential returns and the chance of revolutionary breakthroughs.

– *Purpose-driven.* It aims to make an impact on future industrial ICT research agendas.

– *Multidisciplinary.* It builds on synergies and cross-fertilisation between different disciplines such as biology, chemistry, nano-, neuro- and cognitive science, ethology, social science or economics.

– *Collaborative.* It rallies the best teams in Europe and increasingly worldwide to collaborate on common research topics.

FET is implemented by means of *thematic research* in emerging areas (FET Pro-active) and open, unconstrained *exploration of novel ideas* (FET Open).

2.2. The FET scheme, fostering excellence and seeding innovation in ICT in Europe

The FET scheme fosters excellence by means of collaboration combining the best in science and engineering. Global excellence of FET research is confirmed by Nobel prizes and other prestigious awards. FET projects produce 2.5 times more articles and publications than their share of the ICT Programme at the same time as generating an equivalent number of patents[6].

FET projects attract Europe's best brains, including Nobel Prize winners

Theodor Hänsch (DE), along with Albert Fert (FR) and Peter Grünberg (DE), Nobel Prize winners in physics in 2005 and 2007 respectively, have been partners in several FET projects.

FET research seeds innovation. It has an impact on the long-term competitiveness of the European ICT industry by creating entirely new fields of economic activity, new industries and high-tech small and medium-sized enterprises (SMEs).

FET is a forerunner of mainstream and industrial research agendas worldwide and influences the way foundational multidisciplinary research is supported and organised. FET has inspired funding schemes such as the Agence Nationale de la Recherche (ANR) scheme[7] in France or the NEST Adventure and Pathfinder programme[8] and its successor the European Research Council[9]. FET has also supported new forms of multidisciplinary research organisations, e.g. the European Center for Living Technology[10].

---

6 Commission data.
7 www.agence-nationale-recherche.fr/.
8 http://cordis.europa.eu/nest/home.html.
9 http://erc.europa.eu/.
10 http://www.ecltech.org/.

As a result of its path-finding role, the FET scheme has achieved *major successes in identifying and exploring new research areas* that have become established ICT research topics.

For example, FET's support has been crucial for research on *quantum information technologies* in Europe. These technologies hold out promise of immense computing power beyond the capability of any conventional computer, plus 100% secure communications. By investing early in this area, FET was instrumental in making Europe a global leader[11] and has leveraged a 5- to 7-fold investment in Member States. Further expected impacts include novel technologies such as quantum-based clocks and quantum imaging.

FET launched the first European research projects on *information systems inspired by biology and neuroscience.* Biologists, neuroscientists and computer scientists are exploring together how the brain processes information. The impact of this research, extending well beyond ICT, includes novel neural implants for handicapped people, new models of neural systems, new neuromorphic computing systems or robust self-evolving circuits and networks.

Very early in the Esprit Programme[12] FET supported research on *micro-, nano- and optoelectronics, micro-systems and photonics*. Advanced research topics explored in the '90s[13] were widely adopted in the industry-driven ICT research.

100% secure communications

FET research on quantum technologies opened a new path to 100% secure communications taken up by companies such as Siemens, Thales and the high-tech SME idQuantique SA, a leader in this technology.

Moving by force of thought to restore mobility for paralysed people

*The **MAIA project** developed a novel technology based on non-invasive brain/computer interfaces that empowers a handicapped person to use mental commands to drive a wheelchair.*

Mimicking the perfection of the brain

*The **FACETS project** explores and mimics the way the brain processes information for novel low-power, fault-tolerant computing systems.*

Cognitive robot companion

*The **COGNIRON project** developed a companion robot that understands human activity, interacts socially with humans and learns new skills and tasks.*

FET research on *complex systems* has created a new research area and opened up radically new avenues for many sciences. By modelling the behaviour of complex techno-social systems and providing ICT tools to master the emerging threats in such systems (e.g. financial markets or spread of infectious diseases), this research is contributing to better, *science-based policy-making*, alongside entirely new concepts for emotionally intelligent and trustworthy ICT systems.

FET has put *advanced robotics* on the European ICT research agenda. Key research areas have been pioneered in FET at the same time as strategies for service robotics have been mapped out in the European industry. FET has contributed to consolidating the European

[11] Producing 50% of all peer-reviewed publications worldwide in 2007 (www.qurope.net).

[12] http://cordis.europa.eu/esprit/home.html.

[13] This research laid the foundation for the more-than-Moore and post-CMOS era in Europe.

robotics research community and to setting up the European Technology Platform[14] on service robotics.

In addition, FET has pioneered research on novel ideas such as artificial living cells, synthetic biology, chemical communication, collective intelligence or bidirectional brain/machine interfacing.

2.3. Challenges and opportunities for global leadership in FET research

2.3.1. Insufficient investment in Europe in high-risk transformative research in ICT

FET research seeds innovation and is essential for the sustainability of Europe's ICT industry by addressing roadblocks at the frontier of current technologies. These include coping with the "data deluge" and the increasing complexity of global systems, continuing miniaturisation of ICT components beyond the limitations of current technologies and greening ICT. New paradigms must be explored and radical alternatives assessed to prepare the next generation of ICT technologies and to remove these roadblocks.

Europe's leading competitors have acknowledged the importance of foundational research for gaining and maintaining a leading position in ICT. In the US, rebalancing of the Federal Networking and Information Technology R&D Program was recommended in order to include more large-scale, long-term multidisciplinary activities and visionary research with a high potential pay-off[15]. China has included information technology in its basic research programme[16] to meet the nation's major strategic needs.

More than ever in a difficult economic context, European industries' in-house investment is tending to focus on short-term market-driven research priorities rather than high-risk ICT research. This trend must be reversed by higher public and private investment in high-risk research.

[14] http://ec.europa.eu/information_society/tl/research/priv_invest/etp/index_en.htm.

[15] Report from the President's Council of Advisors on Science and Technology, August 2007.

[16] http://www.973.gov.cn/English/Index.aspx.

2.3.2. Tackling societal challenges calls for open exploration of radically new ideas

ICT is widely recognised for its essential role in transforming the economy and society. Societal challenges related to issues such as sustainable development, climate change, health, the ageing population, social and economic inclusion and security require new paradigm-breaking solutions in which ICT plays a key role.

To allow radical transformations to emerge, researchers need to be given the freedom openly to explore novel unconventional ideas and disruptive approaches and to mature the most promising.

Foundational transformative research combined with a new attitude to entrepreneurship will put Europe in a good position to seize new market opportunities fully as they emerge.

2.3.3. Major scientific challenges call for cooperation across disciplines

Europe requires a sustained scientific effort at the boundaries between ICT and other disciplines to address today's socio-economic challenges and gain technologically competitive advantages. Critical mass should be built up and fragmented research efforts must be integrated around science-driven, goal-oriented, large–scale multidisciplinary flagship research initiatives.

The recently launched Virtual Physiological Human (VPH) initiative[17] and the Blue Brain project[18] confirm the relevance of such endeavours. VPH aims at personalised simulation of the human body, promising unprecedented progress in disease prevention and healthcare. It combines efforts across the Framework Programme[19] with global cooperation, in particular with the USA. Blue Brain is the first comprehensive attempt to reverse-engineer the mammalian brain, in order to understand brain function and dysfunction with the aid of detailed simulations.

Europe needs to support flagship initiatives going beyond the scale of present FET activities.

2.3.4. Overcoming fragmentation and developing a joint strategic vision to increase the impact of European research efforts

Foundational ICT research in Europe today remains fragmented in most domains, leading to duplication of effort, diverging priorities and untapped potential. Europe needs to develop joint research agendas based on a shared vision for foundational research and would benefit from applying the FET model in collaboration with Member States.

2.3.5. Shortage of skilled researchers and multidisciplinary expertise in Europe

The shortage of skilled researchers and global competition for high-level multidisciplinary expertise in emerging research areas are hampering Europe's efforts to gain and maintain excellence in ICT research.

---

17 http://www.vph-noe.eu/.

18 http://bluebrain.epfl.ch/.

19 http://cordis.europa.eu/fp7/home_en.html.

Europe must invest more in excellence to attract the world's best researchers and empower talented young researchers to become research leaders. Multidisciplinary research careers and curricula should be given stronger support.

2.3.6. Boosting exploitation of results from foundational research

High-tech, research-intensive SMEs are particularly crucial for driving the exploitation of the results of foundational research. Closer involvement in FET research would put them in a better position to seize emerging business opportunities.

The strategic research agendas of the ICT-related European Technology Platforms and Joint Technology Initiatives[20] would benefit from including industrial needs for longer-term ICT research. Systematic dissemination of FET results to industry would narrow the gap to application.

New forms of collaboration between industry and the research community have to be found to surmount key technology roadblocks and unlock longer-term industrial development potential.

2.3.7. Untapped potential for international cooperation

International participation is an untapped resource for FET. There is clear added value in pooling resources and boosting excellence at global level. Tackling global challenges, such as control of epidemics, the complexity of the financial markets or the fight against climate change, calls for global, multidisciplinary scientific collaboration.

FET research is especially well placed for international collaboration due to its foundational nature and to the global dimension of the scientific challenges it addresses.

3. THE PATH FOR TURNING EUROPE INTO A GLOBAL LEADER IN FET RESEARCH

3.1. Strategy and objectives

To put Europe in the best position to reap the great socio-economic benefits from future developments in ICT, it is essential that Europe adopt a bold strategy to lead exploration and development of the foundations for future and emerging technologies.

To do so, Europe should aim at, by 2015:

– doubling its investment in transformative foundational research on future and emerging technologies;

– identifying and launching two or three bold new FET research flagship initiatives which will drive larger multidisciplinary research community efforts towards foundational breakthroughs at the frontier of ICT;

– implementing three to five joint calls between national and European programmes to support FET research in domains of common interest;

[20] http://ec.europa.eu/information_society/tl/research/priv_invest/jti/index_en.htm.

– implementing initiatives to empower talented young researchers to engage in and lead high-risk multidisciplinary collaborative research efforts;

– implementing initiatives to encourage research-intensive high-tech SMEs to develop and apply the early results from FET research;

Europe should lay the ground for sustaining the critical mass of effort needed to support these initiatives with cooperation across European and Member States' research funding bodies and beyond where relevant. Europe should ensure faster capitalisation and sharing of the scientific knowledge and technology foundations resulting from publicly supported research, and also encourage and support research collaboration with science leaders worldwide.

3.2. Proposed lines of action

3.2.1. Reinforce FET under the ICT theme

Europe should reinforce its support for FET research under the ICT theme as an essential part of the research and innovation system. It should build up a critical mass of resources for pre-defined FET research initiatives (FET Pro-active) with high potential transformative impact. It should also step up its support for high-risk targeted research unconstrained by pre-defined research agendas (FET Open) as a platform for creativity and unconventional research ideas with high potential impact and as an essential source of novel research topics.

The European Commission supports the increase of the FP7 budget for FET research by 20% per year from 2011 to 2013. It invites Member States to match this effort with similar increases.

Europe should stimulate high-risk research, build and structure emerging multidisciplinary FET research communities and explore new forms of multidisciplinary research collaboration going beyond existing organisational structures and models. It should also reinforce its capability for permanent foresight of future research trends in ICT, for engaging the FET research community in building European research roadmaps and for shaping related future research initiatives.[21]

The European Commission, together with national funding agencies, will support action aiming at creating the best conditions for high-risk research to flourish in Europe and setting up a permanent foresight capability. It also invites the research community to develop, more systematically, common European research agendas.

3.2.2. Launch FET flagship initiatives

Europe should prepare ambitious Europe-wide, goal-driven FET flagship initiatives that can combine large, sustained European research efforts on clearly defined foundational challenges, on a scale too large to be addressed by current FET initiatives. They should foster extensive and ambitious European and global collaboration and pool resources going beyond the existing fragmented initiatives and programmes. These

FET flagship initiative: Understanding life seeds future ICT

An FET flagship initiative could model and run large-scale simulations in order to understand the way nature processes information and to apply this knowledge to

[21] Building on methodologies, such as developed under JRC IPTS foresight actions (http://is.jrc.ec.europa.eu)

large-scale initiatives may require cooperation with other FP7 themes and would aim at creating sustainable world-class European centres of excellence and at establishing Europe as leader for driving innovation in promising fields, while also increasing the return on investment in high-risk targeted research.

develop future biocomputers. Such a unique endeavour would attract the best computer scientists, biologists and physicists from Europe and beyond.

The European Commission will collaborate with Member States and the research community to identify and define potential FET flagship initiatives and launch at least two by 2013.

3.2.3. Engage in joint programming and FET ERA initiatives

Europe should coordinate national and EU-level efforts more closely to identify and support shared research priorities emerging from European research roadmaps. This includes the possibility of launching joint initiatives by Member States in domains of common interest where national initiatives exist. They could focus initially on domains such as quantum and neuro-information technologies where European research roadmaps exist and then be gradually extended to other fields. Such coordinated actions would help to overcome the fragmentation of current European research efforts in selected domains and to strengthen European research collaboration.[22]

The European Commission invites Member States to explore opportunities for strengthening collaboration in FET, in particular by harnessing the potential of the ERA-NET/ERA-NET plus initiatives. They should aim at launching three to five joint calls among Member States over the period 2010–2013 in FET domains of common interest.

3.2.4. Increase young researchers' engagement in FET research

The creativity and dynamism of young researchers are essential for challenging current thinking, for laying new foundations for future ICT and for driving the success of such efforts over time. Europe should step up its efforts to attract young researchers, in particular young women, to FET research and to empower them to lead multidisciplinary research collaboration. Europe should promote definition and early take-up of new multidisciplinary scientific and leadership curricula in Member States and in the context of the EIT[23].

[22] COM(2008)468

[23] European Institute of Innovation and Technology.

The European Commission will implement initiatives to intensify participation by young researchers in FET research and to encourage them to take the lead in multidisciplinary research projects. The research community is invited to use, in particular, coordination and support action[24] and Marie Curie fellowships[25] to develop and promote the take-up of new curricula by national and regional education authorities and in the context of the EIT.

3.2.5. Foster faster capitalisation of scientific knowledge and speed up innovation

The research community and the European industry should intensify their dialogue in order better to identify industrial needs and technological bottlenecks requiring foundational research and ensure rapid take-up of early research results in application-oriented research.

The research community and European industry are invited to intensify their cooperation within ICT-related European Technology Platforms. The research community is invited to intensify action to facilitate dissemination of FET results to stakeholders.

Participation by industry in foundational research should be encouraged. In particular, high-tech, research-intensive SMEs should be supported better as they are essential vehicles to turn early research results into industrial success stories.

The European Commission will implement initiatives to support high-tech, research-intensive SMEs to engage in research and drive the exploitation of early results from high-risk multidisciplinary research.

Europe should encourage a scientific culture of free sharing and wide dissemination of multidisciplinary scientific knowledge. It should also encourage novel approaches to collective building of scientific knowledge resulting from research.

FET participates from 2009 in the European Commission's pilot initiative on "Open Access"[26]. The research community is invited to build on initiatives that strengthen its communication, dissemination and knowledge-creation practices.

3.2.6. Facilitate collaboration with global research leaders and attract global talents to Europe

World-class global collaboration is needed if Europe is to address its foundational scientific research challenges. Europe should attract the very best scientists from all over the world to participate in FET research and settle in Europe. It should actively engage in and, where beneficial for Europe, financially support collaboration with the best research teams around the globe.

Europe should develop partnerships with non-European funding agencies in priority areas. It should also encourage and facilitate collaboration between research teams globally as they emerge, taking a bottom-up approach. These initiatives should enhance Europe's excellence in ICT research and its role in driving progress and innovation worldwide.

---

24 ftp://ftp.cordis.europa.eu/pub/fp7/docs/wp/cooperation/ict/c_wp_200901_en.pdf.

25 http://ec.europa.eu/research/fp6/mariecurie-actions/action/fellow_en.html.

26 http://ec.europa.eu/research/science-society/open_access.

The European Commission will engage with non-European funding agencies, e.g. from the USA, China and Russia, to establish mechanisms to support research collaboration and to build alliances to tackle global challenges.

4. CONCLUSIONS

This Communication highlights the Commission's commitment to strengthening FET research in ICT in Europe. It proposes a combination of initiatives involving not only increased investment, but also stronger coordination and collaboration between all stakeholders and new ambitious FET flagship initiatives. Member States are invited to endorse the proposed objectives, targets and strategy and to encourage national and regional authorities, universities and public research organisations and private stakeholders to participate in the preparations for future action.

The aim of the strategy is to attract the best researchers from around the world to Europe, to increase investment by industry and to fuel innovation. Investment in research that underpins future ICT will pay back by boosting Europe's long-term competitiveness.