Evaluating the effectiveness of European ICT R&D and Innovation Systems

1. The policy background: The importance of a well-linked RTD-innovation system.

Europe's continued growth and prosperity requires that we increase its innovation performance, and the contribution of R&D to it. We must ensure that the brightest minds are provided access to new knowledge and resources.

The December 2006 Competitiveness Council highlighted that innovation plays a critically important role in Europe's ability to respond effectively to the challenges and opportunities of the global economy, and that support for innovation is an essential part of the Lisbon Strategy for Growth and Jobs. The Presidency conclusions of the Spring European Council of 2006 recognised the need to invest more in knowledge and innovation, and the need for a comprehensive approach to innovation policy, including support for markets for innovative goods and services and excellence in research in new technologies, including ICT. It recommended that links should be strengthened between research and development, innovation systems and the business environment to improve the effectiveness of the innovation process.

The European Council called for a broad-based innovation strategy for Europe, building on the ideas in the "Aho Report" on Creating an Innovative Europe. The report recognised that the core contribution of the Framework Programme is in fostering linkage. It recommended that with the focus of the European Research Council being on basic research and single academic teams the rest of the Framework Programme should focus on networking and mobilising firms and other research actors.

2. The Research-innovation context in the ICT area.

The economic and business environment for ICT-RTD has changed: Firms are global, with global R&D teams: Direct “supply-side” employment benefits are no longer realised because of globally distributed manufacturing: Wider business and social benefits arise from use of ICT innovations appropriate to local needs, from where-ever it arises, but these depend on the effectiveness of the “RTD-innovation-take-up” system. Recent analyses, notably by the OECD, have stressed that the public returns to users, and of societal benefits, are much greater than the private returns to RTD participants, particularly for investment in network and infrastructure technologies.

The European Union supports Research and technology development in multi-annual EU Framework Programmes – in the 6th Framework Programme (2003-2006), with a total budget

of 3.8B€ for “Information Society Technologies” over 4 years. EU investment therefore runs at about 1 billion Euros per year, compared with 8 billion per year in National public funding, and about 18 billion per year in private-sector investment in the same period. The EU investment therefore represented about 3% of total investment in IST-RTD in Europe, although it has direct leverage onto a further 3-5% because of the “shared-cost” requirements. In the light of the changed global business and innovation environment, a new approach to evaluation of this investment is needed.

To develop new evaluation and impact assessment tools, we need first to understand the processes by which research contributes to innovation and change, in both the economic or social spheres. There can be no credible impact assessment without a credible theory of causality behind it. And since the contribution of research to innovation is central to the European policy debate, theories of innovation are crucial to developing evaluation capabilities: If we don’t know how innovation works, we won’t be able to assess how increased R&D contributes to it.

Innovation theories have in fact developed substantially in recent years. A consensus is emerging – in the OECD and the Commission - that it is now the inter-play of new knowledge and market opportunities in networks of collaboration and partnership that is crucial. Firms don’t innovate in isolation but in interaction with other “actors” (e.g. universities, research institutions, large science and technology based multinationals, high-tech SMEs, standard setting organisations etc.) within a framework of existing institutional rules (laws, norms, technical standards etc.). Innovation requires a combination of scientific, design, engineering and operational knowledge from different sources, which no individual or organization can master. The most efficient way to create knowledge is enable researchers themselves to identify what is needed, to find each other, link up, and share resources. The knowledge-creating process can be facilitated by understanding how this happens.

In such “innovation systems”, the **links** between innovation actors are thus crucial if the systems as a whole are to function effectively and play a part in economic growth and social welfare. The new model of business R&D is a model of open innovation where firms can tap into world-wide talents pools and acquire external technologies through licensing, **collaborative research**, mergers and acquisitions².

Support to collaborative R&D programmes is thus one way of strengthening the linkages between the actors within innovation systems – primarily those involved in conducting R&D, though increasingly many collaborative programmes have also involve potential users and other interested parties. Collaborative programmes can strengthen the knowledge bases of research and innovation actors and enhance the prospects for subsequent exploitation and innovation via the creation of research networks and enhanced links between the actors. The understanding has also been helped by the dramatic maturation of the science of complex networks since 2000. The recognition of the ubiquity of self-organisation, and of “small-world” characteristics and power-law distributions of linkage, has led to new insights into stability and optimum architectures for knowledge sharing.

### 3. New approaches to evaluation of RTD

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² Benchmarks of our innovation future: February 16, 2005; [www.futureofinnovation.org](http://www.futureofinnovation.org)
The "Aho Report" pointed out that present evaluation techniques have a tendency to undervalue the contribution of R&D, making it essential that rigorous and innovative approaches to socio-economic evaluation of research are used to demonstrate both its past and future value. New evaluation methodologies and tools are required, which identify and measure the systemic effects of increased investments in R&D notably in relation to the current policy priorities of innovation, growth and jobs.

A new approach to evaluation of EU RTD has, in fact, been proposed by the European Commission. The Impact assessment and proposal for the 7th Framework programme set new orientations for evaluation: More focus on outputs and impacts; Verifiable objectives and indicators; A higher-quality “evidence-base”; More focus on “systemic” effects, notably in the research-innovation-competitiveness links, and on “knowledge networks”; More attention on the EU “added-value”; Linked ex-ante – ex post evaluations; and adequate resources for an expanded programme of evaluation studies.

The strategy adopted in the DG for the Information Society and Media (DG-INFSO) therefore looks beyond “outputs” to social and economic “impacts”; at the systemic impact rather than project-level outputs; and at the societal benefit, rather than at private return. **The objective has been to develop the evidence/data and the capacity (skills and tools) to carry out a much more complete evaluation of effectiveness and impact of the ICT-RTD actions in the European Innovation system as part of the ex-post evaluation of the 6th FP in 2007-8, and the interim evaluation of the 7th FP in 2008-9.**

### 4. Evaluating the effectiveness of linkages in ICT-RTD and innovation

In 2002, in as part of the SolEUnet project[^3], new tools of data mining and link analysis showed that EU funding for IST-RTD in the 5th Framework Programme, when tied to an obligation for trans-national collaboration, created a much more intensely-linked network of European research collaborations than would otherwise have been the case.[^4] They confirmed that the network of collaborations is a self-organising “small world” network. But it also shows strong clustering, reflecting the strong influence of national research collaborations and of the administrative structures of the funding programme.

These tools showed that the portfolio of RTD themes addressed in the IST programme was strongly linked by common participations.

They also showed that the participating organisations constitute a highly linked network of collaboration.
This network is dominated by a number of key “knowledge hubs”, which ensure both the connectivity between the research constituencies in different member states, and between different technology areas and research disciplines. The “Hubs” are also the “poles of innovation” and the economically strongest players.

In the light of these observations, DG INFSO commissioned a series of evaluative studies to further develop the understanding of: the structuring effects of FP ICT networks; the positioning of them in global ICT research networks (international reach); the linkages between research, innovation and ICT deployment activities and regional systems of innovation.

4.1 Strengthening linkages in the European Research Area in the transition to the 6th Framework Programme

An evaluative study was carried by RAND Europe in 2004 to assess the degree to which research on the Information Society is integrated across ERA, and how this integration changed with the introduction of new funding instruments (IPs and NoEs) in FP6.

The analysis showed that EU funded IST RTD collaboration was more intense in FP6 than in previous Framework Programmes. This was a result of the introduction of Integrated Projects and Networks of Excellence, which brought together all the key RTD players in key areas. The key measure of the "tightness" of linkage – the average distance (number of links) between RTD organisations had been stable at about 3.14 to 3.16 from 1992 to 2002 in the 3rd, 4th and 5th Framework programmes, but was reduced to 2.63 in the 6th Framework programme: A value similar to that for relatively tightly-linked social networks in business (networks of company directors) and the media. The analysis showed that the collaboration network was also more inclusive: almost all (98%) participants in IST research are included in a single connect network.

The analysis also compared the collaboration networks associated with participation in the 6th FP with those associated with normal academic collaboration (co-publications), and with participation in the EUREKA and COST frameworks for European research. It showed that participation in the EU Framework programme was most effective in: connecting universities and businesses; connecting research in different themes and disciplines; and in integrating New Member States, patent holders and SMEs. It showed clearly that the Framework Programme provides an integrating function by drawing together business, universities and SME at the EU-Level.

Because of their multiple participations in many key integrated projects, large companies and research institutes were more dominant in the 6th Framework programme than previously. Large companies were central to most integrated projects and large, internally-networked research institutes (such as the CRNS and Fraunhofer Institute) were central to Networks of excellence. They acted as "gatekeepers" of participation, particularly in relation to SMEs, through their choices of 1st–tier partners. In contrast, SMEs tended to be at the "edges" of the network and were somewhat 'crowded out' of the 6th FP compared with the 5th.

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4.2 *Is EU-RTD well connected to global RTD and innovation networks?*

This evaluation study, carried out by the CESPRI group of Bocconi University in 2005\(^6\), assessed whether and in what domains European research organisations are leading 'knowledge hubs' in global collaboration networks, and how EU-RTD is linked to them. It also assessed what makes leading 'knowledge hubs' effective. The analysis compared the networks of collaboration in the 5\(^{th}\) and 6\(^{th}\) Framework programmes with the global network alliances between companies in the ICT area (INNET database –Thomson Financial) and the network of collaborations associated with cross-organisational patent citations (European Patent Office data).

The two latter networks show that global innovation in the ICT area is dominated by a small number of large companies which act as "hub" organisations\(^7\). Of the top 100 innovation "hub" companies, only 8% are headquartered in Europe – 62% in the US, and 22% in Japan. Nevertheless, the analysis showed that the European Framework programme (in the IST-RTD theme) is effective in attracting more than half of the top 25 global Hubs (over 70% by linkage). These global research and innovation "hub" organisations, whether headquartered in Europe or elsewhere, are also "hubs" in the European research networks, and provide a strong connectivity between the European IST-RTD community and the global innovation processes. They also act as "Gatekeepers" at the crossroads of knowledge flows both within IST RTD networks and global innovation networks, acting as conduits of knowledge flow between them: Participation in Integrated Projects in particular is very effective at connecting European ICT research participants to the rest of the world.


\(^7\) A "hub" being defined as an organisation in the top 2% of the ranking list, which so dominates the network linkage that their removal would fragment the network to such a degree that the largest remaining component would be only 1/3\(^{rd}\) of the size.

Support for IST-RTD at the European level, through the Framework programmes, is small compared with National funding – 1 billion Euros p.a compared with about 8 billion Euros at the national level. **It is therefore important the European RTD networks are strongly linked into National networks.** This linkage is also provided predominantly by the participation of knowledge "hubs" of the National networks in the European network. The list of national research organisations compiled by the World of Learning\(^8\) has been used to examine whether the major National Research Centres involved in IST-related activities are included in IST-RTD projects. The analysis by CESPRI showed that at least one of the top 3 national "hub" organisations participates in the IST-RTD network for eleven (11) of the EU15 Members\(^9\), but for only 2 out of the 10 new Member States (Poland and Slovenia). In addition, the National Contact Points in Member States were requested to list the two most important National Research Centres in their respective countries. With the notable exceptions of the United Kingdom, Ireland, Cyprus and Estonia, the most important national research centres in Member States were found to be involved in the EU IST-RTD network.

Smaller companies also play a major role in developing IST innovations outside the mainstream of iterative development. Particular attention has therefore been given to their participation in the 6th FP. The analysis by CESPRI showed that SMEs participating in IST-RTD are significantly more technologically active (i.e. they patent more) than non-funded SMEs: around 25% of SMEs involved in the IST-RTD projects have at least one patent vs. 5% of the

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\(^8\) [worldoflearning.com](http://worldoflearning.com)

\(^9\) with the exception of Austria, Denmark, Luxemburg, and Ireland.
non-funded SMEs. National Contact Points in Member States also confirmed that SMEs involved in IST-RTD projects are more innovative than non-funded SMEs.

However, only a small fraction (5.4 percent) of European SMEs holding highly cited ICT patents have participated in IST-RTD projects. This fits in with the independent observation that only a small fraction (3.3 percent) of the most dynamic European SMEs have participated in IST-RTD projects. For most innovative SMEs growth perspectives are crucially linked to a short time-to-market introduction of new products and services. These characteristics, together with potential problems in the definition of intellectual property rights vis-à-vis larger organisations, may act to deter effective participation of smaller innovative companies in European research projects. The evaluation suggests that adopting flexible and relatively fast procedures of proposal evaluation, especially in the case of proposals coordinated by SMEs, and revising the rules defining the financial viability of contractors, shifting the emphasis from tangible assets to intellectual and knowledge related assets may consequently be seen as potentially useful policy steps for increasing the rate of participation of innovative SMEs in IST-RTD projects.

4.3 The effectiveness of RTD-innovation linkage in Europe

The evaluations in 2004 and 2005 indicated that the European RTD community is well networked, with good linkage between business, universities and public research institutes. In addition, this research network is an integral part of the broader global RTD and innovation community in the IST area: It is able to feed into, and draw from the wider knowledge creation community in the US and Asia. Nevertheless, Europe continues to benefit less from IST-based innovations in terms of its growth, productivity and employment.

One structural obstacle to wider exploitation of new innovations apparent from these evaluations is the low participation of the most innovative SMEs in the EU Framework Programme. A second structural obstacle may be poor linkage between the new knowledge and the organisations able to exploit it in new innovative business activities at the regional level.

We know that most innovation takes place at the regional level, and that it is very unevenly distributed: The world is "Spiky", both in its economic activity and its innovation activity\(^{11}\).

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\(^{10}\) Companies achieving the highest rates of growth during the period 2001-2004 in the relevant technological domains. In order to select these companies, CESPRI used the list of the Top500 fastest-growing European companies as reported by *Business Week* (October 24, 2005).

\(^{11}\) Richard Florida: "The world is spiky", The Atlantic Monthly, October 2005
Commercial innovation and scientific advance are highly concentrated in a few regions.\textsuperscript{12}

A third evaluation study\textsuperscript{13} was therefore commissioned, again with the CESPRI group of the University of Bocconi, to assess the effectiveness of network collaboration and knowledge transfers between ICT research, deployment and innovation at the regional level, and to identify where and how the links between them could be strengthened.

The evaluation was based on an analysis of the overlaps between the networks of RTD collaboration, those associated with the EU programmes to support the wider deployment and exploitation of IST-based applications (the eTEN and the eContent programmes), and regional innovation networks. Nine regions were selected for in-depth study, reflecting the diversity of regions in the north, centre and south of Europe, and different levels of economic development.

The analysis showed that regional innovation networks are considerably strengthened by links to the EU-ICT research networks. "Hub" and Gatekeeper organisations that link strongly into both regional innovation networks and into the IST-RTD network play a vital role. While regional Universities and research institutes play this central role in linking regional research networks, the most important hubs in the regional deployment and exploitation of innovations are private companies – notably SMEs: SMEs are deeply rooted in their regions and are best able to deploy specific applications and build relationships with

\textsuperscript{12} WIPO: US patent and trademark office 2005
\textsuperscript{13} Networks of Innovation in Information Society Development and Deployment in Europe - http://ec.europa.eu/dgs/information_society/evaluation/studies/s2005_03/index_en.htm)
regional authorities. The key linkage is therefore between SMEs able to exploit innovations at the regional level, and the global ICT knowledge "hubs" which are most easily accessed via the EU Framework programme for RTD.

The analysis showed that while European IST-RTD is highly networked, most regional deployment and innovation networks are not: Most are weakly linked to the RTD network, and they are poorly connected between regions and across the EU. The initial findings have been communicated to regional development organisations – notably through the European Regional Information Society Association which groups about 40 pioneer regions for information society transformation. However, most European regions (200+ of the 254) do not (yet) have IST-RTD or IST-Innovation hubs or gatekeepers, and few have regional support for linkage either at the local-level or into the RTD networks. Over 100 regions have less than 5 participations in EU IST-RTD projects and 50 have none at all. This lends supports to the proposal in the "Aho report" that structural funds should be seen as a key means of supporting research and innovation capacity and in particular for pursuing cohesion. It proposed that Member States increase the commitment of funds for this purpose from the present 5.9%\(^\text{14}\) to the order of 20%.

A further study\(^\text{15}\) is being carried out by ALTEC SA and Edna Pashner Associates. It aims to assess the extent to which EU ICT RTD and deployment results are integrated into regional innovation systems. It will identify where and how the links between ICT-RTD, technology diffusion and systems of innovation can be strengthened at the EU and regional levels; where and how the leverage of EU ICT RTD and deployment initiatives onto Structural Fund activities, co-ordinated public procurement, and private sector RTD can be strengthened.

\(^{14}\) Of the overall envelope of the ERDF and ESF.
\(^{15}\) Effectiveness of IST-RTD Impacts on the EU Innovation System - http://ec.europa.eu/dgs/information_society/evaluation/studies/s2006_03/index_en.htm