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FP6 IST Impact Analysis Study

Final Report

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Summary

This is the report of the Impact Analysis study of IST-funded research under the Sixth European Framework Programme (FP6) on Research and Technological Development (2002 - 2006). It is the final report under the WING Framework Contract for Impact Analysis of the IST (Information Society Technologies) R&D Programme.

The objective of this study is to provide an assessment of the impacts deriving from FP6 IST-funded projects that had finished by the end of 2007. The methodology applied in the study built on the framework used throughout the WING Framework Contract, in order to allow comparison between FP5 and FP6 in relation to key areas of impact and/or fields of research. The WING Methodological Framework required analysis of the impacts against three ‘horizontal’ dimensions: the typology of actions/instruments; the focus of the research funded; the participating stakeholders. We did the study using literature review, database analysis, a questionnaire survey and statistical data analysis, and a set of interviews.

IST-funded research in FP6

In FP6, the IST strategy was to concentrate on visionary, forward-looking research – either longer term than in FP5 or higher risk or a combination of these – with a view to building critical mass. The work would cover core technologies and ‘pull through’ applications for the realisation of the Ambient Intelligence (AmI) vision “anywhere, anytime, any service, for all”. This vision was adopted as a core idea in the IST Programme; it resulted from the work of the IST Advisory Group (ISTAG) – which advises the Commission on the IST Programme – and was based on an extensive scenario planning exercise. At the time, ISTAG comprised 18 people from leading European ICT companies and 11 University and research institute people, largely from the same area, so the vision was strongly shaped by an industrial and forward-looking research view of the challenges and opportunities to be tackled in order to address future markets. There were 23 thematic research areas referred to as Strategic Objectives. Adapting the classification used in the 2006 IST IPPA report to the needs of this study, we grouped these Strategic Objectives according to their key expected impacts into three major categories or Strategic Objective Clusters (SO Clusters): “Applications-led Research”, research in “Established Fields”, and research in “New Opportunities”. The EC funding was fairly evenly distributed over the three Strategic Objective clusters we have defined, though with a slightly higher budget allocated to research in the New Opportunities field.

The European Commission introduced a number of new instruments to the Framework Programme during FP6, in order to help build the scale and closer integration required by the aim of building a European Research Area (ERA). The new instruments of particular importance to this study are the Integrated Projects (IPs) and the Networks of Excellence (NoEs). Together they aimed to reduce the fragmentation of research capacity and capability across Europe. The other instruments were similar to those used in FP5, with only minor changes being made. The traditional collaborative research instrument was renamed Specific Targeted Research Projects (STREP) in FP6.
In this study, we refer to the IPs and STREPs collectively as ‘RTD’ projects. We refer to Specific Support Actions (SSA) Coordination Actions (CA) and Integrated Infrastructure Initiatives (I3s)¹ as ‘Non-RTD’ projects. We analyse Networks of Excellence separately. In line with its strategic objectives, under FP6 the IST Programme focused its resources on the RTD instruments, taking up ~80% of the total budget and accounting for 76% of the total number of projects. FP5 had a similar RTD focus. About half the FP6 funding went to IPs, so IST under FP6 focused on much larger projects than was the case in FP5.

FP6 IST increased participation by the New Member States and countries beyond the European Union compared with the past. The IST Programme met the FP-wide target of 15% participation by SMEs and while the shares of University and research institute participants in the total were driven up by the presence of NoEs, industry accounted for 40% of participations in the RTD instruments. Industrial participation involved a wide range of actors that included many key players.

IST participants, including large firms, largely prioritised knowledge goals over shorter-term commercialisation objectives, though standardisation was also important. Developing products and processes in the short term is more important to SMEs. Participants’ goals are consistent with the shift in the IST Programme towards longer-term technology development than was pursued in FP5. The IST Programme enabled participants to broaden and deepen mid- to long-term R&D in complex areas of high technology that were core to their activities and therefore likely to be successful.

**Overall impacts**

Research under the first Calls of FP6 effectively enhanced European competitiveness in R&D across all the Strategic Objectives of IST, reducing fragmentation and increasing the interoperability of technologies. It built the foundations for global industrial competitiveness, but the longer-term research focus meant that the economic impact will tend to occur in the longer term.

Impacts on R&D competitiveness were strong in S&T fields that lie at the root of many current – and future - innovations in ICT, notably Communication & Network Technologies, Software, Middle-ware & Distributed Systems, Computing Architectures & Embedded Systems, and Information & Content Management Technologies. They were also particularly marked in fields where innovation is based upon the integration of knowledge from different disciplines, such as Intelligent Interfaces and Bioinformatics. Industrial R&D capabilities were sustained and reinforced especially in S&T fields that are critical for innovation in the era of digital convergence. The strongest impacts on both knowledge and market development were in fields where Europe could build on its traditional strengths, such as semantics and knowledge management technologies, embedded and distributed software.

¹ The highly limited number of I3 projects that concluded their activities by the end of 2007 did not allow for an analysis reached by these instruments in the framework of this study.
Projects under the first calls of FP6 IST had significant impacts on the competitiveness of industry sectors that are vital for the diffusion of innovation in both the public and private sectors, notably the Telecom Equipment & Networks and Telecom Services sectors. They particularly strengthened the competitiveness of the Software & IT Services industry, both in terms of standards and market development. Projects also strongly influenced the development of standards in the field of Telecommunications Networks, reinforcing Europe’s strong position in global markets. Other sectors with strong impact include service providers in the public field and industry sectors active in the Converged Communications market.

The IST Programme strategy relies on the idea that R&D projects will strengthen the capabilities of the research and industrial sectors, leading to better products/services from more competitive European suppliers, which in turn will generate the social benefits foreseen in the Ambient Intelligence Vision.

Impacts on industrial R&D capabilities were reached especially in the field of Software, Middleware & Distributed Systems and Information & Content Management Technologies. Both these Pillars are fundamental for the achievement of a user-friendly information society and an improved access to information and knowledge. The relatively important progress in the field of Technologies for Trust & Dependability responds to the need ISTAG identified for the social acceptance of the Ambient Intelligence technologies, i.e. the improvement of the dependability of technologies, infrastructures and applications. The relevance of these S&T achievements for the enhancement of the competitiveness of market actors in both the private and public sectors leads to – potential – high-level benefits for the European citizen in the social sphere, especially in terms of enhanced access to information and knowledge and an improved social welfare.

**Programme achievements leading to innovation**

**Building technology capital**

IST research funded in FP6 created at least three kinds of technology capital crucial to European competitiveness. As in earlier FPs, it helped build the stock of research tools and longer-term knowledge in EU R&D teams needed to move complex technologies towards development and the market. It generated formal and informal intellectual property of competitive importance. Research under the first calls of FP6 IST also made contributions to the development of – formal and de facto – standards, especially in those areas where these developments are of critical importance for interoperability or to strengthen Europe’s position on the global market. And it generated influential European positions in the global standards-creation process, again building competitive advantage.

**Enhancing human capital**

The IST Programme helped participants further develop their R&D skills, attain critical mass, strategically re-orientate their work – sometime through the adoption of new technological and process paradigms – and agree road maps that defined how industry would overcome technical barriers in developing new product generations.
IST participation provided important benefits in the form of technological and market intelligence. Crucially, it built the long-term strategic relationships needed to compete where products, markets and supply chains are converging and therefore companies have to access large new skill sets. The IST had a major effect on building the **social capital** in the form of networks needed by companies and research organisations alike.

Spillovers should be key impacts of state programmes, so that not only the direct beneficiaries but also society as a whole gets benefits. The IST Programme has created large spillovers in the form of: published knowledge (information); demonstration effects where IST knowledge spreads by imitation; mobility of researchers who take knowledge with them to new organisations and strengthen networks; and by influencing the education and training system so that others obtain the benefits of knowledge from the IST Programme in the course of their training.

The IST Programme was particularly efficient also in terms of strengthening the European research system, fostering the communication and on-going collaboration among the various actors in research and setting up infrastructures and common research tools and methodologies. This was especially beneficial to the actors in the Research System (the research-based stakeholders). An indirect confirmation of the high European Added Value of the research conducted in FP6 derives from the particularly high-level impacts on participants located in the New Member States.

**Bridging between research and innovation**

IST projects increase participants’ ability to innovate, in addition to providing new sources of knowledge that increase their knowledge capital. Participants tend to exploit this knowledge in indirect ways. A minority (especially SMEs) makes direct use of outputs in products and processes but the long-term nature of the IST work means this can often take a long time.

IST made a big difference in the life cycle of the majority of SMEs involved, strengthening innovative positions. This was especially the case for those active in the Software & IT services sector. These RTD-intensive SMEs were driven to participate in the Programme by their corporate strategies. Challenged by the turmoil in their markets caused by the software as services model and eager to take advantage of the rise of new business opportunities thanks to the increasing pervasiveness of software in commodities and other products, they used the IST Programme as a window on technological opportunities. Continuous innovation is key for their competitive advantage, as is the breadth of their network for collaborations, both RTD and business ones. They expected the Programme to contribute to their company strategy by acting as a platform for the enhancement of their abilities to enter in markets new to their organisation. And the Programme lived up to close to all of their expectations.

Public Authorities benefited less from the IST Programme than others. Their need for proven solutions tended to make their interests differ from those of their partners, who were more focused on research than innovation within the project itself and who could take greater risks.
Telecoms services are traditionally an area of European strength, but also one that has been battered by changing economic circumstances and that needs support in innovation. The IST Programme has enabled European industry to strongly contribute to standards development, build technology platforms and increase their international competitiveness.

**Key systemic facilitators**

**Innovation based on cross-fertilisation**

The IST Programme provided a way to build the interdisciplinary teams needed to tackle the complex research and development problems that arise in ICT as technologies and markets converge. The involvement of different actors along the supply chain improved understanding of customer and supplier needs and allowed S&T solutions to be validated, improving the quality and the likelihood of market success. Co-opetition, i.e. the possibility for competitors to work together on common problems, whose solution is in the companies' interest (without necessarily changing the balance in competition) and is in the interest of citizens (such as car and road safety), can happen only in the context of a European programme. The IST Programme's ability to attract the leading research groups and industrial practitioners is vital to its success. Some of these organisations are well known, but less familiar names can also be important especially in smaller niches. Unless the best and most influential are involved, it is not attractive to participate.

**The new instruments**

A recent analysis at overall Framework Programme level, as well as our analysis at FP6 ICT level, showed that each of the new FP6 instruments (Integrated Projects and Networks of Excellence) made a distinct contribution towards reinforcing a European Research Area. The IPs organised key companies along the value chain with leading researchers in order to develop and implement common industry-driven visions. The NoEs helped define and reinforce critical mass within Europe's research communities.

Integrated Projects had significant influence on the research strategies of institutes and Universities and substantially increased the size and quality of their industrial networks. In this sense they act as important ‘focusing devices’ – drawing attention to opportunities and problems that can be addressed through research and innovation and influencing the research and innovation activities of the participants. They were also stronger arenas in which to work on standardisation than the STREPs.

The Networks of Excellence were effective in strengthening the research system in Europe. They acted as platforms for knowledge exchange, strengthening research communities and integrating fields of research, creating knowledge and tools enhancing research efficiency, influencing R&D strategies and education, and generating large knowledge spillover effects - both in terms of publications and conference papers and related to the transfer of researchers to institutions in other European countries or to industry.
Our interviewees regarded the various instruments as complementary, responding to different needs in the various stages of RTD. The scope of the projects, and their alignment with the organisations’ needs, were considered the most important criteria for participation in one instrument rather than another. Despite teething troubles when they were new, the new instruments have enriched FP6 by providing a richer repertoire and allowing the Commission to decide which approach was most appropriate in each individual call.

The research priorities
Quantitative and qualitative data pointed to a cross-fertilisation between EU and national research agendas, facilitated by the common vision of the Knowledge Society – and according to some, the Ambient Intelligence framework.

Research conducted in the specific Strategic Objective Clusters was expected to contribute in different ways to the overall achievement of the Programme’s strategic objectives and the impacts actually achieved by the research activities conducted in the first calls of FP6 were in line with these expectations.

An overall view emerging from this study is that the alignment of the Commission research priorities and instruments with participants’ research agendas and industry needs was a major facilitator for impact achievement – and possibly the most relevant one. Companies, Public Authorities, and research organisations who were interviewed all indicated that they participated in the Programme “only when it fits our own goals”, a finding that is confirmed by the large number of organisations in our survey – from all stakeholder groups – that indicated the (very) high strategic importance of the research for their organisation.

Conclusions

Impact
The IST Programme has had substantial impacts across its Strategic Objective themes, producing knowledge capital, human capital and social capital that have supported the competitiveness of the European ICT sector and helped integrate the industrial and research sector R&D communities that underpin it.

The systemic character of the IST Programme
A key element in the success of the IST Programme has been its systemic character, touching upon and integrating many parts of the research and innovation system in an effort to increase overall performance. This systemic character is as important in the design of the Programme as in its implementation. The Programme has been able to be effective because it builds upon a shared, market-focused vision that derives from participants’ own interests and because it empowers them to implement the vision in the detail. Such a virtuous circle is to a degree risky because it contains a potential for lock-in, but properly governed it is very powerful.
1 Introduction

This is the final report of the Impact Analysis study of IST-funded research under the Sixth European Framework Programme (FP6) on Research and Technological Development (2002 - 2006). It is the final report under the WING Framework Contract for Impact Analysis of the IST (Information Society Technologies) R&D Programme.

The objective of this study is to provide an assessment of the impacts deriving from FP6 IST-funded projects that had finished by the end of 2007. In the future it can be complemented by studies covering the full period of FP6.

Most evaluation looks for a simple, linear connection between an intervention, such as the IST Programme, and its impacts on society. In reality, such connections are neither simple nor linear, but lack of time, understanding and data often force evaluators to take the short cut. In this study, we have tried to understand the IST Programme in a more systemic context by focusing on the knowledge/technology users in the innovation system – those who translate technology into social and economic development. Markets and a range of other signalling mechanisms – which not only provide demand for new goods and services but also help define what those new goods and services should be – mediate this translation. The result is not a uniform process of innovation but one where different markets and niches may innovate in different ways – in business models as well as in technology. Describing the complexity involved is a major challenge. We go some way towards doing this in the appendices to this report. In this short overall report the treatment has to be at a higher level, but this report finishes with a discussion of systemic aspects of the IST Programme, in addition to considering the more ‘linear’ impacts.

This report is structured as follows

- This introductory Section 1 sets the background to this study. It discusses the scope of the study, the methodological and conceptual frameworks adopted as well as the characteristics of IST-funded research in FP6 in terms of its strategic objectives, the nature and focus of research conducted, the stakeholders involved and their drivers for participation.
- Section 2 gives a view of the ‘overall’ impacts on innovation reached by research funded in the first calls of FP6. It focuses on impacts achieved on Europe’s RTD and economic competitiveness and considers the key benefits for society deriving from the achievements reached in specific S&T fields and markets.
- Section 3 looks into the achievements of the Programme that underlie the impacts obtained on research and economic development in the Technology Pillars and industry sectors analysed in the previous section. This encompasses achievements in the field of S&T; impacts on human capital in terms of knowledge creation, transfer and integration of research; and the effects of both the S&T achievements and the knowledge and technology generated during the research activities on the economic performance of the participants.
• Section 4 covers the importance and value of the tools for innovation that were set up in FP6 IST. It highlights the importance of collaborative and multidisciplinary research, looks into the role of the new instruments deployed in FP6, and last but not least, considers the role played by the research priorities defined by the Commission

• Section 5 makes some concluding remarks summarising impacts and discussing the systemic character of the IST Programme

1.1 **Scope & Methodological Framework**

This section sets out the scope of the study (Section 1.1.1). Section 1.1.2 then explains the methodological framework and the concrete steps we took to implement it. Section 1.1.3 describes the ‘research and innovation systems’ conceptual framework that underlies our approach.

1.1.1 **Scope of the Study**

The study covered those IST FP6 research projects (both RTD and non-RTD), which were finished by the end of 2007. Based on the Commission FP6 database, 456 projects were in scope, representing some 40% of the total number of projects in FP6 (1,140). They accounted for 35% of the total EC funding in IST under FP6 (1,445 M €; the total funding was 4,103 M €). The timing of this study meant that we were able to include 90% of the projects funded under Call 1 and about 65% on those in Calls 2 and 3. In this context it should be remembered that each Call had its own thematic focus and that there were considerable shifts during the course of FP6.

1.1.2 **The Methodological Framework**

The methodology applied in this study built on the framework used throughout the WING Framework Contract, in order to allow comparison between FP5 and FP6 in relation to key areas of impact and/or fields of research. The main elements of this methodological framework were

• Construction of the objectives hierarchy & expected impacts of the FP6 Programme

• Analysis of the project portfolio and the constituency, including the focus and nature of the research as well as the goals for participation of the various stakeholder groups involved

• Analysis of the scientific and technological and socio-economic landscape during the timeframe of the Programme

• Impact analysis, based on the evidence collected and setting these impacts against objectives, focus of research, actors involved, and context
The WING Methodological Framework required analysis of the impacts against three ‘horizontal’ dimensions

- The typology of actions/instruments, i.e. RTD projects (in FP6 including Integrated Projects – IPs and Specific Targeted Research projects – STREPs); Non-RTD projects (in FP6 including Specific Support Actions – SSAs and Co-ordination Actions – CAs); and the new instrument Networks of Excellence – NoEs

- The focus of the research funded, categorising the various Strategic Objective areas into Strategic Objective Clusters (hereafter referred to as SO Clusters)

- The participating stakeholders, categorised according to their profile and size. Categories included: Higher Education institutions, Research Institutes, Large Enterprises, SMEs, Public Authorities, and Industry/Citizens Associations. During the analysis, these stakeholders were grouped into ‘research-based stakeholders’, ‘industry/business stakeholders’, and ‘other stakeholders’. The industry/business stakeholders were also classified according to their ‘market area of activity’

We did the study using

- Literature review

- Database analysis, focused on improving the base for the statistical data analysis by complementing and validating the information provided in the EC database in relation to the profiles of the participants and their size categories as well as ‘market areas of activity’

- Questionnaire survey, covering 5,851 participations in the Programme and approaching 4,365 ‘single contacts’. Quite a number of people participated in more than one project. In these cases, we sent only a single request for them to complete the survey. We received responses from 26% of those whom we invited to participate in the survey. This corresponds to 20% of all participations in scope. We aimed to get a representative set of responses from each cell within a complex sampling grid, so reaching this response rate involved several campaigns, where we sent out reminders in order to get up to a 20% response rate in all the cells. After a quality check of the returned questionnaires, 1,047 responses were used. The resulting ‘survey sample’ is statistically representative for the constituencies of the ‘universe’ that constituted the scope for this study

- Statistical data analysis

- Interviews conducted with a select group of participants and more high-level experts active in specific S&T fields and industry sectors. In total, we interviewed 41 people
1.1.3 The Innovation System Framework

Over the past twenty-five years or so, there has been a revolution – a ‘paradigm shift’ – in the way we understand the relationship between research, innovation and socio-economic development. Conventional, neo-classical economics viewed firms, in effect, as autonomous and rational robots using perfect information. In the context of technological change, much of the traditional, neo-classical framework has been superseded during the 1990s, through a convergence of evolutionary economics (which stresses firms as ‘learning organisations’) and research on the innovation process.

This new perspective uses the slogan ‘innovation system’ but there is no definitive ‘innovation systems theory’ – rather there is a collection of research results, which together provide a way of understanding behaviour and interdependencies in what we prefer to call a ‘National Research and Innovation System’ (NRIS): namely, all the actors and activities in the economy, which are necessary for industrial and commercial innovation to take place and to lead to economic development.

The current orthodoxy is that economic well-being is founded on a well-functioning NRIS, in which not only the actors shown in Exhibit 1 but also the links between them, perform well. In contrast to earlier views, which focused on either basic researchers or entrepreneurs as individual heroes, innovation and learning are now seen more as network or collective activities.

It follows that we must see an intervention like the IST Programme as a complex social product. It is not that in practice the Commission, ISTAG or anyone else in their wisdom brings down from the mountain tablets of stone on which is engraved the IST Programme Strategy. The strategy is a product of a complex social process, in which industry, researchers and others play important roles, and the beneficiary research and industrial communities largely accept the strategy because they already own it. In some situations, involving beneficiaries in strategy design in this way risks pork barrelling, where individual beneficiary groups succeed in getting their own interests represented. The virtue of the somewhat technocratic ISTAG process through which the AmI strategy was defined, is that it generates a transparency and a coherence of vision that makes it hard for special interest groups to gain undue influence.

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2 This is generally called a National Innovation System in the literature – essentially because the key authors are researchers on questions to do with economic innovation. This is a very unhelpful name, since all three words are misleading. In fact, such systems can be regional and international as well as national. They incorporate the whole of knowledge production and consumption, not just economic innovation. And they are only ‘systems’ in the sense of many things being connected together. They are not systems in the sense that their behaviour can readily be predicted and controlled.
Equally, the implementation of the IST Programme strategy is a complex social process, in which it matters who is involved and how they act.

The NRIS3 approach stresses the idea that firms and other economic actors have ‘bounded rationality.’ This makes knowledge, learning and institutions key to overall economic performance. In the new view, economic actors are no longer autonomous robots, but are deeply interwoven into the economic fabric. The unit of analysis is no longer only the individual firm but also the ‘system’ of networks within which firms operate. National economic performance is explained as the performance of this total system.


A second key idea, which stems from the central role of learning, is that of historical path dependence. What a company or institution can do today depends upon what it could do yesterday⁴ and what it has learnt in the meantime.⁵ Another implication of path dependence is co-evolution among institutions such as funding agencies, which strive to improve their performance within the existing institutional division of labour.

As a result, they adapt to each other’s presence and different National Research and Innovation Systems develop different institutional ways to achieve similar ends. As Edqvist argues⁶ “the notion of optimality is absent from the systems of innovation approaches. Hence, comparisons between an existing system and an ideal system are not possible.” The NRIS approach is nonetheless normative; in the sense that it claims that certain system characteristics – such as strong network links between actors – are likely to improve performance.⁷

A recent OECD review⁸ summarised key characteristics of innovation systems as follows.

- Interconnection and interdependence are at the heart of the innovation system concept. The innovation systems perspective originated in deliberate opposition to simpler, more or less mono-causal views of innovation and the economy. Modern models of the innovation process are complex, with many linkages among actors. Innovation processes do not always start at one particular place (basic science or the market) but can be prompted by changes anywhere
- Innovative activity encompasses a wide range of phenomena, especially the re-use of the existing knowledge stock in novel ways. It can be ‘soft’ as well as ‘hard’ and technological
- Innovation activities are much more than R&D. Many other activities are central to innovation processes
- Design, engineering and management play key roles in innovation systems
- Business enterprises are central actors in the system. They make the money and the jobs
- Demand, not just supply, drives innovation systems
- Innovation functions do not map tidily to organisations. Roles overlap and may change over time
- National systems are internationally open

In this impact study, we have endeavoured to explore this wider character of innovation than is implicit in the simple ‘chain-link logic’ models of most evaluations.

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⁷ Rodrigo Arocena and Judith Stutz, ‘Looking at national systems of innovation from the South,’ *Industry and Innovation*, Vol 7, No 1, June 2000, pp 55-75
1.2 The Background: IST in FP6

This Section describes the characteristics of IST-funded research in FP6.

Section 1.2.1 provides a brief overview of the strategic objectives set for IST research in FP6; Section 1.2.2 describes the project portfolio and Section 1.2.3 covers the focus of the research funded. The subsequent sections focus on the stakeholders involved (Section 1.2.4) and their drivers for participation (Section 1.2.5). The final Section 1.2.6 considers the nature of the research conducted by these organisations in the context of the RTD projects.

More detailed information and analysis results on these topics are provided in Section 2 of Annex 1 to this report.

1.2.1 Strategic Objectives

The European Community’s Sixth Framework Programme for research, technological development and demonstration (FP6) was established in 2002 and ran until 31 December 2006. It aimed to support innovation and competitiveness in Europe and to contribute to the creation of a European Research Area.

In 2001 the IST Advisory Group (ISTAG) – which advises the Commission on the IST Programme – ran an extensive scenario planning exercise, resulting in the Ambient Intelligence (AmI) vision. At the time, ISTAG comprised 18 people from leading European ICT companies and 11 University and research institute people, largely from the same area, so the vision was strongly shaped by an industrial and forward-looking research view of the challenges and opportunities to be tackled in order to address future markets. Within FP6, the IST strategy was therefore to concentrate and focus, with a view to building critical mass, on visionary, forward-looking research – either longer term or higher risk or a combination of these – covering core technologies and “pull through” applications for the realisation of the AmI vision “anywhere, anytime, any service, for all”.

This vision was adopted as a core idea in the IST Programme. Even more than earlier approaches to ICT, it focuses on users – aiming to make technologies become almost invisible and adapt to people and business needs, leading to an era where “our surroundings are the interface to IST applications and services”.

In order to help deliver the AmI vision, the IST Programme was divided into thematic areas of research called ‘Strategic Objectives’. It also made use of the ‘new instruments’ created in FP6: namely, new types of large consortium projects intended to build critical mass within the EU research landscape.

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1.2.2 The Project Portfolio

In total, under FP6 the IST Programme comprised 1,140 projects. The EU provided a total of 4,130 M Euro in funding. Close to 5,000 organisations were involved in the research activities via a total of 14,330 project participations.

The European Commission introduced a number of new instruments to the Framework Programme during FP6, in order to help build the scale and closer integration required by the aim of building a European Research Area (ERA). The new instruments of particular importance to this study are the Integrated Projects (IPs) and the Networks of Excellence (NoEs). Together they were intended to reduce the fragmentation of research capacity and capability across Europe.

The other instruments were similar to those used in FP5, with only minor changes being made. The traditional collaborative research instrument was renamed Specific Targeted Research Projects (STREP) in FP6.

In this study, we refer to the IPs and STREPs collectively as ‘RTD’ projects. We refer to Specific Support Actions (SSA) Coordination Actions (CA) and Integrated Infrastructure Initiatives (I3s)\(^{10}\) as ‘Non-RTD’ projects. We analyse Networks of Excellence separately.

In line with its strategic objectives, under FP6 the IST Programme focused its resources on the RTD instruments, which took up ~80% of the total budget and accounted for 76% of the total number of projects. FP5 had a similar RTD focus. However, about half the FP6 funding went to IPs, so IST under FP6 focused on much larger projects than was the case in FP5.

1.2.3 Focus of the Research

In FP6, there were 23 thematic research areas referred to as Strategic Objectives. The 2006 IST IPPA report\(^ {11}\) grouped these Strategic Objectives according to their key expected impacts into four major categories or Strategic Objective Clusters (SO Clusters)

- “Applications-led Research” focused on providing continued support to leading and challenging applications responding to emerging needs
- Research in “Established Fields” was expected to reinforce leadership in areas where Europe had already demonstrated strength
- Research in “New Opportunities” had the objective of supporting European industry in exploring new opportunities leading to future markets

\(^{10}\) The highly limited number of I3 projects that concluded their activities by the end of 2007 did not allow for an analysis reached by these instruments in the framework of this study.

• “Long-term Research” was conducting research at the frontier of knowledge. It was expected to contribute to “the search for new research paradigms, paving the way for the next research agenda.”

For the purpose of analysis in this study, we have treated the fourth SO Cluster as part of the New Opportunities cluster. In the wider context of the Framework’s development, however, this fourth cluster was to act as a precursor for the Ideas programme in FP7 and the emergence of the European Research Council.

The FP funding was fairly evenly distributed over the three Strategic Objective clusters we have defined, though with a slightly higher budget allocated to research in the New Opportunities field. Compared with FP5, the IST FP6 thematic priorities involve a clear shift toward longer-term technology development. This implied a shift in funding allocation, with more money going to research in the areas constituting the New Opportunities SO Cluster (from 30% of the budget in FP5 to ±40% in FP6) and more limited financing of research in the Applications-led Research SO Cluster (from ±40% in FP5 to ±30% in FP6).

In the context of the FP5 IST Programme Integrated Programme Portfolio Analysis (IPPA), the Commission analysed a large number of IST-funded projects (mainly RTD) against the technologies employed; we grouped these base technologies, irrespective to their application, into a set of 9 “IST Technology Pillars”. These Technology Pillars are Computing & Embedded Systems; Software & Distributed Systems; Technologies for Security & Dependability; Information & Content Management Technologies; Communication & Network Technologies; Micro- and opto-electronics; Micro-systems and Sensors; Intelligent Interfaces; Bio-informatics and neuro-informatics.

It needs to be stressed that the IST Technology Pillars are only partially overlapping with the research areas defined through the administrative structure of the European Commission in FP6 (the Strategic Objectives). For a description of the IST Technology Pillars, see Annex 1 to this report.

The FP5 IPPA team also identified the market sectors that were typically addressed by IST-funded research. For this study, we grouped them into 13 key Industry/Service sectors: the IT equipment manufacturing industry; Telecom equipment & networks industry; Consumer electronics & home appliances; Automotive industry; Aeronautics & spacecraft industry; Telecom operators and service providers; IT services industry; Electronic publishing & media industry; Transport services; Health/medical services; Education & training and Public. The first five sectors are manufacturing sectors – both ICT suppliers & users; the other five are public and private services sectors.

12 A highly limited number of projects funded in this SO Cluster during the first calls of FP6, concluding their activities by the end of 2007. This study was therefore unable to determine the impacts reached by the research activities conducted in this SO Cluster.
1.2.4 The Stakeholders Involved

Overall, 4,490 organisations participated in the FP6 projects funded by IST. These organisations accounted for a total of 14,330 participations.

Most of these organisations (~75%) were based in the EU15 member states. However, compared to FP5, research had become more ‘international’. Participants from the new non-EU15 member states doubled their share in the total number of participations (from 6% to 12% – most of the increase being accounted for by Higher Education institutions). Those from other European countries increased their share from 5 to 8%. The share of those from the rest of the world rose from 2% to 6%.

Compared to the participating organisations based in the EU15, Public Authorities and Citizen/Industry Associations based in the (EU27) New Member States participated more frequently in IST-funded research (12% of the total participations, compared to 5% in the EU15 group), in contrast to the industry-business organisations (accounting for 27% of the total and for 38% in the EU15 group).

More than half of the participating organisations in FP6 were industry/business ones, accounting for ±40% of the participations.

One third (34%) of the participating organisations were SMEs. They tended to have fewer than average participations so SMEs accounted for some 15% of the participations overall and for 18% of the participations in the RTD projects. In contrast, other participant groups (Higher Education, Research Institutes and Large Enterprises – Exhibit 2) tended to have more participation.

Exhibit 2 Participation of the stakeholders in FP6

NoEs were almost entirely made up of organisations from the knowledge infrastructure (Universities and research institutes). As a result, the knowledge infrastructure has the dominant number of participations in FP6 IST as a whole.
The RTD instruments showed participation more evenly balanced between the knowledge infrastructure and industry (respectively 52% and 42%). This was especially the case for the Integrated Projects where there was a close to fifty/fifty participation level, reflecting the participation levels of the two stakeholder typologies in FP5 RTD projects (respectively 48% and 46%).

Participation of the stakeholders was determined also by the focus of the research and was divergent in the three Strategic Objective clusters.

- RTD projects in the Applications-led research SO cluster saw a balanced participation of research and industry; both groupings accounted for 44% of the participations. This SO Cluster also involved Public Authorities and (Citizens/Industry) Associations, accounting for respectively 8% and 3% of the participations.

- In the Established Fields SO Cluster, instead, the RTD projects saw a strong involvement of market actors and more specifically Large Enterprises (accounting for 37% of participations, compared to 15% for the SMEs); participation by Public Authorities and Associations was highly limited.

- Finally, the New Opportunities SO cluster saw a strong involvement of the research-based organisations, taking up 64% of all participations. Private enterprises accounted for 34% of the participations, quite evenly taken up by Large Enterprises and SMEs (respectively 19% and 15%). Also in this cluster, participation by Public Authorities and Associations was highly limited.

The IST Programme attracted a broad range of market actors under FP6, including electronics & non-electronics manufacturers; software & IT service providers; and providers of other private and public services.

A large number of key players at European and/or national level participated in the IST Programme. About half of the respondents to our survey said that their organisation was a key or at least a highly important player at EU level. Only ~10% of the respondents considered their organisation to be a player of moderate/minor importance or a new entrant at national level.

The profile of participating SMEs is very diverse. One third of these enterprises (~30%) positioned themselves as “key players at European level” while approximately 20% said they were players of moderate/minor importance or new entrants at national level. In the Software & IT services sector, 30% of SMEs said they were key players at EU level while another 30% of these SMEs were players of moderate/minor importance at national level.
1.2.5 Drivers for Participation

In the first calls of FP6, the development and enhancement of R&D capabilities was the key driver for participation for the overall majority of organisations involved (~75%). Participants looked especially for a strengthening of their organisations' social capital through the establishment of R&D alliances and collaborations, an enhancement of their human capital in terms of available knowledge (internal skills and external expertise), and the expansion of their technology portfolio.

The goal to create and/or strengthen R&D alliances was key for the research-based organisations as well as for the overall majority of the companies, Large Enterprises and SMEs alike. The exploration of new technological paths was an important driver for the overall majority of Higher Education institutions as well as – perhaps more surprisingly – the overall majority of Large Enterprises (~75%). Big companies can afford to explore technologies that increase their options in the long and the short term, allowing them to help define and to participate in longer-term developments. SMEs tend to have a small set of technological options – they can in many cases be thought of as being comprised of a ‘single project’ - and may lack the resources to take a longer or wider perspective.

This pattern, where participants primarily seek networks and ‘intermediate knowledge outputs’ (which are used in R&D and decision-making rather than directly to make products and processes) is highly typical of the Framework as a whole. What is unusual in IST, compared with the rest of the Framework, is the high importance of pre-normalisation-related research.

Survey respondents said that commercial/economic goals were less important. Rather than relating directly to sales, these goals related to the creation or strengthening of strategic business alliances and the improvement of innovation capabilities (~30%). Only ~20% of respondents aimed for direct impacts on their commercial performance such as the enhancement of profitability, turnover & productivity. Not surprisingly, companies were more frequently driven by economic goals than other stakeholders with ~30% of these organisations hoping for increases in turnover, profitability or productivity.

One in three participants (~30%) attributed high importance to goals in the policy sphere: namely, goals related to standards development or policy development. This included ~60% of the respondents active in the Public Services sector (including business as well as Public Authorities and Associations).

Compared with FP5, all stakeholders but especially Large Enterprises and SMEs considered goals in the RTD sphere more frequently important. Goals in the economic sphere (both in terms of innovation capabilities and direct tangible impacts) were of higher importance for the Large Enterprises, while contributions to standards and policy development were more important to RTD project participants.

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1.2.6 **Continuity & Nature of the Research**

Respondents indicated in three out of four cases that FP6 research extended previous work in similar areas. In half these cases, national or European Commission Programmes had funded the earlier work. Only one in five respondents said their research focused on a totally new concept or idea.

The major characteristic of the research conducted by the participants in the FP6 projects responding to calls 1 to 3 was the high level of technical complexity. Most respondents also indicated that the research was core to their organisation’s R&D activities and that it was of high strategic importance for their own organisation and for society as a whole. Research tended to be mid-to-long-term and applied in nature, but also included ~10% of more fundamental research. Technical risk was considered moderate to high, while commercial risks were highly variable.

Exhibit 3 shows a substantial change in the research conducted by Large Enterprises and SMEs between FP5 and FP6. These organisations were more likely to do longer-term research in a core RTD area for their organisation in FP6. They considered these research activities had higher strategic importance for their organisation.

Exhibit 3 **Nature of the research conducted by industry participants – FP5 versus FP6, RTD projects**

This stronger focus on research of high importance to the organisation in core RTD areas can be expected to have a positive effect on the level of impacts achieved by these participants and by the Programme in FP6 overall. The findings of the WING impact analysis related to IST research in FP5 (see the WING Second Aggregate report) indicated a strong link between poor impact performance and projects considered by participants to be of peripheral interest and low strategic importance.
2 Overall Impacts

This section of the report provides a view of the overall impacts on innovation reached by research funded in the first calls of FP6. It builds on the integration of the findings reproduced in various sections of the detailed report (Annex 1).

Section 2.1 focuses on impacts achieved on Europe’s RTD and economic competitiveness. It provides a general overview on impacts reached to then look into on the one hand, the characteristics of impacts reached on research in specific IST fields and, on the other hand, the value of advances in specific S&T fields for current - and potential future - development in specific market sectors.

Section 2.2 considers the key benefits for society deriving from the achievements reached in specific S&T fields and/or industry markets.

For this study, we grouped different S&T fields into “IST Technology Pillars” and identified a specific set of “Key Industry Sectors” (see also the preceding Section 1.2.3 in this report and Section 2.2.1 and Section 3 in Annex 1). We recall that the IST Technology Pillars are only partially overlapping with the research areas defined through the administrative structure of the European Commission in FP6.

2.1 Impacts on RTD and Economic Competitiveness

2.1.1 Impacts on Research

The first calls of FP6 led to very strong impacts on knowledge in the S&T communities at large, among ~60% of participants. These impacts were spread over the range of IST Technology Pillars (to which we refer in detail below).

Exhibit 4, below, shows that impacts were greatest in IST Technology Pillars that lie at the root of many current – and future - innovations in ICT, notably Communication & Network Technologies, Software, Middle-ware & Distributed Systems, Computing Architectures & Embedded Systems, and Information & Content Management Technologies.

- Together with computing, Communication and networking technologies constitute the bulk of ICT evolution in the last two decades. Depending on developments in this pillar is the offer of connectivity to residential and mobile users and the creation of the base for a widespread diffusion of Internet and the “Internet of things’
• S&T developments in **Software, Middle-ware & Distributed Systems** have become fundamental for innovation due to an enhanced pervasiveness of software in any application field. This is related to the availability of low cost computational power and the possibility to connect computers through networking and wireless communication technologies. The availability of “middleware,” which often means networking capability, has moved up the rankings in importance as more developers work on network-enabled or communications-enabled embedded systems.

• **Computing Architectures** are the foundation for developing any application. Depending on the market, the focus can be on the performance or the cost/performance which is typical for computing application, or on the integration of heterogeneous functionalities under constraints such as development time, reliability, power consumption, cost, form factor, real-time performance - as is the case with Embedded Systems.

• **Information & Content Technologies** deal with storing and retrieving information; their present and future goal is to provide software components, mainly in the form of services, to support the evolution of the Web, which integrate Artificial Intelligence (AI) technologies, semantic web and 3D interaction with the user.

Exhibit 4 Impacts on the course of developments in S&T fields – RTD projects

% of respondents indicating impacts of (very) high significance - base: 582 resp. - FP6 RTD projects concluded by end 2007

- Communication & Network Technologies: 42%
- Software, Middle-ware & Distributed Systems: 40%
- Computing Architectures & Embedded Systems: 26%
- Information & Content Management technologies: 26%
- Intelligent Interfaces: 22%
- Technologies for Security & Dependability: 20%
- Micro- & Opto-electronics: 13%
- Micro-systems & Sensors: 14%
- Bio-informatics; neuro-informatics: 4%

Source: WING FP6 Impact Analysis, April 2009

Low impact levels (as for example for the bio-informatics pillar) do not imply that research did not contribute significantly to S&T developments in that specific field. They merely suggest that the technology pillar constituted a research focus for a more limited number of projects/participants in the programme overall.

Exhibit 5, below, steps away from this numeric dimension. By reproducing the average impact levels, it highlights the value of the Programme’s contribution to knowledge enhancement and research integration for each specific IST Technology Pillar.
In this exhibit, we plotted the views of the actors in the Research System about the impacts of the Programme on the development of S&T knowledge and on research integration (in the sense of communication and mobility among R&D workers, access to infrastructures, and integration of research teams).

Impacts are high for all Technology Pillars. The lowest average impacts levels were judged to be 4 on a scale from 1 to 5. (‘5’ is the highest score on all the scales we use in this report).

Exhibit 5  Impacts on Key Technology Pillars correlated with impacts on knowledge & research integration in specific S&T fields – FP6 research-based participants

The exhibit suggests that research focusing on technology pillars that constituted the core of the programme such as Communication & Network Technologies or Information & Content management Technologies (showing greater impact levels, represented by the size of the bubbles) reached strong impacts on both research integration and knowledge generation, around well-defined activities.

The areas with the strongest impact levels for both knowledge enhancement and integration are those fields of IST most critical to the development of innovative, intelligent systems, where multidisciplinarity and integration of different S&T communities are keys to success. These include Computing Architectures & Embedded Systems, Micro- & Optoelectronics, Bio-informatics & Neuro-informatics, and Intelligent Interfaces. In the Programme, the core of the research focusing on these pillars was conducted in the New Opportunities SO Cluster, even though impacts on developments in these S&T fields were often indicated also by research stakeholders participating in research under the Transport, e-Health and Inclusion Strategic Objectives (the Applications-led Research SO Cluster).
In these IST Technology Pillars, research succeeded in generating more new knowledge by stimulating multidisciplinary collaboration in R&D and integrating the different research communities. According to survey respondents and interviewees, NoEs were especially important for the achievement of these impacts, for example, in the fields of Intelligent Interfaces and Bio-informatics & Neuro-informatics.

- **The evolution of Intelligent Interfaces** involves developments in: Human-machine communication; Interfaces for improved interaction; Virtual reality and rich media. In *human-machine interaction*, the present situation and the trend of the next five years is to focus on human characteristics and to make ICT interface to them in the most natural, intuitive and effective way possible, increasing the role of tactile and voice controlled interfaces rather than traditional visual-centric interaction. *Tactile (haptic) technologies* are especially important. Their goal is not only to receive commands but also to provide tactile feedback. There will thus be a significant effort in modelling human perception and developing Man-Machine Interfaces (MMI). *Virtual and Mixed Reality systems* are based on a large set of different technologies such as visual interfaces, position trackers, and the computer engine, as well as the capacity for integration of the related technologies and products.

NoEs affecting this Technology Pillar include those funded under the Strategic Objective Multimodal Interfaces as well as some funded under the Technology-enhanced learning & access to cultural heritage Strategic Objective (Applications-led Research SO Cluster).

- **Bio-informatics** started to benefit from the availability of significant advances in computing and simulation methodologies. Problems like computation of molecular-level dynamic behaviours are becoming affordable, opening a new wave of possible applications including personalised therapies or genetic medicine. ICT technologies will be applied in other scientific sectors. Research emerging in this decade is likely to generate opportunities to simulate complex systems and to store and process huge amounts of data.

The Healthcare and the Multimodal Interfaces Strategic Objectives (SO) funded NoEs that were particularly beneficial for this Technology Pillar. The Healthcare SO aimed to use the NoE instrument for “networking of researchers in the areas of medical informatics, bioinformatics and neuroinformatics with the objectives of advancing health knowledge leading to a new generation of eHealth systems assisting in the individualisation of disease prevention, diagnoses and treatment.”
2.1.2 Impacts on Economic Development

This section investigates the value of advances in specific S&T fields for current and potential future economic development.

First, impacts reached on industry RTD capabilities and market development are shown. Subsequently, we describe the ‘constitutive’ role of S&T achievements for the enhancement of competitiveness in specific industry sectors, providing a tool for further analysis. The final sub-section identifies and illustrates the impacts reached on specific industry sectors.

In terms of knowledge & market development

Exhibit 6 shows the extent to which company participants believe achievements in the different IST Technology Pillars led to knowledge enhancement (on the x-axis) or market development (on the y-axis). Bubble size indicates the proportion of company participants in the Programme viewing impacts on an industry sector as high or very high.

Short-term market development impacts were more limited than knowledge ones, in line with the pre-competitive nature of the Programme. The lowest average impact levels on market development were judged to be 3 on a scale from 1 to 5.

Exhibit 6 Impacts on IST Key Technology Pillars correlated with impacts on knowledge & market development – FP6 industry/business participants
Reflecting the research priorities in the Programme, also the industry stakeholders indicated in the Communication & Network Technologies and Software, Middleware & Distributed Systems the IST Technology Pillars with the greatest impacts on the course of developments (illustrated in the exhibit by the bubble sizes).

Impact on knowledge and market development were strongest in fields where Europe could build on its traditional strengths, such as semantics and knowledge management technologies, embedded and distributed software. This affects – both in terms of technological capabilities and market development – technologies for building the Internet of Services (Information & Content Management technologies), Software, Middleware & Distributed Systems, and (to a lesser degree) Computing, Architectures & Embedded Systems. Research focusing on Intelligent Interfaces is expected to have especially large – but longer-term - effects on economic development, thanks to high-level impacts on S&T needed for this field.

The relatively weaker impact of the IST Programme in the field of Micro & Optoelectronics (in terms of industry-relevant knowledge enhancement) calls for a more in-depth analysis when all data for FP6 will be available. The relatively weak impacts on Microsystems & Sensors and Intelligent Interfaces - in terms of market development - can be attributed to the fact that many markets for these technologies are still in their infancy.

The section below looks further into the topic of market development thanks to technological achievements, providing concrete examples.

**S&T advances leading to impacts on industry sectors**

The Technology Pillars of the IST Programme are in varying degrees important to the development of different ICT industry sectors.

Exhibit 7 provides a matrix showing the relationship between advances in Technology Pillars and impacts on specific Industry Sectors. In effect, it shows how important the penetration of results from each Technology Pillar is for the development of each market. (Correspondingly, of course, it also shows the extent to which each market depends upon the Technology Pillars.) The matrix is based on our technical judgement and we expect it to remain relevant for the coming five years or so.

One can clearly see that there are Technology Pillars such as Computing Architectures & Embedded Systems and Technologies for Security & Dependability that are of critical importance for innovation in a wide array of industrial sectors. Reading the matrix in the other direction, innovation in industry sectors such as IT services and Telecommunications services depend on achievements in a wide range of Technology Pillars.
Focusing on the ‘highest-impact’ Technology Pillars, the matrix illustrates, for example, that developments in Information & Content Management technologies are of critical importance for innovation and competitiveness in the IT services, Education & Training, and Electronic Publishing & Media industries (boxes highlighted in blue). These technologies are also increasingly important for Telecom service providers; Health/medical services providers, and Public Administrators (boxes highlighted in orange).

**Exhibit 7  Mapping of Key Technology Pillars against industry sectors in terms of relevance for industry development**

<table>
<thead>
<tr>
<th>Technology Pillars</th>
<th>Telecom equipment &amp; networks industry</th>
<th>IT equipment manufacturing industry</th>
<th>Consumer electronics &amp; home-appliances industry</th>
<th>Automotive industry</th>
<th>Aeronautics &amp; spacecraft industry</th>
<th>IT services industry</th>
<th>Telecom operators &amp; service providers</th>
<th>Electronic publishing &amp; media industry</th>
<th>Transport services</th>
<th>Telecommunication services</th>
<th>IT services industry</th>
<th>Public Administration</th>
<th>Education &amp; training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information &amp; Content Management technologies</td>
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<td>0,4</td>
<td>0,1</td>
<td>0,1</td>
<td>0,3</td>
<td>0,7</td>
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<tr>
<td>Software, Middleware &amp; Distributed Systems</td>
<td>0,4</td>
<td>0,3</td>
<td>0,1</td>
<td>0,3</td>
<td>0,5</td>
<td>1</td>
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<td>0,3</td>
<td>0,6</td>
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<tr>
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<tr>
<td>Micro- &amp; Opto-electronics</td>
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<tr>
<td>Micro-systems &amp; Sensors</td>
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<td>Intelligent Interfaces</td>
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</table>

Source: WING FP6 Impact Analysis, April 2009

**Impacts of developments in Information & Content Technologies**

Interviewees pointed to significant contributions by the IST Programme in the field of Information and Content Technologies, e.g. the improvement of semantics and its implementation for the development of innovative solutions for Public Administrations; developing and improving implementation of web technologies for data management (data representation, search and downloading) to the benefit of environmental sciences; the organisation and processing of multimedia information and search engines for multimedia.
Advances in this field are needed to ensure that Europe has the capacity to influence the Future Internet and help transform it into the desired Internet of Services with all its societal and economic implications. In particular, these advances will enable European citizens to use intuitive services in their everyday life and European industry to be more effective by creating and using service-based applications.

**Impacts of developments in Software, Middle-ware & Distributed Systems**

Software, Middleware & Distributed systems are at the core of the AmI vision. Interviewees mentioned in this context especially the significant contributions of research conducted under FP6 in the field of Service-oriented Architectures (SoA), Grid computing, and the emergence of cloud computing technologies and applications. The IST Programme has made significant contributions to the development of innovative solutions for managing learning, including the design of advanced simulations, intelligent agents and virtual learning spaces.

Developments in Software, Middleware & Distributed Systems are – quite obviously – of critical importance to the suppliers of Software & IT-services, but also to the highly software-intensive Telecommunication Services sector. Innovation in public service sectors is increasingly dependent on S&T advances in this field, as are the Aeronautics & Space industries and Electronic Publishing & Media.

**Impacts of developments in Computing Architectures & Embedded Systems**

Developments in Computing architectures & Embedded systems are of fundamental importance for a broad range of industry sectors, especially aeronautics & spacecraft, automotive, consumer electronics, IT equipment & services, and telecom equipments and services.

In the next decade, embedded systems will be a key to innovation. Almost all industrial sectors, including automotive, aerospace, industrial automation, medical/healthcare, telecommunication and consumer electronics, will integrate Embedded Systems. Embedded Systems have a deep impact on these industries and on the final consumer of their products.

More detailed indications on achievements in specific S&T fields are provided in Section 5.1 of Annex 1 to this report; Section 3 of the annex provides a full view on the S&T context of research in FP6.

**Impacts on specific industry sectors**

Levels of impact achieved in individual industry sectors depended on the focus of IST R&D activities and their relevance to innovation in specific markets. According to the industry/business participants, impacts of the Programme were greatest in the Telecom Equipment & Networks and Telecom Services sectors. Highly significant impacts were also identified in the IT services, IT Equipment manufacturing, Consumer Electronics, and Education & Training market sectors (Exhibit 8)
Exhibit 8  Impacts on industry sectors according to industry/business participants

![Graph showing impacts on industry sectors](image)

Source: WING FP6 Impact Analysis, April 2009

Also in this case, low impact levels in specific markets, such as e.g. transport services, do not imply a lack of efficiency of the research targeting this market; they suggest that this market constituted a research focus for a more limited number of projects/participants.

Exhibit 9 looks into the impact for each Technology Pillar. It shows how industry participants believe impacts on economic competitiveness in specific Industry Sectors relate to impacts on markets and standards development.

Standards are key for the attainment of interoperability of technologies and systems. Depending on the characteristics of markets and technologies, they can also be determining factors for global competitiveness. The crucial value of standards development for Europe’s competitiveness was described in the 2006 ISTAG report, “Shaping Europe’s future through ICT”\(^\text{14}\) as follows: “Standards are an essential feature of the market landscape and will be important in enabling Europe to overcome fragmentation.”

One should recall that the role of standards is linked to technology maturity as well as to market dynamics. RTD projects also typically have only a limited potentiality to impact standards development; this issue is treated further in detail in Section 3.1, below.

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The exhibit reflects the view of the industry/business participants and is based on the relationship between, on the one hand, impacts on the market and, on the other hand, standards development. Bubble size indicates the proportion of participants in the Programme viewing impacts on an industry sector as high or very high.

**Exhibit 9** Impacts on key industry sectors correlated with impacts on market & standard development – FP6 industry/business participants

![High-level Impacts on Key Industry Sectors correlated with impacts on Market & Standards Development](image)

**Notes:** Size of bubbles = % of industry/business participants indicating impacts of (very) high significance on Industry Sectors

Source: WING FP6 Impact Analysis, April 2009

Exhibit 9 shows that projects strongly influenced the development of standards in the field of *Telecommunications Networks*, reinforcing Europe’s strong position in global markets. It should be mentioned that contributions to standards constituted a key focus for the IST-funded research in this field during the first calls of FP6 (see also Section 3.3.4). Other sectors with strong impact include service providers in the *public field* (Public Administration) and industry sectors active in the ‘*Converged Communications*’ market (the IT Equipment and Consumer Electronics sectors). The impacts on the latter indicate a strengthening of industry capabilities in responding to the challenges posed by the products/services convergence in this market, considerably facilitating the development of – mainly existing – markets.

The *Education & Training* services sector saw a strong enhancement of its competitiveness, especially in terms of developments of both new and existing markets. IST finds its application here revolutionising delivery methods (physical and social), diversifying and enhancing content, and expanding and setting up new learning infrastructure.

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**FP6 IST had significant effects on the competitiveness of industry sectors that are vital for the diffusion of innovation in both the public and private sectors.**
The IST Programme had a major effect on the competitiveness of the IT Services industry sector. It produced high-quality contributions to the development of open source software and relevant de-facto industry standards as well as strong impacts on the creation of new markets and the further development of existing ones. Open Source, SoA and the GRID technologies were considered in 2008 the technological trends that were creating the largest expectations in the Software & IT services industry\(^\text{15}\) and the considerable impacts on these technologies indicate that the IST Programme succeeded in exploiting windows of opportunity.

A strong and competitive European Software & IT services sector is crucial to innovation and competitiveness in most manufacturing and services sectors; this regards especially the Information and Communication industry as in this sector, companies increasingly rely on outsourcing for the development of products and services that are not in their core fields of expertise. This provides market opportunities for European SMEs, provided they are able to build up expertise in niche markets and exploit their knowledge of local needs and their position in industry networks.

The impacts reached by the Programme on participating SMEs providing Software & IT services are described in Section 3.3.2 of this report.

We had to omit Health/Medical Services from Exhibit 9 in order to make it readable, due to the particularly low value indications for standards development in this field (impacts on market development were slightly above average). This comparative lack of impact on standards development in the Healthcare and Medical services market may lead to a slower than necessary process of market take-off, thus reducing the opportunities to obtain the economic and social benefits of advances in S&T.

A 2008 report of the eBusinessW@tch study\(^\text{16}\) considered the lack of interoperability of the information systems in the European healthservices market as one of the major hindering factors for the uptake of ICT in this sector. Also a 2008 study on the impacts of IST-RTD on key strategic objectives related to growth and jobs (focusing on, amongst others, eHealth)\(^\text{17}\) indicated in the lack of interoperability standards one of the bottlenecks for the growth of the healthcare IT sector in Europe. The report found that, “Lack of interoperability standards reinforces market fragmentation even where not justified by different needs or systems, which in turn reduces both scale and scope economies.”


\(^{16}\) “Assessment of ICT Standards in the Health Sector”, eBusiness W@tch Sector Report empirica, European Commission, DG Enterprise and Industry, 2008

2.2 Social Benefits

The IST Programme strategy relies on the idea that R&D projects will strengthen the capabilities of the research and industrial sectors, leading to better products/services from more competitive European suppliers, which in turn will generate the social benefits foreseen in the Ambient Intelligence Vision. Inevitably, the time frame for these impacts to occur is long-term. In this study, we can therefore only identify potential social benefits.

Our analysis of the impacts reached on industrial R&D capabilities pointed to significant progress especially in the field of Software, Middleware & Distributed Systems and Information & Content Management Technologies. Both these Pillars are fundamental for the achievement of a user-friendly information society and an improved access to information and knowledge. The relatively important progress in the field of Technologies for Trust & Dependability responds to the need ISTAG identified for the social acceptance of the Ambient Intelligence technologies, i.e. the improvement of the dependability of technologies, infrastructures and applications.

The relevance of these S&T achievements for the enhancement of the competitiveness of market actors leads to – potential – high-level benefits for the European citizen.

The relevance of these S&T achievements for the enhancement of the competitiveness of market actors in both the private and public sectors leads to – potential – high-level benefits for the European citizen in the social sphere, especially in terms of enhanced access to information and knowledge and an improved social welfare. Strong impacts on sectors such as Public Administration, and Health Services mean that IST research is contributing to the attainment of an inclusive Information Society. An application area for IST that is central to the construction of the Knowledge Society and where high-level impacts were reached on R&D and economic competitiveness is Education and Training.
3 Programme Achievements leading to Impacts on Innovation

This section of the report looks into the specific achievements of the Programme that lie at the basis of the impacts reached on research and economic development in the Technology Pillars/industry sectors analysed in the previous section.

Section 3.1 reports on the achievements reached in the field of S&T; the focus is on the outputs of the research activities. In Section 3.2 we analyse the impacts reached by the participants on their knowledge and the social capital. We also look into the mechanisms set up or facilitated by the Programme to transfer knowledge or technology to the communities that were not directly involved in the research, as well as the effects on an improved integration and structuring of European research. Section 3.3 focuses on the effects of both the S&T achievements and the knowledge/technology gained during the research activities on the economic performance of the participants. This includes both the research participants as ‘knowledge intermediaries’ and the industry and public services ones as ‘early adopters’.

We provide a detailed analysis on S&T outputs of the research in Section 5 of the Detailed Report (Annex 1), while the findings on impacts on knowledge and learning are the topic in Section 6. Impacts on economic development are covered in Section 7.

3.1 Building Technology Capital

IST research funded in FP6 created at least three kinds of technology capital crucial to European competitiveness, i.e. the ‘upstream’ knowledge outputs, intellectual property, and contributions to (interoperability) standards.

3.1.1 ‘Upstream’ Knowledge Outputs

The IST Programme has been especially important in developing the ‘upstream’ technology capital needed for longer-term development. This includes new research tools & techniques; models & simulations; and prototypes, demonstrators & pilots. Most participants considered these outputs of (very) high importance (~60% of all participants; ~70% of participants in RTD projects). These items of technology capital provide the basis for progress towards future product generations. Some 75% of participants believed that FP6 projects had a highly positive influence on their future research.

The importance of these longer-term research capabilities can stretch over surprisingly long periods. For example, in automotive ICT applications, capabilities have been developed since the late 1970s (originally in the Eureka Prometheus project and later in the Framework Programme) that provide key modules of capability needed if we are ever to build autonomously controlled vehicles. Many of these have spun out into products, like in-car navigation and parking sensors.
At the beginning of FP6, challenges in the automotive sector were to run automated road vehicles on any infrastructure without any human interface. In that period, there were solutions in most of the fields of interest but not the integration that is fundamental to make operational automated vehicles. Driving assistance, obstacle avoidance and vision systems are only some examples of systems that needed to be integrated. Furthermore, some modifications of the infrastructure were needed; the efficiency in terms of communication capacity was not good enough for high capacity applications. A big step forward was made thanks to the CYBERCAR2 project: the efficiency problem was overcome thanks to communications and cooperation schemes developed in that project.

However, such long-term outputs are not the only ones of value. About one in three participants in RTD projects (30%) also indicated that closer-to-market outputs are highly important. These include new and/or improved products, processes and services. SMEs and Public Authorities/Associations particularly valued these types of outputs (~50%), which are in line with their organisational objectives and needs.

Exhibit 10, below, maps the percentage of participants in RTD projects attributing moderate to high importance to a selection of project outputs onto a set of RTD life cycle phases. It illustrates a shift in key research outputs from Prototypes, Demonstrators & Pilots in FP5 (left-hand graph) to Research Tools & Techniques in FP6 (right-hand graph). The former are results of testing and validation exercises and constitute a critical step towards product/service design; the latter are the typical outputs of research focusing on the ability to do research over the longer term. In relation to the closer-to-market outputs, respondents attributed less importance to the development of new or improved products in FP6 compared with FP5. All these indicators confirm the more pronounced focus of FP6 on more fundamental and longer-term research.

**Exhibit 10  Importance of S&T outputs – FP5 versus FP6, RTD projects**

Source: WING FP6 Impact Analysis, April 2009
3.1.2 Intellectual Property

Intellectual Property is a second aspect of technology capital. Such property can be formally owned through Intellectual Property Rights (IPR); depending on the characteristics of the market sectors, companies may also decide to hold the property ‘informally’ via secrecy\textsuperscript{18}.

Some 15\% of participants overall, but 30\% of all industry stakeholders involved in RTD projects, sought patents or copyrights as a result of the IST participation — a doubling since FP5. Exhibit 11 shows that this increase in IPR applications was especially important in Large Enterprises.

In FP6, Large Enterprises applying for IPR were especially active in the converged Consumer Electronics market (Telecom Equipment and Multimedia Equipment) or were manufacturers of Communication Network Equipment. The ~25\% of SMEs indicating such outputs tended to regard themselves as market leaders at European and/or national level, suggesting that the Programme is important for the economic competitiveness of SME ‘gazelles’.

Exhibit 11 IPR applications deriving from research – FP5 versus FP6, RTD projects

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{iprapplications_chart.png}
\caption{Stakeholders indicating IPR applications}
\end{figure}

Source: WING FP6 Impact Analysis, April 2009

\textsuperscript{18} Dachs, B., et al., Europe’s strengths and weaknesses in Information Society Technologies - A patent analysis, Fistera – Thematic Network on Foresight in Information Society Technologies in the European Research Area, European Commission, DG Information Society and Media, 2005
3.1.3 Contributions to Standards

Standards are a crucial third dimension of technology capital. To the extent that they are open, standards enable market access and the growth of scale; but they can also favour the skills of certain suppliers over others or restrict market access by requiring the use of others’ intellectual property. Participation in standards formulation and pre-normalisation research can therefore be competitively crucial but is also a long-term and risky business from an industrial perspective. The Framework has a long history of involvement in developing standards, such as 3G, that have provided European competitive advantages19.

The FP6 IST Programme contributed to industrial competitiveness by helping to organise European positions in standardisation debates and reducing risk. Research under the first calls made strong contributions to the development of – formal and de facto – standards in all areas where these developments are of critical importance for interoperability or to strengthen Europe’s position on the global market. Our analysis shows that this focused on the fields of Information & Content Management Technologies, Computing Architectures & Embedded Systems, Software, Middleware & Distributed Systems, and Communication & Network Management.

IST research funded in the first calls of FP6 made significant contributions to standards development, as indicated by ~30% of the industry/business participants - but by 40% of the Communication Network Equipment manufacturers. One in five respondents (~20%) considered new or improved de-facto and/or formal standards to be important outputs of their research activities in FP6; they (also) considered their research results to be important input for national or European standardisation bodies and industrial fora & consortia (a considerably lower number considered them relevant to the CEN/ISSS - 10%). One in four (~25%) attributed high value to the developed ‘new or improved open or community source software’.

Survey respondents pointed to contributions by FP6 IST to over 100 specific standards, largely: (1) networking and communications; (2) data/content management, access and transfer (such as file formats, data ontologies and architectures). This latter group often focused on specific applications such as e-business. While both formal and industry standards were supported, the majority were global rather than European in scope, i.e. standards agreed at the IEEE, ITU, IETF, 3GPP etc. They included most of the key networking and communication standards, especially those related to broadband, wireless and digital broadcasting protocols, which are either in use today or are the recognised (and industry led) future development path of these standards.

Standards development is a long-term issue that in most cases goes beyond the life of a single project; often, FP6 projects only led to ‘workshop agreements’, to be further pursued in the standardisation bodies. According to the interviewees, the FP’s ability to engage key industrial players and standardisation bodies in projects is crucial to help setting the base for defacto or formal standards; also the European Technology Platforms and IST-related industrial associations are playing increasing roles.

3.2 Enhancing Human Capital

This Section focuses on the impacts experienced by the participants on their ‘human capital’. This is key to their current and future research strength and competitive advantage.

Section 3.2.1 reports on the impacts they experienced on their R&D competitiveness, while Section 3.2.2 looks into the creation and/or strengthening of knowledge networks. Section 3.2.3 considers to what extent FP6 succeeded in creating knowledge transfer to the S&T communities that were not immediately involved in the Programme. Finally, Section 3.2.4 covers the impacts reached on an improved integration and structuring of European research.

3.2.1 Strengthening R&D Competitiveness

The IST Programme helped participants to further develop their R&D skills, attain critical mass, strategically reorientate their work – sometimes through the adoption of new technological and process paradigms – and agree road maps that defined how industry would overcome technical barriers in developing new product generations.

Participation in FP6 research significantly increased the competitiveness of the R&D skills of all types of organisations, especially the R&D workers’ knowledge base and skills (~65% said this was important). For Higher Education institutions and SMEs in particular, this learning was facilitated by access to complementary expertise (see Exhibit 12). Most company participants (~65%) found that participation in the IST Programme increased their ability to get further R&D funding not only in-house but also (and especially for SMEs) from other EU or national sources.

Exhibit 12 Impacts of (very) high significance on knowledge – per stakeholder, all FP6 projects

Impacts on knowledge bases and skills occurred for more than half of the participants.

Source: WING FP6 Impact Analysis, April 2009
One in three participants (35%) obtained benefits through participation in a greater critical mass of research. NoEs were especially efficient from this perspective (impacts were indicated by ~50% of participants in NoEs), so this benefit was particularly important in the knowledge infrastructure. The IST Programme also had a major impact on the research strategy of one in five participants – 25% of those involved in NoEs and/or IPs, compared to 17% in STREPs.

Interviewees valued the role of the Programme in the defining (new) research directions and methods, especially through the projects focusing on defining technology roadmaps. Examples include the paradigm shift in the field of transport technologies during FP6 towards the cooperative intelligent vehicle and vehicle systems (vehicle-to-vehicle communication) and the implementation of web technologies for data management. Contributions made by the IST Programme in the field of micro-nano electronics are illustrated by the example below.

In the middle of this decade, the main challenge in micro-nano electronics was how to continue the historical pattern of reducing feature sizes on microchips (130nm 90nm 65nm). Cost and reliability were two other major problems. There were several potential solutions for downscaling from 130nm to 65nm but no one knew which was the right one. The IST Programme helped R&D teams work together, discussing research directions and creating roadmaps. It provided the support needed for the development of new ideas, such as gate dielectrics and the use of new-materials.

The overall impression deriving from the evidence collected - including both survey and stakeholder interviews - is that compared to FP5, FP6 led to (even) more pronounced impacts on the participants’ R&D capabilities, affecting both their knowledge & R&D skills and their organisations’ research networks. Exhibit 13 highlights the major benefits drawn by participants in FP6 RTD projects, compared to FP5.

Exhibit 13  Impacts of (very) high significance on knowledge – FP5 versus FP6, RTD projects

<table>
<thead>
<tr>
<th>Knowledge bases</th>
<th>FP5 RTD</th>
<th>FP6 RTD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to complementary expertise</td>
<td>40%</td>
<td>52%</td>
</tr>
<tr>
<td>Critical mass of research</td>
<td>27%</td>
<td>37%</td>
</tr>
<tr>
<td><strong>Knowledge bases</strong></td>
<td>54%</td>
<td>65%</td>
</tr>
</tbody>
</table>

Source: WING FP6 Impact Analysis, April 2009
Industry interviewees pointed to the value of participating in FP6 research activities for sharing technical risks, exploring the feasibility of new technologies, obtaining an improved understanding of market and consumer differences among European countries, defining needs in the value chain, monitoring strategies of competitors and clients and testing products and solutions in different environments.

Several pointed to effects on a change in the ‘innovation culture’ in their organisation, such as increased involvement of suppliers, users and even competitors in the earlier stages of R&D. Thus IST-funded research helped participants move towards Open Innovation, User-Centred-Development and experience prototyping. Participating Public Authorities pointed to enhanced acceptance of technological innovation and recognition of its benefits.

3.2.2 Social Capital in the form of Knowledge Networks

Long-term strategic alliances are increasingly of fundamental importance in the IST industry. Digital convergence among different parts of the industry, the convergence of products and services (e.g. the so-called ‘multiple-play’ strategies by the telecom companies), ‘value chain convergence’ leading to integration along parts of the supply chain and collaboration with manufacturing partners or ‘extended enterprises’ are blurring the lines between traditional ICT service and product segments. In response, new business models are emerging, where partnerships and strategic alliances with experts in complementary areas are the basis for competitive advantage – and sometimes even economic survival. It is therefore not surprising that both large and small firms saw the creation and/or strengthening of their collaboration with other organisations as a key driver for IST participation.

For the overall majority of participants (65%), IST participation was highly significant in creating or strengthening their R&D linkages with Universities and research institutes, almost all (~60%) regarding these as long term. Similarly, ~40% obtained high-impact linkages with companies.

FP6 induced more such relationships than FP5, especially in the creation or strengthening of intra-research, science-industry, and intra-industry collaboration networks (Exhibit 14).

This effect was especially important among SMEs, drawing them into the relationships they need in order to succeed, with the majority (60%) attaining significant longer-term strategic alliances with research organisations and 50% expanding their strategic alliances with other companies. SMEs benefited in particular from their participation in STREPs: ~60% of SMEs that were involved in STREPs experienced impacts on their long-term partnerships with research stakeholders (compared to ~40% in IPs) and ~50% on their intra-industry relationships (compared to ~40% in IPs). These findings seem to confirm the consideration made by some interviewees that STREPs - more than IPs - allowed participating SMEs to gain visibility within the project consortia.
Similar effects on strategic alliances with research organisations and other companies were obtained respectively by close to half (45%) and one third of the Large Enterprises. These effects were especially important for firms in the Software & IT sector and those manufacturing Communication Network Equipment.

On a less positive note, the impacts of both FP5 and FP6 on Public Administrations’ networks were limited and, in the case of FP6 participants, well below their expectations. While half of these participants had aimed to create longer-term R&D alliances, only one third obtained them.

Exhibit 14 Impacts of (very) high significance on networks – FP5 versus FP6, all projects

Source: WING FP6 Impact Analysis, April 2009

The FP6 Integrated Project instrument was particularly effective in enhancing science-industry long-term relationships, to the benefit of Higher Education institutions and Large Enterprises in particular.

The Networks of Excellence played a fundamental role in the enhancement of intra-research collaboration networks in FP6: the overall majority of research-based organisations participating in these instruments, i.e. 75%, indicated impacts of (very) high significance on their intra-research strategic alliances (compared to ~60% of their peer organisations involved in RTD instruments or CAs).

3.2.3 Attaining Multiple Knowledge Spillover Effects

Spillovers should be key impacts of state programmes, so that not only the direct beneficiaries but also society as a whole gets benefits.

The IST Programme generated huge numbers of publications via the trade press and conferences as well as in academic journals. Some 70% of the participants cited project outputs with a strong knowledge transfer function (such as study reports, published papers and conference proceedings) as the most ‘important’ outputs of FP6 IST research. It is hardly surprising that 80% of the research-based stakeholders considered these outputs of very high importance, since in research one must publish or perish. But companies also found that publication was a crucial form of impact. About 60% of all participants said the Programme had high impacts on knowledge in their specific S&T community.
Knowledge spillovers caused by researchers moving to companies were very important. Overall, ~25% of the research organisations and ~20% of the industry/business ones indicated that key members of their RTD teams had moved to (other) firms. Increasing researcher mobility was among the objectives of the Networks of Excellence, and 25% of Higher Education institutions involved in NoE transferred staff to institutions in other countries compared with 15% of those involved in RTD projects (Exhibit 15).

Exhibit 15  Mobility of ‘some’ key members of the research teams involved in FP6 – research-based organisations, all FP6 projects

<table>
<thead>
<tr>
<th>Mobility of 'some' key members of the RTD staff in research organisations</th>
<th>All FP6 projects concluded by end 2007 % of research respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some in other University/research institutions in the same country</td>
<td>23%</td>
</tr>
<tr>
<td>Some in other University/research institutions in another European country</td>
<td>15%</td>
</tr>
<tr>
<td>Some in industry/business organisations</td>
<td>26%</td>
</tr>
</tbody>
</table>

Source: WING FP6 Impact Analysis, April 2009

Overall, 30% of the respondents – and 40% of the research stakeholders – believed that their research activities had significant impacts on Education and Training. These impacts include an influence on course content as well as increased use of eLearning technologies.

More than half of the Higher Education participants (~60%) considered “PhDs and other formal qualifications in their own institutions” to be outputs of the research activities of high importance. This constituted an increase compared to FP5 (~50%). Also in this case, the Networks of Excellence led to highly positive effects: such outputs were considered of high importance more frequently by research-based organisations involved in NoEs than those active in RTD instruments (resp. ~70% and ~60%). From a more long-term perspective, the research activities also fostered the creation of a new generation of true ‘European’ researchers: ~25% of all Higher Education institutions involved and ~40% of those active in NoEs indicated as an important output of their activities the creation of new educational programmes involving several EU institutions.

Programme participants were sceptical about the communication of research findings to external user communities and the broader public. Most interviewees said that communication to user communities – and the broader public – needs considerable improvement, and in fact, overall only ~35% of survey respondents felt the information material for external user communities produced in the context of their projects was important. Equally, only one in three respondents (~30%) considered that the activities implemented in IST FP6 led to significant impacts on an enhanced awareness among industry communities or public organisations.

and by influencing the education and training system.

Improvement is needed in the communication to external user communities and the broader public.

mobility of researchers who take knowledge with them to new organisations and strengthen networks,
3.2.4 Integrating & Structuring Research

Building the ERA by changing the structure of the European research communities was an explicit objective of FP6. Half of the respondents (51%) considered that IST-funded research in FP6 had a significant impact on the integration of research in their field. As many as 70% of NoE participants felt this way. Such impacts were especially important for the actors in the ‘Research System’: 35% of the research-based stakeholders said the Programme had increased researcher mobility and improved access to S&T infrastructures. (The corresponding figures for industry are 10% and 15%.)

Interviewees particularly stressed the importance of achievements in the field of the GRID technologies and the development of research infrastructures for an accelerated integration and improved collaboration of research organisations based in the New Member States with their peer organisations in the EU15 countries. Also certain kinds of outputs have a strong integrating effect, such as joint databases, platforms, test beds and new common methodologies. One in three respondents (~30%) also said the creation of new networks of organisations was important in integrating research. Interviewees emphasised in particular the importance of European Technology Platforms for discussing needs, developing common research strategies and providing platforms for the delivery of contributions to standardisation. They also stressed the importance of the multidisciplinary feature of the IST research activities. Input from an interviewee from this perspective is illustrated below.

In the field of multimedia, major S&T challenges in the mid 2000s were the organisation and processing of multimedia information and search engines for multimedia retrieval. In the beginning of the 2000s, this was an almost exotic concept. IST made significant contributions to advances in this field, by stimulating collaboration between two scientific and industrial communities that until then had worked separately: multimedia processing experts who concentrated on video issues; and semantic web technologists who focused on text. “Working together we could know each other better, find synergies based on our complementarities, and reach critical mass. This would not have been possible without the IST Programme.”

Impacts on participants located in the New Member States

The particularly high-level impacts on participants located in the New Member States constitute an indirect confirmation of the high European Added Value of the research conducted in FP6. For these organisations, participation provided a vital opportunity to work with peers in the EU15, thus accelerating their integration into the European scientific communities. The knowledge deriving from participation, the established RTD networks, access gained to international scientific networks, and improved research infrastructures strongly enhanced their R&D and innovation capabilities.
Close to 80% of these organisations indicated impacts of (very) high significance on the skills and competences of their R&D staff (compared to ~70% of those based in the EU15). For a similar number of organisations, participation in the FP6 research activities led to positive effects on their prospects for follow-on RTD. Facilitating factors for these stakeholders were specifically the access gained to new knowledge in existing disciplines, the opportunity to collaborate with other academic research institutions, and the access gained to international scientific networks (~70%)

### 3.3 Bridging between Research and Innovation

This section reports on the Programme efficiency in ‘bridging the gap’ between research and innovation, i.e. the translation of research outputs into market innovations.

Section 3.3.1 reports on the current exploitation of the project results by the participants and the impacts they experienced on their (potential) commercial performance. Subsequently, we look into overall impacts on specific groups of stakeholders involved in FP6, i.e. the impacts on participating SMEs (Section 3.3.2), and the impacts on participants active in public and private services sectors (respectively Section 3.3.3 and Section 3.3.4).

#### 3.3.1 Fostering Technology Exploitation & Adoption of Innovation

IST projects do not only produce knowledge and networks but also enhance participants’ innovation capabilities. Close to half (~40%) the participants increased their ability to carry out new activities, address new markets or produce and deliver new products, processes or services. About the same proportion saw their competitive position improved as a consequence. Impacts on competitive positioning and innovation capabilities were felt by ~40% of the research actors, Large Enterprises and Public Authorities, and ~50% of the SMEs. For the latter, this constituted a significant increase compared to FP5 where ~30% indicated similar benefits.

While a significant minority of the knowledge produced in the IST Programme is used directly in product and process development, the great majority goes into the ‘stock’ or ‘knowledge capital’ of organisations. More than half of the participants (55%) indicated that (in addition to direct use) their organisations are exploiting the project results indirectly, i.e. re-using the knowledge in other contexts. Close to half (~40%) indicated that they re-used IST technologies or components in the development of other products and services.

As would be expected, research stakeholders were particularly active in the exploitation of knowledge deriving from the RTD projects rather than technology (Exhibit 16). The same pattern was also visible for the Large Enterprises. One should recall here that the exploration of new technological paths was an important driver for participation for the majority of Large Enterprises (~75%).
Close to 60% of the SMEs – and half of the Large Enterprises – indicated that their organisations are currently exploiting the technology for product/service development.

**Exhibit 16  Knowledge & technology exploitation by the stakeholders, FP6 RTD projects**

![Knowledge & Technology Exploitation by the stakeholders - FP6 RTD projects (calls 1 - 3)](chart)

Source: WING FP6 Impact Analysis, April 2009

Few participants (~10%) experienced tangible impacts of their FP6 projects on their commercial performance in the short term. (By tangible impacts, we mean access to new markets, impacts on their productivity, profitability or turnover.)

That said, one third of SMEs indicated that participation significantly increased their access to new markets (compared to 11% of the Large Enterprises). Thus, there are also tangible impacts but these are primarily sought by organisations whose small size means their time horizon has to be comparatively short.

Of course, it also takes time to obtain economic benefits. The majority of the projects covered in this study concluded their activities during the course of 2007, only two years before we surveyed them. Given that most of their IST Programme activities involved long-term research, it is not surprising that there have so far been few tangible impacts. There are also many industry- and target market-specific barriers to implementation, such as lack of awareness and skills among potential IT and Software users and market readiness for innovation in telecoms.

NAVTEQ provides an example of successful exploitation of research outputs.

The company NAVTEQ participated in the PreVENT IP where a technology called ADAS (Advanced Driver Assistance System) was developed to improve road safety and fuel efficiency. An application called RunSmart Predictive Cruise fine-tunes vehicle speed to reduce fuel consumption by integrating the truck’s cruise control system with GPS and NAVTEQ’s slope and height data. Daimler Trucks North America LLC, a top medium- and heavy-duty truck manufacturer, now uses the NAVTEQ map. This is the industry’s first commercial application of digital map data in a fuel efficiency system, independent of a navigation unit.
### 3.3.2 Impacts on SMEs

Overall, the Programme led to major impacts on the majority of the SMEs involved. It provided them with valuable technology input, knowledge, and learning opportunities, setting the basis for their further RTD activities. It supported them in extending and strengthening their networking activities with the other actors in the value chain, provided them with valuable competitive advantage, and ultimately allowed them to exploit the technology for the development of new products and/or services. Finally, for one in three it provided them with the necessary capacities and opportunities to gain access to new markets.

SMEs in the IST Programme place greater importance than Large Enterprises on accessing networks, skills and markets and on establishing long-term alliances and they tend to realise these goals to a greater extent than do the large firms. But they also place higher priority than the big companies on producing and commercialising innovations in products, processes and services. They more systematically re-use project results in other contexts and the Programme has bigger effects on their reputation, competitive position, market and technology capabilities and their ability to access markets. Logically enough, therefore, the Programme makes a bigger difference to smaller and less well established companies than to large ones.

However, when considering these ‘overall’ impacts on SMEs, one should recall that the world of ICT is vast, and so is the world of ICT SMEs. In its 2006 report, the Task Force on ICT Sector Competitiveness and ICT Uptake stated, “When dealing with innovation, the specificities of the ICT sector must be taken into account. One of the most salient is the production of both material/physical (e.g. consumer electronics) and information/digital (e.g. software) goods – and compounds of them. Material and information goods are extremely different and it is necessary to set up an innovation policy for the ICT sector that differentiates between these various kinds of artifacts.” Sectoral Innovation studies confirm this concept and highlight that modes and dynamics for innovation strongly differ among industry sectors. This implies that when analysing the impacts of the Programme on SMEs, one should distinguish between the various fractions of the ‘ICT SME population’ involved.

Quite obviously, though, SMEs do have features – and especially challenges – in common such as their difficulty to invest in high-risk research (and often in research as such), their need to grasp new business opportunities before their competitors, etc.

In an attempt to go more in-depth in the analysis of impacts on SMEs, we looked into the impacts reached on SMEs active in the Software & IT services sector.

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20 One in three SMEs that participated in the survey considered themselves to be key actors at EU level (~30%); approximately 20% were, instead, players of moderate/minor importance or new entrants at national level. Among those involved in RTD projects, ~60% participated in STREPs and ~40% in IP.

Impacts on SMEs providing Software & IT services

Participation in IST was especially beneficial for SMEs active in the Software & IT services sector. These small RTD-intensive SMEs were driven to participate in the Programme by their corporate strategies. Challenged by the turmoil in their markets caused by the software as services model and the rise of new business opportunities thanks to the increasing pervasiveness of software in commodities and other products, they used the IST Programme as a window for technological opportunities. Continuous innovation is key for their competitive advantage, as is the breadth of their network for collaborations, both RTD and business ones. Having a clear business model in mind, they expected the Programme to act as a platform for the enhancement of their abilities to enter in markets new to their organisation and the Programme lived up to close to all of their expectations.

The European Software & IT services sector showed a medium R&D intensity in 2006 of just below 4% on value added and is growing rapidly. However, it lags seriously behind the US in terms of R&D. Key sources for knowledge enhancement are typically research organisations as well as customers, including both public and private organisations. Large Enterprises collaborate with these organisations mostly via outsourcing. Competitive advantage in this sector depends on the value-added and the breadth of the services offered, as described by an interviewee below.

Now more than ever, in the world of software and hardware, competitive advantage comes not from technology but from the capacity to provide real value to our clients with a quick return on investment. Today those who have only one product to sell are in a difficult position and they should be able to establish alliances with organisations with a broader offer. Therefore, SMEs who are very strong on a territory or in a niche market should look for these alliances in order to be able to offer their clients more value. The IST Programme was very useful in putting clients and suppliers together and promoting the concept of the adaptive enterprise. Projects aimed at improving supply chain management have been very useful to the EU industrial system and in particular to SMEs.

The SMEs active in the Software & IT Services sector that responded to the survey questionnaire had a range of quite different positions in their markets. While one third were leaders in their markets at European level, another third were a players of minor to moderate importance at national level or were new entrants. Despite these divergent profiles, they showed a common need to use the Programme as a window on technological opportunities: the majority indicated the exploration of new technological paths as a driver for participation.

In line with their business need for a shorter-term passage to product development, they attributed high importance to the prototypes, demonstrators and/or pilots developed and more than half are currently exploiting the knowledge gained (concepts, ideas) in their corporate context. Driven by their market needs, they were also highly motivated for participation by their quest for access to complementary expertise and expansion of their RTD networks. The impacts reached were slightly below expectations, though: ~60% saw a strengthening and/or creation of longer-term strategic alliances with Universities and research institutes.
The corporate strategy that pushed these SMEs to participate in the Programme is clear when considering that half of them expected that their participation would provide them with the abilities to enter markets new to their organisation and/or to create new markets for their products and/or services. In contrast to the other SMEs, only a minority also expected tangible impacts such as increase in turnover. The Programme lived up to their expectations: half of these SMEs are currently exploiting the technological components in-house for the development of other products and one third (already) gained access to markets new to the company. Finally, similar to the other SMEs, half of them also experienced a strengthening and/or expansion of their longer-term strategic alliances with industry/business organisations, setting the base for potential outsourcing activities and/or joint product/services offers.

The box below illustrates the impacts experienced by one of these SMEs.

The SME interviewed is a pioneer and market leader in advanced video over IP solutions, specialising in video encoding, decoding and streaming for government and law-enforcement agencies, military bases, Telco operators, enterprise organisations and the world’s leading broadcast service providers. Its products have been at the core of professional digital video broadcast solutions worldwide for more than a decade.

A general challenge in their market is to offer the right technology at the right cost in the right market. They are looking for added value to introduce in their sector: quality, functionality for their platforms, to learn situations in their market and technology arena. FP6 IST Programme made a highly valuable contribution to overcoming their technological challenges, providing them with a platform for high-risk research. It led to further research and implementation activities financed by EC funds, national funds and internal funding. In several cases they could bring the research results into product commercialisation. Multi-disciplinarity was at the heart of the projects, and of critical importance.

### 3.3.3 Impacts on Public Services Providers

Public Authorities benefited less from the IST Programme than others. Their need for proven solutions tended to make their interests differ from those of their partners, who were more focused on research than innovation within the project itself and who could take greater risks.

The IST Programme strongly supported capacity building among more ‘high-tech’ public agencies (e.g. public libraries and/or national archives). However, Public Authorities are often present in IST projects as users rather than technology developers. They obtained fewer benefits in terms of strategic partnership building than other stakeholders (see the preceding Section 3.2.2).
Public and private enterprises active in the public sector that tried to exploit research outputs in developing of new products and services encountered major difficulties and the level of exploitation failed to meet their expectations.

Lack of financial resources, lack of acceptance of technological innovation and limited availability of skills were persistent problems in this sector, but interviewees also pointed at barriers caused by over-focus on research in innovation situations where alignment of implementation objectives among the partners are necessary for success.

In FP6, the municipal government was involved in 3 IST STREPs: ONTOGOV (Ontology enabled eGov service configuration), HOPS (Enabling an Intelligent Natural Language Based Hub for the Deployment of Advanced Semantically Enriched Multi-channel Mass-scale Online Public Services) and ICING (Innovative Cities for the Next Generation). In all these initiatives it played the role of pilot and test bed for the development and demonstration of the new services.

The municipal government’s experience was that, while its partners had a good common understanding of the S&T goals to be achieved, they were not committed to the commercialisation or widespread exploitation of the services and products developed in the project. In these projects intended to lead to large-scale, ‘infrastructural’ innovations, both industrial producers and local government users are risk-averse and want to see clear demonstrations of technical and commercial feasibility before committing substantial resources.

Unfortunately, the limited number of Public Authorities involved in the projects studied did not permit more in-depth analysis.

### 3.3.4 Impacts on Telecommunication Services Providers

Telecoms services are traditionally an area of European strength, but also one that has been battered by changing economic circumstances and that needs support in innovation. The IST Programme has enabled European industry to strongly contribute to standards development, build technology platforms and increase their international competitiveness.

Telecommunications services is a large, software-intensive ICT sector, in which Europe has great industrial strength. Companies from the sector that participated in the IST Programme experienced strong impacts in terms of knowledge, networking, and state-of-the-art of the S&T outputs. These were important to a sector facing intense and increasingly global competition in addition to market and technology convergence at a time when companies were still recovering from the crisis in the sector in the early part of this decade and therefore had limited risk capital to devote to research.

In this context the IST Programme provided the actors with a crucial way to strengthen their knowledge and social capital and expand their technology platform. Participants consider the composition of the project consortia, including key research and industry actors, at European level and from different disciplines, suppliers and competitors alike, to be the major facilitator for these critical impacts.
The Programme also had strong impacts in the wider S&T community, integrating the research community and building foundations for standards development. In line with the objectives formulated in the calls, the research activities led to good results in the sphere of standardisation – even if they are slightly below participants’ expectations. One in five participants (20%) attributed high value to the formal and de-facto standards resulting from the projects and one in four (25%) considered them highly valuable inputs to national and European standardisation bodies.

In the mid 2000s, the main interest in the sector was broadband wireless access using frequencies over 20Ghz and below 11Ghz. Concerning the former, the Local Multipoint Distribution Service (LMDS), was considered to be a viable technology for fixed wireless, point-to-multipoint technology for utilisation in the last mile. The scope was to increase cell capacity (and hence the traffic band) using adaptive modulation and adaptive antennas. But LMDS, which was the great hope of many companies, was quickly made obsolete by competing technologies such as Wi-Max (a related technology) and in turn LTE (Long Term Evolution) which currently seems to be the most promising. The EC made the right decision in funding LMDS as part of a technology portfolio of projects. The IST Programme did not endorse any specific standard but funded projects that adhered to the overall concept and might solve specific problems (such as low-cost broadband access technology or broadband interfaces). Therefore, much of the research carried out enables companies to participate in the market irrespective of which specific technological solution that is finally industrialised.

Despite these highly positive outcomes of the Programme on participants’ capacities and competitiveness, exploitation of both the knowledge and technology gained was relatively low – and lower than for other Large Enterprises involved in FP6. Lack of investment is the key bottleneck, with many expecting that governments will go back to funding such infrastructures as they did in the more distant past. Close to half of the participants (40%) pointed to a lack of market readiness for technological innovation and lack of new large-scale markets as barriers for the attainment of economic impacts.
4 Key Systemic Facilitators

This Section of the report covers the importance and value of the tools for innovation that were set up by the Commission for the attainment of the Programme achievements and impacts outlined in the previous sections of this report. For this Section, we built heavily upon the input provided by the interviewees, in most cases validated by the survey respondents.

Section 4.1 highlights the importance of the collaborative research features of the IST Programme, while Section 4.2 looks into the research instruments deployed in FP6. Section 4.3.3 considers the role played by the research priorities defined by the Commission.22

4.1 Innovation based on Cross-fertilisation

In this section we give an overview of characteristics of the research consortia identified by the participants as increasing their research and economic competitiveness. It covers the value of collaboration in research between experts in the various S&T disciplines and between the different actors along the supply chain (section 4.1.1), the importance of fostering collaboration among competitors at European level (section 4.1.2), and the effects of the involvement of key players in the European markets/fields of research (section 4.1.3).

4.1.1 European Multidisciplinary & Collaborative Research

Gaining access to complementary expertise was a major driver for participation in FP6 for most participants - research, industry and public authority participants alike. Almost all industrial problems require multidisciplinary solutions, but this is especially the case in areas of convergence like ICT. Interviewees frequently stressed that multidisciplinarity was fundamental for innovation. Exchanging knowledge with organisations that had complementarity skills and knowledge enabled them to build critical mass. One interviewee said, “Multidisciplinarity was crucial in order to speed up the process of problem solving that would have been slower if only run at the national level”.

The Amigo project is a telling example of the importance of multidisciplinarity for the development of complex integrated systems.

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22 The detailed analysis of the importance of the multidisciplinary and collaborative character of the research and the involvement of the key players is reproduced respectively in Sections 9.1 and 9.2 of the Detailed Report (Annex 1). The detailed analysis in relation to the instruments can be found in Section 9.3.
The aim of the FP6 IST Amigo project (an IP) was to create a networked environment for ambient intelligence at home, where new applications and services could be developed. The project created a prototype of home system applications addressing home care and safety, information and entertainment, and extension of the home environment by means of ambience sharing for advanced personal communication. In a project like this, it was essential to gather behavioural scientists, hardware and software applications engineers, mathematicians and people who were very good at abstraction. A crucial competence was software architecture, which links everything together but is very hard to design.

Other examples of valuable multidisciplinary collaboration offered by our interviewees included: the cooperation between multimedia and semantic web specialists referred to in the previous section; bringing together software developers, marketing experts and human-machine interactions specialists to develop new kinds of digital maps; cooperation between engineers and legal specialists in order to understand constraints on the use of vehicle electronics imposed by law or related to risk and responsibility; combining knowledge of sensors and human factors in order automatically to detect people’s moods; cross-fertilisation among different disciplines – including Digital Signal Processing experts - to generate MIMO (multiple-input and multiple-output) antennas.

Knowledge gained in terms of technology and market intelligence was to be attributed especially to the involvement of the different actors along the value chain. Interviewees considered that the enhanced understanding of customer and supplier needs deriving from such collaboration in research and the validation of S&T solutions in different environments improved the quality of the research outputs and the likelihood of market success. The involvement of organisations based in different countries also enabled participants to improve their understanding of market and consumer differences in different European countries, ensuring the development of products and services with European market value. This is especially important in applications like e-health or e-government, which are nationally and culturally specific.

### 4.1.2 A Platform for Open Innovation

IST provided a unique platform – according to some interviewees, “the only one possible” – for ‘co-opetition’ among key industry players, i.e. the possibility for competitors to work together on aspects of common issues which are not only in the interest of the industry but also in the interest of citizens, such as car and road safety.

Making parts of the innovation process such as the identification of research directions and contributing to standards more open by involving competitors as well as partners allows industry to develop technological and market road maps that strengthen European competitiveness as well as serving the needs of the individual companies.
4.1.3 Involving Key Players

As mentioned in Section 1.2.4, the IST Programme in FP6 was characterised by a high level of participation by the key players in European and national markets; this included top European enterprises such as Philips, Siemens, STMicroelectronics, Nokia, Alcatel, and all major European telecommunication service providers; top research institutions participating include Fraunhofer, IMEC - Interuniversitair Microelectronics Centrum, the Deutsche Forschungszentrum für Kunstliche Intelligenz, the CNRS – Centre National de la Recherche Scientifique. There was also a relatively large number of SMEs, which were leading players in specific niche markets.

It needs to be stressed here that ‘key players’ do not forcefully stand for Large Enterprises or large research centres as the ones listed above. Key players are rather those actors – no matter whether large or small – that have the highest level of expertise for carrying out a specific task in the development of innovative products and/or services. Once again, the specific field of technology and/or market sector needs to be taken into consideration.

Section 3.2.1 highlighted that the IST Programme was an ideal platform for many companies to identify other industry actors with complementary expertise with which to set up collaborations to enhance their competitive advantage. The Programme’s ability to attract key players in the research and industry systems was fundamental to achieving excellence in the research. Participants made it clear that it is only interesting to collaborate if the best are involved, since results will eventually be used in competition.

Various studies financed by the Commission to analyse the characteristics, intensity, and dynamics of the collaboration networks created by the IST Programme over FP5 and FP6 have highlighted the importance of these key players for the creation and diffusion of knowledge. The studies indicated that key players - be they research or industry – “act as ‘gatekeepers’ at the crossroads of knowledge flows both within IST RTD networks and other innovation networks. These central organisations in a network generally serve to organise research and to facilitate the exchange of knowledge among more peripheral groups.”

‘Hub’ and Gatekeeper organisations that link strongly into both regional innovation networks and into the IST-RTD network were considered to play a vital role in regional deployment and exploitation of innovations.

The case study below illustrates the importance of the involvement of a key player among the public authorities for the efficiency of knowledge and technology transfer going beyond the FP6 project.

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Lombardy is one of the major regions of Italy and its RTD and innovation capacities are acknowledged as excellent. The regional healthcare policies and services are considered amongst the most advanced in Europe; its governance and organisational models, deployed ICT infrastructure and eHealth developments (e.g., the Electronic Health Records, ePrescription, professional and citizens health cards, telemedicine, etc.) are frequently proposed for consideration to institutional European players at any level of government.

The Lombardy Regional Ministry of Health transfers knowledge to communities of stakeholders that were not directly involved in IST activities via conferences and workshops. These are organised not only by project partners but also by allied organisations and European and International institutions. (Examples are eChallenges, eHealth Annual Ministerial Conference, World for Health IT). Most important, the RTD FP initiatives benefited additionally from the institutional activities of the Regional Ministry. These aimed to establish alliances with other European regional authorities and were major channels for ‘indirect’ knowledge transfer. MoUs dealing with healthcare and eHealth were signed with Regione del Veneto (2006), Région Rhône-Alpes (2008), Comunidad Autonoma de Andalusia (2008), and Regione Autonoma Friuli Venezia Giulia (2009); talks with Baden-Württemberg and Generalitat de Catalunya are currently in progress.

In terms of regional innovation, the RTD activities carried out by the Regional Ministry in the framework of the FPs are in general jointly performed with local providers – hospitals, general practitioners associations, research and training centres, ICT suppliers – because of their expertise in the relevant fields and in order to expand the impacts of inherent achievements across the region. Integration of the projects’ outputs within the regional healthcare system is ensured in the context of the multiannual Regional Social-Healthcare Plan (PSSR) where the project results are offered for incorporation into hospitals’ and healthcare services providers’ systems, as well as into the Regional Social-Healthcare Information System.

### 4.2 The Research Instruments

In this section, we look into the roles played by the different instruments for the Programme outcome and impact achievements, with a specific focus on the two new FP6 instruments, i.e. the Integrated Projects and Networks of Excellence.

In this Section we first consider the complementarities of the instruments deployed in FP6 (Section 4.2.1), then we look into the specific role of the different instruments for impact achievement. The Integrated Projects are covered in Section 4.2.2 and the Networks of Excellence in Section 4.2.3.
4.2.1 Complementarity among the Instruments

Our interviewees regarded the various instruments as complementary, responding to different needs in the various stages of RTD. The scope of the projects, and their alignment with the organisations’ needs, were considered the most important criteria for participation in one instrument rather than another. An interviewee stated, “The different instruments should be applied at different time periods of the project life cycle. They target different areas and go hand in hand. The key point is to choose the most appropriate instrument according to the changing needs of a long project lifecycle / research topic.”

These reflections seem to find their confirmation in the data regarding the profiles of the participants, their drivers for participation, and the type of research they conducted in the context of the project, as described in the sections below.

They are also in line with the conclusions of a 2009 study assessing the impacts of new FP6 instruments24 (at overall Framework Programme level) that stated, “The strength of the new instruments lies not only in their intrinsic abilities to contribute to the realisation of the ERA, but in their complementarity with the remainder of the research and innovation instruments at national and European level.”

4.2.2 The RTD Instruments: IPs and STREPs

The Integrated Projects (IPs) were a new type of instrument for funding collaborative R&D. They were designed to help build up the ‘critical’ mass in objective-driven research with clearly defined scientific ambitions and aims. They were significantly larger than previous projects, involving more people and higher budgets but also more freedom to evolve their work programme over time. Traditional R&D collaboration was continued in the Specific Targeted Research projects (STREPs) which were intended to support research activities of more limited scope and ambition. Integrated Projects more often involved longer-term research than STREPs (respectively ~60% and ~50% of the participants).

Many organisations – both Large Enterprises and SMEs - used both RTD instruments, confirming the above-mentioned concept of complementarity among the instruments. However, Large Enterprises showed a clear preference for Integrated Projects (~60% of the participations in RTD projects were in IPs versus ~40% in STREPs) and were more strongly driven by their goal to explore new technological paths as well as by goals in the economic/commercial sphere than their counterparts in STREPs. And they were more likely to contribute to developing standards.

SMEs opted more frequently for participation in STREPs (~60% of the participations in RTD projects were in STREPs versus ~40% in IPs). Interviewees attributed their preference to the SMEs’ averseness to risk taking and to the difficulties for SMEs to be visible in large IPs or obtain return on investment in participating. No patterns emerged from the data analysis that pointed at preferences for participation in IPs or STREPs based on the organisations’ industry sector of reference.

The Integrated Projects

Based on both the survey data analysis and interviews, in terms of impacts reached the overall picture emerging from this study confirms the positive conclusions of the before-mentioned 2009 study on the new FP6 instruments, i.e. “The case studies showed that the projects were generally flagships in their fields with main outputs of publications and new or improved techniques or processes, together with new knowledge and relationships.”

In the IST Programme, IPs acted as important ‘focusing devices’ for researchers and technologists - drawing attention to opportunities and problems that can be addressed through research and innovation and influencing the research and innovation activities of the participants. A major facilitator for this impact was the Programme’s ability to attract participation of the key players in these instruments.

Interviewees also regarded IPs as ideal platforms for building longer-term partnerships with other key players in the field; for innovation via co-opetition; for the implementation of strategic research that requires the involvement of multidisciplinary and multinational teams; for value/supply chain building; and for sharing knowledge about user and supplier requirements and needs. They were also more powerful arenas in which to work on standardisation than the STREPs.

As an interviewee said, “It is very important to have in place a value chain in which there are complementary roles (that then becomes a supply chain). The perfect project consortium is one in which all players are present, from technology suppliers to final clients. I think that a large company cannot avoid participating in IPs in areas in which they have or where they want to keep a relevant presence.”

Survey respondents said that the benefits deriving from such large-scale collaboration platforms (compared to the STREPs) included: establishing a critical mass of research; improved knowledge leading to or influencing reorientations of R&D strategies; research integration using shared tools and infrastructures (joint databases, platforms and test beds, were highly appreciated by the industry partners); high efficiency in creating awareness among industry communities; a particularly efficient platform for research-based organisations to establish longer-term strategic alliances with companies; and a large number of contributions to standards development.

For the research organisations, participation in IPs – more than in STREPs - led to a strengthening of their positions as ‘knowledge intermediaries’. On the one hand, their strategic alliances with industry/business participants were more often re-inforced; on the other hand, there was a strong influence on the reorientation of their R&D strategies, pointing at an improved alignment of these organisations’ research agendas with industry needs.


4.2.3 **Networks of Excellence (NoE)**

NoEs had as their objective to “strengthen S&T excellence on a particular research topic by progressively integrating the activities of network partners and thereby creating ‘virtual’ networks of excellence, while at the same time advancing knowledge on the topic.”

The overall majority of participants in the Networks of Excellence were research-based organisations – with a high-level participation by Higher Education institutions.

In relation to the NoEs, the above-mentioned 2009 report on the impacts of the new instruments in FP6 considered, “The main additional concerns for the NoEs were that the concept of durable integration was not well understood at the start of the Programme, and the networks were lacking in real continuation or exit strategies. A further issue raised was that NoEs could not directly fund ‘traditional’ research activities, although they could and did fund research on supporting or integrating topics.” The study however considered that, “Although the Networks of Excellence have received a mixed press generally, the level of support from participants was generally high, and it appeared that sustainable effects of participation would emerge”. An overall finding was that, “The NoEs have proved particularly positive in the development of interdisciplinarity and overcoming fragmentation in particular areas and also in supporting new researchers through new knowledge, relationships and mobility.”

Also in this case, our findings (described below) are in line with the picture emerging at overall FP6 level. In the view of the participants in FP6, the Networks of Excellence were highly effective in strengthening the research system. They acted as platforms for knowledge exchange, strengthening research communities and integrating fields of research.

Throughout the preceding sections, evidence is provided on the contribution of NoEs in creating knowledge and tools enhancing research efficiency, influencing R&D strategies and education, and generating large knowledge spillover effects - both in terms of publications and conference papers and related to the transfer of researchers to institutions in other European countries or to industry.

Section 2.1.1 also highlighted the role of NoEs in the field of Intelligent Interfaces and Bio-informatics in enhancing knowledge and R&D capabilities, playing a catalytic role in building and sustaining new relationships for future multidisciplinary cooperation.

Participants in NoEs attributed these impacts on their R&D capabilities to the essential characteristics of NoEs, namely that they let them work with academic research institutions, provided access to international scientific networks, and involved key European research actors.

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4.3 The Research Priorities

This final section considers the importance of the research priorities defined by the Commission.

In Section 4.3.1, the findings on the created synergies with other research programmes are reported – with a specific focus on national research programmes. Section 4.3.2 considers the efficiency of the research priorities set in the SO Clusters in achieving their strategic objectives. Last but not least, Section 4.3.3 covers the alignment of the research priorities with industry research agendas.

4.3.1 Enhancing Synergies with other Research Programmes

Quantitative and qualitative data pointed at a significant impact of the IST Programme on other research programmes - and especially national research programmes – and viceversa, thanks to a direct and indirect transfer of knowledge and technology.

Research in FP6 was characterised by a relatively strong level of continuity of research previously funded under national programmes (indicated by ~25% of respondents); national programmes also constituted an important (potential) source for the funding of the RTD activities that followed up the IST-funded research (indicated by ~60% of the participants).

Also in this case, the concept of complementarity was often highlighted. Interviewees indicated especially the different time-to-market characteristics of ICT-funded versus national-funded research.

At a more strategic level, interviewees provided examples where research directions initiated in national-funded research programmes are then taken up in the EU ones and vice versa. They considered an increasing influence of the IST Programme on national research agendas; an example brought forward was the creation of technology platforms in various member states ‘mirroring’ the ETPs. According to some, the presence of the over-arching Ambient Intelligence vision helped promote this complementarity between national- and EU-funded research, partly because it makes it possible to communicate an inherently complex set of activities.

This coherence between the IST research programmes at European and national level was confirmed by the FISTERA project, which concluded that, “the need to move towards a knowledge-based society and economy was largely agreed across different social levels, irrespective of Member State. Practically all the Member States of the enlarged Europe shared the same vision and concerns for the long-term future for IST despite their different cultural roots and dissimilar economic conditions.” In other words, there is considerable similarity between the research agenda of the IST Programme and that collectively defined by the strategies of the Member States.

28 “Foresight on Information Society Technologies in the European Research Area (FISTERA) - Key Findings”, European Commission, JRC/IPTS, 2006
4.3.2 Research in the SO Clusters

Research conducted in the specific Strategic Objective Clusters was expected to contribute in different ways to the overall achievement of the Programme’s strategic objectives:

- “Applications-led Research” aimed to provide continued support to leading and challenging applications responding to emerging needs
- Research in “Established Fields” was expected to reinforce leadership where Europe already possessed demonstrated strength
- Research in “New Opportunities” aimed to support European industry in exploring new opportunities that would lead to future markets

The impacts actually achieved by the research activities conducted in the first calls of FP6 were in line with these expectations. Impacts on knowledge in S&T fields were high overall but more pronounced for the Established Fields and New Opportunities SO Clusters; impacts on market development were overall more limited, but however at a higher level in the Applications-led research SO cluster.

These findings on impacts in the SO Cluster are illustrated in Exhibit 17, below. For this graph, we considered the participants in the different SO Clusters and mapped their impact indications (expressed in average values) in relation to knowledge and market development. In fairness, such a general view cannot do full justice to the impacts of the Programme. However, a more detailed analysis per single Strategic Objective could not be implemented in this study due to the small number of projects so far completed. Such analysis should become possible later in the Programme.

Exhibit 17 Impacts on knowledge & market development in the SO Clusters, all FP6 projects

Size of bubbles = share of funding for research in the SO Clusters that concluded their activities by the end of 2007
Source: WING FP6 Impact Analysis, April 2009

Impacts reached in the SO Clusters were in line with the expectations.
Of course, analysis based on the Strategic Clusters, which mirror the administrative structure of the Commission, cannot adequately reflect impacts on specific industry sectors and thus ultimately on innovation in society. Early adopters and suppliers involved in the Programme, tended to participate in projects spread over a range of Strategic Objectives and even Strategic Objective Clusters. Their participation is of course driven by their own strategic research agendas and innovation needs, rather than the policy objectives of the Commission and their use of results from the projects is driven by their market strategies, which do not necessarily coincide with the markets 'officially' targeted in the context of the IST-funded project.

It should be pointed out that this ‘transversal’ character of the participations at organisational level is fully in line with the strong focus in the Programme on an enhanced integration of technologies and systems.

4.3.3 Alignment of Research Agendas

An overall view emerging from this study is that the alignment of the Commission research priorities and instruments with participants’ research agendas and industry needs was a major facilitator for impact achievement – and possibly the most relevant one. Companies, Public Authorities, and research organisations who were interviewed all indicated that they participated in the Programme “only when it fits our own goals”, a finding that is confirmed by the large number of organisations in our survey – from all stakeholder groups – that indicated the (very) high strategic importance of the research for their organisation.

Participants in the IST Programme – under previous FPs and even more so under FP6 – persistently stress the importance of its role as a platform for building multidisciplinary collaborative research and strategic partnerships. They claim the IST Programme plays a catalytic role in letting them generate progress in science and technology, R&D and economic competitiveness. As one interviewee put it, “The project context is even more important than its content”.

This long-term appreciation of the participants is consistent with the concept of the Innovation System where knowledge and innovation are created thanks to the inter-linkages among the various actors. The only actors that seem to fall somewhat outside of these innovation-creation mechanisms created by the Programme are the Public Authorities involved as users in the RTD projects.

Of equally great ‘systemic’ relevance is the high-level alignment of the IST research focus with – current and future - industry needs; this aspect was repeatedly stressed during our interviews and resulted also from the analyses on impacts reached in various industry sectors, included in the previous Sections. The major criticism we encountered was voiced by SMEs considering that limited attention was dedicated to the development of business models.
This high level of alignment is illustrated in the case study below.

A major paradigm shift occurred in the field of automotive electronics during FP6 thanks to the findings of IST-funded projects. It was discovered that a safe and intelligent car was impossible to develop if it had to be autonomous. Without communication between vehicles, the safe car would remain a dream. The Commission and the industry agreed that it was pointless to persist with a paradigm of preventive safety applications and technologies that had reached its limits. This led to a paradigm shift in the last calls of FP6, when the cooperative intelligent vehicle and vehicle systems were adopted as the core vision. Thanks to the big advances of telematics (i.e. the convergence of telecommunications and information processing, which in the automotive sector includes inventions such as the emergency warning system, GPS navigation, integrated hands-free cell phones, wireless safety communications and automatic driving assistance systems), this vision is still relevant for the entire industry. All the automotive industry and its suppliers shared the above described paradigm shift.

Towards the end of the 6th FP, one company we interviewed shifted from preventive to cooperative safety systems, using telematics. Thanks to their participation in the FP6 projects, the researchers saw the feasibility of certain technologies (there was some mistrust even internally about the possibilities offered by the new technology) and the company now has a complete product line built on IST project results. The interviewee finally stated, “The IST Programme was very important. Though it is difficult to quantitatively assess its contribution to industry competitiveness, it taught us to work in a different way, to work in teams, to accept co-operation and collaborate on common interest issues with competitors and other stakeholders. Furthermore, it helps us not to get stuck in our daily routine. In conclusion, if the IST Programme didn’t exist, it would have to be invented!”
5 Concluding Remarks

In this final Section, we first briefly summarise the impacts of the IST Programme identified in the report. Then we discuss the systemic character of the Programme, suggesting that this has been key to its success.

5.1 Impacts

The IST Programme has had substantial impacts across its Strategic Objective themes, producing knowledge capital, human capital and social capital that have supported the competitiveness of the European ICT sector and helped integrate the industrial and research sector R&D communities that underpin it.

The research and innovation system is complex and non-linear. Some of the time the constants involved are very long, and the student of impact is not able to do controlled experiments. Hence, our analysis of the impact of the IST Programme is hedged about with uncertainties, especially as it was done so soon after the relevant projects were completed. Nonetheless, our study strongly suggests that the Programme has had very significant impacts on European research and innovation systems.

The IST Programme has created knowledge across all its Strategic Objective themes, increasing the ‘knowledge capital’ of the industrial and research sectors in Europe. Much of the knowledge produced is of long-term use but there were also outputs usable directly by companies in innovation. IST’s knowledge contributions appear particularly important in areas of convergence, where different disciplines and markets are coming together. It had a significant effect on increasing the competitiveness of the European ICT industries.

Knowledge is far from being the only result of the Programme, however. In addition to building the stock of research tools and longer-term knowledge needed for competitiveness, generating significant amounts of intellectual property and supporting standards development, it built participating organisations’ research and innovation skills, increasing their R&D-skilled human capital in areas of relevance to industrial needs, increasing the availability of industry-relevant education and training up to PhD level and assembling a critical mass of R&D skills and activity in certain areas.

The IST Programme has had important effects on the way organisations work. Through road mapping and large projects such as some of the IPs, it has aligned research agendas across the research and industrial sectors, orientating them towards present and future markets. It has introduced more open innovation processes including various forms of networking and co-opetition with competitors. It has established enduring strategic partnerships. So, it has increased the European ICT R&D community’s social capital as well as its knowledge and human capital.
There have also been important spillover effects. These include obvious ones such as information spillover via papers and publications but also spillovers through human mobility (especially to industry), demonstration effects where IST knowledge spreads by imitation and contributing to educational curricula.

The IST Programme has attracted the key players from European ICT industry and research. These are not only the famous names but also less well-known specialist players. It has benefited from large numbers of SME participations, often strengthening their positions as leaders in their niches and linking them to strong potential partners.

5.2 The Systemic Character of the IST Programme

A key element in the success of the IST Programme has been its systemic character, touching upon and integrating many parts of the research and innovation system in an effort to increase overall performance. This systemic character is as important in the design of the Programme as in its implementation. The Programme has been able to be effective because it builds upon a shared, market-focused vision that derives from participants’ own interests and because it empowers them to implement the vision in the detail. Such a virtuous circle is to a degree risky because it contains a potential for lock-in, but properly governed it is very powerful.

There has been a long-term evolution in innovation policy away from simple and towards complex, systemic interventions. Its scale and scope allow the IST Programme to act across significant parts of the research and innovation system, accounting for its effectiveness to a considerable extent.

A key policy implication of the National Research and Innovation System perspective is that single-point interventions are unlikely to have much influence on overall performance, except where they unblock individual bottlenecks that constrain that performance. Thus, if the system is unable to do research because too few PhDs are produced, then funding more PhD education is likely to increase overall performance. But, in the absence of a bottleneck in fundamental knowledge, increasing the amount of money spent on basic research is not likely to make much difference to innovation. Since systems performance depends on the quantity and quality of activity at multiple points and on the effectiveness of networking and linkages between different parts of the system, then effective interventions are more likely to be multi-point than single-point.

The FP6 IST Programme had just such a systemic character, influencing performance in the company sector, the research and higher education sector, and parts of what Exhibit 1 refers to as ‘infrastructure’, in this case the parts concerned with standards, norms and IPR. Such multi-point intervention works best if relevant policies are ‘joined up’. The example of technological and commercial progress in eHealth being impeded by a lack of agreement about standards shows that technology push is not enough – other policies have to be aligned.
It is axiomatic in innovation systems thinking that innovators do not innovate alone. This impact study has highlighted the importance of the Programme’s approach to this reality, which involves the promotion of networks and strategic relationships, mobility, including complete value chains so that whole sub-systems of innovation are affected by projects and so that the power of producer-user links that are so important in industrial markets is drafted into the projects. Multidisciplinarity is another key requirement for innovation that the Programme also encourages and which, by definition, is not a solo activity.

The IST Programme shared – and to a degree led – the growing globalism of FP6 through the focus on global standardisation processes and also via increasing non-European participation in the Framework. We have not in this study touched greatly on the issue of more global participation in the Framework or how the IST Programme strategy should adapt to the fact that most of the key industry players are global in reach and often in the way they locate R&D. But clearly this question has to be addressed.

In the past, the state has played an active and often successful role in innovation where it has itself been the major customer, as in telecommunications, nuclear energy, railways and parts of defence where ‘development pairs’ involving a supplier and a state customer have created sometimes radically new product technologies. However, since a series of (mis)adventures in the 1960s to the 1980s where states tried unsuccessfully to foster similar innovations in industries where buyers are private or markets cannot be controlled, a strong orthodoxy has emerged that the state should not ‘pick winners’. In the meantime, liberalisation, privatisation and changes in the rules about state aids and trade have seriously reduced the scope for new development pairs to emerge or for old ones to continue to operate. The state is today regarded as intervening legitimately in R&D in order to generate spillovers and reduce innovation risk. However, the IST Programme provides another type of intervention that may be at least as important as the subsidy the Programme provides: namely, signalling and organising consensus.

This type of intervention is not new. Japan’s Ministry of International Trade and Industry organised various ‘visions’ in parts of the electronics industry in the 1970s and 1980s, in which competing manufacturers together developed road maps for new products. Coordinating expectations about the rate of market development and the consequent demand for inputs such as electronic components had a powerful influence. Notably, consensus on a high rate of market growth involved consensus on a high rate of investment, as a result of which Japanese suppliers reaped scale effects more quickly than foreign competitors, which they could then translate into self-reinforcing price advantages. Nor is it new to connect this type of visionary consensus building to research funding. This was an important ingredient in the ramp-up of Swedish mobile communications research, education, development and production capabilities from the latter 1970s. It has to a degree been built into the IST Programme since ESPRIT in the mid-1980s and RACE shortly thereafter. However, it seems that it was particularly well done in FP6, where ISTAGs’s AmI vision has provided a high degree of consensus and coherence to an extremely wide-ranging programme of intervention.
This strategy process used the AmI vision as a focusing device, signalling what technological (and in some cases non-technological) developments were needed in order to reach the goals. These goals were grounded in markets and in industrial participants’ own perceptions of the research results and innovations necessary for competitive success. Research-sector participants drawn into the Programme participate on the basis that their research goals align with the needs of their industrial partners. In line with its legislative aim, FP6 tended here to ‘structure’ the European research effort. While basic research enthusiasts often decry the Framework Programme as ‘top down’, in fact – at least in the FP6 IST Programme – its design is consensual. It involves a virtuous circle in which the beneficiary industrial and research communities provide key inputs into a strategy that is then reflected in Programme design and that in turn is implemented by the stakeholders because it reflects what they already want to do.

A major challenge for the policymakers here is to keep the process honest, avoiding pressures to hand over parts of the agenda to special interest groups. In this, the pressure of global competition supports them. If they permit rent seeking, Programme impacts will shrink and the rent seekers themselves will not prosper in the longer term.

The signs so far are that this virtuous circle of agenda-setting and implementation is repeated in at least some Integrated Projects and many people claim also in the European Technology Platforms, JTIs and Article 169 consortia that are emerging in the wake of FP6. Even more than at the level of the IST Programme, these new arrangements involve a risk of lock-in and will require both transparency and to be challenged if they are to avoid the traditional, self-destructive vices of European oligopolies.

The recognition that most technological and industrial development is incremental in character, to the extent that it can even predictively be road mapped, is also old. It was enshrined in Bell Labs’ famous norm that its researchers should themselves decide how to spend 10% of the resources. The US Department of Defense institutionalised the idea in the VHSIC programme in the 1980s, which allocated 10% of its $200m budget to what the Pentagon described as ‘lunatic fringe’ research\textsuperscript{29}. The IST Programme’s equivalent – the Future Emerging Technologies sub-programme – cannot be evaluated using the same methods or time frame as the rest of the Programme. But the effectiveness of its intended ‘change agent’ role in the Framework and the extent to which this function should be de-coupled from the industry-centred processes that determine the main thrust of the Programme could bear closer examination.

\textsuperscript{29} Erik Arnold and Ken Guy, Parallel Convergence: National Strategies in Information Technology, London: Frances Pinter, 1986
It is in the nature of a consensual activity like the Framework Programme that it can only reflect ideas and interests that are to a degree established. This is evident in the great importance of standards in the IST Programme, which is not only a sign of success but also a sign that the Programme tackles many areas that are quite mature. Shifting Europe towards a more North American pattern of reliance on new industrial and markets for innovation and growth may – if that is possible or desirable – require very different kinds of intervention.

However good the AmI vision may have been, it could not predict in detail what would be needed for it – or something like it – to be implemented. While individual Calls and Work Programmes are much more detailed than the vision, they too are not in a position to specify the details of the plan for realising the vision. These details are largely worked out by the research and economic actors themselves, hence the repeated stress in this report on the IST Programme as primarily being a producer of intermediate knowledge outputs that contribute to the stock of usable knowledge applied in product and process development. This stock of knowledge gives the beneficiaries the ability to pursue their own goals through the twists and turns of development and market competition. The strategy does not have to pick the winners – it has to pick the areas of knowledge that are likely to contribute to developing the winners, a difficult but nonetheless far more tractable task.

Traditionally, we consider impacts of R&D on the research and industrial communities via their effects on institutions: companies; research groups; institutes; Universities. It may, however, also be useful in future to consider their impacts on ‘Knowledge Value Collectives’, i.e. the communities of people who –irrespective of where they work – effectively comprise a virtual community that works together in an area of knowledge. Such collectives are of interest especially because they are likely to survive longer than individual organisations – especially companies – yet they are the stuff of which companies are made. They are capable of persisting through events such as the departure of computer companies from Ireland to the Far East, one result of which has been the strengthening of a vibrant software and systems industry in Ireland. This is a systemic dimension that has barely been explored to date.

The FP6 IST Programme, then, has been systemic both in its design and governance processes on the one hand and in its implementation on the other. This systemic character has shaped it relevance and its effectiveness. Future impact studies should build on this systemic character and could usefully combine an overall assessment of impact with further exploration of the micro-phenomena that underlie it, making the systemic character of the Programme’s design and implementation yet clearer and exploring opportunities for further improvement.

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