Ex-post evaluation of ICT research in the Seventh Framework Programme

Final Report prepared by DG CONNECT

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ACRONYMS

AAL:	Ambient Assisted Living
ACC:	Accession countries
AHA:	Active and Health Ageing
ARTEMIS:	Advanced Research & Technology for Embedded Intelligence in Systems
ASS:	Associated Countries
BEREC:	Body of European Regulators for Electronic Communications
CA:	Coordination or networking actions
CIP:	Competitiveness and Innovation Framework Programme
CP:	Collaborative Project
CSA:	Coordination and Support Action
ECSEL:	Electronic Components and Systems for European Leadership
EIP/AHA:	European Innovation Partnership on Active and Healthy Ageing
EPO:	European Patent Office
ERA:	European Research Area
ETP:	European Technological Platform
FIRE:	Future Internet Research and Experimentation
FP:	Framework Programme
FET:	Future and Emerging Technologies
GOV:	Governmental organisation
HES/REC:	High Education Institutions and Research Centres
HBP:	Human Brain Project
HPC:	High Performance Computing
I4MS:	ICT for Manufacturing SMEs
ICT:	Information and Communication Technology
INFRA:	Infrastructural projects
IP:	Large scale integrating collaborative projects
IPR:	Intellectual Property Rights
IST:	Information Society Technologies
MS:	Member States
NCP:	National Contact Point
NoE:	Network of Excellence
NUTS:	Nomenclature of Territorial Units for Statistics
PO:	Project Officer
PPP:	Public Private Partnership
PSP:	Policy Support Programme
R&D:	Research and Development
RI:	Research Infrastructure
SA:	Specific support actions
SME:	Small and Medium Enterprises
SICA:	Specific International Cooperation Actions
SO:	Strategic Objective
STREP:	Specific Targeted Research Projects
TC:	Third Country
JP:	Joint Programme
JTI:	Joint Technology Initiative
JU:	Joint Undertaking

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Introduction

The report covers the ICT Theme within the Cooperation Programme, eInfrastructures within Capacities Programme, the Joint Technology Initiatives (JTIs) ARTEMIS and ENIAC, the Future Internet Public Private Partnership, the Ambient Assisted and Living Joint Programme (AAL JP).

The main sources of this report are:

- Statistical data on the Programme, based on the MIS database. The data refer to the period 2007-2014 (July)[1];
- A support study[2] commissioned by DG CONNECT. The study reviewed the intervention logic, evaluation criteria and questions, carried out a network analysis of FP7 ICT and FP6 IST, carried out interviews with 70 participants (representatives of organisation receiving funding during FP7 ICT) and 30 stakeholders[3], and processed final project reports to extract structured information self-reported by project coordinators[4].
    - *Limitations: At the time the study was carried out, 1,292 of 2,452 funded projects were completed (53%). The study examined 1,159 reports (47% of the projects funded), but could extract information only from 821. Therefore the assessment on the projects result is partial (it covers only one third of all the projects funded). The extraction of information from the final reports also proved difficult, due to the different reporting methods (the standard template was not followed by all projects coordinators). Also, due to the time lag for effects to manifest, the information from the final report is likely to not capture the effects occurred afterwards but still attributable to the funding received under FP7 ICT. All the above makes the information from this source partial;*
    - *The Network Analysis could only partially compare FP6 with FP7;*
- DG CONNECT self-assessment: 24 interviews were carried out with DG CONNECT Directors and Heads of Unit responsible for research. The section on results in specific research areas relies mostly on this source;
- Study on "Analysis of publications and patents of ICT research in FP7"[5]. The study analysed data resulting from annual surveys of project coordinators carried out by DG CONNECT over the period 2008-2013 and validated the responses against Elsevier's Scopus database, a Scopus Custom Data set (for publications), EPO's PATSTAT database and Espacenet (for patents). Further, the study compared the outputs of FP7 funded projects (Focal sample) against a similar sample of publications and patents (Control sample);

[1] http://ec.europa.eu/digital-agenda/en/research-and-innovation-analysis-and-data.

[2] Study on "Support to the ex post evaluation of the ICT research in ICT FP7". SMART 2013/004, carried out by PwC and OpenEvidence.

[3] These included: Policy officers, ICT Committee Members/Research Infrastructures Committee Members, IST Advisory Group (ISTAG) and CONNECT Advisory Forum (CAF) Members, National Contact Points in particular on access to ICT FP7 funding and Independent experts (observers, evaluators).

[4] Projects managed by DG CONNECT are not in SESAM Research Performance and Impact Reporting tool (RESPIR), the online reporting tool reading and processing data on approved FP7 projects' final reports released by DG RTD in 2012.

[5] Jacob, J., Bulat, S., Smirnov, E., Wintjes, R., Surpatean, A., Notten, A., & Sasso, S. (Forthcoming). Analysis of publications and patents of ICT research in FP7. Brussels: European Commission SMART 2011/0039.

- *Limitations: data is based on voluntary self-reporting, therefore information is not available for all funded project, and not for all the funding years*[6]*. Projects were surveyed up to December 2013, therefore outputs of projects not yet started, or recently started is likely to not be captured. Also, given the time for publications to be published and patents to be applied for, data is likely to not cover the full outputs;*

- The Interim evaluation of the ICT research in FP7[7];
- The "*Evaluation of Pertinence and Impact of Research Infrastructure Activity in FP7*"[8] covering eInfrastructures;
- The final evaluation of Ambient Assisted Living Joint Programme[9];
- The First and Second Interim Evaluations of ARTEMIS and ENIAC Joint Technology Initiatives[10];
- The First Interim Evaluation of Future Internet Public Private Partnership[11].

The full set of documents consulted for this study is reported in the references.

Disclaimer:

At the time of writing, 47% of projects are still open and running. Moreover, there is always a time lag between the completion of each project and when outcomes and impacts manifest themselves. Therefore, the evidence presented in this report can only reflect partially the overall achievements of the FP7 ICT programme.

[6] Out of 2,448 projects funded (ICT Cooperation and e-Infrastructures within Capacity), 1,761 (72% - representing 74% of funding) responded to the survey, 1,336 (55%) reported output, validated for 1,160 (47%) projects, accounting for 55% of funding.

[7] Bravo, A., León, G., Luukkonen, T., Raffler, H., Truvé, S., Turk, Z., Wright, S., & Arnold, E. (2010). Interim evaluation of the ICT research in the 7th Framework Programme. Catalysing European Competitiveness in a Globalising World. Brussels: European Commission.

[8] Technopolis-Empirica Consortium. (2014). Evaluation of Pertinence and Impact of Research Infrastructure Activity in FP7 - EPIRIA. SMART number: 2012/0045.

[9] Busquin, P., Aarts, E., Dózsa, C., Mollenkopf, H., Uusikylä , P., & Sharpe, M. (2013). Final Evaluation of the Ambient Assisted Living Joint Programme. Brussels: European Commission.

[10] Bernotat, W., de Prost, C., Eckstein, E., Georghiou, L., Luukkonen, T., Malcolm, B., Potier, D., & Sangiovanni-Vincentelli, A. (2010). First Interim Evaluation of the ARTEMIS and ENIAC Joint Technology Initiatives.

Goetzeler M., Arden W., Dormoy J., Jansz M., Luukkonen T., de Prost C., Sangiovanni-Vincentelli A. and C.D. Wright (2013), Second Interim Evaluation of the ARTEMIS and ENIAC Joint Technology Initiatives.

[11] Georghiou L., Asimakopoulou A., Bel P, Vickery G, and B. Malcolm (2012), Interim Assessment of the Future Internet Public-Private Partnership.A second interim evaluation is currently on-going.

Rationale

Rationale and objectives

Under FP7, the objective of **Information and Communication Technologies** (ICT) research was to improve the competitiveness of European industry as well as to enable Europe to master and shape the future developments of these technologies so that the demands of its society and economy could be met. FP7 funded research in ICT aimed at helping European leadership in generic and applied technologies, stimulating and driving innovation through ICT use, and aspired to transform ICT progress into benefits for all European stakeholders, including citizens, businesses, and governments. Along the same lines of previous programmes, the FP7 was launched as a programme supporting pre-competitive basic research with the topic of innovation being mentioned among many others. Ever since the launching of the FP7, however, the policy emphasis has gradually moved on the need to increase competiveness through the creation of a European competitive innovation system[12]. After 2010 there has been an attempt in the framing the new calls and related expected impact to add emphasis to the realisation and commercialisation of innovative products. In fact, the Europe 2020 strategy recognised low investment in R&D and innovation and insufficient use of ICT as two structural weaknesses in European competitiveness. It is for this reason that the Digital Agenda for Europe and the Innovation Union were created with the aim of boosting research, development and deployment of ICT.

ICT is as a key engine of growth given its impact on productivity and innovation across manufacturing and service sectors. The ICT sector has also been identified as a potential major player in the fight against climate change, in particular its role in improving energy efficiency. Societal challenges such as the ageing population, sustainable health and social care, inclusion, education and security will also govern policies and drive economic and societal development for the decades to come. ICT R&D plays a major role in providing responses to such challenges. The impact of ICT on social behaviours, on democratic processes and on creativity will also continue to grow with the wider diffusion of web-based social networking and user generated content and services, driven by the roll-out of broadband. All these **industrial, economic, environmental and societal challenges** have been appropriately addressed through eight challenges[13] funded by the ICT Cooperation theme of FP7:

- ICT Challenge 1: Pervasive and Trusted Network and Service Infrastructures
- ICT Challenge 2: Cognitive Systems and Robotics
- ICT Challenge 3: Components and Systems
- ICT Challenge 4: Digital Content and Languages
- ICT Challenge 5: ICT for Health, Ageing Well, Inclusion and Governance

[12] New vision for the ERA (European Council, 2008), the new 2020 Strategy (European Commission, 2010d), the Digital Agenda for Europe (European Commission, 2010b), and the Innovation Union (European Commission, 2010c).

[13] The ICT Work Programmes for 2009-10 and for 2007-08 were divided into seven challenges and research into 'Future and emerging technologies' as Challenge 7 of these Work Programme (ICT for independent living, inclusion and governance) moved to Challenge 5 in the Work Programme 2011-12, and 'ICT for Learning and Access to Cultural Resources' was added to the list of challenges.

- ICT Challenge 6: ICT for low carbon economy
- ICT Challenge 7: ICT for Enterprise and Manufacturing
- ICT Challenge 8: ICT for Creativity and Learning

In addition to the above, specific challenges address International cooperation and horizontal actions. The objectives of these themes were designed to address the above needs, and for the majority they are still relevant today, and will be continued to be tackled in H2020.

The various technological domains funded under FP7 ICT are different regarding the state of the art of the scientific and technological development, the market maturity, and the balance of actors engaged. Each challenge of the Work Programme has therefore a distinct research/technological oriented focus, outputs, outcomes and impacts. The challenges relate to concrete tasks and measures that are planned for distinct technologies, markets, and societal challenges, whereas increased quality in ICT research, an upgrade of human capital and skills, and reinforced coordination are common to all specific challenges (Dinges et al., 2011). Table 3 summarises the objectives by challenges, the specific objectives as from the Work Programmes, the Technological fields and market areas of relevance, as well as the major societal needs addressed by the FP7 ICT funded research.

In addition to the above, the **Future and Emerging Technologies** (FET) scheme aimed at laying new foundations for future ICT by exploring new unconventional ideas that can challenge the understanding of the scientific concepts behind ICT and can impact future industrial ICT research agendas[14]. The activities within the Cooperation specific programme both supported and were supported by other specific programmes in FP7, such as the 'Capacities' programme - particularly with regard to **eInfrastructures**[15]. The main objective of this scheme was to strengthen research by fostering the further development and evolution and global connectivity of high-capacity and high-performance communication and grid infrastructures. This was expected to empower researchers with an easy and controlled online access to facilities, resources and collaboration tools and to foster the emergence of new working methods, based on the shared use of resources across different disciplines and technology domains, reinforcing European computing capabilities (Technopolis-Empirica, 2014). The eInfrastructures scheme was implemented by means of a set of sub-schemes, whose objectives are summarised in Table 1.

Following a path already started in FP6[16], FP7 put stronger emphasis on the creation of synergies and enhanced integration between private and public R&D spending, thus aiming at integrating private and public research efforts. This has been done through the European Technology Platforms (ETPs) and the **Joint Technology Initiatives** (JTIs), aimed at combining private sector R&D investments and/or national and EU R&D funding involving Public-Private Partnerships (PPP). JTIs funded large-scale multinational R&D in areas of major interest to European industrial competitiveness: Embedded Computing Systems

[14] FET projects aim at the realisation of bold ideas involving high risks through high-quality, long-term, visionary research with sound and well-targeted objectives. It has no pre-defined Work Programme and is open to any research related to ICT. As such, the FET scheme is very different from the IPs and STREPs.

15 Part of I3 Integrating Activities within Research Infrastructures.

[16] As illustrated by a DG CONNECT official, tracing back the evolution of the framework programmes, it can be noted in FP4 the activities were closer to the market, in FP5 there was a certain fragmentation, with smaller projects funded that did not lead to much impact. In FP6 the situation was reversed, with projects becoming bigger in size, and effort to consolidate ERA, NoE, and the integration of more industrial research.

(**ARTEMIS**) and Nano Electronics (**ENIAC**)[17], with the aim of to integrating in a pan-European strategic programme, research and technology development in these fields. The **Ambient Assisted Living** (AAL) Joint Programme (joint research undertaken by several Member States under the Article 185 of the EU treaty[18]) represented a new joint R&D funding activity implemented by 20 EU Member States and 3 Associated Countries with EU support. It aimed to use intelligent products and provide remote services to extend the time elderly people can live independently in their home environment. The Programme addressed the challenges and opportunities brought about by the demographic change and ageing in Europe for the citizens, the social and healthcare systems, the industry and the European market.
The FP7 ICT has preserved some continuity, as many of the initiatives supported have their roots in earlier programmes, and has shown responsiveness to emerging needs, by introducing new instruments such as the three major PPPs on Energy-Efficient Buildings, Green Cars and Factories of the Future. They were launched as part of the European Economic Recovery Plan[19] in 2009 as a response to the financial and economic crisis. In May 2011 the **Future Internet (FI) PPP** was also launched, focussing on industrial innovations stemming from the internet as part of the Commission economic recovery initiatives. The objective of the FI-PPP was to advance Europe's competitiveness in Future Internet technologies and to support the emergence of Future Internet-enhanced applications of public and social relevance. FIWARE, an open, demand-driven platform for applications development, was created and is available now as open source and it is currently in the second (sectorial large trials) and third phase (support to start-ups, SMEs and web-entrepreneurs and their ideas granted through a professional network of 16 accelerators)[20].

The FP7 ICT worked on the approach of implementing **strategic roadmaps**, but also kept an open part for **emerging ideas**. The main example of this is the combination of the FET Open (bottom-up) and Proactive (top-down) schemes, bridging between excellent research and future technologies. The open scheme (FET) has influenced very much the thinking of H2020, not only with a focus on ICT but multidisciplinary. At the beginning of FP7 in 2007, FET was a relatively small part of the programme supporting long-term, risky and visionary research linked to ICT. In H2020, the FET scope, visibility and the budget has increased considerably[21]. The FP7 ICT Programme has also captured bottom-up, sustainable social innovation (e.g. Collective Awareness Platforms), and introduced funding methods that can better address emerging challenges (FET Flagships). Some of the demand side instrument such as Pre-Commercial Procurement (PCP) and Public Procurement of Innovative solutions (PPI) started in FP7 and prepared the ground for H2020 (e.g. for societal challenges).

Moreover, FP7 itself stands alongside other EU programmes that are aimed at enhancing European growth, competitiveness and employment such as the Competitiveness and

[17] ARTEMIS and ENIAC are Joint Technological Initiatives organised as tripartite (involving industry, Member States and the European Commission) Public Private Partnerships. JTIs are closely linked to the work of European Technology Platforms. In a small number of cases, European Technology Platforms achieved such an ambitious scale and scope that they required the mobilisation of large public and private investments as well as substantial research resources to implement important elements of their Strategic Research Agendas. The overall contributions for ARTEMIS were anticipated to be €2.5 billion and €2.8 billion for ENIAC, out of which about 1/6 originates from the ICT Theme of FP7. See Table 4 for the funding structure.

[18] Formerly Article 169.

[19] Communication from the Commission to the European Council - A European Economic Recovery Plan (COM/2008/0800)

[20] At the time of writing the second interim evaluation of the Future Internet PPP is ongoing. The first interim evaluation was completed in 2012.

[21] In H2020 €2.6 billion have been earmarked for FET.

Innovation ICT Policy Support Programme (CIP-ICT PSP) focused on take up of technology, and Structural and Cohesion Funds for regional convergence and competitiveness[22].

As pointed out by DG CONNECT officials, the rationale for funding industrial areas in the programme is to offer the industry the possibility to explore new areas and new technologies with potential partners, **reducing the research risk** that they would support on their own[23]. In the semiconductors sectors, for instance, companies spend on average 15-20% of their turnover on R&D, therefore EU funding is only a very small percentage, but the industry interest in participating is to share risk and research effort, while reaching out to Research Technology Organisations. This sector is very capital intensive, requiring costly investments, so getting advice on where to research is important for more forefront technology development, narrowing options and selecting more successful ways forward. For certain sectors, such as Future Networks, European support accounts for one third of the funding (overall, EU investment in ICT research and innovation account for only 5% of all public funding for R&D in Europe). As stated by a DG CONNECT official, the Framework Programmes have provided a crucial support for network technologies and for building leadership in Europe.

Pooling of resources also from different disciplines to achieve **critical mass**, economies of scale and scope is another element justifying intervention in this field. FET for instance addresses multidisciplinary research between blue-sky science and research, not mature enough for industrial investments. The European Added Value of FET lies in facilitating competition on the basis of excellence and according to common rules, making this a strong achievement of the Framework Programmes. At project level, the researchers need cooperation with other researchers on an international dimension, to work with the best people and companies to solve the issues of today and tomorrow. The programme promoted collaborative research and aimed at bringing together all the best teams and talents available in the EU so that member states can benefit from resources that may not be available in their countries. The reduction in national funding has accentuated the need for European funding; however it should be noted that also countries where there is plenty of national support for research are highly present in the Programme. Drivers for the participation are the international dimension, and the fact that not all the competencies requested in an area are available in one country; as pointed out by DG CONNECT officials, stakeholders want to collaborate in clusters of clusters. Furthermore, the landscape for research, development and innovation is increasingly complex and competitive and no country can afford to think of research development and innovation strategies in purely national terms any more.

Participants and stakeholders interviewed in the context of the support study (PwC and OpenEvidence, forthcoming) considered FP7 ICT **relevant** in terms of the coverage of themes. They also recognised its ability to capture/reflect the technological and scientific needs and challenges that their organisation and Europe in general are facing today, and its relevance in terms of alignment with areas of EU competitive advantage was considered high. Stakeholders consulted also recognised that the programme displayed a good degree of **flexibility** in adapting to a rapidly changing environment, though this flexibility was lower with respect to short-term changes. This positive assessment is confirmed for specific components such as the JTIs, AAL, Future Internet PPP, and eInfrastructures. Another

[22] See Figure 1.

[23] In microelectronics for instance there is an industry roadmap on miniaturisation, so participants come to the projects to explore the possibility of smaller memory nodes. The industry then takes the risk of making the technology grow.

indicator of relevance comes from Jacob et al.(forthcoming): an analysis has been performed on the keywords that describe the publication output FP7 ICT funded projects, in order to measure the degree of overlapping national and regional research interests. The study found that publications resulting from FP7 ICT funded projects have a positive affinity with all the considered control sample groups used for comparison.

Funding and distribution in topics and areas

The ICT theme of the 'Cooperation' specific programme of FP7 is the largest research theme within the programme, which is itself the largest Specific Programme in FP7. Under ICT Cooperation, the EU has co-funded over the period 2007-2013[24] 2,316 projects for a total Union funding of about €7.75 billion, approximately €3.7 billion more than the total funding allocated under FP6 (€4 billion) over four years. As pointed out by DG CONNECT officials, FP7 relied on more systematic work on setting the objectives and the priorities on the basis of European strengths and opportunities arising from technological progress and new ways of using ICT. In fact these elements provided the basis for the orientation and the budget allocation. The **strengths** of Europe in 2006 – 2007 laid in the Telecom sector and ICT components, whereas the identified emerging **opportunities** in terms of technologies were ambient intelligence (Internet of Things), microsystems, electronics, autonomous systems and robotics, photonics and laser-based systems, LED. These areas were funded through the first three Challenges. Challenge 1, addressing the future converged communication, computing and media infrastructure and Challenge 3 addressing components, systems and engineering were allocated respectively 25% and 19% of the total budget (see Table 5). Challenge 2 addressed the technologies related to cognitive systems, interaction and robotics, was allocated a total funding of 635 €Mio. As above, **new opportunities** in ICT also emerged from new ways of using and applying ICT for the **benefit of economy and society**, such as ICT as enabling technology transforming health, ageing inclusion and innovative governance (Challenge 5), accounting for 11% of the total budget (€878Mio) and Challenge 6 on ICT for low carbon economy (€727 Mio). Support to industry for the uptake of ICT in all domains of manufacturing was funded with €289Mio, whereas Challenge 4 (ICT for Digital Content and Languages) with €416Mio and Challenge 8 (ICT for Creativity and Learning) with €430 Mio. In addition to these and of great relevance is research in Future and Emerging Technologies (FET), which accounted overall for 11% of budget (€821 Mio).

As for eInfrastructures, the total EC funding over the period amounted to €533Mio. The number of projects funded were 136, involving organisations from 83 countries. At the end of 2013, after six Calls, ARTEMIS-JU had 56 running projects, representing a total R,D & I investment of €1,1 billion,[25], whereas there were 63 active projects in the ENIAC JU programme, for a total of €2.86 billion in eligible costs[26]. As for AAL, the programme´s planned total budget was €700Mio, of which approximately 50% of public funding[27] - from the AAL Partner States and the EC - and approximately 50% of private funding from participating private organisations. At the end of 2013 138 projects had been financed under

[24] Data up to July 2014.
[25] Source: ARTEMIS Joint Undertaking Annual Activity Report 2013.
[26] Source: ENIAC Joint Undertaking Annual Activity Report 2013
[27] The public funding consists of contributions of the national programmes of the AAL Partner States (this funding is only granted to the successful project partners residing in the respective Partner State) and that of the European Community. The EC financial contribution amounts to a maximum of 150 M€ for the duration of the AAL Joint Programme.

the first six calls, involving partners from 23 countries[28]. The first six calls allocated more than €86 million of EU contribution to projects for more than €358 million (Table 5 and Table 6).

Implementation

Participants

As for **ICT Cooperation**, over the period 2007-2013, 6,773 organisations participated in the Programme from 119 countries, compared to 4,487 in FP6 (over four years). On average, 1,830 legal entities took part in FP7 every year. Overall, Higher Education and Research organisations accounted for more than half of all participations[29] (57%) and received the highest funding (64%) of the overall FP7 ICT budget. University and research organisations also coordinated most of the projects (69%); large companies coordinated 18% of projects, whereas SMEs only 10%. Large companies accounted for 20% for participations and 19% of funding (from 24% of participations and 27% of funding in FP6), whereas SMEs for 17% of participations and 14% of funding (from 15% of participations and 12% of funding). SMEs were 35% of the participating organisations (29% in FP6) and were involved in three quarters of projects (large enterprises about 70%). SMEs incidence in terms of participations was higher than in budgetary terms (with some exceptions), indicating that on average SMEs obtained less funding than other types of organisations. In some areas, such as ICT for manufacturing, SMEs account for 21% of funding, as they are active in latest simulation and design tools; in Digital Content and Languages they account for 22% of funding (see Table 9 for the composition of participants by Challenge). According to interviews with DG CONNECT officials, there is need for SMEs in application areas and to this end Competence Centres have been established (2012-2013) to enable access of SMEs to technology and equipment that they would not have otherwise had access to (see Section 5). Participation of SMEs also differed by country: in certain Member States SMEs represented more than one third of participations (Estonia, Slovakia and Bulgaria with 42%, 34% and 33% respectively) and accounted for up to half of total funding (Bulgaria, 51%). In others, such as Croatia and Luxembourg, they accounted for just 8% of participations and similar low shares of funding (8% and 6% respectively). As for **eInfrastructures**, SMEs participated to 54% of projects and large enterprises to 49% of projects, accounting for 28% and 11% of funding respectively (Table 9).

The **JTIs** succeeded in inverting the research/industry ratio in overall participations that is visible in mainstream ICT research: in ARTEMIS 38% of participants to the 63 projects funded were SMEs, 27% research institutes and Universities, and 35% large companies. In ENIAC, 41% of participants were SMEs (accounting for 12% of funding), 33% research institutes and Universities, and 26% large companies[30]. As for the **AAL JP**, among the key achievements of the programme the evaluation (Busquin et al., 2013) highlighted the high participation of SMEs (around 40%), and a further 10% of participants represented by large enterprises. Also, in the programme research was mostly industrially led (67% of projects).

[28] Twenty European Member States (Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece , Hungary, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden and the United Kingdom) and three Associated States: Israel, Norway and Switzerland. http://www.aal-europe.eu/wp-content/uploads/2013/11/Consolidation-statistic-report_final-.pdf

[29] A participation is defined as the involvement of an organisation in a project/programme (i.e. projects have multiple partners and an organization can be the partner of multiple projects).

[30] Source: ENIAC Annual Activity Report 2013.

Have the actions attracted some of the best research organisations and innovation firms in Europe?

A study on the networks of organizations engaged in Framework Programmes (Breschi et al., 2012) concluded that the design of FP6 and FP7 has been able to attract the **leading research organisations** both from older and, with some exceptions, also from new Member States. At the same time, Leading National Research Organisations from older Member States tend to dominate in terms of number of participations and projects co-ordinated[31]. The study found that FP6 and FP7 have been highly effective in attracting leading technology exploiters and innovative technology brokers[32]. At the same time, the selection process into the FPs tends to filter and leave out the technology pioneers and isolates (heterogeneous organisations, typically smaller innovators undertaking research in unexplored fields). The same study found that the existing programmes have been relatively less successful at attracting **highly dynamic SME's** in FPs[33] than they have been at attracting incumbent and established players, who are indeed largely participating in the programme. This result (in the order of magnitude) was confirmed by the support study carried out for this evaluation[34]. The main barriers to participation for innovative SMEs were found to be (Barak *et al.*, 2013): a) rhythm (shorter time cycles need); b) bureaucracy; c) lack of flexibility. According to this study however the reported barriers are a clear function of SMEs' awareness of and experience with EU funding instruments.

Geographical repartition of funds

In absolute terms, Germany and the United Kingdom were the biggest recipients of EC funding. Italy, France and Spain followed, and these five countries accounted for 60% of total EC funding and 57% of participations. However, Cyprus and Greece were the countries with the highest funding in relation to the size of their ICT sector, followed by Slovenia, Austria and Belgium. The same group of countries also accounted for the majority of projects coordinated, with Germany coordinating 18% of projects, followed by Italy (13%), Spain (12%), United Kingdom and France (both with 10%), and Greece (6%). Among non EU countries, Switzerland coordinated 3% of projects. Different **specialisation patterns** emerged

[31] The study also concluded that such an asymmetry may be more associated with differences in the scale and scope of available resources than to any aspect related to the design of the FP. The leading research organisations are typically large organisations (universities and public research organisations) which operate labs and research units with resources that enable them to sustain high levels of cross-institutional co-operation and to take the leadership role in projects. The scale and scope of resources available to such organisations in older Member States, especially the larger countries, is typically larger and broader than to organisations located in new Member States.

[32] While the former organizations focus their research activities towards the exploitation of opportunities in relatively mature fields, the latter do research in new fields and provide access (broker) to those fields for other organisations. Both types of actors tend to be found among relatively large and well established firms.

[33] The authors used the most recent publicly available lists Deloitte Technology Fast 500 EMEA, those from 2006 to 2009. To test for the robustness of the findings they also adopted a different definition of highly dynamic and innovative SMEs, by using information from the Industrial R&D Investment Scoreboard, published annually by the European Commission. Using the sample of innovative SMEs constructed from the Deloitte ranking, out of 830 fast-growing SMEs, only 36 participated in FPs: slightly less than 5%. These companies participated in a small number of projects: 39 in the FP6 and 19 in the ICT FP7. In the alternative sample of 95 R&D intensive SMEs constructed from the Industrial Scoreboard, only 12 companies participated in FPs (around 13%).

[34] The analysis was done by merging MIS data for ICT FP7 with the "Deloitte Technology Fast 500 EMEA". The result is that only 12 of the ICT FP7 funded SMEs can be found in this rank.

from the analysis of country presence[35] by strategic objective. The EU Member States show a relative strength in different areas of research:

- Germany is the top recipient of funds in all Challenges, except ICT for creativity and learning and eInfrastructures. The country attracts 34.5% of funding in ICT for the Enterprise and Manufacturing, and 28% in Cognitive Systems and Robotics;
- The United Kingdom is the leading country in ICT for creativity and learning, with 21% of total funding, and accounts for 16% in ICT for Health, Ageing Well, Inclusion and Governance. It is the leading Member State in eInfrastructures with 28.5% of funding;
- Italy is relatively strong in Cognitive Systems and Robotics, ICT for Health, Ageing Well, Inclusion and Governance (14% of total funding) and in particular ICT for Ageing, FET (13%), ICT for the Enterprise and Manufacturing (13%) and eInfrastructures (12%);
- France has a relatively strong presence in Future Networks and Internet with 16%, Components and Systems (15%), and in particular in Nanoelectronics, and International Cooperation (16%);
- Spanish organisations have high shares of funding in Future Networks and Internet, ICT for Health, Ageing Well, Inclusion and Governance with 11% (in particular present in ICT for inclusion) and Challenge 6 (11%), in particular ICT for Energy Efficiency;
- The Netherlands is relatively strong in Components and Systems (8%), and in particular in Organic and large area electronics, and in eInfrastructures (8%);
- Belgium has a relatively strong presence in Components and Systems (8%), in particular in Nanoelectronics;
- Greek companies are active mostly in Challenge 5 (8%), in particular ICT for Health, and Challenge 4 (7%), in particular ICT for Governance and Policy Modelling;
- Austria has a high share (9%) in ICT for Creativity and Learning.

As for the **international participation**, over 600 organisations participated to 362 projects within FP7 ICT Cooperation Theme and to 67 projects within the Capacities theme (eInfrastructures). The programme is able to attract international players; it is open for participations, but only funds low and middle income countries. There have been some specific coordinated calls with Russia on computing, with Japan on network, and with Brazil, paving ways for global standards. Associated Countries accounted for 6% of participations and 7.5% of funding, mainly due to the presence of research-oriented players such as Switzerland, Israel and Norway. Third Countries took part in the Research Programme but with little EU funding (1%). The rest of the budget and participations were equally distributed among accession countries and Third Countries (TCs). Most of the projects with international participants fall under "FET" (61 projects), "Future Networks" (58 projects), "International Cooperation" (39 projects) and "ICT for Health" (22 projects). Participation to projects by thematic areas is represented in Figure 1. The network analysis carried out in the context of the support study also showed that the majority of collaborations involving countries from

[35] Research and Development activities are concentrated in a number of key regions: the top 50 Regions in the EU (NUTS3 classification) attract 62% of funding and 56% of participations. In some countries the R&D activity is heavily concentrated in the capital Region (e.g. Finland, Portugal, Greece, France and Spain), whereas in others funding is distributed among several important poles of research (e.g. Germany, Italy and the UK). The top 50 regions are located in 15 Members States (as for funding) and 16 Member States in terms of participations. In terms of overall funding and participations over the period 2007-2013, Munich is the European city that leads, followed by Paris, Madrid, London and Athens.

Africa, Asia or from South America take place continent-wise, i.e. non-member states involved in collaborations with member states most of the times only collaborate with countries from the same continent. Other patterns that emerged are: a good reach of Ireland to African countries[36], and of Spain to South American countries[37]. UK, France, Germany, Italy, Spain show the highest number of collaborations with Asian countries. On research domain specific collaborations, ICT for Energy Efficiency gathers a number of African countries but does not involve any country from South America or Asia, whereas FET only involves countries from large emerging or developed economies (PwC and OpenEvidence, forthcoming).

Programme implementation and dissemination

Responses from the participants interviewed in the context of the support study (PwC and OpenEvidence, forthcoming) showed satisfaction with the specific aspects of the funding cycle, from work programme definition to call management to evaluation and negotiation. Similar patterns emerged from experts interviewed on the same topic. Furthermore, almost all experts and NCP interviewed agree that calls for funding have been developed and processed effectively by the Commission, and in particular by DG CONNECT. This is indeed clear from the figure on Time To Grant, which in 2013 was 262 days, the lowest compared to other DGs. The governance model was generally more effective than in FP6, although some pointed out that it should be more future-oriented, so that longer term projects outcomes are properly followed; since the nature of the programme is such that its impacts are due to appear even after 15-20 years. According to the interim evaluation of FP7 ICT (Bravo et al., 2010), the overall view of the participants on FP7 ICT was that there was some improvement in lowering the administrative burden, but one in three survey respondents gave a negative evaluation on the efficiency of the new measures in reducing the costs of the application processes and participation. The major improvements had been recognized in the introduction of: Electronic Proposal Submission System (EPSS); Unique Registration Facility (URF); Financial Guarantee fund; electronic submission and reporting tools. Removing the need of Audit certificate and ex-ante financial viability check were also considered important. Officials in DG CONNECT also reported some scepticism on the effectiveness of the simplification measures introduced in FP7, on the basis of the feedback received from participants. Administrative burden for participants was reported to be still a concern, despite some improvement with respect to FP6. On the other hand, many stressed the need to balance this with the fairness of the procedures, and that there are limits to simplification, due to the accountability for the Parliament and the Court of Auditors. The simplification for the reporting period passed from 6 monthly reporting in FP5 to 12 in FP6 and now 18 months in H2020, and this has worked in the view of some officials. However, this is also perceived as too slow to take corrective actions.

Dissemination was generally perceived as occurring in a productive manner, in particular for scientific dissemination, where the EC emphasis seemed to provide genuine additional effort on dissemination. However, many interviewees were concerned with the effectiveness of this effort, as dissemination too often in practice meant in their view merely producing lengthy documents for the FP7 ICT target community. Participants pointed out that dissemination outside the “FP7 ICT circles” and towards industry was much more challenging. In particular, dissemination was often perceived as a self-referential page-producing effort, as many participants pointed out to the impression that reports were not read and the number of

[36] Collaborating with African countries through 54 projects.
[37] Collaborating with South American countries through 113 projects.

deliverables requested was too high. In their view there should be more emphasis on the quality than the quantity of dissemination. Moreover, according to the participants, there was too little time to disseminate results as the main deliverables of the project come towards the project end. Stakeholders demanded that the EC provide more strategic support to dissemination across projects and after their end (PwC and OpenEvidence, forthcoming). H2020 focus on simplification also addresses the aspects of reduction in reporting burden for participants.

The **legal framework** was considered by experts, NCP and policy officers as being well-designed and improved compared to FP6, but still too difficult specifically for SMEs and new participants. In their view there was the need to fine-tune the instruments to the needs of the participants, and to each specific topic. Although some interviewees referred to the improvement in IPR requirements, which have become clearer as compared to FP6 and important in the Consortium Agreement, they were mentioned as being particularly challenging for SMEs. Overall, FP7 ICT mechanisms were considered still not fully supportive to help translate research results into innovative products, processes and services. Furthermore, as mentioned by several respondents, once the project is completed, there are still activities needed before the research results can be fully deployed. However, it is a well-known fact that the full explication of R&D funding occurs with a time-lag and only to the extent to which the funded entities have the willingness and resources to follow up on the research results obtained (PwC and OpenEvidence, forthcoming).

Achievements - Outputs

Over the period 2007 – 2013, 2,316 projects were funded under the ICT Theme of FP7 Cooperation Programme, roughly the double than FP6 (1,128 over four years). As for eInfrastructures, 136 projects were funded. Compared to FP6, the funding has been strongly rebalanced towards Specific Targeted Research Projects (CP-STREPs), whilst it has been reduced for large scale Integrated Projects (CP-IP) and Networks of Excellence (NoEs). STREPs accounted for about half of funding (34% in FP6) and participations, and 64% of projects. IPs followed, with 41% of funding (50% in FP6), 17% of projects and 29% of participations (Table 11).

Although there was a considerable variation in the success rates of the proposals presented in the different lines of ICT-FP7, the overall oversubscription rate was high. On average, the proportion of proposals that led to contracts was about 14%, in line with FP6 (14.2%). As it can be seen from these figures, the Programme is fairly popular and quite competitive; however, oversubscription is also one of the main challenges. As pointed out by a DG CONNECT official, oversubscription is related to the existing potential of doing research in certain areas. In areas where the entry barriers are low (e.g. applications) the oversubscription rate is higher, whereas in areas more difficult to enter, such as semiconductors, the oversubscription is lower. Page limitation is a way to counter the burden of preparing proposals: in H2020 the number of pages for the proposals has been limited depending on the action. One of the challenges of H2020 is to find the right balance between less prescriptive calls and oversubscription. According to another official, European Technology Platforms and PPPs are *de facto* reducing and containing oversubscriptions, as they provide for a strong filtering.

Network structure

Several studies (Breschi et al., 2012; Pwc and OpenEvidence, forthcoming) found that the network generated by the FP7 ICT is very stable and resilient, indicating that a critical mass for a European Research Area is fairly consolidated. The network is scale-free (few hubs with hundreds of projects and a majority of organisations involved in only one project[38]) and has the characteristics of a small world ("*a friend of a friend is my friend*"), showing no difference with what observed for FP6 and FP5. Differently from FP6, large (private) organizations tend to dominate among organizations having participated in numerous projects. The networks are dominated by hubs representing about 5% of all the organisations, with the majority of these hubs being large public research and academic organisations, ranking in the top 20% organisations in terms of links both in FP6 and FP7 ICT. In this respect, it must be noticed that research organisations from new Member States have increased their participation and ranking. This is a positive fact from the perspective of cohesion policy goals.

The hub role of public research and academic organisations is due to the fact that since its inception the Programme was considered an instrument to promote pre-competitive research. In more recent years the political emphasis has gradually shifted towards application/innovation, which, to be effective, should result in the future more innovation-oriented organisations to take a hub role. Small-world networks and hubs are known to facilitate knowledge diffusion and the cumulative building up of capabilities. Moreover, such networks tend to be also highly resilient: the lines of communication and co-ordination are not affected by the fact that some organizations drop from the network. This finding is mirrored by the answers of participants to FP programmes, who have over time and again stressed benefits from participation as being primarily intangible and indirect (networking, information gathering, capability building) rather than direct benefits in terms of products and process innovations. Findings from the recently completed support study (PwC and OpenEvidence, forthcoming) show that organizations that were involved in FP6 acted as facilitators to bring in new organizations into FP7 projects and that most SMEs that had participated in FP6 experienced an increase of the number of projects they participated in, and the total number of partners they collaborated with in FP7.

Apart from creating critical mass in specific scientific and technological fields at European level and stability over time, such 'networks' have the effect of considerably reinforcing existing collaborations in R&D – on a bilateral basis or within the context of new public-funded research projects. An interesting element of the FP7 in relation to this is the capability of such network to increase their size over the time. In particular during the programme such network extension was particularly strong with around half of the participating organisations being new actors in EC-funded ICT research. The role of the 'core' partners in attracting such new actors is illustrated by the fact that most of the 'new' ICT research actors joined already pre-established partnerships.

[38] 62% of the organisations participated to one project only, and 15% to two projects only, whereas a much more limited number of organisations participated to many projects (≥6), suggesting a scale-free participation pattern (many with one project and only a few with hundreds).

Uptake on cross-cutting issues

From the **workforce statistics** extracted by the final reports of the completed projects[39], it resulted that on aggregate, more than 52.000 people worked with these projects in different roles, with ~9,000 additional research jobs created by 821 projects. The employment effect in FP7 ICT projects was in line and possibly higher[40] than the one resulting from other research themes (10.9 additional researchers vs. 7.8). Unsurprisingly researchers (including experienced researchers, PhD students and temporary researchers) were the most represented category with more than half of workforce. Women were only a third of the workforce, most under-represented among experienced researchers (Table 12). However, it should also be noted that the ICT sector is overall unbalanced in gender terms.
There is no information on gender in the content of research.

As for the **engagement of civil society or policy makers**[41], 40% of projects reported to have engaged societal actors as part of their participation to FP7 ICT. Among these, 77 involved citizens in projects' preliminary phases (typically to define the scope and type of research to be conducted); 81 while implementing the research and 191 while disseminating the results. Policy makers and institutions appear to be more involved in FP7 ICT projects. This is unsurprising given their natural commitment to innovation and contact with research organisations, also as a result of other funding programmes. 115 project coordinators reported that they engaged policy makers in setting the research agenda. 100 were involved in the implementation of the research and 244 during communication and dissemination activities. Concerning the objectives of funded research projects only 27% of respondents claimed that their work had as a primary or secondary objective an outcome (e.g. expertise, scientific advice) for policy makers (
Table **13**).

In relation to the synergies with CIP ICT PSP, it should be reminded that FP7 was more oriented towards research, whereas the former was providing specific support to innovation, but there was no clear link between the two programmes, i.e. CIP projects in general were not end of pipe projects relying on FP7 results. After four calls, about one fourth of the organisations participating in FP7 also participated to CIP ICT PSP. The second interim evaluation of CIP ICT PSP concluded that the programme "*has not developed appropriate linkages with other EU programmes. In general there is a strong linkage to FP7, at least at the policy level, but when it comes to the EU Regional Programmes, national programmes and other CIP instruments and programmes (such as SME financing instruments) there is little evidence of such linkages*" (Vickery et al. , 2011).

The tests carried out in CIP ICT PSP were mostly for public services and societal challenges, resulting in a good synergy. As pointed out by a DG CONNECT official, in the area of **Active and Healthy Ageing** there has been a systemic approach from long-term research to large scale uptake, with a shift across the innovation chain (FP7/AAL JP/CIP/European Innovation Partnership on Active and Healthy Ageing). In this area, returns on investment of the deployment of new products and services developed in FP7 and AAL have been measured in pilot projects financed by ICT PSP CIP with good results in relation to the quality and sustainability of the health and social care services for some of them. In the area of **eHealth**,

[39] Extraction was possible only for 821 projects final reports, out of the 1,159 available.
[40] Taking also into account that the data include an extra year of reporting, compared to the data in DG RTD Annual Monitoring Report 2013.
[41] This data comes from analysis of data extracted from section G of the "Report on societal implications".

large scale pilots have been funded aiming at facilitating cross border healthcare, with interoperable eHR and ePrescriptions (epSOS), citizens' access to their health records and deployment of telemedicine. In the future, further deployment of interoperable eHR and ePrescription services will be funded by the Connecting Europe Facility (CEF). Living Labs have been actively contributing to the Connected Smart Cities CIP pilot projects but the initiative reached a maturity that is providing them self-sufficiency. There existed a certain thematic overlap between CIP and FP7 as for **Smart Cities**, which is resolved by a clear situation in H2020, separated by research, innovation, take-up and policy.

The degree of synergy and coordination between funds for eInfrastructures from FP7 and Structural Funds is considered not very high, the main reason being the lack of alignment of objectives (Technopolis-Empirica, 2014). Overall, additional funding for eInfrastructures by means of the Structural Funds was 8% (7% for the overall research infrastructures).

DG CONNECT officials commented that they seek better coordination with structural funds in certain areas (e.g. photonics). According to another official in H2020 the streamlining of the R&I programmes with other European Programmes such as European Structural and Investment funds has improved but still needs some facilitation. Beyond the activities of the ICT Committee and mirror groups in JTIs and PPPs, it has been pointed out by DG CONNECT officials that more could have been done to allow Member States and Commission to: (i) share knowledge, experience and best practices; (ii) identify key national actors, activities and institutions; and (iii) devise common approaches and complementarities between the various frameworks[42].

Achievements - Results and impacts[43]

Research results

Over the period 2007-2013, out of the 2,448 projects surveyed, 1,160 resulted in 18,169 **publications**[44], out of which 63% were conference proceedings and 37% journal articles (**Source:** PwC and OpenEvidence (forthcoming)
Table 14)[45]. The average number of publications per project was 15.7; however, the distribution was very skewed, with the majority of projects producing only few publications, while a few generated a large amount of publications[46]. In FP6, 927 projects had reported

[42] In the area of Future Internet, to overcome this Future Internet Forum (FIF) was created, composed of representatives of the Member or Associated States' initiatives and activities on the Future Internet. It consists of either high-level officials from the competent ministries, or experts from public or private institutions mandated specifically to represent national Future Internet initiatives.

[43] At the time this report is being prepared, 47% of projects within the scope of this evaluation are still on-going. The evidence referred to in this chapter covers therefore only half of the projects granted within the ICT theme of Cooperation and the eInfrastructures theme of Capacities Programme. Furthermore, systematic evidence on the projects achievements and results is not in a readily available format, therefore an exercise to extract information from the projects final results has been made, delivering unfortunately not complete evidence.

[44] The source of the figures on patents and publications is Jacob et al., (forthcoming). In total, 1,761 projects replied to the survey.
According to the data reported in the OpenAire website (https://www.openaire.eu/stats-fp7/statistics/fp7-stats#projects-with-publications-by-programme) the ICT FP7 produced ICT Programme 14,463 publications, of which 6,511 in open access.

[45] This reflects the fact that scientists in the field of computers science and ICT have a large propensity for publishing in conference proceedings.

[46] Although 59.6% of the projects produce between 1 and 10 publications, a respectable amount of projects produces between 11 and 50 publications, and only a small percentage (5.1%) produces more than 50 publications (one project produced 1036 publications).

5,681 articles (the number of articles only for FP7 was 6,687)[47]. As for the quality of research, 80% of the FP7 ICT articles were cited at least once, whereas only 42% of the FP7 proceedings were cited at least once, with an average of 1.98 citations per proceeding paper and 11.18 citations per journal article (
Table **15**). By means of comparison to a control group, the study concluded that the FP7 ICT research published in the popular and high impact journals and conference proceedings received on average more citations than other research. This is also testament of the high scientific knowledge produced by EU funded research (collaboration at the EU level produces better quality research). As expected, academic organizations led in generating most of the scientific output (93.1%[48]), with total corporate research activity accounting for 6.9%. However, FP7 ICT funded SMEs publish more than their counterparts (not funded by FP7 ICT). This shows that the FP7 ICT projects had a reasonable inclusion in terms of corporations at large, but of SMEs specifically, which is in line with the policy goals of the Lisbon Agenda on the creation of a more inclusive European Research Area. Apart from the Strategic Objectives (SO) "International Cooperation", the SOs with the majority of private/public collaborations were Future Networks and Internet, eInfrastructures, FET and ICT for Environment Management and Energy Efficiency. In terms of internationalization of research, cooperation among the EU-28 countries engaged in ICT research under FP7 was more evenly distributed than for the control sample, suggesting that the project participants displayed a significantly higher degree of internationalization than their control sample counterparts, whom are rather nationally focused.

Over the period 2007-2013, FP7 ICT funded projects resulted in total 289 **patents**, with a very skewed distribution: in general, only a small proportion of projects reported patenting activity (only 139 projects resulted in at least one patent), and most of those reported applied for fewer than 5 patents for the whole period. These findings are in line with the findings from FP6, where only 109 projects (out of 927) reported 273 patents (KITeS-CESPRI - Bocconi University, 2010). Of this, about 6% of the projects filed applications for five or more patents, whereas majority of the projects applied for either one patent (52%), or two patents (27%). More than 90% of the patents were accounted for by two funding instruments, namely Strep and IP, accounting for 60% and 30% of patents respectively. More than 50% of the focal patents were owned by corporations, with the remaining patents shared among universities and public research organizations. About one fifth of the patents resulted from projects with the SO Future Networks and Internet, with 7% coming from Photonic components and subsystems, and 6% from Micro/nanosystems. The vast number of remaining SOs accounted for only small shares of the total focal patents. The patents were associated with very high inter-organizational collaboration (more than 50%), much more than what is observed in both the industry in general (5%) and EU-based industry (about 10%)[49]. Furthermore, while most of the patents in the control samples originated in a single organization, outside of EU in the general industry sample and within EU in the EU-based sample, inter-organizational collaborations within an EU country, between EU countries, and between EU, Japan or the US were important for the focal patents. For most European organizations involved in patenting, the most important source of knowledge outside Europe was the US. Interestingly, the only two European countries that use inventors from BRICS countries are France (inventors from China) and Spain (inventors from India).The focal patents displayed a unique

[47] Source: KITeS-CESPRI – Bocconi University (2010).
[48] Aggregation of the Academic, Government/NGO, and Hospital generated output
[49] The patents resulted from ICT FP7 projects were compared to two randomly selected control samples—one representing the ICT industry in general, and the other the Europe-based ICT industry

EU bias also in regard to the location of both applicants and inventors. Although a couple of EU countries dominated in both of these dimensions, a broad spectrum of EU countries is represented among inventors and applicants. In general, in the focal sample a dominant presence of the EU-28 countries with seven or eight leaders accounting for a majority of the focal patents. This is in sharp contrast to what is observed in the control sample, where only a few large EU economies such as Germany and France had a noticeable presence, while small EU economies were barely visible (e.g. Belgium accounts for 8% of patents in the focal sample but has only about 0.5% share in the control sample). These trends suggest a substantially higher involvement of EU organizations in ICT research due to the FP7 programme than what one observes in the industry as a whole (Jacob et al., forthcoming).

Concerning other forms of **exploitable foregrounds**, information available from the projects final reports showed the following (Table 16):

- 56% of projects within the SO ICT for the Enterprise and 44% of SO Photonics projects reported as results Commercial Exploitation of R&D. Conversely, less than 10% of exploitable foreground is related to Commercial exploitation of R&D results in FET, International Cooperation; Accompanying Measures; Language Technologies and ICT for Governance and Policy Modelling projects.
- Exploitation of R&D results via standards has been quoted by more than 4% of the projects related to the SOs Photonics, Trustworthy ICT; Future Networks and Internet; ICT for Transport and ICT for Inclusion.
- Exploitation of results through (social) innovation has been selected by 22% of Language Technologies project and 10% of eInfrastructures. However the average for this type of the result is just 3% for all topics
- Exploitation of results through EU policies has been quoted by 16% of the 16 ICT for Governance and Policy Modelling projects. The average of this type of result is just 1% for all topics.
- General advancement of knowledge has the highest average (30%). This percentage is higher than 35% in case of ICT for Governance and Policy Modelling; ICT and Ageing; Embedded Systems; Intelligent Information Management; Accompanying Measures; Future Networks and Internet; FET; Nanoelectronics and Organic and large area Electronics.

However, as discussed in the introduction, the extraction of information from the final reports proved difficult, notwithstanding the existence of templates and reporting guidelines[50] requirements. PwC and OpenEvidence (forthcoming) recommended the European Commission to ensure the quality of the reports and their conformity with the information requirements: by checking the reports are filled in, ensure that the submitted documents are of good quality, that they sufficiently answer the Commission's requests, possibly including clear indicators of achieved aims and generated output. As highlighted in the section on dissemination, participants commented on the reporting burden, on this basis the support study recommended to avoid any repetition of information and to focus on the overall impact, using some precise indicators and summarising what has been done[51].

[50] This template is provided to any beneficiary in the "Guidance Note on Projects Reporting" at pages 23-35 (European Commission, 2012).

51 The specific recommendations of the report were that a digital tool should be preferred, different data types in the same answer should not be mixed (i.e. avoid using multiple choice and free text, or numbers and text), a real standard, non-modifiable template should be provided to participants, while ensuring an efficient ex-

As for the AAL Programme, the final evaluation highlighted good exploitation prospects for finished projects, with nearly 50% of the projects from the first two calls having secured IPR results and a number of first commercial results. One of the evaluation's recommendations was to reinforce the market orientation across the Programme, ensuring market entry and commercial exploitation issues to be addressed more explicitly and with greater weight in all aspects. Also, the evaluation recommended improving the knowledge base on project achievements and insights, by developing methodologies and knowledge bases for documenting and sharing project achievements and insights suitable for communication within and beyond the Programme. Likewise for the JTIs, the second interim evaluation reported that "*in specific cases, ENIAC projects have played a kick-starting role in terms of innovation*[52]". One of the recommendations was however that the project reviews should monitor more closely and rigorously the actual and planned exploitation of project results, and the measures put in place by project partners to achieve such planned exploitation. The evaluation also stressed the need for an additional checkpoint on exploitation achievements and plans in a final, post-project, review, i.e. between 6 and 12 months after the end of the project.

Impacts

As discussed in the section on the network structure, the programme contributed to strengthening the existing networks of cooperation among projects participants. According to participants (PwC and OpenEvidence, forthcoming), the **main benefits of participation** in FP7 have been the networking effects, especially in terms of creation of new partnerships and improved R&D linkages with universities and research centres, confirming the results of the Interim Evaluation (Bravo et al., 2010; Technopolis, 2010). Other benefits that have been reported by the large majority of participants are improved research competencies, enhanced reputation, and increased international cooperation with research centres. The main benefits reported by participants are intangible, such as network and reputation, with research-related benefits being more common than business-related benefits. Most participants mention non-commercial benefits such as publication, prototypes, qualified personnel, with only a minority mentioning commercial products and exploitation of results or patents, and fewer mentioning the creation of start-ups and companies (PwC and OpenEvidence, forthcoming).

As described by DG CONNECT officials, the FP7 ICT has also contributed to the acquisition of **new skills and expertise**, and, in some cases, it has allowed access to facilities and know-how that would have been difficult to obtain otherwise (especially, for SMEs). It has also stimulated entrepreneurship. In the field of **photonics**, through ACTPHAST, SMEs are provided with know-how, access to facilities to use photonics technology; ECHORD and ECHORD++, in the fields of **robotics** Innovation Facility, where SMEs can test technologies. However, for ECHORD, FP7 instrument did not allow to put in place this mechanism easily, as all the participants had to sign grant agreements which caused some delays. In H2020 this issue has been tacked, as the scheme is now implemented through cascading grants[53]. Predecessor of the contractual PPPs in H2020, the Future Internet PPP with FIWARE further developed the integration of software-based services and cloud computing, providing a

post analysis of results. The evaluation also recommended the inclusion of additional more precise indicators, such as economic indicators; and to consider the long-term, asking intentions about the continuation of the project when the funding ends, or tracking economic variables for some years in order to be able to make projections on the future.

[52] The projects quoted as good examples are E3Car (electromobility), SmartPM (energy efficiency), LENS and Extreme UV (lithography) and the R&D projects on 450mm.

[53] An original grant can be sub-granted according to certain conditions as laid out in Annex K of GA.

platform for Future Internet applications and services, which is now widely deployed in industrial applications and companies. In its last phase[54] it addressed entrepreneurs with FIWARE, expected to support 1,300 SMEs, and the creation of the StartupEurope initiative[55]. The FIWARE platform is now exploited in Horizon 2020 to leverage national efforts and provide the technology for deployments in the Societal Challenges (e.g. Smart Cities). All in all, this particular area has helped departing from supporting traditional business models to embracing diversity and favouring different economic models (i.e. from purely industrial policy to a more holistic approach, embracing social and user-innovation). ICT for Manufacturing SMEs (I4MS): In the context of the PPP "Factories of the Future", DG CONNECT has focused Work Programme 2013 on bringing ICT innovation into Europe's factories and the manufacturing process chain at large with a new batch of innovation projects, which particularly aims at benefitting SMEs. I4MS focuses on the fast adoption of four groups of ICT technologies[56] which are expected to have a particularly high impact on modernising Europe's manufacturing capabilities. In each project, individual experiments are clustered along with a ***pan-European Network of Competence Centres***, which adds significant value along two dimensions: While supply-side SMEs are supported in collaborating with users outside their ecosystem, sector, or region; demand- side SMEs get access and competences beyond what their local research and service partners can offer.

In addition to the high quality of publications resulting from FP7 ICT projects, the experts and POs interviewed in the context of the support study (PwC and OpenEvidence, forthcoming) also gave generally positive reviews of the overall **scientific/technological impact** of the complete portfolio of projects funded. Experts pointed out that the scientific impact is particularly strong, and that the programme was successful from a scientific point of view. With regard to advancing the state of the art of knowledge areas such as Artificial Intelligence, Internet of Things, Media, Quantum Computing were cited as best examples. Undoubtedly, the main output of the programme has been the knowledge created within the projects and the **overall technological advancements** in the scientific areas. Given the diversity of the scientific domains covered by FP7 ICT, please refer to Annex II for an overview of scientific results in the different domains. Furthermore, in some areas of higher technological maturity, this knowledge has served to develop some **applications** in their early stages of deployment. Projects delivered valuable opportunities not only to the research community and direct beneficiaries of successful proposals but also enabled concrete solutions that are being implemented directly in applicable cases for the benefits of European citizens. EU-funded projects in the area of ICT have led to spin-offs set up to commercialise products and services resulting from EU support. Based on the information extracted from the 821 final reports, 125 spin-off companies were created as a result of the projects. There is also some evidence of SMEs that have been active in the Programme and have grown as a result

[54] In the first phase (2011-2012) the FI-PPP comprised initially 8 projects with various applications (i.e. agriculture, smart cities, logistics etc.), the second phase (2013-2015) was for testing, and the third phase (2014-2016) of the Future Internet PPP targets SMEs and Web entrepreneurs (available budget approx. €80million), by providing smaller grants (some €150K each) for independent ideas. So far, the initiative is funding 16 accelerators and is expected to support over 1000 entrepreneurs.

[55] StartupEurope supports: a) role-model examples ("the leaders club", who has written a manifesto for star-ups), b) Europioneers and Techstars prizes, as well as c) networking (e.g. through accelerators and incubators). The mechanism is sub-granting (under the new Financial Regulation), which allows speedy access to funds by web entrepreneurs.

[56] Clustered in 6 Integrated Projects, in the I4MS initiative more than 88 application experiments address (1) advanced robot solutions for new manufacturing applications, and (2) high performance cloud-based simulation services for engineering and manufacturing SMEs; more than 47 assessment experiments address (3) intelligent sensor- and actuator-based equipment solutions and (4) innovative laser applications in manufacturing.

both in terms of employees and turnover. For examples of such applications, please refer to Annex II.

Keeping in mind that FP7 was largely a research programme, evidence from the interviews carried out in the context of the support study revealed that FP7 ICT mechanisms were considered inadequate to help translate research results into innovative products, processes and services (PwC and OpenEvidence, forthcoming). Some participants mentioned the need for smaller projects and several rounds of funding, others expressed the view that the institutional capacity of research centres is not suited to promote innovation. Overall, most respondents pointed out that FP7 ICT by design targeted research more than innovation and that it was more successful at addressing research objectives than it was at supporting demand-driven innovation. They expect H2020 to perform much better in this respect. Experts, NCPs and Project Officers (POs) reported a general appreciation of the mix of instruments, although these positive answers seldom provide concrete insights. In their comments, many pointed out that instruments were still not effective in attracting small innovative companies, although JTIs were perceived as having successfully brought together key players and new Member States. They often raised criticisms of very large projects, in particular IPs, as some considered that smaller efforts with higher risk were better suited to deliver commercial innovations. This was also the view of some DG CONNECT officials. All experts and POs agrees that the market impact of the Programme was limited, and that FP7 ICT is very good at sustaining knowledge and advancement in research but it was weak at supporting product development and new entries in the market. Several experts and POs observed that in many cases when organisations are closer to the development/implementation of a new solution, projects end and consortia break, so ideas do not continue in the following phases.

As for **eInfrastructures**, according to the assessment by participants, the programme has been effective in the following ways: a) approximately 65% of the interviewed participants reported an impact of the Programme on an optimised functioning and development of research infrastructures in Europe, and about 50% half of them indicated an impact on a reduced fragmentation; b) the FP7 ICT eInfrastructure programme fostered and accelerated an improved structuring of the European research area and considerably enhanced European and international cooperation on research; c) industry actors that were involved in the FP7 ICT eInfrastructure programme were quite positive about the programme's (future) effects (Tecnopolis-Empirica, 2014).

The **Joint Technology Initiatives** were the first instrument for the industrial strategy and they set up partnerships, reached an alignment on the objectives and gathered the pooling of resources. ARTEMIS in particular was recognised by several stakeholders consulted as helping to keep the competitive position of Europe, because of its capacity to involve several key industry players in drafting a common research agenda. According to participants, the JTIs have changed the trade-offs between collaboration and competition, thereby accelerating discovery. As from the conclusions of the evaluation carried out on the JTIs, to overcome the issues related to their heavy governance structures, the two JTIs have been merged in H2020 in one instrument, ECSEL.

In addition to the two primary drivers for research – knowledge creation and knowledge exploitation/application, some developments resulting from FP7 ICT projects have either directly or indirectly **contributed to policy formation** and supported policy objectives beyond research, such as in the case of cloud computing strategy, web entrepreneurship, and

management of radio spectrum (see Annex II for a more complete overview). In general, the loop between policy and research has effectively worked in several domains, and it should be supported in the future, with proper dissemination activities. The Programme success is also testified by the international recognition granted to several areas of EU research, such as eInfrastructures, robotics, photonics and SmartCities (Annex II). The synergies were also in terms of community network and influence on national research programmes. This domain has been very successful in pioneering new ideas, as for instance networks as cloud - not appeared in national programmes until FP7 introduced it, demonstrating the influence the Programme on national programmes for research. Another spill over effect is to have set the European Agenda, as for 5G, where for example Member States are following. Likewise, areas such as e-health, independent living and robotics were all pioneered by the European Commission before they were developed nationally.

European Added Value

Public support at EU level is needed and necessary, as it has several effectiveness, efficiency and synergy effects. The FP7 ICT has enabled the pursuit of research interests at a larger scale, in an increasingly multidisciplinary manner. These effects were broadly recognised by the participants, the stakeholders and the DG CONNECT officials interviewed in the context of this exercise.

There are **pan-European challenges** that have to be tackled at European level. One case is eInfrastructures: according to the recently completed evaluation (PwC and OpenEvidence, forthcoming), the FP7 funded eInfrastructures GÉANT, EGI and PRACE give access to innovative infrastructures that offer high capacity services not matched by any commercial or national offer. In the case of horizontal eInfrastructures and services, European collaboration has led to the development of new methodologies and tools, which make the management and provisioning of advanced services easier and more systematic. In areas, such as High performance computing, collaboration across the EU has helped bring on board smaller and less resourced countries that otherwise could not afford these advanced systems, minimising internal disparities. Similarly, for the two **FET Flagships**, there was the need to create critical mass and to unify resources on a scale that no Member State alone could have afforded, both in terms of financial support and in cooperation among multi-disciplinary teams. The Flagships have been one of the main achievements of FP7 and have brought Europe back to the global context for research and innovation along with all the other industrialised countries. Member States financing and private funding will also be leveraged (half of the budget is expected to be invested by MS and private funding into Partnering Projects). Flagships also influence national choices when defining research programmes; they have a continuous structuring effect of research communities at national and European levels around flagship themes; national structures for each flagship are already appearing to act as information providers and points of access[57]. The support study (PwC and OpenEvidence, forthcoming) reported unanimous consensus that **the scale of EU funding could not be reached by national and local funding**. In particular, EU-level funding was considered unique in fields such as eInfrastructures, FET flagships, JTIs. Furthermore, respondents confirmed that FP7 ICT funding has become more important due to the strong decrease in national funding, but because of the existence of specific research domains where EU-level intervention is able to make a difference by bringing together dispersed knowledge (e.g. quantum computing) and reducing costs (e.g. photonics).

[57] Conclusions of workshop The FET Flagship model, key policy and implementation issues. Conclusions from an external consultation workshop, 29 April 2014, Brussels.

In other areas, such as Future Internet, the EU has been having the role to **set the agenda** and help **the industry coordinate the various streams of research**. Big companies invest large shares of their turnover in R&D, so the level of funding is not comparable to EU resources, but these enterprises invest in technologies that are much closer to the market. The EC plays a key role in keeping open resources for long term risky domains, and it has to engage in strategic thinking and help the convergence process, giving prominence to certain areas. In the telecom area for instance, the main players in the provision of networks in Europe take to the Programme, as they benefit from cooperation in order to maintain their global position. Core work on future generations of telecommunication networks is done in the FP projects, in order to give "breathing space" to these otherwise competitors for research and development work. In addition, this facilitates cooperation in standardisation[58]. In general telecom and Internet of Things are domains where **standardisation** is a very powerful incentive for collaboration among EU partners. Interoperability across infrastructures, players and service providers remain a very strong incentive for collaborative research in these domains. Even if the standards are eventually not developed by projects but by companies, their participation in projects allows them to diminish the risk of available options and lower the costs and the barriers. This observation found confirmation in the responses of participants interviewed (PwC and OpenEvidence, forthcoming), quoting the **need for critical mass** among the main reasons for seeking EU rather than national funding, and the fact that EU countries face **largely similar challenges** across Europe. For instance, in telecommunications, participants stated that "*the technological challenges European incumbent operators are facing are quite similar (cost pressure and increasing traffic enabling the leading European Gigabit societies) […] Especially the collaboration on the transport network level allows to leverage on recently developed technology achieving improved network utilization at lower cost.*"

Interviewees also noted that **identifying top-level expertise** is crucial, especially in new domains. One researcher explained that: "*The key problem for my research group is building critical mass and critical expertise in strategic topics. National funding fails on this level because the projects are too short (ca. 2 years) and too small (ca. 1 FTE) to achieve this. We need EU projects in order to achieve the necessary scale as well as the necessary contact to international experts"*. Fostering collaboration between universities and industry players from different Member States was also seen as a crucial benefit, and the increased interaction and synergies with different types of stakeholders (universities, SMEs, large companies). Some participants further explained how FP7 ICT participation encouraged **longer-term thinking** and **riskier investment** also by SMEs. At the project level no interviewee envisaged that a given project would have been carried out in the same way **in the absence of EU funding**. In most cases the project would have been cancelled or implemented at smaller level, or it would have been less sophisticated, postponed or slower. This demonstrates the importance of EU funding. However, it could also be interpreted as revealing the limited strategic importance of the projects. This seems to imply (quite reasonably) that companies use FP7 ICT as a useful complement for innovative activities, but not to develop core strategic activities (PwC and OpenEvidence, forthcoming).

[58] However, at the demonstration phase, constraints become evident (due to the sensitive nature and competitive advantage in deployment). In Europe, standardisation through the FPs has been successfully achieved in 3G and 4G; however, despite being international leaders in technology in this area (throughout FP6 and FP7), European network operators are not leading in deployment, where the uptake and the infrastructure are more advanced in the US. The EU lags behind in the deployment of 4G, however, the goal is to be leader in 5G (for which talks where initiated between stakeholders in Europe), but with increasing global competition (Korea, Japan, China talk also about it). An agreement on cooperation has been signed with Korea (concerns already H2020).

Setting the vision has also been the case in areas such as **networked media**, so as to include the use of social networks by the creative industry. According to DG CONNECT officials, work is still needed in this area, but the programme has so far achieved the result reinforcing the need of putting together technology in the media sector to move to the new era of convergence and interaction. In areas such as **Cloud Computing**, the European added value has been in supporting the European industry in a key technology revolution that is transforming the way IT is developed and delivered, and that has a strong impact not only in the software sector but also in the productivity of most other sectors which are highly dependent on software. This is particularly important in an area where Europe has a strong industry but is not driving the developments, so it becomes critical to invest in advanced research in order to keep pace with the competitors. In areas such as **robotics,** the EU funding has promoted multidisciplinarity and large scale development, achieving the objective to involve more industrial actors in a sector traditionally dominated by academia. Also, as robots have had a large growth, passing from assembly lines to uses in environment, health, home, transport, the providers participate in the projects to see how to explore new markets. Therefore in this field where in the past the aim was to develop less costly robots, now industry is involved and needs to take risks. In areas such as **ICT for language technologies**, the EU has made a difference in breaching the language barriers and in breaking the national fragmentation, as the extreme diversity of the European landscape makes it difficult for any single provider to cope with it. In areas that are typically a national endeavour, such as ICT for cultural heritage, the benefits come from collaborating at EU level and pulling resources together.

Similarly, various aspects of the added value for Europe from the **AAL JP** were recognised in the evaluation of the programme (Busquin et al., 2013), including the creation of a critical mass of research, development and innovation activity in AAL systems and services at European level, strong network effects and the seeding of communities which bring the AAL field closer to the market. Furthermore, the programme has had a catalytic effect on national initiatives and activity, including leveraging of national funding and a strong commitment shown by Participating Countries, with financial contributions running at around 25-30% above the required minimum. A number of national programmes and initiatives on ambient assisted living have emerged as a direct result of, or stimulated by, the AAL JP[59]. One of the Programme's most visible impacts has been in building synergies with other European initiatives and programmes. Programme representatives have contributed actively to the EIP-AHA, ensuring that the AAL JP is better known within the policy community and that its calls are broadly aligned with the EIP-AHA's strategic priorities.

There was a broad consensus among interviewed participants in the context of the support study (PwC and OpenEvidence, forthcoming) that there is a **need for EU-level intervention in research funding**. Most of the interviewees were able to indicate a project whose results could only have been reached through EU-level research effort. For instance, "*with DOTFIVE Europe set the state-of-the-art in performances of Silicon-Germanium based semiconductors which was previously held by IBM (USA)*[60]". With regard to research outcomes that **would not have been achieved** without FP7 ICT, interviewees mentioned some specific research

[59] These include the German national AAL programme, the Hungarian eVITA initiative for innovative opportunities in the healthcare system, the Spanish EVIA innovation platform, and the UK Technology Strategy Board Assisted Living Innovation Platform (ALIP).

[60] This refers to the achievement of the DOTFIVE project, which helped European companies become leaders in performances of Silicon-Germanium based semiconductors.

topics such as higher fibre-optic broadband speeds, advances in Future Internet and open data. However, the value added appears to be greater in other **more strategic aspects**. Firstly, FP7 ICT is the main driver of European and international cooperation that is crucial to research across different fields. Secondly, some measures such as JTIs have changed the trade-offs between collaboration and competition, thereby accelerating discovery. The interest of participants, including large companies lied indeed in the fact that the "*The aggregation of stakeholders with common goals generates benefits such as less competition and more money which enable them to develop solutions which otherwise would have been very expensive, deficient or hard to get done efficiently*."

Conclusions on FP7 and outlook for H2020

As emerged from interviews with DG CONNECT officials, compared to the previous Framework Programmes, FP7 had three determining differences: the move to more **strategic approaches**, the **development of roadmaps** and the increasing involvement and consultation of **stakeholders**. FP7 ICT aimed at strengthening competitiveness, with the objectives of supporting R&D for Industrial applications in key sectors, ICT application for the benefit of economy and society, research on long-term visionary research linked to ICT (FET) and eInfrastructures. The Programme has tried to support more strategic initiatives with future potential by identifying **priorities** in terms of roadmap based applied research, but also continued to support **open and disruptive research and technologies**. The emerging policy rationale behind this more strategic approach to research and development in ICT has been the realisation that there is an increasing need to share resources and expertise, to specialise in order to be able to compete with other global players in the years to come. This has been particularly evident, where Europe is lagging behind or at risk of losing its competitive position for instance in fields such as high performance computing, or embedded systems. FP7 ICT has also seen the rise of certain fields, such as photonics and robotics to prominence. In the areas where these fields open up new avenues for commercial exploitation closer links with industry have been established via Joint Technology Initiatives and Public-Private Partnerships. The latter also presents a shift in the instruments used to leverage public funding, and to create a more-strategic vision.

The programme has also preserved some **continuity**, as many of the initiatives supported have their roots in earlier programmes, such as FP6 IST, and some activities are also carried on in Horizon 2020. Photonics is a case in point, having started as a topic in FET, it has graduated to a PPP. Quantum technologies are another area, which can be traced back to FP5 and FP6, and which has seen the emergence of niche products only recently. In High Performance Computing, the research-oriented consortium PRACE ensured the sharing of computing power. Simultaneously, there has been a FET Proactive initiative in the area, and most recently, a PPP has been set up increasingly involving industrial participants with the aim to foster the manufacturing of supercomputers in the years to come. Hence, FP7 ICT presents a **build-up of knowledge over time**. The vast majority of the participants consulted observed that FP7 had an overall capacity to **adapt to a changing environment** and the ability to capture/reflect the technological and scientific needs and challenges that their organisations and Europe in general are facing today. The alignment with areas of EU competitive advantage has been recognised consistently by experts and participants in evaluations carried out over the FP7 timeframe. The participants consulted were satisfied in terms of Work Programme coverage of themes and the Programme was found also highly relevant in terms of alignment with current worldwide ICT R&D.

FP7 ICT has been effective in achieving the objective of promoting **trans-national collaboration** among players from the academia and industrial sectors, strengthening a dense collaboration network that is continuing to grow over the Framework Programmes. Alongside a stable core of recurrent participants, new participants have been joining every year. The usual suspects should not be underestimated, as these were largely responsible also for facilitating access to new entrants. This access is of utmost importance to many entities, notably SMEs, which show the tendency to participate only in one project.

The greatest impact of the Programme has been the **knowledge effects** for its participants, where the required competences, resources, scale and scope could not have been achieved to the same degree at the national level. The programme has led to the generation of critical mass in key sectors, and it has overall also been able to attract a balanced set of players across different sectors. This result is especially relevant at a time of reduction of national resources, and in an increasingly complex and competitive landscape where no country can afford to think of research development and innovation strategies in purely national terms any more.

According to DG CONNECT officials, the programme has had a positive effect on safeguarding some of the industrial areas in which Europe has traditionally shown strength. (e.g. equipment and telecom industry, embedded systems, components), although it has not managed to promote European devices, platforms for the web and operating systems. In Internet of Things Europe is positioning itself well. Parts of the recovery package PPPs were useful, developing a model of are partnerships that has become the dominant approach in H2020. Opening through FET open and disruptive innovation was also very important: among the main achievements of the programme was the launch of 320 projects path-finding future ICT across a wide set of promising topics and the scaling up of FET-Open scheme (continuously open for 7 years with some 3,300 proposals submitted).

Direct employment effects of FP7 ICT have been possibly higher than other parts of the Programme and researchers represented more than half of the workforce, which may indicate FP7's ability to enhance EU human capital and quality of EU research. As for women, they were the most under-represented among experienced researchers and most represented among temporary researchers. Participation of SMEs has been in line with the target. SMEs presence varied by area, but the need of increasing their participation persists, and it is particularly important in application areas. To this end, Networks of Competence Centres have been established to enable access of SMEs to technology, equipment and expertise to develop and test ideas. Participants pointed out that rules should be simplified for SMEs, and instruments should address even more specific needs. Processes should be shortened and more flexibility should be granted in order to react to new challenges of the ever-changing ICT environment. H2020 is expected to address SMEs' needs in a more tailored manner, e.g. through the SME instrument.

The impact of the programme on community building is evident not only from the input side, but also in terms of outputs, i.e. **outputs** generated, such as patents and publications. SMEs participating in the programme showed higher productivity in terms of publications that those not participating. Moreover, research undertaken at the European level has been more-highly valued (in terms of citation of publications and further use) than research originating at the national level and has shown a higher degree of internationalization than their control sample counterparts, rather nationally focused. The programme has undoubtedly had high overall impact on knowledge creation, on the **scientific and technological achievements.**

Other impacts were in terms of **policy transfer**, as some policies and research have been pioneered at EU level and taken up by the national programmes, informing national policies in areas such as Future Internet, AAL, and in the areas defined as FET Flagships. FP7 ICT programme initiatives also provided examples to other countries and regions of the world e.g. the US and Latin America (robotics, photonics, Smart Cities, and GEANT). International collaborations are also paving the way for global standards and portraying Europe as leading technology hub. In this context need to be highlighted the coordinated calls with Brazil, Japan and targeted openings with China, Korea and South Africa.

Furthermore, in some areas of higher technological maturity, this knowledge has served to develop some **application**s in their early stages of deployment. Also, from the final reports there is evidence of 125 spin-offs being created as result of funded projects. Projects delivered valuable opportunities not only to the research community and direct beneficiaries of successful proposals but also enabled concrete solutions implemented in applicable cases for the benefits of European citizens. In areas such as telecommunications, internet of things and semiconductors, **standardisation** has also been an outcome of the projects. EU-funded projects in the area of ICT have also led to **dynamic spin-offs** set up to commercialise products and services resulting from EU support. There is some evidence of SMEs that have been active in the Programme and have grown as a result both in terms of employees and turnover, building their success on the programme participation.

However, and keeping in mind that FP7 was largely a research programme, in the view of stakeholders consulted, FP7 ICT mechanisms had limited impact in helping to translate research results into **innovative** products, processes and services and to support demand-driven innovation. At the same time there are great expectations that H2020 will address the obstacles to technology deployment and transfer, facilitating the transition from research to market. Finally, a concurrent cultural shift is needed to effectively put this in practice.

In terms of the **reporting and dissemination of results**, despite the widespread criticism by the participants that reporting of outcomes and results is bureaucratic, repetitive and cumbersome, there is fragmentation in the information provided by the beneficiaries, and this information cannot be aggregated at the Programme level. The reporting requirements and the IT tools have not been targeted enough to inform on project achievements. In H2020 the reporting requirements have been streamlined and the IT tools should provide the data in a structured way. Also, a strategy for more efficient dissemination and exploitation is currently being discussed, in order to respond more effectively to policy and stakeholder needs, based on the wealth of information from all projects throughout their entire life cycle that is available, yet unexploited.

As for the **administration and the implementation** of the programme, a moderate improvement, compared to FP6, was generally observed by interviewees in terms of efficiency in programme administration, especially in terms of the management by DG CONNECT (performance in Time To Grant is among the best of the research family). The administrative burden of participation is a recurrent topic of contention, although the constituency is appreciative of the proposed simplification measures of Horizon 2020. The main challenges for the participants remain the management and coordination of the consortium, the reporting and dissemination requirements, as well as the oversubscription to calls in some areas. As for the latter, there is some scepticism as to whether the reduction in the size of the proposal will effectively address this, or the opposite effect (i.e. the growth of the number of proposals) will ensue.

The **European Added Value** in this area is high and widely recognised by the project participants: public support at EU level is needed and necessary, as it has had several effectiveness, efficiency and synergy effects. The programme has addressed Pan-European challenges, built the critical mass in technological domains, and brought together stakeholders not traditionally cooperating. The programme has set the strategic agenda in key sectors, allowing participants to cooperate on common challenges and lowering risks. Participants interviewed show a wide consensus that there is a need for EU-level intervention in research funding; in their view, the programme “made a difference", generating additional research, increasing interaction and synergies between different players and achieving a scale not reachable at national and local level.

Annex I – Statistical annex

Table 1 Objectives of eInfrastructures scheme

Support sub-scheme	Objective
Data infrastructures & services	Increase in the scale of federation and interoperation of data infrastructures; better exploitation of synergies with the underlying eInfrastructures; reduction of costs; increase of the user base and bridging across disciplines; enablement of cross-fertilisation of scientific results and favouring of innovation.
Virtual Research Communities	Developing global communities or e-Science[61] environments – through the development of collaborative platforms for the recording, sharing and use of global data resources. The main goal is to help users access and effectively use the e-Infrastructure for global, cross-disciplinary research.
Computational infrastructures	Further deployment of grid-empowered eInfrastructures. Expected outputs and outcomes are the continuation of the world-class performance of the European Grid infrastructures and their ongoing global relevance; the availability of repositories of easy-to-install middleware components, combined with consistent training and education programmes; improved access to RI; and a broader interdisciplinary scientific collaboration. Projects focusing on high-performance computing (HPC) address the growing computational and simulation requirements of the European scientific communities and industry.
Communication Networks	Further deploy and evolve the pan-European high-capacity and high-performance communication network GÉANT, which constitutes a core part of the eInfrastructures in Europe, provides Europe with a gateway for global collaboration, supporting the needs of the research and education communities.

Source: Technopolis-Empirica (2014)

Table 2 FET Objectives

Scheme	Objective
FET Open	It supports early-stage joint science and technology research around new ideas for radically new future technologies. The funding scheme is light, topic-agnostic and deadline free research specifically designed to be open and continuously responsive to novel and fragile ideas that challenge current thinking, whenever they arise and wherever they come from.
FET Proactive	It nurtures emerging themes and communities by addressing a number of promising exploratory research themes with the potential to generate a critical mass of inter-related projects. It engages in the coordinated exploration of a new theme, as well as in the consolidation of promising future technologies to be taken up by industry and society.
FET Flagships	It support ambitious large-scale, science-driven research aimed at grand interdisciplinary S&T challenges. The scientific advance should provide a strong and broad basis for future technological innovation and economic exploitation in a variety of areas, as well as novel benefits for society.

Source: FP7 Work Programmes

[61] eScience software environment projects focus on the development, deployment and evolution of scientific application software and simulation infrastructures and services. This includes the development of models, tools, algorithms, and simulation and visualisation techniques. The goal is to replace traditional experimentation for "in silico" experimentation in order to address major scientific, industrial and social challenges. The overall aim is the integration of scientific software applications to enable the full and timely exploitation of high performance and distributed computing capabilities.

Table 3 Objectives of ICT Theme of Cooperation Programme, by Challenge

Challenges	Objective	Specific Objective FP7 ICT: Increase technological excellence of ICT industry	Specific Objective FP7 ICT: Research on themes of major societal needs
Challenge 1	**To develop convergent communication and service infrastructure** • To gradually replace the current Internet networks • To develop the "Future Internet" • To support key technological developments in networking, digital media and services infrastructures • To cover tools and platforms for novel Internet applications through PPP-FI • To support large experimentation in networking, cloud computing, Internet of Things, thrust worthy ICT	Technological field: • Software engineering • Network technologies Market area: • Internet services, • Cloud Computing	General: economic competitiveness, social welfare
Challenge 2	**To engineer more robust, context-aware and easy-to-use ICT systems** • To develop self- improve and self-adapt ICT systems • To enhance the performance and manageability of artificial cognitive systems • To expand and improve functionalities of robotic systems operating with functionality not fully planned for explicitly at design time • To develop artificial systems that operate in dynamic environments, reaching new level of autonomy and adaptability	Technological field: - robotics systems Market area: • Logistics, • Manufacturing technologies, • Transport	General: economic competitiveness, social welfare Specific: new tools assisting citizens
Challenge 3	**To develop increasingly smaller, cheaper, more reliable and low consumption electronic components and systems (WP 2007, 2008, 2009, 2010)** **To develop alternative paths to component and systems (WP 2011, 2012, 2013)** • To build the basis for innovation in all major products and service. • To develop alternative path to next generation technologies for innovation in all major products and services • To enhance miniaturisation and increased performances of key enabling technologies and related component systems. • To enhance heterogeneous integration of key enabling technologies and related components and systems	Technological field: • Several (manufacturing industry) Market area: • IT equipment, components	General: economic competitiveness, social welfare

Challenge 4	**To develop digital libraries and contents (WP 2007, 2008, 2009, 2010)** **To develop technologies for digital contents and languages (WP 2011, 2012, 2013)** • To help preserve, develop and disseminate European cultural assets and improve learning and education systems. To enable individuals and small organizations to create quality content and innovative services. • To allow people to access and use online content and services across language barriers. • To ensure reliability of retrieval and use of digital resources across applications and platforms and the scale up data analysis to keep pace with extremely large data volumes (WP 2011, 2012). • To enable individuals and small organizations to create quality contents and innovative services (WP 2012). • To allow people to access and use online content and services across language barriers (WP 2011, 2012)	Technological field: • Software engineering Market area: • Internet services	General: economic competitiveness, social welfare Specific: new opportunities for SMEs, lower barriers for citizens
Challenge 5	**To develop ICT Tools for sustainable and personalized healthcare (WP 2007, 2008, 2009, 2010)** **To develop ICT for independent living, inclusion and participatory governance (WP 2007, 2008, 2009, 2010)** **Challenge 5 - To develop ICT Tools for health, ageing well, inclusion and governance (WP 2011, 2012, 2013)** • To ensure that all citizens can benefits from ICT for better inclusion and independent living. • To ensure that all citizens can benefit from ICT and the ICT can helps improve participation in public and active life. • To enhance ability to monitor our health and well-being and to treat major illnesses and diseases. To ensure delivery of quality healthcare at affordable costs and contributing to greater efficiency and safety of health systems. • To enhance ability of disease prediction, early diagnosis, prevention, minimally invasive treatment, and overall disease management to health lifestyles. • To prolong independent living and extending working life, enabling accessibility of emerging mainstream ICT solutions and assistive technologies for people with disabilities, • To enhance tools for governance and policy modelling. • To empower individual to improve personal life conditions and participation as a citizen, elderly, patient and consumer.	Technological field: • Software, • data management, • sensors Market area: • Healthcare services	General: economic competitiveness, social welfare Specific: Better healthcare and information systems

Challenge 6	**To develop ICT for mobility, environmental sustainability and energy efficiency** **To develop ICT for a lower carbon economy (WP 2011, 2012, 2013)** • To develop intelligent and safe vehicles and technologies for environmental sustainability and energy efficiency. • To support ICT research in its increasing role of using ICT in reducing energy intensity and in bridging environmental information space and services. • To enhance ICT to achieve substantial efficiency gains in the distribution and use of key resources. • To apply ICT to decarbonise transport and make it safer. • To incorporate ICT contributions to the PPP on Energy Efficient Buildings and Green Cars.	Technological field: • IT systems/tools for specific sectors Market area: • Automotive, • transport, • energy, • water	General: economic competitiveness, social welfare Specific: Lower CO_2 emissions, higher energy efficiency, costs saved
Challenge 7	**To develop ICT for manufacturing & factory of the future (WP 2011, 2012, 2013)** • To incorporates the ICT contributions to the PPP on Factories of the Future. • To bring together suppliers and users for experiments that targets the broad uptake of ICT in all domains of manufacturing.	Technological field: • sensors, • methods, • architectures Market area: • Manufacturing sector	General: economic competitiveness, social welfare Specific: Manufacturing industry
Challenge 8	**To develop ICT for learning and access to cultural resources (WP 2011, 2012, 2013)** • To make people learn more effectively and support the acquisition of new skills. • To ensure the effective use and exploitation of the cultural resources by developing technologies to make them available, usable and re-usable regardless of their form, location • To support the production of more powerful and interactive tools for creative industry.	Technological field: • software applications, • technologies Market area: • Software, • Services	Specific: New possibilities to engage in cultural resources, New training/tutoring possibilities

Source: FP7 Work Programmes and Dinges et al., (2011)

Table 4 Artemis and ENIAC (JTI)'s funding structures:

	ARTEMIS	ENIAC
Member States	€745 million	€800 million
European Commission	€410 million	€440 million
Private sector	€1 645 million (approx. calculation)	€1 360 million (approx. calculation)
TOTAL	€2 800 million	€2 600 million

Source: First Interim Evaluation of the ARTEMIS and ENIAC Joint Technology Initiatives, 2010

Table 5 FP7 ICT Cooperation Theme, EC funding by challenge, cumulated figures 2007-2013

Challenge	EC Funding (€MEUR)	
Challenge 1 - Networks	1,917	25%
Challenge 2 - Cognitive Systems and Robotics	635	8%
Challenge 3 - Components and Systems	1,446	19%
Challenge 4 - Digital Content and Languages	416	5%
Challenge 5 - ICT for Health, Ageing Well, Inclusion and Governance	878	11%
Challenge 6 - ICT for low carbon economy	727	9%
Challenge 7 - ICT for the Enterprise and Manufacturing	289	4%
Challenge 8 - ICT for Creativity and Learning	430	6%
FET	821	11%
Accompanying Measures	99	1%
International Cooperation	92	1%
Total	7,749	100%

Source: MIS, data analysis by DG CONNECT F4

Table 6 Main data about ARTEMIS

ARTEMIS	Call 2008	Call 2009	Call 2010	Call 2011	Call 2012	Call 2013	TOTAL
Projects	12	13	10	9	*8*	4	**56**
No. of partners	227	296	239	213	*284*	205	
National funding	€59.29M	€67.82M	€55.23M	€39.16M	*€66.82M*	€48.19M	**€336.51**
EU funding	€33.25M	€34.05M	€28.32M	€24.01M	*€114.86M*	*€27.28M*	**€261.77**
Countries	27	27	27	27	27	27	

Source: Artemis website and ARTEMIS Joint Undertaking Annual Activity Report 2013 ARTEMIS-ED-2014.75

Table 7 Main data about ENIAC

ENIAC	Call 2008	Call 2009	Call 2010	Call 2011-1	Call 2011-2	Call 2012 -1	Call 2012-2	Call 2013-1	Call 2013-2	TOTAL
Projects	7	11	10	6	5	6	5	**4**	**9**	
National funding	€57.8M	€67.4M	€54.8M	€45.5M	€72.9M	€37.6M	€98.3M	€19M	€153.6	**€396.7M**
EU funding	€32M	€38M	€30.1M	€25.3M	€27.5M	€17.6M	€107.8M	€11M	€158.9M	**€278.3M**
Countries	17	19	21	21	22	21	21	21	21	

Source: ENIAC website and ENIAC Annual Activity Report 2013

Table 8 Main data about AAL JP projects

	call 5*	call 4	call 3	call 2	call 1
Total Cost	€ 83.2M	€ 75.8M	€ 79.1M	€ 73.6M	€ 47.1M
EC contribution	€ 21.5M	€ 16.7M	€ 19.2M	€ 15.4M	€ 13.5M
National contribution	€ 27M	€ 21.2M	€ 24.9M	€ 26.5M	€ 15.6M
Partner contribution	€ 34.5M	€ 38M	€ 35.1M	€ 31.7M	€ 18M
% EC contribution	25.90%	22.00%	24.21%	20.98%	28.66%

* Call 6 figures not available; call 5 figures based on budgets before negotiations

Table 9 FP7 ICT (Cooperation and Capacities), funding by Strategic Objective and type of organisation, cumulated figures 2007-2013

	EC funding				Participations			
	HES/ REC	LARGE	NIL	SME	HES/ REC	LARGE	NIL	SME
Challenge 1 - Networks	54%	30%	2%	14%	50%	30%	4%	17%
Challenge 2 - Cognitive Systems and Robotics	86%	5%	1%	8%	75%	8%	2%	14%
Challenge 3 - Components and Systems	63%	19%	2%	16%	57%	22%	3%	19%
Challenge 4 - Digital Content and Languages	64%	12%	2%	22%	54%	15%	4%	27%
Challenge 5 - ICT for Health, Ageing Well, Inclusion and Governance	67%	12%	5%	17%	58%	13%	9%	20%
Challenge 6 - ICT for low carbon economy	47%	34%	3%	16%	40%	36%	7%	17%
Challenge 7 - ICT for the Enterprise and Manufacturing	48%	30%	1%	21%	40%	30%	3%	27%
Challenge 8 - ICT for Creativity and Learning	69%	8%	7%	15%	63%	8%	11%	18%
FET	92%	4%	1%	3%	89%	4%	2%	4%
Accompanying Measures	41%	27%	17%	15%	45%	20%	20%	15%
International Cooperation	64%	8%	8%	20%	52%	9%	21%	17%
eInfrastructures	63%	5%	12%	20%	74%	6%	14%	6%
Total	**64%**	**18%**	**3%**	**15%**	**59%**	**19%**	**6%**	**16%**

Source: MIS, data analysis by DG CONNECT F4

Table 10 FP7 ICT (Cooperation and Capacities), distribution of EC funding by EU Member State, cumulated figures 2007-2013 (% of total EC funding by challenge)

EU Member State	Challenge 1	Challenge 2	Challenge 3	Challenge 4	Challenge 5	Challenge 6	Challenge 7	Challenge 8	FET	Accompanying Measures	International Cooperation	e-infrastructures	Total
AUSTRIA	2.4%	3.1%	3.9%	5.4%	5.1%	3.7%	2.6%	9.0%	3.5%	6.1%	4.6%	1.0%	3.7%
BELGIUM	4.1%	3.7%	7.9%	1.7%	3.5%	4.6%	1.5%	4.1%	3.3%	5.2%	3.1%	1.0%	4.2%
BULGARIA	0.1%	0.0%	0.0%	1.6%	0.3%	0.2%	0.2%	0.5%	0.1%	0.6%	0.1%	0.6%	0.3%
CROATIA	0.0%	0.1%	0.1%	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%	0.2%	1.2%	0.3%	0.1%
CYPRUS	0.3%	0.3%	0.4%	0.0%	0.6%	0.3%	0.1%	0.4%	0.1%	0.0%	0.1%	0.7%	0.3%
CZECH REPUBLIC	0.3%	1.0%	0.3%	1.5%	0.8%	0.6%	0.9%	0.4%	0.3%	0.4%	0.0%	1.3%	0.6%
DENMARK	1.1%	1.5%	1.7%	0.8%	1.8%	1.4%	1.8%	1.8%	2.0%	0.5%	2.1%	2.8%	1.6%
ESTONIA	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.6%	0.1%	0.0%	0.1%	0.2%	0.1%
FINLAND	2.8%	0.8%	2.6%	1.1%	2.1%	4.2%	2.7%	1.6%	1.3%	1.6%	1.9%	2.5%	2.3%
FRANCE	13.6%	7.2%	14.8%	5.5%	5.7%	6.6%	5.4%	6.0%	13.3%	12.6%	15.6%	8.0%	10.4%
GERMANY	21.2%	28.2%	25.0%	25.5%	17.3%	24.2%	34.5%	17.6%	21.2%	22.8%	17.9%	11.8%	22.1%
GREECE	5.5%	2.7%	3.1%	7.0%	8.3%	4.8%	4.5%	5.3%	1.7%	2.1%	5.0%	4.0%	4.6%
HUNGARY	0.8%	0.3%	0.5%	0.7%	0.4%	0.2%	0.3%	0.3%	0.8%	0.9%	0.0%	1.6%	0.6%
IRELAND	2.4%	0.2%	1.9%	3.2%	1.3%	1.9%	1.1%	2.1%	0.9%	0.6%	2.8%	1.4%	1.8%
ITALY	10.2%	15.4%	8.8%	9.1%	13.4%	11.5%	13.3%	8.2%	13.2%	11.2%	11.9%	11.9%	11.2%
LATVIA	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.1%	0.0%	0.2%	0.2%	0.2%	0.3%	0.1%
LITHUANIA	0.0%	0.1%	0.1%	0.0%	0.2%	0.0%	1.2%	0.1%	0.1%	0.0%	0.1%	0.2%	0.1%
LUXEMBOURG	0.3%	0.0%	0.0%	0.1%	0.3%	0.3%	0.9%	0.6%	0.0%	0.0%	0.0%	0.2%	0.2%
MALTA	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.3%	0.1%	0.0%	0.0%
POLAND	1.0%	0.6%	0.9%	0.8%	0.8%	0.7%	0.1%	0.4%	1.3%	1.3%	1.9%	3.4%	1.0%
PORTUGAL	2.1%	2.4%	0.7%	1.0%	1.2%	1.6%	1.9%	1.8%	1.0%	0.9%	1.6%	0.7%	1.4%
ROMANIA	0.5%	0.1%	0.2%	0.3%	0.6%	0.4%	0.3%	0.2%	0.1%	0.6%	0.3%	0.2%	0.3%
SLOVAK REPUBLIC	0.1%	0.0%	0.1%	0.1%	0.2%	0.2%	0.8%	0.0%	0.2%	1.3%	0.2%	0.2%	0.2%
SLOVENIA	0.4%	1.0%	0.0%	1.7%	0.4%	1.2%	0.6%	0.5%	0.5%	1.6%	0.0%	0.2%	0.5%
SPAIN	11.1%	5.2%	5.4%	9.9%	10.0%	10.6%	10.3%	6.0%	8.2%	9.4%	10.2%	6.3%	8.5%
SWEDEN	3.5%	4.9%	4.0%	2.1%	2.3%	5.9%	2.3%	3.8%	5.6%	3.2%	2.5%	2.3%	3.8%
THE NETHERLANDS	4.1%	4.2%	7.6%	5.7%	7.2%	6.7%	3.6%	7.4%	6.0%	7.2%	3.1%	8.4%	6.0%
UNITED KINGDOM	12.0%	17.0%	10.0%	14.3%	16.1%	8.1%	8.9%	21.0%	14.8%	9.1%	13.5%	28.5%	13.9%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: MIS, data analysis by DG CONNECT F4

Table 11 FP7 ICT Cooperation Theme, EC funding, participations and projects by Challenge and type of instrument, cumulated figures 2007-2013

	EC Funding (Mio€)	Participations	Projects	Strep	IP	NoE	CSA	Average EC Funding/ project	Average EC Funding/ participation
Challenge 1 - Networks	1,917	5,534	493	290	116	14	73	3,888,177	346,381
Challenge 2 - Cognitive Systems and Robotics	635	1,308	152	102	40	2	8	4,174,924	485,159
Challenge 3 - Components and Systems	1,446	4,200	431	294	61	12	64	3,355,632	344,352
Challenge 4 - Digital Content and Languages	416	1,157	142	101	17	4	20	2,931,906	359,836
Challenge 5 - ICT for Health, Ageing Well, Inclusion and Governance	878	2,696	248	154	46	4	44	3,539,548	325,596
Challenge 6 - ICT for low carbon economy	727	2,486	221	169	15	2	35	3,289,193	292,402
Challenge 7 - ICT for the Enterprise and Manufacturing	289	818	69	39	21	0	9	4,194,692	353,831
Challenge 8 - ICT for Creativity and Learning	430	1,263	118	68	28	4	18	3,642,791	340,340
FET	821	2,419	308	226	34	0	48		339,280
International Cooperation	99	703	81	29	2	5	45	1,132,148	130,447
Accompanying Measures	92	554	53	20	1	0	32	1,866,914	178,604
eInfrastructures	533	2,186	136	1	0	0	135	3,921,900	243,997
Total	**8,283**	**25,324**	**2452**	**1493**	**381**	**47**	**531**	**3,377,984**	**327,074**

Source: MIS, data analysis by DG CONNECT F4

Table 12 Workforce statistics

	Women	Men	Total	% of women
Scientific Coordinator	750	1.171	1.921	39%
Work package leaders	1.701	3.865	5.566	44%
Experienced researchers (i.e. PhD holders)	3.709	13.644	17.353	21%
PhD Students	2.227	5.857	8.084	28%
Others	4.297	6.247	10.544	41%
Additional researchers (recruited for the project)	4.453	4.216	8.669	51%
Total people involved	17.137	35.000	52.137	33%

Source: PwC and OpenEvidence (forthcoming)

Table 13 Engaging with policy makers: fields covered

Fields	Answers
Agriculture	0
Audio-visual and Media	39
Budget	11
Competition	76
Consumers	42
Culture	25
Customs	5
Development Economic and Monetary Affairs	18
Education, Training, Youth	79
Employment and Social Affairs Energy	3
Enlargement	6
Enterprise	52
Environment	67
External Relations	15
External Trade	13
Fisheries and Maritime Affairs	22
Food Safety	16
Foreign and Security Policy	13
Fraud Humanitarian aid Human rights	1
Information Society	241
Institutional affairs	8
Internal Market	22
Justice, freedom and security	23
Public Health	80
Regional Policy	43
Research and Innovation	233
Space Taxation	30
Transport	46

Source: PwC and OpenEvidence (forthcoming)

Table 14 Publications from FP7 funded projects in the field of ICT, cumulated figures 2007-2013, by media type

Media type	Number of publications*	Percentage*	Number of publications	Percentage
Book	90	0.5%		
Book Series	2,446	13.5%		
Conference Proceeding	8,946	49.2%	11482	63%
Journal	6,656	36.6%	6687	37%
Trade Journal	31	0.2%		
Total	18,169	100%	18,169	100%

Source: Jacob et al., forthcoming

Table 15 Distribution of citations across media types for publications from FP7 funded projects in the field of ICT, cumulated figures 2007-2013

Media type	Times cited*	Percentage*	Times Cited	Percentage
Book	219	0.2%		
Book Series	5913	6.1%		
Conference Proceeding	16,556	17.0%	22,688	23%
Journal	74,529	76.5%	74,791	77%
Trade Journal	262	0.3%		
Total	97,479	100%	97,479	100%

Source: Jacob et al., forthcoming

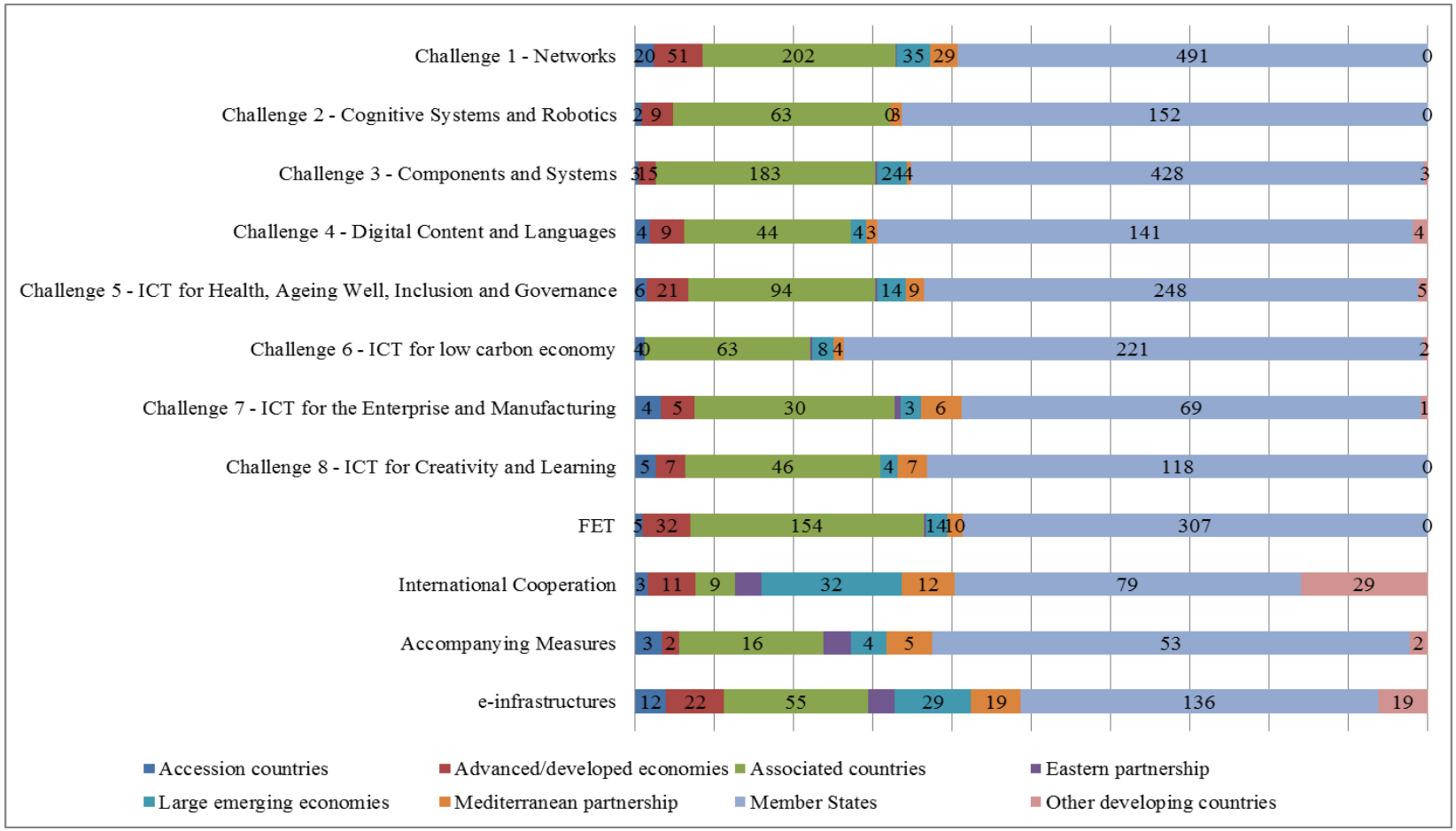
Table 16 Extraction from exploitable foreground section of final reports, by Strategic Objective

	Total	Commercial Exploitation of R&D results	Exploitation of R&D results via standards	Exploitation of results through (social) innovation	Exploitation of results through EU policies	General advancement of knowledge	Others
01 Future Networks and Internet	918	126	46	34	12	353	347
02 Software, Services and internet connected objects	410	92	7	7	1	98	205
03 Trustworthy ICT	388	60	19	5	5	133	166
04 Networked Media	381	100	11	7	1	97	165
05 Cognitive Systems and Robotics	300	50	6	3	0	72	169
06 Nanoelectronics	161	44	2	0	2	60	53
07 Micro/nanosystems	135	43	0	0	3	29	60
08 Embedded Systems	384	93	8	16	1	156	110
09 Photonics	213	93	11	3	0	60	46
10 Organic and large area Electronics	145	54	3	0	0	52	36
11 Language Technologies	129	5	0	28	0	34	62
12 Intelligent Information Management	422	77	15	6	12	166	146
13 ICT for Health	370	81	9	3	2	67	208
14 ICT and Ageing	154	43	3	3	0	68	37
15 ICT for Inclusion	119	40	7	9	2	41	20
16 ICT for Governance and Policy Modelling	38	0	0	3	6	20	9
17 ICT for Energy Efficiency	285	90	11	5	0	29	150
18 ICT for Transport	118	44	7	3	0	23	41
19 ICT for the Enterprise	157	88	7	0	0	28	34
20 ICT for Learning	84	25	0	1	0	5	53
21 Digital Libraries	259	28	9	1	4	68	149
22 FET	316	27	5	3	0	118	163
23 International Cooperation	57	5	0	1	0	19	32
24 Accompanying Measures	29	2	0	0	0	11	16

eInfrastructures	202	26	5	21	2	16	132
Total	**6174**	**1336**	**191**	**162**	**53**	**1823**	**2609**

Source: PwC and OpenEvidence (forthcoming)

Figure 1 FP7 ICT (Cooperation and Capacities), participation to projects, by country group and Challenges, cumulated figures 2007-2013



Source: MIS, data analysis by DG CONNECT F4

Figure 2 Overview of FP7 ICT and other funding

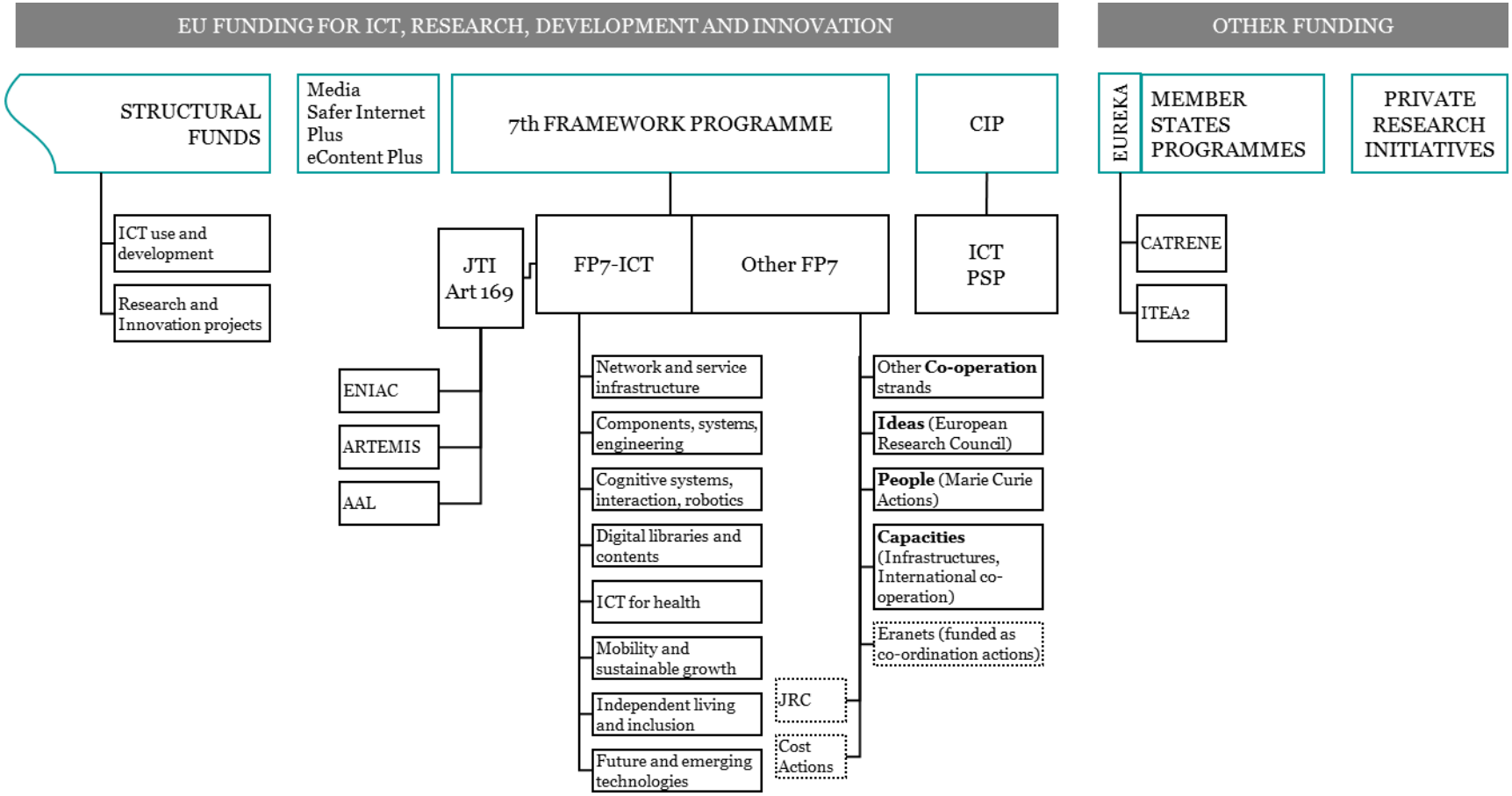
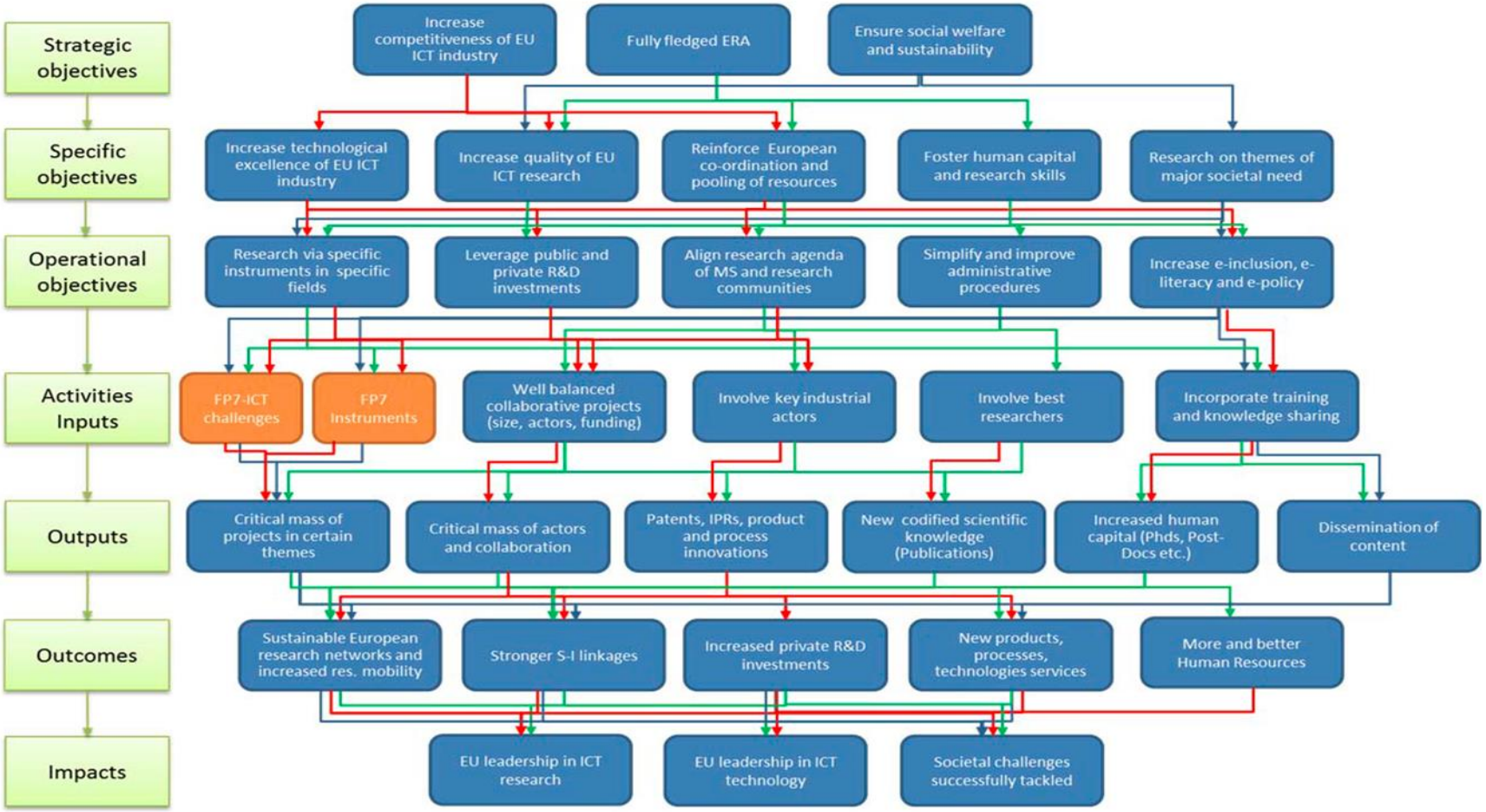


Figure 3 Intervention logic for the FP7 Cooperation Programme - ICT



Source: Dinges et al., (2011)

Annex II

Technological advancements

- In the area of **Future internet**, novel approaches towards capacity increase (spatial diversity) have been started in the optical fibre context, whilst several technologies to increase bandwidth flexibility have been validated. The work towards 400G core network capacity has progressed significantly and these technologies are getting closer to the market. In the software defined optical networks there was strong progress, where cross carrier/cross domain software management of capacity has been modelled and partly made its way into the standardisation domain. On the radio side, multiple projects have demonstrated technologies to use spectrum more efficiently and also to share radio resource better, which is one of the core objectives of the radio spectrum policy pursued by the Union. Also in the **5G domain**, projects have started to validate technological options for next generation radio access, whilst system oriented projects have defined the use cases and their requirements with international recognition[62].
- **Energy efficiency solutions** for wireless communication networks have been developed[63,] optimising the energy use of 4G/LTE (Long-Term Evolution) base stations, which accounts for the highest energy consumption in the mobile network.
- The **Internet of Things** domain has delivered important results, for instance a fully specified IoT platform architecture which is now becoming a reference for standardisation.
- In the field of **Networked media**, FP7 funding has reinforced the need of putting together technology in the media sector to move to the new era of convergence and interaction on content and media. It has explored (the process is still ongoing) the potential of adding social media and social media analytics to the media sector to provide new and disruptive services.
- In the field of **photonics**, the iPHOS project (Integrated Photonic Signal Sources for wireless communications) was able to demonstrate the possibility to integrate into a single chip all the current photonic components required in the communication applications. This chip has been placed at the core of a wireless communication transmitter, giving a big boost to high speed data transmission in a very compact module. These technological advances highly contribute to the European efforts to develop technologies able to access the Terahertz (THz) frequency range, thus providing an extra added value to the applications used in the sectors of medicine and security, where cost effective THz components are especially important for the detection of specific molecules[64].

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[62] The project METIS for instance has outlined the core 5G scenarios and has derived a challenging set of requirements from these scenarios, which are becoming reference scenarios and requirements for the overall 5G vision development.

[63] The project EARTH received in May the 2012 "Future Internet Award" prize for this development.

[64]See the book “Semiconductor Terahertz Technology: Devices and systems operating at room temperature”.

In an era when we increasingly use mobile phones and tablets to download and exchange heavy files of high quality data, wireless super-speed becomes a must. iPHOS is addressing this need by developing relevant devices, aiming for compact and low cost solutions through Photonic Integrated Circuits (PIC). Europe holds currently a leading position in the fabrication of Photonic Integrated Circuits (PIC), being ahead of United States and Japan. In fact, the European photonic industry has established technology platforms for the fabrication of such circuits at a low cost. PICs help increase the functionality of the photonic components. These highly functional components are crucial for the development of fibre optic communication links, as they enable the transfer of huge amount of data during the exchange of high quality digital pictures and videos.

- MODE-GAP has been officially recognised by the Guinness Book of Records for achieving the highest data transmission rate over hollow-core **optical fibre**[65]. The consortium has successfully achieved the world's highest data transmission rate[66] of over hollow core optical fibre on Coriant's testbed facility, which is an astoundingly 50 times faster than the previous record.
- In the domain of **eInfrastructures**, GÉANT gives access to all-optical networks, guarantees interconnectedness with the US, China, Central Caucasus, Japan and South America. Thanks to the EU funding GÉANT remains the most advanced research network in the world and has become the mainstream infrastructure, conceptually and in practice. In the early days of GÉANT, average bandwidths were 155Mbps but with the advent of the hybrid GEANT architecture in 2004, GÉANT became able to transmit data at speeds of up to 10Gbps as standard. Today it operates at speeds of up to 500 Gbps, connects over 50 million users at 10,000 institutions across Europe, and offers unrivalled geographical coverage (43 countries in Europe + 65 beyond).
- The expertise of different computing centres in Europe has allowed the creation of a network of **high performance computing** centres and to launch the race towards exascale. Consortia like PRACE have ensured access to facilities, where resource intensive simulations could be done by partners to whom these facilities were previously inaccessible.
- GÉANT, EGI and PRACE give access to innovative infrastructures that offer high capacity services not matched by any commercial or national offer. In the case of horizontal eInfrastructures and services, European collaboration has led to the development of new methodologies and tools, which make the management and provisioning of advanced services easier and more systematic. In addition, it has fostered a stronger and more integrated NREN community. For sub-areas such as High performance computing, collaboration across the EU has helped bring on board smaller and less resourced countries that otherwise could not afford these advanced systems, minimising internal disparities. Researchers in small, not so well resourced Member States profited from FP7 HPC and communication network funding the most, stressing the relevance of the programme for European cohesion. Coordinated procurement throughout Europe and transnational access has supported specialisation in architectures. As the HPC community is small, major hardware developments are based on activities at the European level. In addition, European collaboration in this area has helped establish a user and provider community, lowering the barriers of entry to access HPC resources and developing unified services that allow researchers to seamlessly switch between centres or relocate computing tasks (e.g. DEISA2 and PRACE). For grid and cloud activities, collaboration at the European level has allowed to train and build a user community of grid computing, to establish a production-quality grid infrastructure in Europe and to work towards the "gridificaction" of on-going research initiatives. In areas such as climate sciences, these grid projects have fostered new global research (e.g. E-Science Grid Facility for Europe and Latin America).
- In the area of **Components & Systems** (Cyber-Physical Systems), Time Triggered Architecture (TTA) - a ground-breaking safety technology for aerospace, automotive, energy, railway and industrial domains in airplanes and cars - has been developed by EU researchers. Applications range from controls for airplanes, latest generation premium

[65] The project targets the 100 fold enhancement of the overall capacity of broadband core networks, and develops multi-mode photonic band gap long haul transmission fibres, sources and detector arrays operating within the 1.8 to 2.1 um region and novel rare earth doped optical amplifiers for the new transmission window.

[66] 57.6Tb/s (gross rate of 73.7Tb/s).

passenger cars, up to industrial equipment such as control for off-shore wind power turbines and many others.

- In the area of **low power computing**, the project Eurocloud has resulted in the reduction of power consumption by a factor of 10, and overall the projects in this area are building the ecosystem on low power computing, addressing basic technologies across computing disciplines, strengthening European industrial actors (large and small), aiming at technology adoption across computing spectrum.
- Over the Framework Programmes, **FET** has contributed to enable Europe to take the lead in such areas as nano-electronics, microsystems, new computing paradigms, dependable embedded systems, photonics, and new materials. It is also pioneering research in promising research fields such as quantum information processing, complex systems and bio-inspired ICT systems. **Quantum technology** has been funded in FP5 to FP6, for €200 million in total of funding, and now the first niche market products are appearing (sensors, metrology, cryptography), with enormous expectations.
- The two **FET Flagships** on Graphene and the Human Brain Project (HBP) have been launched after a four years selection process, bringing back Europe to address big scientific challenges through long-term support. The creation of FET Flagships at DG CONNECT was unique within a whole FP7 landscape and demonstrates an important ability of the programme management to reflect on present situation and come up with a funding method that can better address emerging challenges (e.g. a need for a more intensive and long-term co-operation between academia and industry in the research).
- In the field of **cloud computing** the open source solution OpenNebula has been developed for the management of cloud infrastructures. More recently, Vision Cloud has pioneered innovative work on key technologies for data management in the cloud and content centric access. The work has been recognised by the prestigious Special Award received from the International Broadcasters Convention (IBC). On SME support, CLOUDWATCH has launched (with the participation of Commissioner Neelie Kroes) the EU cloudscout tool guiding SMEs in their steps to use the cloud.
- The EU support on **robotics** has started in FP6 as an academic multidisciplinary research programme; now it is taking more and more an industrial component. Make closer industry to academia was one of the objectives and the programme project iCub built the community by making closer industry to academia and helped derive the science/develop the sector, which is made up by a much diversified community (neurologists, cognitive scientists etc.)[67].
- In the field of ICT for sustainable growth (**ICT in the energy sectors**), research led to clear plans for the first of IoT semantics standard awarded by ETSI for home appliances. Thanks to this achievement the EU gained the world leadership (both industrial and academic).
- As part of the roadmap within the **Energy Efficiency** PPP, a scheme for semantic interoperability along the whole chain for building and construction has been developed, i.e. the whole construction supply chain has been better digitalised. In the building area the EU has been quite successful in achieving leadership.
- As for the development of new knowledge and proven ideas for **ICT** based **innovation for ageing well**, substantial activities with large impact and global potential have been

[67] See for instance iCub (Vol 460|27 August 2009 NATURE|Vol 460|27 August 2009), the humanoid robot developed as part of the project RobotCub and subsequently adopted by more than 20 laboratories worldwide. It started already in FP6, as a robotics platform developed in the programme and then distributed; many different projects and new proposals developed around this. The main characteristics are to be a designed and shared platform and open source. It was tested for aspects such as communication, developed capacities of interaction, very relevant for the underpinning technology.

created in focus areas such as service robotics for ageing well, smart living environments, fall prevention and open service platforms. A new multi-disciplinary science constituency has been established with major international conferences and research papers, as well as stimulating industrial exploitation, through roadmaps, standardisation and investor networks.

- On the policy level, global challenges need fundamentally different approaches, more integrated across sectors and more strongly rooted in evidence and broad societal engagement. **Global Systems Science** (GSS) projects aimed at making full use of progress in ICT to improve the way scientific knowledge can stimulate, guide, be used by, and help evaluate policy and societal responses to global challenges like climate change, financial crisis, pandemics, global growth of cities. Projects in this domain have shown new ways to have citizens engaged into policy processes and process to acquire data. This is linked to aspects of citizen science as social engagement. For example, the FOC project has provided the means to understand and forecast systemic risk and global financial instabilities, for use by players like the ECB and DG MARKT (to write the legislation on shadow banking). Socientize has shown the added value of collaboration and knowledge sharing through digital tools by involving some 12,000 citizens in a large spectrum of science projects from mapping flu outbreaks, labelling images of solar activity and cancer cells to collective music creation at one of the most exciting festivals in Europe, Sonar.
- In the field of **ICT for Trust and Security**, European companies are in position to meet current and emergent cybersecurity challenges. Cybernetica SA – an Estonian SME that has participated in FP7 ICT and specialises in secure e-government solutions, has consulted the governments of and is deploying their solutions in Namibia, Azerbaijan, and Japan.

Projects that delivered innovations and are being developed into products or commercial exploitation

- Large scale facilities, as in the case of **FIRE**, have been created to give researchers access to experimentation wherever they are based in Europe. SmartSantander is a particularly good example of the potential and uniqueness of the experimentally-based research done in FIRE: a holistic approach to experimentation covering the whole spectrum from technology to applications, from prototyping to large-scale deployment in the real-world, with actual end-users, on top of open facilities, not an ad hoc deployment for a specific application. FIWARE applications also offer examples of benefits for segments of the society, such as the SafeCity project carried out their first proof-of-concept (PoC) hazard-detection trial at the city's main airport Arlanda as part of a scheduled emergency exercise in the Arlanda Express train tunnel. SafeCity simulated a train accident in the tunnels under the airport. Using the latest in network technology and harnessing advances in 'sensing' technology, 31 sensors were installed in the tunnel and on the train, monitoring and collecting data such as temperature and levels of potentially dangerous materials, including smoke, CO2, CO and other gases. SafeCity is the first real-life demonstration using 'generic enablers' running on the Seville FI-WARE test-bed platform.
- New **business models** have emerged due to applications tackling challenges such as traffic management (SmartTaxi) and based on an open platform.
- In the area of **computing systems**, the TTA mentioned above has been validated thanks to EU funding and is being commercially exploited by leading innovative companies, such as TTTech, a spin-off of the Technical University of Vienna or ESTEREL Technology. The Airbus A380 for instance has already flown more than 5 million passengers across the

world using EU-funded ICT technology that has developed a new control system for cabin pressure.

- In the field of **electronics**, many spin-offs have been created to commercialise products and technologies developed thanks to EU-funded projects: POC MicroSOLUTIONS in Spain works on smart diagnostics systems that can monitor colon cancer or identify bacteria in food. The French spin-off Primo1D deals with electronic textiles that can be used in various sectors such as healthcare, sports, transport and construction. ATLAS neuroengineering, a spin-off company of Imec (Belgium) and IMTEK (Germany), develops technologies to better understand the human brain. The spin-off Graphensic AB in Sweden is the first business in the world commercialising a specific and efficient type of graphene wafers. EU investment helped ARM to thrive. The company has been involved in ca. 30 EU projects, benefitting from €17 Mio. of EU investment. This support has been key for the start-up to become a world leader in the design of low power micro-processors. More than 95% of world mobile and smart phones are equipped with ARM microprocessors and ARM employs 1,500 people in Europe.
- Half the added value in the automotive sector today comes from the integration of new technologies within cars and the use of new technologies in the design and production of cars. **Car electronics** help reduce fuel consumption, increase safety and comfort. Several EU-funded projects prepare tomorrow's mobility, boosting electric vehicles, such as V-CHARGE[68] (recent successful tests took place at Stuttgart airport) or OpEneR[69] (led by Bosch). Car electronics needs to be extremely safe. The world standard in the field was developed thanks to an EU-funded project CESAR. This puts EU manufacturers who have worked together on this standard at the leading edge world-wide. It also puts car electronics suppliers such as Bosch and Infineon in the pole position[70].
- Investments in **robotics** have helped modernise the fashion shoes industry, which represents 26,000 companies (mainly SMEs) and almost 400,000 employees in Europe. The project Robofoot allowed two SMEs, in Italy and Spain, to increase their productivity. The Spanish partner re-allocated production facilities from Asia to Spain, recreating growth and jobs.
- Other field of applications of scientific advances in **robotics** research are disaster zones. After earthquakes, accidents, avalanches or explosions, robots can take the place of their human teammates, cutting risk to human life and helping boost the chances of rescuing victims. Cutting-edge research projects like NIFTi, WALK-MAN and SHERPA are changing the way rescue services approach disaster situations, and improving the prospects for everyone involved – victims and rescuers alike. The project ARCAS for instance has developed robots that can fly into places too dangerous for humans and work independently on a large range of tasks.
- In the field of **ICT for manufacturing** VISTRA – a Factory of the Future project – has developed a comprehensive platform for simulation and training of manual assembly

[68] The project developed a new driverless car parking system.

[69] Opener has developed intelligent ways for electric vehicles to achieve energy efficiency, making them much more commercially attractive. After three years of intense collaboration and EUR 4.4m of EU investment, the OPENER project recently presented two demonstrator electric vehicles in Spain. Increased driving range was achieved not through enhanced battery technologies, but by the development of an intelligent energy management and recovery system. In particular, the team worked on improving the braking system, the navigation system and surrounding sensors. An adaptive cruise control was also installed to guarantee more economical driving. These “eco-routing” functions are the key to achieving energy efficiency and preserving battery life. In practice, this means that the car is intelligent, and provides the driver with braking tips based on traffic flows and advice on the best route to limit energy use. Up to 30 % of energy can be saved this way, without losing much time along the way.

[70] Europe is the world leading region in car electronics with more than 40 % of world production done in Europe.

processes building on/re-using existing enterprise data structures such as product and manufacturing data to enable interactive, game-based training of complex manual manufacturing processes. A commercialization of the VISTRA system is underway.

- The project EMBOCON developed optimisation methods for **embedded systems** (Real-time, non-linear, parallel and distributed). It resulted from the collaboration between mathematical algorithm developers, control theorists, hardware specialists and industrial application engineers and led to the creation of 2 spin off companies, a patent and first tests in the medical technology market. This technology can provide European embedded systems with a competitive advantage in the near-future market, in several industrial sectors.
- Thanks to a revolutionary new Light Emitting Diode (**LED**) system, funded by the EU research project LED4ART, Michelangelo's paintings in the Vatican's Sistine Chapel have been given a new lease of life[71]. The new system saves 80% on energy costs and emissions, and the gentler technology reduces the ageing of the paintings compared to the old system.
- Examples of **Photonics** applications are those achieved by the project LABONFOIL, which developed a ground-breaking diagnostic system based on smart cards and skin patches combined with a portable reader. Test results can directly be sent to a remote computer, a tablet or a smartphone through a wireless connection. This small lab can already detect cocaine consumption, monitor colon cancer, identify bacteria in food and analyse environmental contamination and many other useful applications can be foreseen. Companies in Spain, Ireland and Denmark will soon commercialise this innovative diagnostic system. The NEUWALK project explored how to make a paralysed rat walk again via electrical stimuli to its spinal cord. Their results have been published in 'Science Translational Medicine'. The research team also announced the opening of a new innovative lab at the Lausanne University Hospital, bringing this ICT project closer to clinical trials. Nine partners from Germany, Finland, France, Italy, the UK and Switzerland did join their expertise to develop neuroprosthetic systems that could restore motor functions after spinal cord injury. The systems could also relieve patients with Parkinson's disease.
- Thanks also to multidisciplinary and long-term supported research involving several scientists across various countries, concrete benefits for society are achieved, as in the case of the project NEBIAS (part of the research was funded **FET**). Thanks to the bionic hand[72], the touch sense in an amputee patient is restored.
- As for **ICT for Ageing well**, a major success has been the impact of the AAL JP where more than 120 projects close to market have been co-financed with Member States. A survey for the first 50 projects financed demonstrated that 25% of projects had secured financing beyond the project for going to the market. There are many cases of projects providing commercial products directly as a result of the funding received. There has also been a substantial increase in investor activity and markets are beginning to scale up globally. For example one company (Robosoft) has just signed a deal with Japan second largest telecom operator to deliver services based on low-cost home robots in Japan.
- The deployment of the **Ambient Assisted Living** solutions for the elderly is limited because it requires significant resources. The UNIVERsal project has developed and validated reference architecture for open service platforms based on internet of things, which should ease the implementation. This has so far been used by 75 other projects

[71] Inauguration took place on 31 October 2014, coinciding with 500th anniversary of the inauguration of the frescos by Michelangelo.

[72] A complex prosthesis full of sensors and electronics, and to new neural interface to provide sensory information in real time from the artificial hand to the patient's brain

including currently running REAAL with 7,000 users, who are helping to validate the open platforms and their interoperability.

- In the area of **ICT for Health**, the achievements of the Virtual Physiological Human (VPH) were found to be significant and succeeded in placing the European research area firmly at the centre of S&T for personalised medicine. The main achievements of VPH programmes include successful demonstrator projects with particular practical impact on personalised cardiovascular care through the development of detailed computational models of biophysics, implemented with user-friendly workflow management. Another example already has practical impact for comparing antiretroviral HIV drugs. Moreover, a comprehensive set of infrastructure tools has also been built including powerful ontologies that are necessary for the integration of multi-scale, multi-disciplinary ICT models.
- In the field of **language technologies**, FP6 and FP7 projects resulted in MOSES, the open-source toolkit for developing customized machine translation systems. Although originally developed for research purposes, it has become increasingly popular among corporate customers, and is currently powering an increasing number of commercial machine translation solutions, including smartphone apps.
- In the field of **Networked Media**, Graphity technology for retrieval in social media (analysis of trending topics on social media and checking of info), developed in SocialSensor project, has already been taken up by various commercial software tools.
- The programme has delivered good tools and methods, as well as attracted the main stakeholders around the projects in the field of **ICT for Digital Preservation**. Likewise, in the field of **ICT for Cultural heritage**, project results are being translated in applications used in Museums also in Third Countries (e.g. 3D COFORM: Digitisation of 3D, the project works on 3D capture of 3D object). Two museums and one university in the US are going to use this technology for their collections.
- A toolbox that supports the production of high quality **cryptographic software** for software engineering is being developed by the project CACE (Computer Aided Cryptography Engineering), leading to spin-offs Partisia from Aarhus University, offering secure auction-as-a-service.
- Mobidot, a very successful spin-off of the project SUNSET (SUstainable social Network SErvices for Transport), has developed an open, scalable ICT platform that measures **individuals' travel behaviours** via smartphones and builds a personal multimodal mobility profile. As such Mobidot has created a basic service on which public or private stakeholders like local or regional public authorities, employers, transport companies, local retailers, service providers and event organisers can couple, integrate or build their own (cross-sectoral) services, Apps and campaigns on a scale of their choice to incentivise travellers (commuters, local citizens, visitors, tourists) with personalised information and advice on sustainable, safe, healthy or cost-effective travel alternatives or challenge and reward (groups of) people for 'good' travel behaviour. Mobidot services are taking momentum in the Dutch market in two areas: monitoring and market research and smart travel (behavioural change).

Policy contributions

- The **FET** part of FP7 ICT has found wider acclaim and has been extended to all areas of the new Framework Programme – Horizon 2020, with a budget increase from 824m Euro in FP7 ICT to 2.6bn Euro in Horizon 2020. Innovation in instruments has also taken place by targeting part of the programme to young researchers and innovative SMEs. The original 2-step submission procedure was adopted by some parts of the new Horizon 2020 programme.

- The launch on the **web-entrepreneurs initiative** is another policy result. Web entrepreneurs have been recognised as crucial in creating new business opportunities in the digital age. This has resulted in developing specific actions which reinforce positive entrepreneurial culture, funding and incentives schemes, retaining talent and understanding the web entrepreneurs' ecosystem in Europe[73].
- Research result feed continuously into policy: e.g. in the area of Future Internet, the results of the project CREW, concentrating on the efficient use of **spectrum**, considering aspects of interference, have been shared with the Body of European Regulators for Electronic Communications (BEREC), to provide cross-fertilisation and policy learning.
- Operational usability of TV **white spaces** is a particular domain that EU projects have pioneered. The project COGEU analysed the gaps between frequencies used for television, known as 'white spaces', and developed a solution that can help all citizens gain access to broadband through the airwaves. It has implemented a proof-of-concept tool with which local and short-term spectrum licences are traded through an online auction mechanism and inspired actions in future spectrum regulations, notably a Commission decision.
- Projects like ECHORD and ECHORD++ have stimulated the uptake of policy schemes to support SMEs with infrastructure and expertise at the regional level. The areas of support include ICT for manufacturing, photonics, and creative content.
- OpenAire has stimulated the debate on open access policies in Europe and elsewhere. **Openness** has been successful and certain developments in FP7 led to new prioritisations in H2020, i.e. on big data, open data and diversity of data. Further, the link between research and policy was recognised and acknowledged in H2020 and is one of the components of the PPP on big data (decision making support and evidence-based policy). This is expected to further grow in H2020, as in FP7 there was not a systematic approach, nor a policy, a framework or a cluster that would allow this link.
- The link between research and policy-making is evident in areas such as **cloud computing**. In 2011 the Commission launched a policy initiative on cloud computing[74], which repositioned Europe on the world policy scene on cloud. Select industry groups were created for: a) service level agreements, b) contractual clauses, c) code of conduct, and d) research. The policy initiative fed then back into research. The strategy also included ETSI action for identifying and mapping existing standards. Another project in this field is Cloud for Europe (C4E) – pre-commercial public procurement of cloud at national level with 12-13 countries.
- **Collective Awareness Platforms for Sustainability and Social Innovation** (CAPS) a new objective introduced in 2013 to promote bottom-up, sustainable social innovation. It is based on the idea that society is innovative and that internet can be the tool for such innovations to take place and be ubiquitous.
- The EU has been successful through its programme in pioneering new ideas, for instance in the field of **Future Internet**, introducing the idea of networks as cloud. This had not appeared in national programmes until FP7 introduced it, so it is a demonstration of the influence the Programme has on national programmes for research. Another spill over

[73] "Unleashing Europe's entrepreneurial potential to bring back growth" (COM(2012) 795 final of 9.1.2013). Commission Staff Working Document providing an overview of the European environment for web entrepreneurs, as well as additional details concerning the support measures envisaged, (11 April 2013). The Startup Europe Leaders' Club put forward the Startup Europe Manifesto gaining political support from the Heads of State and all across the EU institutions.

74 European cloud computing strategy [COM (212) 529]), strongly advocated and supported by Neelie Kroes, the Digital Agenda Commissioner. New initiatives on cloud were established in 2012, both in terms of research effort, as well as in terms of policy strategy (European Cloud Partnership).

effect is to have set the European Agenda, as for **5G**, for example, where Member States are following.

- In the case of **Ageing and Healthy Living**, Member States have adopted national Programmes based on the AAL Programme.
- The **FIWARE** platform in Horizon 2020 is also leveraging national efforts and providing the technology for deployments in the Societal Challenges (e.g. Smart Cities).

International recognition

- International recognition is granted to European funded research in several fields. The EU **robotics** programme is the largest research civilian programme in the world. A similar programme, based on the European model, was launched in the US. Likewise, in the field of **photonics**, the US has been closely following the EU Programme. In the field of **SmartCities** the US looked at Europe to set up a similar grant scheme, and cooperation is ongoing with China.
- The European leadership in the field of **eInfrastructures** is shown by the fact that Cooperation in Latin America Research (CLARA, Cooperación Latino Americana de Redes Avanzadas - Latin American Cooperation of Advanced Networks) was developed on the basis of the European model of GEANT.
- **FIWARE** Platform is used in Brazil and Mexico and **FIRE** is well known in the US.
- Highlight of international collaboration are the **coordinated calls** with Japan and Brazil, and the targeted openings with Korea, South Africa and China. A collaborative project with the NSF (US) – GENI involving FIRE facilities and researchers from both sides has been launched. The international collaboration activities are aimed to achieve global impact. Currently Europe is leading in the field, one aim is to set standards and convince the international partners to use the same or similar tools, as well as expand activities more globally through federation of large scale facilities.
- Europe has been recognised as global leader in research targeting **ICT for ageing well**, with more than €1billion funding and the systemic approach from long-term research (FP7) to applied research (JPI – AAL, PCP) to pilot (CIP), deployment and large scale uptake (EIP and PPI). European researchers are leading in new scientific areas on AAL, which is supported by a large number of conferences and scientific papers accepted in journals world-wide. Cooperation is being established with Japan, Canada and US through OECD.
- The **Human Brain Project FET Flagship** has also triggered or accelerated akin initiatives in US, China, Australia and Japan.

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