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9787/17
ADD 9

RECH 211
COMPET 454
IND 142
MI 458
EDUC 272
TELECOM 148
ENER 255
ENV 551
REGIO 65
AGRI 289
TRANS 227
SAN 224

COVER NOTE

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To:	Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union
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COMMISSION STAFF WORKING DOCUMENT

INTERIM EVALUATION
of
HORIZON 2020

ANNEX 2

{SWD(2017) 220 final}
{SWD(2017) 222 final}

E. LEADERSHIP IN ENABLING AND INDUSTRIAL TECHNOLOGIES - INFORMATION AND COMMUNICATION TECHNOLOGIES (LEIT-ICT)

E.1. INTRODUCTION

E.1.1. Context

Information and Communication Technologies (ICT) underpin **innovation** and **competitiveness** across private and public sectors and enable scientific progress in all disciplines. In the impact assessment accompanying its Horizon 2020 proposal, the Commission *underlined the insufficient technological leadership and innovation capability of firms in the EU, which is leading to a rising technology deficit*[1]. This applied to the ICT sector, as the insufficient use of ICT had been identified as one of the main drawbacks to Europe's competitiveness at the global level[2]. When adopting Horizon 2020, the EU stressed the need to **maintain and build global leadership** through R&I in **enabling technologies** which support competitiveness across a range of existing and emerging industries and sectors. The Regulation stressed the need for the **European industry to remain at the cutting edge of technological developments in ICT**, where many technologies are entering a new disruptive phase and opening up new opportunities.

The Leadership in Enabling and Industrial Technologies (LEIT) ICT part of Horizon 2020 aims at providing a response to the main challenges faced by Europe in the field: the need to maintain a **strong expertise** in key technology value chains and the necessity to move quicker **from research excellence to the market**, transforming knowledge assets into **business successes** and responsible solutions for Europe's most urgent sustainability and **societal challenges**.

The analysis presented in the present thematic annex draws on the following sources:

- CORDA statistical data;
- A "DG CONNECT Self-assessment" based on a written questionnaire carried out within the Directorate General;
- An external study[3] whose scope is the portfolio of ICT Activities within Horizon 2020[4] and which performed an analysis of participation patterns[5]; an abstract analysis of projects; a survey of coordinators, participants and non-participants; case studies and interviews;
- A report by an ad-hoc panel of independent experts that analysed available evidence on the portfolio of ICT Activities within Horizon 2020[6] and carried out interviews, drawing conclusions and recommendations.

E.1.2. Objectives and intervention logic

Starting from the general objective of Horizon 2020 "…*to build a society and a world-leading economy based on knowledge and innovation across the whole Union*", the specific objective of ICT R&I is to enable Europe to support, develop and exploit the opportunities brought by ICT progress for the benefits of its citizens, businesses and scientific communities. In particular, LEIT ICT has the objectives to **maintain strong global presence of EU ICT**

[1] *Commission Staff Working Paper, Impact Assessment accompanying the Communication from the Commission 'Horizon 2020 - The Framework Programme for Research and Innovation'.*
[2] *A Digital Agenda for Europe. COM (2010) 245 final/2, 26.8.2010.*
[3] *SMART 2015/0060, "Support study for the Interim Evaluation of Horizon 2020 – DG CONNECT Activities", carried out by a consortium led by CARSA. The study will be referred to in the present report as "CARSA study".*
[4] *FET Open and Proactive, LEIT ICT, the ICT topics and projects within Societal Challenges 1, 3, 4, 5, 6 and 7.*
[5] *Based on CORDA data up to April 2016.*
[6] *FET Open and Proactive, LEIT ICT, the ICT topics and projects within Societal Challenges 1, 3, 4, 5, 6 and 7.*

Industry, by speeding up development of the technologies and innovations that will underpin tomorrow's businesses and help innovative European SMEs to grow into world-leading companies. The major activity lines of LEIT ICT cover the full range of needs taking into account the competitiveness of European industry on a global scale. They include industrial leadership in generic ICT-based solutions, products and services needed to tackle major societal challenges as well as application-driven ICT R&I agendas which are supported together with the relevant societal challenge.

The six **main lines of activities**[7] of LEIT ICT and their respective objectives are:

Table 42 - LEIT ICT Lines of Activities (as per Regulation) and Objectives

Line of activity	Objective
A new generation of components and systems: engineering of advances, embedded and energy- and resource- efficient components and systems	To **maintain and reinforce European leadership** in technologies related to advanced, embedded, energy -and resource-efficient and robust components and systems. It also includes micro-nano-bio systems, organic electronics, large area integration, underlying technologies for the Internet of Things (IoT), including platforms to support the delivery of advanced services, sensors, smart integrated systems, embedded and distributed systems, systems of systems and complex systems engineering
Next generation computing: advanced and secure computing systems and technologies including cloud computing	To **leverage European assets** in processor and system architecture, interconnect and data localisation technologies, cloud computing, parallel computing, modelling and simulation software for all market segments, including engineering applications (such as uncertainty quantification, risk analysis and decision in engineering).
Future internet: software, hardware, infrastructures, technologies and services	To **reinforce the competitiveness of European industry** in developing, mastering and shaping the next generation Internet that will gradually replace and surpass the current Web, fixed and mobile networks and service infrastructures, and enable the interconnection of trillions of devices (IoT) across multiple operators and domains that will change the way we communicate, access and use knowledge. This includes R&I on networks, software, processes and services, cyber security, privacy, reliability and trust, wireless communication and all optical networks, immersive interactive multimedia and the connected enterprise of the future.
Content technologies and information management: ICT for digital content and for cultural and creative industries	**To strengthen Europe's position** as provider of products and services based on individual and business creativity. This is pursued by providing professionals and citizens with new tools to create, access, exploit, preserve and re- use all forms of digital content in any language and to model, analyse and visualise vast amounts of data (big data), including linked data. This includes new technologies for arts, language, learning, interaction, digital preservation, web design, content access, analytics and media; and intelligent and adaptive information management systems based on advanced data mining, machine learning, statistical analysis and visual computing technologies.
Advanced interfaces and robots: robotics and smart spaces	**To reinforce European scientific and industrial leadership** in industrial and service robotics, cognitive and communicative systems, advanced interfaces and smart spaces, and sentient machines, building on increases in computing and networking performance and progress in the ability to design and build systems that can learn, self-assemble, adapt and react or that optimise human-machine interactions. Where appropriate, the systems developed and advancements in the state of the art should be validated in real-world environments.
Micro- and nanoelectronics and photonics: key enabling technologies related to micro- and nanoelectronics and to	**To take advantage of the excellence of Europe** in these key enabling technologies and support and further enhance the competitiveness and market leadership of its industry. Activities also include R&I on design, advanced processes, pilot lines for fabrication, related production

[7] *Included under each of these six major activity lines are also ICT-specific research infrastructures, such as living labs for experimentation, and infrastructures for underlying key enabling technologies and their integration in advanced products and innovative smart systems, including equipment, tools, support services, clean rooms and access to foundries for prototyping.*

Line of activity	Objective
photonics covering also quantum technologies	technologies and demonstration actions to validate technology developments and innovative business models as well as underlying next generation technologies exploiting advances in quantum physics.

Source: EC services.

To address its objectives, LEIT ICT implements a comprehensive strategy covering the whole innovation cycle and it takes advantage of several **Horizon 2020 instruments**: Research and Innovation Actions (RIAs), Innovation Actions (IAs) and Coordination and Support Actions (CSAs), Innovation Procurement (Pre-Commercial Procurement, PCP, and Public Procurement of Innovative Solutions, PPI), SME-instrument, Fast Track to Innovation (FTI) and cascading grants. A key response to the need for increased European competitiveness in digitally based innovation comes from the increased number of roadmap based **contractual Public-Private Partnerships** (cPPPs) in areas of strategic interest (Photonics, Robotics, 5G communications, Big Data, Factories of the Future, High Performance Computing[8] and Cybersecurity[9]), as well as the **Joint Technological Initiative** (JTI) in 'Electronic Components and Systems' (ECSEL), which merges two JTIs set up in FP7[10].

Table 43 - ICT-related Public-Private Partnerships (PPPs)

ICT cPPPs	cPPP	ETP	maximum Horizon 2020 indicative funding
(DG CONNECT lead)	Photonics	Photonics21	EUR 700 million
	Robotics	euRobotics	EUR 700 million
	Advanced 5G network infrastructure for Future Internet (5G)	5G Infrastructure Assoc. NetWorld2020	EUR 700 million
	Big Data	BigData Value Association NESSI	EUR 534 million
	High Performance Computing (HPC)[11]	ETP4HPC	EUR 700 million (FET and eInfrastructures)
DG CONNECT (co-leads)	Factories of the Future (FoF)	EFRA MANUFUTURE	EUR 450 million
NEW cPPP	Cyber-security	NIS	EUR 450 million from LEIT-ICT and Soc. Challenge 7
JTI/JU	Electronics Components and Systems (ECSEL)	ENIAC, ARTEMIS, EPOSS	EUR 1.2 billion from Horizon 2020 and EUR 1.2 billion from Member States, and EUR 2.4 billion from industry

Source: European Commission.

The ICT cPPPs aim at strengthening the competitive positioning of the ICT sector in Europe and streamlining ICT value creation across industrial sectors. They involve a combination of supply and demand measures and they aim at linking stakeholders across the whole value chain, a necessary condition to accelerate take-up of research results and promote growth and jobs. In addition to the traditional R&I activities, the cPPPs also include actions aiming at attracting investments for SMEs, encourage entrepreneurship (Web entrepreneurs), address

[8] *Funded under FET and e-infrastructures*
[9] *Signed on 5 July 2016 and outside the scope of the analysis.*
[10] *ECSEL is a merger of two previous JTIs set up in 2008: ARTEMIS on embedded systems and ENIAC on Nano-electronics.*
[11] *Funded under FET.*

skills shortage (cooperation with EIT KIC ICT Labs) and develop a single market for goods and services[12]. The ICT cPPPs include actions aiming at coordinating strategies at EU, national and regional level (e.g. ERA-NET Photonics) to ensure complementarity and achieve optimal pooling of resources. This is especially prominent in the JU ECSEL with direct involvement of Member States in the funding of projects. The private partnerships build on the structuring of the EU actors (industry, research and academia) in the relevant sectors carried out through the European Technology Platforms (ETPs). These ETPs are represented in the private association signing the contractual agreement with the Commission and are responsible for providing the roadmaps for investments in research, technology and business development.

Beyond the major initiatives of the cPPPs and the JU (which together make 50% of the budget of LEIT ICT), in the Work Programmes LEIT-ICT in 2014-2015 and 2016-2017 **R&I activities** for Cyber-Physical Systems and Micro-and Nano-Electronics and Organic and Printed Electronics have complemented the higher Technology Readiness Level (TRL) activities of ECSEL and new strands have focussed on low-power computing.

Support to "Component and Systems" and "Advanced Computing"[13], together with the topics in the FoF cPPP and in IoT, has the objective to improve the **digitisation of European industry** by strengthening the digital sector on the one hand, that supplies the technology and knowhow for digital products and processes, and on the other hand to improve the take up of such technologies by other non tech industrial sectors.

In the **Future Internet area**, beyond the 5G cPPP, R&I activities have spanned from networking, to cloud computing, to activities to enhance distributed software development, to the provision of experimental facilities for testing and validation of new solutions, to the innovative use of social platforms and the support to web entrepreneurs.

In the **Content area**, Big Data has started to consolidate, with other actions focusing on the support to technologies for content generation, learning and teaching including gamification, multilingual translation and new ways for human-computer interactions.

Additional activities of more **cross-cutting** or horizontal nature have also been included such as research on digital security and on the IoT. Responsible Research and Innovation (RRI) and Social Sciences and Humanities (SSH) aspects have been thoroughly included in all relevant areas with a hub in the "Human-centric Digital Age" topic.

Activities have been organised around four main **calls** (one per year). These have been supplemented by two calls for cooperation with Japan[14], one with Brazil[15], one with South Korea[16], one with China[17] and one with Mexico[18]; two for support to small and medium-sized enterprises (SMEs) via the SME Instrument targeted at Open Disruptive Innovation (ODI) in ICT and FTI Pilots. In addition, a call in the focus area IoT has been launched in 2016.

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[12] The rationale and main features of the PPPs are developed in the Communication "Public-private partnerships in Horizon 2020: a powerful tool to deliver on innovation and growth in Europe" (COM(2013) 494 of 10/07/2013) which provided the political base for the launch of the cPPPs and in the Communication "Towards a Thriving Data-driven Economy" (COM(2014) 442 of 2/7/2014) more specifically focused on big data. These documents also provide the policy background supporting the decision to launch the various PPPs.

[13] Cyber-Physical Systems and Customised and Smart Anything Everywhere, part of "Components and Systems" and Low Energy Computing, part of the research area "advanced computing".

[14] EU-Japan Research and Development Cooperation in Net Futures (2014), EU-Japan Joint Call (2016) on 5G – Next Generation Communication Networks; IoT/Cloud/Big Data platforms in social application contexts and Experimental testbeds on Information-Centric Networking).

[15] EU-Brazil Research and Development Cooperation in Advanced Cyber Infrastructure (2014), EU-Brazil Joint Call (2017) on Cloud Computing, IoT Pilots and 5G Networks.

16 EU-South Korea Joint Call (2016) on 5G – Next Generation Communication Networks, IoT joint research and Federated Cloud resource brokerage for mobile cloud services.

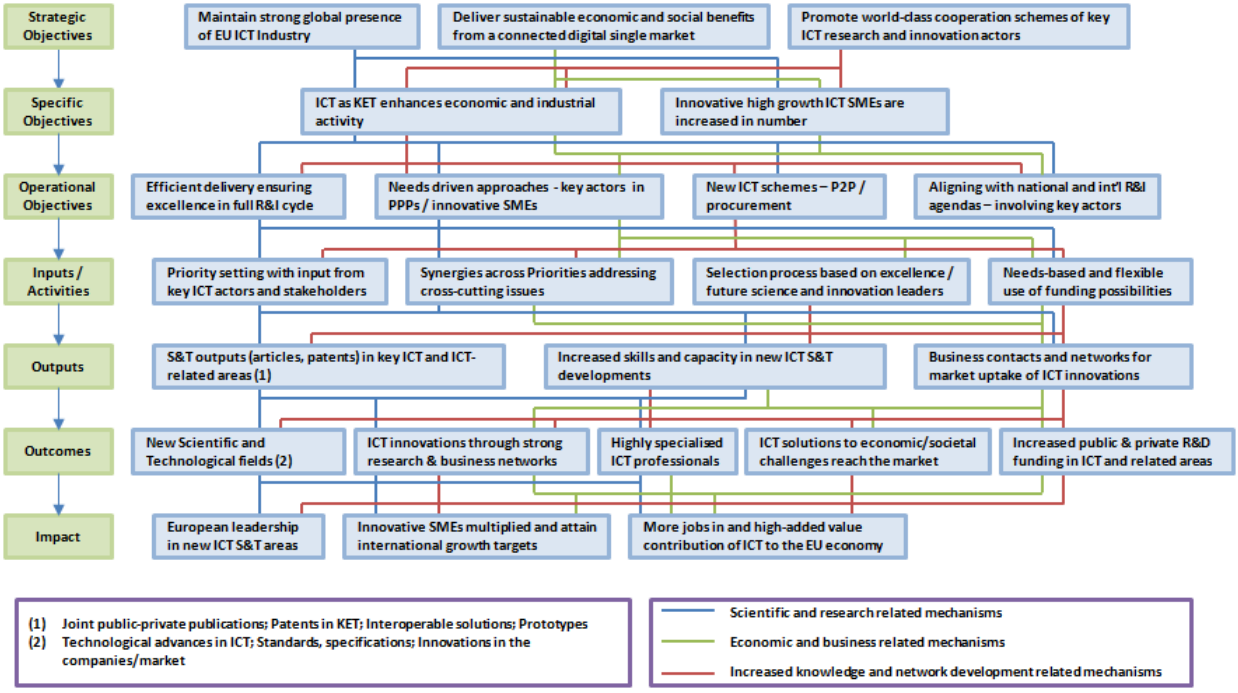
[17] Collaboration on Future Internet (2016).

[18] Collaboration on ICT (2016).

The actions performed in Horizon 2020 ICT **build upon the activities of previous Framework Programmes** (FPs). **Overall, Horizon 2020 puts a stronger emphasis on impact from innovation actions than previous FPs** by, contributing to e.g. and fostering market take-up, as well as by encouraging collaboration among researchers, industry and the civil society. In addition to the development of new products, services and processes on the basis of scientific and technological breakthroughs, innovation is understood to also include aspects such as the use of existing technologies in novel applications, continuous improvement and non - technological and social innovation. The overall approach aims at tackling societal challenges and, at the same time, giving rise to new competitive businesses and industries. In LEIT ICT R&I activities related to key enabling technologies by means of cPPPs are rooted in initiatives which have been prepared and initiated well before Horizon 2020. Main additional novel elements of Horizon 2020 ICT are the use of the SME instrument and horizontal ICT and innovation actions.

The **intervention logic** (Figure 66), derived from review of policy documents[19] shows how the strategic objectives translate into specific and operational objectives and then into expected outputs, outcomes and impacts.[20]

Figure 66 - Intervention logic of LEIT ICT



Source: CARSA study.

E.2. IMPLEMENTATION STATE OF PLAY

E.2.1. Overview of programme inputs and activities

As of **October 1st, 2016**, the state of play is the following. The EC contribution allocated to the implementation of the calls included in Work Programmes 2014-2016 and which have been closed at the date of 1 October 2016 has been **EUR 2.644 billion**, about 38 % of total expected budget allocated to LEIT ICT in Horizon 2020, which is EUR 6.984 billion for the

[19] *Source: CARSA study. For a full explanation on the intervention logic, please refer to the study.*
[20] *The main mechanisms are represented with different coloured lines:*
- *Blue lines refer to scientific and research related mechanisms*
- *Green lines refer to economic and business related mechanisms*
- *Red lines refer to a combination of mechanisms, such as increased knowledge and network development.*

period 2014-2020. These figures also include projects within Factories of the Future cPPP, the SME Instrument (ODI), and the Cross-Cutting Activity (Focus Area) Internet of Things (IoT).

Table 44 indicates the share of the overall LEIT-ICT budget allocated to each activity line through the Horizon 2020 Work Programmes 2014-2016. A part of this budget was allocated through calls implemented in the Factories of the Future Work Programme 2014-2015[21], the Cross-cutting activities (Focus Areas) Work Programme[22] and though the SME Instrument.[23]

Table 44 - LEIT ICT - Activities and allocated share of budget for the programming period 2014-2016

Horizon 2020 Line of Activity	EC Contribution to Selected Projects (EUR million)	Number of projects
Future Internet	473.85	136
Of which 5G cPPP	207.2	24
Content Technologies and Information Management	395.77	136
Of which Big Data cPPP	69.9	15
Micro-and nanoelectronics and photonics	283.46	74
Of which Photonics cPPP	162	45
ECSEL JU	296.00	25
Robotics (cPPP)	235.99	52
ICT Cross-cutting Activities[24]	206.86	32
A new generation of components and systems	204.39	49
ICT for the Factories of the Future (cPPP)	182.76	40
SME instrument - ODI	177.22	429
Next generation computing	107.85	25
International Cooperation	43.57	28
Horizontal ICT Innovation Actions[25]	21.53	13
Responsibility and creativity	14.60	11
Ad hoc call	0.14	1
Total	**2 644.02**	**1 051**

Source: CORDA, 1 October 2016.

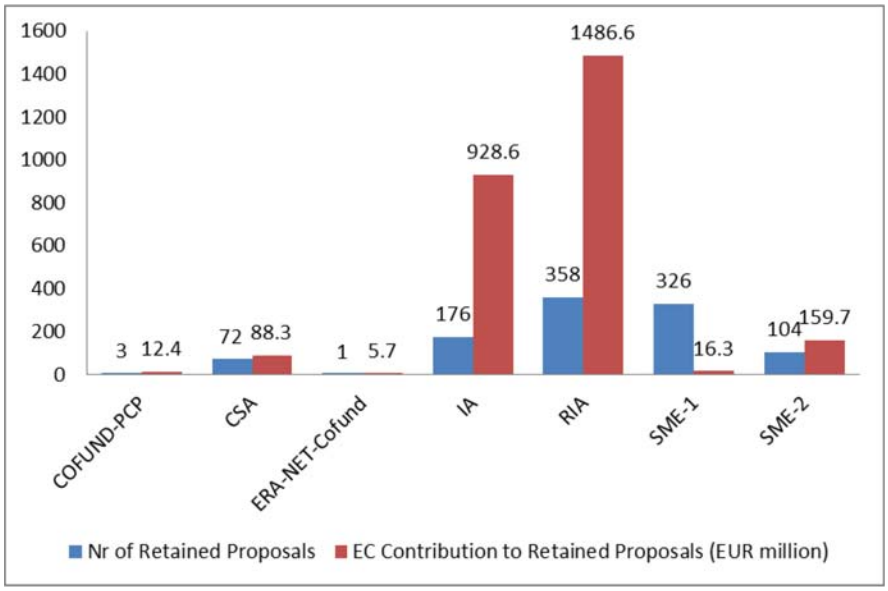
The budget was allocated through 100 topics included in 16 closed calls for proposals on the date of 1 October 2016. Two stage calls were launched in the case of ECSEL JU calls (Horizon 2020-ECSEL-2015-1-RIA-two-stage and Horizon 2020-ECSEL-2015-2-IA-two-stage with a success rate (proposals) of 15.7% and 45.5% respectively.

At the time of the interim evaluation, 309 projects are completed[26] and 582 are ongoing. The programme has so far been implemented mainly through RIAs, followed by projects implemented through the SME Instrument and by IAs. In particular, RIAs account for 35% of projects and 55% of EC contribution, SME instruments projects (Phase I) are many in number (31% of projects) but account only for 1% of EC contribution (in Phase I participants receive a contribution of EUR 50,000), whereas Phase II projects account for 10% of the total and 6% of the EC contribution. IAs are about half of the RIAs (17% of total projects) and account for 34% of the EC contribution. CSAs account for 7% of the projects and 3% of the total EC

[21] *FoF-01-2014, FoF-08-2015 and FoF-09-2015 grouped under "ICT for Factories of the Future"*
[22] *FOF-11-2016, FOF-13-2016 grouped under "ICT for Factories of the Future"; IoT-01-2016, IoT-02-2016 grouped under "ICT Cross-cutting Activities"*
[23] *ICT-37-2014, ICT-37-2015, SMEInst-01-2016-2017 and SMEInst-10-2016-2017.*
[24] *It includes for WP 2014-2015 (within LEIT ICT WP) ICT 30 – 2015: Internet of Things and Platforms for Connected Smart Objects, ICT 31 – 2014: Human-centric Digital Age, ICT 32 – 2014: Cybersecurity, Trustworthy ICT, ICT 33 – 2014: Trans-national co-operation among National Contact Points. For WP 2016-2017: IoT-01-2016, IoT-02-2016.*
[25] *It includes: ICT-35-2014, ICT-36-2015, ICT-36-2015 and ICT-34-2016.*
[26] *Based on end date.*

contribution. LEIT ICT also awarded three PCP projects and one ERA-Net Action (in Photonics).

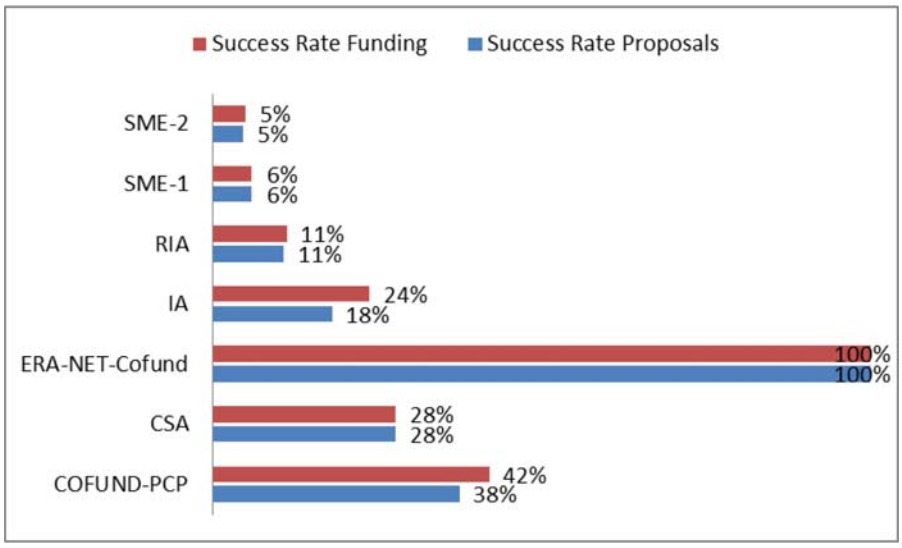
Figure 67 - LEIT ICT - Projects and EC Contribution by type of Action



Source: CORDA, 1 October 2016.

Overall, success rates of proposals are at 8.6% and of funding at 12.9%, with great variations among actions.

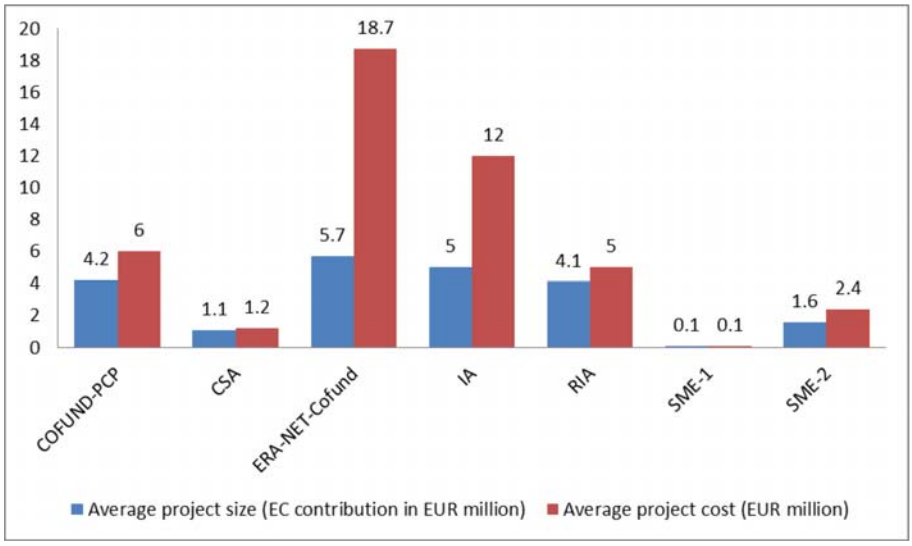
Figure 68 - LEIT ICT - Success rates by type of action



Source: CORDA, 1 October 2016.

The average project cost is EUR 3.6 million and the average EC contribution per project is EUR 2.3 million, with large differences among the types of actions (Figure 69).

Figure 69 - LEIT ICT - Average project cost and project EC contribution (EUR million), by type of action



Source: CORDA, 1 October 2016.

E.2.2. Participation patterns

A total number of **1,051 projects** have been selected so far (891 signed and 160 under preparation).

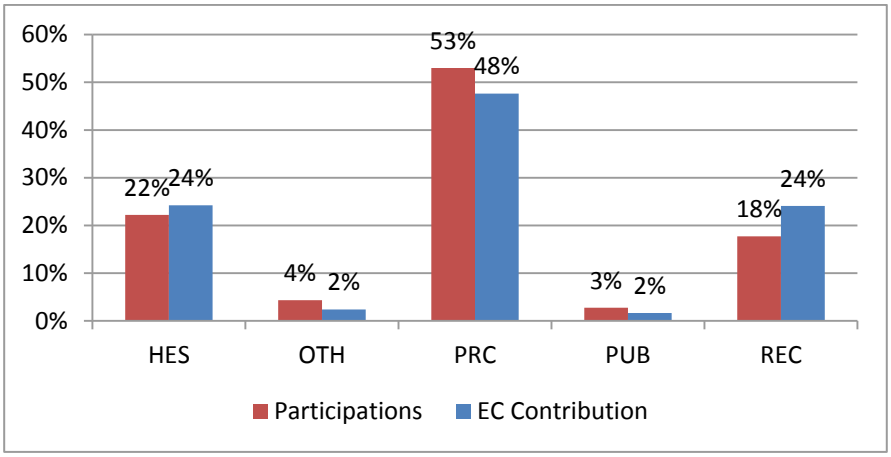
E.2.2.1. Participation per type of organisation

The selected proposals represent a total of **6,724 participations**, mobilising **3,651 distinct participants**. 22% of the participants are research organisations and higher education organisations, 68% are private commercial organisations and 10% other organisations such as government authorities and private-non-profit organisations[27]. **Research and higher education organisations participate more frequently in Horizon 2020 ICT projects**: on average research organisations and high education institutions participate in 3.7 and 3.2 projects respectively, whereas private commercial organisations in 1.4 project only (and other organisations to 1.3 projects). Private commercial organisations account for 53% of participations and 48% of funding, whereas research and higher research organisations account for 40% of participations 48% of funding and other organisations for 7% of participations and 4% of funding.[28]

[27] *Without considering the SME Instrument and the ECSEL JU, 26% of the participants are research organisations and higher education organisations, 61% are private commercial organisations and 13% other organisations such as government authorities and private-non-profit organisations.*

[28] *Without considering the SME Instrument and the ECSEL JU, Private commercial organisations account for 47% of participations and 41% of funding, whereas research and higher research organisations account for 47% of participations and 54% of funding and other organisations for 8% of participations and 5% of funding.*

Figure 70 - LEIT ICT - Participations and EC contribution by type of organisation



Source: CORDA, 1 October 2016.

Research and higher education organisations are the applicants with the highest success rate (33% and 31%), whereas private commercial organisations are those with the lowest one (20% when not considering SME instrument projects and ECSEL JU, 17.5% when considering all projects). Public organisations are those with the highest success rate of applications and funding.

Table 45 - LEIT ICT - Success rates (as % of proposals submitted, and as % of budget available) per organisation

LE TYPE Applicant	Success Rate of Applicants	Success Rate of Applications	Success Rate of Funding (Applicants)
HES	33.2%	12.5%	12.0%
OTH	23.5%	17.1%	13.8%
PRC	17.5%	12.3%	11.8%
PUB	24.2%	19.0%	16.7%
REC	31.4%	16.3%	17.8%
TOTAL	**20.1%**	**13.2%**	**13.0%**

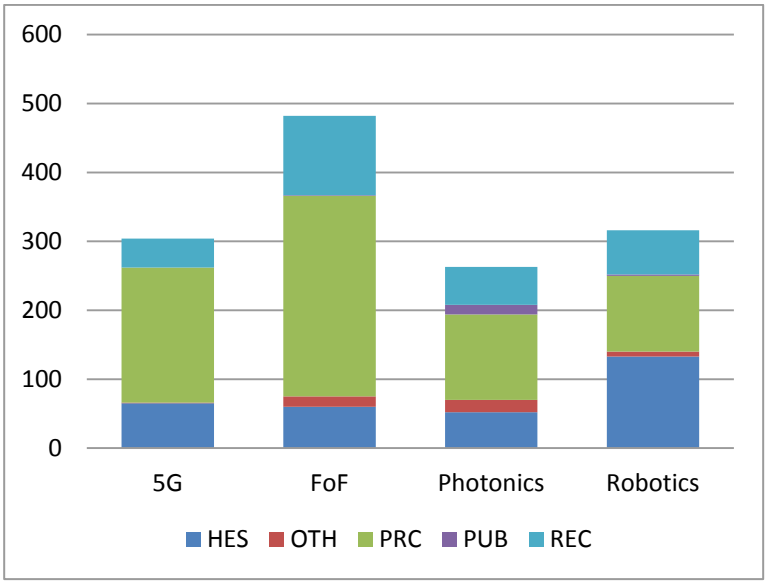
Source: CORDA, 1 October 2016.

E.2.2.2. Participation patterns in cPPPs

The cPPPs are comparable in size but different in terms of their structural composition and participation patterns in the funded projects (Figure 71):

- The cPPP on 5G Networks is characterised by a very high share of enterprises (representatives from the European telecommunications industry), accounting for 63% of total EC contribution and 64% of participations. Research Organisations and Higher Education institutions account for the rest, as there are no public and other organisations participating;
- The cPPP on Factories of the Future is also characterised by a very high presence of enterprises (51% of funding and 60% of participations)
- The cPPPs on Robotics is clearly dominated by Higher Education and Research Organisations (66% of total EC contribution and 62% of participations); and
- The cPPP Photonics has an equal participation of enterprises and Higher Education and Research Organisations (46% of EC contribution respectively), with public organisations accounting for 5% of EC contribution. In terms of participations, enterprises account for 47% of the total, other organisations for 7% and public organisations for 5%.

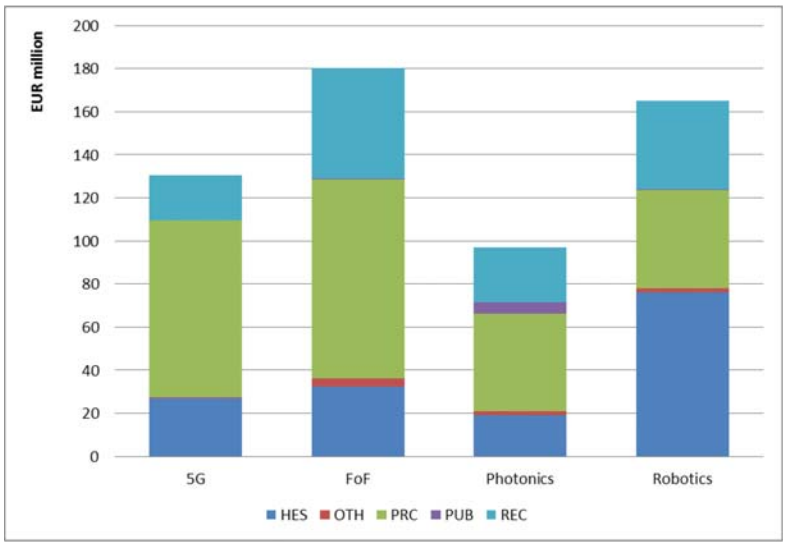
Figure 71 - LEIT ICT - Number of participations by type of organisation in cPPPs



Source: CORDA, 1 October 2016.

In terms of funding (requested EC contribution) the cPPP FoF accounts for the highest total requested funding volume (EUR 180 million), followed by the cPPP on Robotics (EUR 165 million) and the cPPP 5G (EUR 130 million). The cPPP Photonics was allocated in total EUR 97 million of EC contribution.

Figure 72 - LEIT ICT - Requested EC contribution by type of organisation in cPPPs



Source: CORDA, 1 October 2016.

In total, SMEs account for 17% of participations in the cPPPs. The share of SME participations is highest in the cPPP FoF (33%) and cPPP Photonics (22%). The cPPP 5G has 17% participations from SMEs and the cPPP Robotics 10%. 37% of SME participations in the four cPPPs stem from newcomers to the Framework Programme (i.e. they have not participated in FP7). The share is highest in Robotics (42%) and lowest in Photonics (32%).

E.2.2.3. Attraction of new participants/newcomers

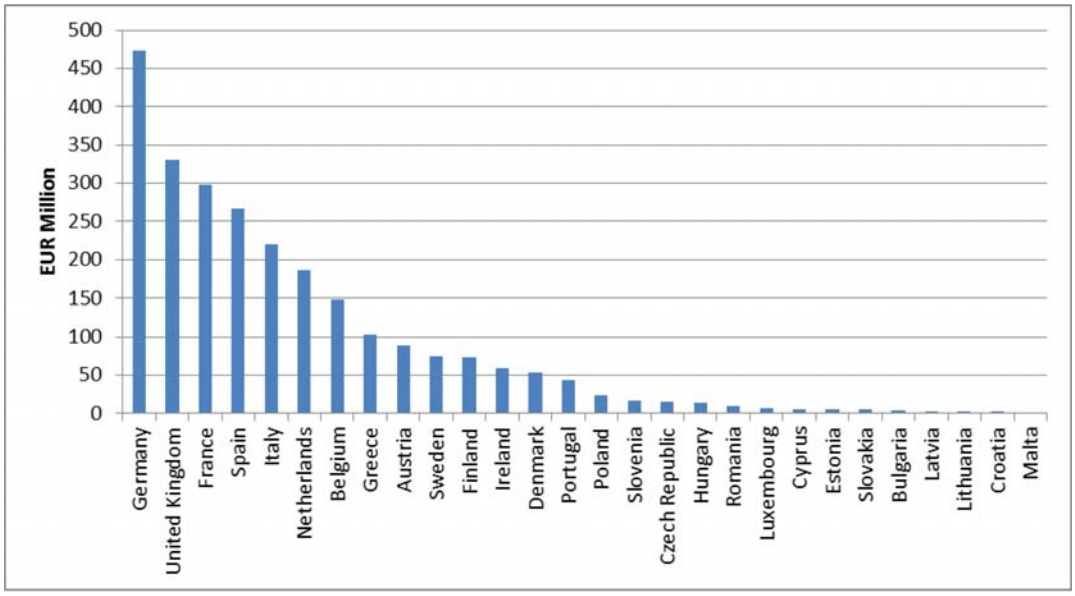
There are **43 %** (1,583) **of newcomers**. These are for the largest majority (85%) private commercial organisations, whereas "Other organisations" represent 8% of newcomers. Public organisations, research organisation and higher education institutions are 3%, 2% and 2% of newcomers respectively. However, as organisations are only differentiated at the very top

level (no departments etc.) the figures for research organisations and higher education organisation have to be interpreted with caution. Also, the population of research institutions is limited (and thus so is the scope for new research organisations to participate).

E.2.2.4. Geographical participation patterns

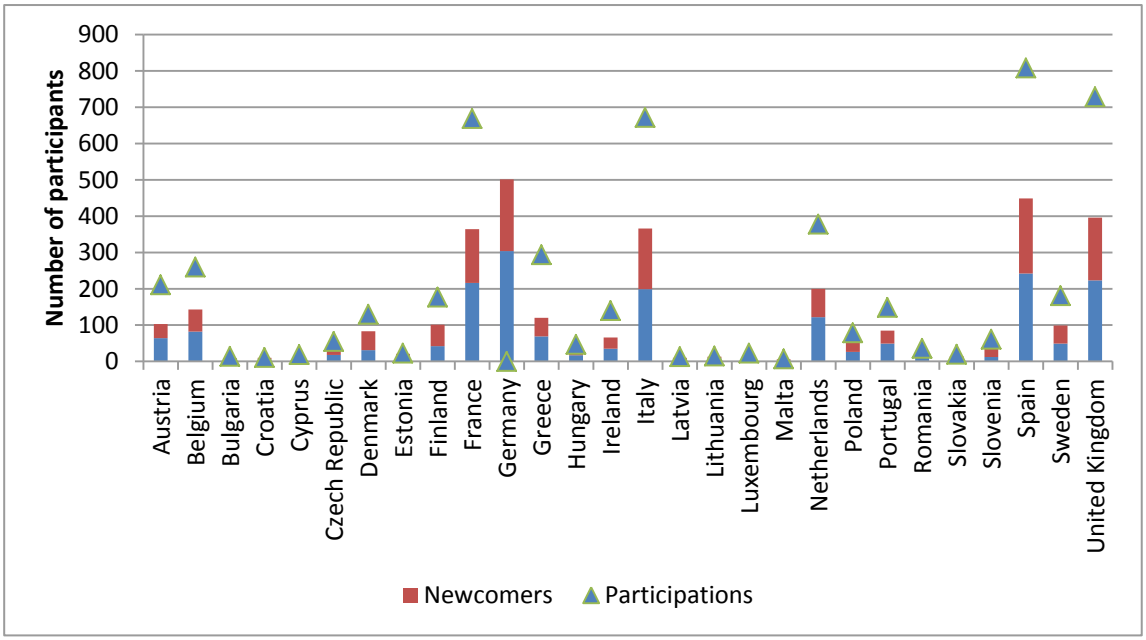
A summary of the geographical participation in LEIT ICT is presented below. In absolute terms, Germany, the United Kingdom, France, Spain and Italy account for the majority of funding, number of participants and participations. These countries are also the one with the highest share of newcomers, with Spain ranking first. Greece, Ireland, Austria, Germany and the Netherlands are the countries with the highest average participations per participant.

Figure 73 - LEIT ICT - EC contribution to participations, by EU-28 country



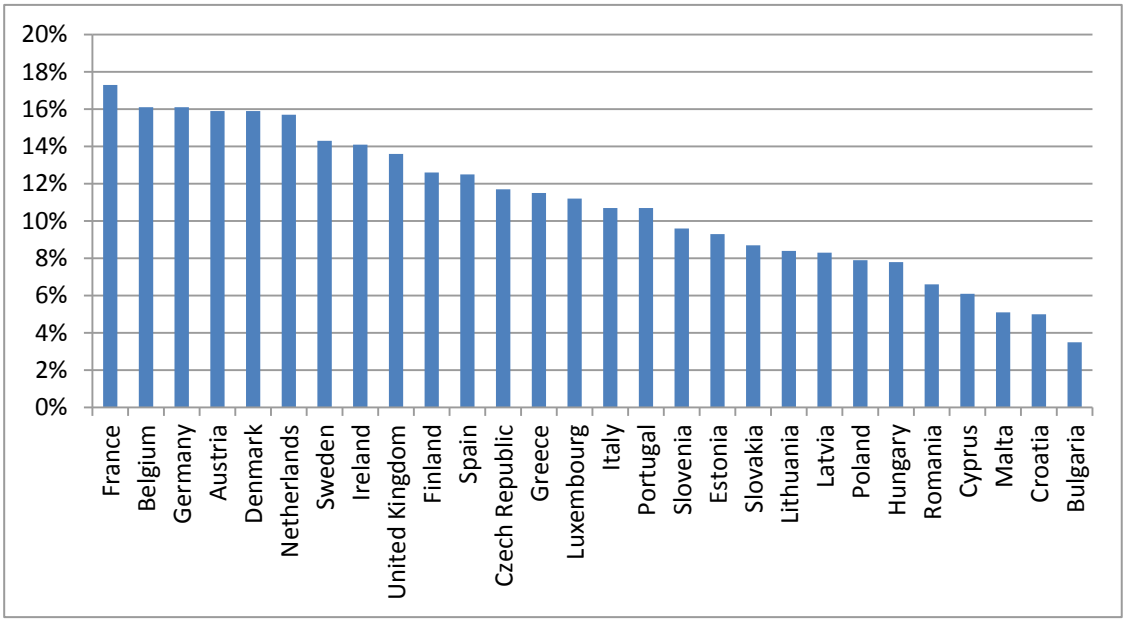
Source: CORDA, 1 October 2016.

Figure 74 - LEIT ICT – Number of participants and participations, by EU-28 country



Source: CORDA, 1 October 2016.

Figure 75 - LEIT ICT - Success rates of applications, by EU-28 country



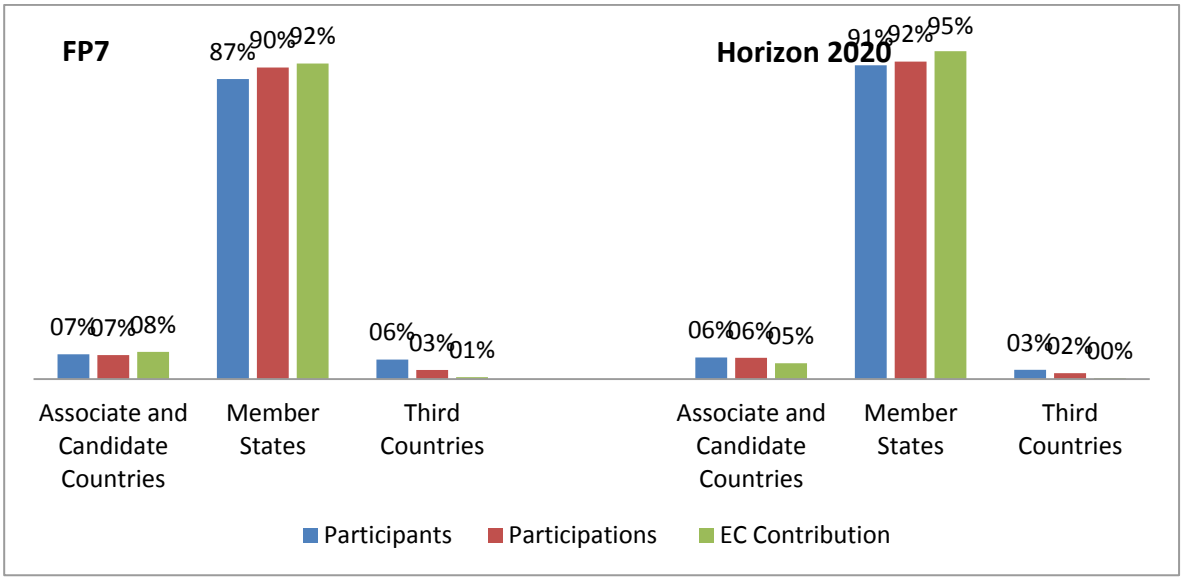
Source: CORDA, 1 October 2016.

E.2.2.5. International cooperation

International cooperation in Horizon 2020-LEIT has been implemented through a) focused coordinated calls with target countries and b) through ad hoc participation of third country partners in the projects from the different research areas. For a), the WP 2014-15 included a coordinated call with Japan in the areas of cloud/IoT/big data; optical communications; access networks and experimental platforms for a total of EUR 6 million, and a coordinated call with Brazil in the areas of cloud, high performance computing and experimental platforms for a total of EUR 7 million. The target countries Japan and Brazil contributed with similar amounts to fund their partners in the joint projects. As regards b), ad hoc participation of third country partners in the projects from the different research areas, from the total requested EC contributions **95% are allocated to EU Member States** and 5% to Associated Countries[29]. Funding volume for co-operation with third countries (developing countries, emerging economies and advanced economies) is very little. A total of 472 entities from **third countries** applied to the programme. 19.3% of these proposals were retained for funding, involving 105 third countries participants. Compared to FP7, it can be noticed that the share of participants, participations and EC contribution to associate and candidate countries, as well as to third countries has slightly decreased (Figure 11).

[29] *For a list of associated countries see:*
http://ec.europa.eu/research/participants/data/ref/Horizon 2020/grants_manual/hi/3cpart/Horizon 2020-hi-list-ac_en.pdf

Figure 76 - Participation by group of countries, FP7 and Horizon 2020



Source: CORDA, 1 October 2016.

Table 46 - LEIT ICT - Success rates (as % of proposals submitted, and as % of budget available) per group of country

Country Group	Success Rate of Applicants	Success Rate of Applications	Success Rate of Funding (Applicants)
Associated Countries	17.9%	13.2%	11.1%
EU-13	11.4%	7.8%	7.0%
EU-15	21.9%	13.8%	13.7%
Third Countries	22.2%	19.3%	9.4%
Total	20.1%	13.2%	13.0%

Source: CORDA, 1 October 2016.

E.2.3. Cross-cutting issues

Projects funded under the 2014-2016 calls of LEIT ICT contributed to the following cross-cutting issues:

- **Sustainable development**[30] (the target for Horizon 2020 is at least 60%): representing 30.1% (EUR 783 million) of LEIT ICT funding and 8% of total Horizon 2020 EC contribution to sustainable development related expenditure.
- **Climate change related expenditure** (it should exceed 35% of the overall Horizon 2020 budget): representing 6.5% (EUR 170 million) of LEIT ICT funding and 4% of total Horizon 2020 EC contribution to climate change related expenditure.
- **Integration of social-sciences and humanities (SSH)**: 8% of all participants were SSH-partners (i.e. participants with a strong background in SSH) accounting for 9% of LEIT ICT funding and 12% of total EC contribution to projects flagged as SSH-relevant.
- **Gender balance** in the projects: women represent 24.5% % of the participants to the projects; 21.6%[31] of coordinators' were women (below Horizon 2020 33.4% average). 24.9% of projects of projects took into account the gender dimension in R&I content.
- **Innovation actions:** 28.2% (EUR 603 million) of LEIT ICT EC contribution was allocated to innovation actions, representing 20% of total EC Contribution to IAs. Within

[30] *Data for sustainable development, climatea action and gender issues, cut off date: 1 January 2017*
[31] *Only projects where the gender of the coordinator is known (approximately half of he projects.)*

the IAs, 128 projects focused on demonstration and piloting activities (99% of budget for IAs) and 2 projects (1% of budget for IAs) on first market replication activities.

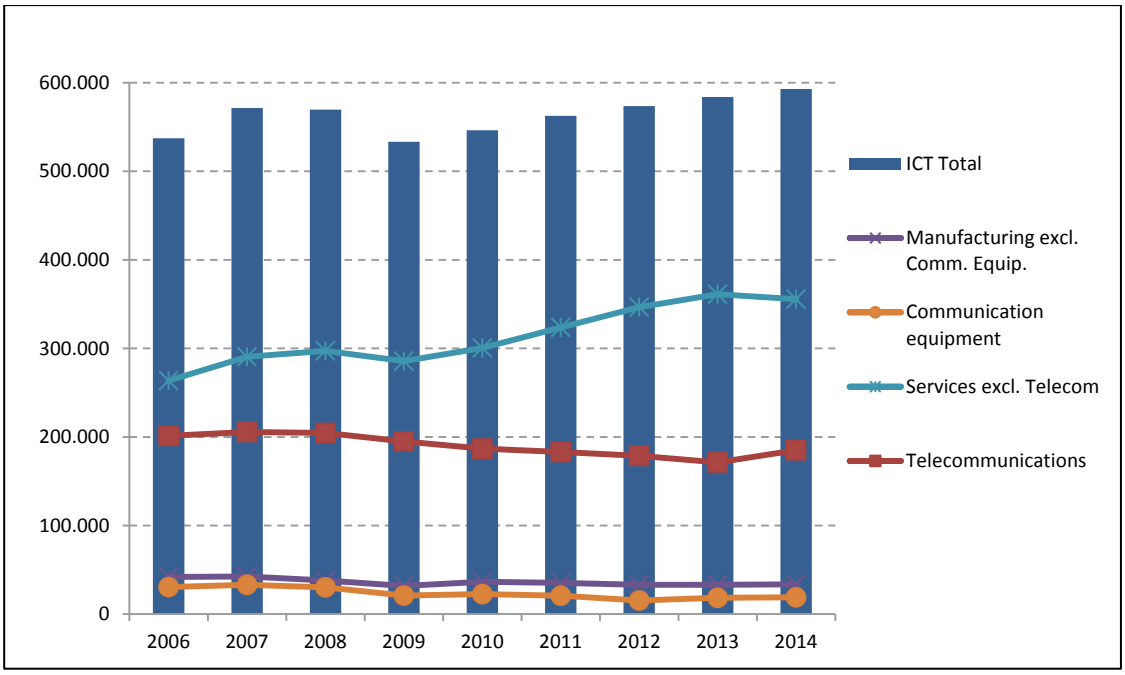
E.3. RELEVANCE

E.3.1. Is LEIT ICT tackling the right issues?

E.3.1.1. The relevance of LEIT-ICT given the challenges to address

In 2011, at the time Horizon 2020 was being prepared, the negative effect of the crisis on the ICT sector[32] appeared to have been dissipated, but aggregated statistics gave evidence of a weak recovery of Europe's ICT sector (relative to the 2007 pre-recession level) and in particular compared to the United States[33]. Further, a new innovation wave brought about by internet and its new applications offered new opportunities but also yielded disruptive changes in the ICT sector market structures, with the United improving its position as market leader and with EU and Japan remaining weaker, while other emerging economies increased their global position. Overall, Europe's competitive position and leadership in many important sectors was being challenged by global competitors. In particular, while some of the ICT industries, especially in the internet and software sectors, experienced only a minor reduction in growth rates, others such as those active in Computer Services or Telecom Equipment were still struggling in 2010 to recover pre-crisis levels of growth. Further, the share of ICT on the GDP in the EU were lower than China, the US and Japan (Figure 77).

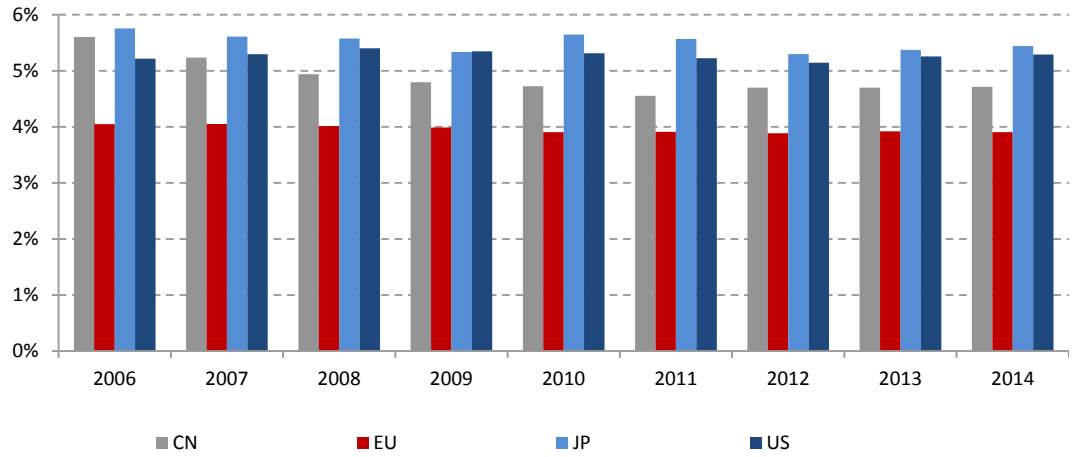
Figure 77 - Value Added in the ICT sector, 2006-2014 (EUR million)



Source: Europe's Digital Progress Report 2017 - The EU ICT sector and its R&D performance.

[32] *The economic and financial crisis had reduced the potential to invest and to create new or expanded markets for products and services that benefited from ICT.*
[33] *European Commission (2013b).*

Figure 78 - ICT Share of GDP, 2006-2014, EU, US, China and Japan



Source: Europe's Digital Progress Report 2017 - The EU ICT sector and its R&D performance.

The importance of the sector required an increase in public investments in ICT R&I so to contribute to maintaining and developing the technology leading edge in key areas such as electronics, photonics, embedded systems, computing, robotics, network technologies and systems, in which the EU had and should keep major strengths, but also those opening new market opportunities and providing solutions to many societal challenges (see Table 42 for objectives by sector). The ICT sector plays a key role for **Europe's global competitiveness and growth**: in 2014 (latest available data), the ICT Value Added amounted to EUR 593 billion (4.2 % of EU GDP), employed 6.3 million people (2.8 % of EU total employment) and generated 16% of total business expenditure in R&D. The ICT sector contributes highly to European innovation[34]:

- 28% in technological innovation as measured by patents;
- 19% in absorption of skills as measured by employment in knowledge intensive activities;
- 27% in competitiveness of knowledge goods as measured by exports of medium-high tech goods;
- 20% in competitiveness of knowledge services as measured by exports of knowledge intensive services;
- 23% in innovative firms' dynamics as measured by employment of innovative fast-growing firms.

However, in terms of Value Added as share of GDP, the EU lags behind China (4.7 %), the US (5.3 %) and Japan (5.4%) (Figure 78)[35]. Only a few European companies featured among the top 10 digital companies in major digital segments: 5 in telecoms, 3 in TV/Broadcasting and none in the increasingly important Over-The-Top segment and in operating systems and devices[36].

Given the diversity of technologies and sectors addressed in LEIT ICT, the table below provides an overview of the needs by area of intervention, and the way needs have been targeted by the LEIT-ICT programme.

[34] *Source: Annarosa Pesole (2016) Measures of the Contribution made by ICT to Innovation Output. An Update of the ICT Innovations Output Indicator; Institute for Prospective Technological Studies, Joint Research Centre. JRC Technical Report EUR 27912 EN; doi:10.2791/569845.*

[35] *For international comparisons, another definition of vaue added in the ICT sector is applied. According to this, value added in the ICT sector in the EU accounts for 3.9% of GDP.*

[36] *BCG (2015), "Five Priorities for acheving Europe's Digital Single Market".*

Table 47 - LEIT ICT – needs by line of activities and intervention 2014-2017

Area	Need	Intervention 2014-2017
A new generation of components and systems: engineering of advanced, embedded and energy- and resource-efficient components and systems	**Technologies for the digitisation of Industry**[37]: Progress in digital technologies changes the way products and related services are produced, commercialised and generate value. European industry has strengths on which it can build, notably in digital sectors such as electronics for industrial and high-reliability applications (e.g. automotive, security, energy, telecom, avionics), but also major weaknesses, notably in the level of investment in ICT-related products but also digital consumer products and services and in Web services. High-tech sectors in Europe fairly advanced in embracing digital innovations while a large part of SME, mid-caps and non-tech industries are still lagging behind. Disparities in digitisation also large between regions.	Strengthening the digital sector on the one hand, that supplies the technology and know-how for digital products and processes, and on the other hand improving the take up of such technologies by other non tech industrial sectors. WP 2014-2015 • Research and Innovation: around EUR 300 million have been oriented to the development of leading edge technologies in the areas of manufacturing, cyber-physical systems (CPS), low-power computing, and IoT. More systematic approach in the design and engineering of integrated systems to lift efficiency gains, to reduce development effort and to allow for better tailored products and services. • Support to innovation: more than EUR 200 million have been used to bring together competence centres and technology supplying companies (large enterprises or SMEs) with technology using SMEs and midcaps. • CSAs for road mapping and community building in the areas of CPS, computing and manufacturing. WP 2016-2017 Focus on leadership for the industrial platforms of the future and ecosystem building to better link with private investors such as venture capitalists and business angels, but also institutional investors such as local governments, with the objective to develop competence centres into vibrant innovation hubs.
	Smart Systems Integration (SSI) is an innovative area in which by combining fundamental disciplines (electronics, mechanics, biology, chemistry, magnetism) and integrating multiple functions (sensing, processing, memory, power, actuation) miniaturised and smart system solutions are developed for a broad range of sectors (health, automotive, food, security, environment, etc.). The Smart System Integration landscape at the onset of Horizon 2020 was still quite diverse with a large variety of technologies and capabilities for integrated systems spread across Europe with limited interaction and cooperation. In addition, the access to manufacturing facilities at reasonable cost for low/medium volume devices was a showstopper. Europe maintains its excellence on Smart System Integration, with novel and promising technologies emerging with a particular emphasis on the nano-biotechnology. New materials for new components and new processes lead to improved device performance and allow 'deep' integration of these devices into smart systems/objects.	RIAs and IAs address and integrate a diversity of technologies at the system level, by pooling together European competences with the aim to support lab demonstration of the next generation of smart systems and bring SSI technology closer to the market. Examples of successful integration are found in the areas of health monitoring and diagnosis, food and water quality control and well-being. This reflects the Smart Systems diversity in terms of applications, but also in terms of materials, core hardware technologies, and heterogeneous integration.

[37] *Cyber-Physical Systems, Customised and Low Energy Computing and Smart Anything Everywhere part of the research areas "components and systems" and "advanced computing". It also addresses Factories of the Future and the Internet of Things.*

Area	Need	Intervention 2014-2017
Next generation computing: advanced and secure computing systems and technologies, including cloud computing	**Cloud computing** has developed very fast, transforming the way businesses and industry provide their IT services and applications. It is bound to have a strong impact on the EU economy as a whole. Europe has developed an important cloud industry both as providers of cloud infrastructures and of software applications, including many small providers with potential to grow. Their challenge is to scale up, move from 'private clouds' to 'hybrid cloud' and 'public cloud' while maintaining the same level of assurance to their customers, address new applications and the trans-national barriers in order to expand outside of their national home markets.	Research activities in the years 2014-17 focus on medium-long term research priorities that maintain their relevance even with the very fast market developments. They focus on priorities that support the business models and needs of European industry and that can help to open new market opportunities considering both the cloud service providers and the end users, with a particular focus on SMEs and the public sector. International collaboration activities with targeted third countries (Brazil, Japan, South Korea) focus on cloud research and policy to develop technologies and services on global scale, and interoperable trans-national solutions for standardization. The main focus of innovation actions in WP 2014-2015 was on public sector cloud procurement. An ambitious call (EUR 22 million of EU funding) was launched for the pre-commercial procurement of public sector cloud computing services (PCP) and for public procurement of innovative cloud computing solutions (PPI). WP 2016-17 focuses the innovation actions on pilots for the public sector and for SMEs, with reinforced link to the policy actions. The WP16-17 innovation actions support uptake of innovative cloud solutions, experimentation in large-scale decentralised and federated environments (linked to FIRE), and address current challenges such as data portability and interoperability, data protection and access control, standardisation, etc.
Future Internet: software, hardware, infrastructures, technologies and services	Over the last 30 years, the Internet has become a major infrastructure for growth, job creation and social progress. The aim is to address the most critical and use aspects for the Internet: i) address the limitations of an Internet not designed to support the very large set of requirements imposed by an ever more diversified usage; ii) support the advent of more efficient computational and data management models responding to the challenges posed by increased device / object connectivity and data-intensive applications; iii) leverage the Internet to foster innovative usages of social and economic value.	The focus is on four interrelated areas: • Networks, where the 5G cPPP industry roadmap is complemented by longer term research; • Software technologies, responding to the need of more flexible, reliable, secure and efficient software for complex and highly connected systems; • Experimentation in large-scale or real-life environments, infrastructures for validating Future Internet technologies, products and services and their application to related areas; • Net innovation, supporting the emergence and nurturing of innovation ecosystems, supporting Web entrepreneurship and social collaboration.
Content technologies and information management: ICT for digital content and for cultural and creative industries	**Big Data**: A data-driven economy will contribute to the well-being of citizens as well as to socio-economic progress through new business opportunities and through more innovative public services. The envisaged actions, once implemented, will result in accelerated innovation, productivity growth and increased competitiveness in data across the whole economy as well as on the global market with Europe as a key player.	The overall and long-term objectives are set out in the Commission Communication "Towards a thriving data-driven economy"[38], adopted in 2014. The activities in the WP 2014-15 are planned to address, over a broad front, all the prerequisites contained in the Communication (i.e. both innovation and research). Industry (including the SMEs and startups) need to be involved and mobilized. This is addressed in particular by the Open Data incubator. CSAs address the framework conditions for the data economy, to ensure broad community-building across sectors and programme areas, and to liaise the SCs fully to the data economy and transfer big data technologies to areas that are less familiar with such technologies. The activities in the WP 2016-17 marked the start of implementing the cPPP. The design of the intervention of this latter part is therefore derived from the SRIA of the cPPP. The

[38] https://ec.europa.eu/digital-agenda/en/news/communication-data-driven-economy

Area	Need	Intervention 2014-2017
		following gives the mapping of WP 2016-17 topics and the elements raised as priorities in the SRIA (and the Communication). • Cross-sectorial and cross-lingual data integration and experimentation • Large Scale Pilot actions in sectors best benefitting from data-driven innovation • Research addressing main technology challenges of the data economy • Support, industrial skills, benchmarking and evaluation • Privacy-preserving big data technologies
Advanced interfaces and robots: robotics and smart spaces	Excellence in **robotics**, autonomous and **AI-based systems** will enable Europe to modernise its industry and thereby to stem the offshoring of production and to even re-shore production in Europe. Robotics is central to the European Commission strategy on Digitising European Industry. It is vital for achieving leadership in platforms, setting up and linking digital innovation hubs and shaping the future digital and labour-market skills. At the onset of Horizon 2020 robotics was well established around the world as a scientific and technical topic. While Europe was in a good position in professional service robotics with about half of the newly sold systems in 2010 coming from Europe, European companies were only tentatively entering the consumer robotics market, which was being dominated by Asian / American players such as Samsung, Toshiba and iRobot. Cooperation between academia and robotics industry in general, especially outside established areas: While Europe has a well-established and recognised research community and also boasted several leading robot manufacturers, the cooperation between academia and industry was still selective and not wide-spread. Also, cooperation often took place within one Member State and did not take full advantage of the opportunities offered in the EU.	WP 2014–2015 focussed primarily on a new generation of industrial and service robots for real-world environments by advancing abilities and technologies relevant to industrial and service robotics in prioritised market domains. WP 2016–2017 WP expanded the scope to take into account autonomous systems.
Micro- and nanoelectronics and photonics: key enabling technologies related to micro- and nanoelectronics and to photonics covering also quantum technologies	**Micro and Nanoelectronics (MNE)** as a Key Enabling Technology (KET) represents a significant industrial sector within the EU economy. The MNE value chain includes process equipment and materials, semiconductor design and manufacturing, test and application integration. It is an essential part of the socioeconomic European infrastructure (telecommunication networks, transport and energy systems, etc.) and it is present in practically all products and services. MNE is R&D intensive with fast introduction of significant technological advances. Industrial competitiveness in the area entails i) substantial investments over sustained periods; and ii) cooperation of industry with RTOs, research centres and universities.	The objectives of the area have been addressed in the first part of Horizon 2020 through RIAs (small scale), IAs and CSAs. This has allowed to the further development of advanced technology of high industrial interest (RIA) and the consolidation of services providing SMEs and academia with access to MNE manufacturing and design (IA). This has been complemented with activities on road-mapping and safety requirement (CSA). MNE activities in Horizon 2020 are an integral part of the EU Strategy for Electronics Components and Systems, which is structured along the following axes: • High TRLs (6-8) technologies with shorter term impact (2-4 years), primarily addressed by the JTI ECSEL • Low TRLs (2-4) technologies with mid-term market impact (4-6 years) addressed in LEIT-ICT • Exploratory research of more academic nature addressed by FET in 'Excellent Science'.

Area	Need	Intervention 2014-2017
	Photonics is one of six *Key Enabling Technologies (KETs)* identified by the European Commission as instrumental for modernising Europe's industrial base. The European photonics industry is among the global technology leaders in this field employing more than 300,000 people directly in over 5,000 SMEs. In view of the rapid pace of photonics technology evolution, pening up new market opportunities in areas such as Cloud computing or non-invasive diagnostics and driving structural changes in traditional ones such as communications or lighting, significant new R&I investments in photonics were considered necessary at the onset of Horizon 2020 in order to sustain Europe's industrial leadership in this area.	The Horizon 2020 intervention in photonics is aimed at strengthening Europe's global market position, and at increasing the number of highly skilled jobs in the photonics industry and also in photonics-enabled industries. In the work programmes 2014-17 a total budget of EUR 324 million has been spent/planned for photonics. Out of this, EUR 291 million are used for dedicated actions under the Photonics KET, and EUR 33 million for joint actions with other KETs and cPPPs. These actions include a broad set of RIAs and IAs[39] ranging from some disruptive research to system integration, pilot production lines and innovation incubators. They are driven by user needs and concrete business cases, and cover the value chains for improved value creation in Europe. The RIAs and IAs are complemented by some CSAs providing strategy support and outreach. In more detail, the following types of actions are covered (planned Horizon 2020 contribution in brackets): • RIAs (EUR 156 million) to develop core photonic technologies and components driven by market requirements such as higher performance, lower size and power consumption, and new photonics-enabled functions. Applications include high-throughput laser-based manufacturing, optical communication in networks and exa-scale data centres, medical screening and diagnostics, solid-state lighting, and sensing for a safer environment. • IAs (EUR 56-60 million)[40] to develop photonics-integrated systems e.g. for medical screening and diagnostics, lighting, and virtual/augmented reality. These developments include validation and testing in real settings. • Four Manufacturing Pilot lines (EUR 47-50 million) for manufacturing advanced photonic components and sub-systems (OLEDs[41]; mid-infrared micro-sensors; PICs[42]; PIC packaging & assembly), and also providing open access services for external users including SMEs. On longer term, they further aim at establishing industrial volume production in Europe. • An 'Innovation incubator' (EUR 8-10 million) providing SMEs with a one-stop-shop access to photonics expertise and services for the design and prototyping of photonic or photonic-enhanced products. This action builds on experiences made in the FP7-ACTPHAST project; on this basis it is expected that some 200 different prototypes will be produced. • CSAs (EUR 14 million) supporting development of regional innovation strategies, promoting skills development and take-up of photonic technologies in particular by SMEs, and providing outreach to young people and general public e.g. through

[39] *RIA: Research & Innovation Action; IA: Innovation Action; CSA: Coordination and Support Action*
[40] *Part of this budget is shared with 'Pilot lines' and 'Innovation incubator' under work programme 2016-17. Only an approximate range can therefore be indicated for the different parts, although the total is already fixed.*
[41] *Organic LEDs, i.e. LEDs based on semiconducting organic materials such as polymers*
[42] *Photonic Integrated Circuit*

Area	Need	Intervention 2014-2017
		MakerLabs, and actions supporting the International Year of Light 2015 as proclaimed by the UN; • Joint and coordinated calls with other Horizon 2020 KETs and cPPPs (EUR 67 million total; half of this contributed by photonics) to exploit synergies and to cover wider value chains, on the following topics: Laser based manufacturing with the 'FoF' cPPP, OLED materials with the 'Advanced materials' KET, and integrated platforms for the healthcare and food sector with the 'Nanoelectronics' KET. • Also one ERANET-Cofund action (EUR 6 million) has been launched. • Further to this, photonics is a technology enabler in some other Horizon 2020 domains where no dedicated photonics budget has been deployed. Examples are ICT-domains like 'High performance computing' and 'Future communication networks' (including '5G mobile networks'), and societal challenges like 'Health' and 'Smart cities and communities'.
Focus area IoT	The **Internet of Things** (IoT) represents the next major economic and societal disruption enabled by the Internet and is considered a game-changer for many industrial sectors critical for Europe's competiveness and economic growth. A number of regions (notably USA, China and Japan) are trying to take the lead in the IoT market and to repeat their success experienced with the mobile revolution. Industry standards defined in the US to apply across the entire globe and may hamper the scope for specific configurations to suit European industry. Although Europe is well positioned, fragmentation between national markets and of industrial silos/applications are preventing growth at global scale. There is also a lack of common platforms, standards and uncertainty about business models	For building stronger relationships between industry, and innovators and to foster European IoT innovation ecosystems, an IoT innovation ecosystem call of EUR 51 million call has been implemented, cutting across several technological areas (smart systems integration, cyber-physical systems, smart networks, big data). The call was motivated by recent technical progress on IoT research and architectures supported through RIAs. A high proportion of participation from SME's in the proposals was given, considering that SMEs are generally considered as crucial drivers of the proliferation of IoT solutions. In the six selected RIA proposals were around 50 SME. Most popular use cases were in Smart Transportation, Environmental Monitoring, Smart Home, Smart Energy and Monitoring domains. Synergies with FIWARE were encouraged. The scientific and technological international cooperation has been intensified regarding IoT architectures, standards, security & privacy and governance, in particular with Asian and the Americas. Joint calls are implemented with Japan, South Korea and Brazil, and a CSA for China. In order to drive more the take-up and deployment of IoT in Europe, an IoT Large Scale Pilot call (IA) with a budget up to EUR 104 million has been implemented, targeting IoT scenarios in Smart Agriculture, Assisted Living, Wearables, Connected Cars and Smart Cities. This program will be complemented by accompanying measures on standardisation, security&privacy, creativity and further research on platforms. It also links to the DSM and questions of free flow of Data and RRI/SSH.

Source: European Commission.

Nowadays **the relevance of LEIT ICT is** still **high**, as the above challenges remain: there is a general sense that we are only at the start of the digital and hyperconnected era and that we must make better use of the great opportunities offered by digital technologies. Big changes– technology and usage-led – are yet to come as the pace of technologies and service innovation accelerates. From a thematic point of view, many of the activities undertaken in Horizon 2020 are in continuity with the FP7 Cooperation Programme; however, some areas have increased relevance and relative distribution of funding has been modified accordingly, so as to take into account technology evolution and new market opportunities (e.g. technologies for digitisation of industry, computing).

In some areas Horizon 2020 has represented a significant shift from FP7: in robotics for instance FP7 research was predominantly academic oriented, whereas in Horizon 2020 the WP has been largely inspired by the Strategic Agenda and Roadmap of the cPPP and of the application needs identified there. In the area of big data, prior to Horizon 2020 the EU research landscape in data management technologies was still dominated by an interest in sophisticated data modelling and advanced inference technologies and – with few exceptions - there was no sustained interest in issues of data quality and scalability (in contrast to what had been the norm in the United States for a few years already), with imperfect connection between the EU research community and the growing innovation needs and requirements of various EU industrial sectors.

This led to the main design principles applied in the first Horizon 2020 work programmes: bring data to the project; involve industry to define (research) challenges; stimulate the participation of SMEs and startups. In the area of IoT, in line with the new emphasis on innovation support and the need for more integrated programming across different EC initiatives, the focus area of IoT has been created as a major novelty in Horizon 2020 to merge technology stream (microsystems, cyber physical systems CPS, IoT) and to bring together demand-driven funding programmes. Research and Innovation topics for Cultural and Creativity Industries have also been introduced, in contrast with FP7, where only the last call included them.

Box 1 - Robotics: facilitating cooperation between academia and industry

ECHORD++, **2013-2018, Collaborative Project, EC contribution: EUR 19,750, 000** Under the slogan "From lab to market" the robotics research project ECHORD++ promotes the interaction between robot manufacturers, researchers and users by facilitating the cooperation between academia and industry. ECHORD++ uses three different instruments to reach this end: the experiments, the Robotics Innovation Facilities (RIFs) and the Public end-user driven Technological Innovation (PDTI). In total 31 **experiments** are funded under the umbrella of E++ experiments involve partners from academia and industry, 80% of them integrate the end users directly. Together with the predecessor project ECHORD, E++ has made a major contribution to closing the gap between industry and academia and has built a community which now cooperates beyond the funding period of E++.

The expert panel concluded that the relevance of the activities of LEIT ICT is high and the intervention is well designed, as **it provides a market informed pull on research**. Topics such as Smart Cyber Physical Systems, Smart Systems Integration, Robotics, Low-Power Computing and ICT Enabling Technologies (Photonics and Micro-Nano-electronics) ensure **feeding the innovation pipeline** with key components and systems without which no downstream activities addressing the Societal Challenges would be possible. Future Internet and Big Data activities complement the efforts towards

digitisation of the European industry and **optimisation of energy & resources**. The **cPPPs address themes for sustainable growth and leadership**; however in view of the experts in some cases they seem to lack top level support. LEIT-ICT is supporting research, innovation and standardization of the **future communication infrastructures**. These will provide the connectivity for new services in eGovernment, Smart Cities, and the Fourth Industrial Revolution. Hereby, access to the IoT will be a significant contribution to the Digital Transformation. The **Factories of the Future** cPPP has been established as a reaction against the financial crisis in 2008 to strengthen Europe's position in the industrial sectors; since then, the topic has even become more important, when the issue of the IoT was introduced in the context named as Industry 4.0 or like in the US as Industrial Internet[43].

The specific R&D objectives[44] are clearly among the key objectives that industrial sectors have to address - in terms of production and more specifically the digitalization of the production. **Big data** is one of the most promising and interesting field for the future of ICT technologies and to boost digital industrial growth in many economic domains. **Advanced Computing[45] technologies are the key technical engines needed to accelerate digitization of the Society** along two directions: the spread of usages and for each usage the capability to go beyond the state of the art. Thus for Europe, mastering these technologies in an independent way is a must to improve its socio-economic competitiveness in a digitized world along also two axes: the socio-economic competitiveness of the societal or economic actors as users of these technologies but also the competitiveness of the producers of these technologies. **The ending of Moore's law** which has already started leads to the need for breakthrough solutions to improve processing speed[46]. The deep impact of this breakthrough on the existing economic models of the digital industry as a whole may lead to a worldwide reshuffling of existing acquired positions. This represents a huge opportunity for Europe to establish new strong positions. **Content technologies and Information Management** are relevant for the multilingual Digital Single Market strategy: digital media technologies have a strong influence on the unification strategy of European market in improving access to eContent and Digital Media product and on the improvement in e-Commerce adoption in Europe. In addition, e-Inclusion and eLearning contribute to several objectives of the European 2020 Strategy and its pillars, such as the key objectives of promoting digital literacy, skills and inclusion or the agenda for new skills and jobs. It is clear, for instance, the importance to educate a new generation of Data Scientists or Digital Media experts in Europe.

The expert panel concluded that the **SME instrument** is one of the most interesting new instruments inside the Horizon 2020 programme. Even despite the low success rates of

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[43] *http://www.iiconsortium.org/*

[44] *High-tech manufacturing processes, including 3D printing, nano- and microscale structuring; adaptive and smart manufacturing equipment and systems, including mechatronics, robotics, photonics; resource-efficient factory design, and data management for increased production performance; collaborative and mobile enterprises, networked factories linking dynamically supply chains to local production; human-centred manufacturing: designing the workplaces of the future; customer-focused manufacturing: linking products and processes to innovative services.http://ec.europa.eu/research/press/2013/pdf/ppp/fof_factsheet.pdf.*

[45] *"Advanced computing" refers to hardware as well as software advanced digital processing capabilities which are embedded in objects and systems of any sort or available in standalone computers. The word "advanced" characterizes cutting edge properties of these processing capabilities expressed in terms of processing speed, energy consumption, resilience, computing mode: sequential, parallel, distributed, remote, manufacturing or ownership cost, miniaturization, density, programmability, algorithmic power, among others.*

[46] *These solutions relying on massively parallel processing at the level of a chip (multi/many cores techniques) or at the level of a system (massively parallel architecture of a supercomputer) are making almost obsolete most of the software developed in the world.*

applications, the SME instrument is a very welcome addition to the toolbox for innovation. However the experts noted that if the goal of the instrument is to foster SME growth and ultimately job creation then for the evaluation more criteria specific to the outcome (e.g. access to the market, TRL level, innovation, operational and scaling potential of the company) need to be considered. If it is also in the scope of the instrument to fund disruptive ideas that are too early or risky for private investment (Angel, Venture Capital) then specific categories/quotas are lacking.

E.3.1.2. The relevance of LEIT ICT to address European objectives

Horizon 2020 was adopted in late 2013, in the context of the **Europe 2020 Strategy** and LEIT ICT directly addresses the strategy's flagship initiative "Digital Agenda for Europe". It also addresses the flagship initiative on creating an "Innovation Union", by supporting activities aimed at bridging the gap between research and market. Since then the political context has evolved and Horizon 2020 remains an important mechanism for supporting and delivering on the **current set of EU policy objectives**, as the EU's main funding programme for R&I until 2020. LEIT ICT is essentially relevant to the two following main political drivers of the Commission objectives: 1) A Connected Digital Single Market and 2) Boosting Jobs, Growth and Investment.

Digital Single Market (DSM) – Digital technologies are changing the world by enabling innovative business models and modifying the value chains and networks in all sectors. A number of actions initiated under Horizon 2020 are strongly aligned with the Commission's 2015 Communication on a Digital Single Market Strategy for Europe. These notably include the launching of a Cybersecurity cPPP[47] in July 2016 which seeks to help Europe protect itself against cyber-attacks and strengthen the competitiveness of its cybersecurity sector (an area highlighted as requiring further EU action in the mid-term review of the Digital Single Market Strategy); under the Work Programme 2016-2017, actions in support of the implementation of the eGovernment Action Plan 2016-2020 and the promotion of ICT-enabled public sector innovation related activities[48] as well as of digital innovation hubs (DIHs)[49], with a view to mobilising further investments in the digitisation of European industry[50] and enabling the creation of better framework conditions for the digital industrial revolution.

Jobs, Growth and Investment: ICT as Key Enabling Technology enhances economic and industrial activity: ICT is not only one of the fastest growing industries, which directly creates jobs, but it is also an important enabler of innovation and development. There are five common economic effects of ICT[51]: Direct job creation; Contribution to GDP growth; Emergence of new services and industries; Workforce transformation; and Business innovation. Innovative high growth SMEs are increasing in number: in Europe there are an estimated 3.8 million persons employed in SMEs in the Information and Communications sector[52].

[47] *http://europa.eu/rapid/press-release_IP-16-2321_en.htm*
[48] *https://ec.europa.eu/digital-single-market/en/ict-enabled-public-sector-innovation-horizon-2020*
[49] *http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs*
[50] *http://europa.eu/rapid/press-release_IP-16-1407_en.htm*
[51] *Elena Kvochko. Manager of Information Technology Industry at the World Economic Forum (April 2013)*
[52] *Source: EUROSTAT.*

Box 2 - Digitising the European Industry – Examples of projects

I4MS. The "**ICT for manufacturing SMEs**" initiative (I4MS) comprises several groups of competence centres across Europe that support SMEs and mid-caps to achieve innovations in manufacturing through digital technologies with the goal to improve their competitive position. The initiative consists of 7 innovation projects that conduct successful, high impact experiments in different technology areas (simulation over cloud-based HPC, Robotics, Lasertechnology, Cyber Physical Systems) such as the following example(s): In a collaborative effort of a technology provider (SME) and 2 end-users (SMEs) a solution was developed that allows the insole scan and design of tailor made shoes for customers with feet anomalies over cloud-based HPC resources. This paves the way to have perfect-fit shoes produced in any back-shop in Europe by 3D printing. The SMEs expect to triple their revenues with this solution within 3 years.

Project CREMA: EC contribution: EUR 5,324,720.
CREMA aims to create an approach for Cloud-based Rapid Elastic MAnufacturing. In order to keep in sync with the increasing demands of the manufacturing industry of the future, companies need to flexibly react to and be able to offer production capacities in a rapid way. Thus companies looking for manufacturing capacity need to be supported by the means to find these capacities, configure them, and integrate them into their own manufacturing processes. The CREMA project creates a flexible way for companies to combine, offer and consume their resources. The project has understood how to create a secure environment for the potential customers to be able to rely on. This is a very big problem for public cloud environments as it is still the biggest single factor that will stop the uptake of cloud based technologies for companies involved with IPR, security, technology and any company that exchanges vulnerable data. The cloud security developed by CREMA presents innovative solutions and a company has been started up to exploit the project results. CREMA's pan-European consortium is user grounded and combines technology expert SMEs, Industry partners, Researchers and Users/Associations Groups.

LEIT ICT is also in line with the three **O's Strategy of Commissioner Moedas**:

Open Science: Digital technologies provide a key contribution to new paradigms of science through open-data, digital science and innovation, and the European Science Cloud, as part of the Digital Single Market Initiative.[53] It aims to develop a trusted, open environment for the scientific community for storing, sharing and re-using scientific data and results as stated in the Commission Communication 'European Cloud Initiative - Building a competitive data and knowledge economy in Europe'.[54]

Open Innovation: Digitisation plays a key role in innovation, through radical reengineering of business processes and redefining the rules of the game in many sectors. The Horizon 2020 programme and instruments show a turn towards more holistic approach to modern, open innovation. The innovation instruments (especially ODI in the SME Instrument) have been very much demanded which is seen in the very high oversubscription rate. Also in LEIT ICT and application oriented parts innovation is embedded more strongly than previously, even taking on board some of the principles of open innovation. Good examples of new activities are start-up support and new knowledge based entrepreneurship. Survey results from the support study suggest that, according to project coordinators, open science principles were applied in a majority of projects (all Pillars). The principles most commonly applied were related to open access (of research publications and data). 82% of project coordinators responded that open

[53] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0192&from=EN
[54] COM(2016) 178 final, https://ec.europa.eu/digital-single-market/en/news/communication-european-cloud-initiative-building-competitive-data-and-knowledge-economy-europe

science principles were being applied in their project, with open science defined as doing science in an open and collaborative way, sharing research results as much as possible.

Open to the world: ICT is a global industry and DG CONNECT has developed a wide, ambitious and effective international cooperation agenda through development of joint R&I activities with third countries, coordinated/joint calls, policy dialogues and collaborations supporting relevant DSM policy goals especially those dealing with standards and interoperability. The international dimension of Horizon 2020[55], aims at supporting EU's R&I excellence and Europe's economic and industrial competitiveness.

Box 3 - International cooperation in ICT

The international collaboration strategy supports the policy objectives defined by the Commission and DG CONNECT in the different fora for international collaboration. The need to strengthen the competitiveness of Europe in the digital economy is an important driver for selecting the priority countries for international collaboration in ICT. Another important driver is the need to ensure that Europe plays an important role in defining global standards (e. g. 5G, IoT...). The policy goals that define the priority setting for international collaboration in the R&D&I field are:

- positioning the EU industry in a way that benefits ICT market developments, seeking best market access (e. g. by addressing also access to regulated activity and/or infrastructures, spectrum and standardisation issues), especially but not exclusively in the most prominent emerging economies,
- promoting the global reach/adoption of technology developments and market innovations in ICT coming from EU players,
- reinforcing the technological basis in Europe by mobilising the "best minds" of the world (especially from the leading countries in ICT) to work with (and in) European-funded research projects.

International cooperation has been an important foundation of ICT research and innovation activities since FP7-ICT which included joint calls with Brazil (2), Japan (1) and Russia (1). In Horizon 2020 LEIT ICT international cooperation activities are in place with **Developed economies** (including notably Japan, Korea, Taiwan, US), focusing primarily on those areas where there is a need to work on common technologies (e. g. 5G, IoT, Cloud) and/or there is significant potential for economies of scale (e. g. societal challenges such as "demographic change/ageing, Smart Cities"); with **Emerging economies** including notably Brazil, Mexico and China, where the development of joint research and innovation activities contributes to the alignment with the EU in new technological developments and facilitates the adoption of standards compatible with those in place in the EU; and with **Developing countries**: The purpose of international cooperation with these countries is not only to establish a presence in markets with important growth potential but also to explore new approaches to ICT development and deployment such as "frugal innovation" that take into account the constraints and conditions of the developing countries. The continuation of the collaboration on co-design, adaptation, demonstration and validation (e. g. pilots) of ICT related research and innovation with Sub-Saharan Africa and ASEAN countries are of especial interest with the EU acting as a catalyst for capacity building, connectivity contributing to a strengthening of the links with Europe.

In terms of thematic focus the basis of international cooperation, **5G** emerges as a federating topic bringing together the main developed economies especially in Asia (Japan, Korea and Taiwan) but also US. This is complemented with developments in software services, cloud computing, IoT and big data involving Japan, Korea and emerging economies like Brazil, China and Mexico.

Source: European Commission.

[55] *Further developed in the communication "Enhancing and focusing EU international cooperation in research and innovation: A strategic approach" from 14 Sep 2012 - COM(2012) 497*

E.3.2. Flexibility to adapt to new scientific and socio-economic developments

Successive Work Programmes have **updated topics** and **reoriented focus** to keep abreast of technological or scientific progress and to changes of the wider socio-economic or political context in the relevant fields. From WP 2014-2015 to WP 2016-2017, for instance, support to innovation capacity has been strengthened through an increase in budget of the 'Open and Disruptive Innovation' topic directed towards SMEs (up from 5% to 8% of the budget for the two years) and through a new open call on 'Fast Track to Innovation' (FTI). The work on advanced computing and relevant parts of the work on photonics and components and systems have been coordinated with developments on HPC carried out under the Excellence pillar (FETHPC) and in particular with the HPC cPPP. The Work Programme introduced cross-cutting actions and reinforced large scale piloting in real-world environments, through the Focus Area 'IoT', with links to use cases in societal challenges. Digital security and privacy as well as RRI are aspects have been strengthened throughout LEIT-ICT.

Further evidence of the relevance of the Horizon 2020 ICT topics in relation to technology trends can be found in a recent study on the technologies that are expected to have significant potential to drive economic impact and disruption by 2025[56]. The criteria used to identify such technologies were:

- the technology is rapidly advancing or experiencing breakthroughs,
- the potential scope of impact is broad,
- significant economic value could be affected, and
- economic impact is potentially disruptive.

Among the 12 technologies that were identified a prominent place is given to (a) Mobile Internet, (b) Automation of knowledge work, (c) the IoT, (d) Cloud technology, and, (e) Advanced robotics. These findings are in agreement to those reported by other prospective studies[57], so they were used as proxies for the future trends in ICT. A very good coverage is observed, taking also into account that the 5 cPPPs have topics that are aligned with future technologies. Table 48 shows the research areas and topics of the 2016/17 Work Programme that relate to these ICT technologies. The degree of alignment should be even stronger, if in addition to the agenda-driven topics that examined, the important number of ODI projects that focus on these technologies is taken into account. Finally, the report of the expert group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020[58] concluded[59] for LEIT ICT that the identified keywords from the EU and International priorities are to a medium degree covered by LEIT ICT, whereas the subsequent technological and scientific advances are to a high degree covered.

[56] *McKinsey (2013). Disruptive technologies: Advances that will transform life, business, and the global economy. McKinsey & Company, 05.2013.*
[57] *Including ESPAS (2015) and Gartner Technology Predictions, to be found in: http://www.gartner.com/technology/topics/trends.jsp*
[58] *Applying relevance-assessing methodologies to Horizon 2020, October, 2016.*
[59] *The relevance was assessed against the Horizon 2020 establishment act, the WP 2014-2015 and WP 2016-2017.*

Table 48 - Alignment of thematic areas of LEIT ICT with topics related to future trends in ICT technologies

Future ICT technologies	A new generation of components and systems	Advanced Computing and Cloud Computing	Future Internet	Content	Robotics and Autonomous Systems	Other topics
Mobile Internet			5G cPPP Networking research beyond 5G Future Internet Experimentation			EU-Japan Joint call / 5G - Next Generation Communication Networks
Automation of knowledge work	Smart Anything Everywhere Initiative			Big Data cPPP Media and content convergence Technologies for Learning and Skills Interfaces for accessibility		
Internet of Things	SSI - Smart System Integration Smart Anything Everywhere Initiative		5G cPPP			International cooperation with China/Mexico EU-Japan Joint calls EU-South Korea Joint calls EU-Brazil Joint calls
Cloud technology		• Customised and low energy computing • Cloud Comput				

		ing				
Advanced robotics					Advanced robot capabilities research and take-up System abilities, development and pilot installations	
Additive transformation	SSI - Smart System Integration					Photonics KET ODI Scheme

Source: CARSA study

E.3.3. Addressing specific stakeholder needs

The LEIT ICT Work Programme is developed through a broad process of **consensus building** around the research priorities among and with the research and industry communities. Bodies involved in the design process of the Work Programme include the CONNECT Advisory Forum for ICT Research and Innovation (CAF), the European Technology Platforms (ETP) and the stakeholders' associations involved in the cPPPs, the Commission experts, and the wide participants' base through consultation meetings. The Work Programme also builds on direct input from the portfolio analyses, studies on technology and market trends, evaluation and impact analyses, and monitoring reports on the projects. The EU Member States are involved through the Strategic Programme Committee and also through the other 13 configurations (each for various parts of the WP) of the Programme Committee consulted throughout the process.

The survey on coordinators and participants carried out on behalf of DG CNECT in the context of the interim evaluation of Horizon 2020[60] sought to gain a better understanding of the extent to which LEIT ICT is addressing stakeholders' needs.[61] Results show that the **Work Programme responds to the needs of the organisations** involved.

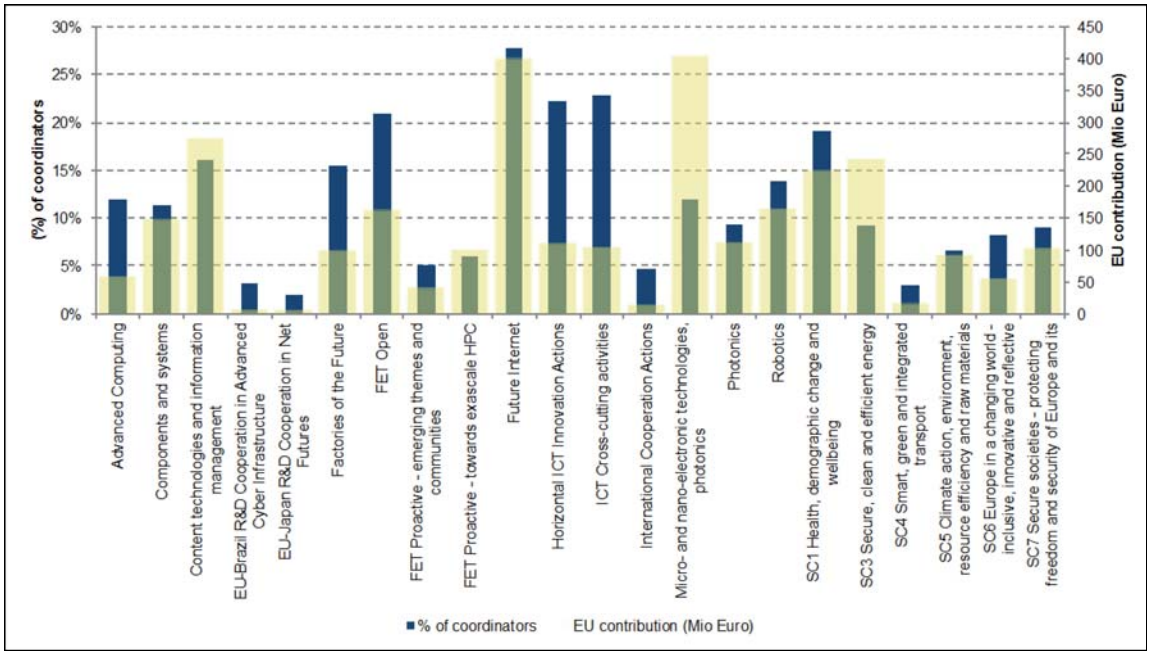
[60] *Survey ran between July and September 2016 by the CARSA study (SMART 2015/0060). Three separate questionnaires used: one for participants (576 responses out of 1449 surveys sent), one for coordinators (462 responses out of 681) and one for a non-participant 'control group' (471 out of 1750 including returned e-mails). The coordinator and participant surveys were launched 4 July 2016 and closed on 25th July, Regarding the non-participant survey, the contractors provided the Commission with the link and suggested email to send out, as contact details of the unsuccessful applicants could not be shared due to confidentiality reasons. The survey was launched on the 26th July 2016 and closed on the 22nd August, running for a slightly longer period to take into account the summer break.*

[61] *Project coordinators were asked to select the research areas that best correspond to their organisation's research and innovation needs (maximum 3). Results are shown in , alongside the EU contribution for each area (in EUR million). They show important differences across programme components.*

All the priorities set out in the Horizon 2020 Specific Programme have been addressed at least once in the **Work Programme (WP) 2014-2015 and 2016-2017**. The Research Areas that are considered the most relevant are:

- Future Internet and Big Data Applications, which also corresponds to a priority from the Programming point of view, since it has received the highest share of funding.
- Horizontal ICT Innovation Actions, for which the large share of SME instrument projects that are bottom-up support actions contribute to this ranking.
- ICT-Cross cutting activities, showing that the themes chosen[62] are of a sufficient variety and high relevance to participants.

Figure 79 - Most relevant research areas (% of coordinators selecting a research area) and EC budget contribution in each research area

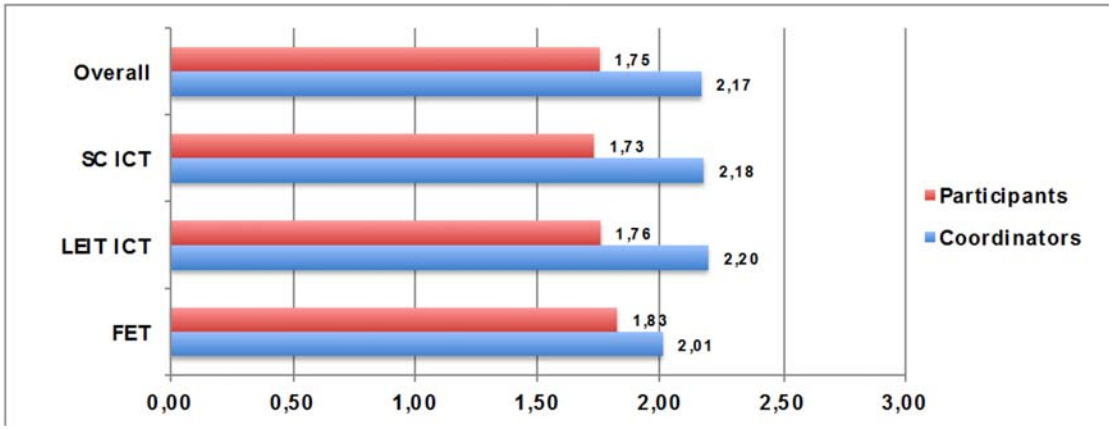


Source: CARSA study.

The survey also indicated that the Work Programme addresses the expectations of participants to a fair extent. Compared to project participants, coordinators show higher levels of satisfaction with the way the Work Programme addresses their participation objectives (Figure 80 and Figure 81). This observation should be related to the fact that coordinators have a more in-depth knowledge and increased experience with EU FPs, which enables them to better identify the relevant parts of the Work Programme.

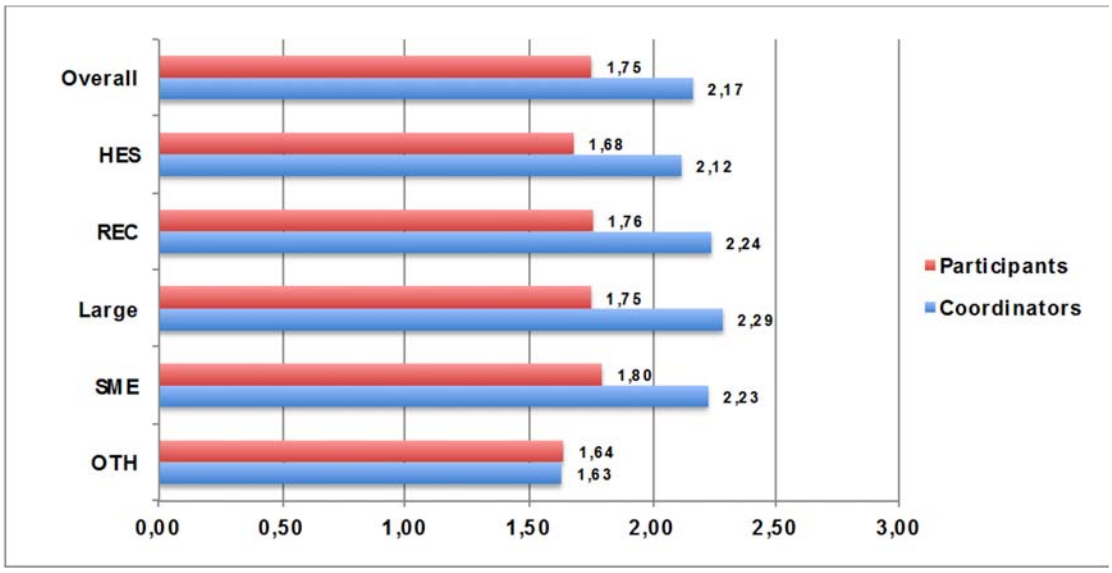
[62] *The themes include a) the Internet of Things embedded in Smart Environments and Platforms, b) technologies, networks and new digital and social media, and c) cybersecurity and trustworthy ICT.*

Figure 80 - Assessment of the degree of coverage of participants' objectives by the Horizon 2020 calls overall and per priority area (average values. 0, 1, 2 and 3 are respectively no, low, fair, high coverage)



Source: Survey carried out in July – September by the CARSA study.

Figure 81 - Assessment of the degree of coverage of participation objectives by the Horizon 2020 calls overall and organisation type (average values, 0, 1, 2 and 3 are respectively no, low, fair, high coverage)



Source: Survey carried out in July – September by the CARSA study.

The highest objective for all participant categories is to expand their relationships/networks, which is fully in line with the collaborative nature of research and innovation actions supported by the Programme. While most participation objectives are considered of medium to high importance, distinct trends are observed across the different types of organisations, showing varying levels of interest in the wide range of actions covered by the Programme[63]. More particularly:

- Universities have as a highest priority to access research funding and to advance scientific knowledge. These are also important objectives for Research Centres, but to a slightly lower degree. Moreover, the academic partners (HES and REC) attach considerable importance in exploring new multidisciplinary approaches, in

[63] *As already mentioned, Horizon 2020 DG CONNECT Activities brings together projects supporting scientific quality, others for highly close-to-market actions, as well as those combining research and innovation ("from idea to application and market").*

addressing scientific/technical challenges and in tackling problems with a European/international dimension.

- The private sector organisations' more important objectives are to maintain and/or enhance their technological advantage and to benefit from knowledge sharing with their partners. For SMEs, developing new products and markets are also very important reasons to participate, together with obtaining access to research funding. These two objectives are also relevant for large organisations, but to a lower extent.
- Finally, public authorities and associations in the "other" category, look primarily to share knowledge with their partners and to tackle problems that have a European/international dimension, which explains their higher participation rates observed in the Societal Challenges ICT priority.

The above trends are similarly observed for the population of newcomers, indicating that, while participation objectives may vary for the different types of organisations, they do not seem to depend on prior FP experience.

It ought to be noted that nearly one-third of the surveyed coordinators and participants (all pillars) stated that they could identify topics not covered by Horizon 2020 that in their view are relevant for LEIT ICT. An overview of such topics is provided in the table below. Please note that some of the topics are already covered in Horizon 2020, thus the information signals the participants' perception and their knowledge of the Programme.

Table 49 - Analysis of topics indicated by coordinators and participants not included in topics of calls under Horizon 2020 DG CONNECT Activities

Category of topics	**Description**	**Example**	**Total respondents citing items in this category (out of 287 respondents)**	***Total coordinator respondents citing items in this category (out of 144 coordinators)***	***Total participant respondents citing items in this category (out of 143 participants)***
Niche tools and techniques	Specific hardware and software tools and techniques in areas such as: - Health - Robotics - Biology -Electricity Storage	Computer assisted surgery Robotics in Agriculture[64]	20%	23%	18%
Data-driven	More projects on	Quantum cryptography[65]	19%	26%	11%

[64] *Addressed both in IoT-01 and SFS-05 in WP2016-1.*

Category of topics	Description	Example	Total respondents citing items in this category (out of 287 respondents)	*Total coordinator respondents citing items in this category (out of 144 coordinators)*	*Total participant respondents citing items in this category (out of 143 participants)*
projects and concerns over data quality handling	using available data and handling it safely. Such projects were cited in areas such as: - Urban Design - Computing - Internet Security	Cross-domain data integration[66]			
Basic research and not directly marketable research	More projects that do not have a product that they can directly bring to market. Respondents in this category emphasized how important basic research is to bring real innovation and breakthroughs in Europe. This was particularly	Fundamental Physics Preclinical studies in neurodegenerative diseases	15%	18%	12%

[65] *Addressed in DS-06 in WP2016-17.*
[66] *Addressed in Big Data cPPP.*

Category of topics	Description	Example	Total respondents citing items in this category (out of 287 respondents)	*Total coordinator respondents citing items in this category (out of 144 coordinators)*	*Total participant respondents citing items in this category (out of 143 participants)*
	emphasized in the context of: - Academic research - Start-up research - SMEs research				
Health, environment and water related projects[67]	More projects being funded on health[68] and environmental issues.	Air pollution Environmental education	14%	8%	20%
Machine-learning, artificial intelligence and language acquisition research	Machine learning and artificial intelligence applicable to: - Robotics - Health¨ - Computing	Bain-computer interface Language Technologies	7%	7%	7%

Source: Survey carried out in July – September by the CARSA study.

The expert panel concluded that while the European Commission Services are making substantial efforts preparing the visions and strategies that feed into work programmes and calls on various topics with high quality and openness, the approach lacks room for quality research beyond the scope of the work programmes. While making sure that all funded projects form a "tightly connected puzzle" has advantages, the panel is concerned that quality research is not funded because it does not fit the calls or the timelines of the calls.

[67] *Water related projects were reported as not appearing in calls in 2015-2016. Examples included energy management in water treatment plants, real time forecast and monitoring systems for integrated management of the whole water cycle and water management by itself, not embedded in agriculture, urban matters, or industry.*
[68] *Dedicated eHealth topcis in Societal Challenge 1.*

The report of the expert group on evaluation methodologies for the interim and ex-post evaluations of Horizon 2020[69] concluded[70] that the needs of EU citizens are to a high degree covered in the relevant documents of LEIT ICT. Keywords emerging from the **needs of society** were found in the relevant documents.

E.3.4. Lessons learnt/Areas for improvement

The ICT sector plays a key role for **Europe's global competitiveness and growth** and its relevance today is as high as at the launch of Horizon 2020. Topics such as Smart Cyber Physical Systems, Smart Systems Integration, Robotics, Low-Power Computing and ICT Enabling Technologies ensure **feeding the innovation pipeline** with key components and systems without which no downstream activities addressing the Societal Challenges would be possible. Future Internet and Big Data activities complement the efforts towards **digitisation of the European industry** and **optimisation of energy & resources**. LEIT-ICT is also supporting research, innovation and standardization of the **future communication infrastructures**, which will provide the connectivity for new services in e.g. eGovernment, Smart Cities, and the Fourth Industrial Revolution.

The research topics funded under LEIT ICT are fully consistent with the programme structure and target R&I activities foreseen under the legislative basis for Horizon 2020. The design of the intervention is appropriate as it is a **market informed pull on research**, with the **cPPPs addressing themes for sustainable growth and leadership**. The expert panel concluded that the **SME instrument** is a successful addition to the toolbox for innovation. However, more criteria specific to the expected outcomes are lacking in the evaluation process.

LEIT ICT has proven flexible to adapt to technological, scientific, economic, political and social developments. It contributes to the **EU policy priorities** of **Digital Single Market** and its strategy for **Digitising the European Industry**, by supporting the technologies that are driving the new industrial revolution. As Key Enabling Technology enhancing economic and industrial activity, it also directly supports the priority of **Jobs, Growth and Investments**. LEIT ICT is also in line with the three **O's Strategy of Commissioner Moedas**. A recent study on relevance also confirmed that LEIT ICT addresses to a high degree citizens' needs.

The activities are planned via a participatory approach involving EU institutions and a variety of consultation bodies, as well as stakeholders. Results from the survey confirm that the **Work Programme responds to the needs of the organisations** involved, although topics not covered by Horizon 2020 were also mentioned by participants, e.g. specific hardware and software tools and techniques in areas such as health, robotics and biology and projects in environment and water management. Experts also found that openness for topics and ideas of the research community is lacking to some extent, due to the prescriptiveness of calls and their timelines.

[69] *Applying relevance-assessing methodologies to Horizon 2020, October, 2016.*
[70] *The relevance was assessed against the Horizon 2020 establishment act, the WP 2014-2015 and WP 2016-2017.*