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# Euro-5g – Supporting the European 5G Initiative

## D2.2: Initial analysis of project portfolio and programme KPIs

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*Abstract*

This document provides an initial analysis of project portfolio and programme KPIs of the 5G PPP. As an introduction, an overview is given of the overall 5G PPP governance model, its bodies, working groups and participating organisations. The main part focuses on the main activities and achievements during 2015. It sketches the implementation of the calls for proposals evaluated in 2015 and gives a summary of the focus of all accepted projects. A first analysis of the progress towards 5G PPP KPIs is provided. The document also gives a summary of the various promotional and support activities, e.g. on the pre-structuring model, contributions to the work programme, establishment of international contacts and relations and the various meetings organised in this respect.

[End of abstract]

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# Abbreviations

| | |
|---|---|
| **4G** | Fourth generation of mobile telecommunications technology |
| **5G** | Fifth generation of mobile telecommunications technology |
| **5G IA** | 5G Infrastructure Association |
| **ADC** | Analog-to-digital converter |
| **CA** | Consortium Agreement |
| **CAPEX** | Capital expenditure |
| **CESC** | Cloud-Enabled Small Cell |
| **cPPP** | Contractual Public Private Partnership |
| **CSA** | Coordination and support actions |
| **D2D** | Device-to-device |
| **DAC** | digital-to-analog converter |
| **E2E** | End-to-end |
| **EC** | European Commission |
| **eDSA** | Extended Dynamic Spectrum Access |
| **EIT** | European Institute of Innovation & Technology |
| **ETP** | European Technology Platform |
| **ETSI** | European Telecommunication Standards Institute |
| **FP7** | Seventh EU Framework Programme for Research and Technological Development |
| **GHz** | Gigahertz |
| **H2020** | Horizon 2020 (EU Research and Innovation Programme) |
| **ICT** | Information and Communication Technologies |
| **IoT** | Internet of Things |
| **IP** | Internet Protocol |
| **KPIs** | Key performance indicators |
| **LEIT** | Leadership in Enabling and Industrial Technologies |
| **M2M** | Machine-to-machine |
| **MAC** | Medium Access Control |
| **mmWave** | Millimeter wave |
| **MIMO** | Mmultiple-input and multiple-output |
| **MoU** | Memorandum of Understanding |
| **NFV** | Network functions virtualization |
| **OPEX** | Operational expenditure |
| **PDCP** | Packet Data Convergence Protocol |
| **PHY** | Physical layer |
| **PoA** | Point of Attachment |

| | |
|---|---|
| **PPP** | Public Private Partnership |
| **QoE** | Quality of Experience |
| **QoS** | Quality of Services |
| **RAN** | Radio Access Network |
| **R&D** | Research and Development |
| **RLC** | Radio Link Control |
| **RRC** | Radio Resource Control |
| **SDN** | Software-Defined Networking |
| **SDK** | Software Development Kit |
| **SME** | Small and Medium-Sized Enterprise |
| **SRIA** | Strategic Research and Innovation Agenda |
| **SW** | Software |
| **TCP** | Transmission Control Protocol |
| **U-HDTV** | Ultra-high-definition television |
| **VNF** | Virtual Network Function |
| **WG** | Working Group |
| **WRC** | World Radiocommunication Conference |

# 1 Introduction

## 1.1 Foreword

The international context of global 5G development, the legal basis of 5G PPP, the research challenges as well as the 5G PPP governance have been described in the Monitoring Report for 2014. During 2015 the different bodies in the overall governance have been established (Figure 1). According to the Statutes of the Association, the Association members are elected by the wider community in the Networld2020 European Technology Platform, which has about 1100 member organisations in Europe and cooperative members from outside Europe. The Partnership Board as the official communication channel between the EU Commission (public side) and the 5G Infrastructure Association (private side) was established.

## 1.2 The 5G Network Infrastructure for the Future Internet cPPP

The governing documents for this PPP were already described and referenced in the Monitoring Report for 2014. After the successful launch of 5G PPP in December 2013, the ICT community in Europe responded to the first 5G PPP Call for proposals in Horizon 2020. These projects are organised in the 5G Initiative, see (Figure 1). These are the Phase I projects.

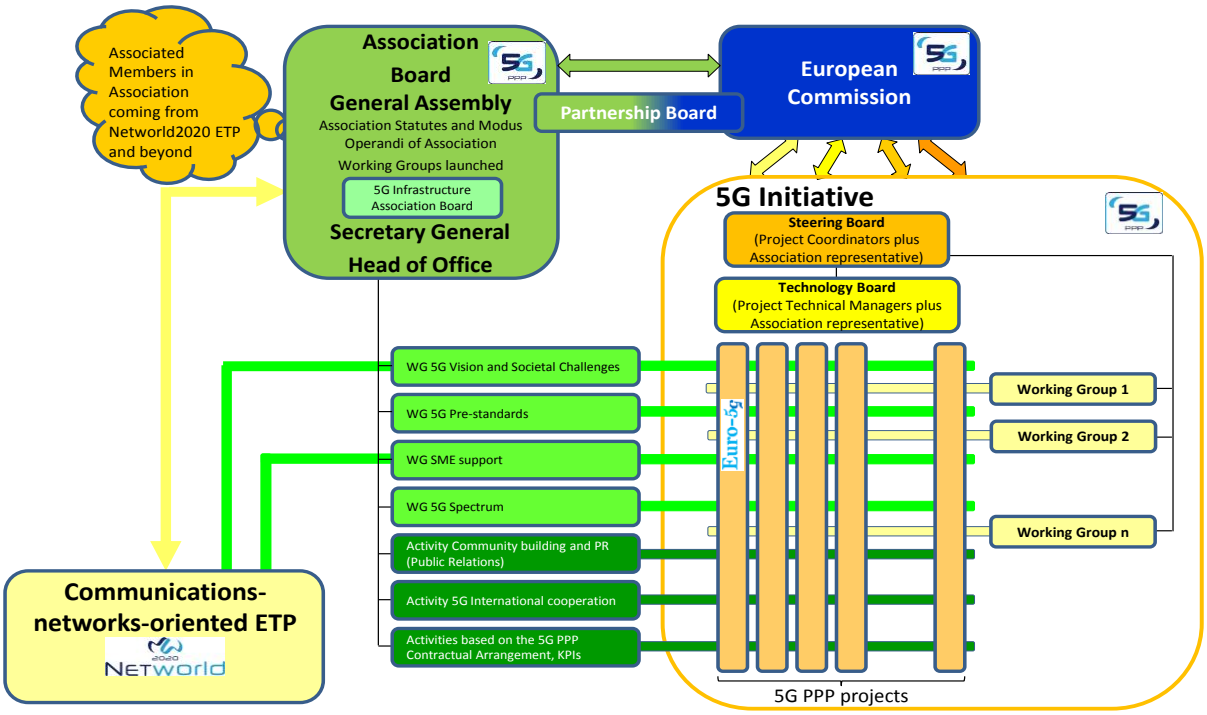


*Figure 1: Overall 5G PPP governance model*

In 2015 a process was initiated to contract a Secretary General and a Head of Office as permanent staff of the Association in order to strengthen the Association by a professional management.

Technical Working Groups are organised by 5G PPP projects to facilitate cooperation between projects. The objective of these projects is to develop consolidated positions across related projects. Policy-oriented Working Groups under the responsibility of the Association are addressing the KPIs foreseen in the 5G PPP Contractual Arrangement (Figure 2).

 

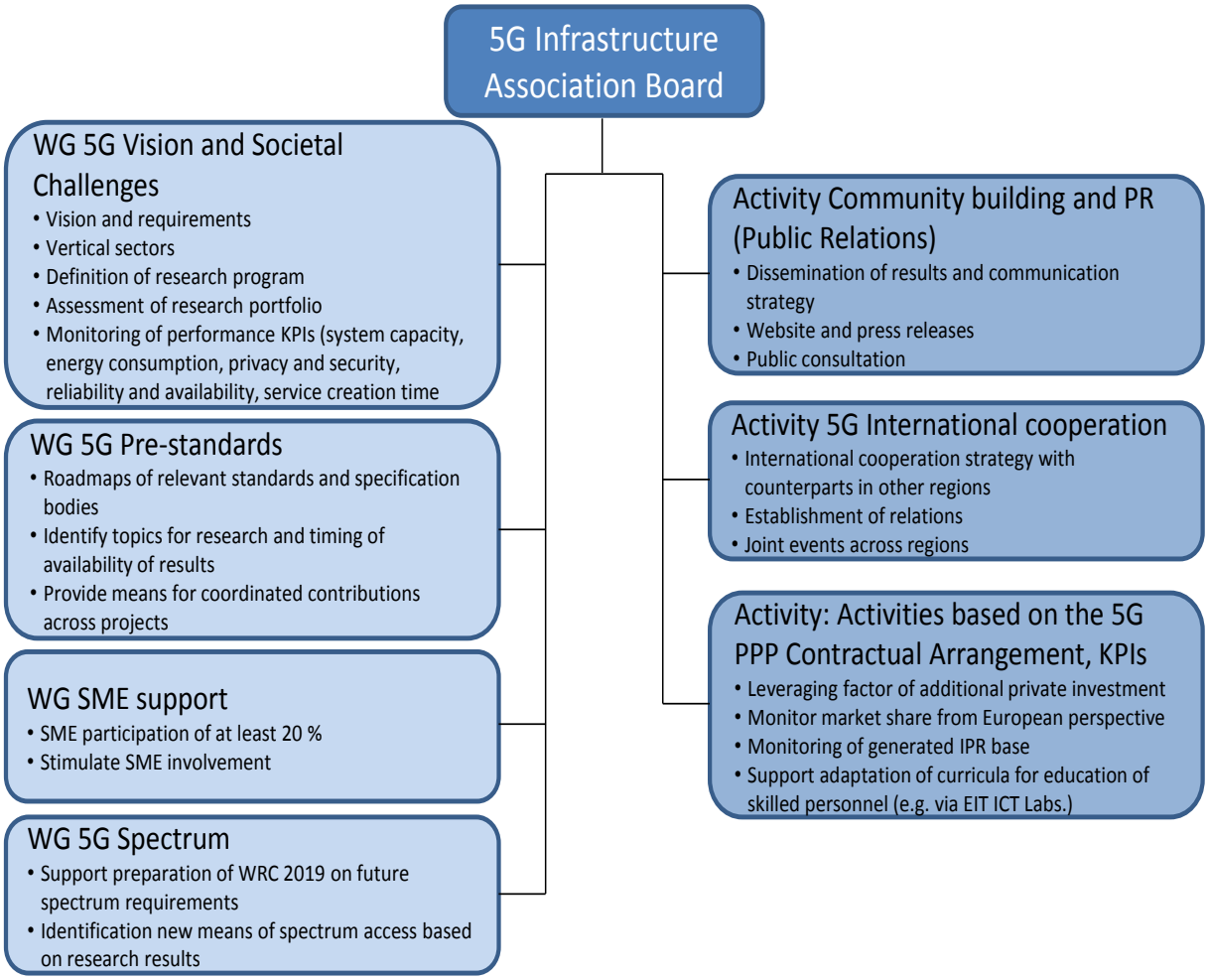


*Figure 2: Policy-oriented Working Groups*

Due to changed priorities and re-organisations in some member organisations two organisations left the Association. The following organisations were members at the end of 2015:

Industry

ADVA Optical Networking SE

Alcatel-Lucent

Airbus

Atos

Deutsche Telekom

DOCOMO Communications Laboratories Europe GmbH

Ericsson

Huawei Technologies Düsseldorf GmbH

IBM Research

Intel Mobile Communications

NEC Europe Ltd., NEC Laboratories Europe

Nokia

Orange Labs

Samsung Electronics Research Institute Ltd.

 

SES

Telecom Italia

Telefónica I+D

Telenor ASA

Telespazio

Thales Alenia Space

Turk Telekomünikasyon A.Ş.

Research

CEA-LETI

Centre Tecnologic de Telecomunicacions de Catalunya (CTTC)

Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT)

Fundacion IMDEA Networks

Instituto de Telecomunicacoes

TNO

University of Bologna – DEI

SMEs

Integrasys SA

INTERINNOV

M.B.I. S.R.L.

Nextworks s.r.l.

Quobis

Sequans Communications

 

# 2 Main Activities and Achievements during 2015

## 2.1 Progress in the implementation of the R&I strategy in the Multi-annual Roadmap in 2015

**Support of the Community**

5G PPP supported the community in order to prepare project proposals as response to the Horizon 2020 5G PPP call, which closed on November 25, 2014.

The 5G Infrastructure Association developed a Pre-Structuring model for Call 1 as a proposed mapping of the Call 1 objectives to targeted research areas. The implementation of the 5G PPP program has to address two main challenges. On one hand, the Call for Proposals is open including an independent evaluation and, on the other hand, all Call objectives should be met through a set of selected projects, which are as complementary as possible. The pre-structuring model shown in Figure 3 is addressing the coherence and complementarity of projects. The model was sent for public consultation to the wider community of the Networld2020 European Technology platform.

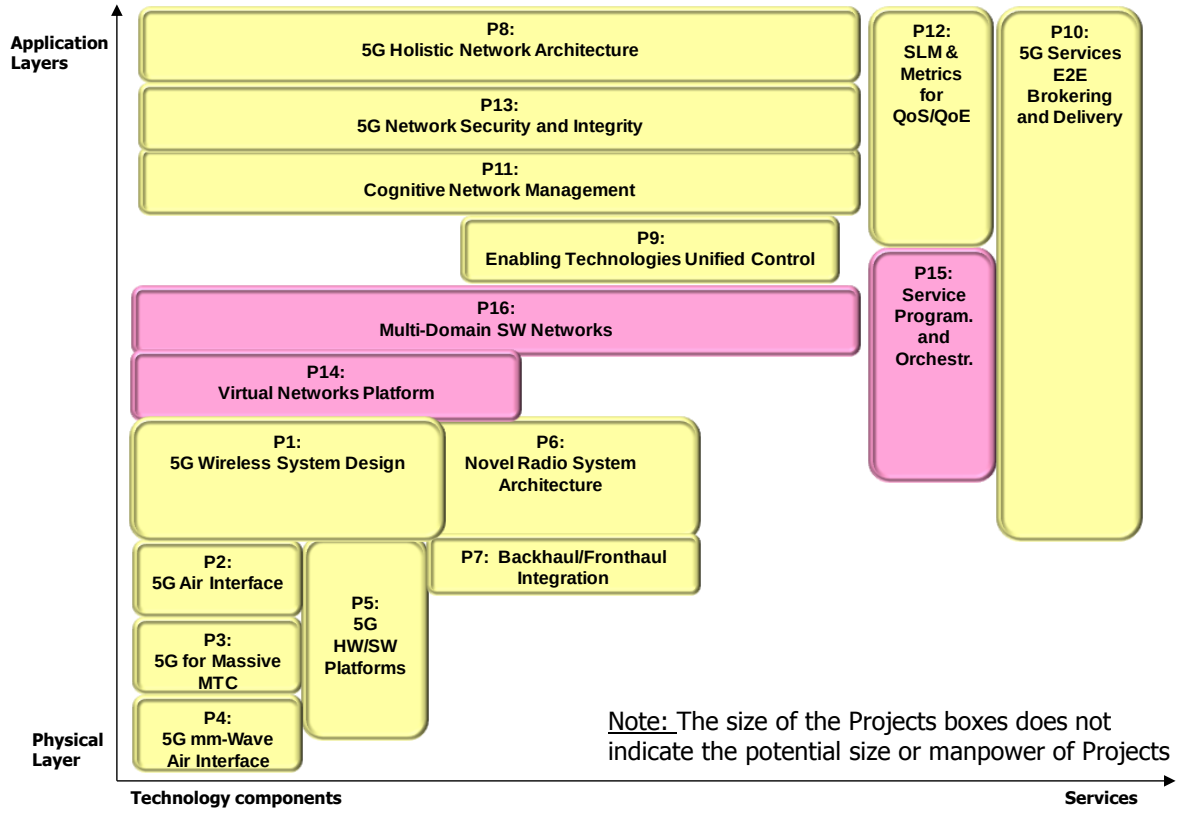


*Figure 3: Pre-structuring model for Horizon 2020 5G PPP Phase I*

In the second half of 2015, a similar approach was followed for the preparation of Call 2. This model depicted in Figure 4, was also sent for public consultation to the Networld2020 community.

 

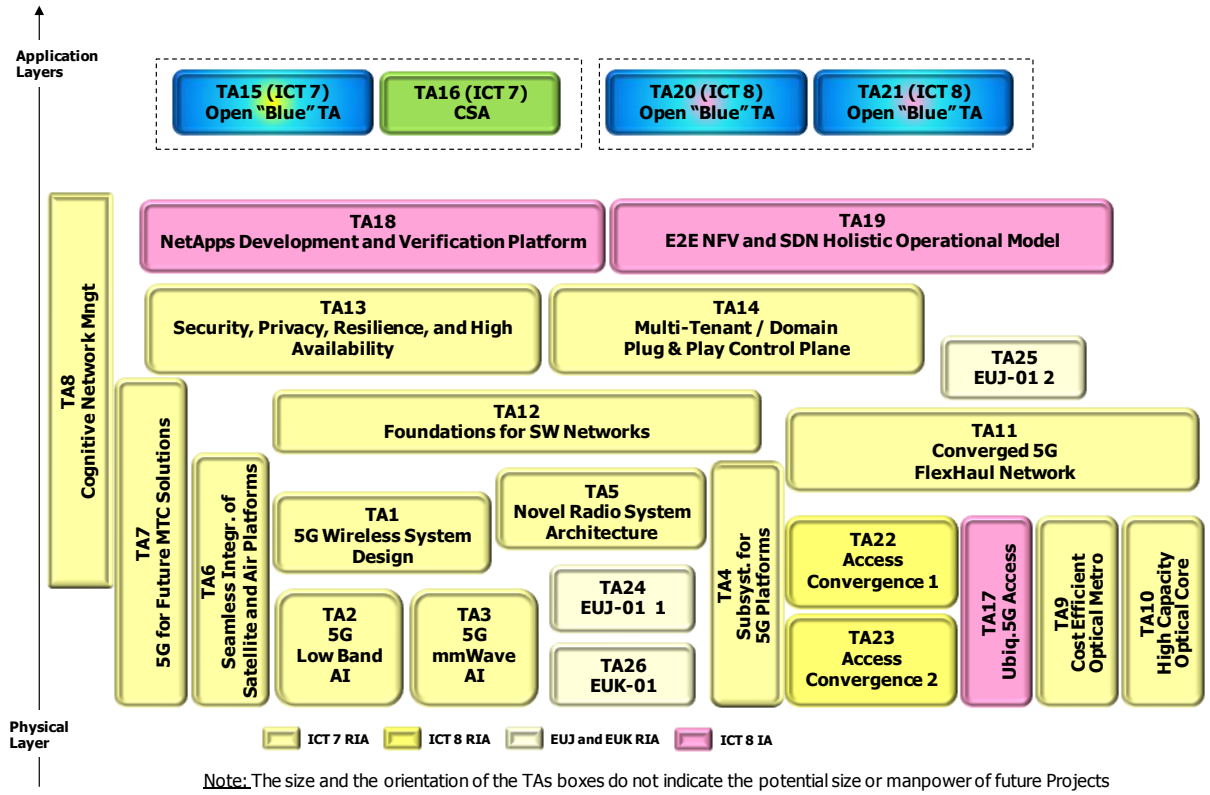


*Figure 4: Pre-structuring model for Horizon 2020 5G PPP Phase II*

5G PPP projects are cooperating in order to support the development of future 5G communication networks. In Call 1, Article 41.4 of the Model Grant Agreement was not used to implement complementary Grant Agreements. Therefore, the 5G Infrastructure Association developed a Collaboration Agreement, which was signed (except one partner) by all participants in 5G PPP Call 1 projects.

The first set of projects started on July 1, 2015. 5G Infrastructure Association supported an implementation workshop in May 2015 in Brussels.

### Contributions to Work Program 2018 - 2020

In 2015, the 5G PPP Working Group on Vision and Societal Challenges in cooperation with the Expert Group of Networld2020, contributed to the preparation of the following White Papers on Vertical Industries:

- 5G-PPP White Paper on eHealth Vertical Sector – October 2015.
- 5G-PPP White Paper on Factories-of-the-Future Vertical Sector – October 2015.
- 5G-PPP White Paper on Energy Vertical Sector – October 2015.
- 5G-PPP White Paper on Automotive Vertical Sector– October 2015.
- 5G-PPP White Paper on Media & Entertainment Vertical Sector – January 2016 (preparatory work for this Paper started in 2015).

In 2015, the 5G PPP Working Group on Vision and Societal Challenges also supported and contributed to the preparation of the following NetWorld2020 White Papers, which are certainly a valuable input to the Horizon 2020 Work Program 2018 – 2020:

- Service Level Awareness and open multi-service internetworking (available soon).
- 5G Experimental Facilities in Europe.
- Research Beyond 5G.

 

**Establishment of international contacts and relations**

With respect to the global 5G research environment, according to requirements of Chapter 2, 5G PPP established contacts with counterparts in the regions and countries, which are most influential in international standardisation and the regulatory process. Therefore, the initial target regions and countries were the Americas, China, Japan, and Korea.

At institutional level, the EU Commission negotiated and signed Joint Declarations with:

- the Korean government on June 16, 2014,
- the Japanese government on May 29, 2015 and
- the Chinese government on September 28, 2015.

Furthermore, in 2015, the EU Commission started discussions with the US government.

These agreements mainly address cooperation on research and regulatory issues as well as means for mutual access to research programs.

In parallel to the EU Commission's Joint Declarations, the 5G Infrastructure Association negotiated and signed Memorandum of Understanding (MoUs) with international counterparts.

Here follows an overview of the MoUs signed between the Association and its counterparts. The content of these MoUs is very similar.

***MoU with 5G Forum (Korea)***

A MoU was signed with 5G Forum (http://www.5gforum.org/eng/main/) in Seoul, Korea already on June 17, 2014 (Figure 5) following the signature of a Joint Declaration between the EU Commission and the Korean government. As part of the cooperation, 5G Infrastructure Association contributed to the Horizon2020 work program on a joint call EU – Korea.


*Figure 5: Signature of MoU in Seoul*

 

The agreed areas of cooperation are:

- Vision of 5G communication systems and networks.
- Requirements on 5G communication systems and networks.
- Discussions on basic system concepts.
- Frequency spectrum (spectrum demand estimates and potential frequency spectrum ranges) in order to support the global regulatory process.
- Preparation of future global standards by identification of common interest and consensus building.

***MoU with 4G Americas (now 5G Americas)***

4G Americas is the industry association in the Americas, which is dealing with 5G. Therefore, a MoU was signed with 4G Americas (http://www.4gamericas.org/en/) on March 2, 2015 in Barcelona, Spain at the Mobile World Congress 2015 (Figure : 6). The research community in the US is organised in a different way than in Europe. 4G Americas prepared 5G white papers on the view of the industry in the Americas.


*Figure : 6 Signature of MoU in Barcelona*

The agreed areas of cooperation are:

- Vision of 5G communication systems and networks.
- Requirements on 5G communication systems and networks.
- Discussions on basic system concepts.
- Frequency spectrum in order to support the global regulatory process.
- Preparation of future global standards by identification of common interest and consensus building.

***MoU with The Fifth Generation Mobile Communications Forum (Japan)***

A MoU was signed with The Fifth Generation Mobile Communications Promotion Forum in Japan (http://5gmf.jp/en/) on March 25, 2015 in Frankfurt, Germany at the NGMN Industry Conference (Figure: 7). The EU Commission and the Japanese government officially signed a Joint Declaration on May 27, 2015 (based on a text that was already agreed in March 2015).

 

*Figure: 7 Signature of MoU in Frankfurt*

The agreed areas of cooperation are:

- Vision of 5G communication systems and networks.
- Requirements on 5G communication systems and networks.
- Basic system concepts.
- Technologies for 5G communication systems and networks.
- Frequency spectrum in order to support the global regulatory process.
- Preparation of future global standards by identification of common interest and consensus building.

***MoU with IMT-2020 (5G) Promotion Group (China)***

The day after the signature of the Joint Declaration between the EU Commission and the Chinese government, a MoU was signed between the IMT-2020 (5G) Promotion Group (http://www.imt-2020.cn/en/introduction) and the 5G Infrastructure Association on September 29, 2015 in Beijing, China (Figure 8).

*Figure 8: Signature of MoU in Beijing*

The agreed areas of cooperation are:

- Vision of 5G communication systems and networks.
- Requirements on 5G communication systems and networks.
- Discussions on basic system concepts.
- Frequency spectrum in order to support the global regulatory process.
- Preparation of future global standards by identification of common interest and consensus building.

 

***Multilateral MoU between all five organisations to organise a series of Global 5G Events***

These five organisations IMT-2020 Promotion Group (China), The Fifth Generation Mobile Communications Promotion Forum (Japan), 5G Forum (Korea),4G Americas and 5G Infrastructure Association agreed to organise a series of Global 5G Events in the coming years to create synergies, optimise resources, foster communication and build global consensus on 5G. To this aim, a multilateral MoU was signed on October 20, 2015 during the EU ICT 2015 Conference in Lisbon in the presence of EU Commissioner H.G. Oettinger (Figure 9).

Figure 9: Signature of MoU in Lisbon

In particular, it was agreed to jointly organise two events per year. The first one in the first half of 2016 hosted by IMT-2020 (5G) Promotion Group and the second one, hosted by 5G Infrastructure Association, in Europe. Each time, these events will be organised in a different continent on a rotary basis. A joint program committee with representatives of the five organisations was set up to coordinate and carry out the necessary activities.

***Further international collaboration partners***

5G Infrastructure Association has been considering the possibility to sign MoUs with other international counterparts. Such potential partners might also enter the Multilateral MoU, if all signing parties agree.

## 2.2 Implementation of the Calls for Proposals Evaluated in 2015

The portfolio of the selected projects in Figure 10 is the result of an independent evaluation process. There are 18 Research and Innovation Projects and 1 Coordination and Support Action. They support different clusters on radio-related projects, fronthaul and backhaul, hardware implementation, network automation, SDN, NFV, cloud and virtualisation, and security.

 

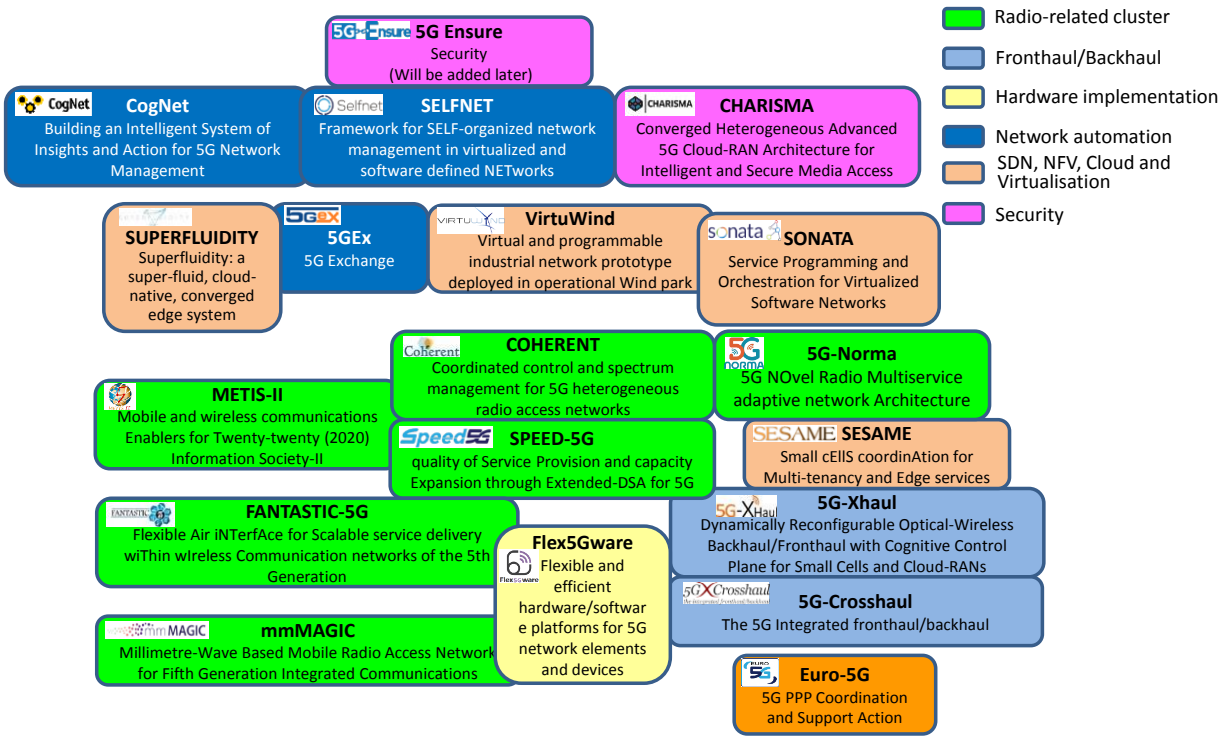


Figure 10: Project portfolio of 5G PPP Phase I

The projects (listed below) support major building blocks for future 5G communication networks and pursue the following objectives:

***FANTASTIC-5G*** – Radio interface below 6 GHz
- https://5g-ppp.eu/fantastic-5g/ - http://fantastic5g.eu/

- Objectives:
    - Develop a flexible and scalable multi-service air interface
    - with ubiquitous coverage and high capacity where and when needed
    - being highly efficient in terms of energy and resource consumption
    - being future proof and allowing for sustainable delivery of wireless services far beyond 2020.
    - Evaluate and validate the developed concepts
    - and build up consensus on reasonable options for the standardization of 5G.

- Addressed areas:
    - PHY/MAC related air interface technologies (< 6GHz, focus on components being relevant for standardization, e.g. waveform/frame design, control channel design, access procedures, multiple antenna mechanisms ...)

 

***mmMAGIC*** – Radio interface above 6 GHz
- https://5g-ppp.eu/mmmagic/
- https://5g-mmmagic.eu/

- Objectives:
  - To develop a flexible and scalable multi-service air interface
  - with ubiquitous coverage and high capacity where and when needed
  - being highly efficient in terms of energy and resource consumption
  - being future proof and allowing for sustainable delivery of wireless services far beyond 2020.
  - To evaluate and validate the developed concepts
  - and build up consensus on reasonable options for the standardization of 5G.

- Addressed areas:
  - PHY/MAC related air interface technologies (< 6GHz, focus on components being relevant for standardization, e.g. waveform/frame design, control channel design, access procedures, multiple antenna mechanisms ...)

***Metis-II*** – Overall RAN design
- https://5g-ppp.eu/metis-ii/
- https://metis-ii.5g-ppp.eu/

- Objectives:
  - Develop overall 5G RAN design, focusing particularly on designing technology for an efficient integration of legacy and novel radio access network concepts into one holistic 5G system
    - Clarification of various key design aspects of the 5G RAN (e.g. level of integration between legacy and novel radio technologies)
    - Comprehensive control and user plane design Description of network elements, functionalities on the different protocol layers, signalling on the radio interface and between network entities
    - Protocol layers in focus:
      - PHY will be investigated from harmonization / integration perspective (building upon input from previous projects and other projects in the 5G-PPP wireless strand)
      - MAC, RLC, PDCP, RRC functionality will be designed in detail in METIS-II
  - Provide the 5G collaboration framework within 5G-PPP for a common evaluation of 5G radio access network concepts

 

- Continue work from METIS on 5G scenarios and requirements, KPI definition
- Facilitate and consolidate the spectrum discussion in 5G-PPP
- Provide a performance evaluation framework for 5G RAN
- Provide an open access visualization platform for 5G RAN concepts

- Prepare concerted action towards regulatory and standardization bodies

***COHERENT*** – Heterogeneous radio access networks


- https://5g-ppp.eu/coherent/
- http://www.ict-coherent.eu/

- Objectives:
  - Research and develop a unified control and coordination framework for heterogeneous radio access networks (RAN) by combining mobile network low layer abstraction, software defined networking , and flexible spectrum management
- Addressed areas:
  - Software defined networking for RANs
  - Efficient radio resource modelling and management in programmable RANs
  - Flexible spectrum management

***NORMA-5G*** – Novel adaptive 5G mobile network architecture


- https://5g-ppp.eu/5g-norma/
- https://5gnorma.5g-ppp.eu/

5G NORMA develops a conceptually novel, adaptive and future-proof 5G mobile network architecture.

- Innovative functionalities:
  - adaptive architecture to support native multi-services
  - on-demand allocation of RAN resources in a fully multi-tenant environment
- Innovative enablers
  - software-defined design to apply SDN principles to wireless functions
  - adaptive allocation of functionalities depending on service and deployment needs
  - joint optimization of core and access functionalities localized together in the central server/cloud
- Impact on manufacturers: novel products
  - Enhanced and flexible 5G base stations: light, flexible and efficient

 

- Software-based centralized controllers: based on software and hence easy to modify and to adapt to different scenarios and services

- Impact on operators: novel and flexible services
  - Flexibility to adapt network operation as desired
  - Reduction of the cost of operating the network

- Support for new and diverse services, thereby increasing revenue
  - Impact on end-users and society
  - Support for more and better services

***SPEED-5G*** – Spectrum access
- https://5g-ppp.eu/speed-5g/
- https://speed-5g.eu/

- Objectives and impact
  - SPEED-5G will address the well-known challenges of predicted growth in mobile connections and traffic volume.
  - Today, lack of dynamic control across wireless network resources is leading to unbalanced spectrum loads and a perceived capacity bottleneck.
  - SPEED-5G will provide solutions through eDSA (extended Dynamic Spectrum Access), which is resource management with three degrees of freedom: densification, rationalized traffic allocation over heterogeneous wireless technologies, and better load balancing across available spectrum.
  - A major challenge is the cost of achieving this
  - Indoor/outdoor scenarios will be considered
  - Two focal points of the work: Resource management techniques across technology 'silos', and medium access technologies to address densification in mostly unplanned environments
  - SPEED-5G will contribute to master the challenge of achieving the anticipated 1000 fold mobile traffic increase over a decade and to efficiently support very different classes of traffic/services

***5G Crosshaul*** – Fronthaul/backhaul
- https://5g-ppp.eu/xhaul/
- http://5g-crosshaul.eu/

- Objectives:
  - To develop 5G integrated backhaul and fronthaul transport network enabling a flexible and software-defined reconfiguration of all networking elements in a multi-tenant and service-oriented unified management environment
  - Fronthaul and backhaul solutions between RAN and packet core capable of dealing with increased traffic load while fulfilling new stringent 5G service requirements in a cost-efficient manner

 

- Demonstration and validation of xHaul technology components will be integrated into a software-defined flexible and reconfigurable 5G Test-bed
- Main components of xHaul transport network
  - high-capacity switches and heterogeneous transmission links (e.g., fibre or wireless optics, high-capacity copper, mmWave)
  - interconnecting Remote Radio Heads
  - 5GPoAs (e.g., macro and small cells)
  - cloud-processing units (mini data centres)
  - points-of-presence of the core networks of one or multiple service providers

***5G-xHaul*** – Fronthaul/backhaul
- https://5g-ppp.eu/5g-xhaul/
- http://www.5g-xhaul-project.eu/

- Objectives:
  - Design a flexible backhaul/fronthaul network for serving current and future RAN deployments in a dynamic, service oriented, and cost-effective way
  - Enable seamless integration of future-proof technologies in the optical and wireless (Sub-6 GHz, mm-Wave) metro/access domains, through a converged software-based control plane
  - Provide a self-consistent transport network design able to operate in a RAN agnostic way. Additionally, 5G-XHaul will make interfaces available to future RAN technologies
  - Integrated demonstrator of 5G-XHaul architecture in a wireless optical testbed, TSON, in the city of Bristol

- Addressed areas:
  - Optical Communications: optical backhauling supporting wireless integration (e.g. mm-Wave), optical fronthaul (WDM-PONs). Flexible bandwidth allocation with TSON
  - Wireless Communications: Sub-6 GHz, mm-Wave and integration among them. Back/Fronthauling for very dense Small Cell deployments. Wireless fronthauling
  - Network management: spatial SDN, NFV, cooperative and cognitive networks

***Flex5Gware*** – Hardware implementation
- https://5g-ppp.eu/flex5gware/
- http://www.flex5gware.eu/

- Objectives
  - Increasing the HW versatility and reconfigurability

 

- Providing HW-agnostic, flexible and cost-effective SW platforms
- Increasing the overall capacity of 5G communication platforms
- Decreasing the energy consumed by 5G communication platforms
- Identifying and prototyping key building blocks

- Addressed areas:
  - RF front-ends and antennas (versatility, TRX > 6 GHz, antennas, …)
  - Mixed-signal technology (broadband DAC/ADC, full duplex, …)
  - Digital front-end + HW/SW split (HW for new waveforms, MIMO …)
  - SW modules and functions (SW re-configurability, energy savings)

**5GEx** – Automated and fast service provisioning
- https://5g-ppp.eu/5gex/
- http://www.5gex.eu/

- Objectives:
  - Design and specify architecture, mechanisms, algorithms and enablers for automated and fast provisioning of infrastructure services in a multi-domain/multi-operator 5G environment
  - Define and validate the novel 5GEx business layer, including the business information model, economic and market mechanisms that promote efficiency of multi-domain services
  - Build a working end-to-end system and deploy a demonstrable prototype
  - Sandbox Exchange - Experiment and validate by implementing selected use cases
  - Contribute to the relevant standard forums and Open Source communities

***SELFNET*** – Automated network management
- https://5g-ppp.eu/selfnet/
- https://selfnet-5g.eu/

- Main objectives:
  - To deliver an innovative framework for the automated management and rapid deployment of self-configuring next-generation networks and services
  - For automated network monitoring and maintenance management tasks
  - Extending the state-of-the-art network management within the Software-Defined Networking and Network Function Virtualization (SDN/NFV) arena
  - Removing the reliance on costly, vendor-specific hardware with an advanced software-based approach
  - Automatically detecting and mitigating a range of common network problems that are currently still being manually addressed by network operators
  - Reducing operational costs and improving user experience

 

***CogNet*** – IoT management
- https://5g-ppp.eu/cognet/
- http://www.cognet.5g-ppp.eu/

- Objectives:
    - R&D for Network Management at the 5G/IOT scale
    - Addressing:
        - Demand Prediction with Smart & Efficient Resource Mgmt
        - Autonomics & Self Organisation
        - Error, Fault & Degradation detection and correction
        - Machine Learning algorithms applied to the above

- Main impact:
    - Capability to efficiently manage networks of scale
    - Cost and Energy usage reductions
    - Improved QoS for the end user
    - Better Security & Fault Tolerance

***SESAME*** – NFV and Edge Cloud Computing
- https://5g-ppp.eu/sesame/
- http://www.sesame-h2020-5g-ppp.eu/

- Objectives:
    - Placement of network intelligence and applications in the network edge through Network Functions Virtualisation (NFV) and Edge Cloud Computing;
    - Substantial evolution of the Small Cell concept, already mainstream in 4G but expected to deliver its full potential in the challenging high dense 5G scenarios;
    - Consolidation of multi-tenancy in communications infrastructures, allowing several operators/service providers to engage in new sharing models of both access capacity and edge computing capabilities.

- Addressed areas:
    - Small Cells Context: Proposition of the Cloud-Enabled Small Cell (CESC) concept for deploying Virtual Network Functions (VNFs) supporting of powerful self-x management & executing novel applications and services inside the access network infrastructure.
    - New network orchestration perspectives in the 5G framework.

 

- Network Functions Virtualisation for Multi-tenancy & NFV Management.
- Self-x Features & Software-defined Networking.
- Cloud technologies & Hardware acceleration through non X86 processors.
- Artificial Intelligence-based radio access management.

***SONATA*** –m NFV, service creation
- https://5g-ppp.eu/sonata/
- http://www.sonata-nfv.eu/

- Objectives in the area of software networks:
  - Reduce time to market for networked services by shortening service development (Programming model and SDK)
  - Optimizing resource utilization and reduce cost of service deployment and operation (Service platform and modular orchestrator)
  - Accelerate the adoption of software networks in industry (full service life cycle, DevOps NFV model for telecoms and vendors)

- Impact in the full value chain: telecom operators, vendors, IT service providers and developers:
  - Open source service platform
  - Open interfaces, OSS and legacy
  - Competition in NFV Orchestration and access to market
  - Compatibility with Integrated Solutions (multi-vendor environment)

- Standardisation:
  - Collaboration with Industry and Standards Groups (e.g. ETSI NFV)

***Superfluidity*** – Cloud-based architecture, virtualisation
- https://5g-ppp.eu/superfluidity/
- http://superfluidity.eu/

- Objectives:
  - Solution based on
    - decomposition of network components and services into elementary and reusable primitives
    - native, converged, cloud-based architecture
    - virtualization of radio and network processing tasks
    - platform-independent abstractions, permitting reuse of network functions across heterogeneous hardware platforms while catering to the vendors' need for closed platforms/implementations

 

- high performance software optimizations along with leveraging of hardware accelerators

- Main impact:
  - A converged cloud-based 5G concept that will enable innovative use cases in the mobile edge, empower new business models, and reduce investment and operational costs

**VirtuWind** – SDN & NFV ecosystem for industrial domains
- https://5g-ppp.eu/virtuwind/
- http://www.virtuwind.eu/

- Objectives:
  - To develop a SDN & NFV ecosystem for industrial domains, based on open, modular, and secure communication framework, leading to a prototype demonstration for intra-domain and inter-domain scenarios in real wind parks as a representative use case of industrial networks, and quantify the economic benefits of the solution.
    - Objective 1: Realize industrial-grade QoS for intra-domain SDN solution
    - Objective 2: Guarantee inter-domain QoS for SDN based multi-operator ecosystem
    - Objective 3: Reduce time and cost for service provisioning and network maintenance
    - Objective 4: Assure security-by-design for the SDN and NFV ecosystem
    - Objective 5: Field trial of intra- and inter-domain SDN and NFV prototype

- Addressed areas:
  - Programmable industrial networks via SDN
  - Multi-tenancy support via NFV
  - Techno-economic analysis for foreseen OPEX and CAPEX reduction
  - Increase in service provisioning velocity

***CHARISMA*** – Security
- https://5g-ppp.eu/charisma/
- http://www.charisma5g.eu/

- Objectives:
  - End-to-end security across all layers of the converged and virtualised open access network
  - Physical layer low-latency security for both wireless and optical, in open, dynamic, multi-user, highly connected and decentralized 5G networks.
  - High bandwidth (10 Gb/s wireless and 100 Gb/s fixed connection) end-to-end low-latency service experience, integrated across back- and front-haul and end-user (ad-hoc) D2D mesh networking.

 

- Build two secure end-to-end pilot demonstrators including concurrent 5G-PPP project demonstrators to provide multi-tenant, multi-user, multi-technology, and virtualised open access infrastructures based on the CHARISMA low-latency and v-security developments.

- Addressed areas:
  - Security, Management

***5G-ENSURE*** – Security
- https://5g-ppp.eu/5g-ensure/
- http://www.5gensure.eu/

- Objectives:
  - Support of more efficient connected devices by minimising unnecessary data transmission, using them only when needed
  - Greater reliability of systems like remote traffic control or surgery
  - To cope with billions of small devices in the Internet of Things (IoT), and billions of heavy data consumers
  - Seamless infrastructure satisfying everyone's communications needs, invisibly but dependably

***EURO-5G*** – Coordination and Support Action, support 5G PPP program
- https://5g-ppp.eu/euro-5g/
- https://5g-ppp.eu/euro-5g-deliverables-list/

- Objectives:
  - The Euro-5g project will drive the 5G-PPP goal to maintain and enhance the competitiveness of the European ICT industry, seeking European leadership in the 5g domain.
  - The Euro-5g project will ensure that European society can enjoy the economic and societal benefits these future networks through promotion of uptake and simulating adoption and use.
  - The Euro-5g project will ensure effective and efficient co-operation and integration between all projects of the 5G-PPP.
  - The Euro-5g project will extend the project and programme level collaboration to other European Commission projects in H2020, the CELTIC Plus Eureka cluster, and related national initiatives to maximize the European momentum towards, and benefits from, the future 5G integrated, ubiquitous and ultra-high capacity networks.
  - The Euro-5g project will monitor and analyse international 5G activities and will facilitate respective activities (e.g. meetings, workshops etc.) and work together with the 5G-Infrastructure Association and the European Commission to create

 

good international relations with these global initiatives, ensure recognition of the European developments and promote global interoperability of 5G solutions.

- The Euro-5g project will, as a core activity, launch and maintain a comprehensive communications and dissemination program emanating from a lively and continuously updated 5G-PPP.eu website and including various social media tools as appropriate. This program level communications plan will be shared with all the 5G-PPP projects and will include annual reports on the program performance.
- The Euro-5g project will also stimulate and involve a highly qualified group of experts for SRIA and WG participation via the NetWorld2020 European Technology Platform.

## 2.3 Monitoring of the Common KPIs and the specific KPIs of the cPPP

In the framework of the 5G Initiative, the document "Planned contribution from projects of the 5G Initiative to 5G PPP KPI achievement" is under preparation. It is a self-assessment from projects on KPIs and, according to the time plan, it should be concluded by the end of September. Therefore, relevant data and information of such self-assessment are not available yet and, as a consequence, it is not possible to appropriately fill in this section of the Report.

Figure 11 below (from the above mentioned document) provides an overview of the projects' relevance and impact on 5G PPP KPIs.

It should also be noted that, since projects started at best in July 2015 (and others in October 2015), it was not possible to carry out a significant KPIs' progress evaluation.

Additional comments can be provided only to some of the 5G KPIs that apply:

Business-related KPIs:

- Leverage effect of EU research and innovation funding in terms of private investment in R&D for 5G systems in the order of 5 to 10 times;
  - The 5G IA would like to discuss this part with the European Commission and verify whether Eurostat can provide relevant data and information.

- Target SME participation under this initiative commensurate with an allocation of 20% of the total public funding;
  - Useful information and data on SME's participation in 5G PPP Call 1, can be found in the results of the following survey carried out by the NetWorld2020 SME Working Group

- Reach a global market share for 5G equipment & services delivered by European headquartered ICT companies at, or above, the reported 2011 level of 43 % global market share in communication infrastructure.
  - As a market for 5G equipment & services does not exist yet, it is not possible to assess the progress made on this KPI. Data on market share will only be available from 2020 onwards

 

Performance KPIs:

- Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010;

- Reducing the average service creation time cycle from 90 hours to 90 minutes (as compared to the equivalent time cycle in 2010);

- Very dense deployments to connect over 7 trillion wireless devices serving over 7 billion people;

- Secure, reliable and dependable Internet with a "zero perceived" downtime for services provision.

Societal KPIs:

- Enabling advanced User controlled privacy;

- Reduction of energy consumption per service up to 90 % (as compared to 2010);

- European availability of a competitive industrial offer for 5G systems and technologies;
    - Information on this issue will only be available once the first 5G standard will be released (i.e. after 2018) and there will be an advanced stage of product development.
- New economically-viable services of high societal value like U-HDTV and M2M applications;
    - The development of innovative products and services will follow the progress made on 5G technology and standards. At the moment, it is not possibile to evaluate or provide sound information on such future 5G applications.

- Establishment and availability of 5G skills development curricula in partnership with the EIT.
    - In 2014, the 5G Infrastructure Association started initial discussions with EIT ICT Labs (now EIT Digital) on possible collaboration.

      Through its connections with the Academic and Research Community of Networld2020 ETP, the Association has been following the progress made of 5G skills development curricula in Europe and is now determined to resume contacts with EIT Digital to explore possible synergies in this area.

 

**Relevance and impact on 5G-PPP KPIs**

| | | 5G-Crosshaul | 5G-ENSURE | 5GEx | 5G-NORMA | 5G-XHaul | CHARISMA | COGNET | COHERENT | FANTASTIC 5G | FlexSGWare | METIS II | mmMAGIC | SELFNET | SESAME | SONATA | SPEED-5G | SUPERFLUIDITY | VirtuWind |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Performance KPIs** | | | | | | | | | | | | | | | | | | |
| P1 | Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010. | High | Low | Low | High | High | High | N.A. | High | High | High | High | N.A. | Low | N.A. | High | High | High | N.A. |
| P2 | Reducing the average service creation time cycle from 90 hours to 90 minutes. | Medium | Low | High | High | Medium | High | High | N.A. | N.A. | Low | Medium | High | High | High | N.A. | High | High | High |
| P3 | Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people. | High | Low | N.A. | High | High | Low | N.A. | Medium | High | High | Medium | N.A. | N.A. | N.A. | High | Medium | Medium | N.A. |
| P4 | Creating a secure, reliable and dependable Internet with a "zero perceived" downtime for services provision. | Medium | High | Low | High | Medium | Medium | High | N.A. | High | Low | Tbd | Medium | Medium | Low | N.A. | Medium | Medium | High |
| | **Societal KPIs:** | | | | | | | | | | | | | | | | | | |
| S1 | Enabling advanced User controlled privacy; | N.A. | High | N.A. | Low | Low | High | N.A. | N.A. | N.A. | Tbd | N.A. | N.A. | N.A. | Low | N.A. | N.A. | Low | Low |
| S2 | Reduction of energy consumption per service up to 90% (as compared to 2010); | Medium | Low | Medium | Low | Medium | Low | Medium | Medium | High | High | Medium | N.A. | N.A. | N.A. | Medium | Medium | Medium | N.A. |
| S3 | European availability of a competitive industrial offer for 5G systems and technologies; | High | Medium | High | High | High | N.A. | Medium | High | Medium | High | High | Low | Medium | Medium | High | High | High | High |
| S4 | Stimulation of new economically-viable services of high societal value like U-HDTV and M2M applications; | Medium | Medium | N.A. | Medium | Medium | Medium | N.A. | N.A. | High | High | High | Low | N.A. | Low | N.A. | Medium | Medium | N.A. |
| S5 | Establishment and availability of 5G skills development curricula (in partnership with the EIT). | N.A. | Low | Medium | Medium | Medium | N.A. | N.A. | N.A. | Medium | N.A. | Medium | N.A. | Medium | N.A. | N.A. | N.A. | N.A. | Low |
| | **Business-related KPIs:** | | | | | | | | | | | | | | | | | | |
| B1 | Leverage effect of EU research and innovation funding in terms of private investment in R&D for 5G systems in the order of 5 to 10 times; | High | Medium | Medium | Medium | Medium | Medium | N.A. | N.A. | Medium | N.A. | High | High | Low | N.A. | Low | Medium | Medium | N.A. |
| B2 | Target SME participation under this initiative commensurate with an allocation of 20% of the total public funding; | High | Low | High | High | High | Medium | N.A. | High | Medium | Medium | Medium | Low | High | Low | High | Medium | Medium | N.A. |
| B3 | Reach a global market share for 5G equipment & services delivered by European headquartered ICT companies at, or above, the reported 2011 level of 43% global market share in communication infrastructure. | High | Medium | Medium | High | Medium | N.A. | Medium | Medium | Medium | High | N.A. | High | Low | Low | N.A. | Medium | High | Medium |

*Figure 11: Relevance and impact of Projects on 5G PPP KPIs*

## 2.4 Additional private investments and outputs

Private investments cannot directly be collected, because this is competitive information. All cPPPs have a similar problem.

It has to be taken into account, to which level of detail private organisations are collecting investment figures versus specific technologies. Therefore, only a trusted independent agency would most probably be able to collect estimates of investment figures. The 5G IA would like to discuss this part with the European Commission and verify whether Eurostat can provide relevant data and information

## 2.5 Mobilisation of stakeholders

The wider community, in particular via the Networld2020 European Technology Platform, was involved via:

- the Working Group Vision and Societal Challenges under the responsibility of the 5G Infrastructure Association
- the Expert Group of Networld2020 and
- in particular, by public consultations on contributions to the Horizon 2020 Work Program and the Pre-Structuring Model for Call 2.

The 5G PPP Call 1 projects involve 165 organisations from 25 countries (including some non-EU Member States) and from the different stakeholder groups: industry, SMEs and research. Figure 12 and Figure 13 show the distribution.

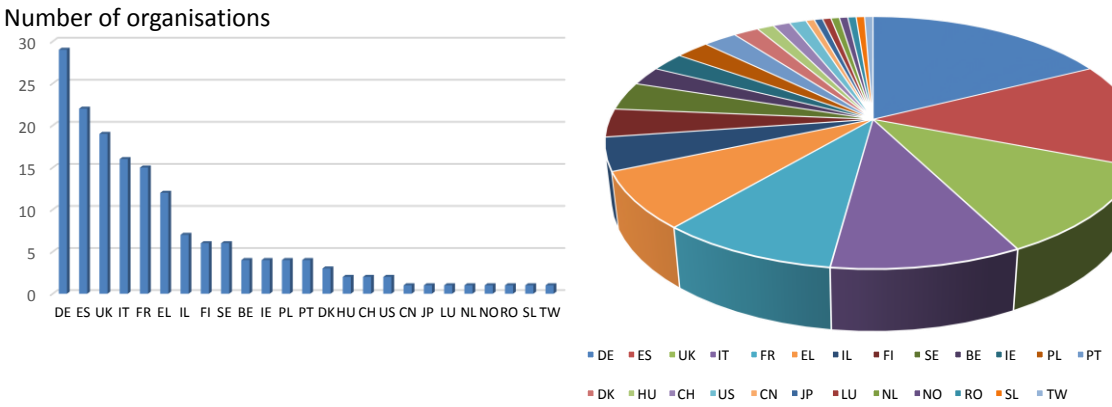


*Figure 12: Number of involved organisations per country in 5G PPP Call 1 projects*

Legend: BE – Belgium, CH –Switzerland, CN – Canada, DE – Germany, DK – Denmark, EL – Greece, ES – Spain, FI – Finland, FR – France, HU – Hungary, IE – Ireland, IL – Israel, IT – Italy, JP – Japan, LU – Luxembourg, NL – Netherlands, NO – Norway, PL – Poland, PT – Portugal, RO – Romania, SE – Sweden, SL – Slovenia, TW – Taiwan, UK – United Kingdom, US – USA

 

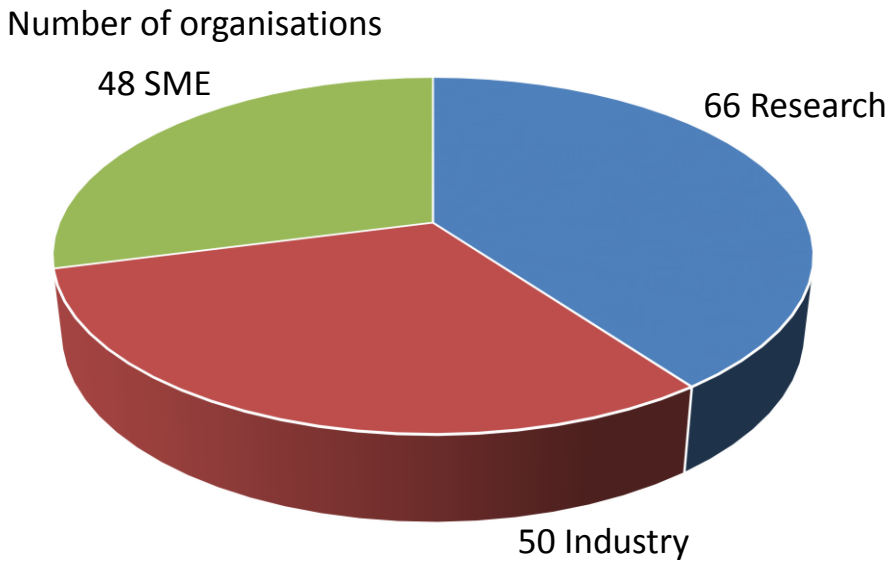


*Figure 13: Number of involved organisations versus stakeholder group industry, SME and research*

## 2.6 Communication and outreach activities

**Awareness meetings and Information days**

Horizon 2020 5G PPP Call 2 awareness meetings are organised in 2016 but not in 2015, because Call 2 was published on May 10, 2016. Preparatory steps for the development of a brokerage platform on the 5G PPP website were initiated in 2015. The platform went live in 2016.

**Pre-structuring model for Call 2**

The Pre-structuring model (described in Section 2.1) was promoted as a recommendation to the community and sent for public consultation to the Networld2020 members in December 2015.

**Mobile World Congress 2015 Press Event**

At the Mobile World Congress 2015, 5G Infrastructure Association organised together with the EU Commission a press event to present the 5G PPP Visions White Paper (cf. Section 2.1). Participants in the press event were EU Commissioner Oettinger and high-level representatives from 5G Infrastructure Association members.

The following issues were presented and discussed at the press event:

- Opening Address – 5G for the Digital Economy
  Mr Günther H. Oettinger, Commissioner for Digital Economy and Society
- 5G key drivers and key enabling technologies including the role virtualization will play in 5G
  Mr Marcus Weldon, Chief Technology Officer and Bell Labs President, Alcatel-Lucent
- 5G requirements, capabilities and key technologies
  Mr Seizo Onoe, Executive Vice President, Chief Technical Officer, and Member of the Board of Directors, Docomo
- 5G: The road to Digitize & Mobilize Industries
  Mr Ulf Ewaldsson, Chief Technology Officer, Ericsson

 

- 5G enabling technologies, business aspects, role of public sector, and Huawei contribution to 5GPPP
  Mr Li Yingtao, President of 2012 Laboratories, Huawei
- How do you see Shannon's law and Moore's law coming together in 5G?
  Mr Hermann Eul, Corporate Vice President General Manager, Mobile and Communications Group, Intel
- 5G use cases and expectations from industry to meet 5G targets
  Mr Hossein Moiin, Executive Vice President, Chief Technology Officer, Nokia Networks
- Customer experience towards a digital and energy aware economy
  Mrs Mari-Noëlle Jégo-Laveissière, Senior Executive Vice President of Innovation, Marketing and Technologies, Orange
- 5G and IoT Vision and Requirements
  Mr Kyungwhoon Cheun, Executive Vice President, Samsung Electronics
- Role of satellites in 5G and cooperation of terrestrial and satellite communities
  Mr Martin Halliwell, Chief Technology Officer, SES


*Figure 14: Photos taken at the MWC 2015 press event, Commissioner Oettinger on the right*

**White Papers, Workshops and Position Papers**

The 5G Infrastructure Association in cooperation with the EU Commission and Networld2020 prepared the following white papers and position papers:

- A "5G Vision" Brochure was presented at the Mobile World Congress 2015 during a press event. The document is publicly available on the 5G PPP website at: http://5g-ppp.eu/wp-content/uploads/2015/02/5G-Vision-Brochure-v1.pdf.


 

An Executive summary is also available at: https://5g-ppp.eu/wp-content/uploads/2015/02/5G-Vision-Exec-Summary-v1.pdf

- In depth discussions and cooperations were carried out with specific vertical sectors:
  - 5G and Factories of the Future
  - 5G and Healthcare
  - 5G and Energy
  - 5G and Media
  - 5G and Automotive

Two workshops were organised to identify the main use cases, requirements and areas for research and innovation.

The first "5G Workshop with Verticals" was jointly organised by the European Commission and the 5G Infrastructure Association and took place on June 18, 2015 in Brussels. The Workshop Report is available at:

https://5g-ppp.eu/wp-content/uploads/2015/07/ReportFrom5GforVerticalsWorkshop-v1-0.pdf

The second workshop "5G: Serving Vertical Industries" was organized on November 9, 2015 in Brussels. Additional information is available at: https://5g-ppp.eu/event/5g-serving-vertical-industries-the-2nd-5g-verticals-workshop/

White papers on vertical sectors are available on the 5G PPP website at: https://5g-ppp.eu/white-papers/ (see also the section "Contributions to Work Program 2018 – 2020").

Based on these activities, the White Paper "5G empowering vertical industries" was presented during a press event at the Mobile World Congress 2016. It is publicly available on the 5G PPP website at: https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf


- The EU Commission and 5G Infrastructure Association organized an international workshop on pre-standardisation and spectrum at the EU ICT Conference 2015 in Lisbon on October 20, 2015. The agenda of the event is attached.

  The Pre-standards and Spectrum Working Groups of the 5G Infrastructure Association prepared a Position ppaper on Pre-standards and a Position Paper on Spectrum as input to that workshop:

## 2.7 Governance

After the establishment of the Partnership Board in September 2014, three meetings were held in 2015:

**February 11, 2015**

- Support of the implementation of 5G PPP projects in order to build a coherent program.
- Discussion on the use of Article 41.4 in the Annotated Model Grant Agreement for the cooperation of projects and means by a Collaboration Agreement on private basis.
- Contributions to the Work Program 2016/17.
- Preparation Mobile World Congress 2015 and EU Vision Paper.
- Update of the 5G PPP Work Plan.

**July 2, 2015**

- Discussion on contributions to the global spectrum discussion.
- Discussion on potential changes of the 5G PPP governance.
- Involvement of vertical sectors in 5G.
- Status of discussion on the Horizon 2020 Work Program 2016/17.

**October 2, 2015**

- Discussion on further steps on re-structuring of the overall 5G PPP governance including the process to contract a Secretary General and a Head of Office.
- Next steps to involve vertical sectors.
- Preparation of the multi-lateral workshop on standards and spectrum with regional initiatives at the ICT Conference 2015 in October in Lisbon.
- Preparation of 5G PPP presence at Mobile World Congress 2016 in Barcelona.
- International cooperation in particular towards counterparts in China.

## 2.8 Success stories

The first set of Horizon 2020 Call 1 5G PPP projects started on July 1, 2015. All projects are successfully implemented. The cooperation across projects is established by means of technology-oriented working groups, which are now working to consolidate views and positions.

White Papers with global reach have been prepared and published (cf. Section 2.6). Such documents are also used for discussions on international level.

The cooperation with vertical sectors is a big achievement and provides a competitive advantage for Europe compared to other regions. The results of this activity will have an impact on global standardisation (Section 2.6).

MoUs with all major regions having a significant influence in global standardisation, were signed. This has opened official communication channels with other regions (Section 2.1).

The Collaboration Agreement across all active 5G PPP projects was signed by all (except one) beneficiaries.

## 2.9 Achievement of the overall goals of the cPPP

5G PPP is working according to the program plan. All major milestones have been achieved by the end of 2015.

 

The SME Working Group is supporting the SME community to be engaged in the preparation of proposals.

In Call 1 about 75 proposals were submitted for independent evaluation. 19 proposals, involving 165 organisations in the program, were finally selected. These figures demonstrate that Call 1 was suitable to a wide variety of stakeholders from several countries.

 

# 3 Monitoring of the Overall Progress Since the Launch of the cPPP

## 3.1 Progress achieved

Considering that some projects were concluded recently and others are ongoing, most of the KPIs cannot be evaluated thoroughly.

There could be a reference to the selected projects (please refer to section 2.2).

The Industry, SME and Research communities were actively involved in 5G initiatives, in particular through NetWorld2020.

Positions on key issues were as much as possible discussed and aligned and were reflected in the published White Papers.

In addition, contributions to the international Pre-standards and Spectrum Workshops were submitted at the EU ICT 2015 Conference in Lisbon in October 2015.

## 3.2 Operational summary

The selected projects are addressing major building blocks for future 5G communication networks. The EU Commission and the 5G Infrastructure Association prepared independently a portfolio analysis of selected projects in relation to the Call for Proposals and the Work Program. There were some different views on the extent to which the objectives of the Call were covered. This is mainly due to a different interpretation of the text of the Call and of its objectives.

The time-to-grant between the submission deadline on November 25, 2014 and the start of projects on July 1, 2015 fits well to the agreed planning.

19 5G PPP projects were selected and successfully launched involving 165 organisations.

## 3.3 Evolution over the years

This is not applicable as yet.

For each call, data on budget and number of grants, and the distribution of participation and EC contribution according to different partner types. References can be made to projects supported in that area before the launch of the cPPP (input by the EC).

# 4 Outlook and Lessons learnt

- An open and timely communication between the public side (EU Commission) and the private side (the Association) is very useful to ensure an effective planning of 5G PPP activities.
- The institutional and private side should align their views and bring common messages to the public in order to have a stronger impact in fostering synergies and consensus on 5G in Europe. This is all the more important in the context of global competition.
- Prompt agreements on key issues between the European Commission and the Association facilitate the smooth development of 5G PPP initiatives and the achievement of its objectives
- The fact that the EU Commission, the 5G PPP CSA and the 5G Infrastructure Association play complementary roles is essential for the efficient management of the program. New ways to support each other's activities could be further explored.

# Appendix A Presentations where 5G PPP was presented

Below is a list of Presentations made by Representatives of the 5G Infrastructure Association in 2015 where the 5G PPP was presented and promoted:

- Tjelta, T.: 5G Special Interest Group, presentation on the activities carried out by the 5G Infrastructure Association and NetWorld2020, Lysaker, Norway, January 27, 2015.
- Soldani, D.: Innovations in Services, Networks and Clouds (ICIN 2015): keynote on "*5G for Connecting People, Things and Machines*", Paris, France, February 17-19, 2015.
- Various representatives of the 5G Infrastructure Association: Mobile World Congress 2015, the Association supported the European Commission in showcasing 5G projects. CTOs from Alcatel-Lucent, DoCoMo, Ericsson, Huawei, Intel, Nokia, Orange, Samsung, SES, participated in the 5G press event of the European Commission, Barcelona, Spain, March 2 – 5, 2015.
- Mohr, W.: 5G Vision and Requirements in 5G PPP. WSA 2015 – 19th International ITG Workshop on Smart Antennas, March 3 – 5, 2015, Ilmenau, Germany, invited keynote.
- Soldani, D.: EU Summit on Innovation for Active & Healthy Ageing: Panel discussion on "*Leveraging Impact of Public Private Partnerships on active and healthy ageing. The example from the robotics sector*", Brussels, Belgium, March 9-10, 2015.
- Mohr, W.: 5G PPP perspective. Panel P2: 5G vision and requirements. IEEE WCNC 2015, New Orleans, USA, March 9 – 12, 2015, invited panel organizer and chair.
- Mohr, W.: 5G Research in Europe in the Context of 5G PPP. Invited participation in panel session Industry Organisations' Global Perspective on 5G. NGMN Industry Conference & Exhibition 2015, March 24 and 25, 2015, Frankfurt, Germany.
- Bedo J.-S.: Net Futures 2015, Presentation on "5G Vision", Brussels, Belgium, March 25, 2015.
- Mohr, W.: 5G Vision and Requirements in 5G PPP. Argela Workshop SDN, NFV, Cloud RAN & other enabling technologies on the path towards 5G, March 31, 2015, Istanbul, Turkey, invited presentation.
- Soldani, D.: Public Lecture "*5G the nervous system of the digital society and digital economy*", IEEE NSW VTS & ComSoc Chapters, CSRIO, Sydney, Australia, April 02, 2015.
- Soldani, D.: IEEE 1st Conference on Network Softwarization (NetSoft): Tutorial on "*5G the nervous system of the system of the silver economy*", London, UK, April 13, 2015.
- Mohr, W.: A European-Global View on 5G R&D. Building America's 5G Ecosystem, April 14, 2015, Light Reading / Heavy Reading event, New York, USA, invited presentation.
- Mohr, W.: 5G Visions and Requirements in 5G PPP. WWRF meeting #34, April 21 – 23, 2015, Santa Clara, California, USA, invited presentation.
- Soldani, D.: 34th Wireless World Research Forum (WWRF): keynote on "*5G the nervous system of the digital society, digital and silver economy*", Santa Clara, USA, April 21-23, 2015.
- Bedo J.-S.: CELTIC-Plus Event 2015, Presentation on "5G Vision", Vienna, Austria, April 27, 2015.
- Soldani, D.: IEEE Vehicular Technology Conference (VTC2015-Spring), plenary speaker on "*5G: The Nervous System of the Digital Society and Digital Economy*", and panel on "*Software Defined 5G Networks and Services*", Glasgow, Scotland, UK, May 11–14, 2015.
- Bedo, J.-S.: IEEE Vehicular Technology Conference (VTC2015-Spring), speaker at the panel on 5G & SDN, Glasgow, Scotland, UK, May 11–14, 2015.

 

- Mohr, W.: 5G Visions and Requirements. Wireless Russia Forum: 4G, 5G & Beyond. May 20 and 21, 2015, Moscow, Russia, invited presentation.
- Mohr, W.: 5G Visions and Requirements. IMT-2020 Promotion Group General Meeting (Summit) 2015, Beijing, May 28 and 29, 2015, invited presentation.
- Soldani, D.: IEEE International Conference on Communications (ICC 2015): panel on "*5G Testbeds, experiments and demonstrations*", June 8, 2015, London, UK.
- Mohr, W.: 5G Research in Europe. The Path to 5G – Continuing the Pre-Standards Debate. IWPC – The International Wireless Industry Consortium. June 15 to 17, 2015, Bonn, Germany, invited presentation.
- Soldani, D.: Zinnov Confluence 2015, Driving IOT innovations: Delivering the connected experience. Keynote speech on "*5G for Mission Critical Machine Communications*", Munich, Germany, June 25th, 2015.

  Video: https://www.youtube.com/watch?v=9MapMCpWZRg
- Mohr, W.: The 5G Infrastructure Public-Private-Partnership. Session "Introducing the 5G-Infrastructure PPP – Launching the 5G Initiative", EuCNC 2015, June 30 to July 2, 2015, Paris.
- Bedo, J.-S.: Chair of the session on "5G for vertical industries - 6th Usage Areas Workshop", EuCNC 2015, June 30 to July 2, 2015, Paris.
- Soldani, D.: Entrepreneurship Summer School – EU Parliament Session: panelist on "*5G: Unlocking European Startup Potential*", Brussels, Belgium, July 15th, 2015.
- Mohr, W.: The 5G Infrastructure Public-Private-Partnership – Project portfolio and expected exploitation of results. ITU GSC-19, Global Standards Coordination 19 meeting, July 15 and 16, 2015, Geneva, ITU premises, Switzerland.
- Mohr, W.: 5G PPP overview presentation. Small Cell Forum Champions Day, September 8, 2015, Rome, Italy, invited presentation.
- Soldani, D.: Webinar at BrightTalk: speech on "*5G Networks, Services and Key Technologies*", September 15th, 2016

  Video: https://www.brighttalk.com/webcast/679/171547
- Mohr, W.: 5G research in Europe. 5G International Summit, September 21 and 22, 2015, Taipei, Taiwan, invited presentations.
- Mohr, W.: 5G PPP – Europe's approach to 5G research. 5G International Summit, September 21 and 22, 2015, Taipei, Taiwan, invited presentations.
- Soldani, D.: RAN World 2015: keynote speech on "*EU 5GPPP Research and Innovation framework in 2015-2020*", Cologne, Germany, September 30th 2015.
- Mohr, W.: 5G PPP – The European 5G Research Program. International Workshop on the Fifth Generation Mobile Communications Systems (5G) – 2015, MIC – Ministry of Internal Affairs and Communications (Japan), Chiba, Japan, October 8, 2015, invited presentation.
- Soldani, D.:The 5G Huddle 2015 – Planning for the 5G Ecosystem: keynote speech on "*Achieving Higher Speed, Lower Latency and a High Degree of Reliability - Research Challenges in Developing 5G for Mission Critical Machine Communications*", Copenhagen, Denmark, October 13th, 2015.
- Soldani, D.: The 5G Huddle 2015 – Planning for the 5G Ecosystem: panel on "*Maximizing the Potential of 5G in the Automotive Industry*", Copenhagen, Denmark, October 14th, 2015.
- Mohr, W.: 5G PPP – The international dimension. EC-Taiwan workshop on the 5G Targeted opening, Lisbon, Portugal, October 21, 2015.
- Mohr, W.: 5G PPP – Implementation of research program and link to vertical sectors. Future Forum, 2015 Future 5G ICT Summit, Beijing, China, November 6 and 7, 2015, invited presentation.

 

- Soldani, D.: International Symposium on Antennas and Propagation (ISAP2015): speech on "*5G for mission critical machine communications*", Hobart, Tasmania, Australia, November 9-12th, 2015.
- Soldani, D.: Monash University: Seminar "*5G for mission critical and massive machine communications*", Melbourne, Australia, November 13th, 2015.
- Soldani, D: Huawei Symposium on 5G: speech on "*5G Private and Public Partnership (PPP) in Europe and global initiates*" and "*Huawei 5G vision and key enabling technologies*", Sydney, November 17th, 2015.
- Tjelta, T.: Digiworld Summit 2015, speech "Through excellent European collaborative research towards the high performance future network" during the panel session "Future Networks Forum. Welcome to the Gigabit era?", November 18, 2015, Montpellier, France.
- Soldani, D.: THE AUSTRALIAN: "*Huawei on track for 5G launch in Australia 'right after 2020'*", Interview, December 1, 2015 12:00AM.
- Soldani, D.: 5G Webinar for Elisa (Finnish Carrier): speech on "*LTE evolution and 5G for mission critical machine communication*", Munich, Germany, December 3th 2015.
- Mohr, W.: Einführung in 5G PPP. 5G for Cyber Physical Systems – Workshop, December 9, 2015, Vienna, Austria, invited presentation by Bundesministerium für Verkehr, Innovation und Technologie.
- Magen, J.: Is 5G a necessity for IoT implementations? Internet of Things Conference, Athens, Greece, December 17, 2015, invited presentation.

 

# Appendix B Common Key Performance Indicators (Article 7 of the cPPP Contractual Arrangements)

| | KPI domain | Key Performance Indicator (KPI) | Value in {2015} | Baseline at the start of H2020 (latest available) | Target (for the cPPP) at the end of H2020 | Comments |
|---|---|---|---|---|---|---|
| 1 | Patents | Number of patent applications.<br><br>Number of patents awarded | {Number} (input by EC),<br><br>{Number} (input by EC) | *reference to FP7 results*<br><br>n.a. [new approach under H2020] | **H2020:** 3 patent applications per €10 million funding | H2020 indicator in Annex II - Council Decision 2013/743/EU) |
| 2 | Standardisation activities (project level)<br><br>Contributions to new standards (cPPP level) | Number of activities leading to standardisation<br><br>Number of working items in European Standardisation Bodies.<br><br>Number of pre-normative research files – prEN - under consultation in ESBs | {Number} (input by EC + Association),<br><br>{Number} (input by EC + Association),<br><br>{Number} (input by EC + Association) | *reference to FP7 results* | No target | |
| 3 | New systems and technologies | Number of systems and technologies developed in the relevant sector in cPPP projects | {Number} (input by EC + Association) | *reference to FP7 results* | From the CA | |
| | Private investment mobilised in cPPP projects<br><br>Private investment mobilised in other R&I activities related to the | Total amount of the private investment mobilised in cPPP projects<br><br>Estimation of the private investment mobilised in other R&I activities related to the | {€ of private investment in cPPP projects} (input by EC)<br><br>{€ of private investment in other | *reference to FP7 results* | From the CA | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | cPPP<br><br>Leverage Factor | cPPP<br><br>Total amount of funds leveraged through the cPPP, (including additional activities) divided by the EC contribution to the cPPP projects | R&I activities related to the cPPP} (input by Association)<br>{ratio} (input by Association) | | | |
| 5 | Participation and benefits for SMEs | Number of SMEs participating in cPPP projects<br><br>Share of participation of SMEs in cPPP projects<br><br>Estimation of the increase in turnover in SMEs participating in the cPPP projects<br><br>Estimation of the increase in number of employees for SMEs participating in the cPPP projects | {number} (input by EC)<br>{ratio} (input by EC)<br><br>{average % of growth in turnover} (input by Association)<br><br>{average % of growth in staff} (input by Association) | n.a. [new approach under H2020]<br><br>*reference to FP7 results* | | H2020 indicator in Annex II - Council Decision 2013/743/EU) |
| 6 | New types of high-skilled jobs and new curricula developed | Number of new types of high-skilled jobs developed in cPPP projects<br><br>Number of new curricula developed in cPPP projects | {number} (input by Association)<br><br>{number} (input by Association) | *reference to FP7 results* | From the CA | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7 | Project results taken-up for further investments (into higher TRLs) | Number of project results taken-up for higher TRLs using additional investments | {number} (input by Association) | *reference to FP7 results* | From the CA | | |
| 8 | Contribution to the reduction of energy use and CO2 emissions | Contribution of the cPPP projects to the reduction of energy use in the area of the cPPP<br><br>Contribution of the cPPP projects to the reduction of CO2 emission in the area of the cPPP | {average % achieved in cPPP project results} (input by Association)<br><br>{average % achieved in cPPP project results} (input by Association) | | From the CA | | |
| 9 | Contribution to the reduction of waste | Contribution of the cPPP projects to the reduction of waste in the area of the cPPP | {average % achieved in cPPP project results} (input by Association) | | From the CA | | |
| 10 | Contribution to the reduction in the use of material resources | Contribution of the cPPP projects to the reduction of material resources in the area of the cPPP | {average % achieved in cPPP projects results} (input by Association) | | From the CA | | |
| 11 | Trainings for a higher quality workforce (at project level) | Number of dissemination events, seminars, conferences organised in cPPP projects<br><br>Number of participants in dissemination events organised in cPPP projects | {Number} (input by Association)<br><br>{Number} (input by Association) | | From the CA | | |

*Table 1: Key performance indicators*

# Appendix C Specific Key Performance Indicators for cPPPs[2]

Please note that this is an example in the case of FoF cPPP

| | KPI domain | Key Performance Indicator (KPI) | Value in {2015} | Baseline at the start of H2020 (latest available) | Target (for the cPPP) at the end of H2020 | Comments |
|---|---|---|---|---|---|---|
| 1 | Operational performance | Time-to-grant | {average number of days} (input by EC) | *reference to FP7 results* | | |
| 2 | Operational performance | Budget share devoted to demos and prototyping | {average % in cPPP projects} (input by Association + EC ) | *reference to FP7 results* | | |
| 3 | Promotion of Entrepreneurship | Number of Spin-offs and Start-ups as result of cPPP projects | {number} (input by Association) | | | |
| 4 | … | … | | | | |

*Table 2: Specific Key performance indicators*

[2] mentioned in the CA or Multi-annual-Roadmap and not covered in Annex 1

# Appendix D Standard Relevant Key Performance Indicators mentioned in H2020[3]

Please note that this table has to be finalised by the EC and is common for all H2020 activities.

| | Key Performance Indicator | Definition/Responding to question | Type of data required | Data to be provided by EC | Baseline at the start of H2020 (latest available) | Target (for the cPPP) at the end of H2020 | Comments |
|---|---|---|---|---|---|---|---|
| 1 | **H2020 LEIT** Patent applications and patents awarded in the different enabling and industrial technologies | Number of patent applications by theme;<br><br>Number of awarded patents by theme | Patent application number,<br><br>Awarded patent number | **EC**<br><br>(project reporting; via worldwide search engines such as ESPACENET, WOPI) | n.a. [new approach under H2020] | **H2020:** 3 patent applications per €10 million funding | H2020 indicator in Annex II - Council Decision 2013/743/EU)<br><br>**Target**<br><br>3 patent applications per €10 million funding |
| 2 | **H2020 -LEIT** - Share of participating firms introducing innovations new to the company or the market (covering the period of the project plus three years) | The share of private companies introducing innovations in the total number of project participants validated as private companies. | Self-reporting (yes/no) of participating firms, based on a common definition of "innovations new to the company or the market" definition to be provided by the central evaluation unit (RTD) | **EC**<br><br>through COMPASS; | n.a. [new approach under H2020] | [To be developed on the basis of first Horizon 2020 results] | H2020 indicator in Annex II - Council Decision 2013/743/EU)<br><br>*reference to FP7 results* |
| 3 | **H2020 - LEIT** - | Number and share of joint | Properly flagged | **EC** through | n.a. [new | [To be developed | H2020 indicator in Annex II |

[3] (Annex II – Council Decision 2013/743/EU)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Number of joint public-private publications | public-private publications out of all LEIT publications. | publications data (DOI) from LEIT funded projects | project reporting; (via DOI and manual data input-flags) | approach under H2020] reference to FP7 results | on the basis of first Horizon 2020 results] | - Council Decision 2013/743/EU)<br><br>*reference to FP7 results* |
| 4 | **H2020 - Risk Finance** - Total investments mobilised via debt financing and Venture Capital investments | Total investments mobilised **via Venture Capital investments** | Aggregate amount(s) in k€ of total investments made by legal entities benefiting from support provided by H2020 Equity Facility *possible split per type of support (debt, equity, etc. …)* | **EC**<br><br>Data provided by EIB/EIF implementing H2020 Financial Instruments | n.a. [new approach under H2020] | €15 billion - globally for investments mobilised via debt financing and Venture Capital investments | H2020 indicator in Annex II - Council Decision 2013/743/EU)<br><br>*reference to FP7 results* |
| 5 | **H2020 - Risk Finance** - Total investments mobilised via debt financing and Venture Capital investments | Total investments mobilised **via debt financing** | Aggregate amount(s) in k€ of total investments made by legal entities benefiting from support provided by H2020 debt Facility *possible split per type of support (debt, equity, etc. …)* | **EC**<br><br>Data provided by EIB/EIF implementing H2020 Financial Instruments | n.a. [new approach under H2020] | €15 billion - globally for investments mobilised via debt financing and Venture Capital investments | H2020 indicator in Annex II - Council Decision 2013/743/EU)<br><br>*reference to FP7 results* |
| 6 | **H2020-Risk Finance**<br><br>**Number** of organisations funded and **amount** of private funds leveraged | Number of organisations funded;<br><br>Amount of private funds leveraged | Number of legal entities benefiting from support provided by H2020 debt and Equity Financial Instruments | **EC**<br><br>Data provided by EIB/EIF implementing H2020 Financial Instruments | [Number of organisations funded: 300] | 5000 organisations funded and €35 billion amount of private funds leveraged | H2020 indicator in Annex II - Council Decision 2013/743/EU)<br><br>*reference to FP7 results* |
| 7 | **H2020 - SME** - Share of participating SMEs introducing | Based on Community Innovation Survey (?). Number and % of participating SMEs that have | Number of SMEs that have introduced innovations; | **EC**<br><br>H2020 beneficiaries through | n.a. [new approach under H2020] | 50% | H2020 indicator in Annex II - Council Decision 2013/743/EU) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | innovations new to the company or the market (covering the period of the project plus three years); | introduced innovations to the company or to the market; | | project reporting | | | *reference to FP7 results* |
| 8 | **H2020 - SME** - Growth and job creation in participating SMEs | Turnover of company, number of employees<br><br>Economic growth | Turnover of company, number of employees; | **EC**<br>H2020 beneficiaries through project reporting | n.a. [new approach under H2020] | to be developed based on FP7 ex-post evaluation and /or first H2020 project results | H2020 indicator in Annex II - Council Decision 2013/743/EU)<br><br>*reference to FP7 results* |
| 9 | **H2020**<br>**New products, processes,** instruments, methods, technologies launched into the market | Number of projects with new innovative products, processes, instruments, methods, technologies | Project count and drop down list allowing to choose the type processes, products, instruments, methods, technologies | **EC**<br>through project reporting | n.a. [new approach under H2020] | [To be developed on the basis of first Horizon 2020 results] | Selected by central evaluation unit in RTD - not a legally compulsory one, but it covers several additional specific indicators requested for more societal challenges by the services in charge. |
| 10 | **H2020 - Share of the overall Energy challenge** funds allocated to the following research activities: renewable energy, end user energy-efficiency, smart grids and energy storage activities | Share of the overall Energy challenge funds allocated to the following research activities: renewable energy, end user energy-efficiency, smart grids and energy storage activities | Financial data related to the funds allocated to the mentioned activities under Societal Challenge "Secure, clean and efficiency energy" | **EC** | n.a. [new approach under H2020] | H2020 85.00% | Selected by central evaluation unit in RTD - but it was added as specific indicator for Societal Challenge "Secure, clean and efficiency energy" by an agreement between DG ENER and DG RTD |
| 11 | ***H2020 - Spreading*** | *Evolution (compared to a reference period prior to the* | *Publications from relevant funded* | *H2020 beneficiaries;* | *n.a. [new approach under* | *[To be determined at the occasion of* | *Selected by central evaluation unit in RTD as a* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | ***Excellence and Widening Participation*** *- Evolution of the publications in high impact journals in the given research field* | *signature of the grant agreement) of the publications in high impact journals in the given research field of the research organisation funded (ERA-Chair and Twinning activities)* | *projects (DOI: Digital Object Identifiers); Journal impact benchmark (ranking) data to be collected by commercially available bibliometric databases.* | *Access to appropriate bibliometric databases* | *H2020]* | *H2020 interim evaluation in 2017 ]* | *specific objective of H2020 during the negotiations, the Commission has to provide a performance indicator also for this objective* |

*Table 3: Standard Relevant Key performance indicators*

# Appendix E Cross-cutting Issues in cPPP calls[4]

Please note that this table has to be finalised by the EC and is common for all H2020 activities.

| # | Cross-cutting issue | Definition/Responding to question | Value in {2015} |
|---|---|---|---|
| 1 | **Widening the participation** | 1.1 Total number of participations by EU-28 Member State | |
| | | 1.2 Total amount of EU financial contribution by EU-28 Member State (EUR millions) | |
| 2 | **SMEs participation** | 2.1 Share of EU financial contribution going to SMEs (Enabling & industrial tech and Part III of Horizon 2020) | |
| | | 2.2 Share of EU financial contribution committed through the SME instrument (Enabling & industrial tech and Part III of Horizon 2020) | |
| 3 | **Social sciences and humanities** | 3.1 Share of SSH partners in selected projects in all H2020 priorities and share of EU financial contribution allocated to them | |
| 4 | **Gender** | 4.1 Percentage of women participants in cPPPs projects | |
| | | 4.2 Percentage of women project coordinators in cPPPs projects | |
| | | 4.3 Percentage of women in EC advisory groups, expert groups, evaluation panels, individual experts, etc. | |
| | | 4.4 Percentage of projects taking into account the gender dimension in research and innovation content | |
| 5 | **Sustainable development and climate change, including information on the** | 5.1 Share of EU financial contribution that is climate-related in Horizon 2020 (EUR), calculated on the basis of the " RIO markers" | |

[4] (Annex III – Council Decision 2013/743/EU)

 

| | | | |
|---|---|---|---|
| | **amount of climate change related expenditure** | 5.2 Share of EU financial contribution that is sustainability-related in Horizon 2020 (EUR), calculated on the basis of the " RIO markers" methodology developed by OECD | |
| | | 5.3 Share of EU financial contribution that is biodiversity-related in Horizon 2020 (EUR), calculated on the basis of the " RIO markers" methodology developed by OECD | |
| 6 | **Bridging from discovery to market application** | 6.1 Share of projects and EU financial contribution allocated to innovation actions in H2020 | |
| | | 6.2 Within the innovation actions, share of EU financial contribution focussed on demonstration and first-of-a-kind activities | |
| 7 | **Digital Agenda** | 67.1 Share of EU financial contribution that is ICT Research & Innovation related in Horizon 2020 (EUR), calculated on the basis of the " RIO markers" methodology developed by OECD: | |
| 8 | **Private sector participation** | 8.1 Percentage of H2020 beneficiaries from the private for profit sector | |
| | | 8.2 Share of EU financial contribution going to private for profit entities (Enabling & industrial tech and Part III of Horizon 2020) | |
| 9 | **Funding for cPPPs** | 9.1 EU financial contribution for cPPP-P2Ps | |
| | | 9.2 cPPPs leverage: total amount of funds leveraged through private side (cPPPs), including additional activities, divided by the EU contribution | |
| 10 | **Participation patterns of independent experts** | 10.1 Proposal evaluators by country | |
| | | 10.2 Proposal evaluators by organisations' type of activity | |