

5G PPP PROGRESS MONITORING REPORT – 2020

This document has been prepared by the 5G Infrastructure Association (5G IA) and it reflects the views only of its authors

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1. Introduction

This document reports the progress achieved by the 5G Public-Private Partnership (5G PPP) during 2020. For reasons of completeness, the document briefly presents the overall 5G-PPP framework (Annexes 1 & 2). It also analyses the activities that were performed under this framework either by the 5G Initiative (i.e., 5G PPP Projects, 5G PPP working groups, Steering and Technology Boards) or the 5G Infrastructure Association - 5G IA (i.e., Verticals Engagement Task Force, 5G IA working groups and specific activities). Detailed information can be found in Annexes 3 through 6.

Furthermore, it presents the results for several Key Performance Indicators (KPIs) for a) a common set of KPIs (i.e., mobilised private investments, new skills/job profiles, impact on the SMEs, Significant innovations), b) specific KPIs for the 5G PPP in terms of network performance, business and societal aspects and c) the contribution to 5G PPP Programme-level KPIs. Detailed information about this topic can also be found in Annexes 7 through 9.

Finally, the document provides a qualitative analysis about the outlook and the lessons learnt and provides some recommendations about the workplan for the following years.

2. Main activities and achievements

5G has become commercially available during 2019, ahead of schedule. Commercial services are already available in many cities throughout Europe. Deployments are on-going throughout Europe with thousands of 5G base stations becoming operational in many European cities. At the end of June 2021, 25 EU-27 countries do enjoy 5G services: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, Malta, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, and Sweden¹.

The underlying technology developed in the context of the 5G PPP Initiative was a key enabler for these success stories. The 5G PPP Initiative has provided several scientific solutions that have been contributed to standardization activities and the global academic and research community through publications. More importantly, solutions that emerged through 5G PPP projects have been integrated into final products. In addition, the 5GPP projects have been driving test and validation activities in Europe, collecting significant experience for all stakeholders and raising public awareness on the capabilities of 5G networks.

In the following sections, it will be explained how the 5G PPP Initiative is organized in different Phases. The first phase (Phase 1) focused on basic research to provide the key concepts and solutions for 5G networks. The second phase (Phase 2) concentrated on bringing this new 5G technology to the vertical industries and finally Phase 3 where large-scale trials and innovation infrastructures are being created. Phase 3 also contains basic research activities to consider evolution beyond 5G.

The last two Phases of 5G PPP have managed to cover a significant number of vertical industries as shown in Figure 1. This is an important achievement because one of the main aims of 5G is the support of the so call verticals.

¹ https://5gobservatory.eu/wp-content/uploads/2021/07/90013-5G-Observatory-Quarterly-report-12_v1.0.pdf

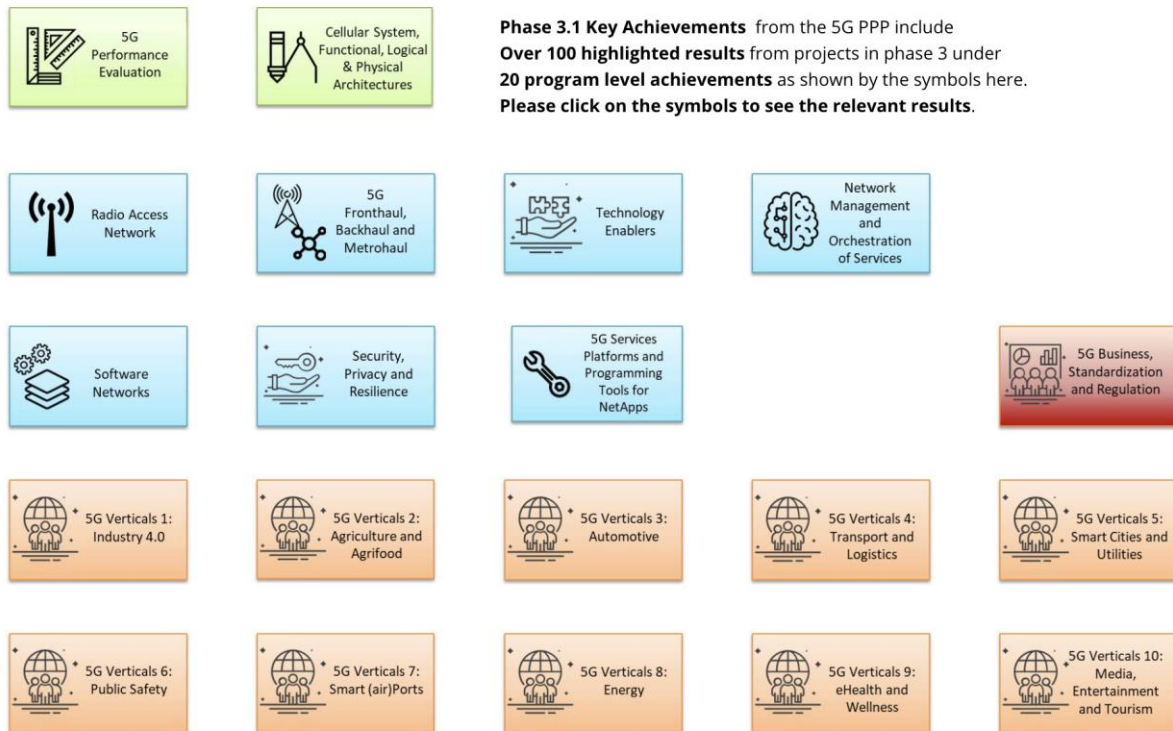


Figure 1: Key achievements and vertical use cases in 5G PPP²

The importance of EU funded projects to build a world-wide consensus in a pre-standardization level, the visionary specification of futuristic use cases and the raising of public awareness about the capabilities of 5G networks is undeniable. **The 5G Infrastructure PPP Initiative and 5G IA achieved significant progress and impact during 2020.** The next subsections provide more detailed information.

2.1 Implementation of the calls for proposals evaluated during the reporting period

2020 has signalled the last phase of the 5G PPP Initiative. This phase will last until the completion of the last 5G PPP Project (i.e., July 2024). This last phase is the most active one of the 5G PPP Initiative as on average 39 projects are active at the same time whereas the maximum number of projects exceeded 50 projects (Figure 3).

During 2020 we have witnessed the successful completion of all Phase 2 projects. Phase 3 ICT-17 Platforms projects (a.k.a. 5G PPP Phase 3, Part 1: Infrastructure Projects), and Phase 3 ICT-18 Corridors projects (a.k.a. 5G PPP Phase 3, Part 2: Automotive Projects), that have started respectively in July 2018 and November 2018, they have been rather active produced significant results during 2020. More specifically ICT-17 projects have setup their platforms and provided their solutions to eight Phase 3 ICT-19 projects (a.k.a. 5G PPP Phase3, Part 3: Advanced 5G validation trials across multiple vertical industries) that have started their activities in 2019 and will run for about three years. These projects are dealing with advanced 5G validation trials across multiple vertical industries. Note that during 2020, the 3 ICT-17

² <https://5g-ppp.eu/key-achievements-v3-1/>

projects provided all information about the capabilities of their platforms³ as well as detailed information about the on-board procedure for ICT-19 projects⁴. Each project has additionally provided several workshops to make the integration among projects as smooth as possible.

Similarly, ICT-18 projects, despite the Covid-19 pandemic, continued their efforts to specify advanced solutions for Connected and Automated Mobility in cross-corridor environments. These projects have provided individually significant solutions and results and produced collectively reports to disseminate the key findings⁵. Note that knowledge produced by these projects has been used to provide the 5G Strategic Agenda for Connected and Automated Mobility in Europe⁶.

In June 2019, eight Phase 3 ICT-19 projects (a.k.a. 5G PPP Phase3, Part 3: Advanced 5G validation trials across multiple vertical industries) have started their activities and will run for about three years. These projects are dealing with advanced 5G validation trials across multiple vertical industries. During 2020, these projects have managed a smooth integration with ICT-17 projects and have worked collectively to analyse the findings from their trials in terms of e.g., the performance KPIs⁷, the business models⁸

In November 2019 eight additional ICT-20 projects (a.k.a. 5G PPP Phase3, Part 4: 5G Long Term Evolution) have commenced their research and innovation activities for the long-term evolution of 5G networks. These projects mainly aim to provide solutions on Advanced Network Management, specification of an evolved RAN, Security, 5G Edge/MEC and localization. Key results and findings have been included in the collective activities of the Technology Board (i.e., TB workshops, Key achievements v3.1).

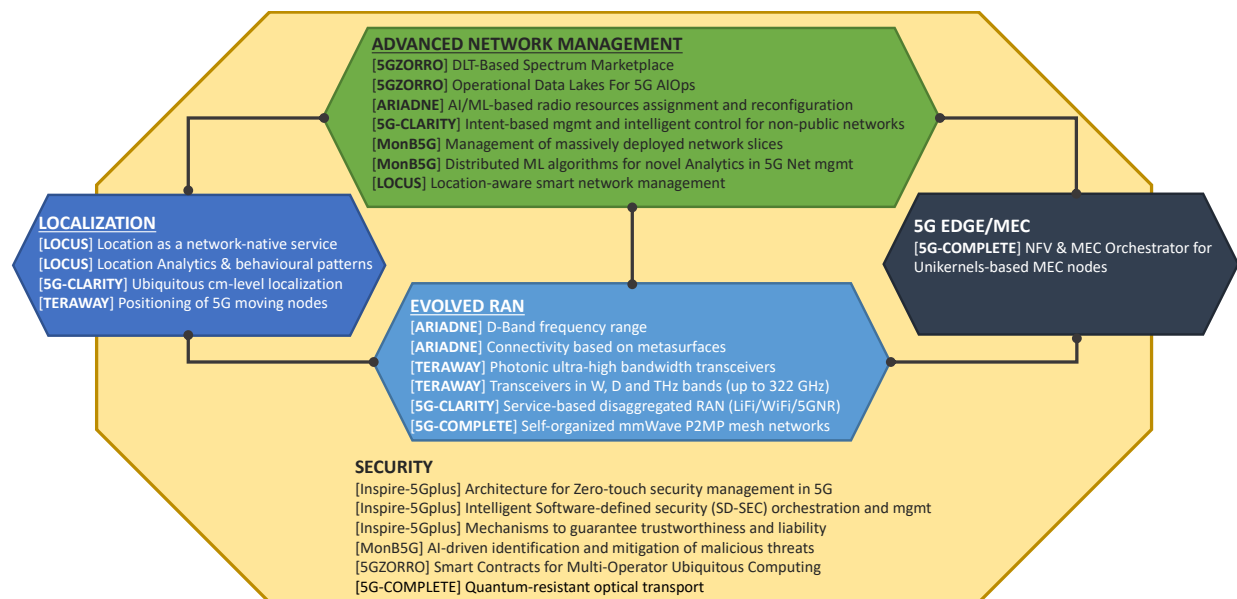


Figure 2: ICT-20 projects main areas of activities

³ https://5g-ppp.eu/wp-content/uploads/2020/03/5PPP_VTF_brochure_v2.1.pdf

⁴ <https://5g-ppp.eu/wp-content/uploads/2020/04/On-Board-Procedure-to-5G-PPP-Infrastructure-Projects-1.pdf>

⁵ https://5g-ppp.eu/wp-content/uploads/2020/10/5G-for-CCAM-in-Cross-Border-Corridors_5G-PPP-White-Paper-Final2.pdf

⁶ https://5g-ppp.eu/wp-content/uploads/2020/10/20201002_5G_SDA_for_CAM_Final.pdf

⁷ https://5g-ppp.eu/wp-content/uploads/2021/06/Service-performance-measurement-methods-over-5G-experimental-networks_08052021-Final.pdf

⁸ https://5g-ppp.eu/wp-content/uploads/2020/06/5G_White_paper_Business-validation-v1.0a.pdf

During 2020 the last 5G PPP calls have been executed and completed. More specifically:

- ICT-42 topic (IA and CSA) “5G core technologies innovation” (opening date 09-July 2019) has received all proposals until 16-01-2020. 8 projects were selected:

Project name	Acronym	Project ID	Starting Date	Ending Date
5G creating opportunities for LOGistics supply chain INNOVation	5G-LOGINNOV	957400	09/20	08/23
5G key technology enableRs for Emerging media COntent pRoDuction Services	5G-RECORDS	957102	09/20	08/22
Monetizing car & mobility data for new Entrants, Technologies and Actors	5GMETA	957360	09/20	08/23
High-tech and affordable 5G network roll-out to every corner	Affordable5G	957317	09/20	08/22
European Core Technologies for future connectivity systems and components	COREnect	956830	07/20	06/22
D-band radio 5G network technology	DRAGON	955699	12/20	11/23
FULLy DisinteGrated private nEtworks for 5G verticals	FUDGE-5G	957242	09/20	02/23
Integrating 5G enabling technologies in a holistic service to physical layer 5G system platform	Int5Gent	957403	11/20	10/23

- ICT-53 topic (IA) “5G for Connected and Automated Mobility” (opening date 09-July 2019) has received all proposals until 13-11-2019. 4 projects were selected:

Project name	Acronym	Project ID	Starting Date	Ending Date
Next generation connectivity for enhanced, safe & efficient transport & logistics	5G-Blueprint	952189	09/20	08/23
5th Generation connected and automated mobility cross-border EU trials	5G-ROUTES	951867	09/20	08/23
Sustainable 5G deployment model for future mobility in the	5GMED	951947	09/20	08/23

Mediterranean Cross-Border Corridor				
5G for future RAILway mobile communication system	5GRAIL	951725	11/20	04/23

- ICT-41 topic (IA) “5G innovations for verticals with third party services” (opening date 19-November 2019) has received all proposals until 17-06-2020. 9 projects were selected:

Project name	Acronym	Project ID	Starting Date	Ending Date
5G ExPerimentation Infrastructure hosting Cloud-native Netapps for public proTectiOn and disaster RELief	5G-EPICENTRE	101016521	01/21	12/23
5G ENHANCED ROBOT AUTONOMY	5G-ERA	101016681	01/21	12/23
5G Intelligent Automotive Network Applications	5G-IANA	101016427	06/21	05/24
Open cooperative 5G experimentation platforms for the industrial sector NetApps	5G-INDUCE	101016941	01/21	12/23
5G Application & Services experimentation and certification Platform	5GASP	101016448	01/21	12/23
5G experimentation environment for 3rd party media services	5GMediaHUB	101016714	01/21	12/23
Experimentation and Validation Openness for Long-term evolution of VERTICAL inDustries in 5G era and beyond	EVOLVED-5G	101016608	01/21	12/23
Smart5Grid - Demonstration of 5G solutions for SMART energy GRIDs of the future	SMART5GRID	101016912	01/21	12/23
Vertical Innovations in Transport And Logistics over 5G experimentation facilities	VITAL-5G	101016567	01/21	12/23

- ICT-52 topic (RIA) “Smart Connectivity beyond 5G” (opening date 19-November 2019) has received all proposals until 17-06-2020. 9 projects were selected:

Project name	Acronym	Project ID	Starting Date	Ending Date
Bring Reinforcement-learning Into Radio Light Network for Massive Connections	6G BRAINS	101017226	01/21	12/23
A secure and reusable Artificial Intelligence platform for Edge computing in beyond 5G Networks	AIatEDGE	101015922	01/21	12/23
Network intelligence for aDAptive and sElf-Learning MObile Networks	DAEMON	101017109	01/21	12/23
Dynamic coverage Extension and Distributed Intelligence for human Centric applications with assured security, privacy and trust: from 5G to 6G	DEDICAT 6G	101016499	01/21	12/23
A flagship for B5G/6G vision and intelligent fabric of technology enablers connecting human, physical, and digital worlds	Hexa-X	101015956	01/21	06/23
MACHINE LEARNING-BASED, NETWORKING AND COMPUTING INFRASTRUCTURE RESOURCE MANAGEMENT OF 5G AND BEYOND INTELLIGENT NETWORKS	MARSAL	101017171	01/21	12/23
REsilient IInteractive applications through hyper Diversity in Energy Efficient RadioWeaves technology	REINDEER	101013425	01/21	06/24
Reconfigurable Intelligent Sustainable Environments for 6G Wireless Networks	RISE-6G	101017011	01/21	12/23
Secured autonomic traffic management for a Tera of SDN flows	TeraFlow	101015857	01/21	06/23

For all the above-mentioned projects dedicated workshops have been organized during 2020 Q1.

The governance model of 5G PPP and the 5G PPP Contractual Arrangement foresee that R&I actions resulting from relevant calls of the Horizon 2020 LEIT ICT actions (and beyond where appropriate) is implemented as a Programme to reach high industrial impact. A particular requirement for new projects is to leverage work and results of Phase 1 and Phase 2 projects. Access for Phase 3 projects to Phase 2 results is ensured by the Collaboration Agreement, which is signed by all project participants. A graphical overview of the 5G PPP program can be found in Figure 3.

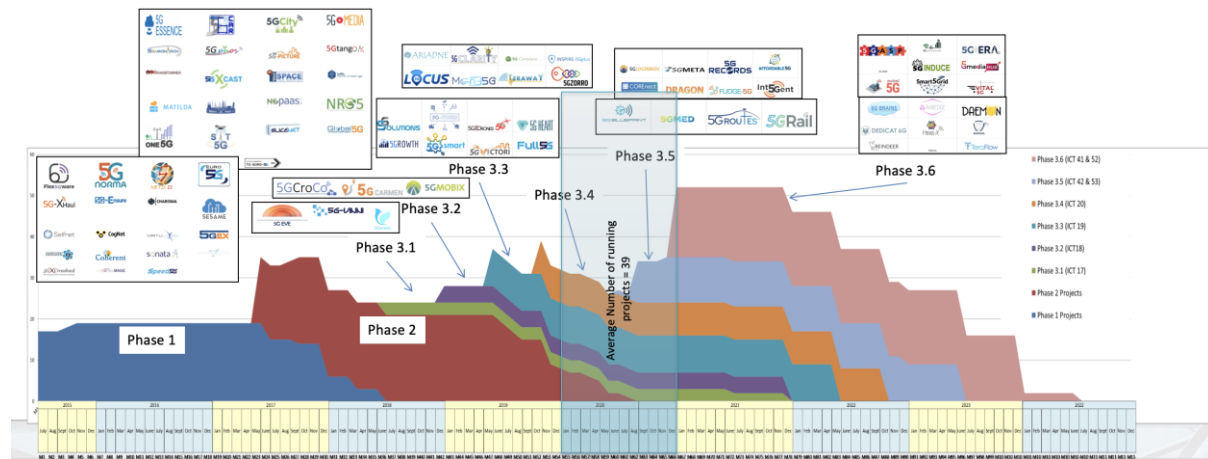


Figure 3: Overview of the 5G PPP Programme

Figure 4: Vertical industries under validation by ICT-17 and ICT-19 projects

Since Phase 1, **92 projects** in total have been contractually active in the 5G PPP Programme, ensuring an **outstanding momentum and dynamism**. Also, note that **Phase 2 Key Achievements from 5G PPP projects include 60 highlighted results** categorised under 14 program level achievements whereas a **latest counting of Key Achievements v3.1**, including an updated list of key achievements from Phase 2 projects and key achievements from Phase 3 projects, **amount to more than 100 innovations under 11 categories** (Annex 3).

5G PPP is an active contributor to 5G standardization globally and technological results have been disseminated in several scientific journals and conferences (Annex 9).

A key part of the 5G PPP structure is a set of cross-projects and cross-initiative **working groups** (Annex 4). The outcome of the work from these groups is presented in white papers. Since 2019, the 5G PPP Initiative has released another **ten white papers** disseminating key findings⁹.

Beyond the Phase 2 and Phase 3 projects achievements, a lot of joint (cross-projects) and programmatic achievements have been further developed, thanks to the overall operation and efficiency of the working groups, Steering Board and Technology Board, in full synchronization with the 5G-IA, and with the strong support of the CSAs projects. On the 10th

⁹ <https://5g-ppp.eu/white-papers/>

of April 2018, the European Commission launched the Innovation Radar: a data-driven online tool which provides easy access to innovations supported by EU funding and the innovators behind them. **By searching “5G” on the Innovation Radar 322 innovations were found recorded.**

Section 3 provides **detailed information about common and specific sets of KPIs** for the 5G PPP program. Most notably, it has been evaluated that the **mobilization of private investment for 2020** has achieved a **leverage factor of 13,58** times the public EC investment in the 5G PPP for large industries and SMEs. (**10,93 for all types of stakeholders**).

Also, an analysis of the data in the latest publicly available reports such as IPlytics¹⁰ (February 2021), indicates that European companies share a 17,82% of active and granted 5G Families and a 20,54 of 5G EP/US granted/active families. **Moreover, an analysis of publicly available results suggests that the EU HQ companies combined share more than 53% of 5G commercial deals**¹¹.

2.2 Mobilization of stakeholders, outreach, success stories

During 2019, several technical workshops, information days and research and innovation events took place to harmonize the activities of projects, promote their results and attract new stakeholders in the following calls. Some of the workshops were organized in the context of the 5G PPP Initiative. In other events, the funded projects had a strong presence. A detailed list of events is available at the 5G PPP web site¹².

The **Verticals Cartography of the Phase 3 projects** was produced together with the **Platforms Cartography (Annex 3)**. These cartographies provided detailed information about the scope and the activities of the Phase 3 projects in relation to vertical industries. Also, they provide information about their planned activities.

According to the H2020 dashboard¹³, **the participation of SMEs in the 5G PPP has reached 21.95% of EU funding**, representing a total of 156.3 M€. SMEs have contributed to 24.43% of the total participation in 5G PPP projects, i.e., 426 SME participations out of 1,744. There were 738 unique SME participations. It is worth noting that 65% of the SMEs participated in 1 project, and 35% in 2 or more projects. Besides, the level of participation of SMEs in RIAs and IAs is similar.

H2020 Participations 1.744 1,08% of H2020	H2020 Unique Participants 738 1,90% of H2020	H2020 Net EU Contribution 712,9M 1,16% of H2020	H2020 Total Cost 804,8M 1,05% of H2020	H2020 SME Participations 426 24,43% SME Participations	H2020 SME Net EU Contribution 156,3M 21,95% SME Part Net EU Contribution
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Figure 5: Extract from the H2020 dashboard – SME participation in the 5G PPP

5G IA has been very active building up international cooperation for 5G networks (Annex 6). Currently, **15 MoUs** and **4 LoIs** with major 5G organizations from around the globe have been

¹⁰ IPlytics, Who is leading the 5G Patent race?, A patent landscape analysis on declared SEPs and standards contributions, February 2021 <https://www.iplytics.com/>

¹¹ <https://www.trendforce.com/presscenter/news/20210728-10872.html>

¹² https://5g-ppp.eu/event-calendar/list/?tribe_paged=1&tribe_event_display=list&tribe-bar-date=2020-01-01

¹³ <https://webgate.ec.europa.eu/dashboard/>

signed. Unfortunately for the reporting period and due to the COVID-19 pandemic the **Global 5G Events** were postponed.

2.3 Governance

In the context of 5G PPP, the 5G Infrastructure Association (5G IA) represents the private side, and the European Commission, the public side. The 5G IA is “*The voice of the European industry for the development and evolution of 5G*”. To this aim, the 5G IA brings together a global industry community of telecoms & digital actors, such as operators, manufacturers, research institutes, universities, verticals, and SMEs. *Figure 6*, presents the overall governance of the 5G PPP.

During the reporting period, the Network Management & QoS WG has successfully completed its activities during this phase. Furthermore, the Spectrum WG has paused its activities as not many 5G PPP projects were dealing with Spectrum issues.

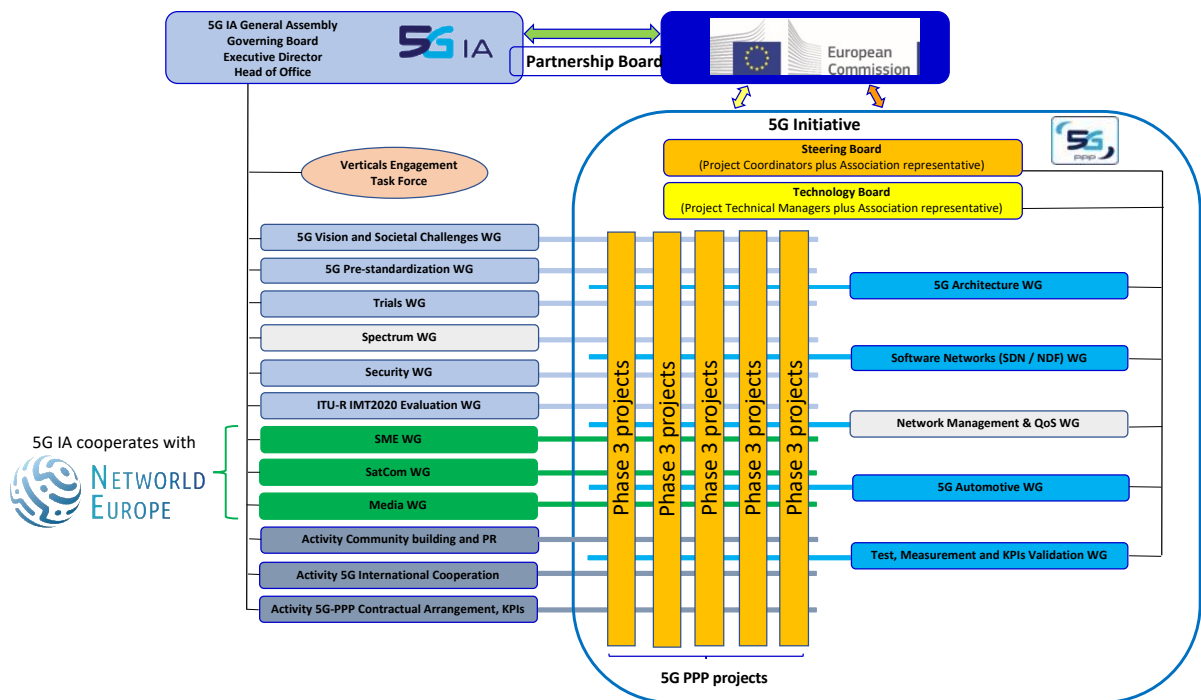


Figure 6: 5G PPP Governance

3. Monitoring of the overall progress since the launch of the 5G PPP

This section, accompanied with detailed information presented in the annexes, presents the overall progress that has been recorded since the launch of the 5G PPP.

3.1 Achievement of the goals of the cPPP

2020 was another successful year for the 5G PPP Initiative. Significant results were achieved in the following key areas for the implementation of the 5G PPP Contractual Arrangement:

- **An efficient and effective 5G PPP Programme:** The *5G PPP Programme* has been *operating smoothly* having now contracts for 92 projects over all 5G PPP phases (Section 2.1 and Annex 3). Phase 2 projects have all successfully completed during 2020 and phase 3 projects proceed at full speed.
- **Optimum profile for the European 5G initiative in a global context:** As described in detail in Annex 6, the 5G IA has in place 15 MoUs and 4 LoI with international peer Associations, Verticals' Associations, SDOs etc.
- **Widespread dissemination of European achievements:** During the past period, the *5G PPP Initiative* was actively engaged in organizing and disseminating results the European achievements through *several different events*. In several important events 5G PPP had the possibility to present its achievements, raise awareness on opportunities offered by 5G and have exchanges with major EU and international organizations.
- **Significant technical input to the standardization bodies:** 5G PPP is an active contributor to 5G standardization globally (c.f., Annex 9)
- **Impact through scientific publications:** Moreover, data collected from the public sites of the funded projects, show that they have provided a significant impact on the scientific community (c.f., Annex 9).
- **Measurable Programme progress and KPIs:** In section 3 follows an analytical discussion about the measurable progress through a set of KPIs. More details are included also in the annexes. Summarizing some of the key findings, the analysis of the data has shown *a leverage factor of 13,58 times the public EC investment for large industry and SMEs*. The SME participation in 5G PPP projects has been increasing in 2020 to reach and even exceed the original objective of 20% (i.e., **21,95%**) participation defined as a KPI of the programme. Finally, specific 5G cPPP KPIs (performance, business and societal) are also addressed in the following section. It is worth noting that during 2020 important steps forward have been taken for the mapping of vertical KPIs to network KPIs as well as monitoring and analyzing the 5G network KPIs achieved in practice through different 5G PPP projects.
- **Maintaining the holistic view of implementing 5G by 2020 and planning for Horizon Europe:** The governance model of 5G PPP allowed to achieve the expected results. As planned, the *Programme is successfully shifting from research activities to large trials and eventually the market*. Moreover, the EU ICT community working closely together with the EC has been very active for the preparation of the framework for the next decade (i.e., Smart Networks and Services for the Horizon Europe Programme).

3.2 Progress achieved on KPIs

In the following subsections common and specific sets of KPIs are presented. More detailed information on their progress is available in the annexes. Note, that some of the reported information relates to data collected through specific Questionnaires. As for this report it was not required to perform a new Questionnaire process, the current report contains information presented in the PMR 2018 for reasons of completeness.

3.2.1 Common set of KPIs

3.2.1.1 Mobilize private investments

As performed for 2018's PMR these calculations took place with the use of dedicated Questionnaires and collection of publicly available information. The calculation of this KPI is based on the data extracted from the 2020 Questionnaire¹⁴, in particular parameters under A.2 (Direct Leverage), B.1 (Follow-up of the project) and B.2 (Beyond the 5G PPP), as defined by the EC in the proposed "Single leverage factor methodology". A.1 was extracted from the statistics publicly available at the H2020 Qlik Sense dashboard¹⁵.

The following specific parameters were considered

- A2.1 - What in percentage terms, was your actual average overhead rate during this 5G PPP project period?
- A2.2 What additional costs (i.e., not reimbursed) in kind contributions did you make to this project?
- B1.1 What total costs has your organization incurred during or after this Project?
- B2.1 What total investments did your organization make in the period 2014-2020 in the technology fields related to the 5G PPP, which you were not directly related to any of the 5G PPP projects you participated in

The following data processing methodology was applied:

- The average values of A2.1, A2.2, B1.1, B2.1 were calculated, per legal entity type (Large Industry, SME, Academic Institution, Research Center)
 - B2.1 is given for the period 2014-2020, so its quota for 2020 was calculated by dividing the value by 7
- On the H2020 Qlik Sense dashboard, the following information has been extracted, per legal entity type, for the following for the following Phase 3 Call Topics: ICT-17-2018, ICT-18-2018, ICT-19-2019, ICT-20-2019-2020, ICT-42-2020, ICT-53-2020, ICT-41-2020, ICT-52-2020:
 - # of beneficiaries,
 - Total cost and
 - Total Net EU contribution
 - The Total cost and Total Net EU contribution has been projected on 2020 only (assuming an average project duration of 36 months) and considering that the grants for ICT-17-2018 and ICT-18-2018 were signed in 2018, the grants for ICT-20-2019-2020 and ICT-42-2020 were signed in 2019, and the grants for ICT-42-2020, ICT-53-2020, ICT-41-2020, ICT-52-2020 in the late part of 2020.
- Then, the following calculations have been performed, for each legal entity type:
 - The average values of A2.2, B1.1 and B2.1 (2020) have been multiplied by the total number of beneficiaries
 - The average Overhead (A2.1) has been applied to the Total Direct costs (= Total cost / 125%), and the difference with the flat OH 25% has been calculated
 - Finally, A.1 has been calculated as the difference between the Total Net EU contribution for 2020 and the Total costs for 2020

¹⁴ <https://5g-ppp.eu/5g-ppp-progress-monitoring-report-data-collection-2020/>

¹⁵ <https://webgate.ec.europa.eu/dashboard/sense/app/93297a69-09fd-4ef5-889f-b83c4e21d33e/sheet/PbZJnb/state/analysis>

- The sum of total A.1, A2.1, A2.2, B1.1, B2.1 provides, for each legal entity type, the additional investment in 2020 w.r.t. the Total Net EU contribution received during the year.
- The total across a subset of legal entity types provides the overall additional investment in 2020 for that subset of beneficiaries and leads to the related Leverage Factor during the year. Two (sub)sets have been considered:
 - Large Industry and SMEs; i.e. the business-oriented (and by far largest) part of private investments.
 - All kinds of beneficiaries.

The result from this calculation procedures show already excellent leverage factors:

- Large Industry and SMEs in 2020 mobilized private investments that sum up to an amount **13,58** times the public EC investment in the 5G PPP in the same period.
- All the types of stakeholders/beneficiaries invested in 2020 a total amount of money that is **10,93** times the public investment in the same period.

3.2.1.2 New skills and/or job profiles

As in the previous section, data for new jobs/skills created were collected through the 2020 Questionnaire from 5G PPP project beneficiaries.

These are defined as progressive values, referring to the period 2014-2020. A finer scale (e.g., per year) is very difficult to implement, since the creation of jobs/skills can be hardly calculated on a per-year basis and attributed to specific periods.

The following procedure was applied to calculate this KPI:

- Data for New jobs/skills created were collected through a questionnaire from 5G PPP project beneficiaries.
- Average values of the number of new jobs/skills were calculated per legal entity type (Large Industry, SME, Academic Institution, Research Center).
- On the H2020 Qlik Sense dashboard, the following information has been extracted:
 - (per legal entity type) # of beneficiaries for the following Phase 3 Call Topics: ICT-17-2018, ICT-18-2018, ICT-19-2019, ICT-20-2019-2020, ICT-42-2020, ICT-53-2020, ICT-41-2020, ICT-52-2020.
- The average values of these parameters have been multiplied by the total number of beneficiaries in each type subset to calculate the projected total values.

The result of this exercise is summarized in the following table, which clearly shows a significant impact in terms of new job/skill profiles.

2014-2020	New jobs/skills	
	Average	Total projected
Overall	7,31	7.443
Large Industry	23,08	5.910
SME	4,06	570
Academic Institution	6,22	527
Research Center	5,33	437

Note here that these numbers have been collected from the stakeholders directly involved in the 5G PPP Initiative and serve as an indication of what is to be expected in following years.

5G deployment will allow several sectors (e.g., industry verticals) to offer a huge variety of new services, solutions and products, which, in turn, will require the creation of many new job profiles to fully exploit the potential of 5G.

3.2.1.3 Impact on SMEs

An SME's business performance can depend on many factors, and not only on the participation in a given R&D Programme. It is up to the individual SME to quantify how the participation in 5G PPP projects had an influence on parameters like turnover, job profiles and staff headcount variations, etc. In most cases, they should manage to provide this information, with some degree of precision.

To capture the impact on SMEs, the following parameters were considered:

- The increase in yearly turnover
- The increase in yearly revenues
- The increase in staff headcount
- The number of new elements of foreground IP

Data for these parameters were collected through the 2020 Questionnaire mentioned in the previous subsection. This Questionnaire has had a specific table to collect this data from the SMEs.

The following procedure was applied to calculate this KPI:

- Data for the 4 parameters were collected through the questionnaire from 5G PPP SME beneficiaries
- An average value for each parameter was calculated over the collected samples.
- On the H2020 Qlik Sense dashboard, the following information has been extracted:
 - (per legal entity type) # of SME beneficiaries for the following Phase 3 Call Topics: ICT-17-2018, ICT-18-2018, ICT-19-2019, ICT-20-2019-2020, ICT-42-2020, ICT-53-2020, ICT-41-2020, ICT-52-2020.
- The average values of increase in staff headcount and number of new elements of foreground IP have been multiplied by the total number of beneficiaries.

The following table shows that the access to public funding for the 5G PPP activities by the SMEs has had a significant impact on the beneficiary SMEs under many viewpoints.

	increase in yearly turnover	increase in yearly revenues	increase in staff headcount	number of new elements of foreground IP
<i>Reference period</i>	2020	2020	2014 - 2020	2014 - 2020
Average values	10,1%	11,9%	16,55	1,78
Total projected	n/a	n/a	2.325	250

Note also that 5G PPP activities have created a stable playground for EU SMEs to be active and results. As reported in Annex 6, The number of members SME Working Group has increased by 17% during the year 2020, reaching 200 members, out of which 170 are SMEs. Moreover, the SME participation in 5G PPP projects has been increasing in 2020 to reach and

even exceed the original objective of 20% participation defined as a KPI of the programme¹⁶. According to the H2020 dashboard¹⁷, **the participation of SMEs in the 5G PPP has reached 21.95% of EU funding**, representing a total of 156.3 M€

3.2.1.4 Significant innovations

The 5G PPP Phase projects have produced a number of significant technological innovations. As described in Annex 3, during the reporting period the Key achievements v3.0 has been produced¹⁸. Contrary to the Phase II key achievements, where these were mainly related to technological breakthroughs, the current list identifies the progress of 5G PPP according to overall plan that is related to gradual shifting from concepts to trials. Thus, most of the reported achievements are related to several trials related to 10 different vertical sectors. Also, many projects have further continued their work in the 5G architecture and in network management and orchestration of the services. These extensions were needed to further support their trials.

A slightly different picture was presented during the collection and processing of key results v3.1¹⁹. In total, more than 100 achievements have been reported that have been grouped in 11 different categories. Compared to the previous version, the latest list of key achievements v3.1 illustrated that the introduction of ICT-20 projects has further pushed the research activities in all technological domains. This is to be expected as the 5G-PPP Phases and the related pre-structuring model have been designed in such a way to allow the promotion of 5G in verticals and at the same time the further investigation of topics related to the evolution of 5G and touching on topics that are currently considered as suitable candidates for 6G networks (e.g., smart surfaces, THz communication, AI for network automation, etc.).

In terms of standardization activities, 5G PPP is an active contributor to 5G standardization globally. Overall, the 5G-IA Pre-Standardization WG has tracked **237 inputs** based on specific and tangible inputs (e.g. technical reports, study/work item, PoC, new commercial requirements) as opposed to broader inputs collected in previous years. Most inputs have been submitted to 3GPP (96), IETF (50) and ETSI (38), with a growing number of inputs to IEEE, and inputs to sector associations working groups for like 5GAA. Moreover, based on 5G PPP project activities two ETSI Work Items have been approved:

- WI-1 Methodologies for E2E Testing & validation of Vertical Applications over 5G&Beyond networks (pre-study)
- WI-2: Specifications for E2E Testing and Validation of Vertical Applications over 5G&Beyond networks (feasibility)

The 5G PPP projects have disseminated their results in several scientific journals, international conferences, book chapters and white papers (Annex 9). **The remaining phase 2 projects that completed their activities in 2020 have produced approximately 726 publications** (22% was published in scientific journals), **whereas Phase 3 projects have produced 602 publications so far** (39% was published in scientific journals).

¹⁶ All 5G PPP calls have been included, now that the latest 5G PPP calls have been completed.

¹⁷ <https://webgate.ec.europa.eu/dashboard/>

¹⁸ <https://5g-ppp.eu/key-achievements-v3/>

¹⁹ <https://5g-ppp.eu/key-achievements-v3-1/>

Also, an analysis of the data in the latest publicly available reports such as IPlytics²⁰ (February 2021), indicates that European companies share a 17,82% of active and granted 5G Families and a 20,54 of 5G EP/US granted/active families. **Moreover, an analysis of publicly available results suggests that the EU HQ companies combined share more than 53% of 5G commercial deals**²¹.

3.2.2 Specific KPIs for 5G PPP

Overall, the 5G PPP is performing well on 5G PPP specific KPIs as far as they can be assessed at this point in time. There are 4 performance KPIs, 3 KPIs related to business aspects 5 KPIs related to societal aspects.

3.2.2.1 Performance KPIs

The technical Annex to the 5G PPP contractual arrangement defines the following performance KPIs:

- Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010.
- Saving up to 90% of energy per service provided.
- Reducing the average service creation time cycle from 90 hours to 90 minutes.
- Creating a secure, reliable, and dependable Internet with a “zero perceived” downtime for services provision.
- Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people.

These KPIs have been refined during the execution of the 5G PPP Programme in various white papers. A more detailed and partly formal definition of the KPIs that are relevant for the performance of the 5G system have been defined by standards bodies such as ITU-T and 3GPP.

Report ITU-R M.2410-0 (11/2017) defines KPIs specific to the radio interface. These include *Peak data rate*, *User experienced data rate*, *Mobility*, *Latency* – separately for user plane and control plane, *Connection density*, *Reliability*, *Area traffic capacity*, *Peak spectral efficiency*, *5th percentile user spectral efficiency*, *Average spectral efficiency*, *Energy efficiency*, *Mobility interruption time* and *Bandwidth*.

In TS 28.554, 3GPP specifies end-to-end Key Performance Indicators (KPIs) for the 5G network and network slicing. 3GPP introduces KPI categories; *Accessibility*, *Integrity*, *Utilization*, *Retainability* and for future updates also *Availability* and *Mobility*. The categories are defined with reference to ITU-T Rec.E.800

Accessibility refers to Registered Subscribers of Network and Network Slice Instance through AMF and UDM, Registration success rate of one single network slice instance, as well as Data Radio Bearer (DRB) Accessibility for UE services. *Integrity* refers to End-to-end Latency of the 5G Network, Upstream/Downstream Throughput for network and network slice instance, Upstream/Downstream throughput at N3 Interface (between RAN and UPF) as well as throughput between RAN and UE. *Utilization* refers to the Mean number of PDU sessions of

²⁰ IPlytics, Who is leading the 5G Patent race?, A patent landscape analysis on declared SEPs and standards contributions, February 2021 <https://www.iplytics.com/>

²¹ <https://www.trendforce.com/presscenter/news/20210728-10872.html>

network and network Slice Instance and the Virtualised Resource Utilization of Network Slice Instance. Finally, *Retainability* refers to QoS flow Retainability.

Furthermore, NGMN published a Testing Framework for the NGMN 5G pre-commercial network trials. Among others this paper specifies general requirements for testing, deployment scenarios, trial setup requirements, trial test requirements and service or technology specific requirements for several identified KPIs, such as *Latency*, *User throughput*, *Cell Capacity*, *Spectral Efficiency*, *Coverage*, *Mobility*, *Reliability and Retainability*, *User Experience*, *Energy Efficiency*, *Inter-RAT procedures*, *RAN architecture split*, as well as *Location/Positioning service* and *Fixed Wireless Access*.

As can be derived from the main references above, there exists several KPIs with partly diverging definitions, although these definitions are being consolidated by the standards bodies and the industry. The *ad hoc* work group of the 5G PPP has made a successful attempt to provide a consolidated view of the KPIs that are being addressed by the various projects of the 5G PPP Programme. As explained in the PMR 2017, there cannot and will not be one single overall system analysis per Performance KPI across all 5G Infrastructure PPP projects. Moreover, the progress of 5G PPP through its phases has identified a specific need to study and develop a mapping of vertical KPIs to network KPIs so that a better understanding is achieved in relation to the actual needs of the verticals from the network infrastructure.

Since October 2019, the work in relation to technological KPIs is under the umbrella of the Test, Measurement and KPIs Validation (TMV) WG, including the active participation and stimulation from Full5G.

The Group is comprised by several Phase II and Phase III 5G PPP projects, and it considers the following research areas and technology domains:

- Testing KPI definition, KPI sources, collection procedures and analysis
- Testing frameworks (requirements, environment, scenarios, expectations, limitation) and tools
- Testing methodologies and procedures
- KPI validation methodologies
- Testing lifecycle (i.e., testing execution, monitoring, evaluation and reporting)
- Common information models for 5G T&M

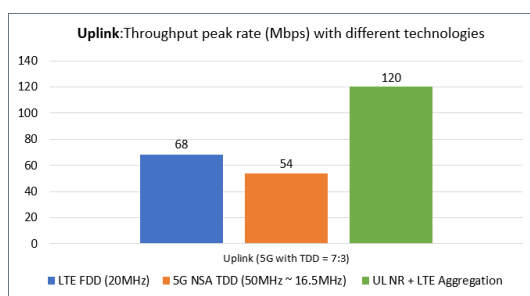


Figure 7: Uplink throughput peak rate

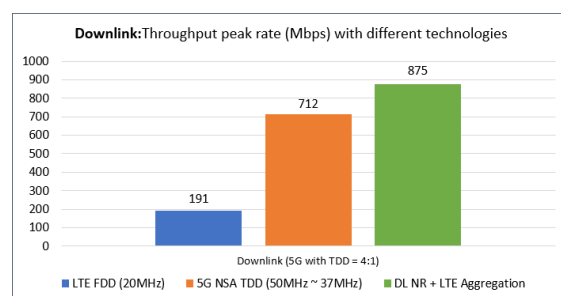


Figure 8: Downlink throughput peak rate

In relation to the 5G activities, and following on the third Phase of the PPP Initiative it was important to perform the following main tasks namely:

1. Collect, analyse, and evaluate the performance of experimental platforms (i.e., ICT-17 projects) and verticals related projects (ICT-19). The TMV WG has provided a white paper that explains the theoretical comparison of 4G and 5G networks and provided results for the impact of transport networks, the core vs edge deployment, the bandwidth availability, the MIMO layers, the uplink vs. downlink intensive patterns, the use of schedulers, the coverage and the transport

layer impact on the performance of the network. The white paper²² reports on key findings (e.g., Figure 7 and Figure 8) from the actual experimental infrastructures that show the benefits of 5G networks. This white paper is the first successful attempt to analyse the real performance of 5G PPP solutions. It is planned that as ICT-19 will have mature results from their testbeds a follow-up white paper will be prepared to provide further insight in the achievements of the projects.

2. Provide, through a concrete methodology a mapping of verticals' related KPIs to network related KPIs. Towards this end a white paper has been produced analysing vertical use cases of various domains for their performance KPIs and provides their mapping to 5G network KPIs²³. The scope was to identify (based on architectural elements analysis, information flow, etc.) the potential impact on the service performance and user perceived quality. The challenge was to understand the relative influence of 5G network performance indicators to the vertical services. The service/vertical KPIs identify the business and operational-oriented benchmarks and figures of merit that must be met to certify that the vertical services, once implemented, are fully functional (i.e., they work as expected to satisfy the demanded vertical requirements and agreed SLAs). The infrastructure KPIs are related to the computing and networking resources which will be allocated to support the vertical service. This work was of significance importance as this was the first time that was performed in a collective way covering the vertical areas of: Industry 4.0, Smart Cities and Utilities, Transportation, Automotive, Media & Entertainment, Agriculture & Agrifood, Smart (Air)-ports and e-health & wellness. This activity will serve as important first steps to improve the communication between vertical service providers and network providers. This work will continue and further enhanced and refined in the scope of the 5G PPP Initiative as additional projects dealing with the verticals are now active and are producing their own results.
3. Work on the test/experimentation procedure on how to collect measurements and calculate the KPI values. The 5GPPP TMV WG has published the basic concepts on experimentation methodology for 5G KPIs, guaranteeing the reliability of the measurements conducted. In addition, 5G PPP infrastructure projects (i.e., ICT-17 projects) have contributed to a recent ETSI Technical report related to Core Network and Interoperability Testing (INT) Methodologies for E2E Testing & Validation of Vertical Applications over 5G & Beyond network²⁴.

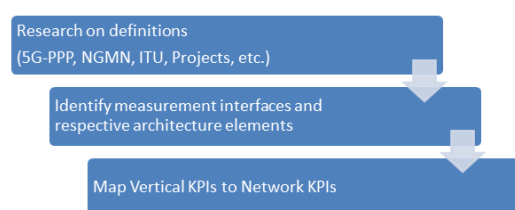


Figure 9: KPI mapping process

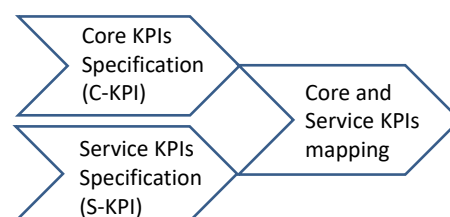


Figure 10: Procedure for mapping service KPIs to network KPIs

²² 5G PPP TMV WG, Understanding the Numbers: Contextualization and Impact Factors of 5G Performance Results, V1.0, July 2021, <https://5g-ppp.eu/white-papers/>

²³ TMV WG, Service Performance measurement methods over 5G experimental networks, May 2021, https://5g-ppp.eu/wp-content/uploads/2021/06/Service-performance-measurement-methods-over-5G-experimental-networks_08052021-Final.pdf

²⁴ ETSI TR 103 761, https://portal.etsi.org/webapp/WorkProgram/Report_WorkItem.asp?WKI_ID=59575

3.2.2.2 Business KPIs

In this section we analyse the KPIs related to business aspects. These are the following:

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

In section 3.2.1.1 a detailed methodology for estimating the leverage factor has been presented. As mentioned before the result from this calculation procedures show already excellent leverage factors:

- Large Industry and SMEs in 2020 mobilized private investments that sum up to an amount **13,58** times the public EC investment in the 5G PPP in the same period.
- All the types of stakeholders/beneficiaries invested in 2020 a total amount of money that is **10,93** times the public investment in the same period.

These numbers surpass the expected KPI values.

B2. Target SME participation under this initiative commensurate with an allocation of 20% of the total public funding

The SME participation in 5G PPP projects has been increasing in 2020 to reach and even exceed the original objective of 20% participation defined as a KPI of the programme²⁵. According to the H2020 dashboard²⁶, **the participation of SMEs in the 5G PPP has reached 21.95% of EU funding**, representing a total of €156.3 M.

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

The race for the deployment of 5G networks is still ongoing and data are constantly changing. European HQ companies have provided information that shows that European solutions are still on the forefront at a global level.

Ericsson itself has announced 143 commercial 5G agreements or contracts with unique operators²⁷. NOKIA itself has reported²⁸ 170 commercial 5G deals and 230+ commercial agreements as well as 67 live 5G operator networks.

Moreover, analysis from independent sources demonstrates that both for 2020²⁹ as well as the beginning of 2021³⁰ the EU HQ key 5G vendors enjoyed together roughly 1/3 of the total worldwide telecom equipment revenues.

At this point, we need to note however that the abovementioned data have been simply collected from public reports over the Internet and cannot be considered necessary as hard evidence, since these reports admit that not all companies have disclosed their total 5G contract wins yet.

²⁵ All 5G PPP calls have been included, now that the latest 5G PPP calls have been completed.

²⁶ <https://webgate.ec.europa.eu/dashboard/>

²⁷ <https://www.ericsson.com/en/5g/contracts>

²⁸ <https://www.nokia.com/networks/5g/5g-in-action/>

²⁹ <https://www.delloro.com/key-takeaways-total-telecom-equipment-market-2020/>

³⁰ <https://www.delloro.com/key-takeaway-1q-2021-total-telecom-equipment-market/>

3.2.2.3 Societal KPIs

In this section we analyse the KPIs related to business aspects. These are the following:

S1. Enabling advanced user-controlled privacy

As there have been no explicit calls in this area there are no date to be reported. It is planned that this societal KPI will be further addressed in the scope of the Smart Networks and Services Partnership.

S2. Reduction of energy consumption per service up to 90% (as compared to 2010)

As there have been no explicit calls in this area there are no date to be reported. It is planned that this societal KPI will be further addressed in the scope of the Smart Networks and Services Partnership.

S3. European availability of a competitive industrial offer for 5G systems and technologies

An analysis of the data in the latest publicly available reports such as IPlytics³¹ (February 2021), indicates that European companies share a 17,82% of 5G granted and active families, a 20,54% share of 5G EP/US granted/active families and a 15,64% share of 5G EP/US granted/active families not declared to earlier generations. In the same report it is illustrated that EU companies included in the “top” companies submitting technical contributions to 5G Standards share a 34,11% of 5G approved technical 3GPP contributions.

Finally, an analysis of publicly available results suggests that the EU HQ companies combined share roughly 1/3 of the total worldwide telecom equipment revenues.

Moreover, vertical industries (automotive, industry 4.0, healthcare, energy, etc.) will be instrumental in delivering the societal benefits of 5G. Currently, 5G PPP is providing solutions 10 vertical use cases (c.f., Annex 3 and Annex 7).

S4. Stimulation of new economically-viable services of high societal value like U-HDTV and M2M applications

Although 5G networks have been operational in several countries their full rollout has not taken place yet. Also, the uptake of 5G devices by consumers has still to pick up pace. Thus, it is still not clear which new services with high societal value will emerge. Note that the economic viability of such services requires some careful analysis and design. Under the context of the Vision and Societal Challenges WG a new Sub-Group has formed, called. “Business Validation, Modelling and Ecosystem SG” (BVME SG). During 2020 the WG has issued a white paper entitled business validation in 5G PPP vertical uses and is also working on the production on a related white paper entitled 5G ecosystems. The outcomes of this WG are expected to offer some useful insight.

In the meantime, 5G PPP Phase 2 and Phase 3 Projects are providing multiple trials and pilots, 17 of which are related to broadcasting and media. The online Verticals Cartography is a key tool for the 5G PPP tracking all use case experiments across phases 2 and 3 of the work programme in terms of:

³¹ <https://www.iplytics.com/>

- Industry verticals: agriculture and farming, automotive cross-border scenarios, automotive, broadcasting and media, energy, health, industry (manufacturing), public safety, satellite for verticals, smart cities (including experiments applicable to multiple verticals and indoor spaces), transport and logistics.
- Countries: experiments in single or multiple countries across Europe.
- Type of experiment: Proof of Concept, Prototype, Demonstration, Trial and Pilot.
- ITU functionality: eMBB, mMTC, URLLC.

The figure below shows the main entry page of this online tool.

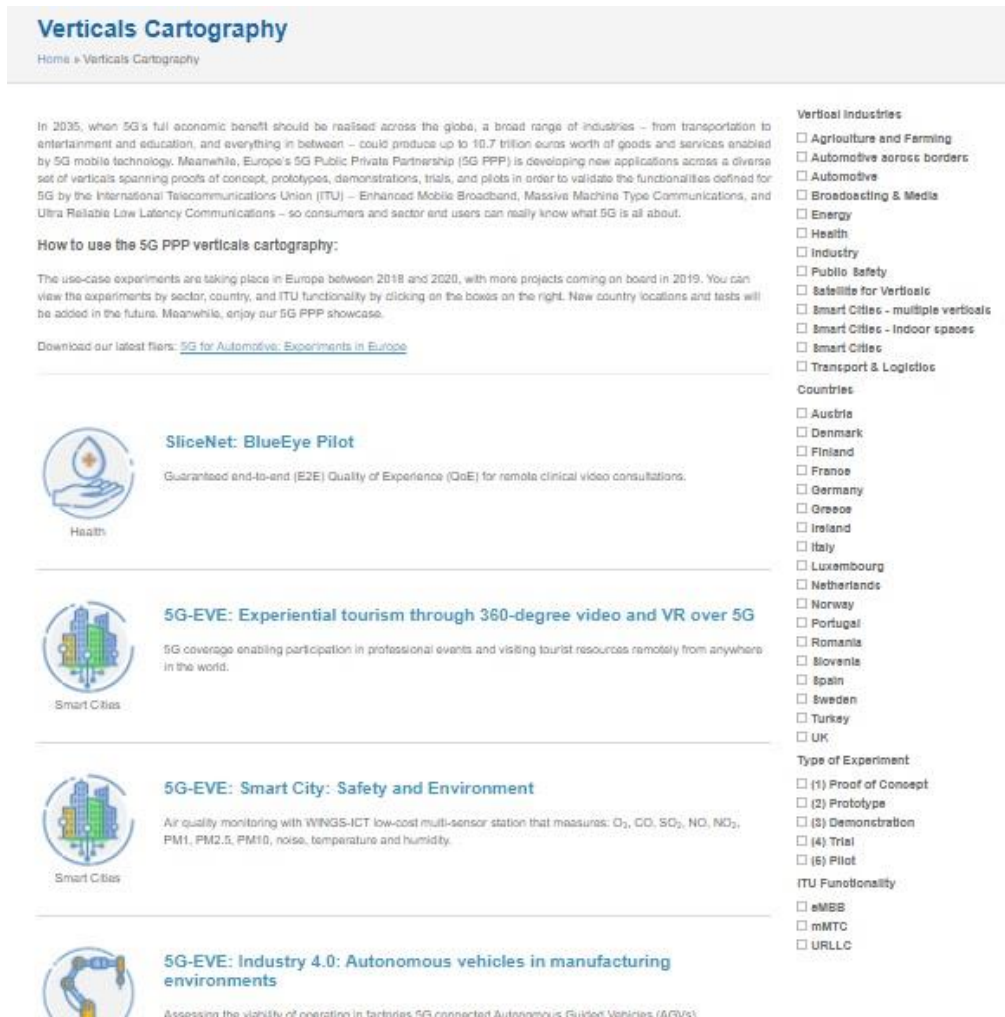


Figure 11: Online Verticals Cartography

S5. Establishment and availability of 5G skills development curricula (in partnership with the EIT)

Data for new curricula/qualifications created were collected through a questionnaire³² from 5G PPP project beneficiaries. These are defined as progressive values, referring to the period 2014-2020. A finer scale (e.g., per year) is very difficult to implement, since the creation of new

³² <https://5g-ppp.eu/5g-ppp-progress-monitoring-report-data-collection-2019/>

curricula/qualifications can be hardly calculated on a per-year basis and attributed to specific periods.

The following procedure was applied to calculate this KPI:

- Data for New 5G curricula and/or educational qualifications were collected through a questionnaire from 5G PPP project beneficiaries.
- Average values of the number of new curricula/qualifications were calculated per legal entity type (Large Industry, SME, Academic Institution, Research Center);
- On the H2020 Qlik Sense dashboard, the following information has been extracted:
 - (per legal entity type) # of beneficiaries for the following Phase 3 Call Topics: ICT-17-2018, ICT-18-2018, ICT-19-2019, ICT-20-2019-2020, ICT-42-2020, ICT-53-2020, ICT-41-2020, ICT-52-2020.
- The average values of these parameters have been multiplied by the total number of beneficiaries in each type subset to calculate the projected total values.

The result of this activity is summarized in the following table. **Again, the current achievements and trends are looking very promising.**

2014-2020	New 5G curricula and/or educational qualifications	
	Average	Total projected
<i>Overall</i>	3,06	3.120
Large Industry	2,00	926
SME	4,33	1.101
Academic Institution	2,89	442
Research Center	4,40	651

3.3 Evolution over the years

The 5G PPP consists of three phases of collaborative research. Thousands of researchers and developers across Europe have been working on innovative solutions for the definition of 5G. The activities for 5G networks started in the context of FP7 producing the first research concepts and directions and continued through Horizon 2020. This approach has served the goal of placing Europe in the leading position. As explained in Section 2.1, The 5G PPP has been designed in a structured way to start with innovative concepts (Phase 1), move through the development of key technical breakthroughs (Phase 2), and follow up with trials and pilots (Phase 3).

During 2020 all Phase II projects have successfully completed their activities and all last 5G PPP calls have been implemented. Thus in 2021 the last 30 5G PPP projects were active and are expected to further build on the momentum of the previous phases and produce results that will not only safeguard EU's position for 5G networks but also provide the initial pillars for 6G networks.

Note that the 5G PPP Programme has successfully managed to capitalize the results produced by past phases and use them in latest projects as shown in Figure 12.

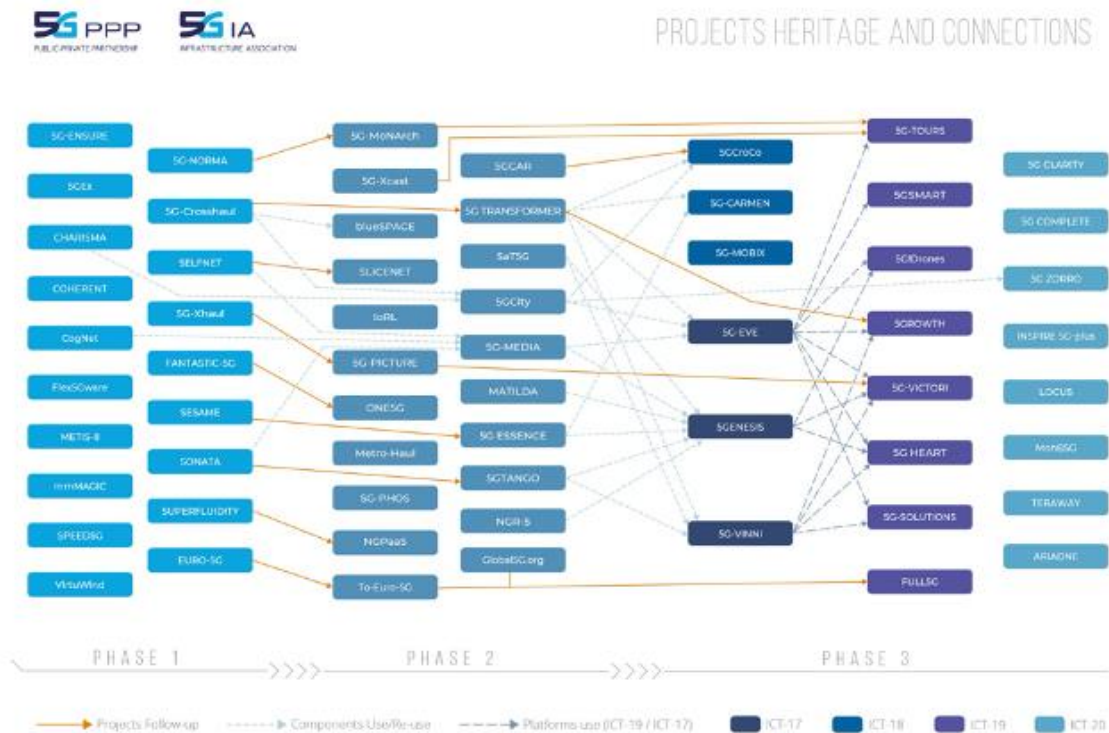


Figure 12: 5G PPP Projects - Heritage Figure

As we will discuss in the following section, the 5G PPP Programme has achieved several important and tangible results. Although in 2020 the last call for new Projects have been completed, already the overall results of the 5G PPP have been taken into consideration for the Smart Networks and Services Programme proposal as discussed in Annex 6.

4. Outlook and lessons learnt

The 5G PPP Programme has continued to provide valuable results during 2020. The quantification of the success has been recorded in this PMR with data and information on Programme KPIs.

The 5G PPP global impact achievements already include:

- A major impact on 5G standards with over 970 Tdoc contributions to SDOs for the definition of architecture options
- Beyond standards, proving the 5G system is working for more than 10 verticals' categories in multiple test/experiment sites
- 15 MoUs and 4 LoI signed between 5G IA and peer industry associations around the globe and industry organizations in priority vertical sectors

The 5G PPP is running smoothly under the current governance scheme. As 5G PPP is entering its final stage, the number of recorded achievements, the input to standardization organizations, the number of scientific publications, the significant number of trials are all proofs of the success of the Programme. The coordinated scientific work in the context of the working

groups and the task forces is ensuring the dissemination of 5G PPP results at a global level. The organization of meaningful trials all over Europe is assisting European companies to test in real life scenarios the 5G technology. Also, the overall planning of new Programme calls through the different versions of the PSM created a unique ecosystem that is bringing together multinational industries, SMEs, research Centres and universities

Moreover, there is a focus on truly disruptive vertical use-cases for 5G, as captured by the verticals' cartography. Note that Europe has strong industries, which provide great opportunities for cooperation between verticals (e.g., automotive, healthcare, transport, utilities) and the ICT domain.

5G PPP has already:

- Created 5G technology leadership for European industry
- Successfully achieved most of the challenging business and technical key performance indicators (KPIs) and is well on track for the societal ones
- Stimulated a high level of SME participation
- Had a positive impact on the innovation capacity of SMEs
- Mobilized huge private investments in 5G

Finally, the work in 5G PPP is enabling citizens and public authorities by:

- Supporting Europe's leadership in the digitization of industry and society
- Facilitating the creation of new societally beneficial services in 10 different vertical areas (e.g., smart cities, e-health, intelligent transport, power, environmental protection, education, entertainment & media)
- Enabling European e-inclusion through the rollout of high performant networks with pervasive access to all services

The abovementioned achievements have been realized through the hard work by many people. However, the work in this thematic area is not over. At the moment, other regions of the world have already started initiatives in the "beyond 5G" domain, placing considerable budgets in R&D activities in an attempt to place themselves in a better position for the 5G race. The 5G IA has setup a task force to design the way forward for the next decade. The Smart Networks and Services Partnership proposal is expected to capitalize on the 5G PPP results and further work to ensure Europe's global leading position in the 5G/6G era.

Annex Part 1 - The 5G Infrastructure Public-Private-Partnership

The 5G Infrastructure Public-Private Partnership (5G PPP) is the 5G collaborative research program that is organized as part of the European Commission's Horizon 2020 program (i.e., the European Union Program for Research and Innovation). Its aim is to foster industry-driven research, monitored by business-related, technological performance and societal KPIs. The 5G PPP will deliver solutions, architectures, technologies, and standards for ubiquitous next-generation communication infrastructure over the coming decades.

5G PPP is a 7-year partnership leading to the introduction of 5G infrastructure and the roll out of 5G services in Europe. It is one the biggest 5G research program in the world. Research in the 5G PPP has a very wide scope far beyond classical telecommunications.

5G PPP is a joint initiative between the European Commission and the European ICT industry. The Commission is investing 700 million € and the industry will leverage this investment by at least a factor of 5, bringing the total investment in the 5G PPP to more than 4 billion €. This will allow to rethink the infrastructure and to create the next generation of communication networks and services. The 5G PPP is therefore a good example of Europe's commitment to invest in ICT research at the right time to lead the world in capturing the benefits of 5G for both European Industry and Society.

Moreover, 5G PPP is aiming at securing Europe's leadership in the areas where Europe is strong and where there is potential for providing novel 5G application capabilities in “vertical” sectors, such as automotive, healthcare, smart factories, smart cities, education, media & entertainment, thus creating a new ecosystem. 5G PPP will therefore reinforce the European industry to successfully compete on global markets opening innovation opportunities.

5G PPP's goal is to maintain and enhance the competitiveness of the European ICT industry and to ensure that Europe can enjoy the economic and societal benefits these future networks will bring.

5G PPP was launched in December 2013. Since then, it has constantly grown and successfully implemented its program plan. 5G PPP's governing documents are available on its website³³.

The 5G PPP consists of three phases of collaborative research:

- **Phase 1** performed fundamental research for the 5th generation of network communications: 19 Projects were retained, many of them completed their work around mid-2017, while some ended their tasks during mid-2018. They provided important results on core 5G technologies and managed to develop solutions that can meet nearly all the performance KPIs for 5G.
- **Phase 2** uses these technologies for the digitisation and integration of vertical industries in Europe. It started in June 2017, with 21 new 5G PPP selected projects. In addition, there are 2 complementary projects dealing with international collaboration with Taiwan. Most Phase 2 projects will be completed in 2019, while some will continue in 2020. This phase is more focused on demonstrating and validating the developed technology and explicitly trying to integrate use cases from vertical industries beyond classical telecommunications.

³³ www.5GPPP.eu

- **Phase 3** addresses the development and rollout of 5G innovation and validation platforms across Europe. It started during the summer of 2018, with further calls preformed in 2019 and 2020.

Thousands of researchers and developers across Europe have been working on innovative solutions for the definition of 5G. 5G PPP projects are building pre-standards consensus and provide contributions to global standardization to strengthen Europe's influence on the 5G development.

Main bodies of the 5G PPP are the "Steering Board" (composed of the 5G PPP projects coordinators) and the Technology Board (composed of the 5G PPP projects technical managers), ensuring efficient collaboration and coordination among projects and working groups.

A key part of the 5G PPP structure is a set of cross-projects and cross-initiative working groups. Such 5G PPP working groups are the means to establish and publish program level opinions and positions on issues that impact all the projects and/or may be the basis for liaison or interaction with external bodies such as other regions or standards bodies. They are a) 5G Architecture WG, b) Software Networks WG, c) 5G Automotive WG, and d) Test Measurement and KPIs Validation WG.

Annex Part 2 - The 5G Infrastructure Association

During 2020 6 organizations were active 5G IA members. From these, 58 were full members whereas 3 of them were associate members. Additionally, 5G IA is collaborating with other partner organisations (e.g., 12 European and International organizations and industry associations) and it has signed 7 MoUs with international cooperation partners. Figure 13 shows the composition of the members.

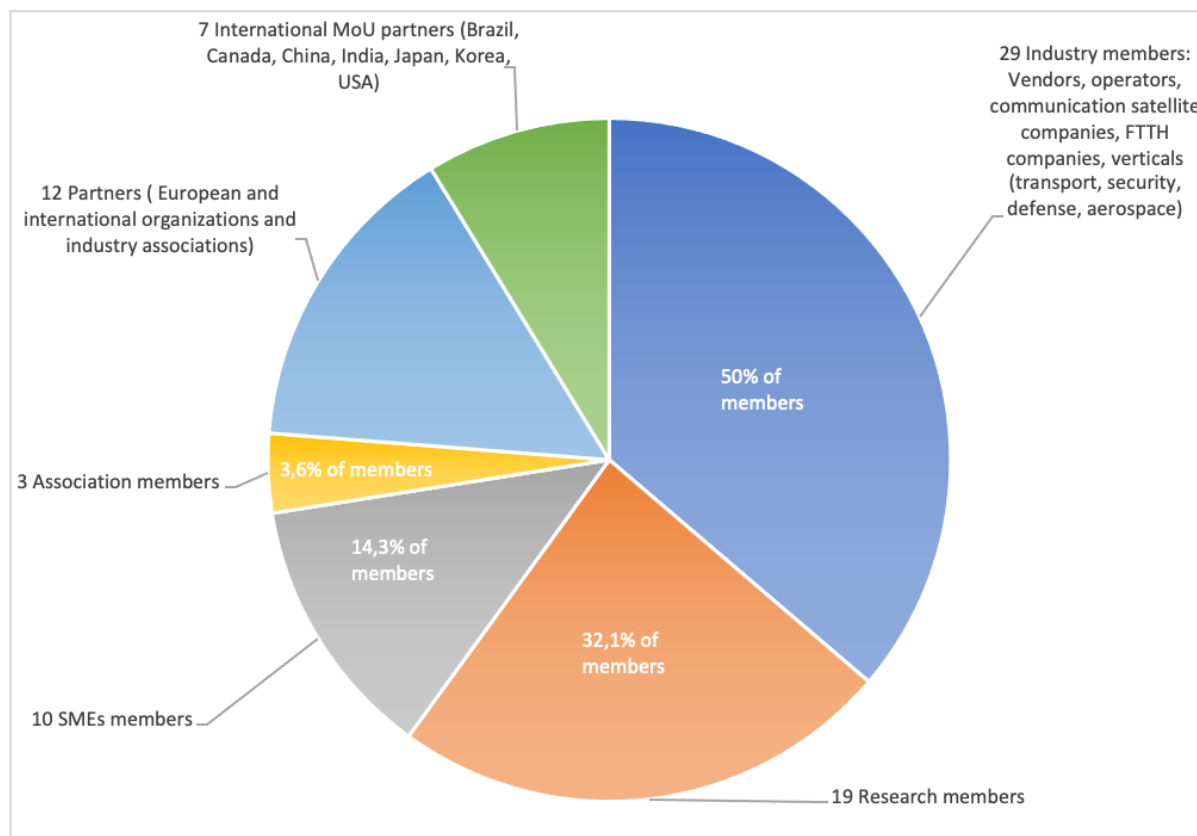


Figure 13: 5G IA membership versus type of stakeholders

The 5G IA carries out a wide range of activities in strategic areas including standardization, frequency spectrum, R&D projects, technology skills, collaboration with key vertical industry sectors, notably for the development of trials, and international cooperation. The overall objectives of the 5G IA are to promote R&D in the networks industry in order to strengthen it in the European Union, to foster technology skills in Europe, and to increase the competitiveness of the European industry by providing new tools and capabilities for manufacturing in Europe. In addition, the 5G IA is working to mobilise the community and in particular the SMEs in the European collaborative research projects.

As required by the 5G PPP Contractual Arrangement, the EU Commission and the Association have established the “**5G PPP Partnership Board**” comprising representatives from the European Commission (EC) and from the private side (i.e., from the 5G IA and Networld2020). This is the main body for dialogue and cooperation between the European Commission and the 5G IA.

Moreover, under the responsibility of 5G IA lie several WGs (c.f. *Figure 6*). These are: a) the Pre-standardization WG, b) the Spectrum WG (the operation of this WG were on pause during 2020 as not many 5G PPP projects are currently active in spectrum issues), c) the Vision and Societal Challenges WG, d) the Security WG, e) the Trials WG and f) ITU-R IMT 2020 Evaluation WG

Finally, 5G IA carries out three additional key activities:

- Activities based on the 5G PPP Contractual Arrangement & KPIs.
- International Cooperation Activity on 5G
- Activity on Community building and Public Relations

Annex Part 3 – 5G PPP Projects

The 5G Infrastructure PPP Programme and its related projects continued their impressive work during 2020, providing key results and significant achievements for 5G networks and their evolution.

	Technological Area	Projects
1	Performance Evaluation	Sat5G, 5G VINNI, 5GENESIS, 5GCroCo, 5G-TOURS, 5G-MOBIX
2	Cellular systems, Functional, Logical & Physical Architecture	5G MonArch, Sat5G, IoRL, 5G VINNI, 5GENESIS, 5G-CARMEN, 5GCroCo, 5G-MOBIX, 5GIDrones, 5GROWTH, 5G-TOURS
3	Radio Access Network	blueSPACE, 5G-PHOS, IoRL, 5G VINNI
4	Fronthaul, Backhaul and Metrohhaul	blueSPACE
5	Technology enablers	blueSPACE, 5G-CARMEN
6	Network Management and Orchestration of services	5G-MEDIA, 5G MonArch, blueSPACE, 5G EVE, 5G-CARMEN, 5GROWTH, 5G-SOLUTIONS, 5G-VICTORI
7	Software Networks	5GCity, 5G-PHOS
8	Security, Privacy, Resilience	5G MonArch, NRG5
9	Services Platforms and Programming Tools NetApps	5G-MEDIA, 5G EVE, 5G VINNI, 5GENESIS, 5G-CARMEN, 5G-VICTORI
10	Verticals Experimentation, Trials and Pilots	
	10.1 Industry 4.0	One5G, 5G EVE, 5G VINNI, 5GROWTH, 5G-SOLUTIONS, 5G-VICTORI
	10.2 Agriculture and Agrifood	5G-HEART
	10.3 Automotive	5GCAR, 5G-TRANSFORMER, One5G, 5G EVE, 5G-CARMEN, 5GCroCo, 5G-MOBIX, 5G-HEART
	10.4 Transport and Logistics	5G-PICTURE, 5G EVE, 5G VINNI, 5GENESIS, 5GIDrones, 5G-HEART, 5GROWTH, 5G-TOURS, 5G-VICTORI
	10.5 Smart Cities and Utilities	5GCity, 5G-PICTURE, One5G, SliceNet, 5G EVE, 5GENESIS, 5G-SOLUTIONS, 5G-TOURS
	10.6 Public Safety	5G ESSENCE, 5G VINNI, 5GENESIS, 5GIDrones
	10.7 Smart (air)Ports	5G MonArch, 5G-SOLUTIONS, 5G-TOURS
	10.8 Energy	SliceNet, 5G EVE, 5G VINNI, 5GROWTH, 5G-SOLUTIONS, 5G-VICTORI
	10.9 eHealth & Wellness	5G-TRANSFORMER, SliceNet, 5G-HEART, 5G-TOURS
	10.10 Media and Entertainment, Tourism	5G ESSENCE, 5G-MEDIA, 5G MonArch, 5G-PICTURE, 5G-TRANSFORMER, 5G EVE, 5GENESIS, 5GIDrones, 5G-SOLUTIONS, 5G-TOURS, 5G-VICTORI
11	Business Standardization and Regulation	5GCAR, 5GCity, 5G-MEDIA, 5G Monarch, Sat5G, SliceNet, 5G-CARMEN, 5GCroCo, 5G-MOBIX, 5GIDrones

Figure 14: 5G PPP Key Achievements v 3.0

During the reporting period the Key achievements v3.0 has been produced³⁴. Contrary to the Phase II key achievements, where these were mainly related to technological breakthroughs, the current list identifies the progress of 5G PPP according to overall plan that is related to gradual shifting from concepts to trials. Thus, as shown in Figure 14, most of the reported achievements are related to several trials related to 10 different vertical sectors. Also, many projects have further continued their work in the 5G architecture and in network management and orchestration of the services. These extensions were needed to further support their trials. Of course, some projects have offered also technological breakthroughs. However, analyzing the collected results it is easily identified that some topics (e.g., Software networks, Security Privacy Resilience, fronthaul, Backhaul and Metrohhaul, Radio Access Networks) had fewer projects working on these topics. This is to be expected to some extent as the Phase III of the 5GPPP Initiative was targeting more on large scale trials where the results from previous phases were being put in the real test.

³⁴ <https://5g-ppp.eu/key-achievements-v3/>

	Technological Area	Projects
1	Performance Evaluation	Sat5G, 5G VINNI, 5GENESIS, 5GCroCo, 5G-MOBIX, 5GROWTH, 5G-TOURS, 5G-VICTORI, ARIADNE
2	Cellular systems, Functional, Logical & Physical Architecture	5G MonArch, Sat5G, IoRL, 5G VINNI, 5GENESIS, 5G-CARMEN, 5GCroCo, 5G-MOBIX, 5GIDrones, 5G-TOURS, 5G-VICTORI, ARIADNE, 5G-CLARITY, 5G-COMplete, LOCUS, TERAWAY
3	Radio Access Network	blueSPACE, 5G-PHOS, IoRL, 5G VINNI, ARIADNE, 5G-CLARITY, 5G-COMplete,
4	Fronthaul, Backhaul and Metrohhaul	blueSPACE, ARIADNE, TERAWAY
5	Technology enablers	blueSPACE, 5G-CARMEN, 5GIDrones, ARIADNE, INSPIRE-5G PLUS, LOCUS, TERAWAY
6	Network Management and Orchestration of services	5G-MEDIA, 5G MonArch, blueSPACE, 5G EVE, 5G-CARMEN, 5GROWTH, 5G-SOLUTIONS, 5G-CLARITY, 5G-COMplete, INSPIRE-5G PLUS, MONB5G, TERAWAY, 5G ZORRO
7	Software Networks	5GCity, 5G-PHOS, 5G-CLARITY
8	Security, Privacy, Resilience	5G MonArch, NRG5, INSPIRE-5G PLUS, MONB5G, 5G ZORRO
9	Services Platforms and Programming Tools NetApps	5G-MEDIA, 5G EVE, 5G VINNI, 5GENESIS, 5G-CARMEN, LOCUS
10	Verticals Experimentation, Trials and Pilots	
	10.1 Industry 4.0	One5G, 5G EVE, 5G VINNI, 5GROWTH, 5G-SMART, 5G-SOLUTIONS, 5G-CLARITY
	10.2 Agriculture and Agrifood	5G-HEART
	10.3 Automotive	5GCAR, 5G-TRANSFORMER, One5G, 5G EVE, 5G-CARMEN, 5GCroCo, 5G-MOBIX, 5G-HEART
	10.4 Transport and Logistics	5G-PICTURE, 5G EVE, 5G VINNI, 5GENESIS, 5GIDrones, 5G-HEART, 5GROWTH, 5G-TOURS, 5G-VICTORI
	10.5 Smart Cities and Utilities	5GCity, 5G-PICTURE, One5G, SliceNet, 5G EVE, 5GENESIS, 5G-SOLUTIONS, 5G-TOURS, 5G-VICTORI
	10.6 Public Safety	5G ESSENCE, 5G VINNI, 5GENESIS, 5GIDrones, 5G-VICTORI
	10.7 Smart (air)Ports	5G MonArch, 5G-SOLUTIONS, 5G-TOURS
	10.8 Energy	SliceNet, 5G EVE, 5G VINNI, 5GROWTH, 5G-SOLUTIONS
	10.9 eHealth & Wellness	5G-TRANSFORMER, SliceNet, 5G-HEART, 5G-TOURS, 5G-VICTORI
	10.10 Media and Entertainment, Tourism	5G ESSENCE, 5G-MEDIA, 5G MonArch, 5G-PICTURE, 5G-TRANSFORMER, 5G EVE, 5GENESIS, 5GIDrones, 5G-SOLUTIONS, 5G-TOURS, 5G-VICTORI
11	Business, Standardization and Regulation	5GCAR, 5GCity, 5G-MEDIA, 5G MonArch, Sat5G, SliceNet, 5G VINNI, 5G-CARMEN, 5GCroCo, 5G-MOBIX, 5GIDrones, 5GROWTH, 5G-SMART, MONB5G

Figure 15: 5G PPP Key results v3.1

A slightly different picture was presented during the collection and processing of key results v3.1³⁵ (Figure 15). In total, more than 100 achievements have been reported that have been grouped in 11 different categories. As this version was based on version 3.0, key achievements from phase II projects (all of them completed by the end of 2020) have been kept in list but marked in red in the following figure so to provide a better understanding of the areas Phase 3 is currently covering.

Compared to the previous version, the latest list of key achievements v3.1 illustrated that the introduction of ICT-20 projects has further pushed the research activities in all technological domains. This is to be expected as the 5G-PPP Phases and the related pre-structuring model have been designed in such a way to allow the promotion of 5G in verticals and at the same time the further investigation of topics related to the evolution of 5G and touching on topics that are currently considered as suitable candidates for 6G networks (e.g., smart surfaces, THz communication, AI for network automation, etc.).

Thus, as shown in the figure, most of the reported achievements are related to a number of trials related to 10 different vertical sectors. Also, many projects have further continued their work in the 5G architecture and in network management and orchestration of the services. These extensions are needed to further support their trials. Of course, some projects have offered also technological breakthroughs the number of which is expected to grow as the ICT-

³⁵ <https://5g-ppp.eu/key-achievements-v3-1/>

20 project will in full speed during 2020. For a detailed presentation of Phase 2 and Phase 3 5G PPP projects' activities the reader can refer to the European 5G Annual Journal of 2020³⁶.

Moreover, 5G PPP Infrastructure, Trials and Pilots Brochure (N° 2), based on the outcomes of the annual competition launched by the 5G IA Trials WG, with the evaluation committee selecting the top ten trials and pilots. The brochure was published in December 2020³⁷.

In relation to verticals, a significant milestone achieved was the production of 5G PPP and EC White Paper, 5G Empowering Vertical Industries (September 2020)³⁸. This white paper analysed how 5G networks have been used by 5G PPP projects to serve several verticals. The analysis has identified key features that have been used and demonstrated that 5G is not only about speed, delay and reliability but it is also about flexible service design, deployment and support.

5G Features	Automotive Section Error!	Transportation Section Error!	Media Section Error!	Smart City Section Error!	Healthcare Section Error!	Smart Factories Section Error!	Energy Section Error!	Public Safety Section Error!	(Air)Ports Section Error!	Tourism Section Error!	Agrifood Section Error!
Network Slicing	X	X	X	X	X	X	X	X	X	X	X
Mobile Edge Computing	X	X	X	X	X				X	X	X
Functional Split in RAN		X	X								
Advanced Security	X			X					X		
Smart network management			X	X	X		X	X			
Location services & Context Awareness	X	X	X		X	X		X	X		
5G NR capabilities	X	X	X	X	X	X	X	X	X	X	X
Softwarization	X		X		X				X		
Service chaining		X	X		X						
Traffic steering			X								
Spectrum and Coverage	X	X	X								
Guaranteed QoS	X	X		X	X	X	X				

Figure 16: 5G functionalities used in 5G PPP vertical trials

³⁶ <https://bscw.5g-ppp.eu/pub/bscw.cgi/d356008/Full%205G%20Annual%20Journal%202020.pdf>

³⁷ 5G PPP, Trials and Pilots, December 2020,

https://5g-ppp.eu/wp-content/uploads/2020/12/5GInfraPPP_10TPs_Brochure2.pdf

³⁸ 5G PPP and 5G IA, Empowering Vertical Industries through 5G networks – Current Status and future trends, <https://5g-ppp.eu/wp-content/uploads/2020/09/5GPPP-VerticalsWhitePaper-2020-Final.pdf>

Finally, based on the 5G PPP projects, the 5G PPP online Verticals Cartography has been developed and used. This is a key tool for tracking all use case experiments across phases 2 and 3 in terms of industry vertical coverage, country locations for trials and pilots and ITU functionalities targeted.

Impacts are measured in terms of views of each entry and overall viewing trends over time. The figure below shows the views for the period September 2020 to July 2021, including August 2020 as the end of the first reporting period.

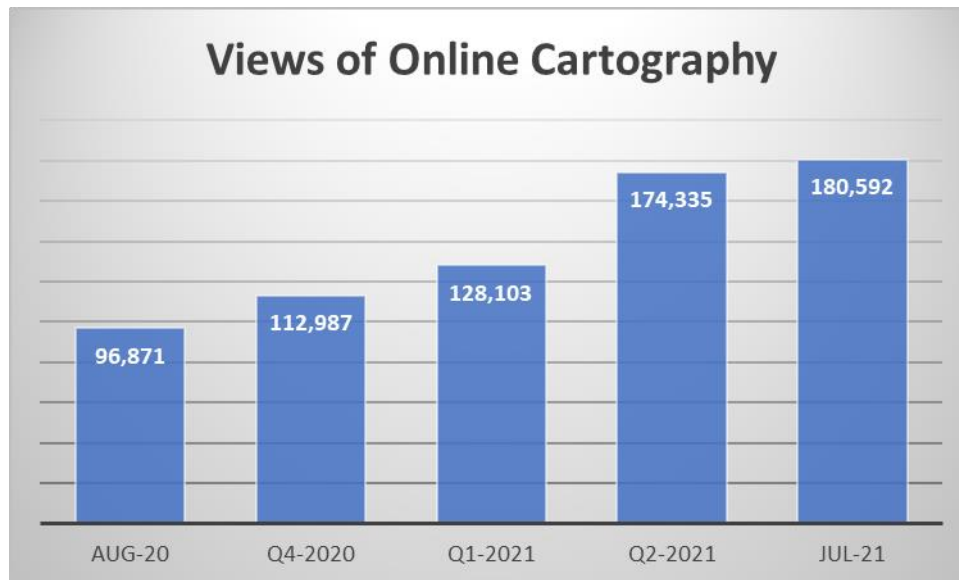


Figure 17: Views of Verticals cartography

Annex 4 - 5G PPP working groups and their activities

As mentioned in section 2, a key part of the 5G PPP structure is a set of cross-projects and cross-initiative working groups. The outcome of the work from these groups is presented in white papers³⁹. The first white paper was produced in October 2015. Below follows a description for the activities of each WG and their achievements during the reporting period.

Architecture WG

The Architecture Working Group (WG) as part of the 5GPPP Initiative has been capturing novel trends and key technological enablers for the realization of the 5G architecture. Also, it has been presenting in a harmonized way the architectural concepts developed in various projects and initiatives (not limited to 5GPPP projects only) so as to provide a consolidated view on the technical directions for the architecture design in the 5G era. With the 5G system being mature with three fundamental 3GPP releases from Release 15 toward Release 17, the work in the Architecture WG is currently factoring in the enhancements beyond 5G (B5G), which will be followed by the foundation of the next generation 6G system. While the work in the WG captures and impacts the most recent specification and standardization works, the scope goes beyond the state-of-the-art with the aim to impact the future standards releases. To this end, Architecture WG brings 5GPPP projects together to attain the European View on the Overall Architecture of Mobile and Wireless Communications Networks and the Network Domains, which is then published in the form of white papers and also presented during the technical workshops in the international conferences and webinars.

The latest publication from the Architecture WG has been the third version of the white paper titled “View on 5G Architecture”, where the final version was released in February 2020⁴⁰. The work in the third version of the white paper has mainly focussed on the 5G PPP Phase II projects and back then newly established Phase III, Part 1 Infrastructure Projects (ICT-17-2018 Call) with special emphasis on understanding the requirements from vertical industries involved in the projects and then driving the required enhancements of the 5G Architecture able to meet their requirements. After the finalization of the white paper v3.0, as part of a typical procedure, the Architecture WG had been inactive to provide the necessary time to the new projects to progress on their research work. On this basis, the WG has re-started the work in October 2020 with the inclusion of ongoing and new 5GPPP Projects (the ones from ICT-17-2018, ICT-18-2018, ICT-19-2019 and ICT-20-2019 calls⁴¹). Further projects from the recent calls (the ones from ICT-41-2020⁴², ICT-42-2020, and ICT-53-2020⁴³ calls) are being integrated.

Along with the reactivation, the Architecture WG has contributed to the 5GPPP white paper “Empowering Vertical Industries through 5G Networks”⁴⁴ with focus on architectural considerations for the verticals, where the key enablers have been outlined. The contribution

³⁹ <https://5g-ppp.eu/white-papers/>

⁴⁰ Simone Redana, Ömer Bulakci (overall editors), et al., “View on 5G Architecture,” Feb. 2020. Available at: https://5g-ppp.eu/wp-content/uploads/2020/02/5G-PPP-5G-Architecture-White-Paper_final.pdf

⁴¹ 5GPPP Phase 3 Projects (ICT 17, ICT 18, ICT 19, ICT 20 calls), <https://5g-ppp.eu/5g-ppp-phase-3-projects/>

⁴² 5GPPP Phase 3 Projects (ICT 41, ICT 52 calls) <https://5g-ppp.eu/5g-ppp-phase-3-6-projects/>

⁴³ 5GPPP Phase 3 Projects (ICT 42, ICT 53 calls) <https://5g-ppp.eu/5g-ppp-phase-3-5-projects/>

⁴⁴ Alexandros Kaloxylas, Raffaele De Peppe, Anastasios Gavras (overall editors), et al., “Empowering Vertical Industries through 5G Networks – Current Status and Future Trends,” Aug. 2020 <https://5g-ppp.eu/wp-content/uploads/2020/09/5GPPP-VerticalsWhitePaper-2020-Final.pdf>

has also been presented in the associated webinar⁴⁵. In a further webinar titled “Beyond 5G Evolution,”⁴⁶ the WG has presented the scope of Architecture WG along with the future plans for providing the consolidated European View on the B5G/6G system.

Since October 2020, the Architecture WG has been working on the next consolidation phase with the involvement of the above-mentioned projects toward the white paper v4.0 with the aim of completion within 2021. It is envisioned that the next white paper will be the last one on the 5G system and the evolution thereof. That is, the white paper v4.0 will highlight the key architectural innovation points and findings from the 5G PPP projects that will bridge the evolution of the 5G architecture toward the future 6G mobile and wireless networks. The newest generation of projects are already working on beyond 5G topics, and most of them have formulated work items under the 6G theme. In particular, the projects kicked off in 2021 within the framework of Smart Connectivity Beyond 5G (ICT-52-2020 call), which are doing research into the 6G system, will be gradually integrated into the Architecture WG to set the scene for the future work focusing on the next generation mobile and wireless networks. The outcome will then be covered in a new white paper with the aim of completion within 2022.

Software Networks WG

During Phase 1, the WG focused on demystifying the important role of Software Defined Networks (SDN) and Network Function Virtualization (NFV) as pillars in the 5G transformation. SDN and NFV are different expressions of an overall transformation trend named “softwarization”.

The expression “softwarization” is often referred to a general paradigm shift in telecom architecture from “boxes” to “functions”, and from “protocols” to “APIs”. The softwarization is one of the features of a more powerful transformation named cloudification.

The cloud has disrupted the established order in many sectors. And the reason is simple. With it, companies have been able to reduce the investment in their internal data centres in favour of unlimited computing resources, available on demand and billed for use. From now on, the competitiveness of a company depends directly on its capability to quickly realize new ideas. Start-ups understand this well, so they rely on native cloud approaches to disrupt traditional sectors. It becomes obvious that innovations should be made cloud-native for being successful where the functions are designed for a cloud environment rather than packaged up and deployed onto it (virtualization).

During the phase 2 and phase 3.1 of 5G PPP, the Working Group achieved to demystify the “Cloud Native”. A first white paper was published in 2018 providing insights into 5G cloud-native design: the shift from the cloud ready to cloud native, from virtual machine to container, from MANO to Kubernetes, etc. As a follow-up of the 2018 Cloud-Native transformation white paper, the WG published a second white paper identifying the adoption barriers. The Software Networks Working Group conducted a survey to collect technical inputs from 5G PPP Phase 2 and Phase 3.1 projects on their 1) supported vertical use-cases, 2) adopted virtualization technologies and 3) followed architecture patterns.

With the launch of the recent phases, a new ToR has been agreed for the period 2021-2023 focusing on the platform approach and identification the key technological challenges to transform the network to a more open model.

⁴⁵ Webinar, “Empowering Vertical Industries through 5G Networks – The 5G PPP experience,” Sept. 2020 <https://5g-ppp.eu/event/webinar-empowering-vertical-industries/>

⁴⁶ Webinar, “Beyond 5G Evolution,” Nov. 2020 <https://www.mdpi.com/about/announcements/2276>

Key Activities and Achievements-

- Main Activities
 - Every three weeks, the WG organize a call where the different involved projects share their technical findings and collaborate on the joint white papers.
 - The WG chair and the participants believe that the WG should be the place where we can learn and exchange between the projects to build and enforce the collaboration. For that, technical workshop has been organized focusing on new technologies/topics, new industry trend, etc. For example, one can cite the serverless and its utility in IoT domain, P4 programming, FPGA virtualization etc.
 - Discussion of Workplan for Y2020/2023 (targeted contributions/material, workshops). Different topics have been identified.
 - Continuous participation in 5G PPP Steering Board (SB) and Technical Board (TB) meetings: working towards whitepapers of concerns and providing WG updates.
 - Continue to cross-fertilise with other WGs of interest e.g. Architecture WG, and others.
 - The WG is editor of Section 6 on the Key Technologies for the EDGE computing in the 5G IA WP on Edge Computing.
- Main Achievements
 - The WG published in Feb 2020 a four-page paper depicting the three phases to evolve from Virtual Network Functions (VNFs) to Cloud-Native Functions (CNFs). This publication has been intended for MWC-2020.
 - The WG is collecting and tracking the different Open-Source contributions from the different projects. This collection has been generalized, beginning of 2020, to all 5G-PPP projects.
 - Workshop in EuCNC 2020: 14 projects are engaged in this workshop which represents a great opportunity to extend collaborations between Phase2 and Phase 3 projects ICT-17, ICT-18, ICT-19 and ICT-20 and paving common exploitation strategies. The title was: “Third edition on From Cloud Ready to Cloud Native transformation: Operations and Performances”.

5G Automotive WG

5G Automotive WG

The objectives of this WG include the following:

- To become a common platform to facilitate the discussion between 5G PPP projects developing V2X and Vehicle-as-Infrastructure concepts, components, applications and trials, with focus on the automotive vertical
- To constitute an interface with another 5G PPP bodies and WG, in order to contribute to the holistic design of 5G
- To work towards the identification of new use cases and requirements for the connected automotive vertical which can go beyond what technology can provide today

- To conduct a gap analysis - at project level - which can generate inputs for the definition of future research roadmap in the automotive field
- To interact with the ITS and 5G ecosystem including all stakeholders identified in the White Papers published to date by this WG, with the aim of facilitating consensus building on the 5G automotive roadmap strategy

Key Activities and Achievements

There was a change in the chairmanship of the WG shortly after the beginning of Year 1 of Full5G. Mikael Fallgren, coordinator of the 5G-CARS project which was concluding in August 2019, passed the chairmanship to Jesus Alonso-Zarate, coordinator of the 5GCroCo project.

There was a hiatus in meetings of the WG in the second semester of 2019, with the WG starting up again in January 2020 under the new chairmanship. One of the first tasks of the WG when starting up again was therefore to determine what its new set of activities would be, after closing out the production of the White Papers in 2019.

One task quickly agreed was continuing contributions from the WG to the evolution of the Strategic Deployment Agenda (SDA). Several SDA meetings were held during the lockdown period in which WG members participated. Several interactions with other stakeholders (GSMA, 5GAA, ACEA etc.) took place for the preparation of the SDA and the endorsement of the SDA by the corresponding alliances / organisations. The updated version of the 5G SDA for Connected and Automated Mobility in Europe published in October 2020. Next steps include: a) the analysis of cooperation models enabling the deployment and use of 5G infrastructure for CCAM and b) detailed deployment planning in view of CEF2; ICT-18 projects will provide a study considering the corridors used in the corresponding projects.

In an analogous initiative, the CCAM partnership prepared a strategy document (the Strategic Research and Innovation Agenda – SRIA), in which the WG members were also invited to contribute – primarily seeking to provide unified feedback and helping to align the SNS and CCAM groups. Automotive WG members prepared an initial list of topics, where collaboration / alignment between CCAM and SNS could be discussed and clarified the requirements and the interests of each partnership.

A contribution was made to the White Paper on Verticals that was planned for the European ITS Congress in May 2020.

In liaison activities, there was a meeting in April 2020 with ERTICO after signature of the MoU with the 5G IA. This resulted in a formalisation of contact with ERTICO and 5GAA to identify possible areas of collaboration within the context of the MoU.

The WG leadership participated in the Technology Board eWorkshop on 26-27 May 2020, chairing a special session on ICT-18 projects.

There have been presentations of projects in which the current WG members participate:

- 5G-CroCo
- 5G-Mobix
- 5G-CARMEN
- 5G!Drones
- 5G-HEART

Further such presentations are planned as appropriate and consistent with the WG membership.

The WG has updated its terms of reference. One particular element of study was the question of whether the scope of the WG should be broadened beyond the pure automotive sector to a more general “transportation” sector. Although there is agreement that this could be desirable, there is some discussion of how to interpret “transportation”. Since, 5G-enabled Connected and Automated Mobility (CAM) has broadened its scope of application to now include road, rail, drones, maritime, etc. It was agreed the Automotive WG to take into consideration these additional industries (e.g., automotive, rail) and transportation means (e.g., buses, trucks, drones, trains).

New memberships were added in the Automotive WG, coming from new projects from Call ICT-53 on 5G for CAM. Furthermore, an Automotive WG White Paper is planned, involving ICT-53 projects, providing a vision of CCAM for the future (e.g., possibly with a 2030 horizon). The target event for presentation is EuCNC-2022.

The WG prepared two white papers during the reporting related to a) 5G trials for CCAM along European cross-border corridors⁴⁷ and b) the strategic deployment agenda for CCAM in Europe⁴⁸.

Test, Measurement and KPIs Validation WG

The Test, Measurement, and KPIs Validation (TMV) Working Group was founded as part of the 5G PPP effort to promote commonalities across projects with strong interest in the T&M methodologies. This in support to the vertical use cases in the 5G Trial Networks. Such efforts include the development of Test and Measurement methods, test cases, procedures and KPI formalization and validation to the greatest possible extent, ensuring a unique European vision on how to support the entire lifecycle of the 5G network, from R&D to actual deployed environments.

The Group is comprised by several Phase II and Phase III 5G PPP projects, and it considers the following research areas and technology domains:

- Testing KPI definition, KPI sources, collection procedures and analysis
- Testing frameworks (requirements, environment, scenarios, expectations, limitation) and tools
- Testing methodologies and procedures
- KPI validation methodologies
- Testing lifecycle (i.e. testing execution, monitoring, evaluation and reporting)
- Common information models for 5G T&M

Another important topic is the use of and contribution towards open-source projects such as OSM, OPNFV or ONAP and standardization bodies like ETSI INT, as well as the identification of relevant exploitation and dissemination targets to promote the European vision on T&M towards a more global adoption.

2020 achievements

TMV WG organised 16 conference calls and one workshop to discuss the WG current activities, progress and identify next steps. TMV WG completed the definition of a set of core KPIs that are used as the basis for the next developments in TMV WG.

⁴⁷ https://5g-ppp.eu/wp-content/uploads/2020/10/5G-for-CCAM-in-Cross-Border-Corridors_5G-PPP-White-Paper-Final2.pdf

⁴⁸ https://5g-ppp.eu/wp-content/uploads/2020/10/20201002_5G_SDA_for_CAM_Final.pdf

TMV WG progressed the work on the testing methodologies, tools, and procedures, on KPI validation methodologies and on the testing lifecycle. During the Q4 of 2020, TMV WG initiated discussions and contributions to the ETSI INT Working Item on “Vertical Application Testing and Validation” and scheduled ad hoc conference calls to coordinate the liaison between the TMV and the ETSI INT WI.

It also continued the onboarding procedures of the new ICT projects within the Group. In addition, TMV WG started the Vertical KPIs Task Force combining the effort of ICT-19 projects toward providing a common understating on vertical KPIs. During 2020, Vertical KPIs TF analyzed 9 vertical areas towards mapping service KPIs to network KPIs are illustrated in the matrix below:

	Industry 4.0	Agriculture & Agri-food	Automotive	Transport & Logistics	Smart Cities & Utilities	Smart (Air)ports	Energy	E-health & Wellness	Media & Entertainment
5G DRONES				x					X
5G HEART		v	v					v	
5G GROWTH	v			v			v		
5G SMART	x								
5G SOLUTIONS	v				v	v	v		v
5G TOURS								v	v
5G VICTORY				v			v		v
5G CROCO			v						

Future plans

The TMV WG is planning to publish two whitepapers by mid-2021 to report the progress and findings of both TMV WG and Vertical KPIs TF:

- Whitepaper to be released by TMV WG on “Contextualization and Impact Factors of 5G Performance Results” based on the analysis and validation results of Phase II and Phase III 5G PPP projects.
- Whitepaper to be released by Vertical KPIs TF on “Service performance measurement methods over 5G experimental networks” based on the analysis of vertical use cases of various domains for their performance KPIs and their mapping to 5G network KPIs.

White papers produced by the 5G PPP WGs

Since the creation of the WGs 30 white papers⁴⁹ have been produced overall until the end of 2020. Ten of these white papers have been produced during 2020. These are:

- INSPIRE-5Gplus Whitepaper on “Intelligent Security Architecture for 5G and Beyond Networks” (November 2020).
- 5G PPP projects impact on Standards Development Organisations (SDOs)— (Technical Report, October 2020)
- 5G Trials for Cooperative, Connected and Automated Mobility (CCAM) along European Cross-Border Corridors – (October 2020)

⁴⁹ <https://5g-ppp.eu/white-papers/>

- 5G Strategic Deployment Agenda for Connected and Automated Mobility in Europe – (October 2020)
- Empowering Vertical Industries through 5G Networks – (September 2020)
- Business Validation in 5G PPP Vertical Use Cases – (June 2020)
- On Board Procedure to 5G PPP Infrastructure Projects – (April 2020)
- 5G PPP 5G Architecture White Paper – Consolidated Version, February 2020.
- 5G PPP Software Network WG Paper: “Cloud-Native and 5G Verticals’ services” February 2020
- 5G network support of vertical industries in the 5G PPP ecosystem, February 2020.

Annex 5- 5G Initiative: Boards’ activities and achievements

The 5G PPP Initiative is a complex structure engaging a significant number of stakeholders. The Steering and Technology Boards play a crucial role in the overall synchronization of the involved entities and the success of the Initiative. **These Boards** in full synchronization and cooperation with the 5G IA Board, the 5G IA Verticals Task Force and the strong support of the CSA project **have produced some significant results** (e.g., white papers from the WGs, workshops organized by WGs or projects, etc.). The Technology Board organized **regular conference calls** (every 2-3 weeks on average) and **two virtual meetings (due to the pandemic)** in 2020.

The list below highlights some of the major achievements at Programme and Technology Board level.

The list below highlights some of the major achievements at Programme and Technology Board level.

- Jointly with the Full5G project, the verticals cartography for Phase 3 projects has been created. It contains information about the experiments per project, their location, the type of the experiment, their scheduled date, their relation to network slice types and the vertical consortium partners involved.
- The “5G Infrastructure PPP – Trials & Pilots Brochure 2.0” has been produced that highlights the key results of ten Phase 2 and Phase 3 Trials & Pilots.
- The 5G PPP “Heritage figure” has been produced. It illustrates the links between the projects during the different phases, demonstrating the continuity of research activities in the context of 5G PPP
- In relation to the analysis of the performance KPIs, TB has assisted the Test, Measurements and Validation WG to record and analyse the measured network KPIs in the PPP platforms and the providing a comprehensive mapping on how vertical services KPIs are mapped into network KPIs. This activity is expected to complete its first phase during the first half of 2021.
- The key achievement list v3.0 has been produced and disseminated, illustrating the impact 5G PPP projects are having in the evolution of 5G networks
- The TB has actively assisted in the interactions with other international activities (e.g., EMPOWER action US NSF / PAWR and PPP / ICT-17/19 Platforms)
- Preparation of two white papers in relation to services provided by ICT-17 projects and the n-board procedure to them have also been produced

- Preparation, in collaboration with 5GIA's Vertical Task Force of a white paper for the empowerment of verticals through 5G networks and dissemination of the key findings via a dedicated webinar
- Creation and update of several cartographies including the trials and pilots' summary table that captures the planned tests from each project
- Organized the collective work between projects for white papers in different technical areas (i.e., Edge Computing, AI & ML in 5G networks, and Indoor 5G networks) that are expected to be delivered in 2021.
- Two TB workshops have been organized. Due to the COVID pandemic both workshops were electronic ones. The first one took place in May 2020. During the meeting, it was discussed how to further coordinate activities for the interworking of ICT-17 and ICT-19 projects, how to capture and analyse the network KPIs, setup the work on white papers, the impact of 5G on business validation, and further work was done on the preparation of Key achievements v3.0. Also, one session was dedicated in the progress of the Automotive projects. The second workshop, that took place in December 2020, focused on the progress of the ongoing white papers, on the activities undertaken mainly from ICT-20 projects for the evolved RAN and the use of AI-ML solutions. Moreover, special emphasis was given on the progress in the area of vertical industries where a whole working day was dedicated to it.
- All working groups have been very active and produced several White Papers, Positions Papers and workshops. During 2019, and the beginning of 2020 seven white papers have been produced covering different aspects for 5G networks.

Annex 6 - 5G IA Activities and Achievements

5G IA is actively involved in the realization of 5G in Europe through several groups and actions, including: the ‘partnership board’, one task force, 9 WGs and three key activities. A detailed description of the activities performed under the 5G IA WGs, will be included in To-Euro-5G Deliverable 5.2 – Year 2 on WG Achievements. The following subsections record their outcomes and key achievements of all 5G IA activities.

Verticals Engagement Task Force

The Vertical Engagement Task force provided top-down guidance to bottom-up activities within 5G PPP Projects, 5G IA Working Groups, 5G Initiative SB/TB, CSAs and Board activities creating more impact and thus engagement of new vertical communities. All activities are reported within a **Vertical Tracker** document regularly updated by the Chair of the Task Force.

Despite the pandemic that has hindered direct participation to industry **events**, high level attendance has been provided through digital platforms for key European sectors such as Health and Media. **Vertical Workshops** organized by Full 5G have been promoted with the participation of most 5GIA partners to drive economies of scope and scale for vertical use cases within standardization bodies. Outside Europe key events have been attended in **Japan** and **Brazil** in collaboration with ETSI. Other events have been cancelled because of the pandemics and have been rescheduled in 2021 (e.g., in the Satellite space). In 2021 participation to vertical events will promote new **Smart Networks & Services JU** to foster more engagement from all vertical sectors.

New **partnerships** have been activated to embrace new vertical sectors. In the **Smart Manufacturing** space an MoU has been signed with 5G ACIA while for the **Intelligent Transportation** sector a similar MoU has been signed with **ERTICO**. In the **Healthcare** sector a collaboration has started with 5G Health Association.

Concerning **vertical paper** dissemination, a strong collaboration with 5G PPP projects has been undertaken. **Empowering Vertical Industries through 5G Networks** issued in September 2020 was prepared by the *5G PPP Technology Board* and the *5G IA Verticals Task Force* to summarize the progress and results produced by 5G PPP projects, while developing some innovative 5G network services for vertical industries. It provides information about requirements and addressed business cases. It also discusses in detail several exemplary use cases from eleven different vertical sectors and identifies key 5G features that have been used to meet the specified requirements. **Business Validation in 5G PPP Vertical Use Cases** (June 2020) carried out an initial survey of various 5G PPP projects with the objective of finding common approaches and processes to business validation. A great deal of business validation work aimed to understand what enables verticals, and how this is articulated through market expansion models, business and society benefits. It triggered understanding regarding how vertical value propositions and business models could be enabled and how, as a consequence, a secondary supply side beneficiary in terms of the designing, building, maintaining and operation of a network may be apparent and could be identified.

5G Vision and Societal Challenges WG

The ToR of the WG was updated during 2020, and the following applied for 2020. The purpose of the WG is to Develop a vision of future Smart Networks and Services (SNS) and Next

Generation Internet under the scientific, technical and socio-economic points of view. It also aims at developing visions and models and interact with the 5G-IA and 5GPPP communities on overarching vision and societal challenges topics. This WG performs its activities in collaboration with the SNS Task Force and with the Expert Advisory Group of Networld2020. The Expert Advisory Group of Networld 2020 is mainly composed of academics and targets mainly a long-term blue-sky research vision. This Vision and Societal Challenges WG has a strong industry profile, is concerned both with long-term and short research objectives, and most importantly, it addresses societal challenges as well as business models, in addition to pure research objectives. For 2020 the objectives were set as follows:

1. Further develop a vision for Smart Networks beyond 2020, covering both advanced research and societal challenges
2. Analyse the mapping of the PPP calls projects portfolios and initially address the anticipated SNS partnership
3. Stimulate the liaison with member state initiatives on 5G and on Smart Networks
4. Enable visions and validations of 5G value propositions, business models and ecosystems

Sub-Groups (SGs)

Due to the broad nature of the objectives of this WG, its activity is organized in several Subgroups. Subgroups are created and removed, according to the activities that are required by the overall WG, but they are quite stable (usually six or more months of operations). The main activities of the WG are undertaken in the SGs. Each SG has a leader that steers and coordinates its activities, calls telcos and meetings, produces the contributions of his/her SG to the yearly plans and periodic activity reports, and acts as the editor of the documents produced. The SGs active in 2020 were:

- Horizon Europe Vision SG (HEUV SG)
- Pre-structuring model SG (PSM SG)
- Member State Initiatives / 5G programs SG (MSI SG)
- Business Validation, Models, and Ecosystem SG (BVME SG)

In addition, a targeted SG for development of an initial draft SNS Work Programme was established in November – December 2020. This SNS WP SG has a specific targeted membership and is based on a mandate by the 5G-IA Board. The main activity of this SG will be in 2021 and is not further reported below.

The WG Chair, Vice-Chair and SG leaders (WG Leadership Team) are meeting regularly for status update, planning and follow-up on the overall functioning of the WG and the SGs. In the following, per SG activity reporting is provided

Horizon Europe Vision SG

A key activity of the HEUV SG was the participation to the Smart Network Task Force (by invitation of specific members). Dedicated contributions to and revision of the SNS Partnership Proposals have been provided, and participation to the follow-up work.

In the fourth quarter the HEUV SG was mandated to set up an editorial team for developing a European 6G Vision whitepaper. An initial time-plan was created as well as a skeleton document. The initial steps were made to prepare for per section editors and teams. (Call for Expression of Interest to contribute as Chapters Editors and Chapters contributors. Deadline on 08.12.20 for Chapters Editors.) Further updates to the WG ToR and the WG yearly planning

were managed via this SG. Contributions to the specific HEUV SG was developed and provided accordingly.

Pre-structuring Model SG

The PSM SG is meeting regularly, by specific telco typically once or twice a month. PSM SG includes around 59 members from 35 different organizations.

The PSM SG focused on the further analysis of the PPP Phases/Calls Portfolios Mapping (incl. gaps) between the defined PSMs (Phase 1, Phase 2, Phase 3.I and Phase 3.II) and the set of selected Proposals (by Reviewers / EC). This analysis is developed over the full PPP.

The answers to the PSM public Consultation towards Community Members have been analysed and bring very interesting/valuable feedbacks and inputs (52 answers in total) for the key lessons learnt and forthcoming recommendations for Horizon Europe (HEU) Smart Networks & Services (SNS) Partnership⁵⁰.

The PSM SG was promoting and encouraging the use of the PPP Brokerage Platform for the remaining PPP Calls (ICT-52 and ICT-41)⁵¹.

The reference PPP Projects Heritage Figure Version 1.0 has been completed and released in cooperation with TB Members⁵². The PPP Projects Heritage figure Version 2.0 will be developed/released in Fall 2021, integrating the ICT-53 and ICT-42 projects.

Analysis of Partners, Partners categories, Partners countries over the complete Programme was initiated, and a first draft PSM SG Summary Report with inputs to be further addressed and communicated towards Full5G colleagues and EC Officers.

Member State Initiatives SG

A new team of volunteer rapporteurs was established to inform on activities carried out at and by the various member states. A template was developed for information gathering by the rapporteurs.

Editorial work towards the finalization of the presentation entitled “5G and Beyond Activities Promoted by Member States” (outcome of the MSI SG as per the 2020 workplan). The presentation includes information from 14 different countries, namely, Austria, Belgium, Finland, France, Germany, Greece, Italy, Latvia, Luxembourg, The Netherlands, Norway, Portugal, Serbia, Spain, and Sweden. It reports on the various activities promoted by MS which are relevant for the deployment of 5G communication networks and their evolution towards beyond 5G and 6G networks. strategies/roadmaps for 5G deployment, and their evolution towards B5G/6G networks in the 2020-2025 timeframe. This includes strategies/roadmaps for 5G deployment, and their evolution towards B5G/6G networks in the 2020-2025 timeframe; spectrum/frequency auctions and consultations; support to 5G open innovation ecosystems, technological clusters, platforms 5G cities and digital innovation hubs; calls for Proposals aimed to conduct trials & pilots and beyond 5G R&D activities, etc.

Business validation, models and ecosystems (BVME) SG

The subgroup was launched in in January 2020. It has 32 individual participants from more than 20 projects. The group meets bi-weekly, one hour. It has carried out one major workshop to brainstorm and share methods for business validation.

⁵⁰ <https://5g-ppp.eu/consultation-about-the-5g-infrastructure-ppp-pre-structuring-model-psm-extended-deadline-for-inputs/>

⁵¹ <https://5g-ppp.eu/brokerage-platform-new/>

⁵² <https://5g-ppp.eu/5g-ppp-heritage/>

The group has worked with two white papers, and one method database. More specifically, a white paper on Business validation in 5G PPP vertical use cases – published June 2020, and a shared insight Excel database on Methods for business validation, shared in the sub-group September 2021, not public access.

In late 2020, the sub-group worked with a second white paper: 5G ecosystems. It will be published in 2021. Many has engaged and in developing the content, drawing on insight from their expertise and project insight. To publish this white paper is regarded as important by the group itself, by reviewers, and target groups.

The sub-group perceives interest and demand for its insight and results both from projects and stakeholders. The Business validation white paper was frequently downloaded from 5G PPP's website.

Workgroup Achievements along 2020

As a result of the activities listed above, the main achievements have been:

5G Infrastructure PPP – Vision Working Group (WG) – Pre-Structuring Model (PSM) Sub-Group (SG)

PPP Phases and Strategic Objectives – Proposals and Projects – Summary Table (Version 05.11.20)

- White paper: Business validation in 5G PPP vertical use cases – published June 2020
- Presentation entitled “5G and Beyond Activities Promoted by Member States” (outcome of the MSI SG), see 5GPPP portal (<https://5g-ppp.eu/wp-content/uploads/2020/12/201209-Member State Initiatives 5G FINAL.pdf>)

Pre-standardization

The main activities of the Pre-Standardization WG have been:

- Tracking inputs to standards organizations from the 5G PPP projects.
- Enabling projects to showcase results during the monthly calls and pinpointing success stories that can feed into the online Standards Tracker.
- Producing a Standards Roadmap (due for publication in late Q3-2021) with a view to supporting inputs during the SNS lifecycle.
- Liaising with ETSI, 3GPP specialists to keep the WG members up to speed on standardization work, and StandICT.eu on the EU ICT standards landscape.
- Continuing the 3GPP MRP 5G User Event Series supporting industry verticals and responding to recommended actions in the EC 2021 ICT Standardisation Rolling Plan was published in March 2021⁵³, wherever relevant.

The WG has contributed the chapter on Standardization Activities related to Verticals in the 5G PPP White Paper on “Empowering Vertical Industries through 5G Networks – current status and future trends” (September 2020) and a technical report, “5G PPP Impacts on Standards Development Organizations (SDOs)” aimed at improving impacts on standards by facilitating the transfer of research to research to SDOs in the next European Framework Programme (October 2020). The involvement of the ETSI Director of New Technologies, has brought new perspectives on technology mapping and potential for transfer of results and is also part of the Standards Roadmap editorial board.

⁵³ <https://ec.europa.eu/docsroom/documents/44998>; <https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/5g>.

The WG composition responds well to ACTION 1 of the EC's Rolling Plan for ICT Standardization by emphasizing EU-led inputs to global SDOs, such as 3GPP and ETSI ensuring regular interactions and updates by having specialists on board as members. The MoU with CSA StandICT.eu helps reinforce cross-EU inputs to ICT standardisation in areas supporting the Digital Single Market.

The 3GPP MRPs have worked very closely with high-profile standards experts from 3GPP and ETSI as part of the EU-led 5G event series. This series has played a vital role in connecting industry verticals and the telecom industry to support sector-specific use cases, encouraging the mapping of common requirements and driving collaboration and partnerships. Requirements have been gathered and shared across diverse verticals, spanning automotive (5GAA, AECC), broadcasting and media (5G-MAG), energy (EUTC), manufacturing (5G-ACIA), maritime (IALA), public safety/critical communications (PSCE, TCCA), rail (UIC) and satellite as an enabler of verticals (supported by ESOA). Understanding common and priority requirements is key to driving joint efforts in pushing them through the standardization process. The work with the MRPs responds well to ACTION 4 of the EC's Rolling Plan on SDOs to work with the stakeholders in standardisation for the uptake of 5G in vertical sectors.

To drive inputs as close to the market as possible, input tracking has focused on tangible inputs to working and study groups, including study and work items, gap analyses, PoCs, technical reports and technical specifications rather than on meetings and presentations, which were counted at the beginning of Phase 1. Inputs that are being normalized are also tracked. This approach helps the EC understand where EU leadership in standardization is coming from while bearing in mind the focus and project lifecycles, especially for the Phase 3 projects with their diverse timelines.

The figure below shows the overall inputs collected.

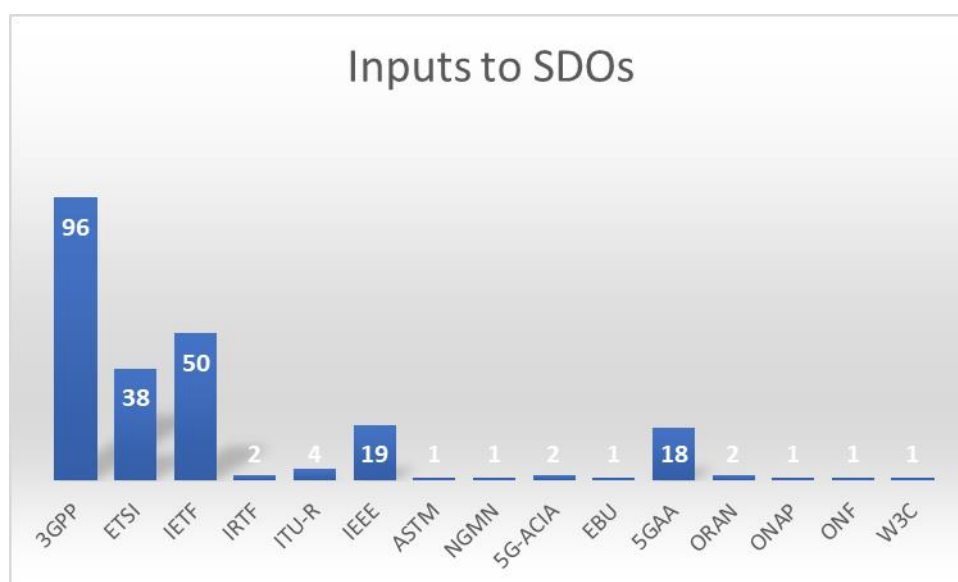


Figure 18: 5G PPP Inputs to Standards Organisations

The WG and the MRP activities are highly complementary in showcasing EU excellence in 5G standardization in a global context. Overall, the 5G-IA Pre-Standardization WG has tracked the following inputs to standardization organizations.

Most inputs have been submitted to 3GPP (96), IETF (50) and ETSI (38), with increasing inputs to

IEEE, and inputs to sector associations like 5GAA.

The WG is also working on a Standardization Roadmap supporting B5G/6G under the SNS programme.

Trials

The Trials Working Group was launched by 5G Infrastructure Association in September 2016 after the publication of the 5G Manifesto of industry in Europe and in the context of the 5G Action Plan of the EU Commission. In 2020, the active Streams in the Trials WG were (i) Private Trials / Observatory, led by Didier Bourse (Nokia) and Frederic Pujol (iDATE); (ii) 5G and towards 6G Verticals, led by Valerio Frascolla (Intel); (iii) 5G Trials Cities, led by Jyrki Huusko (VTT); and (iv) 5G International Cooperation: Baruch Altman (LiveU-TV). The current Chair of the Trials WG is Carles Antón-Haro (CTTC).

The main activities carried out by the WG in 2020 are the following:

- Elaboration of the PPP Trials and Pilots (T&Ps) Brochure n°2: This is a joint activity with the TB. In this context, the PPP T&Ps Summary Table was further developed and released (several updates) The Table includes 175+ inputs from Phase 2, Phase 3.I and Phase 3.II Projects. This Table further serves as reference for the development of the PPP Verticals Cartography (<https://www.global5g.org/cartography>). In total, 22 candidate T&Ps were received by the submission deadline. Out of them, the evaluation panel selected 10 T&Ps for the brochure. The Brochure n°2 was officially released on 15.12.20 (<https://5g-ppp.eu/the-5g-ppp-infrastructure-trials-and-pilots-brochure-n2-is-out/>).
- Editorship of the ‘White Paper on Edge Computing for 5G Networks’: This activity includes the editorship of the Trials WG chair for the section entitled ‘5GPPP Projects approach to Edge Computing’ in the aforementioned WhP, as well as the elaboration of inputs by selected WG participants (in coordination with their projects). The interest raised by this activity in the Trials WG was massive: in total, 17 questionnaires (from Ph2 and Ph3 projects, mostly) were returned to the section editors. The final page count of this section was 23 pages (out of 99 pages in total) and, thus, it constituted one of the main pillars of the White Paper, which was released in early 2021.
- Keynote Speech at the 5G-FORUM: On 06.05.20, the WG chair gave a keynote speech entitled ‘5G PPP: 5G Pan-European Trials, Verticals and a Glimpse into the Future’ at the 5G-Forum. In this talk, particular attention was paid to recent 5G trials and pilots carried out by Phase 2/3 projects addressing a number of vertical markets (e.g., transportation, media).
- Joint webinar on ‘5G Spectrum for Industry Verticals’: On 18.06.20, a webinar on ‘5G Spectrum for Industry Verticals’ was organized by the EU 5G Observatory (with direct involvement of the champion of the WG-trials’ stream on Private Trials/Observatory), the Full5G CSA, and a sub-set of 3GPP MRPs. The webinar counted with 296 registered attendees and around 155 participants from 34 countries: 16 in EU27; 18 from outside EU27. This is up by 7 countries with respect to the first edition.
- Organization of the 2nd European 5G Observatory Stakeholder Workshop: On 25.09.20, a workshop/webinar on ‘5G for growth and recovery’ was organized by the EU 5G Observatory (again, with direct involvement of the champion of the WG-trials’ stream on Private Trials/Observatory). The workshop included several presentations, keynote speeches by EC officers, and two panel discussions. This very successful workshop counted with 320 registered attendees and around 250 participants.

- Review of former standalone report of city trials stream: The main conclusion was that use cases for city trials are still valid but require some refinements. Subsequent updates were mainly based on the recent Eurocities statement⁵⁴ on 5G which called for a more balanced and fairer 5G deployment in less densely populated areas; responsible, sustainable and safe 5G deployments; and a common and simplified EU regulatory framework on the use of public infrastructures, among others.
- Liaison with international bodies similar to the 5G-IA: In the context of the ‘5G International Cooperation’ stream, an initiative to share info with international bodies similar to 5G-IA on trials and pilots was initiated. The initiative includes 5G MF, Japan; IMT2020, China; 5G Forum, Korea; TSDSI, India; and non-participatory interest from 5G Brasil project. The official kick-off meeting was held on 22.09.20. The international stream held a stream phone call on (04.11.20) where the highlights from the Global 5G Test Forum (Glo-5GTP) initiative kick-off call were shared and discussed with stream members.
- Elaboration and approval of the Terms of Reference (ToR) and WorkPlan of the Working Group: Both documents were approved by the Board without any amendment on 22.06.2020 and, thus, they entered into force.

Other activities and meetings: The following two presentations were given by the co-leader of the 5G Private Trials/Observatory stream (Didier Bourse): "Working for Verticals in 5G PPP Past and Present Status" at the PPP Vertical Webinar organized on 09.09.20; and "5G Infrastructure PPP Programmatic Perspectives" at the PPP Webinar "5G Trials in Europe - 5G Experimentation Facilities and Vertical Trials"⁵⁵ held on 14.10.20. Besides, the 5G Annual Journal 2020 was edited by the Full5G project (incl. Private Trials Champion) with inputs from 5G PPP TB. The report was released and posted on 5GPPP website (<https://5g-ppp.eu/annual-journal>). Plenary PhCs were held on 23.03.20, 26.05.20, 16.09.20. Besides, coordination PhCs with Sub-Working Group Chairs (Streams) were organized on 18.03.20, 17.12.20. The trials WG participated in the 5G-I-SB meeting (28.05.20, 21.07.20, 13.10.20, 02.12. 20) where on-going work was reported.

Security

During the reported period (Year'20) the 5G IA Security WG did perform according to the Term of References previously established and as per Work plan defined also communicated for Year 2020. Despite impacted as other WGs by COVID 19 situation that impacted all, the Security WG did continue to accommodate new 5G IA members as well as representatives from the new 5G PPP Projects awarded. Overall, it managed to foster collaboration and exchange within members of the WG thanks here to the new awarded projects on Security topics through scope and extend (also ambitions) those projects have (aka 5G & Beyond Security). 5G IA Security WG did also contribute to specific actions set also events organized by TB and SB also reported to them on work achieved vs ongoing/planned.

Among the various actions performed during Y2020 we can quote the following:

- Co-chairs did organize a meeting in early 2020 to review 2019 achievements but also defined within the group a shared and agreed work plan for Y2020.
- 5G IA Security WG did join TB meetings and contributed to plan and actions. Further to this 5G IA Security did support & contributed to a number of Whitepapers agreed at

⁵⁴ http://nws.eurocities.eu/MediaShell/media/EUROCITIES_statement_on_5G_.pdf

5G TB level among which the Whitepapers on Edge Computing for 5G networks⁵⁶ but also others to come (e.g., European Vision on 6G Networks and/or IA & ML for Networks).

- Security being a cross-cutting concern, 5G IA Security WG did follow-up on actions performed by other WGs of interest (e.g., Architecture WG) and stepped in whenever needed to support from perspective addressed (e.g., Security Architecture)
- 5G-IA Security WG did join the Virtual TB Workshop organized in December 2020 (09-13/12/2020).
- Work with ENISA was pursued through involvement of 5G IA Security WG co-chairs who contributed to the “5G Threat Landscape update” through Experts Group set by ENISA on the field⁵⁷.
- A joint workshop between 5G PPP and Cybersecurity PPP (ECSO) was worked out and submitted to EuCNC 2020. Unfortunately, due to the COVID 19 situation the workshops had to be cancelled. Nevertheless, this workshop proposal was decided to be revived next year and so be resubmitted to EuCNC 2021 since highly relevant.
- Progresses at Project or Member level on topics have been continued to be monitored/assessed and clustered. This for all projects to date and has continued with the new ones (i.e., ICT20, ...)
- Regarding 5G IA Sec WG Whitepapers work has been organized around a set of short and focused Whitepapers namely: Access Control Mechanisms to Verticals, SDN/NFV virtualisation, 5G Slicing and Security Considerations, 5G Attack Referential, (critical) Vertical security needs. These Short Whitepapers are planned to be released in 2021. In the meantime, and thanks to IC20 Projects on-boarded and especially INSPIRE-5Gplus an additional whitepaper on Intelligent Security Architecture for 5G and Beyond Networks has been released⁵⁸.
- Further investigation of interested & interesting projects to team with us outside of 5G PPP was conducted. Several of them have been identified and specific events have been or would be organized with them (similar to what was done with SENDATE Celtic project in 2018, aka joint Webinar)
- Regarding Security KPIs another push was given this year with support from the newly awarded projects since of concerns for them.
- No physical meeting this year due to COVID 19 situation but regular meetings were continued to be organized with material presented/discussed uploaded on BSCW as usual.

IMT 2020 Evaluation WG

ITU-R WP5D launched a global evaluation process for IMT-2020 (5G) Radio Interface Technologies (RITs and SRITs – Set of RITs), which will be submitted by SDOs (Standards Developing Organisations) to ITU-R to be recognised as member of the IMT family of systems for mobile and wireless communications. This evaluation process of Step 4 of the overall ITU-R process started formally in June 2018.

After registration of 5G Infrastructure Association (5G-IA) as an Independent Evaluation Group at ITU-R this group was formally established in January 2018. This was the only active Evaluation Group from Europe. ETSI also registered but only to be prepared to contribute to

⁵⁶ <https://bscw.5g-ppp.eu/pub/bscw.cgi/d397473/EdgeComputingFor5GNetworks.pdf>

⁵⁷ https://www.enisa.europa.eu/publications/enisa-threat-landscape-report-for-5g-networks/at_download/fullReport

⁵⁸ <https://bscw.5g-ppp.eu/pub/bscw.cgi/d381923/INSPIRE-5Gplus White Paper HLA FV GA Abbrev.pdf>

the process if needed. In addition to these European groups there were 13 additional Evaluation Groups from Africa (support by several countries), Canada, China, Egypt, India, Japan, Korea, Taiwan and USA.

The 5G-IA Evaluation Group was supported by 5G PPP during Phases 2 and 3 by the RTD projects Clear5G, One5G, 5G Essence, 5G Genesis, 5G Monarch, 5G Solutions, 5G Tours, 5G Vinni, 5G Xcast and CSA projects Full5G, Global5G.org and To-Euro-5G, which provided the technical experts.

ITU-R requested the evaluation of 16 technical capabilities of submitted Radio Interface Technologies (i. peak data rate, ii. peak spectral efficiency, iii. user experienced data rate, iv. 5th percentile user spectral efficiency, v. average spectral efficiency, vi. area traffic capacity, vii. user plane latency, viii. control plane latency, ix. connection density, x. energy efficiency, xi. reliability, xii. mobility, xiii. mobility interruption time, xiv. bandwidth, xv. support of a wide range of services and xvi. supported spectrum bands/ranges), which were investigated by means of extensive link- and system-level simulations, analytical calculations and inspection of the system specification.

The objectives of the WG were:

- To perform an independent evaluation of IMT-2020 proposals to support ITU-R WP5D for the finalisation of the IMT-2020 recommendation in 2020.
- To prepare a complete evaluation report from the European perspective in the global context of other evaluation groups from other regions and to demonstrate the importance and global presence of communication technology industry and the research community in Europe.
- To focus evaluation activities on the 3GPP Releases 15 and 16 to check, whether this proposal meets the minimum 5G requirements of ITU-R and whether this proposal can be regarded as an IMT-2020 system.

This WG has provided a number of significant achievements. Evaluation activities are based on the ITU-R reports “Minimum requirements related to technical performance for IMT-2020 radio interface(s)” (Report ITU-R M.2410-0, 11/2017), “Requirements, evaluation criteria and submission templates for the development of IMT-2020” (Report ITU-R M.2411-0, 11/2017) and “Guidelines for evaluation of radio interface technologies for IMT-2020” (Report ITU-R M.2412-0, 10/2017), where the minimum requirements as well as the evaluation methodology are described. For the necessary link- and system-level simulations existing simulators were extended and adapted according to the radio interface specifications of the evaluated technologies and the requested ITU-R scenarios. These simulators were calibrated against each other and with other available simulation results, e.g. from SDOs. A good agreement was achieved, which ensures confidence in the simulation results.

The submitted RIT and SRIT submissions to ITU-R WP5D by different SDOs were considered as the relevant system descriptions. During the evaluation process these documents were updated by SDOs with further details of the system specification.

The 5G-IA Evaluation Group focused on the 3GPP 5G NR RIT and partly on the LTE component in the 3GPP SRIT submission. Implicitly, the submissions from China, Korea and the 5G NR component of the ETSI DECT submission were evaluated as well, because they are technically the same. Towards the end of the independent evaluation process this Group investigated some specific evaluation characteristics for the ETSI DECT2020, EUHT (Nufont) and TSDSI submissions, which are different compared to the 3GPP submission. However, the TSDSI submission is rather similar to 5G NR.

Detailed evaluation activities confirmed that the 3GPP submission 5G NR RIT meets all requested minimum requirements. Also, the partially evaluated LTE component meets the minimum requirements for the evaluated scenarios. Some concerns were raised for the ETSI DECT2020 and the EUHT submissions, which will be further treated by ITU-R WP5D. For the investigated scenarios the TSDSI submission meets the minimum requirements.

The interim evaluation results for the 3GPP submissions were summarised in an Interim Evaluation Report, which was presented to ITU-R WP5D in a workshop in Geneva on December 10 and 11, 2019 and discussed with SDOs and other Evaluation Groups. Four 5G-IA Evaluation Group members attended this workshop.

For the final evaluation in total four evaluation reports were submitted to ITU-R WP5D: Complete Evaluation Report for the 3GPP submission, partial Evaluation Reports on ETSI DECT2020, EUHT and TSDSI. These reports were introduced to the ITU-R WP5D 34th meeting in Geneva on February 19 to 26, 2020. The 5G-IA Evaluation Group contributed to working documents during this WP5D meeting to support the evaluation process and participated in discussions with proponents.

With this ITU-R WP5D meeting Step 4 of the evaluation process was finalised. In the following Steps 5 to 7 a consensus building process is ongoing towards the final decision in Step 8, which are performed by WP5D without the participation of Independent Evaluation Groups.

All documents on the Interim and Final Evaluation Reports are available at the 5G PPP Evaluation website⁵⁹ for the exchange of information with other Independent Evaluation Groups.

The 5G-IA Evaluation Group worked as a virtual team via e-mail and regular conference call around every 3 weeks to check progress and status.

Open questions on the implementation of algorithms especially for simulation activities have been raised towards 3GPP for clarification and discussed in the Evaluation Group to get a common understanding, because not all necessary parameters for simulation and evaluation purposes are specified and some assumptions needed to be made.

Several 5G-IA Evaluation Group members participated in a 3GPP Evaluation Workshop in Brussels on October 24 and 25, 2018 and used this opportunity to clarify open issues with 3GPP experts.

The working group chair participated in the 5G PPP Steering Board meetings to report the status.

With the formal finalisation of Step 4 of the ITU-R Evaluation process at the ITU-R WP5D 34th meeting in February 2020 the mission of Independent Evaluation Groups is accomplished. Therefore, the 5G-IA Evaluation Groups has completed its activities.

SME Community

The impact of the 5G PPP on SMEs can be measured by various factors. One of them is their participation in the projects, another one that might even be more relevant is their interest to be involved. And then the actual impact is in terms of products and solutions commercialised by SMEs.

⁵⁹ <https://5g-ppp.eu/5g-ppp-imt-2020-evaluation-group/>

The SME participation in 5G PPP projects has been increasing in 2020 to reach and even exceed the original objective of 20% participation defined as a KPI of the programme⁶⁰. According to the H2020 dashboard⁶¹, **the participation of SMEs in the 5G PPP has reached 21.95% of EU funding**, representing a total of 156.3 M€.

SMEs have contributed to 24.43% of the total participation in 5G PPP projects, i.e., 426 SME participations out of 1,744. There were 738 unique SME participations. It is worth noting that 65% of the SMEs participated in 1 project, and 35% in 2 or more projects. Besides, the level of participation of SMEs in RIAs and IAs is similar.

The interest of the SMEs in the 5G PPP and more generally in H2020 and in the upcoming Smart Networks & Services (SNS) Partnership planned for Horizon Europe, has increased throughout the year. Membership in the Networld2020⁶² SME Working Group has increased by 17% during the year 2020, reaching 200 members, out of which 170 are SMEs. The SME Working Group was keen to contribute to the upcoming SNS Partnership, releasing in December 2020 a position paper highlighting recommendations, comments, and questions from SMEs in relation with SNS⁶³. The SME contribution was conveyed and considered by the 5G IA Board and the 5G IA Vision WG sub-group working on the draft of the 1st SNS work programme.



Figure 19: SME WG SNS Position Paper

The SME-related web pages on the NetWorld2020 web site were revisited and updated, supporting the achievement in terms of participation in the 5G PPP, as highlighted above. A new “SME WG” web page was created⁶⁴. The “Find the SME you need” web page was updated a couple of times during the year⁶⁵. Not only does it include information on more SMEs than before, but it is also possible to sort SMEs by technological expertise or by knowledge of vertical sectors. New success stories have been released.

⁶⁰ All 5G PPP calls have been included, now that the latest 5G PPP calls have been completed.

⁶¹ <https://webgate.ec.europa.eu/dashboard/>

⁶² In March 2021, NetWorld2020 was officially renamed NetworldEurope. We use NetWorld2020 in this report as this was the name used in 2020.

⁶³ “SME WG SNS Position Paper”, 4 November 2020, <https://www.networldeurope.eu/wp-content/uploads/2020/12/sme-wg-sns-position-paper-final.pdf?x70854>

⁶⁴ <https://www.networldeurope.eu/sme-wg/>

⁶⁵ <https://www.networldeurope.eu/find-the-sme-you-need-new-page/>

SME BY DOMAIN OF TECHNOLOGICAL EXPERTISE

Each technological domain is shown with the logos of the SMEs who have declared expertise in the domain. The list and coordinates of all SMEs may be found below on this page. The table below summarizes the technological expertise of each SME. The list and coordinates of all SMEs may be found below on this page.

Domains of Technological Expertise ▾
 ↶ Reset

Search:






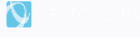

SME	5G	IoT	SatCom	NGI	Others
 Accelleran	X	X	X	X	RAN/vRAN Software Solutions, Products and Services
 ACTA Ltd	X	X	X		
 Aetheric Engineering			X		
 AICO		X			
 AppArt	X	X			Data Modelling, Analytics and Visualization, Machine Learning, Network Automation
 Arctos	X	X		X	Network Automation
 Arteevo	X	X		X	DLT, AI

Figure 20: “Find the SME you need” web page: SMEs by technological expertise

SME BY VERTICAL SECTOR

Each vertical sector is shown with the logos of the SMEs who have declared expertise in the domain. The list and coordinates of all SMEs may be found below on this page. The table below summarizes the vertical sectors in which each SME has expertise. The list and coordinates of all SMEs may be found below on this page.

Expertise in Vertical Sectors ▾
 ↶ Reset

Search:


SME	Media & Content	Transport & Logistic	Manufacturing	Health	Energy	Smart Cities	Public Safety	Others
 Accelleran	X	X	X		X	X	X	
 ACTA Ltd		X				X	X	
 Aetheric Engineering								
 AICO		X		X	X	X		
 AppArt	X			X	X	X		

Figure 21: “Find the SME you need” web page: SMEs by vertical sector

In addition, there were also a couple of updates of the “European SME Expertise in 5G and Beyond” brochure⁶⁶. Information on 61 European SMEs is now included in the brochure, along

⁶⁶ https://bscw.5g-ppp.eu/pub/bscw.cgi/d391067/2021-01_5G_SME_Brochure.pdf

with significant success stories, most of which are related to the participation of SMEs in 5G PPP projects. It is worth noting that **the SME brochure has been downloaded more than 1,000 times⁶⁷**, showing its interest among all stakeholders.



Figure 22: The “European SME Expertise in 5G and Beyond” brochure

The “Find the SME you need” web page was viewed more than 2,500 times in 2020, making it **the most viewed page on the NetWorld2020 web site**, after the home page. It is worth noting that **the “SME support” page**, which has since become the “SME WG” page, **ranks #6 with almost 600 views**. This shows the interest of the visitors of the web site in SME-related information, and the corresponding impact on the 5G ecosystem stakeholders.

Page	Pageviews	Unique Pageviews	Avg. Time on Page	Entrances	Bounce Rate	% Exit	Page Value
	14,297 % of Total: 100.00% (14,297)	11,756 % of Total: 100.00% (11,756)	00:02:13 Avg for View: 00:02:13 (0.00%)	7,604 % of Total: 100.00% (7,604)	57.31% Avg for View: 57.31% (0.00%)	53.19% Avg for View: 53.19% (0.00%)	\$0.00 % of Total: 0.00% (\$0.00)
1. /	2,874 (20.10%)	2,309 (19.64%)	00:01:48	1,966 (25.85%)	39.60%	48.16%	\$0.00 (0.00%)
2. /find-the-sme-you-need-new-page/	2,533 (17.72%)	1,973 (16.78%)	00:03:56	1,872 (24.62%)	73.08%	73.04%	\$0.00 (0.00%)
3. /sria-and-whitepapers/	897 (6.27%)	810 (6.89%)	00:04:19	547 (7.19%)	52.62%	68.90%	\$0.00 (0.00%)
4. /our-members/	628 (4.39%)	526 (4.47%)	00:01:54	167 (2.20%)	32.54%	36.15%	\$0.00 (0.00%)
5. /overview/	627 (4.39%)	537 (4.57%)	00:01:40	129 (1.70%)	38.46%	30.94%	\$0.00 (0.00%)
6. /sme-support/	581 (4.06%)	504 (4.29%)	00:01:35	379 (4.98%)	56.84%	51.46%	\$0.00 (0.00%)

Figure 23: Statistics re. the NetWorld2020 web page visits – January to December 2020

The average time spent by the viewers reading the page is quite high, i.e., almost 4 minutes. This clearly demonstrates that **viewers are navigating thoroughly through the SME page, to find the information they need**.

⁶⁷ The December 2020 version of the SME brochure has been downloaded 1,071 times since its publication until end of April 2021.

Page	Pageviews	Unique Pageviews	Avg. Time on Page	Entrances	Bounce Rate	% Exit	Page Value
	2,533 % of Total: 17.72% (14,297)	1,973 % of Total: 16.78% (11,756)	00:03:56 Avg for View: 00:02:13 (77.28%)	1,872 % of Total: 24.62% (7,604)	73.08% Avg for View: 57.31% (27.53%)	73.04% Avg for View: 53.19% (37.32%)	\$0.00 % of Total: 0.00% (\$0.00)
1. /find-the-sme-you-need-new-page/	2,533 (100.00%)	1,973 (100.00%)	00:03:56	1,872 (100.00%)	73.08%	73.04%	\$0.00 (0.00%)

Figure 24: Statistics re. the “Find your SME” web page – January to December 2020

Peaks of visits were achieved at the time when a new update of the page and a new brochure were made available and promoted, however there was a permanent flow of visits throughout the year.



Figure 25: Statistics re. the “Find your SME” web page – January to December 2020

International Cooperation Activity on 5G

The 5G IA has been very activity building up international cooperation for 5G networks. This is obviously of the outmost importance for keeping Europe in the frontline of key players at a global level.

The 5G IA has signed the following MoUs:

International Multilateral MoU

Signatories Organizations	Status
5G IA, IMT-2020, 5G Forum, 5GMF, 5G Americas, 5G Brazil	Signed

International Bilateral MoUs

Organization	Status
5G MF (Japan)	Signed
IMT-2020 (5G) Promotion Group – (China)	Signed
5G Forum (Korea)	Signed
5G Americas (USA)	Signed
Telebrasil – Projeto “5G Brasil” (Brazil)	Signed
ENCQOR (Canada)	Signed
TSDSI (India)	Signed

Agreements with Organizations representing Vertical Sectors

Organization	Status
5GAA (Automotive)	MoU Signed
ERTICO (Automotive)	MoU Signed
ECSO (Security)	MoU Signed
PSCE (Security)	LoI Signed
NEM (Media)	MoU Signed
5G ACIA (Industry)	MoU Signed
Other possible agreements to be signed with:	
<ul style="list-style-type: none">- UIC (Railways)- EUTC (Utilities)- 5G Health Association	

Other Agreements

Organization	Status
NetWorld Europe	MoU Signed
AIOTI (IoT)	MoU Signed
ESA (SatCom)	LoI Signed
ECC (Regulation)	LoU Signed
ETSI (Standards)	LoI Signed
NGMN Alliance (Mobile broadband technologies)	Liaison Statement on the “ <i>Definition of the Testing Framework for the NGMN 5G Pre-Commercial Network Trials</i> ”

Activity Community Building and Public Relations

5G IA has been very active in creating links with all major stakeholders involved in the creation of 5G networks. In the previous sections, a detailed presentation has been provided for the activities and achievements of the 5G-PPP activities. These include the realization of Phase 2 and Phase 3 projects, the production of a significant number of white papers, the provision of technical contributions to standardization bodies, the mobilization of SMEs and the dissemination of results in workshops and conferences. All these activities have significantly contributed to raise awareness on the innovations 5G networks will bring in everyday life and also to enable vertical industries to enter this very promising field. The key results of the EU funded projects have been recently published in the European Annual Journal 2020.

5G IA has played a central role in the abovementioned activities. The pre-structuring model, the activities of the Verticals Engagement Task Force, the work of 5G IA WGs (i.e., pre-standardization, trials, spectrum, security and the IMT 2020 Evaluation group), its close collaboration with NetWorld2020, have been the enabler for success. Finally, 5G-IA has signed 15 MoU and 4 LoI with peer-organizations or other global regions ensuring that the European activities will have a global impact.

Smart Connectivity Digital Innovation Hub Network

This activity is contributing to stimulate the overall digital ecosystem and mainly the Digital Innovation Hub which is part of the next Digital Europe Program. For that purpose, DIH which are offering 5G services in the S3platform catalogue were identified and work on services that they are expected from a network was undertaken. Following on these actions, it was decided

to extend to a larger domain addressing Smart connectivity encompassing 5G, IoT, Cybersec and AI. These technologies are considered as the key pillars for the further evolutions of 5G as well as 6G networks. The conclusion was to merge the 5G initiative with the AIOTI initiative⁶⁸ in order to become stronger. The Smart Connectivity DIH Network (SCoDIHNet) was born in September 2020.

The Smart Connectivity DIH Network (SCoDIHNet) initiative is contributing to the European Industry Digitalisation helping companies to improve their processes, products and services through the use of Smart connectivity technologies.

The SCoDIHNet initiative is co-supported by the 5G IA and the AIOTI.

Work on the Smart Networks and Services

Although 5G PPP has already provide plenty of results, it is important for design the roadmap for the next decade. The 5G IA has been very active during 2020 to setup the Smart Networks and Services (SNS) Partnership proposal⁶⁹. A key goal of the SNS Partnership is to define and implement the research, innovation and deployment roadmaps that will enable Europe to lead in the creation of the next generation of smart network technologies and services. These will be designed and implemented in such a way that European values like security and privacy are safeguarded, and European technological sovereignty is further strengthened. The Partnership will also focus on the full digitization of European society including vertical industries and public administration. Thereby, the SNS Partnership targets to have a positive impact on the quality of life for European citizens and boost the European data economy.

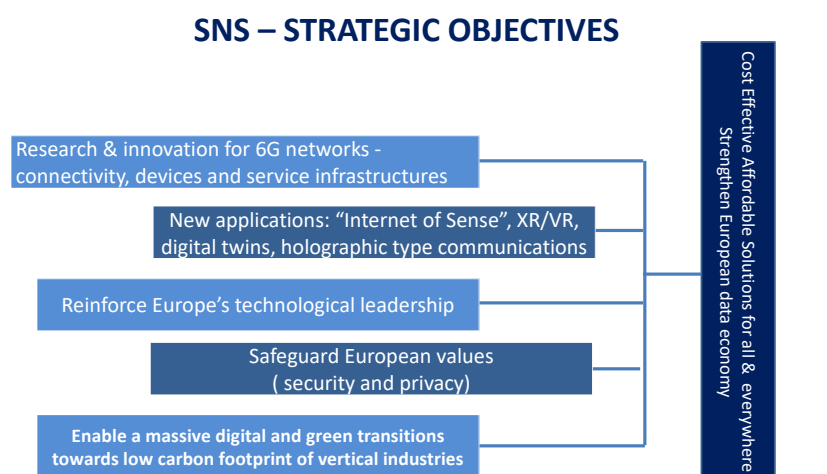


Figure 26: SNS Strategic objectives

Figure 26 illustrates the key strategic objectives of the SNS Partnership. These include the support of new advanced applications, the needed research and innovation to develop the technologies that will support these applications and the full digitization of the vertical industries. A key objective is the re-enforcement of EU leadership in 6G networks by integrating enablers like AI/ML, cybersecurity, and high-performance computing. Special attention is proposed to be paid to topics like the integration of IoT and dedicated hardware so that SNS Partnership will be able to provide a complete and competitive system. All proposed

⁶⁸ www.aioti.eu

⁶⁹ https://ec.europa.eu/info/files/european-partnership-smart-networks-and-services_en

activities are designed in way to safeguard European values (e.g., security and privacy) as well topics that will cater UN's Sustainable Development Goals (SGs), minimize the energy consumption of future 6G systems. Thus, the overall goal will be to develop cost-effective and affordable solutions that will improve the every-day life of European citizens and strengthen the European economy.

Following up on the initial definition of the SNS proposal, the SNS roadmap has been updated, specifying four highly complementary Streams which are in line with the industry roadmap (Figure 27), and potentially targeting a wide set of stakeholders across the value chain. The SNS Phase 1 is expected to build upon the outcomes of Horizon 2020 5G-PPP projects, as well to capitalize on the results from other instruments (e.g., Member States' initiatives, other Horizon 2020 activities, other activities that follow open principles, etc.). The Roadmap (Figure 27) illustrates the phases of the 4 streams.

- **Stream A: (Evolutionary)** Follow an evolutionary path towards the development of 6G networks. The proposed research topics are selected in such a way to create a complete system view when these are considered all together
- **Stream B: (Revolutionary)** Research for radical technology advancement towards 6G. Low TRL technologies that are expected to deliver in real life networks in a mid-and/or long-term time period.
- **Stream C:** SNS experimental infrastructures to be used during the second phase of the SNS by other Streams
- **Stream D:** Large Scale SNS Trials and Pilots. Explore and demonstrate technologies and advanced applications (e.g., Immersive communication, holographic telepresence & Augmented Reality / Virtual Reality (AR/VR), etc.). as well as advanced services in the vertical domains (e.g., connected mobility and smart transport and logistics, media and entertainment, public safety, e-Health, smart factories, smart cities etc.)

Notably the need for Stream A's second and third phases will be evaluated near the completion of the first phase, as Stream A is following an evolutionary path from 5G to 6G networks. The outcomes of Stream A and B are expected to be used in the subsequent phases of Streams C and D. The same is expected to apply for the outcomes of Stream C that are expected to be used by the subsequent phases of Stream D.

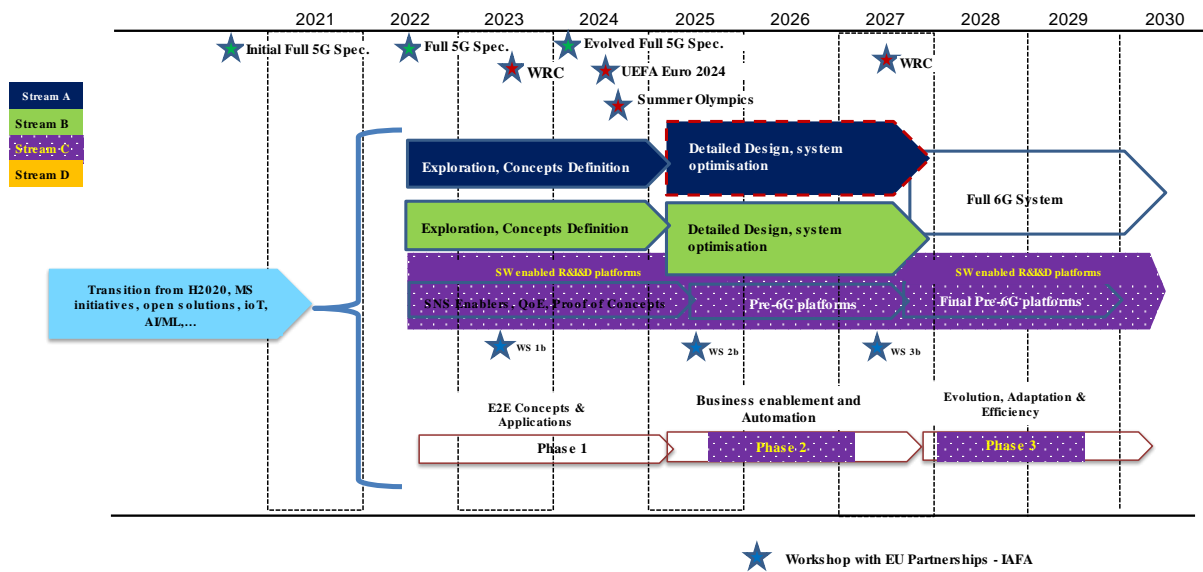



Figure 27: SNS updated roadmap

Annex Part 7 – Common Priority Key Performance Indicators

	Key Performance Indicator (KPI)	Value in 2018	Baseline at the start of H2020 (latest available)	Target (for the cPPP) at the end of H2020	Comments																					
1	Mobilised Private Investments	<ul style="list-style-type: none">13,58 considering Large Industry and SMEs10,93 considering all types of beneficiaries		Between 5 and 10.	The methodology used for this assessment is described in Section 3.2.1.1																					
2	New skills and/or job profiles	<table><tr><th>2014-2020</th><th colspan="2">New jobs/skills</th></tr><tr><th></th><th>Average</th><th>Total projected</th></tr><tr><td>Overall</td><td>7,31</td><td>7.443</td></tr><tr><td>Large Industry</td><td>23,08</td><td>5.910</td></tr><tr><td>SME</td><td>4,06</td><td>570</td></tr><tr><td>Academic Institution</td><td>6,22</td><td>527</td></tr><tr><td>Research Center</td><td>5,33</td><td>437</td></tr></table>			2014-2020	New jobs/skills			Average	Total projected	Overall	7,31	7.443	Large Industry	23,08	5.910	SME	4,06	570	Academic Institution	6,22	527	Research Center	5,33	437	The methodology used for this assessment is described in section 3.2.1.2. Additional considerations (source The future of work: ICT Professionals ⁷⁰): <ul style="list-style-type: none">• Employment for IT professionals is projected to grow by 11% over the period 2018 to 2030, with 395,000 jobs created.• Combined with the number of those leaving the occupation in the same period (an estimated 1.2 million), this growth indicates that 1.6 million jobs in ICT will need to be filled between 2018 and 2030.• The number of ICT professionals who hold medium-level qualifications will remain more or less unchanged at 23% in 2030.• The number of ICT professionals who hold high-level qualifications is expected to increase to 74% in 2030.
2014-2020	New jobs/skills																									
	Average	Total projected																								
Overall	7,31	7.443																								
Large Industry	23,08	5.910																								
SME	4,06	570																								
Academic Institution	6,22	527																								
Research Center	5,33	437																								

⁷⁰ https://ec.europa.eu/eures/public/en/news-articles/-/asset_publisher/QOSmqQGuvdnC/content/the-eu-job-market-and-workplace-in-the-2020s?inheritRedirect=false&redirect=https%3A%2F%2Fec.europa.eu%2Feures%2Fpublic%2Fen%2Fnews-articles%3Fp_id%3D101_INSTANCE_QOSmqQGuvdnC%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3D_118_INSTAN

3	Impact of the 5G PPP on SMEs	<table><tr><td></td><td>increase in yearly turnover</td><td>increase in yearly revenues</td><td>increase in staff headcount</td><td>number of new elements of foreground IP</td></tr><tr><td>Reference period</td><td>2020</td><td>2020</td><td>2014 - 2020</td><td>2014 - 2020</td></tr><tr><td>Average values</td><td>10,1%</td><td>11,9%</td><td>16,55</td><td>1,78</td></tr><tr><td>Total projected</td><td>n/a</td><td>n/a</td><td>2.325</td><td>250</td></tr></table>						increase in yearly turnover	increase in yearly revenues	increase in staff headcount	number of new elements of foreground IP	Reference period	2020	2020	2014 - 2020	2014 - 2020	Average values	10,1%	11,9%	16,55	1,78	Total projected	n/a	n/a	2.325	250	<p>The methodology used for this assessment is described in section 3.2.1.3.</p> <p>Note also:</p> <ul style="list-style-type: none">• The number of members SME Working Group has increased by 17% during the year 2020, reaching 200 members, out of which 170 are SMEs.• The SME participation in 5G PPP projects has been increasing in 2020 to reach and even exceed the original objective of 20% participation defined as a KPI of the programme.• According to the H2020 dashboard, the participation of SMEs in the 5G PPP has reached 21.95% of EU funding, representing a total of 156.3 M€	
	increase in yearly turnover	increase in yearly revenues	increase in staff headcount	number of new elements of foreground IP																								
Reference period	2020	2020	2014 - 2020	2014 - 2020																								
Average values	10,1%	11,9%	16,55	1,78																								
Total projected	n/a	n/a	2.325	250																								
4	Significant Innovations	<p>The key achievements v3.0 contains the latest information about key achievements from Phase 2 projects (not previously reported) and Phase 3 projects.</p> <div><p>Key achievements v3.0.docx</p></div> <p>The key achievements v3.1 is the latest version reporting more</p>				<p>Section 3.2.1.4 presents in more detail the significant innovations</p>																						

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		than 100 key achievements.  Key achievements v3.1.docx			
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Annex Part 8 – Specific Key Performance Indicators for the 5G PPP

	KPI domain	Key Performance Indicator (KPI)	Value in 2020	Baseline at the start of H2020 (latest available)	Target (for the cPPP) at the end of H2020	Comments
1	Performance	P1. Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010	Analysis about the KPis (network and verticals) can be found at 1. 5G PPP TMV WG, Understanding the Numbers: Contextualization and Impact Factors of 5G Performance Results, V1.0, July 2021, and 2. TMV WG, Service Performance measurement methods over 5G experimental networks, May 2021			A detailed analysis for the Performance KPIs can be found at section 3.2.2.1
2	Performance	P2. Reducing the average service creation time cycle from 90 hours to 90 minutes				
3	Performance	P3. Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people				
4	Performance	P4. Creating a secure, reliable and dependable internet with a "zero perceived" downtime for services provision				
5	Business	B1. Leverage effect of EU research and innovation funding in terms of private investment in R&D for 5G	<ul style="list-style-type: none"> 13,58 considering Large 		Between 5 and 10	The methodology used for this assessment is described in Section 3.2.1.1.

		systems in the order of 5 to 10 times	<p>Industry and SMEs</p> <ul style="list-style-type: none"> • 10,93 considering all types of beneficiaries 			
6	Business	B2. Target SME participation under this initiative commensurate with an allocation of 20% of the total public funding	The SME participation in 5G PPP projects has been increasing in 2020 to reach and even exceed the original objective of 20% (i.e., 21,95%) participation defined as a KPI of the programme.		20%	An analysis of the impact of the 5G PPP on the SME community, including information on the reported KPI can be found in Annex 6.

7	Business	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	<u>Publicly available reports suggest that EU HQ companies currently have more 30% of total worldwide telecom equipment revenues.</u>			This KPI is further discussed in section 3.2.2.2
8	Societal	S1. Enabling advanced user - controlled privacy				This KPI is presented in Section 3.2.2.3
9	Societal	S2. Reduction of energy consumption per service up to 90% (as compared to 2010)				This KPI is presented in Section 3.2.2.3
10	Societal	S3. European availability of a competitive industrial offer for 5G systems and technologies				This KPI is presented in Section 3.2.2.3
11	Societal	S4. Stimulation of new economically-viable services of high societal value like U-HDTV and M2M applications				For this KPI please refer to section 3.2.2.3


12	Societal	S5. Establishment and availability of 5G skills development curricula (in partnership with the EIT)	<table><tr><th>2014-2020</th><th colspan="2">New 5G curricula and/or educational qualifications</th></tr><tr><td></td><th>Average</th><th>Total projected</th></tr><tr><td>Overall</td><td>3,06</td><td>3.120</td></tr><tr><td>Large Industry</td><td>2,00</td><td>926</td></tr><tr><td>SME</td><td>4,33</td><td>1.101</td></tr><tr><td>Academic Institution</td><td>2,89</td><td>442</td></tr><tr><td>Research Center</td><td>4,40</td><td>651</td></tr></table>	2014-2020	New 5G curricula and/or educational qualifications			Average	Total projected	Overall	3,06	3.120	Large Industry	2,00	926	SME	4,33	1.101	Academic Institution	2,89	442	Research Center	4,40	651	The methodology used for this assessment is described in section 3.2.2.3
2014-2020	New 5G curricula and/or educational qualifications																								
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Annex Part 9 – Contribution to Programme-Level KPI's

	Key Performance Indicator	Definition/Responding to question	Type of data required	Data [Commission]	Baseline at the start of H2020 (latest available)	Target (for the cPPP) at the end of H2020	Comments
1	Patents	An analysis of the data in the latest publicly available reports such as IPlytics ⁷¹ (February 2021), indicates that European companies share a 17,82% of 5G granted and active families, a 20,54% share of 5G EP/US granted/active families and a 15,64% share of 5G EP/US granted/active families not declared to earlier generations.	Number of patent applications. Number of patents awarded				Information on IPRs is always difficult to assess as certain time-periods are required from the IPR request submission to the grant of the patent.

⁷¹ <https://www.iplytics.com/>

2	<p>Standardisation activities (project level)</p> <p>Contributions to new standards (PPP level)</p>	<p>Online Standards Tracker</p> <p>Tracking activities in the Pre-standardization WG</p>	<p>Number of activities leading to standardisation</p>	<p>In terms of standardization activities, 5G PPP is an active contributor to 5G standardization globally. Overall, the 5G-IA Pre-Standardization WG has tracked 237 inputs based on specific and tangible inputs (e.g. technical reports, study/work item, PoC, new commercial requirements) as opposed to broader inputs collected in previous years. Most inputs have been submitted to 3GPP (96), IETF (50) and ETSI (38), with a growing number of inputs to IEEE, and inputs to sector associations working groups like 5GAA</p>			
3	<p>Operational performance</p>	<ul style="list-style-type: none"> • ICT-42 • ICT-53 • ICT-41 • ICT-52 					<p>All operational performance information is available at section 2.1</p>

5	H2020 - LEIT - Number of joint public-private publications	<p>The document hereunder contains available information collected from the public sites of the remaining Phase 2 projects that completed their activities in 2020 and Phase 3 projects.</p> <div>  <p>cPPP_publications_updated_270721</p> </div>	<p>Information collected from cordis.europe.eu and project's sites</p>	<p>The remaining phase 2 projects that completed their activities in 2020 have produced approximately 726 publications (22% was published in scientific journals), whereas Phase 3 projects have produced 602 publications so far (39% was published in scientific journals).</p>			
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