

5G PPP PROGRESS MONITORING REPORT – 2019

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

Brussels August 2019

Table of contents

1. INTRODUCTION	4
2. MAIN ACTIVITIES AND ACHIEVEMENTS	4
2.1 IMPLEMENTATION OF THE CALLS FOR PROPOSALS EVALUATED DURING THE REPORTING PERIOD	5
2.2 MOBILIZATION OF STAKEHOLDERS, OUTREACH, SUCCESS STORIES	11
2.3 GOVERNANCE	12
3. MONITORING OF THE OVERALL PROGRESS SINCE THE LAUNCH OF THE 5G PPP	13
3.1 ACHIEVEMENT OF THE GOALS OF THE CPPP	13
3.2 PROGRESS ACHIEVED ON KPIS	14
3.2.1 <i>Common set of KPIS</i>	14
3.2.2 <i>Specific KPIS for 5G PPP</i>	18
3.3 EVOLUTION OVER THE YEARS	23
4. OUTLOOK AND LESSONS LEARNT	24
ANNEX PART 1 - THE 5G INFRASTRUCTURE PUBLIC-PRIVATE-PARTNERSHIP	26
ANNEX PART 2 - THE 5G INFRASTRUCTURE ASSOCIATION	28
ANNEX PART 3 – 5G PPP PROJECTS	30
ANNEX 4 - 5G PPP WORKING GROUPS AND THEIR ACTIVITIES	36
ARCHITECTURE WG	36
SOFTWARE NETWORKS WG	37
NETWORK MANAGEMENT & QoS WG	38
5G AUTOMOTIVE WG	39
TEST, MEASUREMENT AND KPIS VALIDATION WG	39
WHITE PAPERS PRODUCED BY THE 5G PPP WGS	40
ANNEX 5- 5G INITIATIVE: BOARDS' ACTIVITIES AND ACHIEVEMENTS	42
ANNEX 6 - 5G IA ACTIVITIES AND ACHIEVEMENTS	44
VERTICALS ENGAGEMENT TASK FORCE	44
5G VISION AND SOCIETAL CHALLENGES WG	45
PRE-STANDARDIZATION	47
TRIALS	49
SECURITY	50
IMT-R IMT 2020 EVALUATION WG	51
SME COMMUNITY	53
INTERNATIONAL COOPERATION ACTIVITY ON 5G	55
ACTIVITY COMMUNITY BUILDING AND PUBLIC RELATIONS	56
WORK ON THE SMART NETWORKS AND SERVICES	57
ANNEX PART 7 – COMMON PRIORITY KEY PERFORMANCE INDICATORS	59
ANNEX PART 8 – SPECIFIC KEY PERFORMANCE INDICATORS FOR THE 5G PPP	61
ANNEX PART 9 – CONTRIBUTION TO PROGRAMME-LEVEL KPI'S	66

List of Figures

Figure 1: Mapping of use cases to vertical categories (source)	5
Figure 2: Overview of the 5G PPP Programme	6
Figure 3: ICT-19 Platforms' Geography	7
Figure 4: Vertical industries under validation by ICT-17 and ICT-19 projects	8
Figure 5: 5G PPP Phase 3 Reference Figure	9
Figure 6 Comparative focus of 5G PPP phase 2 and phase 3 projects	10
Figure 7: Extract from the H2020 dashboard – SME participation in the 5G PPP	12
Figure 8: 5G PPP Governance	12
Figure 9: 5G PPP Projects - Heritage Figure	24
Figure 10: 5G IA membership versus type of stakeholders.....	28
Figure 11: The overall picture of WGs	29
Figure 12: 5G PPP Key achievements from Phase 2 projects	30
Figure 13: 5G PPP Phase 2 projects	31
Figure 14: Collaboration among ICT-17 and ICT-19 projects	32
Figure 15: ICT-20 projects main areas of impact	32
Figure 16: 5G PPP Key achievements v3.0	33
Figure 17: 5G PPP Vertical Cartography website entry page.....	34
Figure 18: Views of the online cartography	34
Figure 19: Inputs to 5G Standardization.....	48
Figure 20: <i>Example of “Find your SME” web page – Technology skills and expertise</i>	53
Figure 21: Example of “Find your SME” web page – Verticals skills and expertise.....	54
Figure 22: Statistics re. the “Find your SME” web page – July to December 2019.....	54
Figure 23: Statistics re. the “Find your SME” web page – July to December 2019.....	54
Figure 24: The 5G PPP stakeholders picture (source Full5G).....	57
Figure 25: SNS Partnership Proposal - Impact Areas.....	58

1. Introduction

This document reports the progress achieved by the 5G Public-Private Partnership (5G PPP) during 2019. 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 a number of 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.

Please note, that some of the reported information relates to data collected through specific Questionnaires. As for this report it was agreed with the EC not to perform a new questionnaire process, the current report contains some information taken from the 2018 questionnaire.

2. Main activities and achievements

5G has become commercially available during 2019, ahead of schedule. Within one year, 62 operators had launched 5G services in 32 markets, while a further 94 operators have announced plans to launch the service¹. Europe has been at the forefront of 5G launches. At the end of 2019, 5G commercial services were available in 10 countries². During the year as the first 5G systems were becoming available focusing on the existing consumer mass market, in parallel the next stage of 5G was being validated (i.e., design was checked for its appropriateness to meet verticals' requirements) and evaluated (i.e., quantitative information of some characteristics of a certain design, such as key performance indicators, were calculated). This next 5G release is focused on industrial applications and involves multiple trials across 28 member states. In the automotive sector, trials are taking place at a pan-European scale through 11 cross border corridors. Vertical trials have been performed through 5G Public Private Partnership projects (5G PPP) funded by 700M€ of the European Union research funding grants and matched by 3,5B€ of private funding in the 2014 - 2020 timeframe.

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 a number of scientific solutions that have been contributed to standardization activities and also the global academic and research community through publications. In addition, the 5GPP projects have been

¹ GSMA: Global 5G Landscape 1Q2020, Online: <https://data.gsmainelligence.com/research/research/research-2020/global-5g-landscape-q1-2020>

² The 5G Observatory (EC), Online: <https://5gobservatory.eu/>

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.

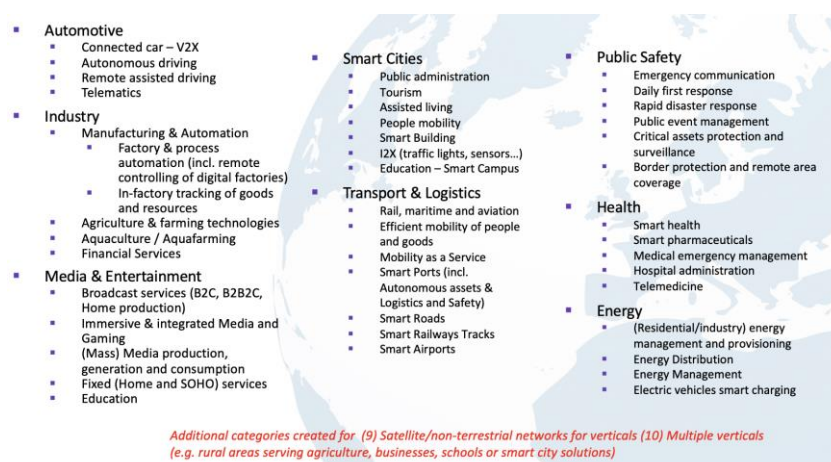


Figure 1: Mapping of use cases to vertical categories (source ³)

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 2019.** The next subsections provide more detailed information.

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

2019 was a transition period as the Programme ramped-down Phase 2 activities whilst at the same time ramped-up Phase 3 projects. Although several Phase 2 projects concluded their operation by mid-2019 several of them continued their activities throughout 2019. 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), started respectively in July 2018 and November 2018, they have been ramping-up very actively and are developing cross-projects synergies and programmatic actions. In June 2019, eight Phase 3 ICT-19 projects (a.k.a. 5G PPP Phase 3, 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

³ <https://global5g.org/>

industries. Finally, 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.

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 2.

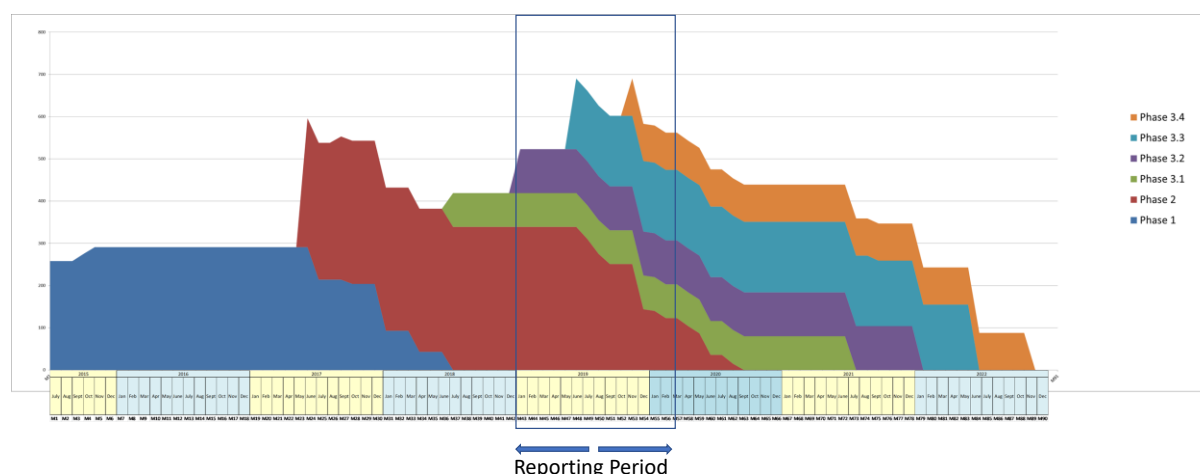


Figure 2: Overview of the 5G PPP Programme

Phase 2 started in June 2017, with **21 new 5G PPP** projects, including **2 complementary CSA projects**. These projects relied on the technologies, produced during Phase 1, for the digitisation and integration of vertical industries in Europe. Most Phase 2 projects successfully completed in 2019, while some are continuing in 2020. This phase was more focused on demonstrating and validating the developed technology and explicitly trying to integrate use cases from vertical industries beyond classical tele-communications.

During 2018, the **Phase 3** of the 5G-PPP framework was initiated with the first Phase 3 projects. This involved essentially the roll out of 5G platforms across Europe. The target was to enable large scale trials to help the stakeholders testing, in realistic environments, the key findings from the previous phases and draw significant conclusions. In 2018, **three infrastructure projects** were selected to create a pan-European large-scale 5G test platform to be used by a number of vertical use cases. **During 2019** these projects have setup a significant part of their platforms and provided a clear a detailed roadmap of their features that will be offered in multiple sites all over Europe⁴ (c.f., Figure 3). Also, these projects have clearly identified how their platforms can be used for advanced testing by other projects⁵.

⁴ Technology Board white paper, 5G network support of vertical industries in the 5G PPP ecosystem, February 2020, https://5g-ppp.eu/wp-content/uploads/2020/03/5PPP_VTF_brochure_v2.1.pdf

⁵ Technology Board white paper, On board procedure to 5G PPP Infrastructure Projects, April 2020, <https://5g-ppp.eu/wp-content/uploads/2020/04/On-Board-Procedure-to-5G-PPP-Infrastructure-Projects-1.pdf>

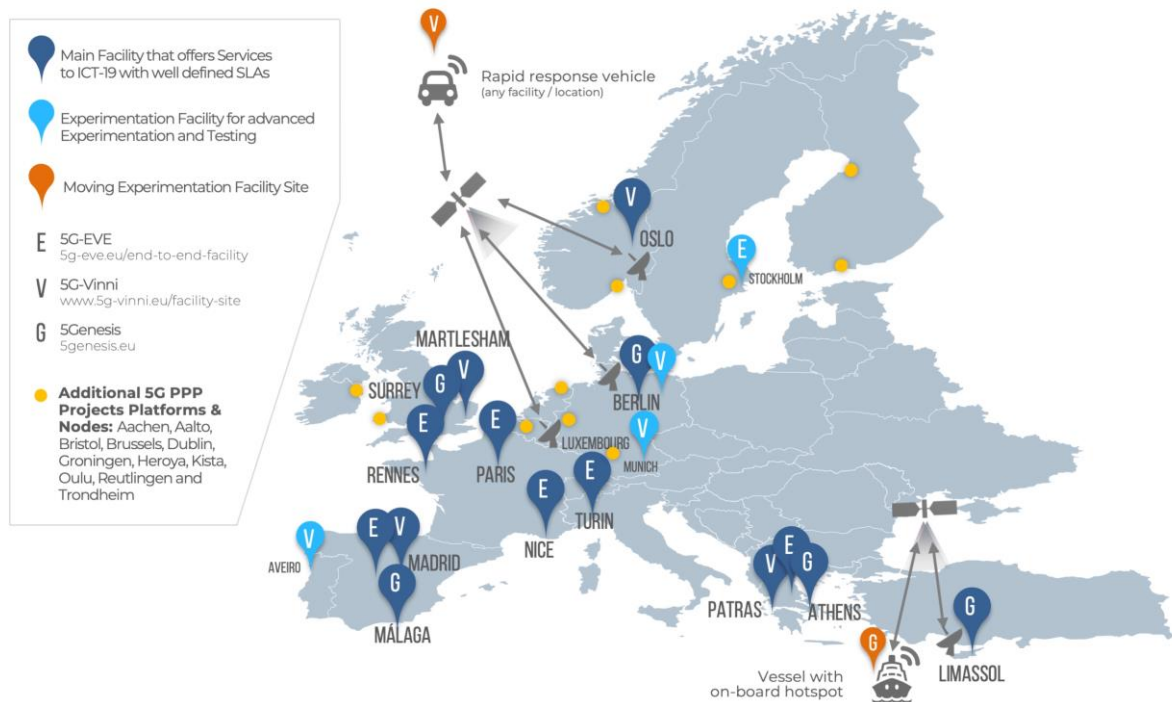


Figure 3: ICT-19 Platforms' Geography

Also, in November 2018, **three ICT-18 automotive/corridors projects** started their activities implementing and testing advanced scenarios and **one additional automotive project** is also active in the context of EU-China Collaboration. During 2019 these projects have completed the identification of the use case to be validated in cross border/Mobile Network Operators/Vendor/Generation trials. They have identified network requirements, potential changes in the network architecture and provided recommendations for regulation and spectrum. Some initial small-scale trials have been reported and some fine-tuning of the large-scale trials has been recently reported due to the Covid-19 pandemic⁶.

⁶ <https://5g-ppp.eu/5g-ppp-technology-board-workshop-2020/>

	 Industry 4.0	 Agriculture & agri-food	 Automotive	 Transport & logistics	 Smart Cities & utilities	 Public Safety	 Smart (air)ports	 Energy	 eHealth & wellness	 Media & entertain.
5G EVE	✓		✓		✓	✓		✓	✓	✓
5GENESIS				✓	✓	✓				✓
5G VINNI	✓			✓		✓		✓		
5GIDRONES				✓		✓				✓
5G HEART		✓	✓	✓					✓	
5GROWTH	✓			✓				✓		
5G SMART	✓									
5G SOLUTIONS	✓				✓		✓	✓		✓
5G TOURS				✓	✓		✓		✓	✓
5G VICTORI	✓			✓				✓		✓

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

In relation to the **ICT-19 projects**, **eight projects** (seven R&I and one CSA projects) have been selected out from the 32 proposals that were evaluated by the EC, in response to the 5G-PP ICT-19-2019 call. The projects mainly rely for their trials on the three ICT-17 platform projects, although some of them are also developing their own platforms to perform further testing. The ICT-17 and ICT-19 projects are covering a significant number of vertical industries as shown in Figure 4. The first three rows illustrate the vertical industries being covered by the ICT-17 projects while the remaining seven, present those covered by the ICT-19 projects. Significant information has been included in the Platforms Cartography as presented in the 7th Global 5G Event⁷, the platforms cartography web page⁸ and updated in early 2020⁹.

In November 2019, and under the **ICT-20 call**, **eight new projects** have started working on the longer-term vision for telecommunication networks. These projects target providing innovative solutions to transform the network into a low energy distributed computer. In such a system, processes and applications will be dynamically created, moved and suppressed, depending on the information flows and customer needs. In the evolved networks, new terminal types based on gestures, facial expressions, sound and haptics may also form the basis of the interaction between humans and infosystems. Figure 5 is Phase 3 reference Figure of 5G PPP.

⁷ <https://www.7thglobal5gevent.eu/s/6-Didier-Bourse.pdf>

⁸ <https://5g-ppp.eu/5g-ppp-platforms-cartography/>

⁹ Technology Board white paper, 5G network support of vertical industries in the 5G PPP ecosystem, February 2020, https://5g-ppp.eu/wp-content/uploads/2020/03/5PPP_VTF_brochure_v2.1.pdf

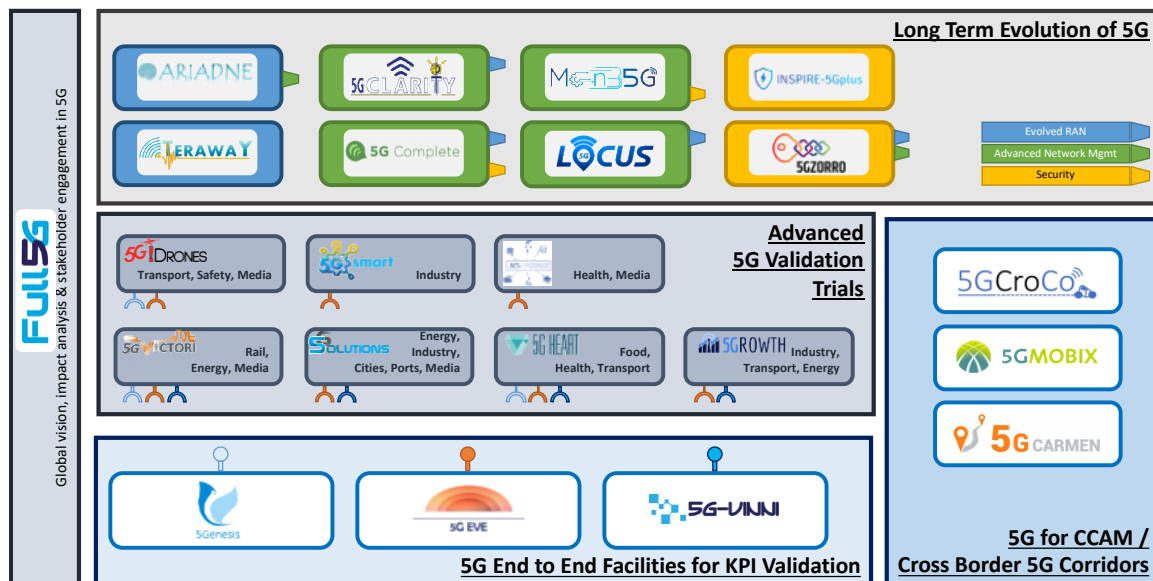


Figure 5: 5G PPP Phase 3 Reference Figure

An extremely useful tool for the identification of topics during the 5G PPP Phases has been the Pre-structuring Model (PSM). The Phase 3 (Part 2) PSM Version 2.0 was released by the 5G-IA in July 2019. Targeting a successful and coherent PPP Phase 3.II research and innovation programme and building on PPP Phase 1, Phase 2 and Phase 3.I experience, the 5G IA members have developed the Phase 3.II Pre-Structuring Model. The goal was to ensure that the forthcoming set of projects (portfolio) will cleverly work together in Phase 3 and between Phase 2 and Phase 3. The Model focused on Phase 3.II projects portfolio and related projects, not on proposals, and was building on the EC Work Programme 2018-2020 (final version of the WP2020 officially released on 02.07.19¹⁰). The Model presented features and recommendations to guarantee smooth integration of new projects in the existing coordinated Programme. It was targeting system recommendations to develop future efficient cross-projects cooperation, ensuring a comprehensive coverage of R&I (Research & Innovation) topics, with no gaps or redundancies.

The PSM Phase 3.II is focusing on the following EC Strategic Objectives:

- ICT-42-2020 – 5G Core Technology Innovations (IA and CSA) – Deadline for submissions was on 16.01.20.
- ICT-53-2020 – 5G for Connected and Automated Mobility (CAM) (IA) – Deadline for submissions was on 13.11.19.
- ICT-52-2020 – Smart Connectivity beyond 5G (RIA) - Deadline for submissions is on 17.06.20.
- ICT-41-2020 – 5G Innovations for Verticals with Third Party Services (IA) – Deadline for submissions on - Deadline for submissions is on 17.06.20.

The PSM Version 2.0 was presented during the EC Proposers Days on 19-20.09.19 in Helsinki and received very good feedbacks¹¹. There was a public Brokerage resource for the 5G PPP calls with proposal submissions in 2020 specifically addressing the H2020 Strategic Objectives ICT-41, ICT-42 and ICT-52.

¹⁰ http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-leit-ict_en.pdf

¹¹ <https://www.ideal-ist.eu/news/ict-proposers-day-2019>

Phase 2 and Phase 3 projects follow the overall Programme's goal to move from initial research results to large scale test-beds, getting closer to market applications. An analysis of the work of 5G PPP projects clearly shows (c.f. Figure 6) that in 5G PPP Phase 2 the focus was on the development of key technical breakthroughs whereas phase 3 projects cover all vertical industries and perform trials and pilots.

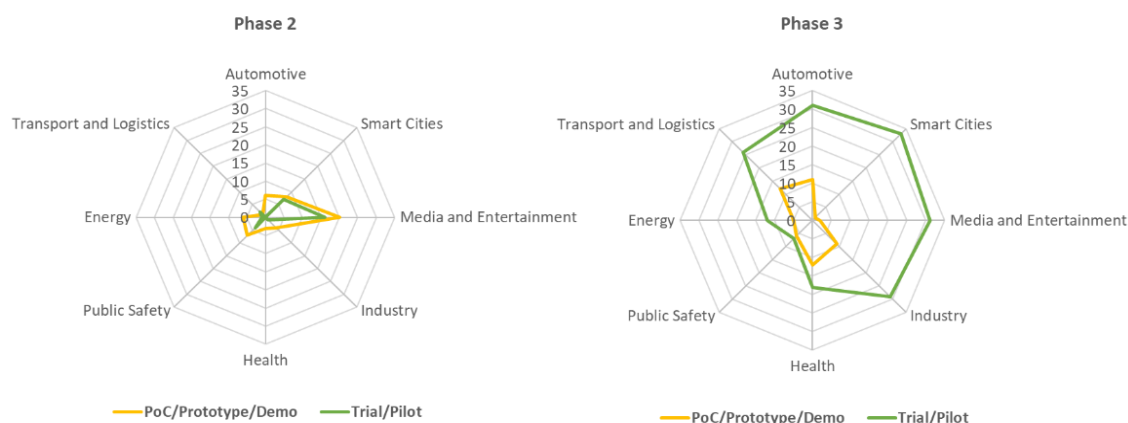


Figure 6 Comparative focus of 5G PPP phase 2 and phase 3 projects¹²

Since Phase 1, **62 projects** in total have been so far 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 v3.0**, including an updated list of key achievements from Phase 2 projects and key achievements from Phase 3 projects, **amount to 80 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 **eight white papers** disseminating key findings¹³.

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 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 129 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**

¹² https://bscw.5g-ppp.eu/sec/bscw.cgi/d342935/5G-PPP_Phase_III_Verticals_Cartography_Results_13032020.pptx

¹³ <https://5g-ppp.eu/white-papers/>

investment for 2018 has achieved a **leverage factor of 10,12** times the public EC investment in the 5G PPP for large industries and SMEs. **(7,24 for all types of stakeholders)**.

Also, an analysis of the data in the latest publicly available reports such as IPlytics¹⁴ (January 2020), indicates that although European companies share only a 17% of the declared 5G families (granted or pending patent applications), **they have the highest grant rate with just over 66%**. Analysing the percentages of the “at least granted in one patent office” from the declared 5G families one can extrapolate that the **European companies have approximately 24% of the granted patents**. The number of the **granted patents** is significant as it is a good indication about the placement of worldwide companies in the 5g race. **Moreover, an analysis of publicly available results suggests that the EU HQ companies combined share more than 50% of 5G commercial deals**.

2.2 Mobilization of stakeholders, outreach, success stories

Since 2019, a number of 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 site¹⁵.

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.

Another success story with global dimension is that 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. 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. 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 (Annex 6).

According to the H2020 dashboard¹⁶, the participation of SMEs in the 5G PPP has reached 19.13% representing a total of 91.38 M€ in EU funding, a little under the objective of 20% defined as a KPI of the programme¹⁷. A dedicated SME call is scheduled in 2020, hopefully

¹⁴ <https://www.iplytics.com/>

¹⁵ https://5g-ppp.eu/event-calendar/list/?tribe_paged=1&tribe_event_display=list&tribe-bar-date=2019-01-01

¹⁶ <https://webgate.ec.europa.eu/dashboard/>

¹⁷ These figures include the following calls: Phase 1: H2020-ICT-2014-2 / ICT-14-2014; Phase 2: H2020-ICT-2016-2 / ICT-7-2016; Phase 3 (1): H2020-ICT-2017 / ICT-17-2017; Phase 3 (2) H2020-ICT-2018 / ICT-18-2018; Phase 3 (3) H2020-ICT-2019 / ICT-19-2019; Phase 3 (4) H2020-ICT-2019 / ICT-20-2019.

allowing the 20% participation to be reached by the end of the initiative. 226 SME participation are accounted for, i.e. 20.96% of the 1,078 participations (Annex 6).

H2020 Participations 1.078 0,79% of H2020	H2020 Unique Participants 495 1,41% of H2020	H2020 Net EU Contribution 477,7M 0,91% of H2020	H2020 Total Cost 506,8M 0,77% of H2020	H2020 SME Participations 226 20,96% SME Participations	H2020 SME Net EU Contribution 91,38M 19,13% SME Part Net EU Contribution
--	---	--	---	---	---

Figure 7: 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, **13 MoUs** and **4 LoIs** with major 5G organizations from around the globe have been signed. A series of **Global 5G Events** also took place. These are a unique series of summits organized by the world's leading 5G organizations committed to bringing 5G technology successfully to their country or region. It has been developed in the framework of a multilateral Memorandum of Understanding in the interest of building global consensus on 5G and achieving efficiencies in the roll-out of 5G technology between 5G IA (EU), 5G Americas, 5G Forum (Korea), 5G MF (Japan), 5G Brazil and IMT-2020 (China).

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 8, 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.

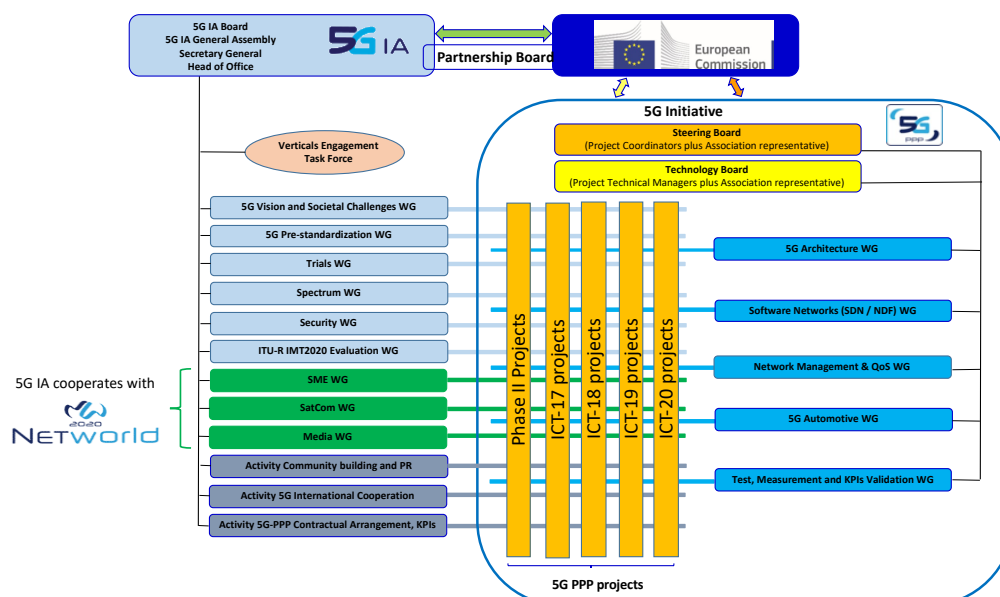


Figure 8: 5G PPP Governance

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

2019 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 (Annex 3), having most of *Phase 2 projects* successfully completing their activities whereas *a few of them* continuing for some additional months. Moreover, in the context of Phase 3, *the 3 infrastructure projects* have started their task to implement and test *advanced 5G infrastructures* in several EU countries. Moreover, *3 automotive projects* continue their design and initial testing of *advanced use cases for autonomous driving* in cross border infrastructures. *An additional automotive project*, in the context of EU-China collaboration, *continues building pre-commercial end-to-end testbeds* in two cities with sufficient coverage to extensively test eMBB and IoV trials. Moreover, 2019 was an important year as eight projects (seven R&I and once CSA) have started their work for advanced 5G validation trials across multiple vertical industries. Additionally, another set of eight projects have started their activities to design and validate the longer-term vision of 5G networks, since November 2019. Finally, ICT-42 5G Core Technology Innovations (IA and CSA) and ICT-53 5G for Connected and Automated Mobility (CAM) calls were successfully organized and ICT-52-2020 – Smart Connectivity beyond 5G (RIA) and ICT-41-2020 – 5G Innovations for Verticals with Third Party Services (IA) calls were successfully complete in 17.06.2020. All the aforementioned projects and calls follow the overall Programme's goal to move from initial research results to large scale test-beds, getting closer to market applications.
- **Optimum profile for the European 5G initiative in a global context:** As described in detail in Annex 6, the 5G IA has in place 13 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 like the EuCNC, the 5G Global Events and the Information day 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 10,12 times the public EC investment for large industry and SMEs*. Also, a *significant increase of new jobs/skills for all participating entities has been recorded*. This number is expected to rise considerably in Europe also due to the greater involvement of vertical industries when 5G networks will start their commercial roll-out. As for the *SMEs*, the collected data show that the Programme had a significant impact in the yearly turnover (10,1%) and yearly revenues (11,9%). Finally, specific 5G cPPP KPIs (performance, business and societal) are also addressed in the following section. Note here, that some of the reported information relates in the processing of data collected through specific Questionnaires. As for this report it was not required to release these Questionnaires, the current report contains information presented in the PMR 2018 for reasons of completeness.

- **Maintaining the holistic view of implementing 5G by 2020:** 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* (c.f. Figure 6)

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

The calculation of this KPI is based on the data extracted from the 2018 Questionnaire¹⁸, 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 dashboard¹⁹.

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 2014-2019 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:

¹⁸ <https://5g-ppp.eu/5g-ppp-progress-monitoring-report-data-collection-2019/>

¹⁹ <https://webgate.ec.europa.eu/dashboard/sense/app/93297a69-09fd-4ef5-889f-b83c4e21d33e/sheet/PbZJnb/state/analysis>

- 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 2014-2018, so its quota for 2018 was calculated by dividing the value by 5
- On the H2020 Qlik Sense dashboard, the following information has been extracted, per legal entity type, for ICT-07-2017 and ICT-08-2017 Call Topics (i.e., Phase 2 projects):
 - # of beneficiaries,
 - Total cost and
 - Total Net EU contribution
- The Total cost and Total Net EU contribution has been projected on 2018 only (assuming an average project duration of 36 months)
- Then, the following calculations have been performed, for each legal entity type:
 - The average values of A2.2, B1.1 and B2.1 (2018) 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 2018 and the Total costs for 2018
- The sum of total A.1, A2.1, A2.2, B1.1, B2.1 provides, for each legal entity type, the additional investment in 2018 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 2018 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 2018 mobilized private investments that sum up to an amount **10,12** times the public EC investment in the 5G PPP in the same period.
- All the types of stakeholders/beneficiaries invested in 2018 a total amount of money that is **7,24** 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 2018 Questionnaire from 5G PPP project beneficiaries.

These are defined as progressive values, referring to the period 2014-2018. 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:

- 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 numbers of beneficiaries (per legal entity type) for ICT-07-2017 and ICT-08-2017 Call Topics (i.e., Phase 2 projects) have been extracted;

- The average values of these parameters have been multiplied by the total number of beneficiaries in each type subset, in order 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.

2014-2018	New jobs/skills	
	Average	Total projected
<i>Overall</i>	<i>5,09</i>	<i>1.969</i>
Large Industry	6,67	1.147
SME	2,33	205
Academic Institution	4,50	329
Research Center	5,33	288

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 a large number of 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.

In order 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

Some of them (increase in staff headcount and number of new elements of foreground IP) were sought as progressive values, referring to the period 2014-2018; some of them (variation in turnover and revenues) have a yearly focus. Data for these parameters were collected through the 2018 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 a questionnaire from 5G PPP project SME beneficiaries
- An average value for each parameter was calculated over the samples collected;
- On the H2020 Qlik Sense dashboard, the following information has been extracted:
 - (per legal entity type) # of SME beneficiaries for ICT-07-2017 and ICT-08-2017 Call Topics (i.e. Phase 2 projects)

- 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>	2018	2018	2014 - 2018	2014 - 2018
Average values	10,1%	11,9%	4,00	1,50
Total projected	n/a	n/a	352	132

The number of members in the SME Working Group, whose main objective is to promote the skills and expertise of SMEs, has been regularly increasing. By end of 2019, there were 171 members, including 142 SMEs.

An important add-on to the web page in 2019 was the publication of the first “SME success stories”, showing the first achievements of SMEs thanks to their involvement in the 5G PPP. Emphasis was made on actual results, therefore demonstrating the impact of the participation of SMEs in the 5G PPP on products and solutions from each SME. SME success stories were also highlighted in the SME section of the 2019 5G PPP Annual Journal²⁰. By end of 2019, 7 full SME success stories had been released -with more to come in 2020. The latest version of the brochure “European SME Expertise in 5G and Beyond” has been published in June 2019²¹.

3.2.1.4 Significant innovations

The 5G PPP Phase projects have produced a number of significant technical innovations. As described in Annex 3, 60 highlighted results were captured and categorized under 14 program level achievements for Phase 2 projects. Moreover, in continuation of the 5G PPP Phase II key achievements²², Figure 16 presents the “Key achievements v 3.0” from 27, Phase 2²³ and Phase 3²⁴, 5G PPP Projects. Approximately 80 achievements have been reported that have been grouped in 11 different categories. Contrary to the Phase II key achievements, were these were mainly related to technological breakthroughs, the latest list identifies the progress of 5G PPP according to overall plan that is related to gradual shifting from concepts to trials.

Also, an analysis of the data in the latest publicly available reports such as IPlytics²⁵ (January 2020), indicates that although European companies share only a 17% of the declared 5G families (granted or pending patent applications), **they have the highest grant rate with just over 66%**. Analysing the percentages of the “at least granted in one patent office” from the

²⁰ <https://bscw.5g-ppp.eu/pub/bscw.cgi/d302069/Euro%205G%20PPP%20Annual%20Journal%202019-web.pdf>

²¹ <https://www.networld2020.eu/wp-content/uploads/2019/06/2019-sme-brochure-final-web.pdf>

²² <https://5g-ppp.eu/phase-2-key-achievements/>

²³ <https://5g-ppp.eu/5g-ppp-phase-2-projects/>

²⁴ <https://5g-ppp.eu/5g-ppp-phase-3-projects/>

²⁵ <https://www.iplytics.com/>

declared 5G families one can extrapolate that the **European companies have approximately 24% of the granted patents**. The number of the **granted patents** is significant as it is a good indication about the placement of worldwide companies in the 5g race. **Moreover, an analysis of publicly available results suggests that the EU HQ companies combined share more than 50% of 5G commercial deals.**

5G PPP is an active contributor to 5G standardization globally. Overall, the 5G-IA Pre-Standardization WG has tracked **139 inputs**, including 4 Technical Reports and 2 Technical Specifications in 3GPP and 1 Technical Report in ETSI (SES SCN), as well as industry vertical associations with WGs feeding inputs into 3GPP Market Representation Partners, e.g. 5GAA, 5G-ACIA. While the number of overall inputs is lower than in previous years, major inputs include the authorship of 3GPP technical specifications for the integration of satellite in 5G (e.g. 3GPP TS 23-737 and 26.501), **counting over 800 Tdoc contributions to SA1, SA2 and RAN3, and ETSI TR 103.611 for the definition of architecture options.**

The 5G PPP projects have disseminated their results in a number of scientific journals, international conferences, book chapters and white papers (Annex 9). **Phase 2 projects have produced approximately 1120 publications until now** (25% was published in scientific journals), **whereas Phase 3 projects have produced 208 publications** (31% was published in scientific journals).

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. Note here, that some of the reported information relates in the processing of data collected through specific Questionnaires. As for this report it was not required to release these Questionnaires, the current report contains information presented in the PMR 2018 for reasons of completeness.

3.2.2.1 Performance KPIs

The technical Annex to the 5G PPP contractual arrangement defines the following 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 in the course of 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 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 a large number of 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 an 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. The METIS-II Project assessed some of the performance KPIs results in February 2017. The METIS-II follow-up proposal for Phase 2 was not successful and no other PPP project has continued METIS-II work on the evaluation of some of the Performance KPIs. The To-Euro-5G project and the Technology Board decided to further the work on PPP Performance KPIs through a dedicated TB Performance ad-hoc Team involving Projects TMs/TMDs and specific Projects Performances KPIs Champions. The work was developed in 2018 and boosted thanks to the dedicated PPP Technical Workshop organized on 20-22.11.18 in Kista. **Since October 2019, this work is under the umbrella of the Test, Measurement and KPIs Validation WG. This WG has provided a core set of KPIs (i.e., Minimum Expected Upstream Throughput, Minimum Expected Downstream Throughput, UL Peak throughput, DL Peak Throughput, Maximum Expected Latency, Network reliability, Quality of Experience). The WG is working towards the validation aspects of these KPIs and is working on Test Cases formalization and is planning to release a handbook around the end of 2020. Moreover, this WG has initiated during the end of 2019 a sub-working group where all members of the ICT-19 projects participate in an attempt to map vertical Services/Application KPIs into network KPIs. The expectation is that the work will be also finalized during the end of 2020.**

An important task in relation to the evaluation of KPIs has been developed in the contact of the IMT2020 Evaluation WG (c.f., Annex 6). 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. **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. 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. 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.

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 2018 mobilized private investments that sum up to an amount **10,12** times the public EC investment in the 5G PPP in the same period.
- All the types of stakeholders/beneficiaries invested in 2018 a total amount of money that is **7,24** 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

SMEs represent an average of 19% of the participants in budget in the 5G PPP Phase 1 and Phase 2 projects, almost reaching the objective of 20% that is the minimum share set as a KPI for the 5G PPP. The share of SMEs has been decreasing in the first Phase 3 calls as they were specific calls for infrastructure and automotive (17% and 12% respectively) but are expected to be higher in the next calls that are more focusing on trials and verticals.

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

Since the full-scale commercial 5G roll-out has not taken place yet, it is difficult to provide accurate information about the global market share for 5G equipment and services delivered by European headquartered ICT companies. However, in forecasts that have been published recently, some interesting data are reported. For example, REUTERS has reported²⁶ that as of 17-06-2020 Ericsson has reported 93 5G commercial agreements and 40 live networks in 22 countries. NOKIA has reported respectively 73 commercial 5G deals and 23 live networks. Finally, Huawei has reported 91 commercial contracts. In other public report²⁷, ZTE has reported to secure 46 5G commercial contracts globally as of February 2020, whereas also Samsung has reported to secure 5G contracts²⁸, although the exact number is not publicly available.

Ericsson itself has announced 97 commercial 5G agreements, 55 publicly available 5G contracts and 45 live 5G networks (web site visited July 2020²⁹). NOKIA itself has reported³⁰ 125 commercial 5G engagements, 74 commercial 5G deals and 29 live 5G networks (website visited July 2020). Another recent report from Dell'Oro³¹ has reported that the revenues shares in the worldwide telecom equipment marked for Ericsson and NOKIA amounts at roughly 30%.

Based on the above-mentioned numbers it seems to be a valid assumption that the EU HQ companies combined share more than 50% of 5G commercial deals.

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.

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 data to be reported. It is hoped that this societal KPI will be further addressed in the future.

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

As 5G projects are currently in validation trials, this societal KPI is currently difficult to be addressed.

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

²⁶ <https://www.reuters.com/article/us-telecoms-5g-orders-factbox/factbox-deals-by-major-suppliers-in-the-race-for-5g-idUSKBN23O2G4>

²⁷ <https://www.rcrwireless.com/20200225/5g/zte-already-secured-46-5g-commercial-contracts-globally>

²⁸ <https://news.samsung.com/us/samsung-telus-5g-provider-canadian-operator/>

²⁹ <https://www.ericsson.com/en/5g/5g-networks/5g-contracts>

³⁰ <https://www.nokia.com/networks/5g/5g-in-action/>

³¹ <https://www.delloro.com/key-takeaways-the-telecom-equipment-market-1q20/>

Also, an analysis of the data in the latest publicly available reports such as IPlytics³² (January 2020), indicates that although European companies share only a 17% of the declared 5G families (granted or pending patent applications), **they have the highest grant rate with just over 66%**. Analysing the percentages of the “at least granted in one patent office” from the declared 5G families one can extrapolate that the **European companies have approximately 24% of the granted patents**. The number of the **granted patents** is significant as it is a good indication about the placement of worldwide companies in the 5g race. **Moreover, an analysis of publicly available results suggests that the EU HQ companies combined share more than 50% of 5G commercial deals.**

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., Figure 4). Moreover, in Annex 8 collected results about the verticals cartography for Phase 3 projects provide detailed information about the vertical use cases, the type of experiments, their location, the planned date, the vertical partners involved etc.

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). The suggestion of such a SG was coming from and discussed at the extended TB Workshop in October in Malaga, based on input from Telenor and the context of ICT-19. The outcomes of this WG are expected to offer some useful insight.

In the meantime, 5G PPP Phase 2 and Phase 3 Projects have provided 23 trials and pilots (higher level of maturity), and almost half of them are related to Broadcasting and Media (12 trials and pilots).

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

Data for new curricula/qualifications created were collected through a questionnaire³³ from 5G PPP project beneficiaries. These are defined as progressive values, referring to the period 2014-2018. A finer scale (e.g., per year) is very difficult to implement, since the creation of new 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.

³² <https://www.iplytics.com/>

³³ <https://5g-ppp.eu/5g-ppp-progress-monitoring-report-data-collection-2019/>

- 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 ICT-07-2017 and ICT-08-2017 Call Topics (i.e. Phase 2 projects)
- The average values of these parameters have been multiplied by the total number of beneficiaries in each type subset, in order 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.**

2014-2018	New 5G curricula and/or educational qualifications	
	Average	Total projected
<i>Overall</i>	<i>1,24</i>	<i>481</i>
Large Industry	1,38	237
SME	0,25	22
Academic Institution	2,56	187
Research Center	0,67	36

Moreover, 5G IA and EIT Digital have established contacts to discuss how the two organizations could mutually benefit from a close cooperation in particular in relation to the establishment and availability of 5G skills development curricula.

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). Obviously, a strand for further telecommunication research activities has also remained open (ICT-20 projects), as these activities could not stop until the new Programme activities start. **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 9.**

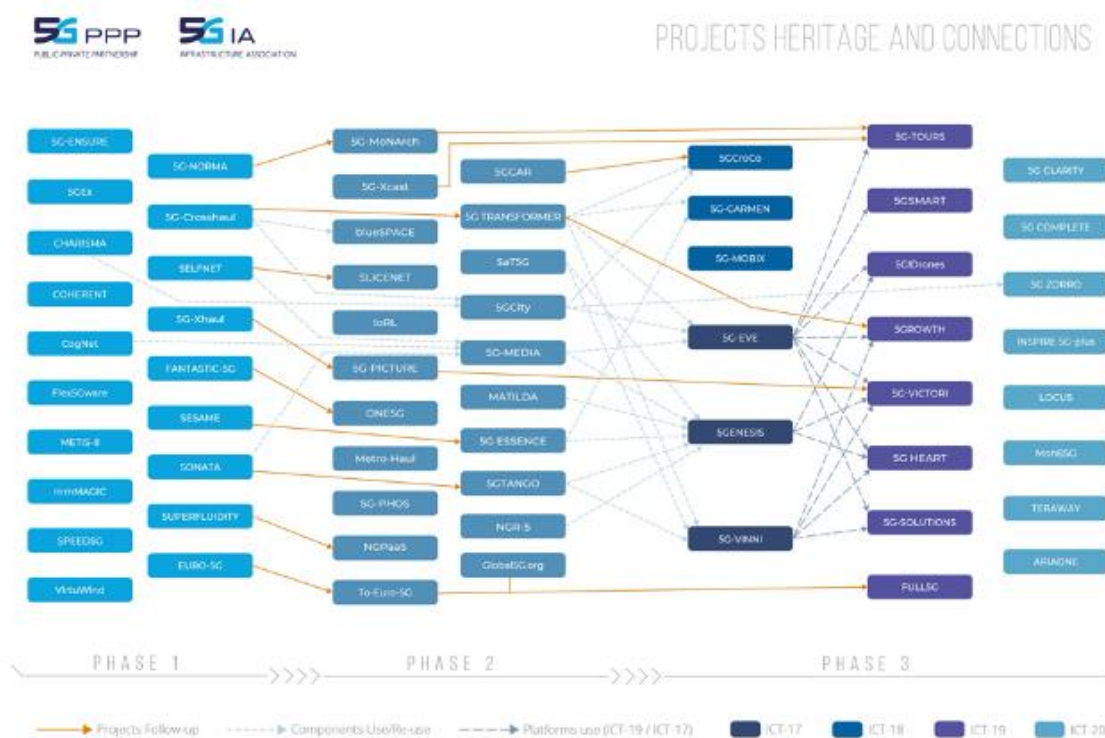


Figure 9: 5G PPP Projects - Heritage Figure

As we will discuss in the following section, the 5G PPP Programme has achieved a number of 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 2019. 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 800 Tdoc contributions to SA1, SA2 and RAN3, and ETSI TR 103.611 for the definition of architecture options
- Beyond standards, proving the 5G system is working for verticals in 70 test/experiment sites
- An active engagement in the IMT-R IMT 2020 evaluation process
- 13 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

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

5G IA's position paper on "a European Partnership on Smart Networks & Services under Horizon Europe"³⁴, nicely summarizes the current status which is none else than the fact that 5G PPP places Europe ahead in the global 5G race.

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.

³⁴ https://5g-ppp.eu/wp-content/uploads/2019/02/5G-IA-Position-Paper-Smart-Networks-and-Services_Horizon-Europe.pdf

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 website³⁵.

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 are able to 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

³⁵ www.5GPPP.eu

explicitly trying to integrate use cases from vertical industries beyond classical telecommunications.

- **Phase 3** addresses the development and rollout of 5G innovation and validation platforms across Europe. It started during the summer of 2018, with calls planned 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 in order 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 of 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) Network Management and QoS WG, d) 5G Automotive WG, and e) Test Measurement and KPIs Validation WG.

Annex Part 2 - The 5G Infrastructure Association

During 2019 56 organizations were 5G IA members. From these, 54 were full members whereas are 2 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 10 shows the composition of the members.

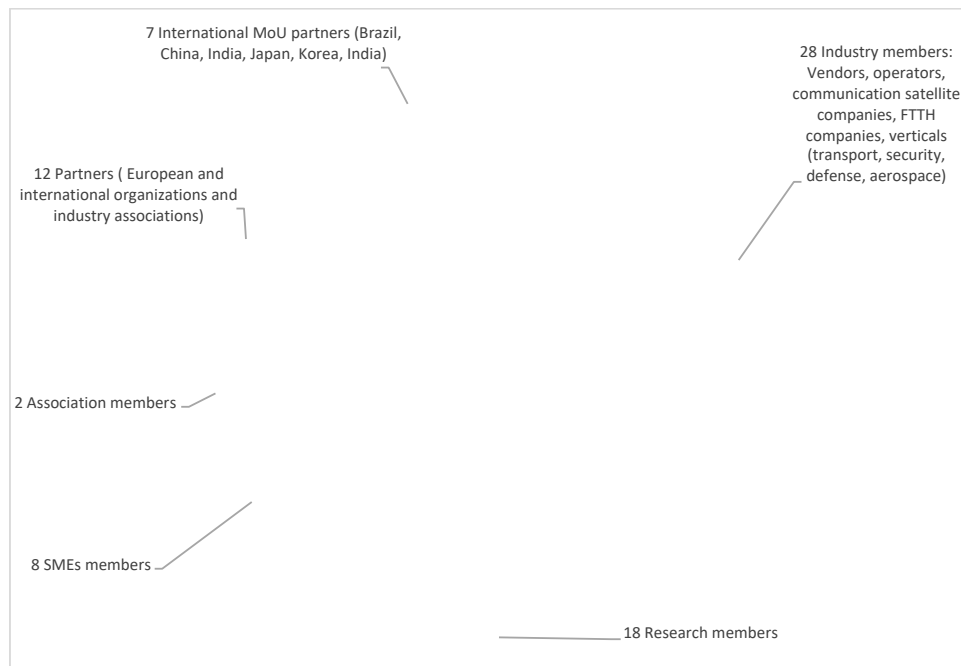


Figure 10: 5G IA membership versus type of stakeholders

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. These are: a) the Pre-standardization WG, b) the Spectrum WG, c) the Vision and Societal Challenges WG, d) the Security WG e) the Trials WG and f) the IMT-2020 Evaluation Group

Figure 11 is a summarized illustration of all active WG under the responsibility of 5G IA, 5G PPP Initiative and the NetWorld 2020.

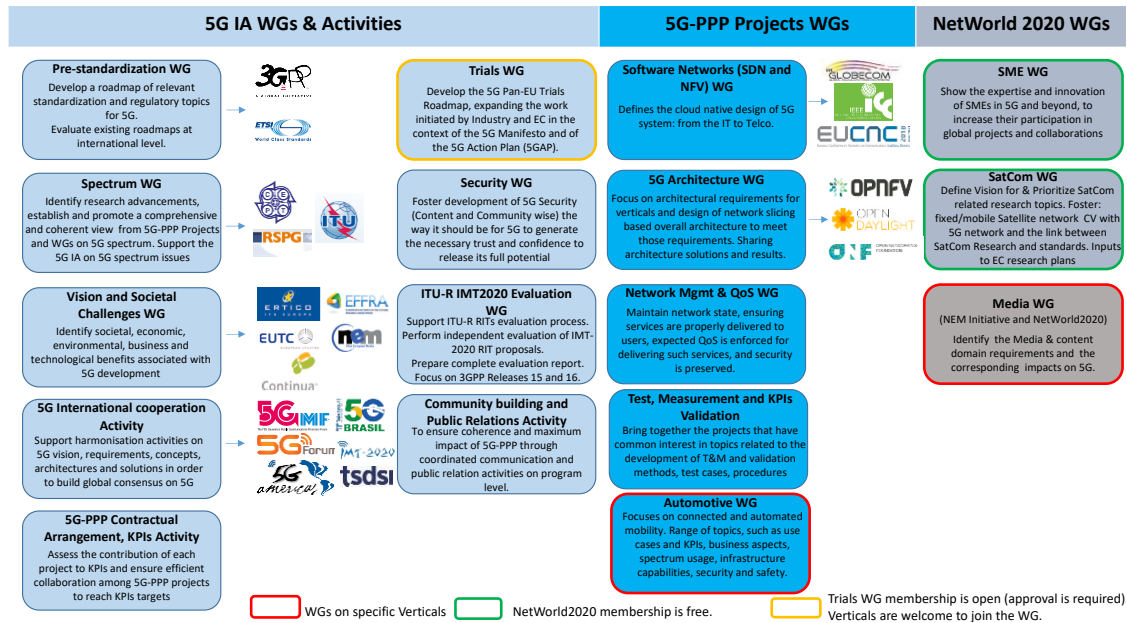


Figure 11: The overall picture of WGs

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 2019, providing key results and significant achievements for 5G networks and their evolution.

Following up on the successful completion of Phase 1 projects, the technological development provided by 5G PPP 2³⁶ projects has kept Europe in the leading position in the 5G race. The importance of EU funded projects to build a worldwide consensus at 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. 21 Phase 2 projects, having started in June 2017 delivered high-value results. Although some Phase 2 projects have completed their operation in June 2019, several projects continued their work into 2020. The Phase 2 “key achievements” include 60 highlighted technological results³⁷, having prototyped, validated, tested and piloted 5G in several vertical sectors (c.f. Figure 12).

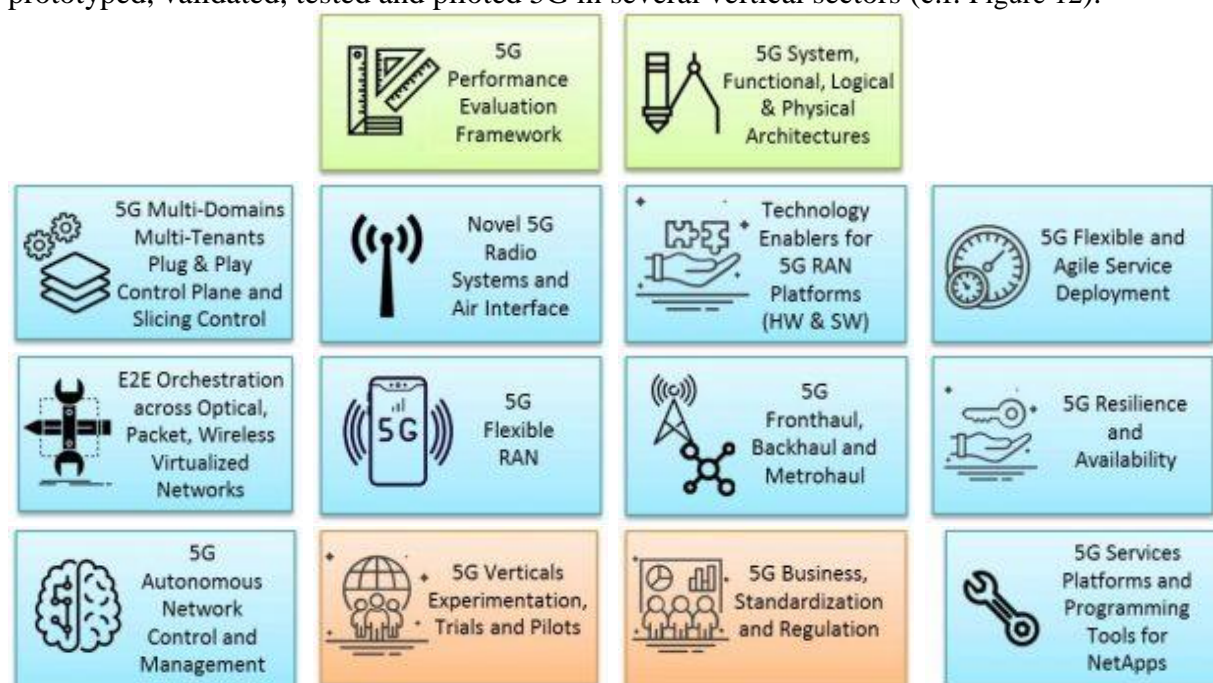


Figure 12: 5G PPP Key achievements from Phase 2 projects

Figure 13 illustrates these projects and their main technical areas. These areas covered the complete landscape from the radio access network (including the satellite communications), the fronthaul and backhaul and the control and management plane of the 5G networks in all network domains (access, transport and core). A significant number of these projects had a special focus to enhance the network readiness for verticals.

³⁶ <https://5g-ppp.eu/5g-ppp-phase-2-projects/>

³⁷ <https://5g-ppp.eu/phase-2-key-achievements/>

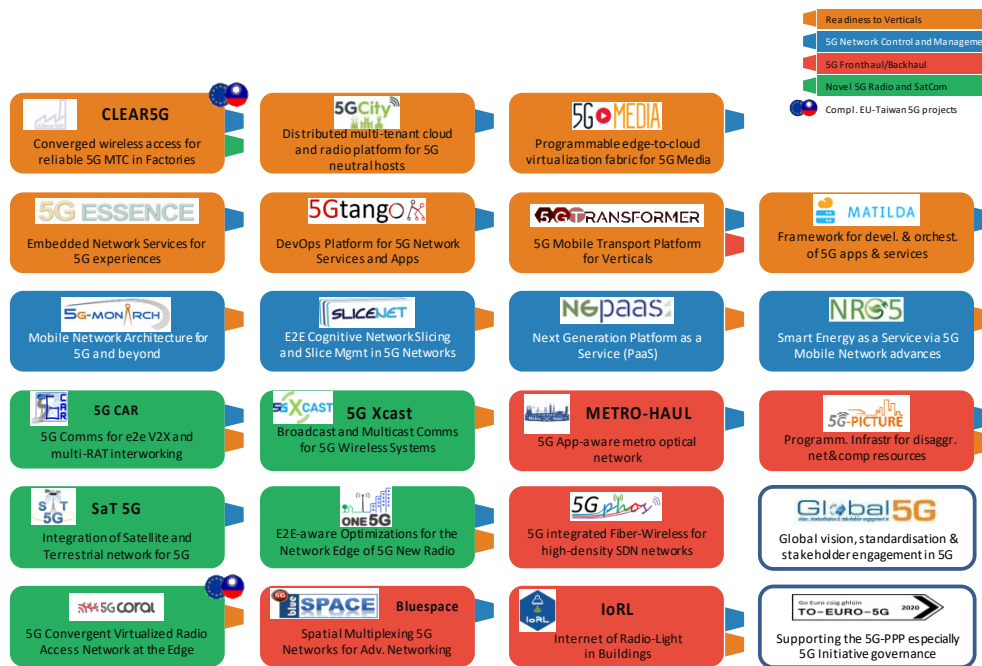


Figure 13: 5G PPP Phase 2 projects

The “5G Infrastructure PPP – Trials & Pilots Brochure” highlights 10 of these Phase 2 Trials & Pilots, selected by a PPP panel based on the assessment of the Trials & Pilots impact³⁸. Project overviews and results, test architectures and deployment schemes to validate use cases, as provided by vertical players participating on 5GPPP projects, have covered the most relevant European industrial sectors.

Started in 2018, three automotive projects, under the ICT-18 call have continued, throughout 2019, to test advanced cross border scenarios for autonomous driving. Apart from their independent tests and achievements, these projects, under the umbrella of the 5G automotive working group, have provided collective results with two white papers, namely: “Business Feasibility Study for 5G V2X Deployment”³⁹, and “Initial proposal on how 5G Strategic Deployment can support Connected and Automated Mobility (CAM) in Europe”⁴⁰.

Furthermore, 5G Infrastructure PPP Phase-3⁴¹ (c.f., Figure 5) includes three platforms projects (through the ICT-17 call) that have started their work in July 2018. The projects are providing large-scale end-to-end 5G validation network infrastructures. They cover about 20 EU sites and nodes on a pan-EU basis and will be operational until 2021. Their infrastructure provides an adequate level of openness to make it possible for vertical industries to test their innovative 5G business cases. A summary of their activities can be found in the “5G Network Support of vertical industries in the 5G PPP ecosystem”⁴².

As 5G networks aim to support the vertical industries, another set of eight Verticals Pilot projects (through the ICT – 19 call) have started their activities in June 2019. They demonstrate advanced 5G validation trials across multiple vertical industries. These projects will take advantage of the abovementioned ICT-17 projects and interwork with them using

³⁸ https://5g-ppp.eu/wp-content/uploads/2019/09/5GInfraPPP_10TPs_Brochure_FINAL_low_singlepages.pdf

³⁹ https://bscw.5g-ppp.eu/pub/bscw.cgi/d293672/5G%20PPP%20Automotive%20WG_White%20Paper_Feb2019.pdf

⁴⁰ <https://5g-ppp.eu/wp-content/uploads/2019/10/20191031-Initial-Proposal-5G-SDA-for-CAM-in-Europe.pdf>

⁴¹ <https://5g-ppp.eu/5g-ppp-phase-3-projects/>

⁴² <https://5g-ppp.eu/wp-content/uploads/2020/02/Vertical-industries-in-the-5G-PPP.pdf>

different infrastructure exposure levels as shown in Figure 14. Overall, ICT-17 and ICT-19 projects cover a wide range of vertical industries. Also, they will create the necessary knowledge to smoothly integrate different verticals with the 5G network infrastructure.

	5G EVE	5Genesis H2020 EU PROJECT	5G-VINCI
5G!DRONES	✓	✓	
5G HEART	✓	✓	✓
5G GROWTH	✓		✓
5G smart	✓		
5 SOLUTIONS 5G Solutions for European Citizens	✓		✓
5G TOURS	✓		
5G VICTORI	✓	✓	✓

Figure 14: Collaboration among ICT-17 and ICT-19 projects

In November 2019, and under the ICT-20 call, eight new projects have started working on the longer-term vision for telecommunication networks. These projects target providing innovative solutions to transform the network into a low energy distributed computer. In such a system, processes and applications will be dynamically created, moved and suppressed, depending on the information flows and customer needs. In the evolved networks, new terminal types based on gestures, facial expressions, sound and haptics may also form the basis of the interaction between humans and infosystems. Figure 15 illustrates the main area of impact for these projects.

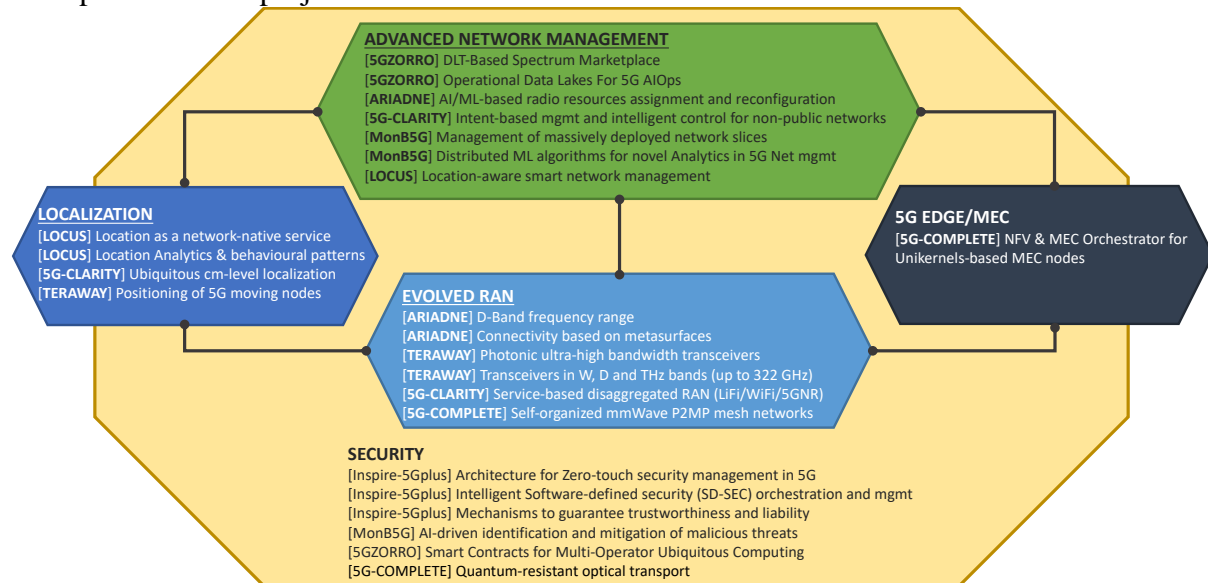


Figure 15: ICT-20 projects main areas of impact

Moreover, in continuation of the 5G PPP Phase II key achievements⁴³, Figure 16 presents the “Key achievements v 3.0” from 27, Phase 2⁴⁴ and Phase 3⁴⁵, 5G PPP Projects. Approximately 80 achievements have been reported that have been grouped in 11 different categories.

Contrary to the Phase II key achievements, were 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 the figure below, 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-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 2020⁴⁶.

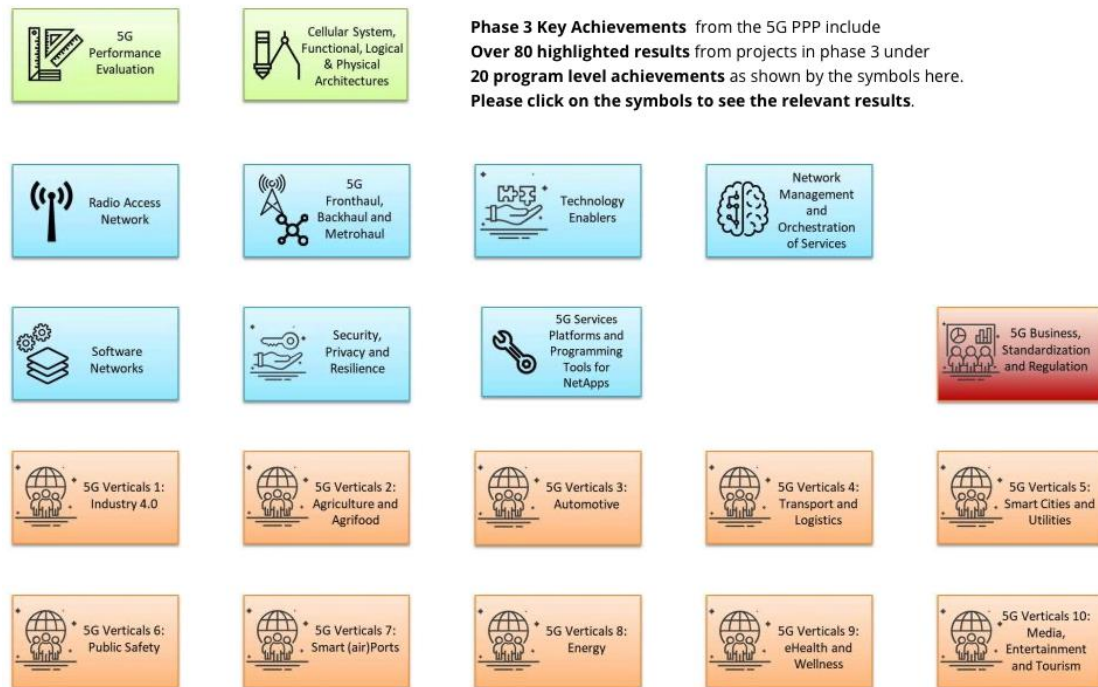


Figure 16: 5G PPP Key achievements v3.0

5G PPP Projects (Phase 2 & 3) are tracked to gather feedbacks on vertical use cases, 5G KPIs and realize a gap analysis on verticals needs. The methodology used to fulfil this task is the following. The 5G Initiative TB in collaboration with the Global5G produced a **Verticals Cartography**⁴⁷ that can be navigated.

⁴³ <https://5g-ppp.eu/phase-2-key-achievements/>

⁴⁴ <https://5g-ppp.eu/5g-ppp-phase-2-projects/>

⁴⁵ <https://5g-ppp.eu/5g-ppp-phase-3-projects/>

⁴⁶ <https://bscw.5g-ppp.eu/pub/bscw.cgi/d356008/Full%205G%20Annual%20Journal%202020.pdf>

⁴⁷ <https://global5g.org/cartography>

A detailed list of all use case experiments, that are taking place in Europe between 2018 and 2020, can be found in the verticals' cartography. Using the cartography, interested parties can find information on a vertical industry, country, type of experiment and ITU-T usage scenarios for 5G (i.e., eMBB, mMTC and URLLC). Figure 17 below shows the entry page of the verticals' cartography website with the verticals' industry filter. Also, the platforms cartography⁴⁸ provides information about vertical trials, the 5G features to be supported, the location of the trials and their scheduling in time.

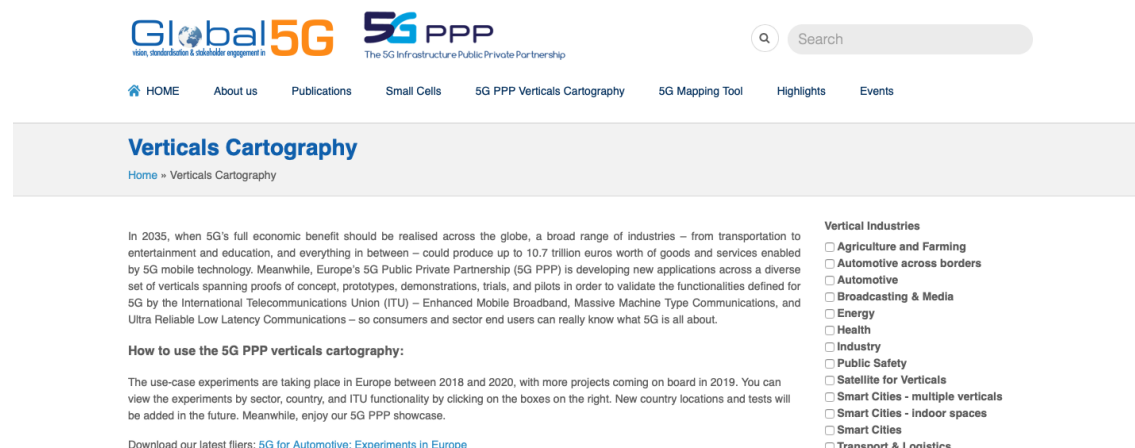


Figure 17: 5G PPP Vertical Cartography website entry page

Progress on the use-case experiments in phases 2 and 3 (ICT-17, -18 and -19) is tracked through the abovementioned online tool. Since its launch in mid-September 2018, the cartography now counts over 80 entries collected through cross-project collaboration, with very high visibility as shown in Figure 18.

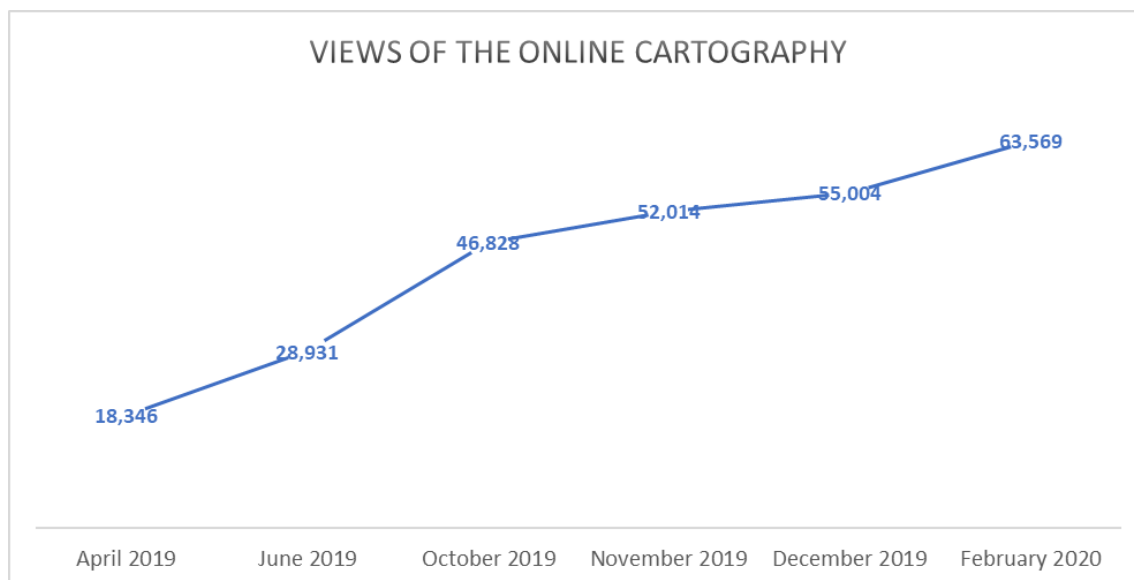


Figure 18: Views of the online cartography

⁴⁸ <https://5g-ppp.eu/5g-ppp-platforms-cartography/>

Moreover, the Mobile World Congress 2019 held in Barcelona from the 25th to the 28th February was a great opportunity for 5G IA and for 13 projects of the 5G PPP initiative to showcase the latest developments of their work under the motto '*Experience the future of 5G now*'.

Three project partners of [5G-MoNArch](#) (5G Mobile Network Architecture) - a Phase 2 5G PPP project - **received the prestigious '[5G Industry Partnership Award](#)**, which is one of the Global Mobile Awards 2019, for '*first large scale industrial commercial 5G trial*'. They deployed a 5G network in the 8,000-hectare Port of Hamburg originally as a proof of concept testbed and now is being used as an operational network.

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 papers⁴⁹. 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 5G Architecture Working Group (WG) as part of the 5G PPP Initiative has been looking at capturing novel trends and key technological enablers for the realization of the 5G architecture. One of the main targets of the WG is presenting, in a harmonized way, the architectural concepts developed in various 5G projects and initiatives (not limited to 5G PPP projects only) so as to provide a consolidated view on the technical directions for the architecture design in the 5G era. 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. Furthermore, the consolidated architecture views are provided in the form of white papers and also presented during the organized technical workshops in the international conferences.

On this basis, in 2019, the Architecture WG has prepared the third version of the white paper titled “View on 5G Architecture”, which was then published for public consolidation in June 2019 with the final version released in February 2020⁵⁰. The work in the third version of the white paper has mainly focussed on the 5G PPP Phase II and Phase III projects 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. Thus, White Paper Version 3.0 presents the consolidated European view on the architecture design. From a more technical perspective, the white paper has provided an overall architecture with various enhancements to the 3GPP Rel.15 system architecture to address specific requirements from vertical industries. The RAN architecture is presented along with the relevance of the edge to enable local computing and local path to support diverse variety of requirements in terms of latency, throughput and reliability. The CN architecture and the infrastructure connectivity provided by the Transport Network architecture are depicted. In order to achieve the required flexibility promised by the 5G system, the management and orchestration architecture plays a key role as captured by the white paper. Examples of architecture deployments investigated and analysed in the 5GPPP projects are detailed, which enable different verticals and large variety of requirements need to be supported. In addition, the standardization is summarized which highlights the impact that has already been achieved in different standardization bodies with special focus on 3GPP and ETSI.

The last but not the least, the findings and analyses of the Architecture WG with particular focus on 5GPPP Phase 2 projects and early findings of 5GPPP Phase 3 projects within the white paper framework have been presented in the organized International Workshop on 5G Architecture at EuCNC 2019⁵¹. While the standard implications on the ongoing specifications, e.g. in 3GPP Rel.16 and ETSI, were highlighted in the workshop, various

⁴⁹ <https://5g-ppp.eu/white-papers/>

⁵⁰ 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

⁵¹ 5GPPP Architecture WG International Workshop on 5G Architecture, EuCNC 2019, <https://www.eucnc.eu/workshops/workshop-8/>

achievements presented in the White Paper are also expected to impact 3GPP Rel.17 and beyond Study Items and Work Items. The workshop included a panel with online discussions with the workshop participants.

Software Networks WG

The software network Working Group (WG) has been created since 5G-PPP Phase 1 focusing initially on SDN & NFV. Starting from Jan 2018, a new term of reference has been adopted. A high priority was given to the cloud native transformation, since 5G and Beyond network has to offer a high degree of flexibility and dynamicity to embark easily the vertical industries.

Following the first White-Paper titled “From web scale to Telco, the cloud -native journey⁵²” published in June 2018, the WG worked on how 5G-PPP projects interpret cloud-native design patterns. This helped us to identify the different cloud-native adoption barriers. The analysis is based on a survey collecting technical inputs from the different phase 2 and phase 3 projects about their use-cases, the virtualization technologies they use, and the architecture patterns they follow. The results has been published in the second White Paper, titled “Cloud-Native and Vertical’s Services -5GPPP projects analysis⁵³”. It is published in **September 2019**. Our findings and conclusions are referred in 5G-Americas white paper on 5G wireless industry⁵⁴ putting the EU/5G-PPP at front on this kind technology made by Silicon Valley.

The WG continued its effort to give the right visibility to the cloud-native work conducted so far by publishing 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.

Besides this production activity, the WG organized a series of Workshops “from cloud ready to cloud native”. In EuCNC 2019, the WG organized a very successful second edition⁵⁵. It attracted more than 40 people with a strong interaction between different actors: research institutes, academia, industry and SMEs. 80% of the responses of the satisfaction’s survey are very positive with the content and the quality of the presentation and the discussion. A third edition has been submitted to EuCNC 2020.

Another area in which the WG is active is the Open-Source, which is eating more and more the Telco world. The WG is collecting and tracking the different Open-Source contributions from the different projects. This collection has been generalized, late in 2019, to all 5G-PPP projects.

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.

⁵² <https://5g-ppp.eu/wp-content/uploads/2018/07/5GPPP-Software-Network-WG-White-Paper-July-2018.pdf>

⁵³ https://5g-ppp.eu/wp-content/uploads/2019/09/5GPPP-Software-Network-WG-White-Paper-2019_FINAL.pdf

⁵⁴ <https://www.5gamericas.org/5g-and-the-cloud/>

⁵⁵ <https://www.eucnc.eu/workshops/workshop-2/>

Network Management & QoS WG

The 5G PPP Network Management and QoS Working Group (NMQ WG) was established in October 2015 by the 5G PPP Steering Board to discuss two closely correlated themes namely:

- **Network Management** aims to maintain the operations of the network in a manner that ensures that the required services are properly delivered to the users, that an expected quality of service is enforced for delivering such services to the end user and that security is maintained. To do so, network management is mainly focused on the control plane of the network to make sure all the services and operations running in the data plane are working properly.
- **Quality of Service** covers areas such as networking, packet scheduling, traffic adaption and any other technique implemented in both data and control plane to make sure an expected quality of service is implemented for the delivery of services to the end user (bandwidth, low latency, mobility and availability)

Network Security is in the scope of the NMQ Working Group if it refers to the **security of the control plane of the network**.

The NMQ WG worked actively from its creation until mid-2019 with the contributions of the following 5G PPP projects:

- Phase-1 CogNet, SelfNet, 5GEx, 5G Ensure, Speed-5G, Coherent, Charisma, Sonata, SESAME
- Phase-2 5G-City, 5G-Essence, IoRL, Matilda, 5G-Media, One-5G, NRG-5, 5G-Phos, Sat-5G, SliceNet, 5G-Transformer

During its lifetime, this WG provided the following outcome:

1. White paper “5G-PPP Cognitive Network Management for 5G – March 2017”⁵⁶,
2. Workshop on Network Management, Quality of Service and Security for 5G Networks, EuCNC 2016, Athens, Greece⁵⁷
3. 2nd workshop on Network Management, Quality of Service and Security for 5G Networks, EuCNC 2017, Oulu, Finland⁵⁸,
4. 3rd workshop on Network Management and QoS for 5G Networks, EuCNC 2018, Ljubljana, Slovenia⁵⁹,
5. Brochure “Tackling Network Management Challenges for Vertical Sectors – June 2018”⁶⁰

The NMQ WG had interacted with other 5G PPP WG on various aspects with a focus to ensure consistency of messages by the 5G PPP programme. The main WG with which the NMQ WG interacted include the:

- 5G Architecture WG
- Software Networks WG
- Security WG
- Vision and Societal challenges WG

Cooperation among projects of the 5G PPP remains crucial for achieving the overall objectives of the 5G PPP Programme. Due to absorption of project resources by other bodies

⁵⁶ https://5g-ppp.eu/wp-content/uploads/2017/03/NetworkManagement_WhitePaper_1.pdf

⁵⁷ <https://www.eucnc.eu/2016/www.eucnc.eu/index66e2.html?q=node/119>

⁵⁸ <https://www.eucnc.eu/2017/www.eucnc.eu/indexef91.html?q=node/115>

⁵⁹ <https://www.eucnc.eu/2018/www.eucnc.eu/workshops/workshop-7/index.html>

⁶⁰ https://5g-ppp.eu/wp-content/uploads/2018/06/NMQ-WG_Brochure_web.pdf

– mainly standardisation groups – the progress of the NMQ WG has slowed down in 2019 and reach a level which entails the closure of the NMQ WG. However, many challenges remain. In case in the course of the late 5G PPP programme phases, “hot” topics arise and sufficient backing by the current and future projects exists, it is recommended that a new WG with a new mandate (ToR) and approval by the 5G PPP steering board is formed.

5G Automotive WG

Two main activities of the Automotive Working Group (WG) during 2019 have been the ongoing work with the Strategic Deployment Agenda (SDA) and the Business feasibility study for 5G V2X deployment. Further, the Automotive WG has contributed to some broader 5G PPP and 5G-IA activities from the V2X perspective, such as the pre-structuring model and the TB performance KPIs. More details on the SDA and Business feasibility activities are outlined below.

Early February the Automotive WG contributed to the first SDA for Connected and Automated Mobility (CAM) workshop⁶¹ by giving a presentation of the draft SDA outline. These first SDA elements were supported by all present stakeholders. The Automotive WG, leading the SDA work, then took the received inputs into account for further development. In addition to regular SDA telco meetings, some of the active stakeholders also met face-to-face in May for a work meeting to prepare material for the 5G SDA for CAM presentation that later was given at ITS Europe in June⁶². Further work led up to the material that was presented in early October during the Digital Transport Days⁶³. Based on these discussions and the previous SDA material, an initial proposal on how 5G SDA can support CAM in Europe⁶⁴ was released shortly after.

Late February 2019 the Automotive Working Group (WG) White paper version 2, “Business Feasibility Study for 5G V2X Deployment”, was released⁶⁵. The hardcopy version was handed out during Mobile World Congress as well as highlighted in a presentation in the Mobile World Capital. In June, some additional business-related presentations were given and panels attended from the V2X perspective by the Automotive WG in the 5G Global Event and EuCNC.

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 that have strong interest in the Test and Measurement methodologies needed to provide support to the vertical use cases in

⁶¹ 5G Strategic Deployment Agenda (SDA) for Connected and Automated Mobility (CAM) Workshop in Brussels (Belgium), 7 February 2019. <https://ec.europa.eu/digital-single-market/en/news/5g-strategic-deployment-agenda-sda-connected-and-automated-mobility-cam-stakeholder-workshop>

⁶² 13th ITS European Congress in Eindhoven (Netherlands), 5G deployment for Automated Mobility, 4 June 2019. <https://www.eventbrite.com/e/5g-deployment-for-automated-mobility-registration-61032016404>

⁶³ Digital Transport Days in Helsinki (Finland), 5G for connected and automated mobility, 9 October 2019. <https://www.digitaltransport.eu/2019>

⁶⁴ 5G PPP Automotive WG, “Initial Proposal: 5G Strategic Deployment Agenda for Connected and Automated Mobility in Europe”, October 2019. <https://5g-ppp.eu/wp-content/uploads/2019/10/20191031-Initial-Proposal-5G-SDA-for-CAM-in-Europe.pdf>

⁶⁵ 5G PPP Automotive WG White Paper Version 2, “Business Feasibility Study for 5G V2X Deployment”, February 2019. <https://5g-ppp.eu/2nd-5g-ppp-automotive-wg-white-paper-released/>

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 OpenTAP and identification of relevant exploitation and dissemination targets to promote the European vision on T&M towards a more global adoption.

During 2019 the WG organized 11 conference calls. It also completed the onboard procedure of most of the ICT-19 projects within the group. The WG achieved an agreement on a set of common “Pre-qualification” test cases: basic verification checklist to be performed before handing over the trial infrastructure to testers/experimenters. Also, the WG was present at the EuCNC 2019 and released a White Paper on “Validating 5G Technology Performance – Assessing 5G architecture and Application Scenarios” at the 15th of June 2019.

The WG is planning for two different white papers:

- The Vertical KPIs Task Force will release its findings by the end of 2020
- Before the end of summer of 2020 an overview document of “Testing for Dummies” that contains an overview on how to start independent verifications with a bundle of open source software

White papers produced by the 5G PPP WGs

Since the creation of the WGs 24 white papers⁶⁶ have been produced overall. Eight of these white papers have been produced since 2019. These are:

1. 5G PPP Automotive White Paper: “**Business Feasibility Study for 5G V2X Deployment**” – (Version 2.0 **February 2019**)
2. 5G PPP Test, Measurement and KPIs Validation Working Group White Paper - June 2019: “**Validating 5G Technology Performance - Assessing 5G architecture and Application Scenarios**”: This paper proposes a unified vision on the Test and Measurement topics for 5G, allowing for common procedures and terminology and provides substantiated answers to more high-level relevant questions such as “does slicing help fulfilling vertical requirements for 5G?” (**June 2019**)
3. 5G-PPP Software Network White Paper: “**Cloud-Native and Verticals' services - 5G-PPP projects analysis**”. The paper analyses how 5G-PPP projects interpret Cloud-Native design patterns and identify adoption barriers (**September 2019**).

⁶⁶ <https://5g-ppp.eu/white-papers/>

4. 5G PPP Automotive WG “**Initial proposal on how 5G Strategic Deployment can support Connected and Automated Mobility (CAM) in Europe**”. This 5G Automotive WG Paper is an Initial Proposal showing how the 5G Strategic Deployment Agenda can reach out towards a broader range of potential stakeholders in the area of connected and automated mobility in Europe. (**October 2019**)
5. TB White paper: “**5G network support of vertical industries in the 5G PPP ecosystem**”, The paper contains an overview of the extended pilot trials that are being executed to validate 5G for vertical use cases using the three research infrastructure projects 5G-EVE, 5GENESIS and 5G-VINNI. These trials are being performed in the context of the 5G Public-Private Partnership (5G PPP) programme and cover multiple domains, like autonomous driving, smart factories, healthcare, media, energy, etc. (**February 2020**)
6. 5G-PPP Software Network WG Paper: “**Cloud-Native and 5G Verticals’ services**”. To highlight the value and challenges of becoming Cloud-Native, the 5G-PPP Software Network WG prepared this publication titled, Cloud Native and 5G Verticals’ services, depicting the three phases to evolve from Virtual Network Functions (VNFs) to Cloud-Native Functions (CNFs). (**February 2020**)
7. 5G PPP 5G Architecture WG: “**View on 5G Architecture (Version 3.0)**”. The white paper is the consolidated European view on 5G architecture design including the inputs from the Public Consultation phase. (**February 2020**)
8. TB White paper: “**On Board Procedure to 5G PPP Infrastructure Projects**”. This white paper describes the basic procedures that must be followed when vertical sector-oriented projects of the 5G PPP plan to use the 5G PPP infrastructure project services. For each of the infrastructure projects this paper informs – among others – about how to interact with the infrastructure, what information is needed for running experiments, what output and how is provided, as well as what are the future plans of each infrastructure project for the longer-term support of vertical applications. (**April 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 projects **have produced some significant results** (e.g., white papers from the WGs, workshops organized by WGs or projects and the global 5G events co-organized by 5G IA). The Technology Board organized **regular conference calls** (every 2-3 weeks on average) and **two face-to-face meetings** in 2019.

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

- Jointly with the Global5G 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 Network Support of vertical industries in the 5G PPP ecosystem” report for ICT-17 and ICT-19 projects has been produced. It provides information about the capabilities of the infrastructure platforms, the relation of their functionality to standards, their time-plan and their link to ICT-19 projects.
- The “5G Infrastructure PPP – Trials & Pilots Brochure” has been produced that highlights the key results of ten Phase 2 Trials & Pilots.
- Two face-to-face TB meetings have been organized. The first one took place in Brussels in May 2019. During the meeting, the production and update of cartographies and brochures took place. The second meeting took place in Malaga in October 2019. In this meeting, apart from the continuation of the work on the cartographies, effort was spent on the synchronization of ICT-17 and ICT-19 projects as well on specific technical topics like Edge Computing. As a result, two new White Papers have been initiated at a Technology Board level. The first one is related to the impact of 5G networks in the vertical industries. The second one will analyse the significance of edge computing in 5G networks and their evolution. 5G-PPP was present in MWC 2019 with 13 5G-PPP projects presenting their innovations and results. As a highlight, 5G-Monarch -a Phase 2 5G PPP project - received the prestigious ‘5G Industry Partnership Award’, which is one of the Global Mobile Awards 2019, for ‘first large scale industrial commercial 5G trial’.
- The 5G PPP initiative was present at the EuCNC 2019 conference participating in many sessions, workshops, tutorials, panels, special sessions, presenting 21 technical papers and showcased their results in 25 booths. In the booths, visitors could find out what projects are working on and how to get in touch with them. Also, the 5G PPP SME booth allowed visitors to meet some of the SMEs that are participating in the initiative. The best booth award of EuCNC was awarded to the EU 5G Cross Border Corridor Projects (i.e., 5G-CARMEN, 5G CroCo and 5G-MOBIX).
- The 7th Global 5G Event “Creating the Digital Future” took place in Valencia, Spain in June 2019). The event was co-located with EuCNC 2019 (18-20 June 2019). Thanks to the great synergy between these two major events, besides the conference sessions, visitors enjoyed an exhibition area with over 75 stands with compelling state-of-the-art indoor and outdoor 5G demonstrations, including those from many 5G PPP projects. Over 550 participants from all over the world attended this edition of

the Global 5G Event for over two days, contributing to make it a remarkable success. The 7th Global 5G Event featured six sessions with 49 top-class international presenters from business, research, European Commission and governments across the globe, covering key aspects of 5G technology and provided excellent insights and perspectives from different regions of the world.

- The Pre-Structuring Model (PSM) Phase 3.II was released by the 5G IA in Versions 1.0 and 1.1 in February 2019. The PSM Phase 3.II Version 2.0 was released in July 2019⁶⁷. The PSM is prepared by the 5G IA Vision and Societal WG. The PSM presents features and recommendations to guarantee smooth integration of the forthcoming Phase 3 projects in the existing coordinated programme. It also targets system recommendations to develop future efficient cross-projects cooperation. Based on the PSM model, ICT-41, ICT-42, ICT-52 and ICT-53 calls were issued in 2020. These could potentially enable the funding for up to 51 new projects. Their activities will be integrated into the overall TB activities.
- 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.

⁶⁷ https://5g-ppp.eu/wp-content/uploads/2019/09/190712_5GInfraPPP_PSM-Phase3.II_V2.0_Final.pdf

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 European Commission has asked to define a strategy to support vertical engagement. This was also defined as an objective by the Board of the 5G IA and a Vertical Engagement Task Force (“VTF”) was set up in the beginning of 2018. This task force provides a top down guidance complementing the bottom up activities within 5G PPP Projects, 5G IA Working Groups, 5G Initiative SB/TB, CSAs and Board activities. 5G IA’s VTF has the following objectives: a) Enhance verticals engagement in 5G PPP, b) Promote relevant funding Calls within verticals industries c) Gather verticals feedback on 5G needs and potential barriers for adoption and d) Raise awareness of 5G potential.

For the reporting period the following achievements have been made. **Priority vertical sectors** were addressed starting from the Automotive one as it is considered a key sector for the EU economy and for 5G adoption. This sector is impacted also by other EU funded programmes for large scale testing & trials (e.g., CEF) and it has suffered from a controversial decision on V2X communication technology (WiFi vs 4G/5G). Other key sectors were addressed by the VTF, namely Smart Manufacturing and Public Safety. In these sectors, key industry events were attended with 5G PPP high level speakers to influence decision makers on 5G adoption while partnerships through MoUs have been undertaken (*5G AA - Automotive, PSCE and ECSO – Public Safety*). Contacts have been initiated in the remaining sectors (*Media, Energy, Health, Smart Manufacturing*) to create impact in 2019 (e.g., through events and MoUs).

A **smooth governance model** was performed by a team of key people (5G Initiative SB/TB Chairs, Vertical WGs Chairs, Secretary General, To-Euro-5G and Global5G.org representatives and Satellite Board Member) who expressed a strong team spirit under the guidance of the Chair and Vice Chair acting together to coordinate meetings and activities. To leverage synergies and avoid useless duplications a cross governance model with the Global5G.org was established (the CSA focused on standardization and verticals). The VTF Chair was invited to join Global5G.org Advisory Board to attend meetings in 2019. Communication with verticals was addressed with To-Euro-5G which implemented a Vertical focused portal on 5G PPP website. A Vertical Tracker document was edited to track VTF activities with contributions from the 5G Initiative TB (Vertical Cartography of 5G PPP Projects) and the 5G Observatory Quarterly Report (map of 5G Trials). The Tracker was used in 2018 as a one shop stop document to collect vertical related information and as a reporting tool for Board meetings. Feedback on the activities of the VTF presented whenever relevant in the TB and the Verticals WGs by their Chairpersons who are involved in the VTF.

Active engagement actions were performed in priority sectors (i) attending 15 verticals industry events with 5G PPP speakers and (ii) defining partnerships with vertical sectors by the means of signed MoUs with key industrial fora.

5G Vision and Societal Challenges WG

The objectives of the Vision and Societal Challenges WG are to:

- Facilitate the creation of a pre-structuring model for future 5G PPP calls
- Further develop a vision for Smart Networks beyond 2020, covering both advanced research and societal challenges
- Stimulate the liaison with member state initiatives on 5G and on Smart Networks

The WG is organized in a number of sub-working groups. The main activities of the workgroup along 2019 have been the following:

Horizon Europe Vision (HEU) Sub-Group

A small dedicated task force was established to engage with the Alliance for Internet of Things Innovation (AIOTI) for the purpose to follow-up on target set by the MoU with them established in December 2018. A kick-off conf.call 14.2, further calls 21.2; 28.2; 7.3.

Horizon Europe Subgroup engaged in five conference calls with AIOTI, targeted to define and finalize the common vision document and next the common research and innovation topics document. We also engaged in several conf. calls and as well as f2f meetings with the Smart Networks and Services (SN&S) Task Force (TF) under the 5G-IA, including contributions and reviewing of ongoing scoping work (towards Horizon Europe).

The core team of HEU Vision Subgroup, in collaboration with AIoTI, finalized the common topics vision document for smart networks and services (SNS). After final review and approval by the 5G-IA Board a press release was announced by the 5G-IA⁶⁸.

Also, the core team engaged with the SNS Task Force to continue working with the SNS Partnership proposal preparations, including gap analysis, ..., roadmap, activities and mechanisms, among other things to follow up from the common topics work with AIoTI.

The VSC WG Core team (Chair, Vice-Chair, SG Leaders, 5G-IA Executive Director) discussed and agreed to set up a new Sub-Group, the “Business Validation, Modelling and Ecosystem SG” (BVME SG). The suggestion of such a SG was coming from and discussed at the extended TB Workshop in October in Malaga, based on input from Telenor and the context of ICT-19.

Pre-Structuring Model (PSM) Sub-Group

The Pre-Structuring Model (PSM) Sub-Group (SG) was launched with the organization of specific telcos on 11.01.19, 21.01.19, 25.01.19, 01.02.19, 08.02.19, 18.02.19 and 25.02.19. The PSM SG then included 44 members from 29 different organizations.

The PSM Version 1.0 was completed in January 2019, released and communicated on 08.02.19. The PSM Version 1.1 was developed in February 2019, released and communicated on 28.02.19.

⁶⁸ https://5g-ia.eu/single_post/?slug=5g-ia-and-aioti-smart-networks-and-iot-common-topics-for-research-and-innovation-in-horizon-europe

The Pre-Structuring Model (PSM) Sub-Group (SG) activities were launched with the organization of specific conf. calls on 09.04.19 and 26.04.19. The PSM SG then included 55 members from 32 different organizations.

The Pre-Structuring Model (PSM) Sub-Group (SG) activities were launched boosted with the organization of specific telcos on 03.09.19, 04.10.19 and 06.11.19. The PSM SG then included 57 members from 34 different organizations.

The PSM Phase 3.II Version 2.0 was presented by Didier Bourse during the EC Proposers Days / 5G Infrastructure PPP Session organized on 20.09.19 in Helsinki. The PSM Phase 3.II Version 2.0 addressed ICT-52 Smart Connectivity beyond 5G (DL on 22.04.20), ICT-53 5G for Connected and Automated Mobility (CAM) (DL on 13.11.19), ICT-41 5G Innovations for Verticals with Third Party Services (DL on 22.04.20) and ICT-42 5G Core Technology Innovations (DL on 16.01.20).

The PSM Version 2.0 was used, during the PPP Technical Workshop 2019, as input to specific discussion in the Session “PPP Cross-Phases Synergies” point “Expected integration of forthcoming Verticals / ICT-41 Projects”.

The PSM SG also performed the analysis of the PPP Phases/Calls Portfolios Mapping (incl. gaps) by the defined PSMs (Phase 1, Phase 2, Phase 3.I and Phase 3.II) and the set of selected Proposals (/Reviewers /EC). This analysis was developed over the full PPP, also considering (/up-dating) the previous high-level analysis already developed in the context of PPP Phase 1 and Phase 2. A specific PPP PSM short summary document was targeted for release in 1Q20, incl. approach, objectives, key take away points and lessons learnt.

The Pre-Structuring Model (PSM) Sub-Group (SG) activities have been boosted with the organization of specific telcos on 06.11.19, 09.12.19 and 10.01.20. The PSM SG includes 57 members from 34 different organizations.

The PSM SG is currently focused on the analysis of the PPP Phases/Calls Portfolios Mapping (incl. gaps) bw the defined PSMs (Phase 1, Phase 2, Phase 3.I and Phase 3.II) and the set of selected Proposals (/Reviewers /EC). This analysis is developed over the full PPP, also considering (/up-dating) the previous high-level analysis already developed in the context of PPP Phase 1 and Phase 2. A specific PPP PSM summary document is targeted for release in 1Q20, incl. PSM approach, objectives, key take away points and lessons learnt (incl. also Brokerage Platform). A specific Survey will also be launched towards Community Members.

The PPP Brokerage Platform has been reactivated thanks to FULL5G / Eurescom⁶⁹. The PPP Brokerage Platform reactivation has been communicated in the PPP NewsFlash December 2019⁷⁰.

Member States Initiatives (MSI) Subgroup

Member States Initiatives (MSI) Subgroup: The kick-off conf. call of the MSI subgroup took place on May 10th.

⁶⁹ <https://5g-ppp.eu/brokerage-platform-new/>

⁷⁰ <https://5g-ppp.eu/newsflash-december-2019/>

The Member State Initiatives subgroup worked as the main editor of (and also providing contributions for) a book chapter on “5G deployment in Europe” for the book “5G in Italy”. The Member State Initiatives subgroup continued its work as the main editor of (and also providing contributions for) a book chapter on “5G deployment in Europe” for the book “5G in Italy”.

Workgroup Achievements along 2019

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

- PSM Version 1.0 released and communicated on 08.02.19.
- PSM Version 1.1 released and communicated on 28.02.19.
- A draft joint vision document with AIOTI on collaboration for Horizon Europe was released
- A common Vision document with AIOTI was released.
- Contributions to the SN&S scoping work and document.
- Collecting feedbacks on the PSM Version 1.1.
- Open Consultation on the PSM Version 1.1 launched on 03.04.19. Initial DL on 25.04.19 extended to 17.05.19.
- Development of the draft PSM Version 2.0 addressing ICT-52 Smart Connectivity beyond 5G (DL on 22.04.20), ICT-53 5G for Connected and Automated Mobility (CAM) (DL on 13.11.19), ICT-41 5G Innovations for Verticals with Third Party Services (DL on 22.04.20) and ICT-42 5G Core Technology Innovations (DL on 16.01.20).
- Presentation of the PSM Phase 3.II Version 2.0 during the EC Proposers Days / 5G Infrastructure PPP Session organized on 20.09.19 in Helsinki.
First early draft version (V0.1) of the PSM Mapping PPT slides set collecting raw inputs for the PSM Mapping analysis.
- By the end of October, the ToC of the chapter for the 5G Italian Book has been agreed and the main editors and contributors of each subsection were assigned. The main references were also gathered and studied.
- Release of the “Common Research Topics” vision paper with AIOTI.
- Version V0.2 of the PSM Mapping PPT slides set further collecting raw inputs for the PSM Mapping analysis. Progress on Mapping analysis related to ICT-19 and ICT-20 Projects.
- The Member State Initiatives subgroup submitted the final version of the 5G Italy book chapter to the main editors of the book. It is now available online for download⁷¹

Pre-standardization

The main activities of the Pre-Standardization WG in 2019 have been: Tracking inputs from 5G PPP projects to global standardization work on 5G; co-organizing two workshops with 3GPP TSG Chairs and Market Representation Partners (February and July 2019), contributing to the white paper of the Architecture WG (June 2019; consolidated version February 2020), and rolling out an online Standards Tracker.

Regular updates on 5G PPP project inputs collected in the WG tracking documents during monthly conference calls. 3GPP delegates within the WG have provided quarterly debriefs on

⁷¹ <https://www.5gitaly.eu/5g-italy-book/>

3GPP Plenary Meetings, helping to identify opportunities for inputs, with gap analyses also shared with STANDICT.eu⁷².

The WG also worked closely with the Architecture WG to track inputs to standards organizations and open source initiatives, in close synergy with the WG chairs. The WG tracker was extended to include four key aspects: Overall architecture, radio and edge, core and transport and MANO (management and network orchestration). The findings are reported in Chapter 7 (Standardization Impacts) of the Architecture WG white paper V3.0, “View on 5G Architecture”.

The first 5G Vertical User Workshop brought together four 3GPP MRPs (5GAA, 5G-ACIA, 5G-IA, PSCE) and industry alliances for broadcasting (EBU), energy (EUTC) and satellite (ESOA) to define steps aimed at lowering entry barriers to 5G standardization for industry verticals. The second Workshop extended vertical coverage to maritime, rail and smart mobility and was co-located with the 3GPP SA6 meeting to share information on mission-critical applications relevant to diverse verticals. The workshop collected technical viewpoints and requirements and performed a mapping of common requirements (e.g. non-public networks, NR for non-terrestrial networks, positioning enhancements) to encourage verticals to join forces and build consensus. Another key outcome of the workshop was the need for an online tool acting as a bridge across standards and sector specialists. The result is the online Standards Tracker⁷³. Practical guides for verticals were also produced, published on the online Tracker and shared across the network.

5G PPP is an active contributor to 5G standardization globally. Overall, the 5G-IA Pre-Standardization WG has tracked several inputs in different standardization bodies (Annex 9).

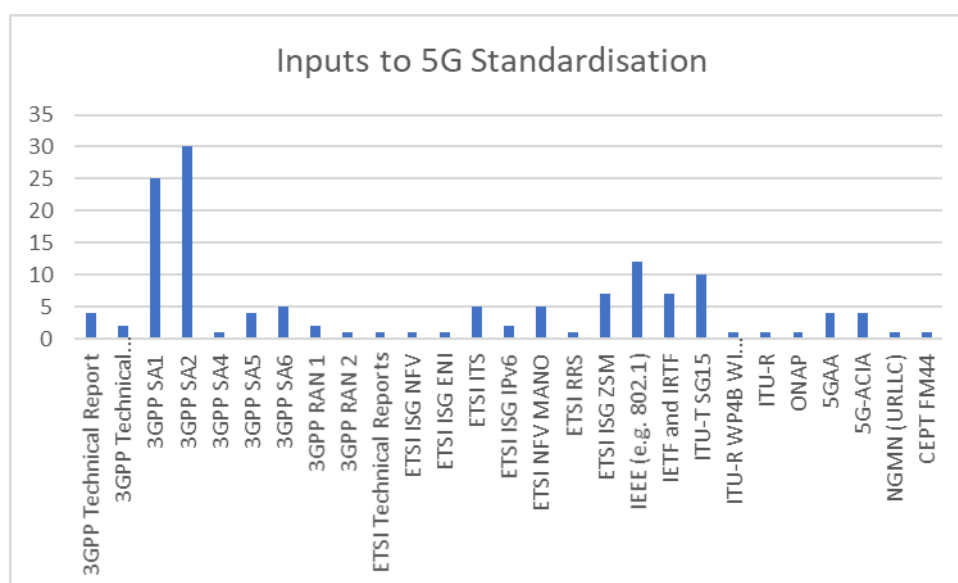


Figure 19: Inputs to 5G Standardization

Most inputs have been submitted to 3GPP TSG WGs (74), followed by several ETSI ISGs (23), IEEE (12), ITU-T and ITU-R (12), the Open Network Automation Platform (ONAP), and industry alliances.

⁷² <https://www.standict.eu/>

⁷³ <http://global5g.org/online-tool-standards-tracker>

Trials

The Trials WG is focused on the definition of the 5G Pan-EU Trials Roadmap, following the actions defined in the 5G Manifesto and the 5G Action Plan. During 2019, the Trials WG further developed the overall (plenary) actions and the 6 WG Streams actions in parallel: 5G Private Trials, 5G UEFA EURO 2020, 5G Trials Cities, 5G Platforms, 5G Vertical Pilots and 5G International Cooperation.

The Trials WG operation was organized through specific Plenary and Streams interactions:

- WG Plenary PhCs organized on 14.01.19, 08.02.19, 11.03.19, 01.04.18, 18.04.19, 09.05.19, 05.06.19, 28.06.19, 05.07.19, 12.07.19, 28.08.19, 03.09.19 and 13.09.19.
- Dedicated WG Streams PhCs organized from January to September 2019.
- 5G UEFA EURO 2020 Stream F2F meetings organized on 14.03.19 in Amsterdam (Amsterdam CTO) and 10.07.19 in Brussels (EC Beaulieu).

Among the main activities developed in 2019:

- Further boost of the PPP Verticals Cartography, with joint actions between Trials WG, TB, Global5G.org and Verticals Task Force (VTF).
- Further boost of the PPP Platforms Cartography with joint action between Trials WG and TB ICT-17 and ICT-19 Projects TMs/TMDs.
- Further definition and implementation of the Trials WG and Streams Plans for 2019, considering the boost of 5G activities (incl. Trials and Pilots) in EU / MSs / Countries (as reflected, e.g. in the 5G Observatory), at National levels, from (Industry) stakeholders' perspectives, and at international level outside the EU.
- Development of the PPP 10 Trials & Pilots (T&Ps) Brochure in tight connection with the TB and To-Euro-5G (incl. target, process, evaluation/selection panel, flyers, brochure layout, etc.).
- Further definition of the interface between the Trials WG / 5G Private Trials Stream and the EC 5G Observatory (EC study developed by IDATE). Participation to the first Observatory Workshop organized on 17.05.19 in Brussels.

Among the main achievements in 2019 are included:

- Contributions to the PPP Cartographies.
- Publication of the PPP Platforms Cartography webpage⁷⁴ (with support of To-Euro-5G & Eurescom).
- Up-dates and implementation of the 5G Trials Roadmap / 5G EU Cities webpage, supported by To-Euro-5G⁷⁵.
- Further definition of the interface between the Trials WG / 5G Private Trials Stream and the 5G Observatory.
- Presentation of the 5G Trials Roadmap up-dates during 7th G5GE on 17.06.19 in Valencia.
- Development of the PPP 10 Trials & Pilots Brochure⁷⁶ released and distributed first during the Trials Workshop organized on 01.10.19 in Dresden.

⁷⁴ <https://5g-ppp.eu/5g-ppp-platforms-cartography/>

⁷⁵ <https://5g-ppp.eu/5g-european-cities/>

⁷⁶ https://5g-ppp.eu/wp-content/uploads/2019/09/5GInfraPPP_10TPs_Brochure_FINAL_low_singlepages.pdf

Security

Work was performed according to the Term of References that applied also work plan defined for 2019. Security WG as 5G IA WG has fostered cooperation between projects representatives and 5G IA members on topics in scope or of concerns. A number of new representatives but also members have joined the group. Co-chairs have structured and organized the work for the WG to perform and deliver as expected. 5G IA SEC WG reported to the Boards (TB, SB) on a regularly basis (bi-monthly) also through meetings organized and attended.

During Y2019 the following main results have been achieved:

- Co-chairs have interacted with 5G-TB, 5G-SB and WG of concerns to represent SEC WG and work (or organize the work) on the needed contributions (e.g. security TA input to PSM),
- Security being a cross-cutting concern cross collaboration was continued to be supported with other WGs with which SEC WG had established liaison as well as the ones most recently created (e.g. TMV, Business, ...) in order to investigate possible participation
- Participation to 5G TB Workshop in Malaga TB - PPP Technical Workshop 2019 - (07.10.19) with update on 5G SEC WG activities also interaction with phase 3 projects of concerns.
- 5G SEC WG was represented at EuCNC and Global 5G event and interaction took place with projects and working group representatives.
- 5G Security WG has continued to advance 5G Security Vision. Members have been busy also answering EC calls to get further implemented this Vision.
- Following recommendation issued by EC on Cybersecurity of 5G networks, the two co-chairs did inform the team and adapt work plan to accommodate and support.
- Liaison with ENISA has been further developed and co-chairs have been invited to join Experts Group on 5G Threat Landscape. This report was shared once made publicly available by ENISA. This with objective to get it further developed.
- Monitoring of Cybersecurity PPP activities from both research and vertical perspectives of concern. Development of liaison agents with objectives to foster cooperation taking advantage of signed MoU between the 2 PPPs.
- Dedicated concertation meetings were also held (e.g. meeting with Institut Mines Telecom).
- Progresses at Project or Member level on topics of shared interest (5G security related) have been monitored. With for what concerns projects, focus on Phase 2 projects since ending but most importantly on Phase 3 (ICT17/ICT18), 3.1 (ICT19). As well as Initial engagement with Phase 3.2 (ICT20) projects.
- Regarding Whitepapers work has been organized around a set of short focused Whitepapers (total 4) as well as contribution to other Whitepapers coming from 5G TB (e.g. Whitepaper on Edge Computing) due by next year.
- Further investigation of interesting projects outside of 5G PPP with objective to perform some level of interaction (similar to the one we had with SENDATE Celtic project in 2018, aka joint Webinar)
- We continued to push / move things forward on Security KPIs
- Regular audio conferences (Feb, 5&9 Avril, 20 May, 27 Sep) were held together with a physical meeting by end of the year with objective to assess the work performed and

prepare update of the work plan for Year 2020 (meeting hosted by Orange on Nov 22nd, 2019). Minutes have been produced for each of the meetings conducted.

IMT-R 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 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, Blobal5G.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 (Nufront) 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 website⁷⁷ 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.

⁷⁷ <https://5g-ppp.eu/5g-ppp-imt-2020-evaluation-group/>

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.

According to the H2020 dashboard⁷⁸, the participation of SMEs in the 5G PPP has reached 19.13% representing a total of 91.38 M€ in EU funding, a little under the objective of 20% defined as a KPI of the programme⁷⁹. A dedicated SME call is scheduled in 2020, hopefully allowing the 20% participation to be reached by the end of the initiative. 226 SME participation are accounted for, i.e. 20.96% of the 1,078 participations.

The number of members in the SME Working Group, whose main objective is to promote the skills and expertise of SMEs, has been regularly increasing. By end of 2019, there were 171 members, including 142 SMEs.

Furthermore, SMEs have been expressing their willingness to contribute and appear on the “Find your SME” web page⁸⁰ as well as in the “SME brochure”⁸¹. Those have therefore been subject to a bi-annual update, while there was previously only an annual release. The latest update was performed in December 2019 and included 54 SMEs.

The “Find your SME” web page shows both the expertise and skills of SMEs in 5G-related technology, but also their involvement in vertical sectors. Examples are shown below.



Figure 20: Example of “Find your SME” web page – Technology skills and expertise

⁷⁸ <https://webgate.ec.europa.eu/dashboard/>

⁷⁹ These figures include the following calls: Phase 1: H2020-ICT-2014-2 / ICT-14-2014; Phase 2: H2020-ICT-2016-2 / ICT-7-2016; Phase 3 (1): H2020-ICT-2017 / ICT-17-2017; Phase 3 (2) H2020-ICT-2018 / ICT-18-2018; Phase 3 (3) H2020-ICT-2019 / ICT-19-2019; Phase 3 (4) H2020-ICT-2019 / ICT-20-2019.

⁸⁰ <https://www.networld2020.eu/find-the-sme-you-need-new-page/>

⁸¹ <https://www.networld2020.eu/wp-content/uploads/2020/02/01-2020-sme-brochure-web.pdf>



Figure 21: Example of “Find your SME” web page – Verticals skills and expertise

Statistics show that this page was viewed almost 1,000 times in the 2nd semester of 2019, with peaks at certain stages when project calls were launched, or specific promotion of the web page was made.

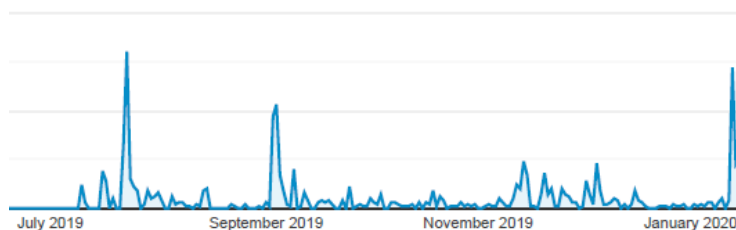


Figure 22: Statistics re. the “Find your SME” web page – July to December 2019

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

Page	Pageviews	Unique Pageviews	Avg. Time on Page
	952 % of Total: 7.54% (12,627)	772 % of Total: 7.18% (10,753)	00:04:02 Avg for View: 00:02:15 (78.56%)
1. /find-the-sme-you-need-new-page/	950 (99.79%)	770 (99.74%)	00:04:02

Figure 23: Statistics re. the “Find your SME” web page – July to December 2019

Although the actual impact is not known for sure, considering the confidentiality involved in proposals, the SME WG Chair receives regularly information, both from SMEs and from large organisations, stating that this page was useful and helped SMEs being involved in project consortia.

Another measure of the interest of SMEs to be involved in the 5G PPP is their contribution to the 5G PPP online brokerage platform⁸². 100% of the “proposals & project ideas” and 73% of the “profile & expertise offerings” come from SMEs.

⁸² <https://5g-ppp.eu/brokerage-platform-new/>

An important add-on to the web page in 2019 was the publication of the first “SME success stories”, showing the first achievements of SMEs thanks to their involvement in the 5G PPP. Emphasis was made on actual results, therefore demonstrating the impact of the participation of SMEs in the 5G PPP on products and solutions from each SME. SME success stories were also highlighted in the SME section of the 2019 5G PPP Annual Journal⁸³. By end of 2019, 7 full SME success stories had been released -with more to come in 2020.

The 2019 edition of the SME brochure, entitled “European SME Expertise in 5G and Beyond”, was released in June 2019, and then updated online in December 2019. Considering the increasing number of SME success stories, it is planned to include all the success stories in the 2020 edition of the brochure, therefore demonstrating by the example the impact of the programme on SMEs.

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
4G Americas ⁸⁴ (Americas)	Signed
Telebrasil – Projeto “5G Brasil”	Signed
ENCQOR (Canada)	Signed
TSDSI (India)	Signed

Agreements with Organizations representing Vertical Sectors

Organization	Status

⁸³ <https://bscw.5g-ppp.eu/pub/bscw.cgi/d302069/Euro%205G%20PPP%20Annual%20Journal%202019-web.pdf>

⁸⁴ Now “5G Americas”

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

Other Agreements

Organization	Status
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 enter this very promising field. The key results of the EU funded projects have been recently published in the European Annual Journal 2020. The Full5G project has released the revised 5G PPP stakeholders picture, along with the accompanying glossary⁸⁵. This new picture and glossary are now in line with the current 5G PPP priority target stakeholders. Figure 24 provides a graphical representation of the interactions with the 5G stakeholders.

⁸⁵ <https://5g-ppp.eu/revised-5g-ppp-stakeholders-picture-and-glossary/>

5G PPP Target Stakeholders

April 2020

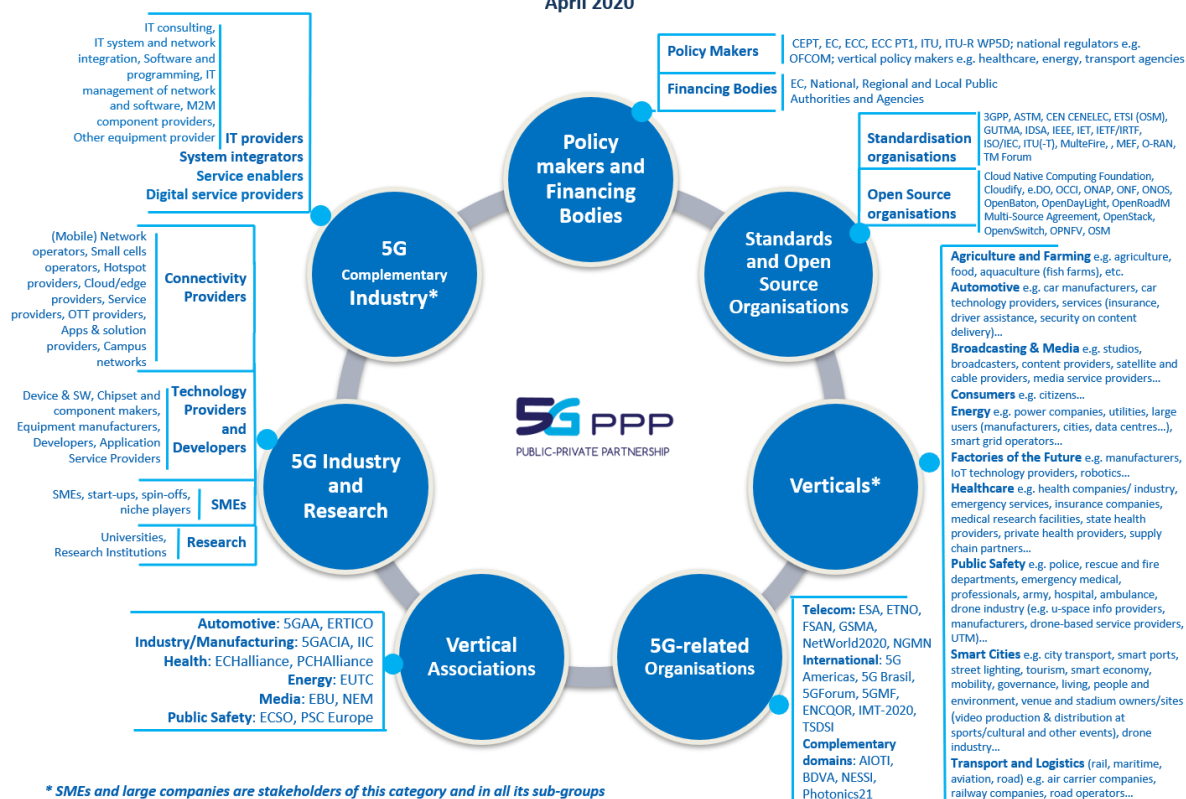


Figure 24: The 5G PPP stakeholders picture (source Full5G)

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 13 MoU and 4 LoI with peer-organizations or other global regions ensuring that the European activities will have a global impact.

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 2019 to setup the Smart Networks and Services (SNS) Partnership proposal⁸⁶. 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

⁸⁶ https://ec.europa.eu/info/files/european-partnership-smart-networks-and-services_en


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. The SNS Partnership aims to provide solutions in the impact areas captured in Figure 25.



Figure 25: SNS Partnership Proposal - Impact Areas


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">• 10,12 considering Large Industry and SMEs• 7,24 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>2014-2018</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>5,09</td><td>1.969</td></tr><tr><td>Large Industry</td><td>6,67</td><td>1.147</td></tr><tr><td>SME</td><td>2,33</td><td>205</td></tr><tr><td>Academic Institution</td><td>4,50</td><td>329</td></tr><tr><td>Research Center</td><td>5,33</td><td>288</td></tr></table>			2014-2018	New jobs/skills			Average	Total projected	Overall	5,09	1.969	Large Industry	6,67	1.147	SME	2,33	205	Academic Institution	4,50	329	Research Center	5,33	288	The methodology used for this assessment is described in section 3.2.1.2. Additional considerations: <ul style="list-style-type: none">- The following report provides useful information: <i>e-Skills in Europe - Trends and Forecasts for the European ICT Professional and Digital Leadership Labour Markets (2015-2020)</i>. http://eskills-lead.eu/fileadmin/lead/working_paper_-_supply_demand_forecast_2015_a.pdf (e.g., see Table 1 at pg. 5)- Softwarisation driven by 5G will require new skills and increasingly in the software domain in the telecom business.	
2014-2018	New jobs/skills																										
	Average	Total projected																									
Overall	5,09	1.969																									
Large Industry	6,67	1.147																									
SME	2,33	205																									
Academic Institution	4,50	329																									
Research Center	5,33	288																									

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>2018</td><td>2018</td><td>2014 - 2018</td><td>2014 - 2018</td></tr><tr><td>Average values</td><td>10,1%</td><td>11,9%</td><td>4,00</td><td>1,50</td></tr><tr><td>Total projected</td><td>n/a</td><td>n/a</td><td>352</td><td>132</td></tr></table>		increase in yearly turnover	increase in yearly revenues	increase in staff headcount	number of new elements of foreground IP	Reference period	2018	2018	2014 - 2018	2014 - 2018	Average values	10,1%	11,9%	4,00	1,50	Total projected	n/a	n/a	352	132	The methodology used for this assessment is described in section 3.2.1.3.
	increase in yearly turnover	increase in yearly revenues	increase in staff headcount	number of new elements of foreground IP																			
Reference period	2018	2018	2014 - 2018	2014 - 2018																			
Average values	10,1%	11,9%	4,00	1,50																			
Total projected	n/a	n/a	352	132																			
4	Significant Innovations	<p>The Phase 2 ‘Key achievements’ https://5g-ppp.eu/phase-2-key-achievements/ are a good indicator of innovation.</p> <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>		Section 3.2.1.4 presents in more detail the significant innovations																			


Annex Part 8 – Specific Key Performance Indicators for the 5G PPP

	KPI domain	Key Performance Indicator (KPI)	Value in 2018-2019	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	Please refer to the documents at https://5g-ppp.eu/5g-ppp-imt-2020-evaluation-group/			<p>The IMT-2020 evaluation WG has provided detailed series of analytics and simulated evaluations for the Minimum requirements related to technical performance for IMT-2020 radio interface(s).</p> <p>The Test, Measurements and Validation WG has provided a core set of KPIs to be validated by 5G PPP Projects. Also the the TMV has created a sub group to address the mapping of vertical applications/services KPIs to network KPIs</p>
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	Also the defined core KPI as agreed in the TMV WG			
4	Performance	P4. Creating a secure, reliable and dependable internet with a "zero perceived" downtime for services provision	 TMV KPIs core.xlsx			
5	Business	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	<ul style="list-style-type: none"> • 10,12 considering Large Industry and SMEs • 7,24 		Between 5 and 10	The methodology used for this assessment is described in Section 3.2.1.1.

			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	SMEs represent an average of 19% of the participants in budget in the 5G PPP Phase 1 and Phase 2 projects. The share of SMEs in the first <i>Phase 3</i> calls for <i>infrastructure</i> and <i>automotive</i> were respectively 17% and 12%.		20%	<p>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.</p> <p>The share of SMEs has been <i>decreasing</i> in the first Phase 3 calls as they were specific calls for infrastructure and automotive (17% and 12% respectively) <u>but are expected to be higher in the next calls that are more focusing on trials and verticals.</u></p>

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 than 50% of commercial contracts.</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				<p>This KPI is presented in Section 3.2.2.3</p> <p>Analysis of publicly available results suggest the EU HQ companies may currently have more than 50% of 5G commercial contracts. Also, they appear to currently have have approximately 24% of the granted 5G patents.</p> <p>Currently, 5G PPP is providing solutions 10 vertical use cases. The file below has collected results about the verticals cartography for Phase 3 projects providing detailed information about the vertical use cases, the type of experiments, their location, the planned date, the vertical partners involved etc.</p>

						<div> Phase 3_VerticalsCartogr</div>																					
11	Societal	S4. Stimulation of new economically-viable services of high societal value like U-HDTV and M2M applications	Please refer to https://global5g.org/cartography			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><thead><tr><th>2014-2018</th><th colspan="2">New 5G curricula and/or educational qualifications</th></tr><tr><th></th><th>Average</th><th>Total projected</th></tr></thead><tbody><tr><td>Overall</td><td>1,24</td><td>481</td></tr><tr><td>Large Industry</td><td>1,38</td><td>237</td></tr><tr><td>SME</td><td>0,25</td><td>22</td></tr><tr><td>Academic Institution</td><td>2,56</td><td>187</td></tr><tr><td>Research Center</td><td>0,67</td><td>36</td></tr></tbody></table>			2014-2018	New 5G curricula and/or educational qualifications			Average	Total projected	Overall	1,24	481	Large Industry	1,38	237	SME	0,25	22	Academic Institution	2,56	187	Research Center	0,67	36	The methodology used for this assessment is described in section 3.2.2.3
2014-2018	New 5G curricula and/or educational qualifications																										
	Average	Total projected																									
Overall	1,24	481																									
Large Industry	1,38	237																									
SME	0,25	22																									
Academic Institution	2,56	187																									
Research Center	0,67	36																									


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 ⁸⁷ (January 2020), indicates that although European companies share only a 17% of the declared 5G families (granted or pending patent applications), they have the highest grant rate with just over 66%. Analysing the percentages of the “at least granted in one patent office” from the declared 5G families one can extrapolate that the European companies have approximately 24% of the granted patents.	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.

⁸⁷ <https://www.iplytics.com/>

2	<p>Standardisation activities (project level)</p> <p>Contributions to new standards (PPP level)</p>	<p>Online Standards Tracker (http://global5g.org/online-tool-standards-tracker)</p> <p>Tracking activities in the Pre-standardization WG</p>	<p>Number of activities leading to standardisation</p>	<p>139 inputs including 4 Technical Reports and 2 Technical Specifications in 3GPP and 1 Technical Report in ETSI (SES SCN), as well as industry vertical associations with WGs feeding inputs into 3GPP Market Representation Partners, e.g. 5GAA, 5G-ACIA</p> <p>Counting over 800 Tdoc contributions to SA1, SA2 and RAN3, and ETSI TR 103.611 for</p>			
---	---	--	--	---	--	--	--

				the definition of architecture options			
3	Operational performance	<p>Time-to grant ICT-19-2019:</p> <ul style="list-style-type: none"> • Call closure date: 14 November 2018 • 5G PPP Projects 5G Solutions, 5G-Tours, 5G!Drones, 5G HEART, 5GROWTH, 5G SMART, 5G VICTORI started at 01/06/2019 and FULL5G started at 01/09/2019. More details available at: https://5g-ppp.eu/5g-ppp-phase-3-projects/ <p>Time-to grant ICT-20-2019:</p> <ul style="list-style-type: none"> • Call closure date: 28 March 2019 • 5G PPP Projects ARIADNE, 5G CLARITY, 5G COMPLETE, INSPIRE-5GPLUS, 					

		LOCUS, MonB5G, TERAWAY, 5GZORRO started in November 2019 – More details available at: https://5g-ppp.eu/5g-ppp-phase-3-projects/					
5	H2020 - LEIT - Number of joint public-private publications	<p>The document hereunder contains available information collected from the public sites of all Phase 2 and Phase 3 projects.</p> 	Properly flagged publications data (DOI) from LEIT funded projects	1120 publications from Phase 2 projects and 208 publications from active Phase 3 projects			DOI information was not available on the web sites for all publications.