5G PPP PROGRESS MONITORING REPORT – 2018

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

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1. Introduction

This document reports the progress achieved by the 5G Infrastructure Public-Private Partnership during 2018. 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 IA (i.e., Verticals Engagement Task Force, 5G IA working groups, specific activities). Detailed information is placed in Annexes 3 through 7.

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 8 through 10.

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

2. Main activities and achievements

The dawn of the 5G era has arrived. The first 5G networks launches were reported in 2018. The full-scale arrival of 5G networks is picking up pace having a number of vendors announcing their first 5G enabled smartphones. At the end of March 2019, as many as 180 trials had been listed so far (in EU 28, Russia, San Marino, Norway, Turkey and Switzerland). A little more than a third of the trials are technical tests.

There were **147 5G trials in the 28 member states of the European Union**. Trials are the most numerous in France, Germany, Italy and Spain. These top four countries are totalling 40% of trials. The most trialled verticals are media and entertainment (32 trials) followed by transport (25 trials) and automotive (18 trials). The most used frequency band for trials is by far the 3.4-3.8 GHz.

Although these facts are not directly associated with the 5G PPP, **the underlying technology development of the 5G PPP phase 1 and 2 projects was a key enabler for these success stories** (Annex 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 (Annex 1) and 5G IA (Annex 2) achieved outstanding progress and impact during 2018. The next subsections provide more detailed information.

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

All projects developed a very strong momentum during the reporting period, with Phase 2 projects running full speed (some Phase 2 projects concluding mid-2019) and Phase 3 ICT-17 Platforms projects and Phase 3 ICT-18 Corridors projects, having started

respectively in July 2018 and November 2018, ramping-up very actively and rapidly developing cross-projects synergies and programmatic actions.

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

During 2018, the **Phase 3** of the 5G-PPP framework was initiated. This involved essentially the roll out of 5G platforms across Europe. It will enable large scale trials to help the stakeholders testing, in realistic environments, the key findings from the previous phases and draw significant conclusions. **Three infrastructure projects** have been selected to create a pan-European large-scale 5G test platform to be used by a number of vertical use cases. In 2018, **three automotive projects** also started their activities implementing and testing advanced scenarios and **one additional automotive project** is also active in the context of EU-China Collaboration.

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) should be 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 1.
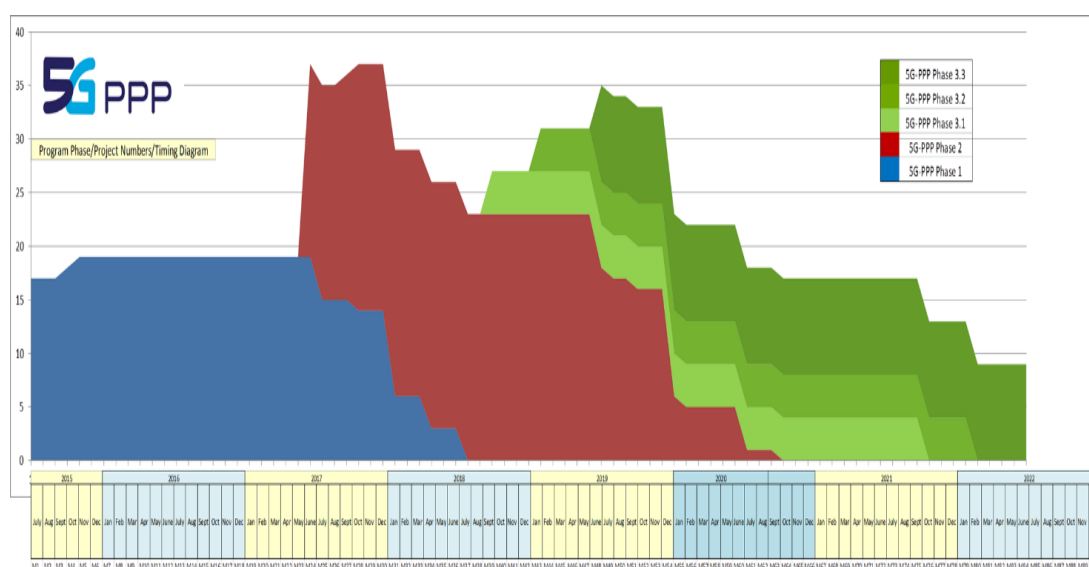

Figure 1: Overview of the 5G PPP program

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.

Since Phase 1, **46 projects** in total have been so far contractually active in the PPP Programme, ensuring an **outstanding momentum and dynamism.** Note that **Key Achievements from the Phase 2 5G PPP projects include 60 highlighted results** categorised under 14 program level achievements (Annex 3).

5G PPP has had **significant influence in building pre-standardization consensus** across key actors. Major impact on the 5G architecture ideas has also been achieved through **611 activities leading to standardization (Phase 1: 315; Phase 2: 296 contributions).** 5G PPP Phase 2 projects submitted input **contributions to over 20 groups** within standards organisations and industry alliances (Annex 7).

The 5G PPP projects have disseminated their results in a number of scientific journals, international conferences, book chapters and white papers (Annex 10). **Phase 2 projects have produced 756 publications until now** (22% was published in scientific journals)**, whereas Phase 3 projects have produced 54 publications** (26% was published in scientific journals).

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 2018, the 5G PPP Initiative has released **five white papers** disseminating key findings. Recently, another working group has been launched (**5G PPP Test, Measurement and KPIs Validation WG**).

In the context of the 5G IA Vision and Societal challenges WG, **5G IA has released the Pre-Structuring Model (PSM) Phase 3.II.** It was released in Versions 1.0 and 1.1 in February 2019. The PSM Phase 3.II. Version 2.0 was released on 12th July 2019 (Annex 7).

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 Board and the 5G-IA Verticals Task Force, and with the strong support of the two CSAs projects. On the 10th of April 2018, the European Commission launched the <u>Innovation Radar</u>: 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 128 innovations were found recorded** (Annex 3)**.**

Section 3 provides **detailed information about common and specific sets of KPIs** for the 5G PPP program. Most notably, it has been evaluated that the **mobilization of private investment for 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 publicly available reports indicates that a **21,31% of globally declared 5G patent families comes for Europe based HQ** companies. Looking at the global numbers of the **granted patents this number <u>raises up to 29,45%.</u>** Moreover**, in the 5G declared SEP families (Standard Essential Patents) in the auto industry, 25,32%** comes from Europe based HQ. Finally, as for the **number of 5G standards contributions per company related to a vehicular application,** comes from Europe based HQ companies. Finally, in publicly available reports, it is mentioned that in the **5G subscriber share by RAN vendors**, **two**

European headquartered companies will have approximately the 45,6% of the global market.

2.2 Mobilization of stakeholders, outreach, success stories

Since 2018, <u>a number of technical workshops, information days and research and innovation events</u> 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 (Annex 6).

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 thus, a Vertical Engagement Task Force ("VTF") was set up beginning of 2018. **Priority vertical sectors** were addressed including: <u>Automotive,</u> <u>Smart Manufacturing</u> and <u>Public Safety</u>. In these sectors, key industry events were attended with 5G PPP high level speakers to influence decision makers on 5G adoption (Annex 7).

The **Verticals Cartography of the Phase 2 projects** was produced together with the **Platforms Cartography** (Annex 5). Both Cartographies are expected to be further developed and converge into a **Meta-Cartography**, considering the forthcoming integration of ICT-19 Verticals projects (Verticals Trials over Platforms).

The Trials Roadmap Version 4.0 was successfully presented at the 6th Global 5G Event in Rio (28-30 November 2018). It highlighted the <u>key EU cities that are targeted for 5G</u> early deployments, already engaged in <u>5G pre-commercial/commercial trials and pilots</u>, engaged in 5G trials and pilots and also making available 5G R&I platforms. A description of the major EU cities engaged in the <u>5G UEFA EURO 2020 Flagship event</u> was also provided (Annex 7).

ITU-R WP5D launched an evaluation process starting with an ITU-R WP5D Evaluation Workshop in October 2017 for Radio Interface Technologies (RITs), which are submitted by SDOs (Standards Developing Organisations) to ITU-R. In that process ITU-R is looking for opinions by independent Evaluation Groups. **The 5G Infrastructure Association was registered at ITU-R as one of the 11 globally recognized groups. In the reporting period several evaluation characteristics were completed and available evaluation results have been collected in the draft evaluation report. The preparation of the complete evaluation report towards ITU-R is on a good track.** (Annex 7).

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 (respectively 17% and 12%)* but are <u>expected to be higher in the next calls that are more focusing on trials and verticals (Annex 7)</u>.

5G IA has been very active building up international cooperation for 5G networks (Annex 7). Currently, **7 MoUs** 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).

Within the international cooperation stream of the 5G IA Trials WG, information was gathered on **international trials outside Europe with European stakeholders.** The collected data capture **26** different such **trials all around the world**, giving to the European companies the opportunity to strengthen their lead in the 5G race (Annex 7).

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 2, presents the overall governance of the 5G PPP.

During the reporting period, 5G IA has established the 5G PPP **Verticals Engagement Task Force (VTF)** to coordinate and monitor activities related to the collaboration with vertical sectors. For more information please refer to Annex 7.
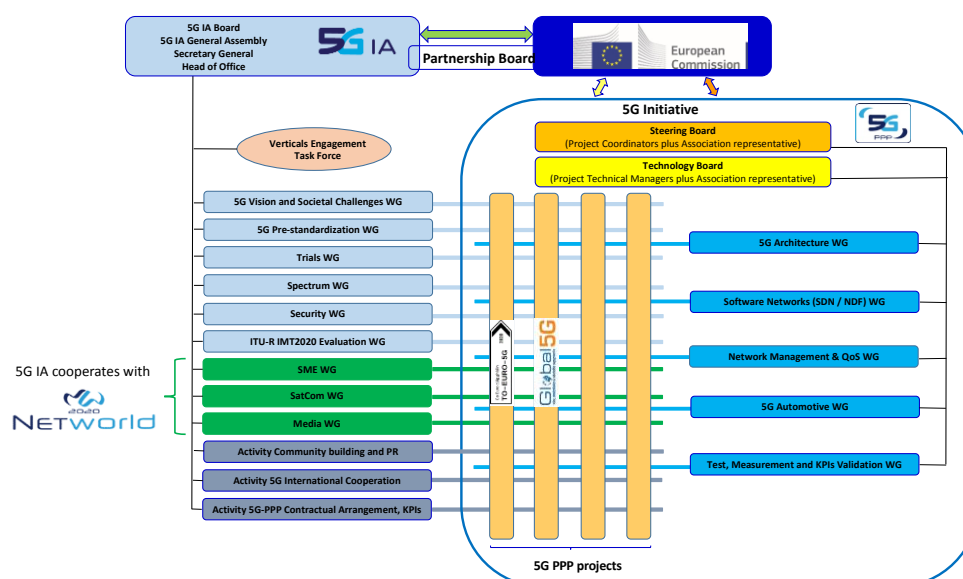

Figure 2: 5G PPP Governance

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

2018 was an important and successful year for 5G development. Many strategic initiatives, initiated in 2018, are currently being progressed and implemented in 2019. In 2018, 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* have started testing *advanced use cases for autonomous driving* in cross border infrastructures. Finally, *an additional automotive project,* in the context of EU-China collaboration, *has started building pre-commercial ed-to-end testbeds* in two cities with sufficient coverage to extensively test eMBB and IoV trials. These projects follow the overall Programme's goal to move from initial research results to large scale test-beds, getting closer to market applications. Note also that extensive work has been undertaken to release the *draft version of the PSM Phase 3.II.*

- **Optimum profile for the European 5G initiative in a global context:** As described in detail in Annex 7, during the past period, *2 MoUs have been signed* (one with *TSDI-India and one with ENCQOR-Canada*) to foster the collaboration of the EU with these regions in terms of Research, Standards, Regulations and Policies as well testing existing solutions. As graphically illustrated in Figure 24, *the currently active MoUs (with Brazil, Canada, China, India, Japan Korea, Americas)* cover most of the globe giving the possibility to communicate and synchronize activities with the strongest influencers worldwide. Moreover, 5G IA has signed, during 2018, *MoUs with ECSO and PSCE (Public Safety), ESA (Satellites), 5GAA (Automotive) and, 5G AIOTI (Internet of Things).* They are meant to foster collaboration and 5G adoption by verticals.

- **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:** Pre-standardization activities are one of the most important outcomes from the 5G PPP projects as they strongly influence the evolution of 5G networks and the future footprint of the different companies in the 5G ecosystem. 5G PPP has had significant influence in building pre-standardization consensus across key actors. Major impact on the 5G architecture ideas has also been achieved through 611 contributions leading to standardization (Phase 1: 315; Phase 2: 296). 5G PPP Phase 2 projects submitted input contributions to over 20 groups within standards organisations and industry alliances. Inputs come in diverse formats, such as technical reports, specification documents, white papers, proof of concepts, interoperability tests, and source codes. Details about these activities can be found in Annex 7. Moreover, data collected from the public sites of the funded projects, show that they have provided a significant impact on the scientific community through 756 publications from Phase

2 projects and 54 publications from phase 3 projects. More information on this topic can be found at the Annex.

- **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. In some cases, as required by the European Commission, *the methodology to collect the necessary information, through public data and online questionnaires, for the evaluation of the KPIs has been updated.* 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.

- **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.*

- **Enhancement of 5G roadmaps and visions:** Annex 7 contains detailed information about the 5G Trials Roadmap and strategy. During 2018, the *Roadmap Version 4.0* has been presented at the 6th Global 5G Event). It highlighted the *key EU cities that are targeted for 5G early deployments*, already *engaged in 5G pre-commercial/commercial trials and pilots.* A description of the major EU cities engaged in the *5G UEFA EURO 2020 Flagship event* was also provided. As presented in the 5G Pan-EU Trials Roadmaps, the acceleration of 5G in EU is also happening thanks to a specific joint strategy between Industry (hand in hand with Research Centres, Academics and local communities), EC and member states and initiatives in specific domains. *The vision is to further progress the design of 5G and beyond 5G networks and achieve a large-scale adoption of 5G by vertical sectors*

A number of *international trials outside Europe with European stakeholders* (Annex 7) took place. The collected data show that 26 activities (pilots, demonstration, trials, PoC) all around the world (i.e., Australia, Canada, China, India, Japan, Russia, South Africa, South Korea, Taiwan, UAE, USA) have been undertaken by major European HQ based vendors, Universities and Research Centers as well as SMEs.

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.

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 Questionnaire[1], 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 dashboard[2].

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:

- 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.

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[1] https://5g-ppp.eu/5g-ppp-progress-monitoring-report-data-collection-2019/
[2] https://webgate.ec.europa.eu/dashboard/sense/app/93297a69-09fd-4ef5-889f-b83c4e21d33e/sheet/PbZJnb/state/analysis

- 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**
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

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:
  - o (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
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

In 2018, 34 SMEs advertised their expertise and interest in the 5G PPP topics and business verticals for Phase 3[3]. This has created a list providing a preliminary mapping of the SME community to the verticals, along with a tool to search SMEs and connect

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[3] https://www.networld2020.eu/find-the-sme-you-need/

them to the broader community of 5G stakeholders (both industry and academia). Figure 3 presents in which vertical business sector(s) SMEs could contribute.
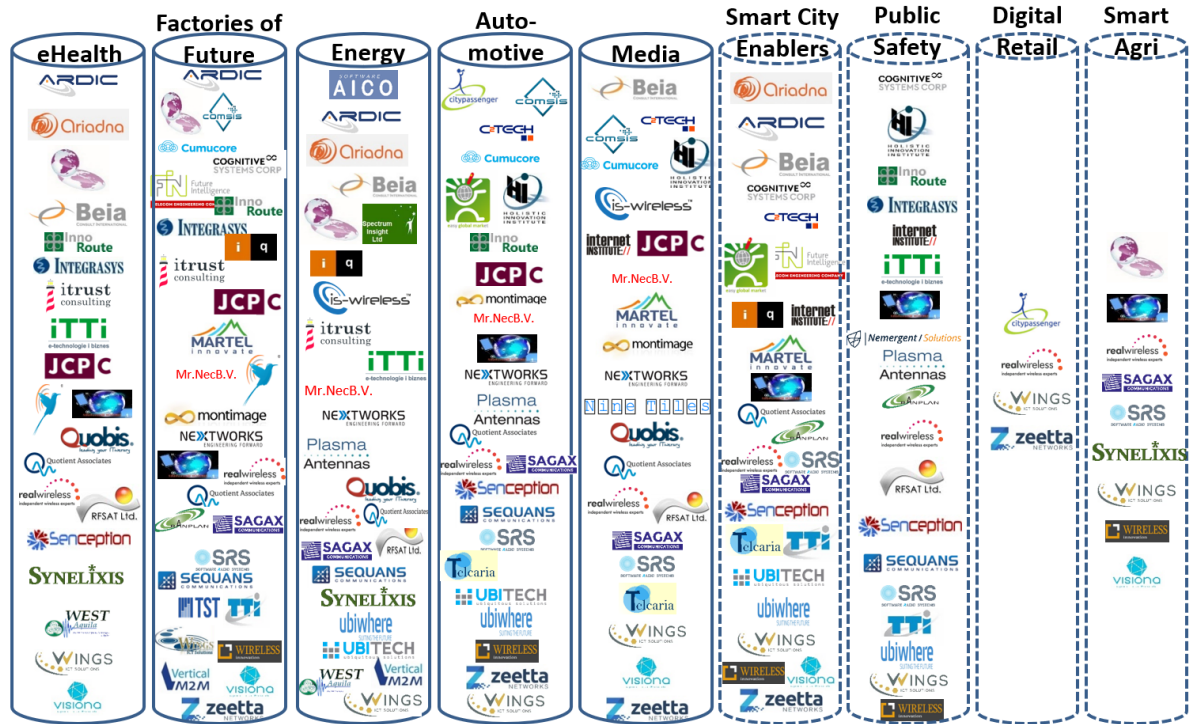
SMEs shown in alphabetical order

Figure 3: Mapping of SMEs to Verticals

The same exercise had already been done for Phase 1 and Phase 2. Information is also available in the SME brochure[4], that was released for Phase 2. **A fully revised and updated brochure was published in June 2018 for Phase 3, under the name "SME Expertise and Skills in the 5G Domain"**[5]. The brochure highlights the expertise and skills from 34 selected European SMEs in 5G and related domains, and this time focuses more on the expertise that might be useful in various industry vertical sectors (automotive & transport, media & content, manufacturing & logistics, energy, health, etc.). **The success stories described in the brochure show that the impact of 5G PPP on SMEs is significant, and that SMEs bring great added value to the 5G value chain by providing innovative concepts and solutions.**

The latest version of the brochure **"European SME Expertise in 5G and Beyond"** has been published in June 2019[6].

3.2.1.4 Significant innovations

The 5G PPP Phase 2 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. These achievements covered the complete 5G picture from the *radio access network* (e.g., Flexible RAN, novel radio systems and interfaces, enablers for 5G RAN platforms, 5G Fronthaul, Backhaul and Metrohaul), *5G Autonomous Network and Control Management* (including categories such as E2E Orchestration across optical, packet,

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[4] https://bscw.5G PPP.eu/pub/bscw.cgi/d119698/SME-A5-brochure-final-web.pdf
[5] https://5g-ppp.eu/wp-content/uploads/2018/06/A4-sme-brochure-final-web5G-PPP.pdf
[6] https://www.networld2020.eu/wp-content/uploads/2019/06/2019-sme-brochure-final-web.pdf

wireless virtualized networks, 5G resilience and availability), *the support of 5G multi-domains, multi-tenants plug & play control plane and slicing control*, to the *5G flexible and agile service deployment and the 5G services platforms and programming tools for NetApps*. Additionally, achievements were recorded under the groups of performance evaluation framework, the 5G System Functional, Logical and Physical Architectures, Vertical experimentation trials and pilots and last but not least 5G business standardization and regulation.

In terms of **IPRs**, the document **"5G IP Landscape Analysis" (July 2018)** enclosed in the Annex, prepared by 5G IA Member Thales, aims at determining early trends for 5G mobile network underlying technologies and may represent a contribution to the definition of IP KPIs for the 5G PPP. It analysed how stakeholders are gearing up towards the next 5G through the angle of patent filed for a period of 10 years. It is a starting point that could be enriched by the 5G PPP community. Moreover, in the annex it is included an excel file that presents a synthesis of an initial 'patent search' made on the European Patent Office' Espacenet[7]. We need to note here that this task is extremely difficult to perform as several of the filed patent ideas are protected for a significant amount of time. During this time, they are not publicly available. Moreover, it is quite common that the patent titles do not contain the term "5G" as the inventors try to be generic and have their ideas applicable for future systems as well. Thus, such approaches can indicate some trends but cannot form a solid basis to draw safe conclusions.

Alternatively, there are some commercial reports from companies that try to analyse the current trends for 5G technology. For example, two recent reports entitled "Who is Leading the 5G patent race?" and "5G declared SEP families Standard Essential Patents in the auto industry - the case of 5G" produced by IPlytics[8] present some interesting results. An analysis of the data in these reports indicates that a **21,31% of declared 5G patent families** comes for Europe based HQ companies. From these, the **29,45% is thereof granted.** Moreover**,** in **the 5G declared SEP families (Standard Essential Patents) in the auto industry, 25,32%** comes from Europe based HQ. Finally, as for the **number of 5G standards contributions per company related to a vehicular application, 41,15%** comes from Europe based HQ.

In terms of **standardization**, **major impact on the 5G architecture** ideas has been produced by 5G-PPP projects through 611 contributions leading to standardization (**Phase 1: 315; Phase 2: 296).** 5G PPP Phase 2 projects submit input **contributions to over 20 groups** within standards organizations and industry alliances. Inputs come in diverse formats, such as technical reports, specification documents, white papers, proof of concepts, interoperability tests, and source codes. Details about these activities can be found in Annex 7.

Finally, the **5G PPP projects** have disseminated their results in a number of scientific journals, international conferences, book chapters and white papers. **Phase 2 projects have produced 756 publications until now** (22% was published in scientific journals)**, whereas Phase 3 projects have produced 54 publications** (26% was published in scientific journals).

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[7] https://worldwide.espacenet.com/

[8] https://www.iplytics.com/

3.2.2 Specific KPIs for 5G PPP

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

3.2.2.1 Performance KPIs

The technical Annex to the 5G PPP contractual arrangement defines the following 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, among others in "5G empowering vertical industries"[9]. 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

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[9] https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf

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.

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**.

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 running study leads to a summary of clustered projects contributions to the Performance KPIs in a structured programmatic approach.** The PPP Performance KPIs definition, at Programme level, elaborates on the PPP Phase 1 Flex5GWare KPIs definition approach, expanding the analysis to the overall set of PPP Phase 2 Projects. The **related document**, included in the PMR Annex, **consolidates the available KPIs** from the different sources of the 5G Infrastructure PPP Programme Working Group activities and projects. It consolidates an agreed definition for each KPI and provides an agreed method of measurement. **The PPP Performance KPIs work has also then been further developed on specific Performance KPIs**, starting first with **Latency and Service Creation Time**. This information is included in the PMR Annex. It contains the up-to-date status on these KPIs / Projects contributions. Note that the work is under progress and their final versions will be released during the second half of 2019. Potential additional White Papers could be developed on Peak Data Rate KPI, Summary of individual Projects Performance KPI and PPP KPIs Cartography.

The overall work on Performance KPIs evaluation will be further developed in the context of the Testing, Measurement and Validation (TMV) WG, including the 3 ICT-17 Projects and specific Phase 2 Projects.

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, BusinessWire has provided[10] the key findings of a recent report from Strategy Analytics[11]. There, it is mentioned that in the **5G subscriber share by RAN vendors**, **two European headquartered companies will have approximately the 45,6% of the global market**. Also, other announcements[12,13] provide some initial estimations that in the 5G race, European headquartered vendors are very well placed. *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 societal aspects. These are the following:

S1. Enabling advanced user-controlled privacy

Safeguarding users' privacy is of great importance to Europe. The recently adopted GDPR is today a worldwide benchmark. 5G networks will enable a tighter collaboration with service providers as the 5G architecture provides a network exposure function to them. Also, a lot of work has been made to support MEC solutions closer to the RAN.

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[10] https://www.businesswire.com/news/home/20190416005724/en/Strategy-Analytics-Huawei-point-lead-2023-5G

[11] https://www.strategyanalytics.com/access-services/service-providers/networks-and-service-platforms/complimentary/report-detail/comparison-and-2023-5g-global-market-potential-for-leading-5g-ran-vendors-ericsson-huawei-and-nokia

[12] https://www.reuters.com/article/us-nokia-5g/nokia-says-it-has-moved-ahead-of-huawei-in-5g-orders-idUSKCN1T428W

[13] https://marketrealist.com/2019/06/how-many-5g-contracts-has-ericsson-won/

Moreover, 5G networks will support a number of different logical networks (network slices) over the same underlying infrastructure. In terms of security, **several 5G-PPP projects have thoroughly examined how these slices will be isolated** so as to protect the information and also safeguard their performance. Moreover, **3GPP** has worked a lot on the existing 5G releases to **provide security mechanisms for the 5G network**. As for user-controlled privacy schemes these should be examined closely together with the new applications/services. Thus, data and information protection should be studied in all dimensions. This task is planned to be investigated and a holistic solution to be provided in the context of the forthcoming Smart Networks and Services.

S2. Reduction of energy consumption per service up to 90% (as compared to 2010)
Regarding the energy consumption KPI, METIS-II reported some initial findings. For example, for mMTC cases the extension of the DRX cycle, the control plane latency reduction and deep sleep conservation features could achieve more than 10 years of operation for a 5 Mh battery. Moreover, for the capacity x1000 network energy efficiency improvements of 350-7500 were reported for Dense Urban environment. These savings depend on the load level in an LTE-A/5G network.

Currently, the running study for the KPIs is collecting information from all 5G PPP projects on how energy can be reduced to the desired level. The technical breakthroughs include the use of the optimization of the deployment of wireless/optical and intra-DC network domains (theoretical investigation considering a converged transport underlay network), the consumption reduction related to new node technology (e.g. PIC, filter-less technology), dynamic service infrastructure (set-up/tear-down services) with respect Baseline Metro Network (evaluated through modelling), the use of algorithms for the appropriate placement of NVFs (to be evaluated by computing CAPEX and OPEX reduction), the energy consumed per useful bit transferred from the MNO's Central Office to the user area using the 5G-PHOS analog Radio-over-Fiber solution (to be evaluated in demos), the reduced consumption due to ARoF fronthaul and the use of improved switch-off/deep sleep state and usage efficiency due to availability of remote-fed energy via power-over-fiber (to be evaluated against typical benchmarks) and the use of VLC (comparison with available solutions).

S3. European availability of a competitive industrial offer for 5G systems and technologies
As discussed in previous sections, the current results look rather promising as forecasts suggest a 45,6% share by European HQ vendors for 5G RAN and a 29,45% for granted 5G patents at a global level and a 25,32% for 5G declared standard essential patents in the automotive industry.

Moreover, vertical industries (automotive, industry 4.0, healthcare, energy, etc.) will be instrumental in delivering the societal benefits of 5G. Therefore the projects' selection in 5G PPP Phase 2 has strongly included vertical stakeholders representing various types of applications (autonomous vehicles, immersive media, virtualized transport platforms with network slicing, smart energy as a service, smart manufacturing, public safety, emergency real time intervention, 5G rail service, test-beds in sea-port and touristic city, etc.).

On a more general level, the NetWorld2020's and 5G IA's document "**Economic considerations on Smart Networks as key enabler of the Human Centric Internet**

and the digital transformation research in FP9", available in the annex, provides an excellent description of the essential link between 5G and Smart Networks and their strong positive impact on economy and society in Europe and worldwide.

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

In March 2018 the joint NEM (New European Media) - NetWorld2020 Media WG provided a joint publication about **5G Phase 3 – Media Pilots**[14]. The objective of the paper was to describe potential pilots from the Media and Content domain that could take advantage of the 5G networks. The document **identified 11 potential use cases** related to media and indicated **10 potential pilots**. The use cases included indicatively: ultra-high-fidelity imaging for medical applications, on site live experience, immersive and integrated media, collaborative gaming, virtual reality, UHD content distribution over 5G CDNs and smart education. As for M2M, this area is considered one of the main application pillars of the 5G networks that pose specific requirements in the underlying network infrastructure.

Although the deployment, testing and eventually stimulation of such applications is at an early stage, projects of the 5G-PPP have already demonstrated the applicability and the business feasibility of the 5G networks is such areas. As an indicative example, the two pilots of the 5G-MonArch project[15], have provided some impressive capabilities in the areas of **on-site live experience and large deployment of M2M applications in the port of Hamburg**. As mentioned earlier, three project partners of 5G-MoNArch 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 award was given for a 5G network deployed in the 8,000-hectare port of Hamburg originally as a proof of concept testbed and now as an operational network.

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

Data for new curricula/qualifications created were collected through a questionnaire[16] 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.
- 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)

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[14] https://www.networld2020.eu/wp-content/uploads/2018/03/nem-network_5g-phase-3-media-pilots_final-march-2018.pdf
[15] https://5g-monarch.eu/5g-monarch-events-turin-and-hamburg/
[16] https://5g-ppp.eu/5g-ppp-progress-monitoring-report-data-collection-2019/

- 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**
Overall	*1,24*	*481*
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. In this Progress Monitoring Report (PMR), as well as in the previous one, collected data prove that Europe has had a significant impact in terms of global activities (e.g., standardization). Also, coming closer to the commercial roll-out of 5G networks, the 5G-PPP trials are assisting EU based companies to obtain the necessary experience in real-life scenarios and, at the same time, work closer with all stakeholders and especially the vertical industries. Moreover, the dissemination of the results has lifted public awareness for the capabilities 5G networks will offer, creating a new business momentum. Finally, the structure of the Programme has assisted European SMEs to enter into a competitive and very promising domain, and already several success stories have been recorded. With the new calls it is expected that their number will increase even more. Finally, international collaboration activities have assured that Europe is one of the key players in the 5G ecosystem.

Although the digital transformation of some sectors in society and economy in Europe has started with 5G, thanks to the research and trial activities in 5G PPP, this is just the beginning of this paradigm shift. Our vision is that the convergence of ICT and vertical sectors as well as the analogue and the digital world by means of artificial intelligence, ambient connectivity, the IoT and cloud computing is leading to the emergence of ambient intelligence (a kind of Artificial Intelligence 2.0). This trend is expected to be a continuous process during the next decade. Ambient intelligence is already a reality, its

foundations have been laid and new technological building blocks will soon be added to consolidate them, led by 5G. The next decade will be decisive for Europe to concretely roll-out 5G and in parallel to maintain and reinforce the technology leadership for beyond 5G. Europe should target building a solid infrastructure offering both connectivity and computing to enable the ambient intelligence of tomorrow.

4. Outlook and lessons learnt

Collaborative research in Europe contributed in the past significantly to the development and application of mobile systems such as 2G (GSM), 3G (UMTS) and 4G (LTE), which are providing broadband Internet access and many applications to more than half of the world's population. This success story has continued under Horizon 2020 with the 5G PPP. The quantification of the success has been recorded in this PMR with data and information on strategic issues, including: a) the mobilization of private investments, b) the active participation of SMEs in 5G activities, c) the existing and projected numbers for new jobs profiles, d) significant innovations like technical innovations, e) the considerable amount of inputs to standardization bodies, f) the number of filed and approved patents by European HQ based companies. Moreover, the overall mobilization of the scientific community (Universities and Research Centers) in Europe as well as the business sector (a significant number 5G contracts announced) is a real proof that the overall plan that started in the context of FP7 and continued through Horizon 2020, was well designed and has achieved its goals up to now. It is also worth noting that the activities of 5G IA to link European activities to the vertical industries and the rest of the world as well as the participation in major events have lifted the public awareness about 5G networks. This significantly contributed to place Europe as one of the key players for 5G networks at a global level.

The 5G PPP global impact achievements already include:
- A major impact on 5G standards with 610 technical contributions to IEEE802, 3GPP, ETSI, etc. from Phase 1 and Phase 2 projects
- Beyond standards, proving the 5G system is working more than 100 test/experiment sites
- An active engagement in the IMT-R IMT 2020 evaluation process
- 7 MoUs signed between 5G IA and peer industry associations around the globe (Americas, China, Japan, South Korea, Brazil, India and Canada)
- Foster 5G uptake from vertical industries (e.g. several MoUs signed with industry organizations in priority vertical sectors)

The 5G PPP is running smoothly under the current governance scheme. The coordinated scientific work in the context of the WGs and the task forces is ensuring Europe's leadership in the 5G ecosystem. The organization of meaningful trials all over Europe is assisting European companies to test in real life scenarios the 5G technology.

Moreover, there is a focus on truly disruptive vertical use-cases for 5G - including URLLC (Ultra-reliable, low latency communications) and critical communications, enabling new players entering the market with new services. 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, 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 such as 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"[17], 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. **Europe should hence strengthen the key area on future smart networks and services.**

Europe needs to build on the excellent work started with the 5G PPP and develop new opportunities across the value chains from cloud-based service provisioning to IoT and new opportunities for smart devices. Europe must retain its leadership in communication infrastructure research and innovation, in terms of both services and component manufacturing. Smart Networks is the essential digital infrastructure that will ensure that Europe remains globally competitive for decades ahead.

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[17] 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 website[18].

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

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[18] www.5G PPP.eu

collaboration with Taiwan. Most Phase 2 projects will be completed in 2019, while some will continue in 2020. This phase is more focused on demonstrating and validating the developed technology and explicitly trying to integrate use cases from vertical industries beyond classical telecommunications.

- **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

56 organizations are 5G IA members. From these, 54 are 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 4 shows the composition of the members.

7 International MoU partners (Brazil, China, India, Japan, Korea, India)

28 Industry members: Vendors, operators, communication satellite companies, FTTH companies, verticals (transport, security, defense, aerospace)

12 Partners (European and international organizations and industry associations)

2 Association members

8 SMEs members

18 Research members
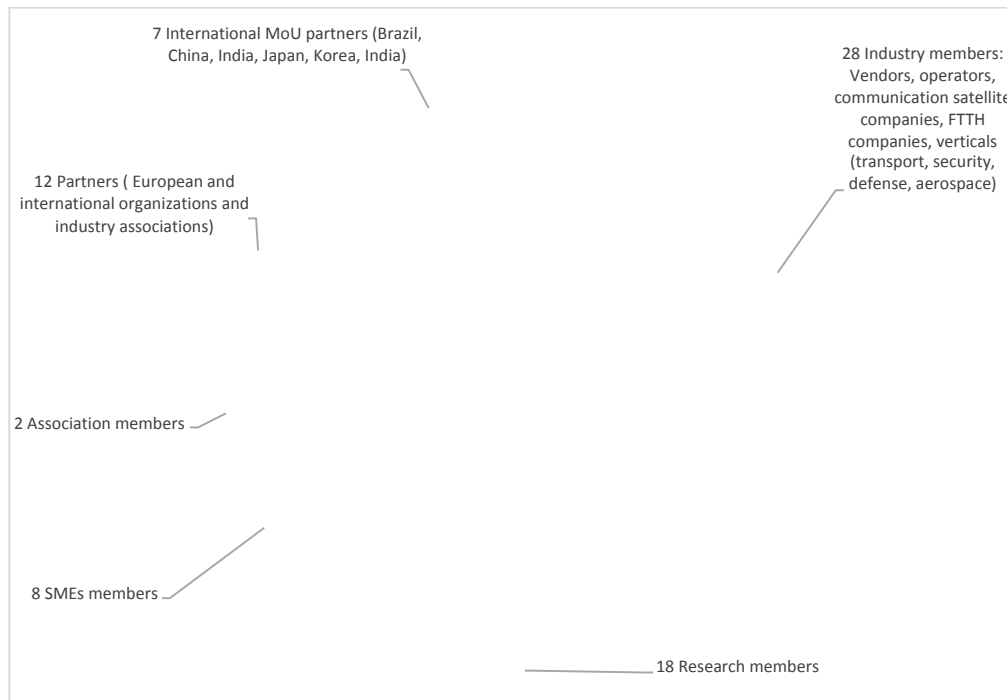
Figure 4: 5G IA membership versus type of stakeholders

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 5 is a summarized illustration of all active WG under the responsibility of 5G IA, 5G PPP Initiative and the NetWorld 2020.
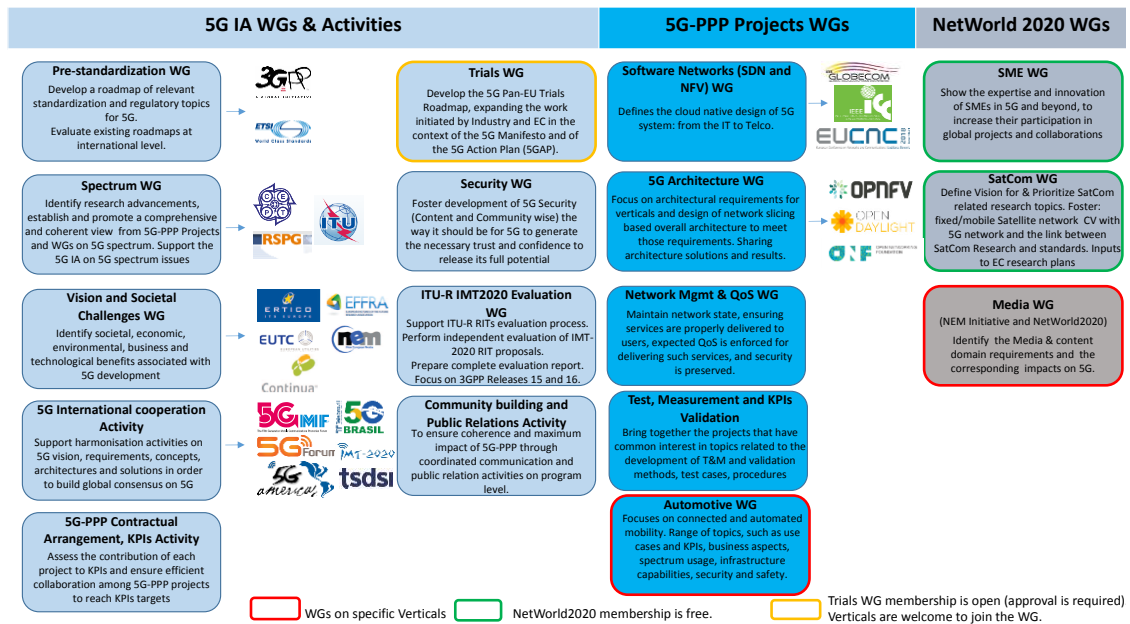
Figure 5: The overall picture of WGs

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 and their innovations

Phase 2 Projects

Phase 2 projects relied on the technologies produce during Phase 1 for the digitisation and integration of vertical industries in Europe. This Phase started in June 2017, with 21 new 5G PPP selected projects. In addition, there are 2 complementary projects dealing with international collaboration with Taiwan. Most Phase 2 projects will be completed in 2019, while some will continue in 2020. This phase is more focused on demonstrating and validating the developed technology and explicitly trying to integrate use cases from vertical industries beyond classical telecommunications.

While during Phase 1, 167 beneficiaries were involved in the funded projects. In Phase 2 there were 224 beneficiaries (**an increase of 34%**). 62% of partners in phase 2 were not involved during Phase 1. Figure 6 illustrate 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.

For a detailed presentation of 5G PPP Phase 2 projects' activities the reader can refer to the European 5G Annual Journal of 2019[19].

As part of the preparation for Phase 2 of the **5G PPP a brokerage service** was created and introduced. This service allows people to submit either proposal ideas or expertise offer profiles to the Brokerage platform. Each submission is published after approval by the brokerage platform moderator team from To-Euro-5G. Proposal ideas may be posted without publishing the idea owner's identity if they only wish to be contacted via the Brokerage platform. The platform offers search and contact request forms which allows idea proposers to find matching partners for a project consortium and companies to find interesting proposal ideas to cooperate in. This service has been reinstated to support Phase 3 proposals[20]. The Brokerage Service will also be used in the context of the PSM Phase 3.II.

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[19] The European annual journal 2019, pages 20-75, https://5g-ppp.eu/annual-journal/
 https://bscw.5g-ppp.eu/pub/bscw.cgi/d302069/Euro%205G%20PPP%20Annual%20Journal%202019-web.pdf
[20] http://5g-ppp.eu/brokerage-platform-new
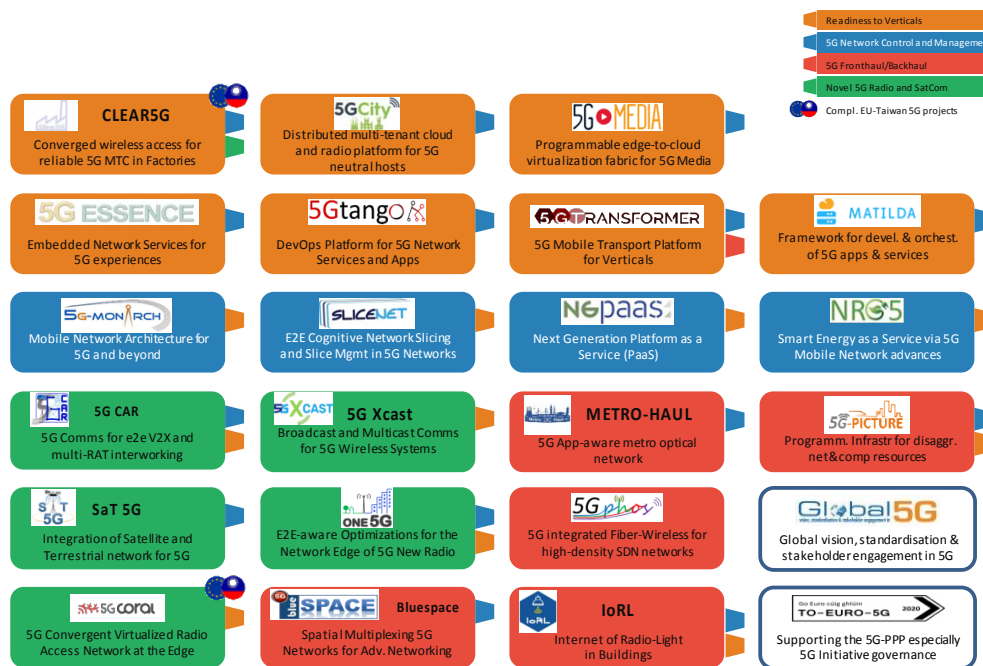
Figure 6: 5G PPP Phase 2 projects

Phase 2 projects key achievements

During Phase1, the Technology Board (TB) defined the process of identifying the Programme "key achievements". These were essentially the most significant results and achievements of the 5G PPP projects. This process was continued for Phase 2 projects during the second quarter of 2018. The final converged version has been released in February 2019, allowing all PPP projects to fully understand and match their individual contributions inside the overall programme achievements. The Phase 2 "key achievements" are illustrated in Figure 7. A clickable version of this figure with detailed relevant results can be found in on the respective web page [21].

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[21] https://5g-ppp.eu/phase-2-key-achievements/

Note that key achievements from Phase 2 5G PPP projects include 60 highlighted results categorised under14 program level achievements as shown by the symbols below.
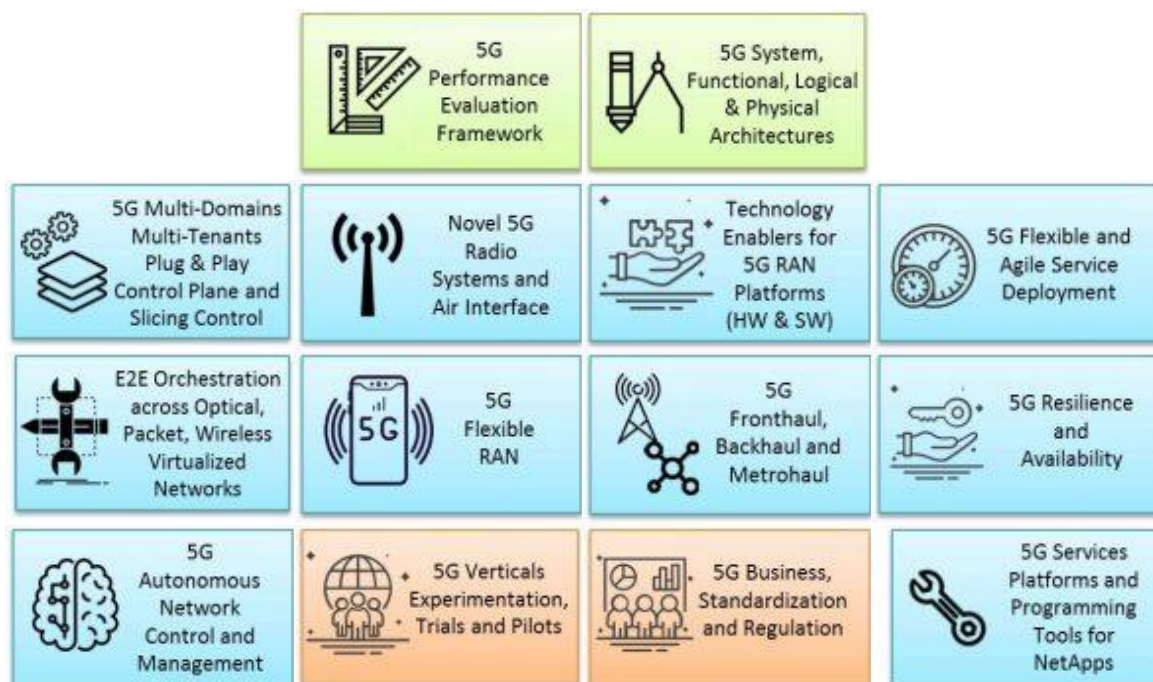
Figure 7: 5G PPP Key achievements from Phase 2 projects

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.

Phase 3 Projects

During 2018, the third phase of the 5G-PPP framework was initiated. This involved essentially the roll out of 5G platforms across Europe. It will enable large scale trials to help the stakeholders testing, in realistic environments, the key findings from the previous phases and draw significant conclusions. **Three infrastructure projects** have been selected to create a pan-European large-scale 5G test platform to be used by a number of vertical use cases. In 2018, **three automotive projects** also started their activities implementing and testing advanced scenarios. For a detailed presentation of 5G PPP Phase 3 projects' activities the reader can refer to the European 5G Annual Journal 2019[22].

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[22] https://5g-ppp.eu/annual-journal/

5G PPP Phase 3, Part 1: Infrastructure Projects

5G Infrastructure PPP Phase-3 platforms projects (Figure 8) started in July 2018 and will provide a pan-EU large-scale end-to-end 5G validation network infrastructure, **covering about 20 EU sites and nodes on a pan-EU basis until 2021.** This infrastructure will provide the adequate level of openness to make it possible for vertical industries to test their innovative 5G business cases using ad-hoc network resource control.

3 Projects have been selected from the 16 proposals received in response to the 5G-PPP ICT-17-2018 call. These three projects started on 1st July 2018 and will run for 3 years implementing and testing advanced 5G infrastructures in Europe. These projects are a) *5G EVE – 5G European Validation platform for Extensive trials*, b) *5G-VINNI: 5G Verticals INNovation Infrastructure* and c) *5G GENESIS: 5th Generation End0toEnd Network, Experimentation, System Integration, and Showcasing*. For a detailed presentation of 5G PPP Phase 2 projects' activities the reader can refer to the European 5G Annual Journal 2019.

Figure 8: 5G PPP Phase 3 - Infrastructure projects

The key platforms and cities of the PPP Phase 3 platforms projects are summarized in the geographic cartography presented in Figure 9.
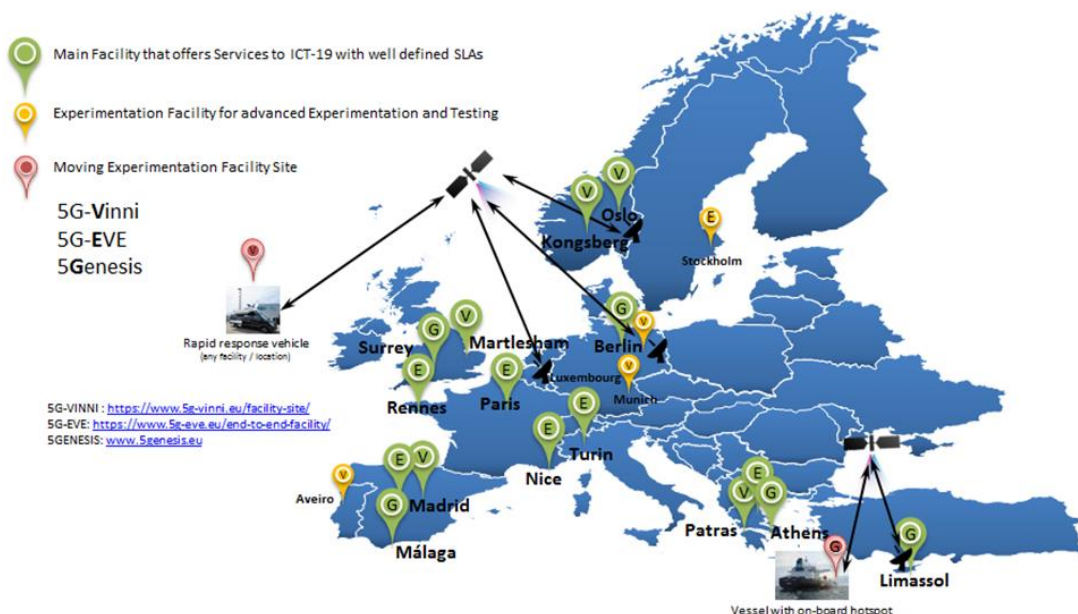
Figure 9: 5G PPP Platforms Cartography

5G PPP Phase 3, Part 2: Automotive Projects

Three Projects have been selected from the 6 proposals received by the EC in response to the 5G-PPP ICT-18-2018 call (Figure 10). These three projects started in November 2018 and run for different durations implementing and testing advanced cross border 5G infrastructures in Europe.

More specifically, the *5GCroCo (5G Cross-Border Control)* project aims at validating 5G technologies in the Metz-Merzig-Luxembourg cross-border corridor, traversing the borders between France, Germany and Luxembourg. It aims at defining new business models that can be built on top of this unprecedented connectivity and service provisioning capacity. Ultimately, 5GCroCo is expected to impact relevant standardization bodies for the telecommunications and automotive industries.

5G-CARMEN (5G for Connected and Automated Road Mobility in the European unioN) has the objective to leverage on the most recent 5G advances to provide (Virtual) Mobile Network Operators, Over-the-Top providers, and service providers with a multi-tenant platform that can support the automotive sector transformation towards delivering safer, greener, and more intelligent transportation with the ultimate goal of enabling self-driving cars. 5G-CARMEN will focus on the Bologna to Munich corridor (600 km, that crosses three countries).

5G MOBIX (5G for cooperative & connected automated MOBIlity on X-border corridors) aims at executing CCAM trials along cross-border and urban corridors using 5G core technological innovations to qualify the 5G infrastructure and evaluate its benefits in the CCAM context as well as defining deployment scenarios and identifying and responding to standardization and spectrum gaps. 5G-MOBIX will execute CCAM trials along two cross-border corridors and six urban trial sites.

Figure 10: 5G PPP Phase 3 - Automotive projects

Complementary to the three aforementioned automotive projects, and under the EU-China 5G collaboration topic, *5G-DRIVE* has commenced its activities at the 1st of September 2018. It deals with technical, regulatory and business objectives (Figure 11). A detailed list of its objectives can be found at https://5g-ppp.eu/5g-drive/.

Figure 11: 5G PPP Phase 3 - Complementary automotive project

On April the 10th 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[23]. **By searching "5G" in the Innovation Radar 128 innovations were found recorded** (shown on the map in Figure 12).

Figure 12: 5G Innovations

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[23] https://www.innoradar.eu/

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 papers[24]. The first white paper was produced in October 2015. Below follows a description for the activities of each WG and their achievements. A detailed description of the activities performed under these WGs, is included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements". In the following subsections we provide some indicative information.

Architecture WG

Its goal is to serve as a common platform to facilitate the discussion between 5GPPP projects developing architectural concepts and components and foster the discussions based on the KPI's described in the 5GPPP contract. The group could also facilitate consensus building on the 5G architecture. A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements". During the reporting period indicative activities and achievements follow below.

A Special Session entitled "5G Architecture towards Verticals" was organized at EuCNC 2018 on June 21st, 2018, concluding with a panel session. It was attended by 21 representatives of the main architecture stakeholders, namely, operators, verticals, and vendors, provide views on the 5G mobile network architecture requirements and standardization status[25]. Inputs were collected from phone conferences and the special session at EuCNC18, building the basis for the envisioned new 5G Architecture White Paper, which was published in 2019. Moreover, numerous project presentations were given to the community on vertical requirements and architectural aspects. A contribution was made to the 5G PPP Technical Workshop in Kista on the 20-22nd of November 2018. A face to face meeting was organized in Munich on 18-20th of March 2019. Finally, a workshop in the context of EuCNC 2019 was organized and the architecture white paper was presented.

Software Networks WG

Its purpose is to analyse and address unification and applicability of key research topics related to Software Networking including software defined concepts, infrastructures, systems and components for Wire and- Wireless Networks, including Networked Clouds, IoT and Services, i.e. Software Defined Networks (SDN) and Network Function Virtualization (NFV) as developed and promoted by the 5G PPP projects. A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements". During the reporting period indicative activities and achievements follow below.

The WG organized a workshop in EuCNC 2018, with the title "From cloud ready to cloud native transformation: What it means and Why it matters"[26]. More than 10 projects presented their contributions in the telco cloud native challenge. The Workshop at EuCNC 2018 was attended by approximately 40 participants, mostly from the 5G-PPP community.

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[24] https://5g-ppp.eu/white-papers/
[25] http://www.eucnc.eu/special-sessions/special-session-5/
[26] http://www.eucnc.eu/workshops/workshop-2/

Technical results from Phase 1 projects were identified and presented for the consideration of Phase 2 projects. The WG released the white paper "From Webscale to Telco, the Cloud Native Journey" in July 2018. It was disseminated at EuCNC 2018, in IEEE 5G WF, in Santa Clara and in the SDN/NFV World Congress event. Also, a related contribution to the 5G PPP Technical Workshop in Kista on 20-22nd of November 2018.

Moreover, a table has been set-up, listing all the cloud native requirements identified in the latest white paper. Each project filled the table with their inputs from their PoCs. The WG is working on a new White Paper Vertical and Cloud Native impact. For that, each project was asked to describe its vertical use-cases and how the project implements it. Also, the second edition of the workshop "From cloud ready to cloud native" took place at EuCNC 2019.

Network Management & QoS WG

The Network Management and Quality of Service (NMQ) work group has been established at the start of 5G PPP phase I and was tasked to address two closely correlated themes namely network management and QoS. Network Security is in the scope of the WG if it refers to the security of the control plane of the network. A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements". During the reporting period indicative activities and achievements follow below.

The WG organised the 3rd Network Management and QoS for 5G Networks workshop at EUCNC 2018[27]. The workshop at EuCNC 2018 was attended by approximately 20 participants, mostly from 5G-PPP community. Discussions during the panel session covered the following: trust of machine learning algorithms in real-world scenarios, addressing specific vertical sector challenges at network management level, and the role of SDN and NFV in use-cases. Furthermore, it produced a brochure on "Tackling Network Management Challenges for Vertical Sectors"[28]

5G Automotive WG

The 5G Automotive Working Group focuses on connected and automated mobility and serves as a common platform between 5G-PPP projects developing V2X and Vehicle-as-Infrastructure concepts and components. The aim is to consider a wide range of automotive related topics, such as use cases and KPIs, business aspects, spectrum usage, infrastructure capabilities, security and safety. A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements". During the reporting period indicative activities and achievements follow below.

A main activity has been to finalize the White Paper version 2.0 entitled "Business Feasibility Study for 5G V2X Deployment" for Mobile World Congress (MWC) in Barcelona on the 25-28th of February 2019. In order to prepare it, the WG scheduled a face-to-face meeting on the 8th of February 2019 in Paris. In addition, the WG held weekly conference to finalize the white paper to be ready before the MWC event.

A number of presentations and keynote speeches were given from chairman and the co-chair of the WG at the following venues: a) the V2X Summer School in London, 12

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[27] http://www.eucnc.eu/2018/www.eucnc.eu/workshops/workshop-7/index.html
[28] http://5g-ppp.eu/wp-content/uploads/2018/06/NMQ-WG_Brochure_web.pdf

June, 2018, b)EuCNC 2018, c) the Workshop in Brussels on 16th of November 2018, with the newly started cross-border projects (5GCroCo, Carmen, 5G-MOBIX), d) the 6th 5G Global Event, e) 5GAA meeting on 22nd of May, f) the 13th ITS European Congress in the "5G deployment for Automated Mobility" workshop and g) EuCNC 2019.

The WG has contributed to the 5G PPP Technical Workshop in Kista, assisted the work of the Technology Board for the Performance KPIs and the Trials WG for the Trials Roadmap 4.0 as well as the Smart Networks & Services scoping paper.

Test, Measurement and KPIs Validation WG

The Test, Measurement, and KPIs Validation (TMK) 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 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. Another important topic is the use of and contribution towards open source projects such as OSM, OPNFV or ONAP and identification of relevant exploitation and dissemination targets to promote the European vision on T&M towards a more global adoption. A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements". During the reporting period indicative activities and achievements follow below.

A face-to-face workshop was organized in Malaga on the 9-10th of April. The workshop allowed to have information sharing on key topics amongst the TMK participant projects and the first core of practical KPIs were defined. Contributions to the Global 5G event with 3 presentations in the 5G KPI Measurement Technical Session were made. 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.

White papers produced by the 5G PPP WGs

Overall, 13 white papers[29] have been produced overall. Five of these white papers have been produced since 2018. These are:

1. 5G PPP Automotive White Paper: *"A study on 5G V2X Deployment" – (Feb 2018).* This paper discusses the role of stakeholders and business models. Also, it provides a brief technoeconomic analysis. As the title suggests, the goal of the white paper was to offer insights into the deployment models for 5G Vehicle to Anything (V2X).
2. 5G PPP Software Network White Paper: *"From Webscale to Telco, the Cloud Native Journey"* (July 2018). The paper highlights what must be done in order to design a cloud-native 5G system. The white paper highlighted that one should ensure compatibility with a cloud environment to design a 5G system that would

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[29] https://5g-ppp.eu/white-papers/

benefit from the best technologies of the cloud industry and the technical assets of 5G-PPP projects.

3. 5G PPP Automotive White Paper: "**Business Feasibility Study for 5G V2X Deployment**" – (Version 2.0 February 2019). This white paper relied on the white paper "A study on V2X deployment", and on top it included further information that targets the description of the 5G V2X ecosystem and stakeholder relationships, different sharing models for network infrastructure as well as a business setup and finally a techno-economic assessment.

4. 5G PPP Test, Measurement and KPIs Validation White Paper: "**Validating 5G Technology Performance – Assessing 5G architecture and Application Scenarios**" – (June 2019). This white paper is a first attempt to provide a clearer view on topics like the role and expectations of vertical customers, the need of a Test as a Service (TaaS), a clear definition of KPIs for testing and validation and a common formalization process for standardizing tests.

5. 5G PPP 5G Architecture White Paper: "**View on 5G Architecture – Version 3.0**" (June 2019). This is the third version on this topic as the first one has been released in 2016. The document captures the latest findings and projects-wide consensus for the overall 5G architecture. This version pays special attention on understanding the requirements from the vertical industries and how these affect the 5G architecture.

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 **Verticals Cartography**[30],[31] **of the Phase 2 projects** (Figure 13) was produced together with the **Platforms Cartography**[32]. Both Cartographies are expected to be further developed and converge into a **Meta-Cartography**, considering the forthcoming integration of ICT-19 Verticals projects (Verticals Trials over Platforms).

The Technology Board organized **regular conference calls** (every 2-3 weeks on average) and **two face-to-face meetings** in 2018. In 2018, the key points regularly addressed during these interactions include indicatively 1) actions review, 2) plans and priorities, 3) the PPP Programme key achievements Version 2.0, 4) PPP Performance KPIs, 5) the PPP Verticals Cartography, 6) the PPP Platforms Cartography, 7) WGs plans, 8) PPP White Papers, 9) PPP Reference Figures and 10) Cross-projects synergies.

The Technology Board has organized the PPP technical workshop in November 2018 in Kista, which was successful and is presented in the following subsection.

Figure 13: 5G PPP verticals cartography

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[30] https://5g-ppp.eu/5g-trials-roadmap/
[31] https://www.global5g.org/cartography
[32] https://5g-ppp.eu/5g-trials-roadmap/ and https://5g-ppp.eu/5g-ppp-platforms-cartography/

Annex 6 -5G PPP: Organization/Participation in workshops and events

Since 2018, several technical workshops, information and research days/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. Below, follows a list of these events.

- **Webinar organized by PICASSO project (5G in the focus among other topics - May 2018):** This Webinar was about "EU-US collaboration on 5G funding opportunities in Horizon 2020" and the corresponding slides are available[33].

- **EUCNC 2018 (18-21 June 2018 in Ljubljana):** The 5G PPP initiative was present at the EuCNC conference with many sessions, workshops, technical papers and a booth. At the 5G PPP booth, the latest 5G PPP results were shared, the 5G IA international activities were discussed, and the *leading demos developed by SMEs* were showcased. The exhibit was well attended particularly when 5G PPP speakers were on stage. Specific PR material was available and disseminated at the event including *the new SME brochure*. Eight workshops were organised during the first day. An equal number of special sessions took place. *Eleven booths highlighted 5G PPP* project and programme achievements. Two panels were held. Fourteen projects showcased results and achievements and shared their views. The 5G PPP booth was shared with the 5G IA and the European Commission. It also provided information and demos from SMEs. *Fifteen Technical Papers* were presented by project representatives during the conference sessions.

- **Dissem (September 14th, Brussels):** This event was organised in the context of the ongoing implementation of the 5G PPP program of inter-working and collaborating projects to share necessary information for proposers for the next 5GPPP call H2020 ICT-19. The European Commission presented its expectations for ICT-19. It was designed to offer ICT-19 proposers with an opportunity to better understand the services offered by the three ICT-17 platform projects and the related inter-working framework (both technical and legal) that they may provide. The ICT-17 platform projects were available to answer questions from potentially interested proponents under ICT-19. The second part of the agenda allowed anyone interested in making a pitch looking for players to join their proposal or for people to promoting their competence as a participant to proposals under discussion.

- **Cloudscape Brazil 2018 (25 July 2018 in Natal, Brazil):** During this event the following engagement took place:
  - 5GINFIRE (automotive; manufacturing) participated in the session "Triggering new digital markets".
  - 5G-RANGE participated in the session "Excellence in ICT co-operation".
  Also, 5G PPP contributed with the following position papers:
    - *"Support SMEs in becoming competitive and exploiting the potential of international markets: EU-Brazil SME cooperation[34]"*

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[33] http://www.picasso-project.eu/eu-us-collaboration-on-5g-funding-opportunities-in-horizon-2020/
[34] https://www.atmosphere-eubrazil.eu/support-smes-becoming-competitive-and-exploiting-potential-international-markets-eu-brazil-sme

- o *"Impact of 5G on Vertical Industry Sectors[35]"*
- **5G PPP Technical Workshop (20-22 November 2018 in Kista):** The 5G PPP Technical Workshop enabled significant progress in defining 5G Infrastructure Performance KPIs, how these will be evaluated and qualifying and quantifying projects' innovation/enablers on these KPIs. The PPP technical workshop also offered great experience of team work and team building, with very active and engaged participation from representatives of almost all PPP Phase 2 projects and all PPP Phase 3 ICT-17 Platforms projects[36]. The workshop gathered more than 30 PPP Phase 2 and Phase 3 (ICT-17 Platforms) projects. Participants comprised technical managers, scientific experts, and specific WGs Chairs. The Technical Workshop included the PPP Performance KPIs Workshop that was organised on the 20th and the 21st, and it was followed by the Technology Board meeting on the 22nd. The Technical Workshop was hosted by Ericsson (PPP Phase 2 5GCAR project) in Ericsson HQ in Kista.
- **ICT-2018: Imagine Digital – Connect Europe, (4-6 December 2018 in Vienna):** The research and innovation event focused on the European Union's priorities in the digital transformation of society and industry. ICT 2018 had four main components converging around the theme Imagine Digital – Connect Europe. These were: a) Conference, b) Exhibition, c) Networking opportunities and Innovation and d) Startups forum. Citizens joined science community members, policymakers, and fellow ICT-enthusiasts to discuss the future in a digital Europe. 5G PPP projects were very active with four 5G PPP related booths:

  - A 5G PPP 'Information Kiosk' where videos, brochures and flyers were displayed
  - A 5G PPP 'Demo booth' where some projects presented their demos.
  - Two project booths: 5GCity and 5GCAR

  The following networking sessions were also organised:
  - *Stimulating innovation over next generation 5G network infrastructures*: organised by Eurescom on behalf of 5G EVE, 5G-VINNI, and 5GINFIRE.
  - *Artificial Intelligence – New Solutions for Real-time Service Delivery:* organised by Eurescom on behalf of SliceNet
  - *Network Slicing:* organised by 5G-MoNArch

- **One5G and 5G-XCast Workshop on "5G Advanced: The Next Evolution Step of 5G New Radio" at IEEE Globecom 2018, (9 - 13 December 2018, Abu Dhabi, United Arab Emirates):** One5G and 5G-XCast organised a full day workshop and a special session on "The Local Impact of 5G" to attract regional SMEs and Startups[37].
- **The Architecture Working Group Workshop (Munich - March 2019):** This workshop took place for the purpose of finalizing the third version of the "View on 5G Architecture" white paper. This face-to-face workshop was important since it brought together researchers from all over Europe and different projects, to share their view and converge on the findings for the 5G architecture.

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[35] https://www.atmosphere-eubrazil.eu/impact-5g-vertical-industry-sectors
[36] https://5g-ppp.eu/newsflash-december-2018/
[37] https://5g-ppp.eu/event/one5g-and-5g-xcast-ws-on-5g-advanced-the-next-evolution-step-of-5g-new-radioieee-globecom-2018/

- **EUCNC 2019 (17-18 June 2019 in Valencia):** 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 gave the opportunity to 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)***

Note that **5G PPP projects** have disseminated their results in a number of scientific journals, international conferences, book chapters and white papers. **Phase 2 projects have produced 756 publications until now** (22% was published in scientific journals)**, whereas Phase 3 projects have produced 54 publications** (26% was published in scientific journals). This information was collected by visiting each project's web site. There was no information about a DOI identifier for all papers. More detailed information can be found in the Annex.

Annex 7- 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.

The VTF strategy is articulated around three axes:

- Priority vertical sectors (Automotive, Smart Manufacturing, Media, Energy, Public Safety, Health).
- A governance model to coordinate activities.
- An active engagement action towards vertical stakeholders, e.g., in terms of industry influencing and partnerships, to attract verticals in 5G PPP orbit and gather feedbacks.

The 5G IA and industry associations are involved in promoting 5G usage by vertical players. In the **automotive sector, the 5GAA** (Automotive Association) already gathers more than 110 members working together on all aspects of C-V2X including technology, standards, spectrum, policy, regulations, testing, business models and go-to-market. **5G ACIA** (5G Alliance for Automated Industries and Automation) is involved in defining 5G use cases for Industry 4.0. Its mission is to "Ensure the best possible applicability of 5G technology and 5G networks for the manufacturing and process industry by addressing, discussing and evaluating relevant technical, regulatory and business aspects".

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 where performed in priority sectors (i) attending 11 verticals industry events with 5G PPP speakers and (ii) defining partnerships with vertical sectors by the means of signed MoUs with key industrial fora such as 5GAA (automotive), ESA (satellite), ECSO and PSCE (Public Safety), 5G ACIA (Smart Manufacturing - close to be signed). A list of 2019 key events with 5G PPP speakers is already defined while new key vertical fora are addressed to start negotiations (e.g., EBU and NEM for Media, EUTC for utilities, EDSO for Smart Grids. HIMMS for Health) with the objective to have a partnership in place for all priority sectors.

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 ad hoc team produced a **Vertical & Platform Cartography**[38] that can be navigated on 5G PPP, Global 5G.org and on the Paderborn University Webpage. Moreover, the trials WG has supported the activities though PoCs.

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

A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements".

Indicative activities and main achievements include:
- The WG chair and WG vice-chair were appointed in October 2018.
- A new Terms of Reference document has been defined for the WG, and has been approved by the Board of the 5G IA

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[38] https://www.ip45g.de/en/5g-testbeds/

- The 'Horizon Europe Vision Subgroup' has been established to engage with the Alliance for Internet of Things Innovation (AIOTI) for the purpose to follow-up on target set by the MoU between 5G IA and AIOTI established in December 2018. Since then, several conference calls have been organized.
- Preparation, in coordination with the 5G IA Board and AIOTI, of the "*Joint 5G IA - AIOTI Vision on Future Networks, Services and Applications – High societal and economic impact potentials for a collaborative approach in the Horizon Europe Programme*"[39].
- The 'Member State 5G programs Subgroup' kicked off in May 2019
- The PSM Version 1.0 has been further developed in January 2019, released and communicated on 08.02.19. The PSM Version 1.1 has been developed in February 2019, released and communicated on 28.02.19. The PSM Phase 3.II. Version 2.0 was released on 12th July 2019[40].
- Contribution to the "*5G Italy White Book – From Research to Market*"[41].

As mentioned above, the PSM was released in Versions 1.0 and 1.1[42] in February 2019. The PSM SG now includes 55 members from 32 different organizations. The PSM Phase 3.II. Version 2.0 was released on 12th July 2019.

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.
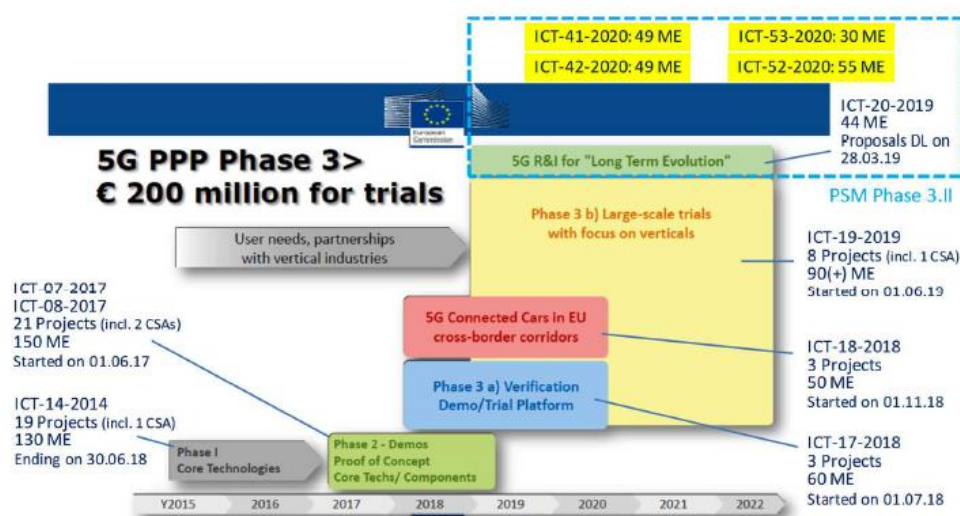

Figure 14: Phases, strategic objectives and projects

Figure 14 provides a graphical representation of the phases of the PPP programme, the strategic objectives and the projects (source Pre-structuring model Phase 3.II, version 2.0).

[39] https://bscw.5g-ppp.eu/pub/bscw.cgi/d293954/Vision on 5GIA-AIOTI partnership v1.0.pdf
[40] https://5g-ppp.eu/phase-3-part2-pre-structuring-model/
[41] https://www.5gitaly.eu/wp-content/uploads/2019/04/5G-Italy-White-eBook.pdf
[42] https://5g-ppp.eu/wp-content/uploads/2019/02/190228_5GInfraPPP_PSM-Phase3.II_V1.1.pdf

The 5G Public Private Partnership has a very pro-active relationship with standards development, with many mechanisms in place to help vertical stakeholders participate in various ways in the process, through the 5G-IA Pre-Standardization WG.

5G PPP Phase 2 projects submit input contributions to over 20 groups within standards organization's and industry alliances. Inputs come in diverse formats, such as technical reports, specification documents, white papers, proof of concepts, interoperability tests, and source codes.

The 5G-IA Pre-Standardization WG is tasked with tracking such inputs through its members, sometimes collaborating with other WGs, e.g. the Architecture WG, on assessing contributions from different perspectives. Each input is tracked in terms of contributing project, targeted SDO and its specific group, title of the input, reference documentation or link, history (e.g. Q2-2018) and partners involved. The data collected is used to generate statistical graphs and tables. A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements".

Demonstrated impacts: **5G PPP has had significant influence in building pre-standardization consensus across key actors. Major impact on the 5G architecture ideas has also been achieved through 611 activities leading to standardization (Phase 1: 315; Phase 2: 296).**

A **standardisation Roadmap** has been produced to guide the 5G PPP projects on timely contributions to standardization bodies aligned with the industry time line for 5G functionalities (eMBB, mMTC and URLLC) moving towards those functionalities that have significant added value for Europe.

The Pre-standardisation WG has also kept track of the ongoing work in the standards bodies, e.g. the open work items and the informal discussions that take place at standards meetings. This provides an easier way to obtain information about what is ongoing in the standards domain and helps projects to better plan for engaging with standards activities. Three WG subgroups (i.e., Smart Networks, Pre-structuring model and Member State Initiatives) have been created and contributors identified. The WG participated on the 5G vertical user workshop on the 12-13th of February in Brussels and in the 2nd 5G vertical user workshop in Rome on the 9010th of July 2019 in Rome.

5G PPP Phase 2 projects submit input **contributions to over 20 groups** within standards organisations and industry alliances. Inputs come in diverse formats, such as technical reports, specification documents, white papers, proof of concepts, interoperability tests, and source codes.

The 5G-IA Pre-Standardization WG is tasked with tracking such inputs through its members, sometimes collaborating with other WGs, e.g. the Architecture WG, on assessing contributions from different perspectives. Each input is tracked in terms of contributing project, targeted SDO and its specific group, title of the input, reference documentation or link, history (e.g. Q2-2018) and partners involved. The data collected is used to generate statistical graphs and tables.

Impacts: During the past 12 months, a total of 297 inputs have been tracked by the Pre-Standardization WG. 219 of these inputs relate to the development of 5G architectures, analysed in close collaboration with the 5G PPP Architecture WG.

The table below shows a breakdown of the inputs for the development of 5G architectures.
The table below shows shows a breakdown of the inputs for the development of 5G architectures.

Number of contributions per architectural area	
Overall architecture: Mostly to 3GPP, with many inputs on the implementation of 5G V2X systems and multimedia broadcast or streaming services.	70
Radio and edge architecture: Mostly to 3GPP, with many inputs on 5G NR enhancements for V2X and multimedia broadcast.	41
Core and transport architecture: Mostly to 3GPP, with most of the inputs related to terminals.	58
Management and orchestration architecture: Mostly to three ETSI groups, namely, the ZSM ISG, NFV ISG and OSM.	50
Total	**219**

The figure below shows the overall spread of inputs tracked from phase 2 projects through the Pre-Standardization WG blueprint.
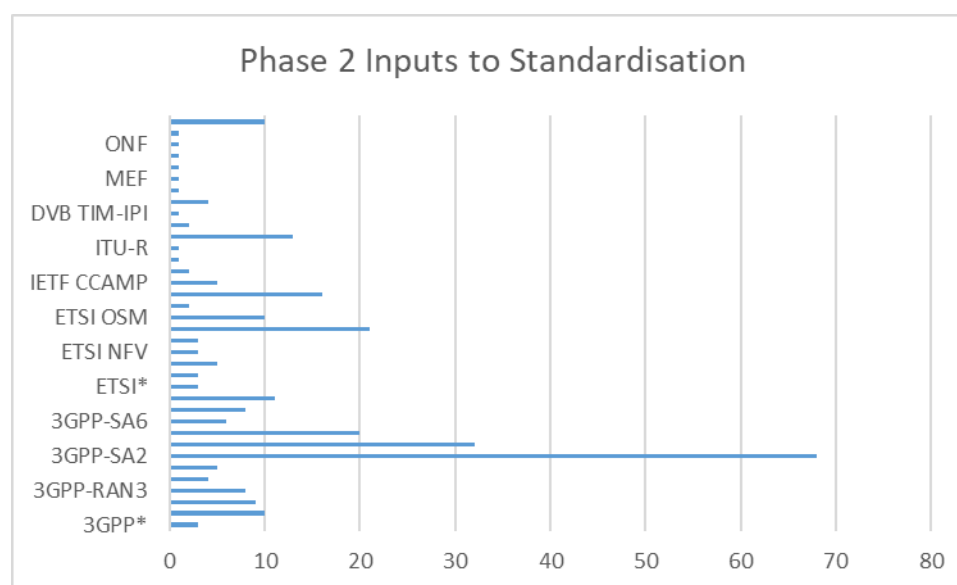

Figure 15: Phase 2 Project Inputs to 5G Standardization

5G PPP inputs on *5G overall architecture* (Figure 16) focus mostly on the implementation of 5G V2X systems and multimedia broadcast or streaming services. The breakdown for 3GPP is:

- 3GPP SA2 – Architecture: 40 contributions.
- 3GPP SA4 – Codec: 25 contributions.
- 3GPP SA6 – Mission-critical applications: 3 contributions

- 3GPP SA1 – Services: 1 contribution
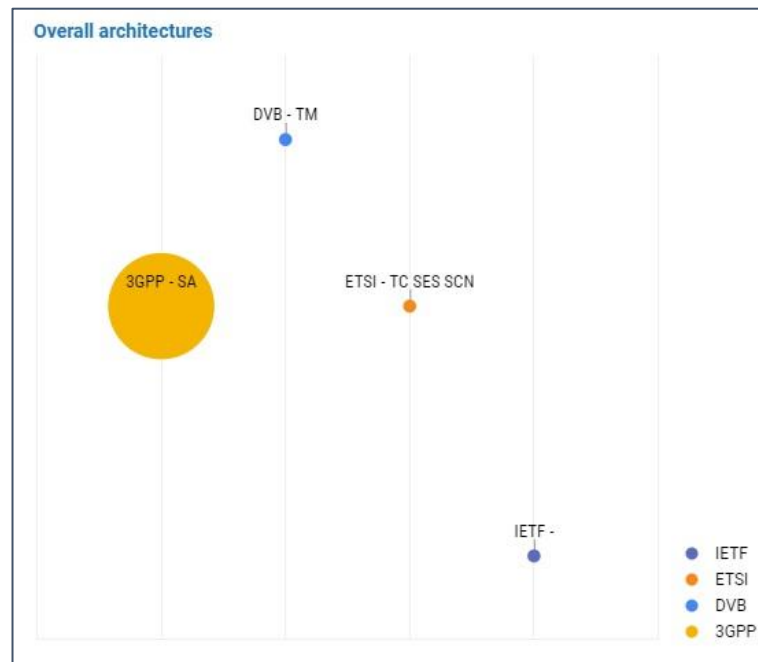- 3GPP SA5 – Telecom Management: 1 contribution.

Figure 16: Inputs to SDOs for the overall architecture

5G PPP inputs related to *RAN architectures* (Figure 17) mostly target the WGs of 3GPP TSG RAN. Most of the focus is on 5G NR enhancements for V2X and multimedia broadcast. The latter is also targeted towards the DVB industry alliance. Contributions to edge architectures mostly target two ETSI Industry Specification Groups: ETSI MEC and ETSI NFV. The bullet points below show the breakdown for 3GPP RAN:

- 3GPP RAN 1: 10 contributions.
- 3GPP RAN 2: 8 contributions.
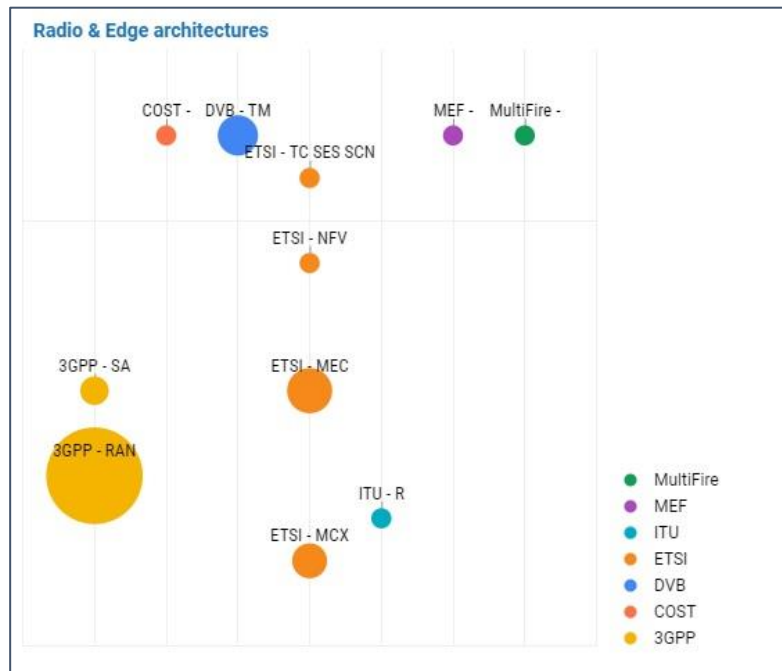- 3GPP RAN 3: 6 contributions.
- 3G RAN (WG not specified): 4.

Figure 17: Inputs to SDOs for Radio and Edge

5G PPP phase 2 project inputs for *5G core network architectures* (*Figure 18*) also confirm the trend towards 3GPP. In this case, the targeted TSGs are SA and CT (core network and terminals). As for contributions related to transport architectures, inputs on microwave/millimetre wave transport have been towards IETF. Contributions for optical-based transport have targeted mostly ITU-T and IETF.

The breakdown for 3GPP is:

- 3GPP CT1: 8 contributions.
- 3GPP CT4 – 11 contributions.
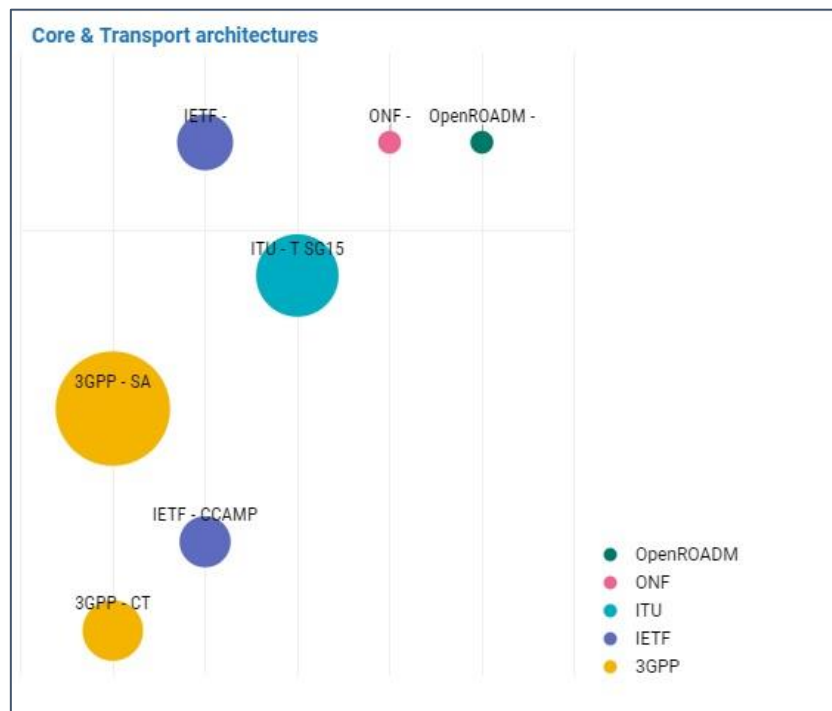- 3GPP SA 2 – 21 contributions.

Figure 18: Inputs to SDOs for Core Network and Transport

Inputs for *MANO architectures* (Figure 19) within the 5G PPP phase 2 have targeted ETSI, mostly:

- ETSI Zero Touch Network and Service Management (ETSI ISG ZSM).
- ETSI NFV for the virtualisation of network functions (ETSI ISG NFV).
- ETSI Open Source MANO (ETSI OSM), an open source NFV Management and Orchestration (MANO) software stack aligned with ETSI NFV Information Models

Outside of ETSI, there have been contributions to 3GPP mostly targeting the SA WG5 (Telecom Management), which specifies architecture and solutions for provisioning, charging and management of mobile networks (including RAN and core) and their services.

A key link between the Pre-Standardisation WG and the Verticals Task Force is the Task Force formed by a sub-set of 3GPP Market Representation Partners (MRPs) upon the recommendation of the 3GPP Project Coordination Group (PCG). The main remit of the Task Force is to organise workshops targeting vertical industries with the aim of boosting inputs to 3GPP 5G standardisation. The sub-set of 3GPP market partners comprises: 5GAA, 5G-ACIA, 5G IA and its WGs (primarily Pre-Standardization WG), and the Verticals Task Force and PSCE.

Two 5G Vertical User Workshops took place during 2019. More information about these activities can be found in the attached file related to standardization activities in the Annex.
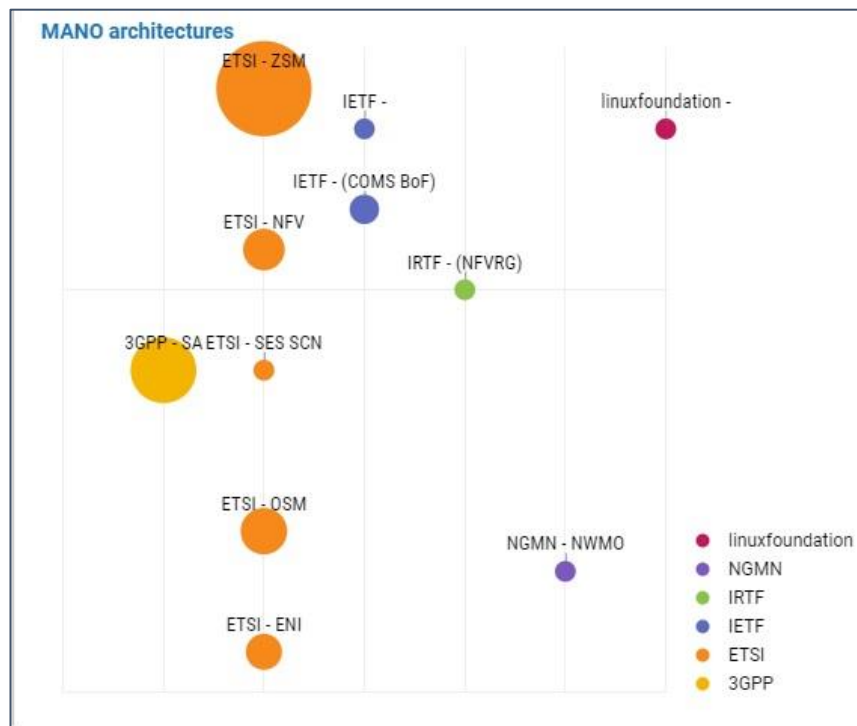
Figure 19: Inputs to SDOs for MANO

Trials

The 5G IA launched an activity in 2016 to first generate a strategy for developing a **Pan-European 5G Trials Roadmap**, and then, prepared the comprehensive **Trials Roadmap** (Figure 20). To generate these documents and roadmaps, the 5G IA coordinates a 5G Trials Working Group expanding the work initiated by the Industry and EC in the context of respectively the 5G Manifesto of industry in Europe and the 5G Action Plan of the EC. This group has to date produced four versions of the Trials Roadmap. The WG has worked on 6 WG streams in parallel (i.e., 5G private trials, 5G UEFA EURO 2020, 5G trials cities, 5G platforms, 5G vertical pilots and 5G international cooperation).
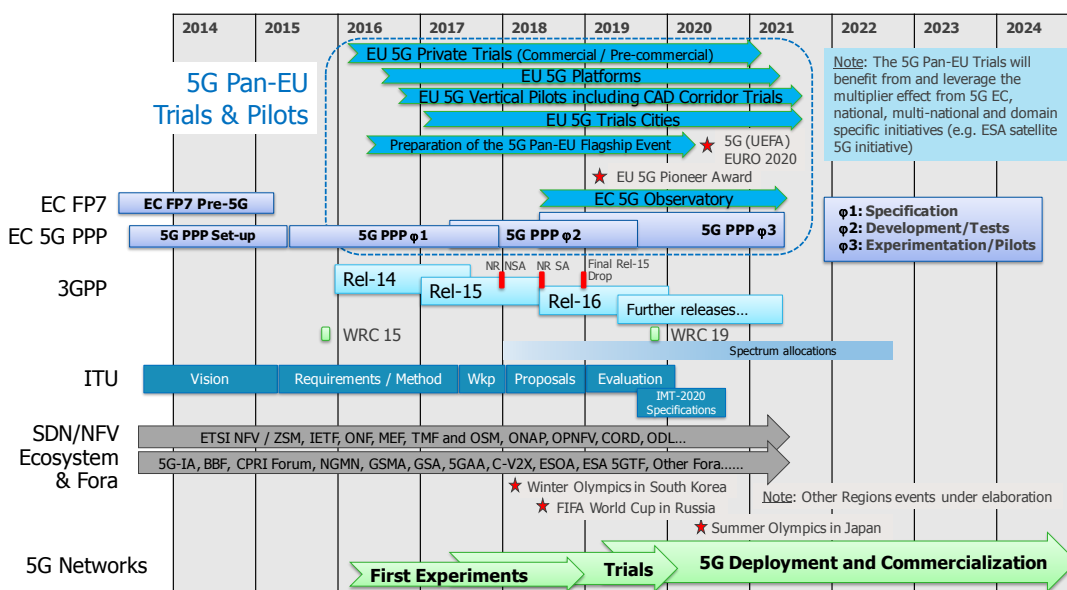

Figure 20: 5G Pan-EU Trials Roadmap - Timeplan– Source Roadmap Version 4.0

51

Two 5G PPP trials roadmaps were released in 2018 and two in 2017. **The Roadmap Version 3.0**[43] was successfully presented at the 5th Global 5G Event in Austin (16-17 of May 2018). It addressed the latest up-dates of the Roadmap strategy, 5G Private Trials, 5G Vertical Pilots, 5G Pan-EU Flagship event 5G for UEFA EURO 2020 and 5G Trials Cities.

The Roadmap Version 4.0[44] was successfully presented at the 6th Global 5G Event in Rio (28-30 November 2018). It highlighted the key EU cities that are targeted for 5G early deployments, already engaged in 5G pre-commercial/commercial trials and pilots, engaged in 5G R&I trials and pilots and also making available 5G R&I platforms. A description of the major EU cities engaged in the 5G UEFA EURO 2020 Flagship event was also provided.
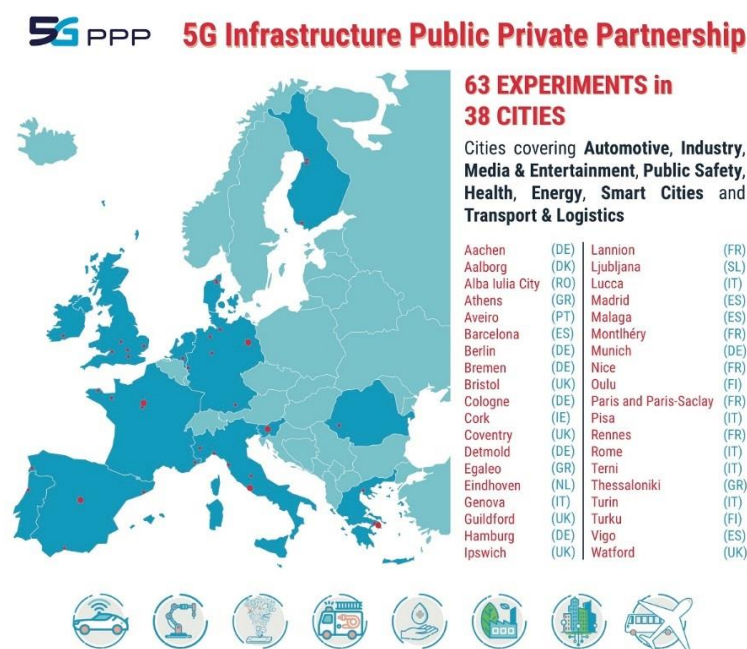

Figure 21: A Cityscape of the Verticals Cartography– Source Roadmap Version 4.0

As detailed in the 5G Pan-EU Trials Roadmaps, the acceleration of 5G in EU is also happening thanks to a specific joint strategy between Industry (hand in hand with Research Centres, Academics and local communities), EC and member states and domains specific initiatives (Figure 21). The EU 5G strategy is clearly targeting large scale adoption of 5G by vertical sectors[45]. Expanding bilateral and multilateral private trials, the EU strategy hence relies on the development of initiatives addressing 5G vertical pilots, 5G corridors, 5G platforms, 5G trials cities and the 5G UEFA EURO 2020. Verticals engagement in 5G deployment is strongly supported by the 5G Infrastructure PPP through a specific Board Task Force providing guidance to relevant activities in terms of vertical industries education and partnerships, Memorandums of Understanding (MoUs) with relevant verticals fora such as 5GAA (Automotive), 5G ACIA (Smart Manufacturing – close to be signed), ECSO and PSCE (Public Safety), ESA (Satellites) are developed/envisaged as partnerships models in order to foster adoption and clear roadblocks in vertical sectors.

[43] https://5g-ppp.eu/wp-content/uploads/2018/05/5GInfraPPP_TrialsWG_Roadmap_Version3.0.pdf
[44] https://5g-ppp.eu/wp-content/uploads/2018/11/5GInfraPPP_TrialsWG_Roadmap_Version4.0.pdf
[45] https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf

The running 21 5G Infrastructure PPP Phase 2 projects[46] (2017-2019) contribute to the prototyping, experimentation and trialling of 5G technologies and components for specific use-cases including vertical use-cases developed with vertical stakeholders. The 3 PPP Phase 3 pan-EU 5G end-to-end facilities / platforms (ICT-17) projects[47] started in July 2018 cover 20 platforms/nodes in EU and the 3 PPP Phase 3 corridors (ICT-18) projects started in November 2018 address multiple EU test corridors. In June 2019, 6-9 PPP Phase 3 Vertical Pilots (ICT-19) projects will target large scale trials and pilots including complete end-to-end 5G systems and leveraging the existing platforms projects. Additional 5G test corridors projects will be launched in the context of the PPP Phase 3. In addition, the current definition of the EC Connecting Europe Facility (CEF2) programme (2021-2027) includes a specific focus on 5G corridors deployment[48].

To highlight some of the key elements of the Roadmap Version 4.0, the overall 5G Pan-EU Trials Roadmap time plan and relevant standardization, regulatory and ecosystems time plan are summarized in Section 2 of the prementioned document. The categorization of 5G trials and pilots in EU, from test to pre-commercial/deployment, is detailed in Section 3 respectively.

The major EU cities engaged in 5G R&I trials and pilots (including PPP Phase 2 projects and Phase 3 corridors projects), providing 5G R&I platforms (including PPP Phase 3 platforms projects) and currently engaged in the potential trials and pilots in 5G UEFA EURO 2020 are detailed respectively in Sections 4, 5 and 6 of the Roadmap (Figure 21). Figure 22 presents the 5G trials and pilots in EU MSs. All figures presented in this subsection are copied from the Roadmap Version 4.0. The ICT-17 Platforms Cartography included in Section 4.1.2 was also developed in the context of the Roadmap Version 4.0.
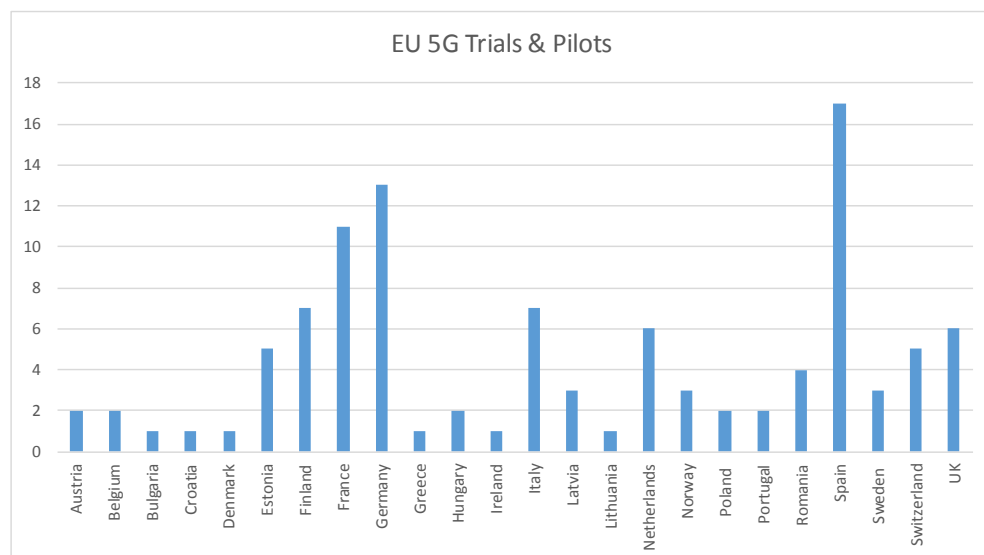

Figure 22: 5G Trials & Pilots in EU MSs – Source Roadmap Version 4.0

[46] https://5g-ppp.eu/5g-ppp-phase-2-projects/
[47] https://5g-ppp.eu/5g-ppp-phase-3-projects/
[48] https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-cef-regulation-annex_en.pdf

As stated above, the wider community was mainly involved via the 'Trials Working Group', created by the 5G IA in September 2016. Besides the 5G IA Members, this WG is also open to organisations from the European ICT domain, and vertical sector organisations that are not members of the Association.

Additional achievement of the WG are the participation/presentations in the 6th and 7th Global 5G events and the IEEE 5G summit. Finally, work has be done for the further definition of the interface between the 5G Observatory (EC study started on 01.07.18 and piloted by IDATE[49]) and the Trials WG / 5G Private Trials Stream.

A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements".

Spectrum

During 2017, the 5G IA Spectrum WG suggested suitable spectrum bands in response to the RSPG public consultation that was held prior to issuing the opinion. For the reporting period and in the context of the Spectrum WG the following activities have been made:

- Regular teleconferences of the WG
- Identification of future spectrum-related activities (including request for input from WG Members, 5G IA Board. Inputs from other WGs and Projects is also welcome).
- Contribution to the Spectrum & Regulatory panel at the Global 5G Event in Brazil (presented by 5G IA's Secretary General).
- Working document related to the RSPG 3rd Opinion with respect to the spectrum for verticals (currently being prepared/finalised)
- Coordination for the WG's role/involvement in the possible preparation of a Verticals White Paper

Moreover, its main outcomes for the reporting period are included in the following list:

- Response to PC on the draft text of the 3rd RSPG Opinion on 5G;
- WG Spectrum High-level overview of key expected spectrum issues and areas for FP9.
- Input on the recommended 'spectrum areas' for Horizon Europe.

A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements".

Currently**, in Europe** 5G pioneer bands identified at EU level are the 700 MHz, the 3.6 GHz (3.4-3.8 GHz) and the 26 GHz (24.25-27.5 GHz) frequencies (Figure 23). Whereas the 700 MHz band has been harmonised through an EC Implementing Decision (EU) 2016(687) of 28 April 2016, a '5G-ready' amendment of the 3.6 GHz implementing decision was adopted in January 2019. The European Commission is about to adopt a harmonisation decision for the 26 GHz band in Q1 2019[10].

Member States have adopted a common deadline for the effective usability of pioneer spectrum in the European Electronic Communications Code, namely the 3.6 GHz band

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[49] https://ec.europa.eu/digital-single-market/en/european-5g-observatory

and at least 1 GHz within the 26 GHz band have to be assigned in all Member States by end of 2020. All Member States have recognised the need for significant harmonised spectrum for 5G. Work is ongoing. The review of progress towards making spectrum available to 5G shows various stages.
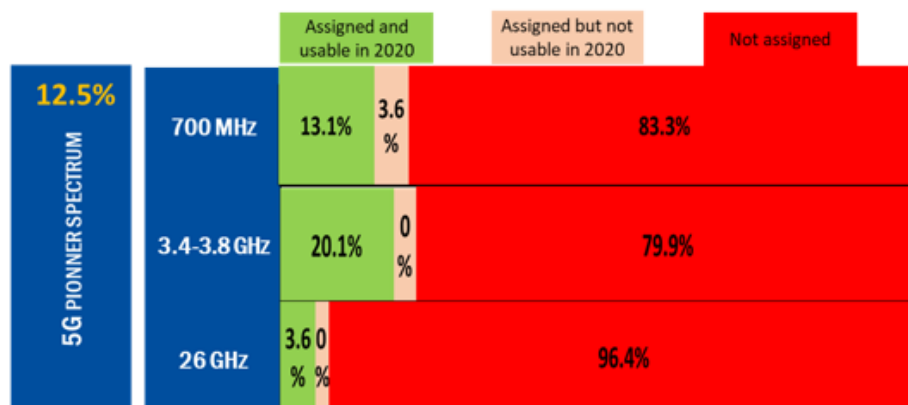

Figure 23: 5G pioneer spectrum assignment in EU-28 (March 2019) - source 5G Observatory

In nine Member States at least one spectrum auction is complete or ongoing as at March 2019. The 700 MHz band has been assigned in five Member States: Germany, France, Finland, Italy and Sweden and the 3.4-3.8 GHz band has been assigned in accordance with 5G technical conditions in 5 MSs: Austria, Finland, Ireland, Italy, Latvia, Spain and United Kingdom. Italy was the first Member State to auction 1 GHz of the 26 GHz band.

In the other countries worldwide, the situation is as follows. **South Korea** awarded 2,400 MHz spectrum at 28 GHz and 280 MHz in the 3.6 GHz band in June 2018. In the **USA**, the 600 MHz (T-Mobile), 2.5 GHz (Sprint), 28 GHz (Verizon and AT&T) and 39 GHz (AT&T) bands are going to be used for 5G commercial services. In Asia-Pacific, **China** has authorised mobile operators to use the 2.6 GHz, 3.5 GHz and 4.8 GHz bands for 5G whereas in **Japan**, the 3.6-3.8 GHz, 4.4-4.9 GHz and 28 GHz are under consideration.

Security

In September 2017, the 5G IA Board agreed to move the Security WG under the umbrella of the 5G IA. As such, this WG is open to both 5G PPP projects and 5G IA Members. The purpose of the group is to foster development of the 5G Security Community consisting of 5G security experts and practitioners who pro-actively discuss and share information to collectively progress and align on the field. The WG organises specific communications/events (e.g. whitepapers, workshops); interacts with other WGs whenever Security input is needed and liaises with other relevant Security communities.

Its main activities cover a number of areas such as:

- Attract Members from 5G PPP Phase 2 and Phase 3 projects and from the 5G IA
- Discuss/Coordinate security related issues with relevant projects as well as 5G IA Members
- Work on security-related KPIs
- Analysis of the EC recommendation on Cybersecurity for 5G Networks

- Contribution to the Phase 3 (Part 2) Pre-structuring Model Version 1.1 released by the 5G Infrastructure Association on 28.02.19

Moreover, an enhanced cooperation with both PSCE and ECSO is of particular interest to the Security WG. ECSO and 5G IA signed a MoU in December 2018 with the aim of enhancing future cooperation in the field of cyber security and 5G communication networks. A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements".

During 2018 the Security WG participated in 3 international workshops were held in the following venues:

- EuCNC 2018: Workshop 8: Next generation network systems security[50] (June 18-21, Ljubljana)

- ACM SIGCOMM: Workshop on Security in Softwarized Networks: Prospects and Challenges (SecSoN[51]) (Budapest, Hungary, on August 20-24, 2018)
- 13th International Conference on Availability, Reliability and Security – ARES 2018: – Workshop on 5G Networks Security (5G-NS 2018[52]) held in conjunction with the ARES Projects Symposium 2018 (27 – 30 August 2018, Hamburg)

IMT-R IMT 2020 Evaluation WG

ITU-R WP 5D launched an evaluation process for Radio Interface Technologies (RITs) starting with an ITU-R WP 5D Evaluation Workshop for RITs in October 2017. RITs can be submitted by Standards Developing Organisations (SDOs) to ITU-R to be recognised as members of the IMT-2020 family of systems for mobile and wireless communications (effectively "5G"). In that process ITU-R is looking for second opinions by independent Evaluation Groups in addition to self-evaluation by SDOs. The final evaluation report is due in February 2020. The **5G IA was registered at ITU-R as one of the 11 globally recognized groups in November 2016.** For this activity 5G IA has created the IMT-R IMT 2020 evaluation WG. 5G IA is supported by several 5G PPP projects and Association members. This WG was set up at the end of 2017 and its activities started in 2018.

The 5G PPP IMT-2020 Evaluation Group is focusing on the 3GPP submission due to its globally supported approach. In 2018 the Evaluation Group organized itself and agreed a work split for the 16 evaluation characteristics according to relevant ITU-R documents. Means for evaluation are analytical calculations of certain characteristics, inspection of the RIT submission and simulations according to ITU-R guidelines. This requires substantial technical work.

A detailed list of the main activities and key achievements are included in the To-Euro-5G Deliverable 5.2 – "Year 2 report on WG Achievements".

An indicative list of the key activities and main achievements include:

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[50] https://www.eucnc.eu/2018/www.eucnc.eu/workshops/workshop-8/index.html
[51] https://conferences.sigcomm.org/sigcomm/2018/workshop-secson.html
[52] https://5g-ppp.eu/event/5g-ppp-workshop-on-5g-networks-security-5g-ns-2018/

- In the reporting period the following evaluation characteristics were completed: Peak data rate (analytical), Peak spectral efficiency (analytical), Control Plane latency (analytical), Connection density (simulation), Energy efficiency (inspection), Bandwidth (inspection), Supported spectrum band(s) / range(s) (inspection)
- Available evaluation results are collected in the draft evaluation report, which is a living document until its final submission to ITU-R in February 2020
- Adaptation of link-level and system-level simulators according to the 5G RIT proposals as well as ITU-R requirements.
- Calibration of simulators with respect to other available results.
- Clarification of open issues in the 3GPP RIT submission with 3GPP.
- Liaison statements have been received from ITU-R with initial submissions from 3GPP, China, India and Korea and the DECT Forum as well as a liaison statement from 3GPP on intended activities towards independent evaluation groups. Based on the initial submissions, first evaluation activities have been performed on spectrum bands and supported bandwidth.

The Working Group is on a good track to prepare a complete evaluation report towards ITU-R by February 2020 from the European perspective.

SME Community

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 (respectively 17% and 12%) but are expected to be higher in the next calls that are more focusing on trials and verticals. Detailed information about SMEs statistics is available[53].*

Examples of **recent results and success stories from European SMEs** involved in 5G PPP projects are starting to be released. Such examples were included in the second version of the brochure entitled "**SME Expertise and Skills in the 5G Domain**" (released mid-2018). It included the description of 34 European SMEs. Now that a new phase of the 5G PPP is being launched, with on the one hand the objective of targeting vertical sectors, and on the other hand of looking beyond 5G, SMEs are faced with new challenges. *A revised version of the brochure considering those new challenges was released in the 7th Global 5G Event.*

Moreover, *similar information was included in the 2019 5G PPP Annual Journal*. There, the success stories of 9 SMEs were presented together with new initiatives such as the "Wireless Innovation Arena" in Sweden that aims to create favourable conditions for SMEs for 5G technologies. The SME web pages have been updated several times in 2018 to best present the expertise of SME in 5G and in vertical sectors, especially in light of the requirements from the 5G PPP Phase 3 Calls.

A dedicated SME booth was present at EuCNC 2018, attracting much attention. The **SME Working Group still holds regular teleconferences, and by the end of 2018 it**

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[53] https://www.networld2020.eu/wp-content/uploads/2019/04/sme-statistics-5g-ppp-call-ict-18-2018-v1.pdf

included about 150 members including 110+ SMEs. The SME WG is jointly supported by NetWorld2020 and the 5G IA. More than 350 SMEs are members of NetWorld 2020.

International Cooperation Activity on 5G

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 reported activities belong to the following main categories:
- MoUs with regions and associations
- (Co-)organization and participation (Europe and other regions) in selected events
- Information collection on a selection of international trials outside Europe with European stakeholders

MoUs with other regions

For the reporting period, the following MoUs have been signed. Figure 24 is a graphical representation of all MoUs signed by 5G IA with international peer organizations from the start of the 5G PPP.

- **Telecommunications Standards Development Society, India (TSDSI)** and the 5G IA signed a MoU in May 2018 to foster collaboration on Research, Standards, Regulations and Policies over the next 3 years. TSDSI and 5G IA will seek to develop and deploy mechanisms to promote 5G-related R&D initiatives based on the aligned opportunities identified by both parties.

- **ENCQOR (Canada)** and 5G IA signed a MoU in January 2019 (prepared in 2018) Large trials project announced in Canada (5G corridor put at the disposal of organizations (special focus on SMEs) to test their solutions over a 5G infrastructure. Potential topics for cooperation are:
  - ICT-17 projects and partners in Canada putting in place the corridor
  - Trials with vertical sectors (a lot of intersections with European interests: e.g., automotive in Quebec – potential cooperation with ICT-18). Cooperation with ICT-19 projects is also possible
  - SME focus: consider possible access to the Canadian corridor for European SMEs (and possibility to grant similar access for Canadian players to ICT-17)
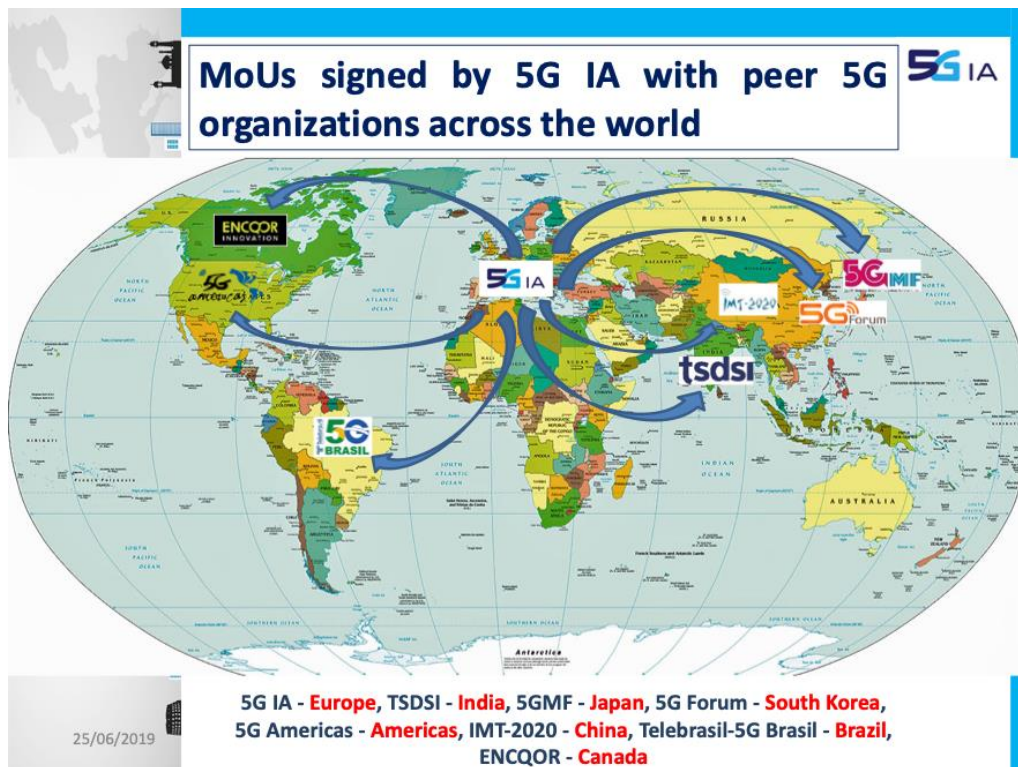
Figure 24: MoUs signed by 5G IA with international peer organizations from the start of the 5G PPP

MoUs with peer organizations

The 5G Infrastructure Association has been very active in the past twelve months with the signature of many Memorandums of Understanding (MoUs) and cooperative agreements with peer organization. These were:

- 5G IA and **ECSO** signed a MoU in December 2018 with the aim of enhancing future cooperation in the field of cyber security and 5G communication networks. ECSO and 5G IA have a shared objective of establishing a common and coordinated strategy for a secure and trustworthy 5G communication network, as its application will have an impact on many sectors, including e-health, industry 4.0, intelligent transport, entertainment & media, just to mention a few.

- 5G IA and the **Alliance for Internet of Things Innovation (AIOTI)** signed a MoU in December 2018, at the ICT-2018 conference in Vienna. This partnership will set the scene for exploring the opportunities for new combinations of IoT applications built on world-class digital infrastructures.

- The **European Space Agency (ESA)** and 5G IA signed a Letter of Intent in October 2018, to enable new and innovative 5G solutions and services in support of European industry and the 5G vertical markets and to further strengthen the ties between the space sector and the 5G IA, with its broad membership from the terrestrial and satellite industries, SMEs and Academia.

- **Public Safety Communication Europe (PSCE)**, the European public safety Association, and 5G IA, signed a Cooperation agreement in May 2018 to foster collaboration on 5G development. The objective is to make sure that 5G will bring

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the necessary developments to the security and safety communications for improving the activities of the PPDR (Public Protection and Disaster Relief) community.

- **5G Automotive Association (5GAA)** and 5G IA signed a MoU on the 17th of September 2018. Active exchanges in 3GPP-PCG initiative jointly taken and successfully implemented to organise a 5G Verticals workshop with Verticals, 3GPP, 5G-ACIA, PSCE and other Verticals Associations during the 12th and the 13th of February 2019, in Brussels. The main target was how to involve as soon as possible the Verticals in the 5G standardisation process. Final report mid-March sent to 3GPP-PCG.

(Co-)organization and participation (Europe and other regions) in selected events

1. The **EU-INDIA Workshop** organised by 5G IA, Telecommunications Standards Development Society, India (TSDSI) and Broadband India Forum (BIF) (5th and 6th of February 2018) in Delhi brought together technology experts from the EU and India geographies to share their experiences and explored areas of mutual collaboration. 5G IA, 5G PPP and EC speakers took active part, alongside high-level Indian officials and experts. *Key takeaways* included:
    a. 5G IA recommended that India may consider 5G Rural projects on similar lines as the EU-Brazil 5G-Range project for remote areas access in Brazil; therefore, it could be examined by EC the possibility to issue a similar call for project between EU and India. Collaboration between the India 5G Trials Initiatives and corresponding 5G Trials workgroup of 5G-IA (International Cooperation Stream) are being explored. 5G IA also suggested that TSDSI applies for joining the Multilateral MoU existing between Europe (5G-IA), China (IMT2020 PG), Japan (5GMF), Americas (5G Americas), Korea (5G Forum) and Brazil (5G Brazil).
    b. 5G PPP Project participation: 5G-MoNArch, IoRL, 5G-Xcast, Sat5G and NGPaaS.
    c. Possibility of conducting hackathons and Interoperability events leveraging the multi-institute 5G Test Beds programme of India.
    d. Continuous dialog among experts, sharing of experiences from trials and implementations, and alignments to ensure globally harmonized standards is crucial for 5G.
2. **The 5G vertical user Workshop, (12-13 February 2019)**
    The 5G Vertical User Workshop, an initiative of 3GPP Market Representative Partners 5GAA, 5G IA, 5G-ACIA and PSCE, was organised as a collaborative event for strategic dialogue between industries and 3GPP by exchanging on future needs and upcoming cellular standard developments. The workshop aimed at producing a report shared directly to 3GPP Project Coordination Group (PCG) to stimulate and facilitate greater involvement of the 5G Vertical Users in the 3GPP process. The workshop brought together a host of experts from 5G standardisation and several vertical industries hoping to harness 5G including Automotive, Public Safety, Industry Automation, Utilities, Broadcasting, Satellites and Railways; as well as policy makers at the EU and Member State level. A second event with more focus on practical steps to be taken by 5G

vertical industries and SDOs to improve vertical input would be of value, however the setting of this event is yet to be determined. The 5G Vertical User Workshop (Brussels – February 2019) was a collaborative event for strategic dialogue between industries and 3GPP by exchanging on future needs and up-coming standard developments. The workshop as a result, produced a report shared directly with 3GPP Project Coordination Group (PCG) to stimulate and facilitate greater involvement of the 5G Vertical Users in the 3GPP process.

3. **5th Global 5G Event** on May 16-17, 2018 in Austin (Texas, USA) under the responsibility of 5G Americas. The fifth Global 5G Event[54] took place in Austin, TX and was organised by 5G Americas on May 16-17, 2018. The 5G IA was represented by eight speakers and moderators. The 5G New Horizons Wireless Symposium discussed the status and progress of 5G.

4. **Workshop on 3GPP submission towards IMT- 2020** (Brussels - October 2018). 3GPP held a Workshop aimed at informing the ITU sanctioned Evaluation Groups, policy makers and interested experts on the progress of the 3GPP work to meet and exceed the performance requirements for IMT-2020 radio interface technologies. This event was in addition to the evaluation material being sent to the ITU, using the IMT-2020 'submission templates' detailing the service, spectrum and technical performance results achieved by 3GPP Radio Interface Technologies (RITs) or Set of Radio Interface Technologies (SRITs).

5. **6th Global 5G Event** on November 28-30, 2018 in Rio de Janeiro (Brazil) under the responsibility of 5G Brazil. The sixth Global 5G Event[55] was held in Rio de Janeiro, Brazil on November 28-30, 2018. The event was hosted by 5G Brazil. 5G IA and 5G PPP projects were present with 9 5G-IA/5G PPP speakers.

6. 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 over the 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. A highlight of the event was the keynote speech by Tomás Alonso (Orange, Spain), which demonstrated an impressive live 5G holographic videocall.

7. The **2nd 5G Vertical User Workshop** took place 9-10 July in Rome, organised by 5G-IA (via Global5G.org), co-hosted with 5GAA, 5G-ACIA and PSCE. The workshop was co-located with the 3GPP SA6 Meeting to help boost technical discussions with direct access to the on the development of specifications applicable to many verticals. Another key feature of the workshop was the gathering and discussion of common requirements across vertical industries,

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[54] http://5gnewhorizons.com/agenda-2/ and http://5gnewhorizons.com/presentations/
[55] http://5gbrasil.telebrasil.org.br/ecossistema/eventos/82-6th-global-5g-event-brasil-2018

with the aim of boosting cross-industry support and thus help accelerate time to reach consensus. The post-event reports will be published on Global5G.org[56].

Information collection on a selection of international trials outside Europe with European stakeholders

Within the *international cooperation stream of the 5G IA Trials WG*, information was gathered on international **trials outside Europe with European stakeholders**. This activity has now been absorbed by the 5G-Observatory[57] within the section on "Major international 5G trials and pilots"[58].

Countries	Date of trial	Operators	Manufacturers	Additional Stakeholders	Verticals	5G Trialed Functionalities	Frequencies	5G Demonstration category	Source
Australia	July, 2018	Telstra	Ericsson	Intel	N/A	Testing 5G capabilities	3.4 - 3.8 GHz	Demonstration	https://www.ericsson.com/en/press-releases/2018/7/ericsson-telstra-and-intel-achieve-first-end-to-end-multi-vendor-5g-commercial-network-data-call-over-licenced-3.5ghz-spectrum
Australia		Telstra	Ericsson	Intel	Automotive and Road Transport	Broadcast and Streaming Functions	N/A	Trial	https://www.ericsson.com/en/news/2018/4/telstra-5g?928769227) https://www.telstra.com.au/aboutus/media/media-releases/Telstra-offers-Australias-first-taste-of-5G
Brazil				UC3M					5G-RANGE EUB Project (http://5g-range.eu/)
Canada	N/A	Shaw Communications	Nokia	CableLabs, Rohde&Schwarz	N/A	Testing 5G capabilities	28 GHz	Trial	http://5gnewhorizons.com/wp-content/uploads/2018/05/Day-1_14.05_Panel_5G-Trials.pdf
Canada									https://www.rcrwireless.com/20180417/5g/rogers-partners-ericsson-launch-5g-trials-canada-tag23

[56] https://www.global5g.org/snapshot-2nd-vertical-user-workshop
[57] http://5gobservatory.eu
[58] http://5gobservatory.eu/5g-trial/major-international-5g-trials-and-pilots/

China	June, 2018	China Mobile	Nokia	Prisma Telecom	N/A	Testing 5G capabilities	3.4 - 3.8 GHz	Demonstration	https://www.rcrwireless.com/20180613/5g/nokia-compltes-5g-test-part-china-national-5g-trial-tag23 https://www.rcrwireless.com/20180817/5g/nokia-china-mobile-complete-5g-single-user-downlink-test
China		China Mobile, China Unicom, China Telecom	Nokia/Ericsson	Huawei, ZTE	N/A	Testing 5G capabilities	3.4 - 3.8 GHz	Trial	https://www.rcrwireless.com/20180502/5g/chinese-government-greenlights-5g-trials-major-cities-tag23
China	Aug, 2018	China Mobile	Nokia	N/A	N/A	IoT Enabler Functions	N/A	Trial	https://www.nokia.com/en_int/blog/china-mobile-verifies-cloud-ran-benefits-pave-way-5g
China	June, 2018	China Mobile	Ericsson	Intel	N/A	Testing 5G capabilities	3.4 - 3.8 GHz	Demonstration	https://www.ericsson.com/en/press-releases/2018/6/ericsson-intel-and-china-mobile-achieve-3gpp-compliant-multi-vendor-standalone-5g-nr-interoperability
China				VTT					5G-DRIVE project (https://5g-drive.eu)
India	Early 2019	DoT (govt)	Ericsson/Nokia	Cisco, Samsung	N/A	N/A	N/A	Trial	https://telecom.economictimes.indiatimes.com/news/india-rings-cisco-samsung-nokia-ericsson-for-5g-trials-bars-chinese-huawei-zte/65800938 http://www.dot.gov.in/whatsnew/making-india-5g-ready-report-5g-high-level-forum
Japan		NTT Docomo	Nokia	N/A	N/A	Broadcast and Streaming Functions	Above 80 GHz	Trial	https://www.telecomtv.com/content/5g/docomo-collaborates-with-nokia-on-5g-at-the-dizzy-heights-of-90ghz-16645/
Japan				VTT					5G-ENHANCE EUJ Project (https://www.vtt.fi/sites/5g-enhance/)

Country	Date	Operator	Vendor				Frequency	Type	Reference
Japan									ThoR EUJ Project (no webpage known, yet)
Russia	June-July, 2018	MTS	Ericsson	N/A	Media and Entertainment	Heterogeneous NW Access	15 GHz	Pilot	https://www.rcrwireless.com/20151228/carriers/5g-trials-coming-to-2018-world-cup-tag23 https://www.silicon.co.uk/networks/carriers/5g-ericsson-mts-russia-2018-182649 https://www.ericsson.com/en/press-releases/2018/6/ericsson-and-mts-to-deliver-superior-mobile-broadband-experiences-for-football-fans-at-tournament-in-russia
South Africa	January, 2018	MTN South Africa	Ericsson	N/A	N/A	Testing 5G capabilities	15 GHz	Trial	https://techcentral.co.za/mtn-launches-5g-trial-johannesburg-gets-20gbit-s/78938/
South Africa		Vodacom	Nokia	N/A	Automotive and Road Transport	Broadcast and Streaming Functions	N/A	Trial	https://www.nokia.com/en_int/news/releases/2017/11/07/nokia-and-vodacom-collaborate-to-shape-the-future-of-5g-in-south-africa https://www.rcrwireless.com/20171108/5g/nokia-vodacom-enterprise-5g-tag23
South Korea	Feb. 9 - 25, 2018	KT	Ericsson, Nokia, Samsung, Intel, Qualcomm	Hyundai	Automotive and Road Transport	Broadcast and Streaming Functions	28 GHz	Pilot	https://www.rcrwireless.com/20160629/asia-pacific/kt-confirms-5g-services-pyeongchang-winter-olympics-tag23 https://es.slideshare.net/Netmanias/netmaniaskcr-2017q2 https://www.mobileworlddlive.com/featured-content/top-three/kt-eyes-3-5ghz-for-nationwide-5g/?ID=00Qw000000nClC6EAK&utm_source=sfmc&utm_medium=email&utm_campaign=MWL_20180427
South Korea				Aalto University					PRIMO-5G EUK Project (https://primo-5g.eu)

Country	Date	Operator	Vendor	Partners	Sector	Use Case	Frequency	Type	Source
South Korea									5G ALL-STAR EUK Project (no webpage known, yet)
Taiwan	November, 2018	N/A	Ericsson, Adlink, InterDigital	ITRI, UC3M, SICS, NCTU,	Media and Entertainment	Cloud and Edge computing functions	3.4 - 3.8 GHz	PoC	http://5g-coral.eu/?page_id=156 http://5g-coral.eu/wp-content/uploads/2018/04/D1.1_final7760.pdf http://5g-coral.eu/wp-content/uploads/2018/09/D4.112820.pdf
Taiwan	Oct./Nov. 2019	Private factory network: Fair Friend Enterprise Co., LTD	Toshiba, ADLINK	Institute for Information Industry, National Taiwan University, Netherlands Organisation for Applied Scientific Research, WINGS ICT Solutions	Industry 4.0	Heterogeneous NW Access	3.4 - 3.8 GHz	Trial	CLEAR5G EU-Taiwan Project (http://clear5g.eu/)
UAE	August, 2018	Etisalat	Ericsson	N/A	N/A	Testing 5G capabilities	N/A	Trial	https://www.ericsson.com/en/news/2018/8/etisalat-and-ericsson-trial-massive-mimo-technology-in-the-uae
USA	October, 2018	AT&T, T-Mobile	Ericsson	Intel	N/A	Testing 5G capabilities	Other	Demonstration	https://www.ericsson.com/en/press-releases/2018/9/ericsson-and-industry-partners-advance-5g-commercial-readiness-in-north-america
USA	September, 2018	Verizon	Nokia	N/A	Automotive and Road Transport	Testing 5G capabilities	28 GHz	Trial	https://www.zdnet.com/article/verizon-trials-5g-in-washington-dc-with-nokia/
USA	January, 2018	T-Mobile	Nokia	Intel	N/A	Testing 5G capabilities	28 GHz	Trial	https://www.rcrwireless.com/20180104/5g/t-mobile-us-5g-28-ghz-nokia-intel-tag17

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 2019. Figure 25 provides a graphical representation of the interactions with the 5G stakeholders.
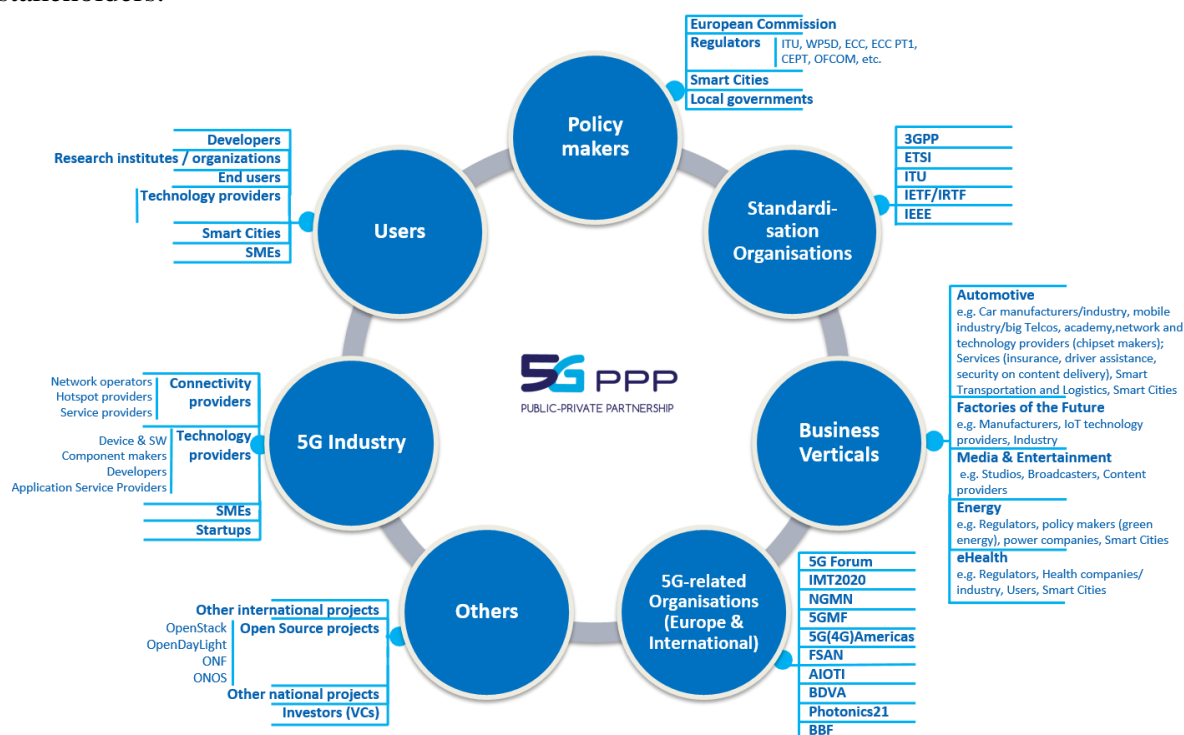
Figure 25: Interactions with 5G stakeholders (source Euro-5G: D1.1)

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 7 MoU with peer-organizations or other global regions ensuring that the European activities will have a global impact.

Annex Part 8 – 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	• **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	(see table below)			The methodology used for this assessment is described in section 3.2.1.2. Additional considerations: - The following report provides useful information: *e-Skills in Europe - Trends and Forecasts for the European ICT Professional and Digital Leadership Labour Markets (2015-2020)*. 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							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	The Phase 2 **'Key achievements'** https://5g-ppp.eu/phase-2-key-achievements/ are a good indicator of innovation. The document **"5G PPP Phase 1 and 2 Projects in the EC Innovation Radar"** hereunder provides information on 128 innovations from 5G PPP Projects. Available at: https://bscw.5g-ppp.eu/pub/bscw.cgi/312755?op=preview&b				Section 3.2.1.4 presents in more detail the significant innovations

		ack_url=312744 In the file below you can find the **"5G PPP 5G Pan-EU Trials Roadmap Version 4.0"** produced by the 5G IA Trials WG. <u>Available at</u>: <u>https://bscw.5g-ppp.eu/pub/bscw.cgi/312769?op=preview&back_url=312744</u>			

Annex Part 9 – Specific Key Performance Indicators for the 5G PPP

	KPI domain	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	Performance	P1. Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010	Please refer to the document **"5G PPP Phase II Projects Performance KPIs"** hereunder produced by the 5G Initiative Technology Board. Available at: https://bscw.5g-ppp.eu/pub/bscw.cgi/312793?op=preview&back_url=312807			The 5G Initiative Technology Board produced the enclosed document on the definition, assessment and development of '5G PPP Phase II Projects Performance KPIs'. The document includes a summary of clustered projects contributions to the Performance KPIs.
2	Performance	P2. Reducing the average service creation time cycle from 90 hours to 90 minutes				
3	Performance	P3. Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people				
4	Performance	P4. Creating a secure, reliable and dependable internet with a "zero perceived" downtime for services provision				
5	Business	B1. Leverage effect of EU research and innovation funding in terms of private	• **10,12** considering		Between 5 and 10	The methodology used for this assessment is described in Section 3.2.1.1.

		investment in R&D for 5G systems in the order of 5 to 10 times	Large Industry and SMEs • **7,24** 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 *Phase 3* calls for *infrastructure* and *automotive* were respectively *17%* and *12%.*		20%	An analysis of the impact of the 5G PPP on the SME community, including information on the reported KPI can be found in Annex 7. 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.

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	Forecasts suggest a 45,6% share by European HQ vendors for 5G RAN			As 5G services have not yet been introduced to the market it is too early to report on this business KPI. Note that the reported value has been calculated through the analysis of public reports available on the Internet and that not all companies have disclosed their total 5G contract wins. Therefore, it should be considered an indicative value. On the other hand, information was gathered on **international trials outside Europe with the participation of European companies.** The collected data capture **26** different such **trials all around the world**, giving to European companies the opportunity to strengthen their lead in the 5G race.
8	Societal	S1. Enabling advanced user -controlled privacy				This KPI is presented in Section 5.2.2.3
9	Societal	S2. Reduction of energy consumption per service up to 90% (as compared to 2010)				This KPI is presented in Section 5.2.2.3
10	Societal	S3. European availability of a competitive industrial offer for 5G systems and technologies	Please refer to the document hereunder produced by NetWorld2020 and 5G IA **"Economic consideratio ns on Smart**			Forecasts suggest a 45,6% share by European HQ vendors for 5G RAN and a 29,45% for granted 5G patents at a global level and a 25,32% for 5G declared standard essential patents in the automotive industry. Apart from the advances achieved in the telecommunication area by the 5G-PPP projects, Phase 2 and Phase 3 projects have placed significant focus on vertical industries. Their results are expected to strengthen the European stakeholders and

			Networks as key enabler of the Human Centric Internet and the digital transformation research in FP9". Available at: https://bscw.5g-ppp.eu/pub/bscw.cgi/312828?op=preview&back_url=312817			boost their market share. Moreover, the next activities in the context of the Phase 3.II calls will ensure the continuity of the activities and their further progress.
11	Societal	S4. Stimulation of new economically-viable services of high societal value like U-HDTV and M2M applications	Please refer to the document hereunder **"5G Phase 3 – Media Pilots"** by NEM 5G joint Working Group with NetWorld2020 ETP. Available at: https://bscw.5g-ppp.eu/pub/b			For this KPI please refer to section 3.2.2.3

			scw.cgi/3128 45?op=previ ew&back_url =312817			
12	Societal	S5. Establishment and availability of 5G skills development curricula (in partnership with the EIT)				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 10 – 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	The document hereunder **"5G IP Landscape Analysis",** prepared by 5G IA Member Thales in July 2018, aims at determining early trends for 5G mobile network underlying technologies and may represent a contribution to the definition of IP KPIs for the 5G PPP. <u>Available at</u>: <u>https://bscw.5g-ppp.eu/pub/bscw.cgi/312873?op=preview&back_url=312862</u> The Excel file hereunder presents a synthesis of a **'patent search'** made on the European Patent Office's Espacenet <u>https://worldwide.espacenet.com/</u> <u>Available at</u>: <u>https://bscw.5g-ppp.eu/pub/bscw.cgi/d312</u>	Number of patent applications. Number of patents awarded				An analysis of the data in public reports indicates that a **21,31% of globally declared 5G patent families** are from Europe based HQ companies. Looking at the global numbers of the **granted patents this number raises up to 29,45%.** Moreover, in **the 5G declared SEP families (Standard Essential Patents) in the automotive industry, 25,32%** are from Europe based HQ companies. Finally, as for the **number of 5G standards contributions related to a vehicular application,**

					41,15% are from Europe based HQ companies. 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.
		891/Patent%20Search%20on%20the%20European%20Patent%20Office%27s%20Espacenet.xlsx				
2	Standardisation activities (project level) Contributions to new standards (PPP level)	The document **"Standardisation activities: Contributions to new Standards (PPP Level)"** hereunder provides an overview of the main activities, successes and challenges related to pre-standardization activities. Available at: https://bscw.5g-ppp.eu/pub/bscw.cgi/312918?op=preview&back_url=312903	Number of activities leading to standardisation Number of working items in European Standardisation Bodies. Number of pre-normative research files – prEN - under consultation in ESBs	**611 activities leading to standardization (Phase 1: 315; Phase 2: 296)** Input **contributions to over 20 groups** within standards organisations and industry alliances		

3							
	Operational performance	Time-to-grant ICT-07-2017: • Call closure date: 08 November 2016 • Start of large majority of the projects: 1 June 2017 – More details available at: https://5g-ppp.eu/5g-ppp-phase-2-projects/ Time-to-grant ICT-08-2017: • Call closure date: 08 November 2016 • Start of large majority of the projects: 1 June 2017 – More details available at: https://5g-ppp.eu/5g-ppp-phase-2-projects/ Time-to grant ICT-17-2018: • Call closure date: 31 January 2018 • 5G PPP Projects 5G EVE, 5G-VINNI, 5Genesis started in July 2018 and run for 3 years – More details available at: https://5g-ppp.eu/5g-ppp-phase-3-projects/					

		Time-to grant ICT-18-2018: • Call closure date: 17 April 2018 • 5G PPP Projects 5GCroCo, 5G CARMEN, 5GMOBIX started in November 2018 and run for different durations – More details available at: https://5g-ppp.eu/5g-ppp-phase-3-projects/					
5	**H2020 - LEIT** - Number of joint public-private publications	The document hereunder contains available information collected from the public sites of all Phase 2 and Phase 3 projects. Available at: https://bscw.5g-ppp.eu/pub/bscw.cgi/d312939/5G%20PPP%20Phase%202%20and%20Phase%203%20Projects%20Publications.xlsx	Properly flagged publications data (DOI) from LEIT funded projects	756 publications from Phase 2 projects and 54 publications from active Phase 3 projects			DOI information was not available on the web sites for all publications.