

5G PPP PROGRESS MONITORING REPORT – 2021

This document has been prepared by the 6G Smart Networks and Services Industry Association (6G-IA) and it reflects the views only of its authors

Brussels August 2022

Table of contents

1. INTRODUCTION	4
2. MAIN ACTIVITIES AND ACHIEVEMENTS	4
2.1 IMPLEMENTATION OF THE CALLS FOR PROPOSALS EVALUATED DURING THE REPORTING PERIOD	6
2.2 MOBILIZATION OF STAKEHOLDERS, OUTREACH, SUCCESS STORIES	8
2.3 GOVERNANCE	9
3. MONITORING OF THE OVERALL PROGRESS SINCE THE LAUNCH OF THE 5G PPP	10
3.1 ACHIEVEMENT OF THE GOALS OF THE CPPP	10
3.2 PROGRESS ACHIEVED ON KPIS.....	11
3.2.1 <i>Common set of KPis</i>	11
3.2.2 <i>Specific KPis for 5G PPP</i>	16
3.3 EVOLUTION OVER THE YEARS.....	24
4. OUTLOOK AND LESSONS LEARNT	25
ANNEX PART 1 - THE 5G INFRASTRUCTURE PUBLIC-PRIVATE-PARTNERSHIP	27
ANNEX PART 2 - THE 6G SMART NETWORKS AND SERVICES INDUSTRY ASSOCIATION (6G-IA)	29
ANNEX PART 3 – 5G PPP PROJECTS	31
ANNEX 4 - 5G PPP WORKING GROUPS AND THEIR ACTIVITIES.....	36
ARCHITECTURE WG	36
SOFTWARE NETWORKS WG	37
TEST, MEASUREMENT AND KPIS VALIDATION WG.....	38
ANNEX 5- 5G INITIATIVE: BOARDS' ACTIVITIES AND ACHIEVEMENTS.....	40
ANNEX 6 - 6G-IA ACTIVITIES AND ACHIEVEMENTS.....	41
VERTICALS ENGAGEMENT TASK FORCE.....	41
5G VISION AND SOCIETAL CHALLENGES WG.....	44
PRE-STANDARDIZATION WG.....	45
5G AUTOMOTIVE WG.....	47
TRIALS WG	48
SECURITY WG.....	50
OPEN SMART NETWORKS AND SERVICES WG	51
SME COMMUNITY.....	53
INTERNATIONAL COOPERATION ACTIVITY ON 5G.....	56
ACTIVITY COMMUNITY BUILDING AND PUBLIC RELATIONS	57
SMART CONNECTIVITY DIGITAL INNOVATION HUB NETWORK	57
THE TRANSCONTINUUM INITIATIVE	58
WORK ON THE SMART NETWORKS AND SERVICES	60
ANNEX PART 7 – COMMON PRIORITY KEY PERFORMANCE INDICATORS ERROR! BOOKMARK NOT DEFINED.	
ANNEX PART 8 – SPECIFIC KEY PERFORMANCE INDICATORS FOR THE 5G PPP	65
ANNEX PART 9 – CONTRIBUTION TO PROGRAMME-LEVEL KPI'S.....	67

List of Figures

Figure 1: 5G PPP Phases	5
Figure 2: Active 5G PPP Projects	7
Figure 3: Verticals clustering	8
Figure 4: 5G PPP Governance	10
Figure 5: Broadcasting & Media by Experiment Type.....	22
Figure 6: Broadcasting and Media. Target ITU Functionalities	23
Figure 7: 5G PPP Projects - Heritage Figure	25
Figure 8: 5G IA membership versus type of stakeholders.....	29
Figure 9: 6G-IA members as of May 2022	30
Figure 10: 5G PPP Key Achievements v 3.1	31
Figure 11: 5G PPP Key results v3.1 – projects & technological areas.....	32
Figure 12: NetworldEurope ETP SRIA	33
Figure 13: Mapping 5G PPP activities in the SRIA pillars	34
Figure 14: Views of Verticals cartography	35
Figure 15: White Papers released by the Architecture WG	36
Figure 16: 5G Vertical Users Webinar Series.....	43
Figure 17: 5G PPP Inputs to Standards Organisations	47
Figure 18: “Find the SME you need” web page: SMEs by technological expertise	54
Figure 19: “Find the SME you need” web page: SMEs by vertical sector.....	54
Figure 20: Statistics re. the NetworldEurope web page visits – January to December 2021 ..	55
Figure 21: The “European SME Expertise in 5G and Beyond” brochure views in 2021.....	55
Figure 22: The Transcontinuum wheel	59
Figure 23: SNS Strategic objectives	60
Figure 24: SNS updated roadmap	61
Figure 25: A high level view of SNS JU indicative R&I topics.....	62

List of Tables

Table 1: Overview of data on new job/skills collected through the 2020 Questionnaire	13
Table 2: Overview of the data collected on SME impact through the 2020 Questionnaire	14
Table 3: Overview of data on new 5G curricula and/or educational qualifications through the 2020 Questionnaire	24
Table 4: SCoDIHNet services.....	58

1. Introduction

This document reports the progress achieved by the 5G Public-Private Partnership (5G PPP) during 2021. 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 6G Smart Networks and Services Industry Association (6G-IA), i.e., Verticals Engagement Task Force, 6G-IA working groups and specific activities. Detailed information can be found in Annexes 3 through 6.

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

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

Please note, that some of the reported information relates to data collected through specific Questionnaires. As for this report it was agreed with the EC not to perform a new questionnaire process, the current report contains some information taken from the 2020 questionnaire.

2. Main activities and achievements

5G became commercially available during 2019, ahead of schedule. Commercial services are already available in many cities throughout Europe. Deployments are on-going throughout Europe with thousands of 5G base stations becoming operational in many European cities. The 5G rollout in Europe is progressing and is comparable to most of the other global regions¹. Moreover, in Europe a 64% population coverage has been achieved by the end of 2021 in EU27².

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

Also, an analysis of the data in the latest publicly available reports such as IPlytics³ (June 2022), indicates that **European headquarter companies share a 15,59% of active and granted 5G US or EP granted patent families**. As the report indicates “However, not all self-declared patents are essential and valid, also SEPs vary by value – with some covering core technologies of the standard and others only claiming inventions on minor improvements to

¹ <https://5gobservatory.eu/observatory-overview/international-5g-scoreboard/>

² <https://5gobservatory.eu/observatory-overview/eu-scoreboard/>

³ IPlytics, Who is leading the 5G Patent race?, A patent landscape analysis on declared SEPs and standards contributions, June 2022 <https://www.iplytics.com/>

the standard”. Therefore, the same report also examines the **number of approved technical 5G contributions of European companies**. Their share is **37.04%** and brings European companies in the first place. **Moreover, publicly available results suggests that the EU HQ companies combined share the majority of 5G commercial deals⁴, where as other reports suggest that the European HW companies holder 30% of the Telecom equipment market⁵.**

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

The last two Phases of 5G PPP have managed to cover around 10 vertical industries. This is an important achievement because one of the main aims of 5G is the digitization of the so call “verticals”.

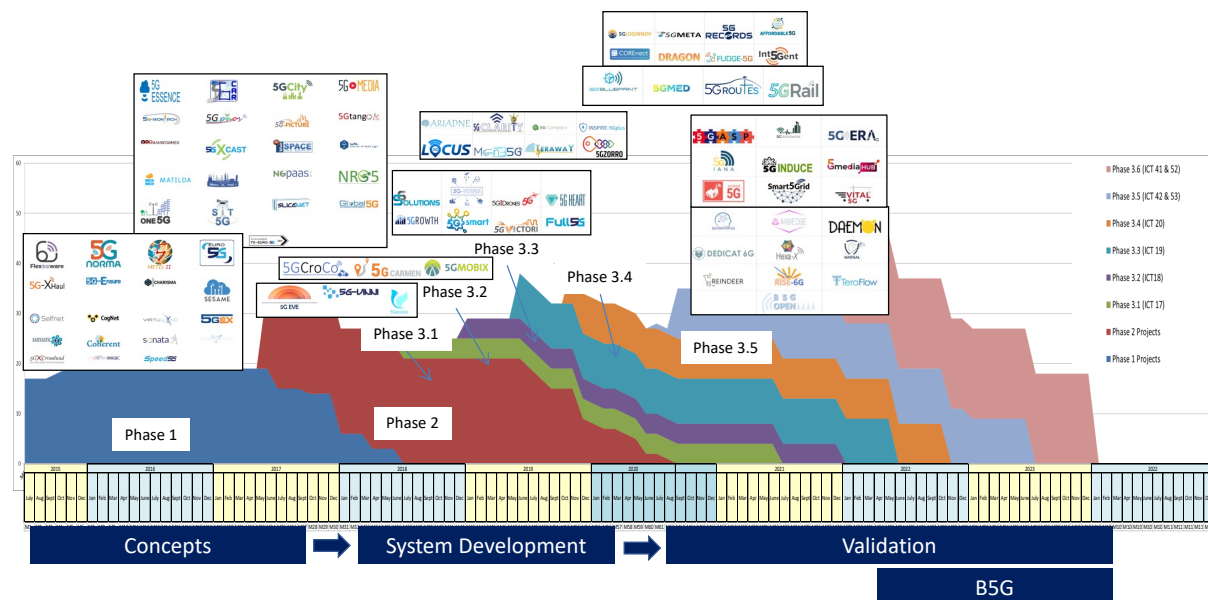


Figure 1: 5G PPP Phases

The importance of EU funded projects to build a world-wide consensus in a pre-standardization level, the visionary specification of futuristic use cases and the raising of public awareness about the capabilities of 5G networks is undeniable. **The 5G Infrastructure PPP Initiative and 5G IA achieved significant progress and impact during 2021.** The next subsections provide more detailed information.

⁴ <https://www.spglobal.com/marketintelligence/en/news-insights/research/5g-tracker-79-markets-worldwide-have-commercial-services>

⁵ <https://www.delloro.com/key-takeaways-2021-total-telecom-equipment-market/>

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

In 2021, there was no new call for projects in the 5G PPP Initiative as the Programme has already entered its final phase and all remaining calls were successfully completed in 2020 as follows:

- ICT-42 topic (IA and CSA) “5G core technologies innovation” (opening date 09-July 2019) has received all proposals until 16-01-2020. 8 projects were selected
- ICT-53 topic (IA) “5G for Connected and Automated Mobility” (opening date 09-July 2019) has received all proposals until 13-11-2019. 4 projects were selected
- ICT-41 topic (IA) “5G innovations for verticals with third party services” (opening date 19-November 2019) has received all proposals until 17-06-2020. 9 projects were selected
- ICT-52 topic (RIA) “Smart Connectivity beyond 5G” (opening date 19-November 2019) has received all proposals until 17-06-2020. 9 projects were selected

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

Since Phase 1, **92 projects** in total have been contractually active in the 5G PPP Programme, ensuring an **outstanding momentum and dynamism**. The Programme has managed to mobilise during its lifetime 166 unique beneficiaries in Phase 1, adding 144 new beneficiaries in Phase 2, and another 384 new beneficiaries in phase 3. By the completion of Phase 3.6 there were **700 organisations who are parties to the 5G PPP collaboration agreement**.

Also, note that **Phase 1 projects have produced 57 key achievements⁶, where Phase 2 key achievements⁷ include 60 highlighted results** categorised under 14 program level achievements whereas the **latest counting of Key Achievements v3.1⁸**, including an updated list of key achievements from Phase 2 projects and key achievements from Phase 3 projects, **amounted to more than 100 innovations under 20 program level achievements** (Annex 3).

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

⁶ <https://5g-ppp.eu/phase-1-key-achievements/#1507204993795-3eec9c4c-5911>

⁷ <https://5g-ppp.eu/phase-2-key-achievements/>

⁸ <https://5g-ppp.eu/key-achievements-v3-1/>



Figure 2: Active 5G PPP Projects

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. During 2021, the 5G PPP Initiative has released another **seven white papers** disseminating key findings⁹. The complete 5G PPP program so far has produced **more than 40 white papers**.

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 6G-IA, and with the strong support of the CSAs projects. On the 10th of April 2018, the European Commission launched the Innovation Radar: a data-driven online tool which provides easy access to innovations supported by EU funding and the innovators behind them. **By searching “5G” on the Innovation Radar 445 innovations were found recorded from 310 innovators.**

⁹ <https://5g-ppp.eu/white-papers/>

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

2.2 Mobilization of stakeholders, outreach, success stories

As mentioned in the previous section, more than **700 organisations** have been identified who are parties to the **5G PPP collaboration agreement**. This clearly demonstrates a successful mobilization of the European stakeholders that are involved in various forms with 5G technologies. Moreover, this demonstrates an open initiative where competition is open for all.

During 2021, several technical workshops, information days and research and innovation events took place to harmonize the activities of projects and promote their results. Some of the workshops were organized in the context of the 5G PPP Initiative. In other events, the funded projects had a strong presence. A detailed list of events is available at the 5G PPP web site¹⁰, where **more than 80 events are recorded for 2021**.

During 2021, the **Verticals Cartography of the Phase 3 projects** was updated (**Annex 3**). This cartography provided detailed information about the scope and the activities of the Phase 3 projects in relation to vertical industries (Figure 3). Also, they provide information about their planned activities. 222 use cases were analysed across all Phase 3 projects. A high number of trials and pilots was identified compared with phase 2. The top verticals were: Automotive (incl. cross-border), industry (manufacturing), transport (maritime, rail) with increased number of use cases for energy, health and public safety. Also, synergies were established with the ScoDIHNet initiative (Annex 6).

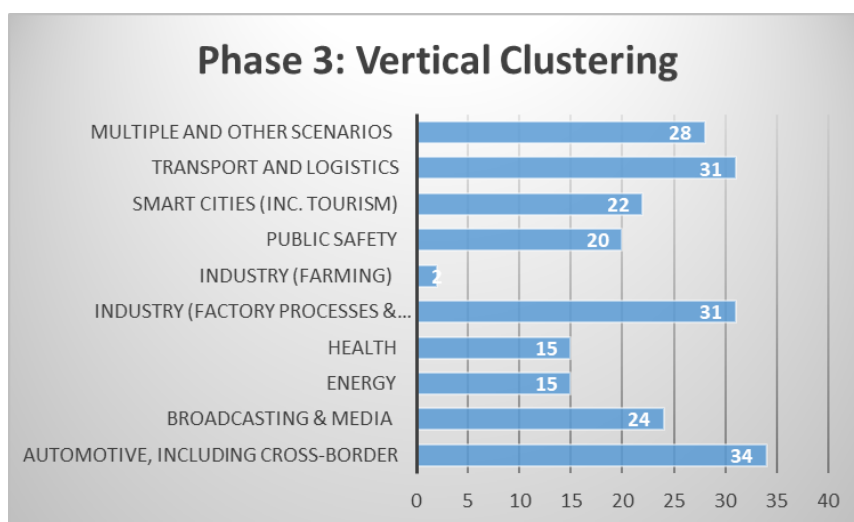


Figure 3: Verticals clustering

In relation to the SME engagement the 5G PPP initiative has successfully met the Programme KPI of 20% SME participation by reaching a 21,95% SME participation in

¹⁰ https://5g-ppp.eu/event-calendar/list/?tribe_paged=1&tribe_event_display=list&tribe-bar-date=2021-01-01

funding. This represents 156.3 M€ EC funding for SMEs in the initiative overall. SMEs have contributed to 24.5% of the total participation in 5G PPP projects. 65% SMEs participated in one project, 35% in two or more projects. Their level of participation in RIAs and IAs was the same.

In 5G PPP Phase 3 projects 167 different SMEs participated for a total EC funding of about 100 M€. **49% SME participation was reached in the ICT-41 call**, which was calling for “5G innovations for verticals with 3rd party services” and was recommending “50% of SMEs [...] targeted for this action”.

These results were reached through:

- The EC “positive discrimination” towards SMEs,
 - with 20% KPI
 - 50% SME participation requested in the ICT-41 call
- The activities of the NetworkEurope SME Working Group
- The interaction between 5G IA, AIOTI, and the Smart Connectivity DIH Network

In terms of international collaboration 6G-IA has been very active building up international cooperation for 5G networks (Annex 6). Currently, **15 MoUs** and **4 LoIs** with major 5G organizations from around the globe have been signed. 5G PPP activities and 6G-IA activities led to a significant number of participations in European and global events (i.e., more than 80 during 2021). The **8th Global 5G Event** took place in electronic form (due to the covid pandemic) on 14th and 15th of October.

2.3 Governance

In the context of 5G PPP, the 6G Smart Networks and Services Industry Association (6G-IA) (formerly known as the 5G Infrastructure Association - 5G IA) represents the private side, and the European Commission, the public side. The 6G-IA is “*The voice of the European Industry and Research for Next Generation Networks and Services*”. To this aim, the 6G-IA brings together a global industry community of telecoms & digital actors, such as operators, manufacturers, research institutes, universities, verticals, and SMEs. *Figure 4*, presents the overall governance of the 5G PPP.

During the reporting period, the 5G for Connected and Automated Mobility WG shifted from the 5G Initiative under the umbrella of the 6G-IA to work more closely on issues related to the SNS and the CEF Programme. Moreover, new WG entitled Open Smart Networks and Services has been created to promote and support the evaluation, adoption, deployment, and evolution of open solutions for 5G and beyond 5G/6G networks.

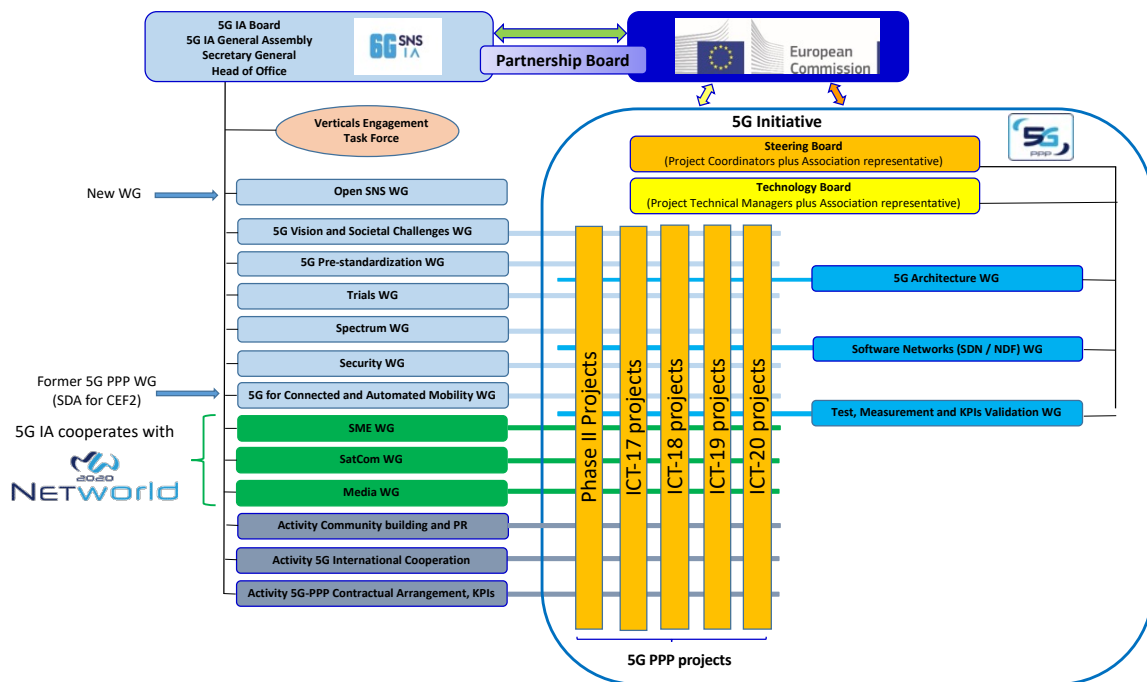


Figure 4: 5G PPP Governance

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

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

3.1 Achievement of the goals of the cPPP

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

- **An efficient and effective 5G PPP Programme:** The *5G PPP Programme* has been *operating smoothly* having now contracts for 92 projects over all 5G PPP phases (|Section 2.1 and Annex 3). Phase 3 projects proceed at full speed.
- **Optimum profile for the European 5G initiative in a global context:** As described in detail in Annex 6, the 5G IA has in place 15 MoUs and 4 LoI with international peer Associations, Verticals' Associations, SDOs etc.
- **Widespread dissemination of European achievements:** During the past period, the *5G PPP Initiative* was actively engaged in organizing and disseminating results the European achievements through *more than 50 events*¹¹. In several important events 5G PPP had the possibility to present its achievements, raise awareness on opportunities offered by 5G and have exchanges with major EU and international organizations. Additionally, 6G-IA organized or participated in more than 30 global events, promoting the European results.
- **Significant technical input to the standardization bodies:** 5G PPP is an active contributor to 5G standardization globally. Twenty-two projects (all Phase 3, except

¹¹ <https://5g-ppp.eu/event-calendar/>

SliceNet) have contributed to two rounds of inputs in Q4-2020 and Q2-2021. **In this activity over 230 contributions to Standards Developing Organisations have been tracked.** (c.f., Annex 9)

- **Impact through scientific publications:** Moreover, data collected from the public sites of the funded projects, show that they have provided a significant impact on the scientific community. **Phase 3 projects have produced 1249 publications so far** (40% of which was published in scientific journals) (c.f., Annex 9).
- **Measurable Programme progress and KPIs:** In section 3 follows an analytical discussion about the measurable progress through a set of KPIs. More details are included also in the annexes. Summarizing some of the key findings, the analysis of the data has shown *a leverage factor of 13,58 times the public EC investment for large industry and SMEs*. The SME participation in 5G PPP projects has been increasing in 2020 to reach and even exceed the original objective of 20% (i.e., **21,95%**) participation defined as a KPI of the programme. Finally, specific 5G cPPP KPIs (performance, business and societal) are also addressed in the following section. It is worth noting that during 2021 important steps forward have been taken for the mapping of vertical KPIs to network KPIs as well as monitoring and analysing the 5G network KPIs achieved in practice through different 5G PPP projects. Moreover, work was undertaken to identify beyond 5G/6G KPIs and target values from ICT-52 projects as well as a basic testing guide for 5G KPIs verification. Related to the latter contributions to ETSI were also provided by 5G PPP projects and the TMV WG.
- **Maintaining the holistic view of implementing 5G by 2020 and planning for Horizon Europe:** The governance model of 5G PPP allowed to achieve the expected results. As planned, the *Programme has successfully shifted from research activities to large trials and eventually the market*. Moreover, the EU ICT community working closely together with the EC has successfully contributed to the launch of the Smart Networks and Services for the Horizon Europe Joint Undertaking and the first call for proposals.

3.2 Progress achieved on KPIs

In the following subsections common and specific sets of KPIs are presented. More detailed information on their progress is available in the annexes. Note, that some of the reported information relates to data collected through specific Questionnaires. As for this report it was not required to perform a new Questionnaire process, the current report contains information presented in the PMR 2020 for reasons of completeness.

3.2.1 Common set of KPIs

3.2.1.1 Mobilize private investments

As performed for 2018's PMR these calculations took place with the use of dedicated Questionnaires and collection of publicly available information. The calculation of this KPI is based on the data extracted from the 2020 Questionnaire¹², 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

¹² <https://5g-ppp.eu/5g-ppp-progress-monitoring-report-data-collection-2020/>

the EC in the proposed “Single leverage factor methodology”. A.1 was extracted from the statistics publicly available at the H2020 Qlik Sense dashboard¹³.

The following specific parameters were considered

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

The following data processing methodology was applied:

- The average values of A2.1, A2.2, B1.1, B2.1 were calculated, per legal entity type (Large Industry, SME, Academic Institution, Research Centre)
 - B2.1 is given for the period 2014-2020, so its quota for 2020 was calculated by dividing the value by 7
- On the H2020 Qlik Sense dashboard, the following information has been extracted, per legal entity type, for the following for the following Phase 3 Call Topics: ICT-17-2018, ICT-18-2018, ICT-19-2019, ICT-20-2019-2020, ICT-42-2020, ICT-53-2020, ICT-41-2020, ICT-52-2020:
 - # of beneficiaries,
 - Total cost and
 - Total Net EU contribution
 - The Total cost and Total Net EU contribution has been projected on 2020 only (assuming an average project duration of 36 months) and considering that the grants for ICT-17-2018 and ICT-18-2018 were signed in 2018, the grants for ICT-20-2019-2020 and ICT-42-2020 were signed in 2019, and the grants for ICT-42-2020, ICT-53-2020, ICT-41-2020, ICT-52-2020 in the late part of 2020.
- Then, the following calculations have been performed, for each legal entity type:
 - The average values of A2.2, B1.1 and B2.1 (2020) have been multiplied by the total number of beneficiaries
 - The average Overhead (A2.1) has been applied to the Total Direct costs (= Total cost / 125%), and the difference with the flat OH 25% has been calculated
 - Finally, A.1 has been calculated as the difference between the Total Net EU contribution for 2020 and the Total costs for 2020
- The sum of total A.1, A2.1, A2.2, B1.1, B2.1 provides, for each legal entity type, the additional investment in 2020 w.r.t. the Total Net EU contribution received during the year.
- The total across a subset of legal entity types provides the overall additional investment in 2020 for that subset of beneficiaries and leads to the related Leverage Factor during the year. Two (sub)sets have been considered:
 - Large Industry and SMEs; i.e. the business-oriented (and by far largest) part of private investments.
 - All kinds of beneficiaries.

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

¹³ <https://webgate.ec.europa.eu/dashboard/sense/app/93297a69-09fd-4ef5-889f-b83c4e21d33e/sheet/PbZJnb/state/analysis>

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

3.2.1.2 New skills and/or job profiles

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

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

The following procedure was applied to calculate this KPI:

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

The result of this exercise is summarized in Table 1, which clearly shows a significant impact in terms of new job/skill profiles.

Table 1: Overview of data on new job/skills collected through the 2020 Questionnaire

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

Note here that these numbers have been collected from the stakeholders directly involved in the 5G PPP Initiative and serve as an indication of what is to be expected in following years. 5G deployment will allow several sectors (e.g., industry verticals) to offer a huge variety of new services, solutions, and products, which, in turn, will require the creation of many new job profiles to fully exploit the potential of 5G.

3.2.1.3 Impact on SMEs

An SME's business performance can depend on many factors, and not only on the participation in a given R&D Programme. It is up to the individual SME to quantify how the participation in 5G PPP projects had an influence on parameters like turnover, job profiles and staff

headcount variations, etc. In most cases, they should manage to provide this information, with some degree of precision.

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

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

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

The following procedure was applied to calculate this KPI:

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

Table 2 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.

Table 2: Overview of the data collected on SME impact through the 2020 Questionnaire

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

Note also that 5G PPP activities have created a stable playground for EU SMEs to be active and results. As reported in Annex 6, The number of members SME Working Group has increased by 17% during the year 2020, reaching 200 members, out of which 170 are SMEs. Moreover, the SME participation in 5G PPP projects has been increasing in 2020 to reach and even exceed the original objective of 20% participation defined as a KPI of the programme¹⁴. According to the H2020 dashboard¹⁵, **the participation of SMEs in the 5G PPP has reached 21.95% of EU funding**, representing a total of 156.3 M€

¹⁴ All 5G PPP calls have been included, now that the latest 5G PPP calls have been completed.

¹⁵ <https://webgate.ec.europa.eu/dashboard/>

3.2.1.4 Significant innovations

The 5G PPP projects have produced several significant technological innovations. As described in Annex 3, during the reporting period the Key achievements v3.1¹⁶.

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

In terms of standardization activities, 5G PPP is an active contributor to 5G standardization globally. Overall, the 5G-IA Pre-Standardization WG has tracked **237 inputs** based on specific and tangible inputs (e.g. technical reports, study/work item, PoC, new commercial requirements) as opposed to broader inputs collected in previous years. Most inputs have been submitted to 3GPP (96), IETF (50) and ETSI (38), with a growing number of inputs to IEEE, and inputs to sector associations working groups for like 5GAA. Moreover, 5G PPP projects through the TMV WG provided contributions in ETSI INT in TR about recommendation on Application Testing and Validation Frameworks (ETSI TR 103 761). The purpose of this technical report is to provide recommendations on methodologies for end-to-end testing and validation of vertical applications over 5G and beyond networks. Such recommendations can be equally applicable to a wide range of industry verticals, application cases and beyond 5G scenarios. The final document was published in ETSI¹⁷.

The 5G PPP projects have disseminated their results in several scientific journals, international conferences, book chapters and white papers (Annex 9). **Phase 3 projects have produced 1249 publications so far** (40% of which was published in scientific journals).

Also, an analysis of the data in the latest publicly available reports such as IPlytics¹⁸ (June 2022), indicates that **European headquarter companies share a 15,59% of active and granted 5G US or EP granted patent families**. As the report indicates “However, not all self-declared patents are essential and valid, also SEPs vary by value – with some covering core technologies of the standard and others only claiming inventions on minor improvements to the standard”. Therefore, the same report also examines the **number of approved technical 5G contributions of European companies**. Their share is **37.04%** and brings European companies in the first place.

White papers produced by the 5G PPP WGs

Since the creation of the 5G PPP and the 6G-IA WGs more than 40 white papers¹⁹ have been produced overall until the end of 2021. Seven of these white papers have been produced during 2021. These are:

- AI and ML enablers for Beyond 5G Networks (May 2021)

¹⁶ <https://5g-ppp.eu/key-achievements-v3-1/>

¹⁷ https://www.etsi.org/deliver/etsi_tr/103700_103799/103761/01.01.01_60/tr_103761v010101p.pdf

¹⁸ IPlytics, Who is leading the 5G Patent race?, A patent landscape analysis on declared SEPs and standards contributions, June 2022 <https://www.iplytics.com/>

¹⁹ <https://5g-ppp.eu/white-papers/>

- Service Performance measurement methods over 5G experimental networks (May 2021)
- Understanding the number – Contextualization and Impact Factors of 5G Performance Results (July 2021)
- 5G Ecosystems (September 2021)
- Delivery of 5G Services Indoor – the wireless/wire challenge and solutions (September 2021)
- 5G PPP – View on Architecture V4.0 (November 2021)

3.2.2 Specific KPIs for 5G PPP

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

3.2.2.1 Performance KPIs

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

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

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

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

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

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

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

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

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

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

In 2021 the TMV WG has produced the following two white papers.

Whitepaper on vertical KPIs

This white paper analyses vertical use cases of various domains for their performance KPIs and their mapping to 5G network KPIs. The scope is to identify (based on architectural elements analysis, information flow, etc.) the potential impact on the service performance and user perceived quality. The challenge is to understand the relative influence of 5G network performance indicators to the vertical services. The KPIs mapping methodology includes three steps:

- Research on definitions and information derived from the respective 5G PPP projects, standardisation bodies and respective alliances e.g. ITU, NGMN etc., as well as definition of use cases from 5G PPP projects' respective.
- Identification of relevant key service KPIs and their definitions that are of importance to the respective industry.
- Mapping of selected services KPIs on the respective network KPIs that impact the operation of the architectural elements that participate in the service provision process.

The white paper is available from the 5G PPP website as a full version²⁰ or as a short version²¹.

Whitepaper on 5G performance results

In the 5G PPP project a large number of 5G performance results are collected. The first questions that emerge from the experts and non-experts (verticals) and tried to be answered using the outcome are the following: a) are the results close to the 5G theoretical values and

²⁰ <https://zenodo.org/record/4748385>

²¹ <https://zenodo.org/record/4748482>

the KPI targets promised by the 5G domain? b) can we identify some factors that practically affects the results, while others not? c) does the results fulfill the application requirements or better does the results satisfy the expectations of the verticals?

In this whitepaper, the goal was to give answers to the first and second questions, while the third question can be answered when the results from the ICT-19 projects will become available (as a next version of the current document and in cooperation with the vertical KPI Task Force).

Therefore, in the current white paper the effort is focused on trying to clarify the details behind the performance numbers and provide a series of interpretation guidelines that could help the reader better understanding the 5G domain. In addition, based on the analysis of performance results, the main impact factors that affect the results are identified, while a high-level explanation is provided that is clearly understandable by non-experts. The motivation is to create a first bridge between the telecommunications and verticals domains and reach a common understanding in explaining what they can really expect from 5G. The white paper is available from the 5G PPP website²² or directly on zenodo²³.

Moreover, during the reporting period the TMV WG actively worked on the preparation of a white paper entitled “Beyond 5G/6G KPIs and Target Values” that was released in June 2022. The main objective of this document is to present the current view of the available B5G and 6G KPIs from 5G PPP phase III projects with a focus on projects of the ICT-52 call. This view includes mapping to KPIs previously defined for 5G and evaluating how they might evolve to fit the B5G and 6G visions. We are presently at the start of the 6G research era, where visionaries and researchers are interplaying to define a vision for 6G. To ensure the direction of innovations towards realizing 6G it is critical that KPIs are defined at an early stage to help steer the process. The KPIs are either evolved from previous generation KPIs or are new and being defined in coordination with definition of new features and use cases. It is at this stage that this white paper makes its contribution, in collecting KPIs from active research projects based on work on new features and use cases. The paper consists of two main technical parts. The first part gives an overview of standard network KPIs with defined target values for 5G system. These are well known KPIs that will be evolved to 6G by changing target values. The second part presents KPIs collected from ICT-52 research projects aimed at B5G and 6G system. These KPIs are processed in terms of being grouped according to KPI type or context, and they are presented with references to standards and target values where possible and available. The white paper is intended to be updated and re-published every year to track the B5G and 6G KPIs evolutions. The evolutions will occur as projects, use cases and functionalities mature. KPI definitions from new B5G and 6G projects from projects participating in the 6G SNS R&I Work Programme will be taken into account when available (2023). Future version of this report will also integrate more information on KPIs target values and definition of methodology for how to measure them.

Whitepaper on Basic Testing Guide

During 2021 the TMV worked on a white paper entitled Basic Testing Guide: A starter Kit for 5G KPIs Verification published on January 2022²⁴. This Basic Testing Guide document is a practical guide describing the starter kit developed in the context of the 5G PPP Test, Measurement and KPI Validation work group. The guide enables the interested developer to understand how this can be applied to measure and verify basic 5G KPIs. The document starts

²² <https://5g-ppp.eu/wp-content/uploads/2021/08/TMV-Results-Explanation-White-Paper-V1.0.pdf>

²³ <https://doi.org/10.5281/zenodo.5094973>

²⁴ https://5g-ppp.eu/wp-content/uploads/2022/01/TMV-Basic-Testing-rev005-17112021_clean.pdf

from describing the idea intention to measure up to the actual realization of the test. To enable the test, a description of the environment, how to install it, the test tools and the methodology is provided. It goes from idea to run the actual test, step by step. The proposed framework with the support of the described android agents can in principle support the validation of application level KPIs running at the android UEs, while for other application-specific KPIs running at other systems, the development of specialized plugins is necessary.

Finally, the TMV WG provided contributions in ETSI INT in TR about recommendation on Application Testing and Validation Frameworks (ETSI TR 103 761). The purpose of this technical report is to provide recommendations on methodologies for end-to-end testing and validation of vertical applications over 5G and beyond networks. Such recommendations can be equally applicable to a wide range of industry verticals, application cases and beyond 5G scenarios. The final document was published in ETSI²⁵.

3.2.2.2 Business KPIs

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

B1. Leverage effect of EU research and innovation funding in terms of private investment in R&D for 5G systems in the order of 5 to 10 times

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

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

These numbers surpass the expected KPI values.

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

The SME participation in 5G PPP projects was increased and in 2020 (last calls for the 5G PPP Initiative) they reached and even exceeded the original objective of 20% participation defined as a KPI of the programme²⁶. According to the H2020 dashboard²⁷, **the participation of SMEs in the 5G PPP has reached 21.95% of EU funding**, representing a total of €156.3 M.

B3. Reach a global market share for 5G equipment & services delivered by European headquartered ICT companies at, or above, the reported 2011 level of 43% global market share in communication infrastructure

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

²⁵ https://www.etsi.org/deliver/etsi_tr/103700_103799/103761/01.01.01_60/tr_103761v010101p.pdf

²⁶ All 5G PPP calls have been included, now that the latest 5G PPP calls have been completed.

²⁷ <https://webgate.ec.europa.eu/dashboard/>

Ericsson itself has announced 170 commercial 5G agreements or contracts with unique operators²⁸. NOKIA itself has reported 228 commercial 5G deals as well as 75 live 5G operator networks²⁹.

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

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

3.2.2.3 Societal KPIs

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

S1. Enabling advanced user-controlled privacy

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

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

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

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

Also, an analysis of the data in the latest publicly available reports such as IPlytics³¹ (June 2022), indicates that **European headquarter companies share a 15,59% of active and granted 5G US or EP granted patent families**. As the report indicates “However, not all self-declared patents are essential and valid, also SEPs vary by value – with some covering core technologies of the standard and others only claiming inventions on minor improvements to the standard”. Therefore, the same report also examines the **number of approved technical 5G contributions of European companies**. Their share is **37.04%** and brings European companies in the first place. **Moreover, an analysis of publicly available results suggests that the EU HQ companies combined share the majority of 5G commercial deals³². Moreover, publicly available results suggests that the EU HQ companies combined share the majority of 5G commercial deals³³, where as other reports suggest that the European HW companies holder 30% of the Telecom equipment market³⁴.**

²⁸ <https://www.ericsson.com/en/5g/contracts>

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

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

³¹ IPlytics, Who is leading the 5G Patent race?, A patent landscape analysis on declared SEPs and standards contributions, June 2022 <https://www.iplytics.com/>

³² <https://www.spglobal.com/marketintelligence/en/news-insights/research/5g-tracker-79-markets-worldwide-have-commercial-services>

³³ <https://www.spglobal.com/marketintelligence/en/news-insights/research/5g-tracker-79-markets-worldwide-have-commercial-services>

³⁴ <https://www.delloro.com/key-takeaways-2021-total-telecom-equipment-market/>

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

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

Although 5G networks have been operational in several countries their full rollout has not taken place yet. Also, the uptake of 5G devices by consumers has still to pick up pace. Thus, it is still not clear which new services with high societal value will emerge. Note that the economic viability of such services requires some careful analysis and design. Under the context of the Vision and Societal Challenges WG the “Business Validation, Modelling and Ecosystem SG” (BVME SG). During 2021 the WG has issued a white paper entitled “5G ecosystems offering some useful insight.

As reported by the Full5G project during the reporting period there were 28 use cases on broadcasting and media, 4 of which also cover smart city contexts, e.g., for tourism, up from 18 in 2020. These come from ICT-17 (5G-EVE, 5GENESIS, 5G-VINNI); ICT-19 (5G!DRONES, 5G-SOLUTIONS, 5G-TOURS, 5G-VICTORI); ICT-41 (5GMediaHub); ICT-42 (FUDGE5G, 5GRECORDS).

- **5G!DRONES** : 1 use case. A demonstration on Connectivity during crowded events targeting eMBB and URLLC in Greece in Q2-2021.
- **5G-EVE**: 1 use case. The Pilot is on UHF Media, On-site Live Event Experience and Immersive and Integrated Media targeting eMBB and with testing in Q3-2020 and Q2-2021 in Madrid.
- **5GENESIS**: 2 use cases. A demonstration, called the Festival of Lights, targeting eMBB, URLLC in Q3-2020 in Berlin. A trial at a large-scale public event targeting eMBB, mMTC in Athens in Q2-2020 (small-scale) and Q4-2020 (full-scale).
- **5GMediaHub**: 3 use cases. These focus on Immersive Augmented, Virtual and Extended Reality applications; Smart Media Production and Smart Media Content Distribution.
- **5GRECORDS**: 3 use cases. Live audio production. Multiple Camera Wireless Studio. Live Immersive Content Production.
- **5G-SOLUTIONS**: 5 use cases, 4 of which have customised slicing. A trial on Ultra High-Fidelity Media in Q4-2020, Q2-2021 and Q2-2022. A trial on an Onsite Live Event Experience in Q2-2021 and Q2-2022. A trial on User and Machine Generated Content in Q3-2020, Q2-2021 and Q2-2022. A trial on Immersive and Integrated Media and Gaming in Q3-2020, Q2-2021 and Q2-2022. A trial on Cooperative Media Production in Q4-2020, Q2-2021 and Q2-2022. All trials take place in Patras, Greece.
- **5G-TOURS**: 2 use cases. These focus on High Quality Video Service Distribution and on Remote and Distributed Video Production, both taking place in Turin in 2022.
- **5G-VICTORI**: 1 use case. A pilot on CDN Services in Dense Static and Mobile Environments, targeting eMBB in Berlin and Patras in Q3-2021 with earlier testing affected by COVID-19.
- **5G-VINNI**: 5 use cases, 3 of which also cover other verticals. A trial on Media Production and Distribution targeting eMBB and URLLC, taking place in Oslo in Q3-

2020. A trial on QoS Management for Media Broadcast in Martlesham, UK in Q1-2020.

- **FUDGE5G**: 1 use case. This focuses on Concurrent Mail Delivery.

Multiple Verticals: Broadcasting and Media; Smart Cities

- **5GMediaHub**: 1 use case on Smart Media Content Distribution in smart cities.
- **5G-VINNI**: 3 use cases. A pilot with 5G-SOLUTIONS on 360° Immersive Experience in smart city contexts for tourism, targeting eMBB and taking place in Patras in Q3-2020 and Q2-2022. Another trial on 360° Immersive Experience taking place in Martlesham (UK) and Leganés (Spain) targeting eMBB, URLLC in Q1-2020, Q2-2021, again for tourism in smart cities. A location-independent trial on Efficient Edge Content Delivery via Satellite Multicast/Broadcast in targeting eMBB, URLLC in Q2-2021.

Figure 5 shows the distribution by experiment type.

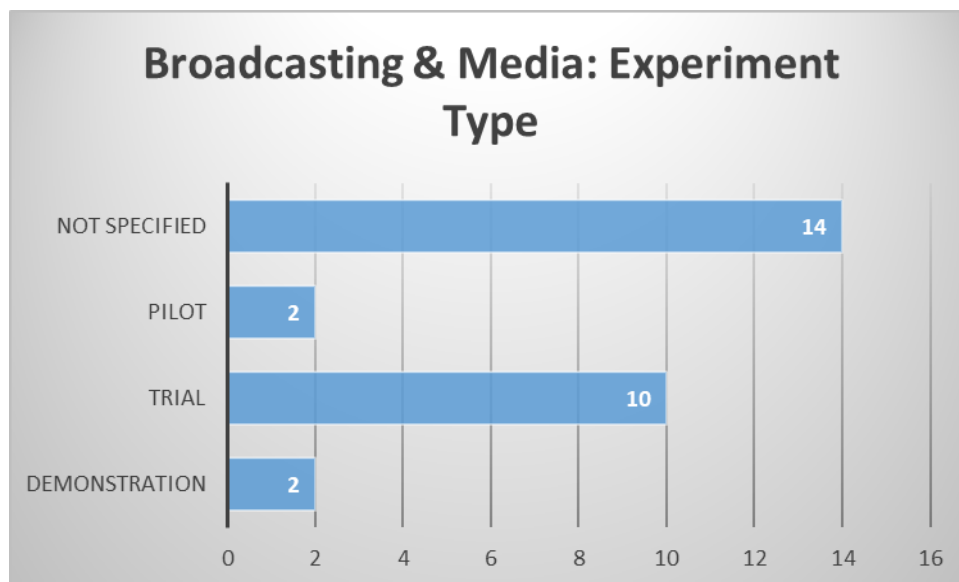


Figure 5: Broadcasting & Media by Experiment Type

Figure 6 shows the target 5G functionalities for broadcasting and media, noting that several projects have yet to report on their targets and/or indicate relevance for their experiments.

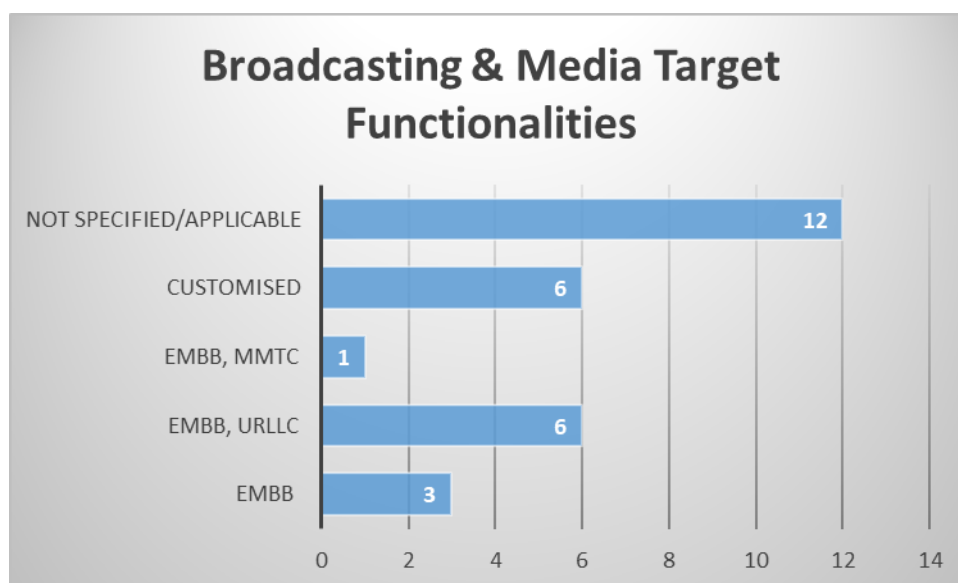


Figure 6: Broadcasting and Media. Target ITU Functionalities

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

Data for new curricula/qualifications created were collected through a questionnaire³⁵ from 5G PPP project beneficiaries. These are defined as progressive values, referring to the period 2014-2020. A finer scale (e.g., per year) is very difficult to implement, since the creation of new curricula/qualifications can be hardly calculated on a per-year basis and attributed to specific periods.

The following procedure was applied to calculate this KPI:

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

The result of this activity is summarized in Table 3. **Again, the current achievements and trends are looking very promising.**

³⁵ <https://5g-ppp.eu/5g-ppp-progress-monitoring-report-data-collection-2019/>

Table 3: Overview of data on new 5G curricula and/or educational qualifications through the 2020 Questionnaire

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

3.3 Evolution over the years

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

During 2021 the last 30 5G PPP projects were active and are working to build on the momentum of the previous phases and produce results that will not only safeguard EU's position for 5G networks but also provide the initial pillars for 6G networks.

Note that the 5G PPP Programme has successfully managed to capitalize the results produced by past phases and use them in latest projects as shown in Figure 7. The heritage figure is expected to be further updated in 2022.

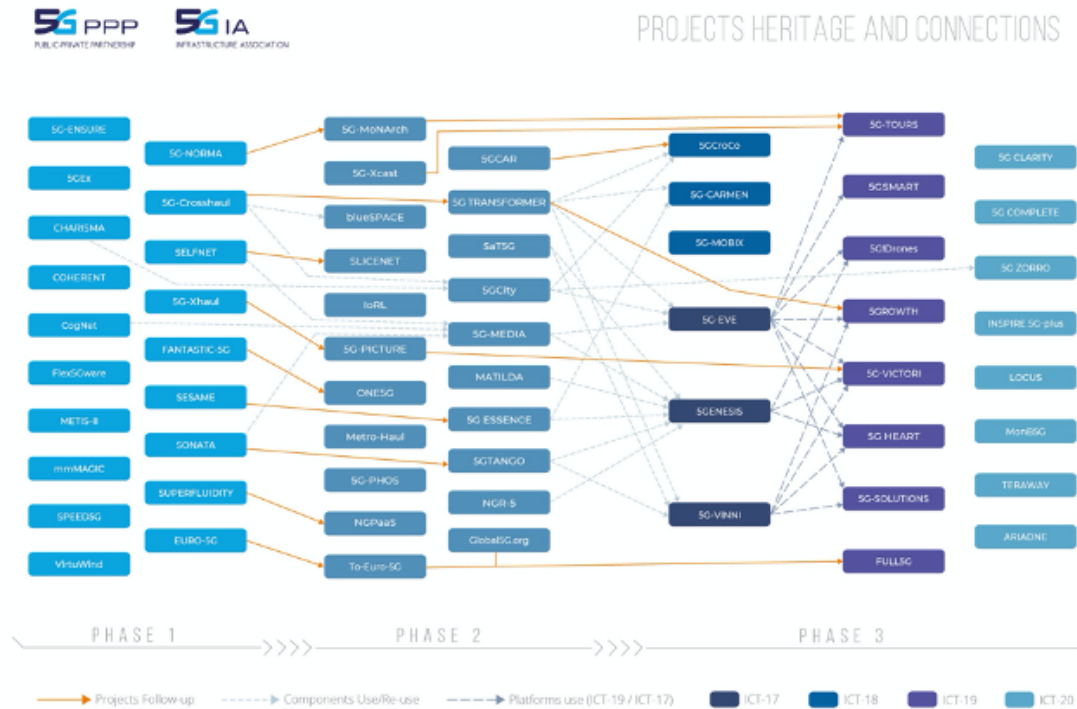


Figure 7: 5G PPP Projects - Heritage Figure

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

4. Outlook and lessons learnt

The 5G PPP Programme has continued to provide valuable results during 2021. The quantification of the success has been recorded in this PMR with data and information on Programme KPIs.

The 5G PPP global impact achievements already include:

- A major impact on 5G standards with continuous efforts with contributions to SDOs
- Beyond standards, proving the 5G system is working for more than 10 verticals' categories in multiple test/experiment sites
- Phase 3 projects have produced 1249 publications so far (40% of which was published in scientific journals).
- Successful pan-European mobilization in the activities with more than 700 parties to the 5G PPP collaboration agreement.
- Successful engagement of all types of organizations where notably 21,95% of the stakeholders were SMEs
- 15 MoUs and 4 LoI signed between 5G IA and peer industry associations around the globe and industry organizations in priority vertical sectors

5G PPP has already:

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

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

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

The above-mentioned achievements have been realized through the hard work by many people. The 5G PPP is running smoothly under the current governance scheme. As 5G PPP has entered its final stage, the number of recorded achievements, the input to standardization organizations, the number of scientific publications, the significant number of trials are all proofs of the success of the Programme. The coordinated scientific work in the context of the working groups and the task forces is ensuring the dissemination of 5G PPP results at a global level. The organization of meaningful trials all over Europe is assisting European companies to test in real life scenarios the 5G technology. Also, the European ICT community, through the close collaboration between the 6G-IA and the EC has managed to plan and successfully launch the follow up Programme, as Joint Undertaking. This certifies the strategic role of the ICT sector for Europe where is now in a unique position to create a live ecosystem that will bring together multinational industries, SMEs, research Centres, universities, and vertical industries.

Annex 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 website³⁶.

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

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

³⁶ www.5GPPP.eu

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

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

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

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

Annex 2 - The 6G Smart Networks and Services Industry Association (6G-IA)

During 2021 76 organizations were active full or associated 6G-IA members. Additionally, 6G-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 8 shows the composition of the members.

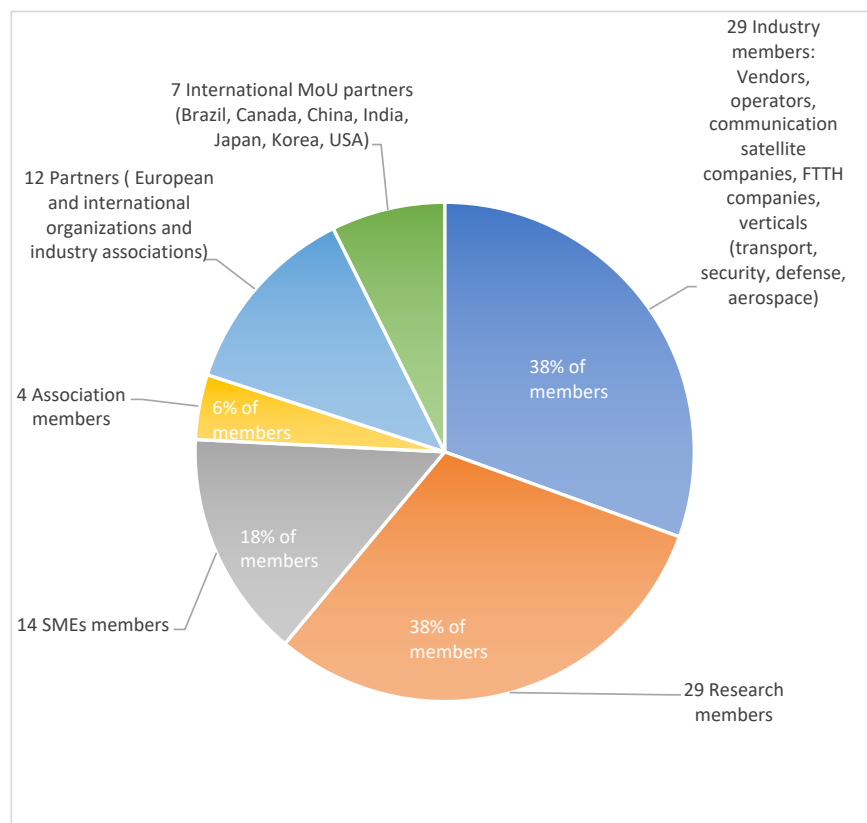


Figure 8: 5G IA membership versus type of stakeholders

The 6G-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 6G-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, 6G-IA is working to mobilise the community and in particular the SMEs in the European collaborative research projects.

During 2021 a significant effort was placed in the preparation of the Smart Networks and Services Joint Undertaking. Based on these efforts in 2022, the 6G-IA has witnessed a significant rise in the number of its members as it is illustrated in Figure 9.

203 Full members & 44 Associated members – May 2022

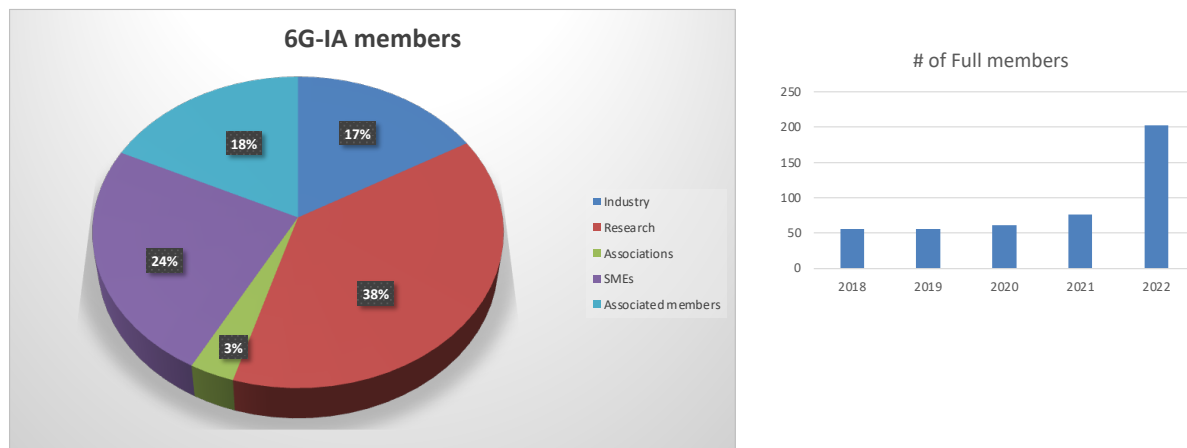


Figure 9: 6G-IA members as of May 2022

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

Moreover, under the responsibility of 5G IA lie several WGs (c.f. Figure 4). These are: a) Open Smart Networks and Services WG, b) the Pre-standardization WG, b) the Spectrum WG (the operation of this WG were on pause during 2021 as not many 5G PPP projects are currently active in spectrum issues), c) the Vision and Societal Challenges WG, d) the Security WG, e) the Trials WG and f) 5G for Connected and Automated Mobility WG

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

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

Annex 3 – 5G PPP Projects

The 5G Infrastructure PPP Programme and its related projects continued their impressive work during 2021, providing key results and significant achievements for 5G networks and their evolution.



Figure 10: 5G PPP Key Achievements v 3.1

Following up on the previous years a compiled list of key achievements (version 3.1³⁷) was produced on February 2021. As shown in Figure 10 the achievements were grouped in 9 technical areas, one for business standardization and regulation and 10 vertical sectors. In total, more than 100 achievements have been reported that have been grouped in 11 different categories. As this version was based on version 3.0, key achievements from phase II projects (all of them completed by the end of 2020) have been kept in list but marked in red in Figure 11 so to provide a better understanding of the areas Phase 3 is currently covering.

³⁷ <https://5g-ppp.eu/key-achievements-v3-1/>

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

Figure 11: 5G PPP Key results v3.1 – projects & technological areas

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

Thus, as shown in Figure 11, most of the reported achievements are related to a number of trials related to 10 different vertical sectors. Also, many projects have further continued their work in the 5G architecture and in network management and orchestration of the services. These extensions are needed to further support their trials. For a detailed presentation of Phase 2 and Phase 3 5G PPP projects' activities the reader can refer to the European 5G Annual Journal of 2021³⁸.

Moreover, several 5G PPP projects have been working on technological areas that are closely related to B5G/6G technologies. The list of technological areas was compiled and presented in the NetWorldEurope SRIA on September 2020³⁹. In Figure 12 7 main pillars and a plethora of

³⁸ <https://bscw.5g-ppp.eu/pub/bscw.cgi/d424095/5G%20European%20Annual%20Journal%202021.pdf>

³⁹ <https://bscw.5g-ppp.eu/pub/bscw.cgi/d367342/Networld2020%20SRIA%202020%20Final%20Version%202.2%20.pdf>

concrete technological areas are illustrated.

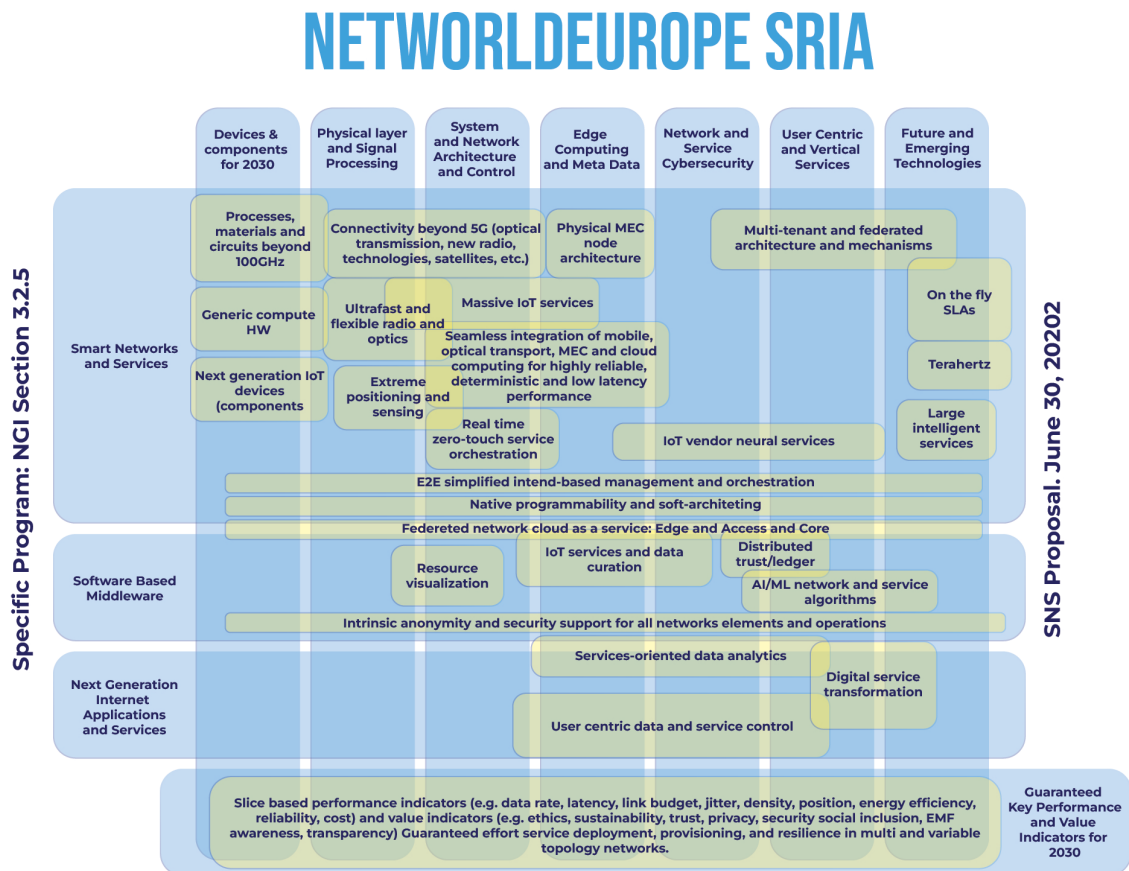


Figure 12: NetworkEurope ETP SRIA

As shown in Figure 13, 27 projects have reported on being active in these seven B5G/6G pillars. Most projects are dealing to an extend to system and network architecture and control, where also multiple projects are active in Network and service cybersecurity, future and emerging technologies, Edge computing and meta-data and user-centric and vertical services. Also, some projects are working on devices and components for 2030 and in physical and signal processing.

The most engaged topics are: connectivity beyond 5G, Real-time zero-touch service orchestration, AI/ML networks and services algorithms, end-to-end simplified intend-based management and orchestration and seamless integration of mobile optical transport MEC and cloud computing.

5GPPP ACTIVITIES TO THE SRIA



Figure 13: Mapping 5G PPP activities in the SRIA pillars

Moreover, 5G PPP Infrastructure, Trials, and Pilots Brochure (N° 3) was prepared, based on the outcomes of the annual competition launched by the 5G IA Trials WG, with the evaluation committee selecting the top ten trials and pilots. The brochure was published in October 2021⁴⁰.

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

Impacts are measured in terms of views of each entry and overall viewing trends over time. Figure 14 below shows the views of the verticals' cartography.

⁴⁰ https://5g-ppp.eu/wp-content/uploads/2021/10/5GInfraPPP_10TPs_Brochure2021_v1.0.pdf,

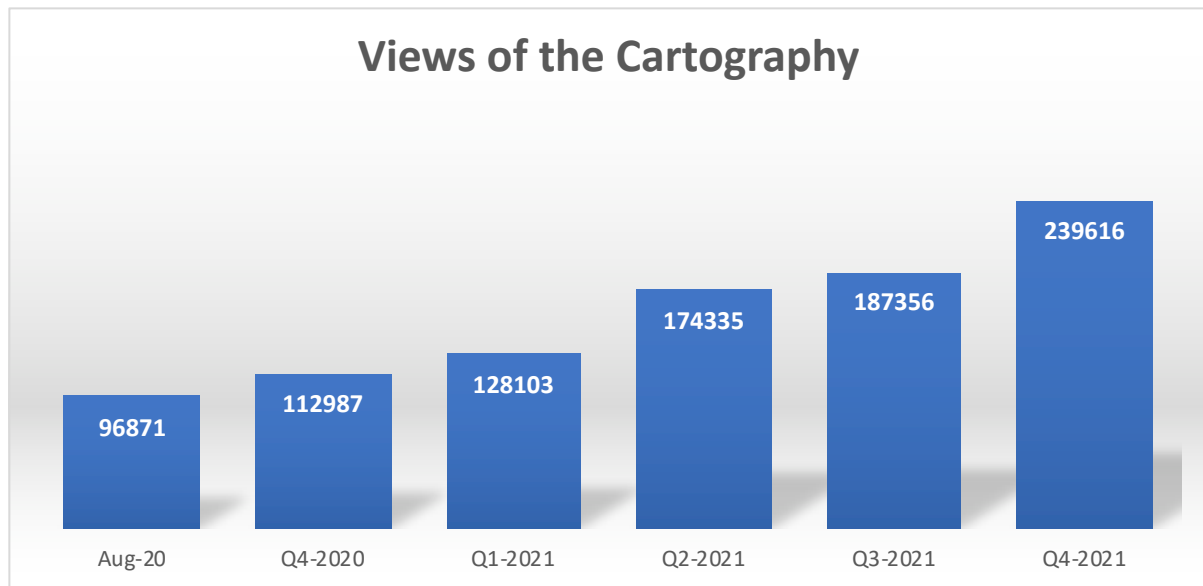


Figure 14: Views of Verticals cartography

Finally, as recorded in the 5G PPP site⁴¹, during 2021 the 5G PPP community has organized or participated in more than 50 events.

⁴¹ <https://5g-ppp.eu/event-calendar/>

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 papers⁴². The first white paper was produced in October 2015. Below follows a description for the activities of each WG and their achievements during the reporting period.

Architecture WG

The overall goal of the Architecture Working Group (WG) within the 5GPPP Initiative is to consolidate the main technology enablers and the bleeding-edge design trends in the context of the 5G Architecture. As a result, it provides a consolidated view of the architectural efforts developed in the projects part of the 5G PPP initiative and other research efforts, including standardization. This effort serves not only to review the current state of the art, but also to identify promising trends towards the next generation of mobile and wireless communication networks, namely, B5G/6G.

Architecture WG brings 5GPPP projects together to attain the European View on the Overall Architecture of Mobile and Wireless Communications Networks and the Network Domains, which is then published in the form of white papers and presented during the technical workshops in the international conferences and webinars. As illustrated in Figure 15, the latest white paper from the WG is the fourth release, of which beginning dates back to July 2016. Since then, this effort continuously captured the technology trends as developed by the different phases of 5GPPP projects: the first phase (Phase I), that lied the foundation of the network slicing-aware operation we are seeing these days; the second one (Phase II) which provided the first proof of concepts; and the third one (Phase III) that has targeted the first large scale platforms. All these efforts were captured in the subsequent releases of the white paper (version 2 in January 2018 and version 3 in February 2020).



Figure 15: White Papers released by the Architecture WG

The latest Version 4.0 of the white paper⁴³, released in October 2021, has thus focused on the output of the 5GPPP Phase III projects, thus, discussing the latest findings in terms of the integration of large infrastructure and vertical industries, also known as verticals, the long-term evolution of the 5G technologies and the service-specific features. The view consolidated in the fourth version of the white paper presents the current overview on the 5G Architecture as developed by European research efforts. The white paper v4.0 has highlighted the key architectural innovation points and findings from the 5G PPP projects that will bridge the evolution of the 5G architecture toward the future 6G mobile and wireless networks.

The work in the fourth version of the white paper has mainly focussed on the 5G PPP Phase III projects (ICT-17-2018, ICT-18-2018, ICT-19-2019, ICT-41-2020, ICT-42-2020, ICT-53-2020, ICT-20-2019, ICT-52-2020 Calls⁴⁴). After the finalization of the white paper v4.0, as

⁴² <https://5g-ppp.eu/white-papers/>

⁴³ Ömer Bulakci, Marco Gramaglia (overall editors), et al., “View on 5G Architecture,” Oct. 2021. Available at: <https://5g-ppp.eu/wp-content/uploads/2021/11/Architecture-WP-V4.0-final.pdf>

⁴⁴ 5GPPP Phase 3 Projects, <https://5g-ppp.eu/5g-ppp-phase-3-projects/>

part of further dissemination, the Architecture WG has arranged a two-part online event⁴⁵. In the first part, hosted by 5GPPP, the white paper has been presented by the chapter editors along with the keynotes from ICT52 projects as well as a joint panel. The second part is hosted by IEEE 5G WF as a regular workshop that comprised the key notes and the technical papers submitted to the workshop⁴⁶.

After the publication of the white paper v4.0, the WG has continued the work toward the next version of the white paper with a particular focus on B5G/6G, i.e., main content emerging from ICT-52-2020 call. An international workshop at Globecom 2022, titled “2nd Workshop on Architectural Evolution toward 6G Networks – 6GARCH”⁴⁷ has already been accepted, where the next version of the white paper will be presented along with keynotes, technical paper presentations as well as a joint panel.

Software Networks WG

After the completion of the Cloud Native transformation phase with the publication of four white papers, the Working Group worked on setting up the new Term of Reference having in mind the network evolution toward 6G. For that, it has been agreed to focus on the period 2021-2023 on the platform approach, service exposure and identification the key technological challenges to transform the network to a more open model.

A first work has been started earlier in 2021 on the analysis of the different APIs deployed in the different projects. The idea was to run analysis on the nature of the APIs, their format, their programming language etc., to see in what sense can we harmonize the Telco APIs.

For that, a set of internal technical workshops have been organized by the different projects from ICT52, ICT41, ICT53, ICT42 and ICT19 to share their views.

At that time, the Technical Board has also initiated a work on the Network Applications. After the concertation with the TB chair, it has been decided that the Software Network WG take the lead and work on a white paper demystifying the network application concept.

The WG worked during in that direction and a first draft will be published in June 2022.

Key Activities and Achievements

- Bi-weekly call during it the different involved projects share their technical findings and collaborate on the joint white papers.
- The WG chair and the participants believe that the WG should be the place where we can learn and exchange between the projects to build and enforce the collaboration. For that, technical workshop has been organized focusing on new technologies/topics, new industry trend, etc. For example, one can cite the serverless and its utility in IoT domain, service exposure etc.
- Discussion of Workplan for Y2020/2023 (targeted contributions/material, workshops). Different topics have been identified.

⁴⁵ Two-part Architecture WG Event, Part 1, 5GPPP Webinar on White Paper v4.0, “Introduction to the 5G PPP Architecture,” Oct. 2021, <https://5g-ppp.eu/event/16811/>

⁴⁶ Two-part Architecture WG Event, Part 2, IEEE 5G WF Workshop, “Architectural Evolution toward 6G Networks: A European View,” Oct. 2021 <https://5g-ppp.eu/Architectural-Evolution-toward-6G-Networks/>

⁴⁷ Globecom 2022 Workshop, “2nd Workshop on Architectural Evolution toward 6G Networks – 6GARCH,” Dec. 2022, <https://globecom2022.ieee-globecom.org/workshop/ws21-2nd-workshop-architectural-evolution-toward-6g-networks-6garch>

- Propose a new Workplan adopted by the SB in April 2021.
- Continuous participation in 5G PPP Steering Board (SB) and Technical Board (TB) meetings: working towards whitepapers of concerns and providing WG updates.
- Continue to cross-fertilise with other WGs of interest e.g., Architecture WG, and others.
- Leadership of the NetApp and API landscape white paper. This work has been merged with the initiative of the TB to assess the lessons learnt from phase 3 project to onboard the verticals. The WG becomes the focal point for this activity at 5G PPP level.
- Organize a Special Session in EUCNC 2022. It is planned on WED 08-06-2022 from 16:00-17:30, Room A305. <https://www.eucnc.eu/programme/special-sessions/special-session-10/> . The following projects are involved :
 - 5GIANA, 5GASP, 5G-INDUCE, 5G-SOLUTIONS, EVOLVED-5G, 5G-EPICENTRE, 5G-ERA, Smart5Grid, VITAL-5G, 5G-MediaHub.
- Workshop submitted to IEEE MEDITCOM 2022 (<https://meditcom2022.ieee-meditcom.org/>) has been **accepted**. The following projects are involved:
 - 5GIANA, 5GINDUCE, 5GASP, EVOLVED-5G, VITAL-5G, Smart5Grid, 5G-INDUCE, 5GMediaHub, 5GERA, 5G-EPICENTRE, 5G-SOLUTIONS, TERAFLW.
- Preparation of Special Issue for IEEE IoT magazine: [Call for Special Issue Proposals | IEEE Communications Society \(comsoc.org\)](#). The list of the Guest Editors are:
 - Bessem Sayadi, Nokia Bell Labs, France
 - Chia-Yu Chang, Nokia Bell Labs, Antwerp, Belgium
 - Christos Tranoris, University of Patras, Patras, Greece
 - Qi Wang, University of the West of Scotland, Paisley, UK
 - Abhimanyu Gosain, Northeastern University, Boston, MA, USA
 - Akihiro Nakao, The University of Tokyo, Tokyo, Japan
 - Yue Wang, Samsung R&D Institute, Staines-upon-Thames, UK

Test, Measurement and KPIs Validation WG

The Test, Measurement, and KPIs Validation (TMV) Working Group was founded as part of the 5G PPP effort to promote commonalities across projects that have strong interest in the T&M 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.

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

- Testing KPI definition, KPI sources, collection procedures and analysis
- Testing frameworks (requirements, environment, scenarios, expectations, limitation) and tools
- Testing methodologies and procedures
- KPI validation methodologies
- Testing lifecycle (i.e. testing execution, monitoring, evaluation and reporting)

- Common information models for 5G T&M

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

Key Activities and Achievements

During 2021, TMV WG: a) organized 19 conference calls to discuss the WG current activities, progress and identify next steps; b) organized one webinar for presenting and disseminating its outcomes; c) published two whitepapers on the topics of 5G performance results and vertical KPIs; d) provided contributions to ETSI INT in TR about recommendation on Application Testing and Validation Frameworks (ETSI TR 103 761).

Whitepaper on vertical KPIs

This white paper analyses vertical use cases of various domains for their performance KPIs and their mapping to 5G network KPIs. The scope is to identify (based on architectural elements analysis, information flow, etc.) the potential impact on the service performance and user perceived quality. The challenge is to understand the relative influence of 5G network performance indicators to the vertical services. The KPIs mapping methodology includes three steps:

- Research on definitions and information derived from the respective 5G PPP projects, standardisation bodies and respective alliances e.g. ITU, NGMN etc., as well as definition of use cases from 5G PPP projects' respective.
- Identification of relevant key service KPIs and their definitions that are of importance to the respective industry.
- Mapping of selected services KPIs on the respective network KPIs that impact the operation of the architectural elements that participate in the service provision process.

The white paper is available from the 5G PPP website as a full version⁴⁸ or as a short version⁴⁹.

Whitepaper on 5G performance results

In the 5G PPP project a large number of 5G performance results are collected. The first questions that emerge from the experts and non-experts (verticals) and tried to be answered using the outcome are the following: a) are the results close to the 5G theoretical values and the KPI targets promised by the 5G domain? b) can we identify some factors that practically affects the results, while others not? c) does the results fulfill the application requirements or better does the results satisfy the expectations of the verticals?

In this whitepaper, we tried to give answers to the first and second questions, while the third question can be answered when the results from the ICT-19 projects will become available (as a next version of the current document and in cooperation with the vertical KPI Task Force).

Therefore, in the current white paper the effort is focused on trying to clarify the details behind the performance numbers and provide a series of interpretation guidelines that could help the reader better understanding the 5G domain. In addition, based on the analysis of performance results, the main impact factors that affect the results are identified, while a high-level explanation is provided that is clearly understandable by non-experts. The motivation is to create a first bridge between the telecommunications and verticals domains and reach a common understanding in explaining what they can really expect from 5G.

⁴⁸ <https://zenodo.org/record/4748385>

⁴⁹ <https://zenodo.org/record/4748482>

The white paper is available from the 5G PPP website⁵⁰ or directly on zenodo⁵¹.

Contribution to ETSI INT

TMV WG provided contributions in ETSI INT in TR about recommendation on Application Testing and Validation Frameworks (ETSI TR 103 761). The purpose of this technical report is to provide recommendations on methodologies for end-to-end testing and validation of vertical applications over 5G and beyond networks. Such recommendations can be equally applicable to a wide range of industry verticals, application cases and beyond 5G scenarios. The final document was published in ETSI⁵².

Webinar

TMV WG organized a webinar on “Practical insights from 5G Test, Measurement and KPI Validation with vertical applications” in 18 June 2021 09:00 – 13:00.

This webinar presented the results of the work group, which are two-fold. The first session focused on the presentation and contextualization of the performance results obtained so far, as well as identifying the impact factors that influence the performance. The second session focused on the mapping of verticals service and application KPIs onto network performance KPIs, as well as exemplifying this mapping for several vertical sectors.

The webinar content can be found here⁵³.

Future plans

The TMV WG is planning to publish two whitepapers during 2022 to report the progress and findings of TMV WG

- A whitepaper to present a basic Testing Guide - A Starter Kit for Basic 5G KPIs Verification. This will be a practical guide describing the starter kit developed in the context of the 5G PPP TMV WG which enables the interested developer to understand how the tools can be applied and use in order to measure and verify basic 5G KPIs.
- A whitepaper on the definition and measurement of B5G/6G networks KPI. TMV WG intend to obtain insights on the projects’ B5G/6G KPIs and together elaborate on their measurability today with this approach and if not, on the need for research and development.

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 6G-IA Board, the 6G-IA Verticals Task Force and WGs as well as the 5G PPP WGs, with the strong support of the CSA project **have produced some significant results** (e.g., white papers from the WGs, workshops organized by WGs or projects, etc.). The Technology Board organized **regular conference calls** (every 2-3 weeks on average) and **two virtual meetings (due to the pandemic)** in 2021.

⁵⁰ <https://5g-ppp.eu/wp-content/uploads/2021/08/TMV-Results-Explanation-White-Paper-V1.0.pdf>

⁵¹ <https://doi.org/10.5281/zenodo.5094973>

⁵² https://www.etsi.org/deliver/etsi_tr/103700_103799/103761/01.01.01_60/tr_103761v010101p.pdf

⁵³ <https://5g-ppp.eu/event/practical-insights-from-5g-test-measurement-and-kpi-validation-with-vertical-applications/>

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

- Jointly with the Full5G project, the verticals cartography for Phase 3 projects has been created. It contains information about the experiments per project, their location, the type of the experiment, their scheduled date, their relation to network slice types and the vertical consortium partners involved.
- The “5G Infrastructure PPP – Trials & Pilots Brochure 3.0” has been produced that highlights the key results of ten Phase 2 and Phase 3 Trials & Pilots.
- In relation to the analysis of the performance KPIs, TB has assisted the Test, Measurements and Validation WG to record and analyse the measured network KPIs in the PPP platforms and the providing a comprehensive mapping on how vertical services KPIs are mapped into network KPIs. This activity completed its first phase during the first half of 2021 and has continued working in 2022 on how to define measure B5G/6G networks KPIs.
- The key achievement list v3.1 has been produced and disseminated, illustrating the impact 5G PPP projects are having in the evolution of 5G networks
- Co-organized with the Full 5G project three workshops for the on-boarding of ICT-42, ICT-41 and ICT-52 projects
- The TB has actively assisted in the interactions with other international activities (e.g., EMPOWER action US NSF / PAWR and PPP / ICT-17/19 Platforms)
- Managed the update of several cartographies including the trials and pilots’ summary table that captures the planned tests from each project
- Organized the collective work between projects for white papers in different technical areas (i.e., Edge Computing, AI & ML in 5G networks, and Indoor 5G networks) that were delivered in 2021.
- One TB workshop have been organized. Due to the COVID pandemic both workshops were electronic ones. The first one took place in in May 2021. During the meeting, in May 2021 there were sessions about various ongoing white papers, the scope of the various WGs so that the large number of new projects to become orientated in the 5G PPP structure, as well on specific technological topics (localization, ICT-17 projects northbound interfaces, micro-electronics and components) and the 5G business ecosystem. An additional workshop took place early in 2022.
- All working groups have been very active and produced several White Papers, Positions Papers, and workshops. During 2021 seven white papers have been produced covering different aspects for 5G networks.

Annex 6 - 6G-IA Activities and Achievements

6G-IA is actively involved in the realization of 5G in Europe through several groups and actions, including: the ‘partnership board’, one task force, 7 WGs and three key activities. The following subsections record their outcomes and key achievements of all 6G-IA activities.

Verticals Engagement Task Force

The Vertical Engagement Task force provided strategic guidance to vertical related activities within 5G PPP Projects, 5G IA Working Groups, 5G Initiative SB/TB, CSA projects and Board activities to create more impact and engagement of vertical communities. All activities are

reported within a **Vertical Tracker** document regularly updated by the Chair of the Task Force.

Vertical **events** were strongly affected by COVID-19 restrictions on travelling and only online events could be considered. A key event attended online during 2021 was IET INDIA, an international workshop organized by ETSI on 5G. 5GIA Chairman, the Executive Director and the Vertical Task Force Chairman attended several sessions to share European use case and thoughts on rollout of 5G in Europe. The session had over 150 attendees participating from organizations including DoT, Atal Innovation Mission, MeitY, Intel, Powergrid, L&T, GE Healthcare, World Bank, AT&T, Black & Veatch, Tata Communications, TCS, Schneider Electric, John Deere, Lenovo, Robert Bosch and Accenture.

Guidance was provided during whole 2021 to the *5G Vertical Users Webinar Series* to create impact in the **standardization** area, with several vertical partner fully engaged in delivering speeches (e.g., 5GAA, PSCE and 5G ACIA). The webinar on *Mobile Edge Computing and Artificial Intelligence* in April were highly attended and successful - the first part was focused on vertical viewpoints on use case with the second part more focused on creating impact at standardization level. Polls were collected at the end of each webinar and shared with the Vertical Task Force for post elaboration. A supplementary workshop on *RAN* requirements was held in June. Finally, a workshop on *5G and AI* was held in December to influence forthcoming 6G roadmap and the regulatory environment.

Globally the 5G Vertical Users Webinar Series reached a vast audience across Europe and across vertical industries, as shown in Figure 16



18

Figure 16: 5G Vertical Users Webinar Series

Concerning **partnership** activities, the focus in 2021 was on renewal of existing portfolio of MoUs taking into consideration the evolution to 6G IA and the new SNS JU environment. The MoU with 5GAA in the automotive sector was renegotiated and will be signed in 2022. Contact with new industry associations in the eHealth and Utility sectors were started to formalize partnership agreement, although some associations were collaborating with 6GIA during 2021.

Finally, several **documents** were orchestrated by the Vertical task to promote 5G uses cases in different industries. The 3rd brochure on *5G Trials & Pilots* was released on August. A focused document on 5G Trials and Pilots in the **automotive** sector was released by the Connected and Automated Mobility WG in May.

A measure of success of the vertical engagement activities is given by a vertical partner in the Public Security domain –**PSCE** – which became member of 5GIA and was elected as Member of 6GIA Board in the last General Assembly.

The Vertical Task force actively participated by the mean of its Chairman to the SNS JU implementation phase to migrate vertical engagement activities to the newly formed private public partnership on 6G.

5G Vision and Societal Challenges WG

The mandate of the Vision and Societal Challenges WG is to work out a comprehensive vision and high-level technology roadmap for the 5GPPP and the 6GIA by involving the 6GIA community and its experts. This roadmap should capture the most relevant, promising technological trends and analyze them in terms of:

- Technological excellence, suitability and relevance
- Economic impact of both upcoming and recently introduced technologies
- Regulatory and political impact
- Societal impact and value

Beyond this, the VSC WG constantly and continuously analyzes the project portfolio of the running 5GPPP projects and tries to distill the difference between its own findings and the accomplished research project work in the form contributions to the future 5GPPP calls.

To do all this, VSC WG has been running several subgroups (SG), dedicated to the impact analysis of the different technological developments in the sense of the above. As a reaction to the expected changes in the 6G research era and with the upcoming SNS JU, in 2021, the Working Group has been reorganized and slightly restructured. The novel structure includes the following subgroups:

- Smart Networks and Services Vision SG – SNSV SG
Responsible for the identification and analysis of the most promising technological trends
- Business Validation, Models, and Ecosystem SG – BVME SG
Responsible for the field of economic validation of novel and emerging use cases in the sense of the required ecosystem adaptations and suitable business models.
- Member State Initiatives in 5G/6G SG – MSI SG
Responsible for the identification of and liaison with the local member state research and other initiatives
- Societal Needs and Value Creation SG – SNVC SG
Responsible for the identification of methods to include a societal value-thinking into technology development.
- Portfolio Structuring and Analysis SG – PS&A SG
Responsible for the structuring (e.g. PPP Pre-Structuring Model (PSM)) and analysis of the research and innovation portfolio.

In 2021, the SNSV SG (previously Horizon Europe Vision SG) has produced a comprehensive and consensual whitepaper on the 6G Vision of the European Industry, published on June 7, 2021 ([6G Vision white paper](#)). To be able to gather the relevant inputs, this subgroup is tightly linked with the networking research community at large and the NetworkEurope ETP in particular. As such, the group was involved in several relevant workshops, e.g., 6G Networking Summit and Visions for Future Communications Symposium. Members of the group also

participate in the relevant activities of the most relevant research community, most importantly/ in the establishment and updates of the Strategic Research and Innovation Agenda of the NetworldEurope ETP, de facto implementing the liaison of this ETP with the 6GIA.

The BVME SG has produced and published two whitepapers, one analyzing the 5G Ecosystems ([5G Ecosystems](#)), and another validating vertical use cases of the 5GPPP business-wise ([Business validation in 5G PPP vertical use cases](#)). Beyond this, the group has initiated work on the 5G Business Models.

As in the previous years, the Member State Initiatives in 5G/6G has prepared and compiled the yearly edition of the member state initiatives report, which was published, with some delay, in early 2022.

To better match the established vision of the technological progress to the future societal needs and to specifically work out possible values of new technologies for the society and its different pillars, in 2021, the VSC Working group opted for the creation of an additional subgroup dedicated to these purposes. The Societal Needs and Value creation SG was launched in 2021 as a new subgroup with the and initiated its work on 6G use cases, ICT for sustainability, new opportunities that 6G should and will open, both in the sense of novel types of services and applications, as well as in the sense of the expected perspectives and benefits for relevant stakeholders, i.e., foremost for consumers and verticals. After the kickoff, the subgroup has started its own promotion process.

Given that 5GPPP comes to its end with the last project calls in 2021, the Portfolio Structuring and Analysis (PS&A) SG (previously PSM SG) has initiated work on a comprehensive portfolio analysis of the 5GPPP as a whole (so-called *post-mortem analysis*). The PS&A SG also further developed in connection with the Technology Board (TB) the PPP Projects Heritage table and figure, on the basis of the Version V1.0 ([Heritage Figure](#)) released in 2020. Besides, the group contributed its vast experience (including key lessons learnt) to the establishment of SNS and the compilation of the Phase 1 Work Programme of the latter.

Pre-standardization WG

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

- Tracking and analyzing inputs to standards organizations from 5G PPP projects.
- Encouraging projects to showcase these inputs during monthly calls as part of the drive to collect success stories and support impact reporting.
- Strengthening the collaboration with ETSI, its Roadmap Technical Report and mapping of EU research in terms of relevant ETSI activities to encourage interactions and inputs.
- Continuing close collaboration with 3GPP on the 5G User Event series: two-part edge computing webinars (industry vertical perspectives and ETSI MEC; 3GPP SA2 and SA6); Vertical Industry Requirements for RAN Release 18; AI in 5G and upcoming 6G networks.
- Liaising with ETSI, 3GPP and other specialists to keep the WG members up to speed on standardization work, including dedicated 3GPP debriefs.
- Finalizing the B5G/6G Standards Roadmap with a view to supporting inputs during the SNS lifecycle and liaison on the forthcoming SNS JU.

The tracking of 5G PPP project inputs to EU and global standards organizations has covered contributions to 3GPP, ETSI, IETF, IEEE as well as vertical associations like 5GAA, 5G-

ACIA within Phase 3. Tracking such inputs has also been an effective way to pinpoint EU leadership in a global context as success stories to be highlighted through the WG. Examples include an industry-led WG in IETF; 5G-VINNI (PoC “Automated Network Slice Scaling in Multi-Site Environments” accepted by ETSI ZSM WG); 5GROWTH (various groups within 3GPP, ETSI and IETF); 5G-DIVE (3GPP, ETSI, IETF, IEEE); 5G-CLARITY (3GPP, ETSI, IETF).

The strengthened collaboration with ETSI enables the WG to give its members practical guidance on transferring their results through standardization. The collaboration is also an opportunity to highlight relevant ETSI activities members can join and potentially lead, such as forming an Industry Specification Group (ISG) for B5G/6G. One example is Reconfigurable Intelligent Surfaces (RIS ISG) as a cross-industry initiative. Regarding the ETSI Technology Radar, members have selected their priority enablers for analysis. Among other relevant resources, the Radar will continue to play a key role as a reference document for B5G/6G technology trends and related standardization.

The 5G User Event series has enabled the WG and MRPs to impart new knowledge on ETSI MEC, 3GPP SA2 and SA6, industry vertical perspective, acting as a forum for educating multi stakeholders on edge computing. Insights into related standardization work also highlighted an important gap in the EC ICT Standardization Rolling Plan 2021 on edge computing. The workshop on RAN Release 18 brought together not only the subset of MRPs, namely 5GAA, 5G-ACIA, 5G-MAG, PSCE, but also EUTC (energy), IALA (maritime), TCCA (critical communications), UIC (rail), ESOA (non-terrestrial networks), as well as Novamint (French SME), which has supported several verticals in 3GPP, and 5G-SOLUTIONS. Close interactions took place with a WG member RAN specialist who gave a detailed report on the 3GPP RAN Release workshop two weeks later, including coverage of topics of interest to verticals. The webinar on AI in 5G and upcoming 6G networks was a first investigation into the evolving role of artificial intelligence with insights from Digital Catapult, NetworkEurope, Nokia (3GPP) and Siemens (industry vision and connections to the AI Data Robotics Partnership). This also picked up on an invited talk on AI standardization from a standards specialist (NEC Labs Europe and expert in StandICT.eu) in reference to the proposed EC legislation by polling registrants on their familiarity with said legislation, machine and deep learning.

To capture the highlights and impacts of the 5G User Event series from May 2020 to June 2021, a brochure (*Supporting Industry Verticals on the Road to 5G Standardisation*) was produced, published and promoted in August 2021⁵⁴. Overall, the series responds directly to Action 4 of the Rolling Plan to work with stakeholders in standardisation for the uptake of 5G in vertical sectors.

The 5G IA Pre-Standardized WG tracks and analyses the inputs of 5G PPP projects to standards organisations. Twenty-two projects (all Phase 3, except SliceNet) have contributed to two rounds of inputs in Q4-2020 and Q2-2021. **In this activity over 230 contributions to Standards Developing Organisations have been tracked.**

To drive inputs as close to the market as possible, input tracking has focused on tangible inputs to working and study groups, including study and work items, gap analyses, PoCs, technical

⁵⁴ https://bscw.5g-ppp.eu/pub/bscw.cgi/d460058/FULL5G_3GPP_MRP_Impact_Report_A4_Aug2021_web.pdf

reports and technical specifications rather than on meetings and presentations, which were counted at the beginning of Phase 1. Inputs that are being normalized are also tracked. This approach helps the EC understand where EU leadership in standardization is coming from while bearing in mind the focus and project lifecycles, especially for the Phase 3 projects with their diverse timelines.

Figure 17 below shows the overall inputs collected.

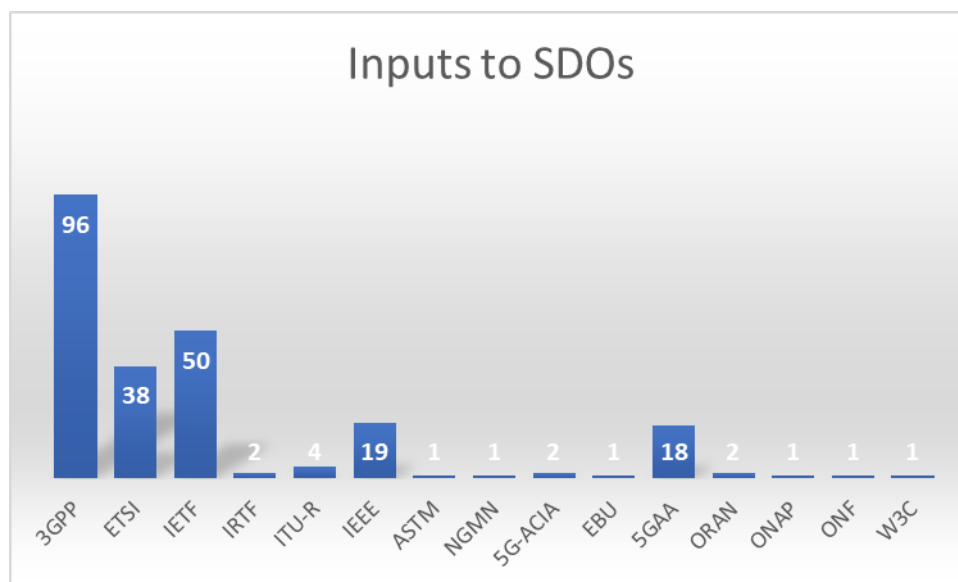


Figure 17: 5G PPP Inputs to Standards Organisations

5G Automotive WG

The “5G for CAM Working Group” is a 6G-IA Working Group. It has been established as a means of supporting 5G for CAM activities funded under EU Programmes covering both R&I and deployment activities in two work streams:

- (i) R&I: Establish a knowledge base and facilitate the exchange of information on ongoing R&I activities in the field. Relevant findings should be disseminated e.g. in form of white papers. This activity should also develop suggestions for Strategic Research and Innovation Agendas for SNS and the new PPP on Cooperative Connected and Automated Mobility (CCAM).
- (ii) Deployment: Prepare elements of strategic guidance in view of European deployment programmes on the field, in particular, 5G Corridors for CAM under the CEF2 Digital Programme. Such activities should be the basis for the establishment and update of Strategic Deployment Agendas adopted by the Governing Board of the SNS JU as foreseen in the Council Regulation establishing the JU. The group should also facilitate broader stakeholder cooperation and building of project pipelines through workshops and networking activities. This activity will get major input from the planned programme support action on the 5G corridor SDA under CEF2 Digital, which is planned to be launched early 2022.

Key achievements

The year 2021 was an important year for the group. This WG gives continuation to the previous 5G Automotive Working Group of the 5G PPP. In June 2021, it was agreed to change the status

of the group, and become a working group which directly reports to the 6G-IA Governing Board. In this process, Jesus Alonso-Zarate (i2CAT) was appointed Chairman of the group, and it was agreed to appoint a vice-chair for each of the two streams. Apostolos Kousaridas (Huawei Technologies) is the co-chair for the R&I Stream, and Edwin Fischer (Deutsche Telekom) is the vice-chair for the deployment stream.

This transition process from 5GPPP to 6G-IA took certain time and effort until the conditions for the migration were clear. There was also an exercise to invite new members to the group, especially, those who are 6G-IA members but not active in any particular CCAM-related project of the 5G PPP.

Once set up, the WG had regular weekly meetings. The meetings have been alternating between R&I stream and deployment stream. The meetings for the R&I stream have been used, in addition to producing documents – described below – to host presentations from active 5GPPP projects, but also other invited speakers from sister initiatives; for example: the CCAM association, with whom it is planned to establish a long-term collaboration. The deployment stream, has been focusing on becoming a common ground for ICT-18 and iCT-53 projects developing both cooperation models and deployment studies to assess how 5G coverage could be deployed and offered across European 5G Corridors.

Along the year 2021, the WG elaborated the CAM Trials Brochure⁵⁵, which was made available on May 2021. This is a very visual document summarizing the main trial activities related to CAM and occurring across Europe funded with projects of the 5GPPP. The WG plans to release an updated version of the Brochure in 2022. At the end of the year, the WG had started to shape a white paper aimed at providing the 5G to 6G Vision from the CCAM perspective. It has been set as a goal to publish the white paper at the EuCNC 2022.

In addition, the WG agreed to organize frequent updates by the CAM related projects to inform the members about their outcomes as well as about next planned activities. In 2021, 5GMOBIX, VITAL-5G, 5G-IANA projects had the opportunity to present their results in the WG, while presentations of the other projects have been scheduled for 2022. It was also agreed to invite external stakeholders/associations (e.g., ETSI ITS, Connected Motorcycle Consortium, C2C Communication Consortium (C2C-CC), Urban rail-based systems) to update the WG about their objectives/goals and also get informed about WG's and related projects' activities.

The WG has also interacted with the Connected, Cooperative and Automated Mobility (CCAM) association and updated each other on the progress/status of each partnership.

Trials WG

The Trials Working Group was launched by 5G Infrastructure Association in September 2016 after the publication of the 5G Manifesto of industry in Europe and in the context of the 5G Action Plan of the EU Commission.

The main activities carried out by the WG in 2021 are the following:

- Elaboration of the WorkPlan 2021 of the Working Group, updating of the Terms of Reference (ToR) and approval by the 5G-IA board: In this reporting period, the WG chair and Stream Champions have worked towards the elaboration of the Terms of Reference (ToR) of the WG and WorkPlan at the stream level with priorities for 2021, as requested

⁵⁵ <https://5g-ppp.eu/trials-and-pilots-for-connected-and-automated-mobility/>

by 5GIA board. The Stream '*5G Vertical*' was renamed into '*5G and towards 6G Verticals*', its charter was extended and updated. Draft versions of both documents were presented at the plenary PhC of the WG and the final version was circulated for comments to the email reflector. Both documents were submitted for the consideration of the 5G-IA board on 03.02.21 and approved with one minor modification.

- Elaboration of the PPP T&Ps Summary Table: The PPP T&Ps Summary Table has been further developed and released in the TB context (version released on 09.12.21). The table includes 280+ inputs/rows from Phase 2, Phase 3.I and Phase 3.II Projects. This table further serves as reference for the development of the PPP Verticals Cartography⁵⁶ and the PPP T&Ps Brochures (see next item).
- Elaboration of the PPP Trials and Pilots (T&Ps) Brochure n°3: Following the successful edition and release (15.12.20) of the PPP T&Ps Brochure n°2⁵⁷, the process for the PPP T&Ps Brochure n°3 has been developed, jointly between both Trials WG and TB. The Brochure n°3 brings to the readers' attention 10 additional Phase 2 and Phase 3 Trials & Pilots that were recently completed. All documents in relation with the selection process (Process, Flyer Form / Guidelines and Criteria Form) were updated, released and communicated towards TB Members, Trials WG Members and SB Members. The members of the Editorial Team were D. Bourse, A. Kaloxylou, C. Anton-Haro, M. Alarcón, F. Pujol and C. Manero. The extended deadline for the reception of PPP Projects 2 pages "Flyer" Form and 2-5 pages "Criteria" Form was 29.03.21. A large number of 28 T&Ps contributions were received from the 5GCity, IoRL, 5G-EVE, 5G-VINNI, 5GENESIS, 5G-CROCO, 5GROWTH, 5GSolutions, 5G Victori projects. The coverage of the various verticals was balanced (Industry 4.0, Media, Transportation, Tourism, e-health, Public Safety and Infotainment, etc). The pre-defined criteria included e.g., impact of 5G networks, achieved KPI, Technology and Market Readiness Levels, societal impact, 5G empowerment. In carrying out the selection, the Panel Members tried to cover as much as possible different vertical applications, avoiding addressing the same few use-cases with different projects. The Panel Members also considered the balance between Projects. A refinement/improvement round of the selected flyers, followed to the notification of acceptance in close collaboration with the corresponding contact persons. The Brochure n°3 has been officially released on 07.10.21 and communicated towards Community Members via the 5G-IA website⁵⁸, the trials WG and TB reflectors, postings to 6G-IA members, etc.
- Cities Stream: The report entitled 'Smart city trials in Europe - current activities in smart city vertical segments/use cases' (25 pages) was finalized, including information from Phase 3 part 6 projects on short review of 5G PPP activities. The report illustrated the requirement and lessons learned in building and designing 5G enabled living labs and experimentation facilities for cities. The report was published at 5G-IA webpages but with additional note on collaboration with Digital Transition Partnership for part of the report. Besides, an update for trials cities report took place. The main focus is on 5G PPP project and various city networks' activities in member states to complement the previous report.
- Contributions to the definition of Stream D in the SNS Workprogramme: The WG chair has actively contributed to the definition of the Stream D ('SNS Large Scale Trials and Pilots (LST&Ps) with Verticals, including the required Infrastructure') which is of critical

⁵⁶ <https://www.global5g.org/cartography>

⁵⁷ <https://5g-ppp.eu/the-5g-ppp-infrastructure-trials-and-pilots-brochure-n2-is-out/>

⁵⁸ https://5g-ppp.eu/the-5g-ppp-infrastructure-trials-and-pilots-brochure-3-is-out,https://5g-ppp.eu/wp-content/uploads/2021/10/5GInfraPPP_10TPs_Brochure2021_v1.0.pdf

importance for WG participants. This includes contributions to drafting/scope, budget definition, etc.

- International Cooperation Stream: A 5GIA-TSDSI Webinar on “5G Trials and Pilots” was held on 22.09.21. It was organized, promoted and hosted by LiveU Ltd.”The goal was to share experiences on the realization of T&Ps both in the EU and India, and lessons learnt (in the EU) on how to design multi-year R&D programs. The webinar raised very high interest from TSDSI and 5G-IA sides alike and counted with +280 registered attendees (India + EU) and +140 actual attendees. All presentations (9 speakers, 2 h) were recorded, and all the materials (slides, recording, etc.) were uploaded to the 5G PPP portal⁵⁹ as well as to the TSDSI portal⁶⁰. Dr. Colin Wilcock (6G-IA) and Ms. Nena Satak (Astrome Technologies Ltd) gave keynote speeches on the 5GIA framework and 5G T&P in India, respectively. The program revolved around 4 distinctive blocks addressing 4 verticals of mutual interest, namely, Smart Grids, Smart Cities, Broadcast and Media production. Each block featured two presentations: one from the 5G-IA/5G PPP side and one from the TSDSI side.
- 5G and towards 6G Verticals: A Table of Content of the White Paper was discussed and agreed upon. The scope is to identify relevant use cases that have the potential to go well beyond 5G/5G-Advanced requirements, the ones that most probably will compose the first set of 6G use cases.
- Other activities and meetings: As a recurrent activity, the general email reflector has been updated with additional members (23 projects/institutions in this reporting period). The trials WG participated in the 5G-I-SB meetings on a regular basis where on-going work was reported and several announcements were made (e.g., release of T&P brochure, reports), calls for additional members from recently awarded projects as well as volunteer contributors/section editors were issued, etc. Besides, a number of Trials WG plenary meetings and Stream Champion meetings were organized for internal coordination and planning purposes. The agenda of plenary meetings included inter-alia an overview of the various activities organized at the stream level, short presentations on new projects/recent Trials and Pilots, plans for the upcoming new WhP, etc.

Security WG

During Year 2021 the 6G-IA Security WG did foster collaboration among 5G PPP Projects representatives and 6G-IA interested members. Over the year new representatives (either from projects or 6G-IA) have joined the group. Overall collaboration and exchange within members of the WG did continue despite once more impacted by COVID 19 situation which prevented to have physical meeting. Nevertheless, meetings despite limited were fruitful in view of information exchanged also inputs coming from members who delivered and shared their results.

Among the various actions performed during 2021 we can quote the following:

- Assessment of work performed in 2020 in order to plan work for Year 2021. This was done at the beginning of Year 2021
- Attendance to both TB and SB meetings in order to maintain awareness, join the discussions but also work on action items of concerns with support

⁵⁹ <https://5g-ppp.eu/event/5gia-tdsi-online-webinar-on-5g-tests-and-pilots>

⁶⁰ <https://tsdsi.in/event/5gia-tdsi-webinar-on-5g-tests-pilots>

from members

- Participation to conferences namely EuCNC 2021 and ARES conferences where security workshops have been prepared and submitted (i.e. Workshop 8 : From 5G to 6G Automated and Intelligent Security: FAST at EuCNC) together with CfP for ARES 2021 workshop (i.e. The 4th International Workshop on Emerging Network Security (ENS 2021))
- Follow-up of activities from other WG of concerns (e.g., Architecture WG, Vision WG, Pre-Standardization WG), this with focus on security
- Catch-up with ENISA work following involvement of WG co-chairs as members of Experts Group set to support production of “5G Threat Landscape” and its update.
- Monitoring of work on Cybersecurity from ECSO interesting for 5G&beyond (6G) with ambition to further develop liaison.
- Progresses at Project or Member level on topics have been continued to be presented/discussed (shared) in order to further drive joint research actions on those fields
- Work organized in 2020 on short whitepapers (Access Control Mechanisms to Verticals, SDN/NFV virtualisation, 5G Slicing and Security Considerations, 5G Attack Referential, (critical) Vertical security needs) was continued in 2021. Decision regarding those short whitepapers was finally postponed to 2022.
- On security KPIs some projects started to progress also share interesting results.
- Significant work was done to continue to share on security enablers developed or in scope with objective to get it done in terms of “What”, “Why” and “How”.
- No physical meeting held in 2021 this due to pertaining COVID 19 situation nevertheless a number of virtual meetings took place to continue to exchange/share and align. Material as usual was uploaded on bscw.
- By end of Year 2021, assessment of collective results achieved was performed in order to further drive the work of 5G IA SEC WG for the next Year (2022).

Open Smart Networks and Services WG

The Open SNS WG promotes and supports the evaluation, adoption, deployment, and evolution of open solutions for 5G and beyond 5G/6G networks. One of the first tasks of the WG is to promote and support the evaluation, adoption, deployment, and evolution of open, disaggregated, intelligent and fully interoperable networks as a key technology for future mobile networks (5G and beyond). For this, the Working Group bridges the open initiatives in the industrial domain with the ongoing or planned R&D and standardization work (3GPP, O-RAN Alliance...), bringing together subject matter experts from the academy (university, research institutes, etc.) and industry (operators, vendors, SMEs, verticals, etc.), aiming to accelerate the development of an EU wide open ecosystem of technologies that will include hardware equipment and software-defined, virtualized, and automated solutions.

Different open network sub-domains have been considered as part of this working group including Radio Access Networks (RAN), transport, non-terrestrial networks (NTN), platforms, core and services where different members have the capability to debate and interact on the specific topics that those domains may have.

The Main Open SNS working group's objectives are to:

- Influence the definition of the technical work programme to evolve the maturity of open solutions.
- Support the continued development and dissemination of Open R&D projects with the aim of creating a dynamic and vibrant ecosystem of technologies, hence strengthening the European industry.
- Support the evaluation and the adoption of disaggregated solutions in legacy and future networks to enable a true multi-vendor environment.
- Engage with industry to understand and develop solutions for innovative use cases.
- Create bridges between the standardization (e.g. 3GPP, O-RAN Alliance), product test & validation activities (e.g. TIP) and the research projects.
- Promote a common understanding of standards and architectures and maturity status.
- Engage with European Security Framework to assure the Open based networks comply with the security standards defined by EU.

The Working group was created in July 2021 having a first Kick off session on October 1st, 2021 holding monthly meetings since then with total 28 members by end 2021.

The Working Group presented a paper for Visions for Future Communication Summit on November 23rd, 2021. In this paper, open, disaggregated, intelligent, secured, efficient and fully interoperable networks were presented to be the baseline on which 6G, and future mobile networks should be built. Key areas of interest to be considered were:

1. Openness in RAN, transport, Core and services
2. Disaggregation in open network architectures with open interfaces
3. Open source-based designs and platforms
4. Virtualization with innovative Open AI/ML methodologies and platforms
5. Near-real-time multi-resource allocation protocols and scheduling algorithms
6. Minimize complexity of radio units/digital units, maximize chip cloudification
7. Faster and more compressed fronthaul designs
8. Energy efficiency as part of novel architectural solution with new metrics
9. Security as integral/by design part of the architecture
10. Advanced 3rd party apps to interact with networks running at the edge
11. Extensive use of APIs in RAN, transport and core
12. Automation of zero touch provisioning, development of lifecycle CI/CD platforms
13. E2E Service Management and Orchestration (SMO) and use cases
14. Multi-vendor federated Electronic Management System (EMS)
15. New eastbound/westbound interfaces and APIs

The Working Group has now as target to deliver its first whitepaper during 2022 focusing on defining the status of Open Networks, listing the gaps/strengths/maturity levels, proposing what the future networks should require and drafting what needs to be built. As Open Networks are a wide concept in the E2E system, parallel discussions are ongoing on the different sub-domains. The outcome of these parallel streams will be later consolidated into a single whitepaper.

SME Community

After the successful participation of SMEs in the 5G PPP, with an overall participation of 21.95% in EU funding, SMEs contributed in 2021 to the preparation of the Smart Network & Services Partnership, further to the release in November 2020 of a dedicated position paper⁶¹. It is worth noticing that the SNS JU recommends a minimum 20% participation from SMEs in the upcoming projects, replicating one of the KPIs of the 5G PPP initiative.

The number of members in the NetworldEurope SME Working Group has continued to increase throughout 2021, reaching almost 220 members, including 190 SMEs. This represents an increase of 10% in one year. The overall number of SMEs that are members of NetworldEurope reached 356 by the end of 2021. A dozen SMEs were members of 6G IA at the same date.

The SME-related web pages⁶² on the NetworldEurope web site were updated twice in 2021, at the beginning of the year and at mid-year, along with the “European SME Expertise in 5G and Beyond” brochure⁶³. The “Find the SME you need” web page now includes 73 SMEs, while the latest edition of the brochure (released in June 2021) includes 69 SMEs. Relevant examples of the “Find the SME you need” web page using different categorization are depicted in Figure 18 and Figure 19.

⁶¹ “SME WG SNS Position Paper”, 4 November 2020, <https://www.networldeurope.eu/wp-content/uploads/2020/12/sme-wg-sns-position-paper-final.pdf?x70854>

⁶² <https://www.networldeurope.eu/sme-wg/>, <https://www.networldeurope.eu/find-the-sme-you-need-new-page/>

⁶³ https://bscw.5g-ppp.eu/pub/bscw.cgi/d391067/2021-01_5G_SME_Brochure.pdf






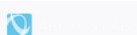


Domains of Technological Expertise								Search:
SME		5G	IoT	SatCom	NGI	Others		
	Accelleran	X	X	X	X		RAN/vRAN Software Solutions, Products and Services	
	ACTA Ltd	X	X	X				
	Aetheric Engineering			X				
	AICO		X					
	AppArt	X	X				Data Modelling, Analytics and Visualization, Machine Learning, Network Automation	
	Arctos	X					Cloud, virtualisation, MEC	
	Arteevo	X	X		X		DLT, AI	
	AUSTRALO	X	X		X		Data, AI, Cloud	

Figure 18: “Find the SME you need” web page: SMEs by technological expertise






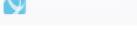


Expertise in Vertical Sectors										Search:
SME		Media & Content	Transport & Logistic	Manufacturing	Health	Energy	Smart Cities	Public Safety	Others	
	Accelleran	X	X	X		X	X	X		
	ACTA Ltd						X	X	Aquaculture	
	Aetheric Engineering									
	AICO		X		X	X	X			
	AppArt	X			X	X	X			
	Arctos									
	Arteevo	X	X	X	X	X	X		Business process automation	
	AUSTRALO	X		X	X		X		Security, Agriculture, Social Innovation	

Figure 19: “Find the SME you need” web page: SMEs by vertical sector

2021 showed a continued interest in the SME web pages and the SME brochure. **The “Find the SME you need” web page was viewed more than 3,000 times in 2021, making it the most viewed page on the NetworldEurope web site, after the home page.** The “SME WG” page ranks #8 with almost 350 views. The relevant statistics are depicted in Figure 20.

Page	Pageviews	Unique Pageviews	Avg. Time on Page	Entrances	Bounce Rate	% Exit	Page Value
	16,122 % of Total: 100.00% (16,122)	13,106 % of Total: 100.00% (13,106)	00:01:46 Avg for View: 00:01:46 (0.00%)	8,634 % of Total: 100.00% (8,634)	64.48% Avg for View: 64.48% (0.00%)	53.55% Avg for View: 53.55% (0.00%)	\$0.00 % of Total: 0.00% (\$0.00)
1. /	3,906 (24.23%)	3,299 (25.17%)	00:01:15	3,015 (34.92%)	60.08%	55.66%	\$0.00 (0.00%)
2. /find-the-sme-you-need-new-page/	3,051 (18.92%)	2,074 (15.82%)	00:02:19	1,986 (23.00%)	64.00%	63.88%	\$0.00 (0.00%)
3. /sria-and-whitepapers/	933 (5.79%)	838 (6.39%)	00:03:20	596 (6.90%)	63.25%	72.13%	\$0.00 (0.00%)
4. /overview/	650 (4.03%)	535 (4.08%)	00:01:44	89 (1.03%)	61.80%	36.77%	\$0.00 (0.00%)
5. /webinar-on-5g-for-health-and-wellbeing-27-october-2021/	587 (3.64%)	449 (3.43%)	00:03:01	291 (3.37%)	67.70%	58.77%	\$0.00 (0.00%)
6. /our-members/	522 (3.24%)	416 (3.17%)	00:01:51	76 (0.88%)	56.58%	31.23%	\$0.00 (0.00%)
7. /webinar-on-enabling-technologies-and-requirements-for-future-rail-transport-vertical-14-july-2021/	444 (2.75%)	365 (2.78%)	00:03:10	295 (3.42%)	72.54%	64.86%	\$0.00 (0.00%)
8. /sme-wg/	340 (2.11%)	267 (2.04%)	00:01:12	121 (1.40%)	52.07%	37.06%	\$0.00 (0.00%)

Figure 20: Statistics re. the NetworldEurope web page visits – January to December 2021

The average time spent by the viewers reading the page is more than 2 minutes, showing on the one hand that viewers are navigating thoroughly through the SME page, to find the information they need, and on the other hand, that the “search” system put in place allows a quicker search than previously. In addition, the SME brochure was downloaded almost 150 times⁶⁴, making it the 2nd most viewed/downloaded document of the NetworldEurope web site after the NetworldEurope SRIA. The relevant statistics are depicted in Figure 21.

Event Label	Total Events	Unique Events	Event Value	Avg. Value
	786 % of Total: 58.09% (1,353)	737 % of Total: 58.49% (1,260)	0 % of Total: 0.00% (0)	0.00 Avg for View: 0.00 (0.00%)
1. https://bscw.5g-ppp.eu/pub/bscw.cgi/d367342/networld2020%20sria%202020%20final%20version%202.2%20.pdf	219 (27.86%)	211 (28.63%)	0 (0.00%)	0.00
2. https://bscw.5g-ppp.eu/pub/bscw.cgi/d392313/annex%20v2.3%20-%20public.pdf	167 (21.25%)	160 (21.71%)	0 (0.00%)	0.00
3. https://bscw.5g-ppp.eu/pub/bscw.cgi/d391067/2021-01_5g_sme_brochure.pdf	92 (11.70%)	82 (11.13%)	0 (0.00%)	0.00
4. https://bscw.5g-ppp.eu/pub/bscw.cgi/d437286/2021-07%20sme%20brochure.pdf	53 (6.74%)	47 (6.38%)	0 (0.00%)	0.00
5. https://bscw.5g-ppp.eu/pub/bscw.cgi/d322688/nem%20networld2020%205a%20media%20slice%20v1-	18	17	0	0.00

Figure 21: The “European SME Expertise in 5G and Beyond” brochure views in 2021

This demonstrates the interest of the visitors of the NetworldEurope web site in SME-related information, and the corresponding impact on the ecosystem stakeholders.

It is also worth mentioning that the information of the SME WG was also shared regularly on the 5G PPP web site and disseminated via the 5G PPP and 5G IA mailing lists.

In 2021, the SME WG also expended its reach and established a liaison with the European DIGITAL SME Alliance, an association dedicated to strengthening SME presence at policy

⁶⁴ When we add the two editions of the brochure released in 2021.

level in Europe⁶⁵. A joint workshop focusing on “5G, Edge computing and IoT” was co-organised on September 16, 2021⁶⁶.



International Cooperation Activity on 5G

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

The 5G IA has signed the following MoUs:

International Multilateral MoU

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

International Bilateral MoUs

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

⁶⁵ <https://www.digitalsme.eu/>

⁶⁶ Cf. <https://www.digitalsme.eu/events/workshop-on-5g-edge-computing-and-iot/>. The video of the workshop is available at <https://youtu.be/HtR4kY5Es3E>.

TSDSI (India)	Signed
---------------	--------

Agreements with Organizations representing Vertical Sectors

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

Other Agreements

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

Activity Community Building and Public Relations

5G IA has played a central role in the abovementioned activities. The activities of the Verticals Engagement Task Force, the work of 6G-IA WGs (i.e., pre-standardization, trials, spectrum, security and the IMT 2020 Evaluation group), its close collaboration with NetWorld2020, have been the enabler for success. Finally, 5G-IA has signed 15 MoU and 4 LoI with peer-organizations or other global regions ensuring that the European activities will have a global impact.

Smart Connectivity Digital Innovation Hub Network

This activity is contributing to stimulate the overall digital ecosystem and mainly the Digital Innovation Hub which is part of the next Digital Europe Program (DEP). For that purpose, during 2020, DIHs that are offering 5G services were identified in the S3 platform catalogue and we began to work on services that such DIHs are expecting from a network. Following this, in 2021 it was decided to extend to a larger domain addressing Smart connectivity encompassing 5G, IoT, Cybersec and AI. Finally, the conclusion was to merge the 5G initiative with the AIOTI initiative to become stronger.

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

The *SCoDIHNet* initiative is co-supported by AIOTI⁶⁷ and the 6G-IA. In turn it supports Digital Innovation Hubs that are providing services on 5G, IoT, Cybersecurity and artificial intelligence. 5G and IoT are key technologies to develop digitalization of European industry together with AI and cybersecurity it will ensure flexibility, adaptability, and end-to-end security.

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

The *SCoDIHNet* initiative is currently well-known from the community, and more than 80 members are participating regularly to the monthly meetings. The further activities will target support of the DIHs which will apply to the next Digital Europe Program calls to get funding. Most of them have been already pre-selected by member states following the process put in place by the EC. *SCoDIHNet* is seen as an intermediate network between the DIH operating at local/regional level and the Digital Transformation Accelerator encompassing all DIH.

Following the output of the 2020 activities, it has been identified a number of services that should be offered at *SCoDIHNet* level as some others should stay at DIH level ([document available on the SCoDIHNet web site](#)). The following table gives an overview of the services offered at each level.

Table 4: *SCoDIHNet* services

Services	SCoDIH	SCoDIHNet
Community building		X
Digital development Strategy	X	
Ecosystem learning		X
Representation, promotion	X	
Strategy RDI (to rise use cases and PoCs)		X
R&D and Innovation Projects		X
Technical support on scale up	X	
Provision of Technology infrastructure		X
Testing & Validation for technology developers	X	
Growth for SMEs		X
Incubator / Accelerator support for startups (optional)	X	
Digital marketplace dynamization (optional)		X
Helpdesk management		X
One stop shop / single point of attention	X	
Innovation vouchers (optional)	X	
Consulting (optional)	X	
Support / Expertise (optional)	X	
Digital campuses		X
Digitalisation and I4.0 training (demand capacitation)		X
Workshops 'train the trainer' (professional capacitation and training)		X
Job Offering (optional)	X	

The Transcontinuum Initiative

This activity is contributing to stimulate the overall digital ecosystem and mainly the future Horizon Europe missions. The objective is to concentrate all digital competencies in one

⁶⁷ www.aioti.eu

initiative which is better able to bring solutions to the programs/projects and making 5G part of the story.

In 2020, Eight European associations and projects committed to the Transcontinuum Initiative to promote cross-domain collaboration for EU R&D programmes.

The Transcontinuum Initiative, or TCI, is developing a vision of the characteristics of the infrastructure required for the convergence of data and compute capabilities in many leading edge industrial and scientific use scenarios as depicted in Figure 22. A paradigm change is needed: we will have to design systems encompassing millions of compute devices distributed over scientific instruments, IoT, supercomputers and Cloud systems through LAN, WLAN and 5G networks.

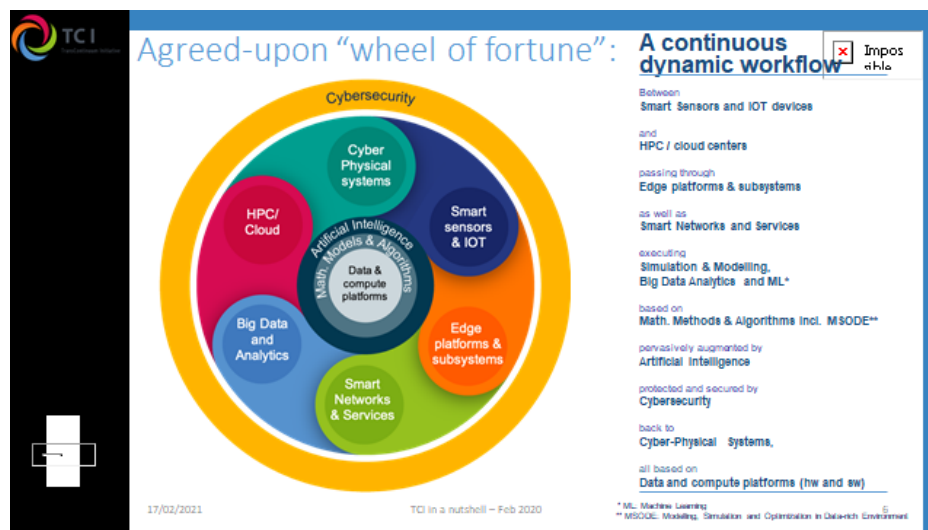


Figure 22: The Transcontinuum wheel

The ambition of TCI is also to become a meeting place or a competence centre of experts representing various digital disciplines in both science and industry – an asset that Europe can apply in the resolution of its other challenges such as healthcare, climate change or smart cities.

The foundations of the work to be carried out by the TCI have now been defined in a [Vision document](#) signed by eight organisations, covering eight domains:

- 5G IA, the 5G Infrastructure Association,
- AIOTI, the Alliance of Internet Of Things Innovation,
- BDVA, the Big Data Value Association,
- CLAIRE, the Confederation of Laboratories for Artificial Intelligence Research in Europe,
- ECSO, the European Cybersecurity Organisation,
- ETP4HPC, the European Technology Platform for High-Performance Computing,
- EU-Maths-In, the European Service Network of Mathematics for Industry and Innovation,
- HiPEAC project (High Performance Embedded Architecture and Compilation)

Looking to the specific 5G domain, we have identified five technologies that could contribute to the Trancontinuum:

1. **Network slicing** to “customize” the network with regards to the application needs in

terms of data speed, quality, latency, reliability, security, and services.

2. **5G New Radio (NR) capabilities** to provide the air interface able to support application requirements in terms of reliability, availability, latency, QoS, scalability and throughput.
3. **Smart Network Management** to provide mechanisms able to allow fast and easy deployment of networks in specific locations for specific applications.
4. **Guaranteed QoS** to ensure end2end guaranteed bandwidth and latency, meeting the more stringent requirements.
5. **Location Service and Context Awareness** to provide an accurate location of terminals in- and outdoor.

Work on the Smart Networks and Services

Although 5G PPP has already provide plenty of results, it is important for design the roadmap for the next decade. The 6G-IA has been very active during 2021 to setup the Smart Networks and Services (SNS) Partnership Joint Undertaking. A key goal of the SNS Partnership is to define and implement the research, innovation and deployment roadmaps that will enable Europe to lead in the creation of the next generation of smart network technologies and services. These will be designed and implemented in such a way that European values like security and privacy are safeguarded, and European technological sovereignty is further strengthened. The Partnership also focuses on the full digitization of European society including vertical industries and public administration. Thereby, the SNS Partnership targets to have a positive impact on the quality of life for European citizens and boost the European data economy. The SNS strategic objectives are depicted in Figure 23.

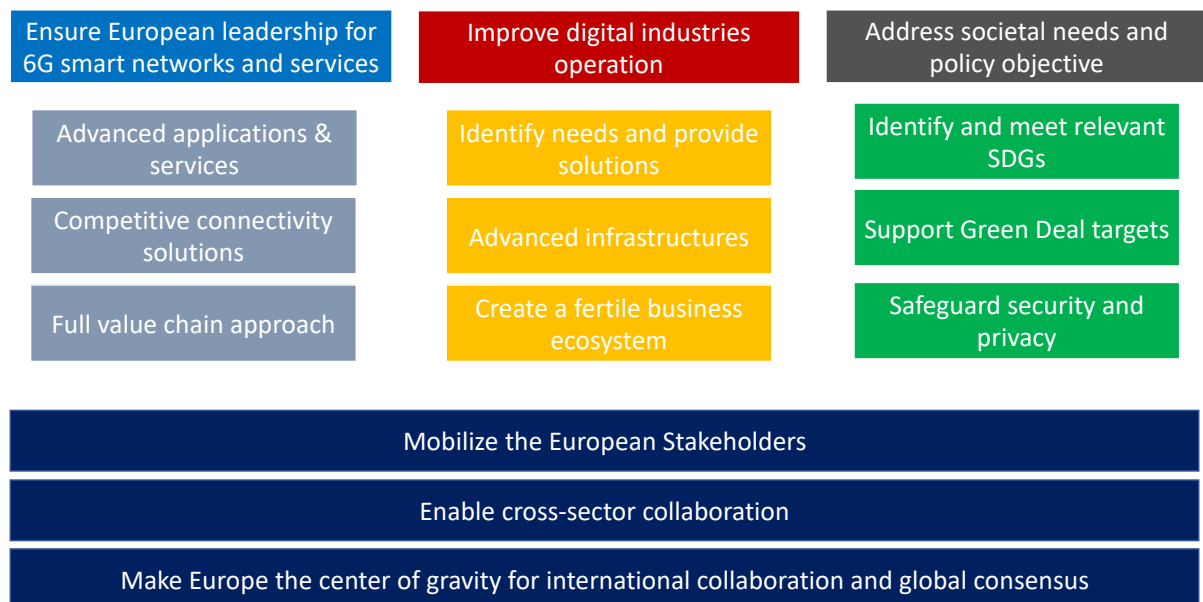


Figure 23: SNS Strategic objectives

Following up on the initial definition of the SNS proposal, the SNS roadmap has been updated, specifying four highly complementary Streams which are in line with the industry roadmap (Figure 24), and potentially targeting a wide set of stakeholders across the value chain. The

SNS Phase 1 is expected to build upon the outcomes of Horizon 2020 5G PPP projects, as well to capitalize on the results from other instruments (e.g., Member States' initiatives, other Horizon 2020 activities, other activities that follow open principles, etc.). The Roadmap (Figure 24) illustrates the phases of the 4 streams.

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

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

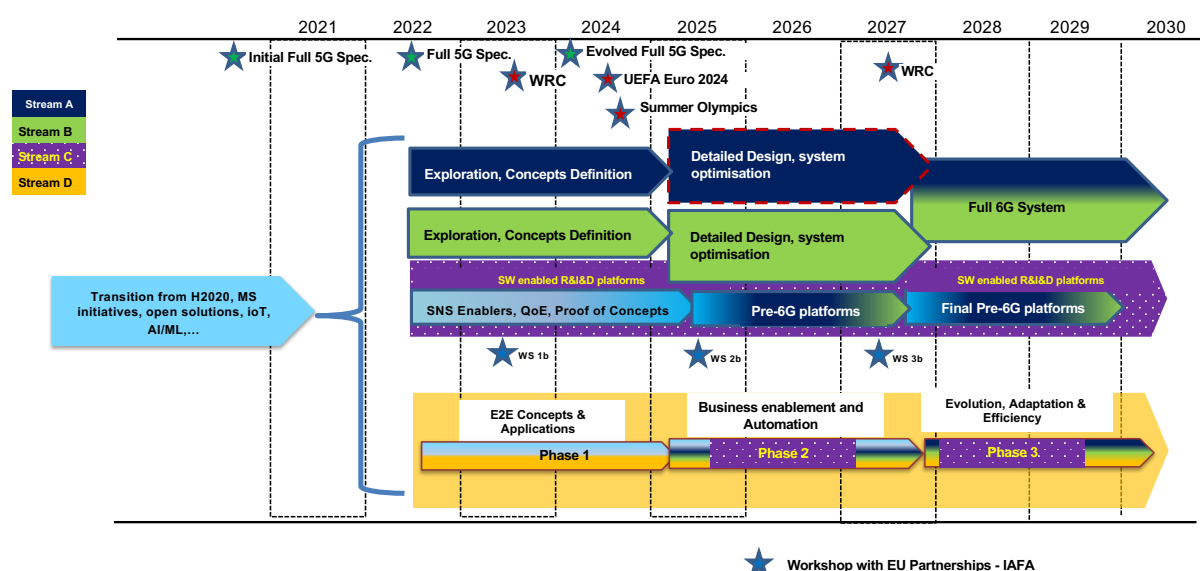


Figure 24: SNS updated roadmap

The SNS Partnership was successfully launched in December 2021⁶⁸, and a detailed Work Programme was released following the principles of the abovementioned roadmap. In Figure

⁶⁸ <https://digital-strategy.ec.europa.eu/en/policies/smart-networks-and-services-joint-undertaking>

25, a high-level view of the SNS topics for the first R&I WP are illustrated. These are covering the full chain of smart networks and services on the road to 6G.

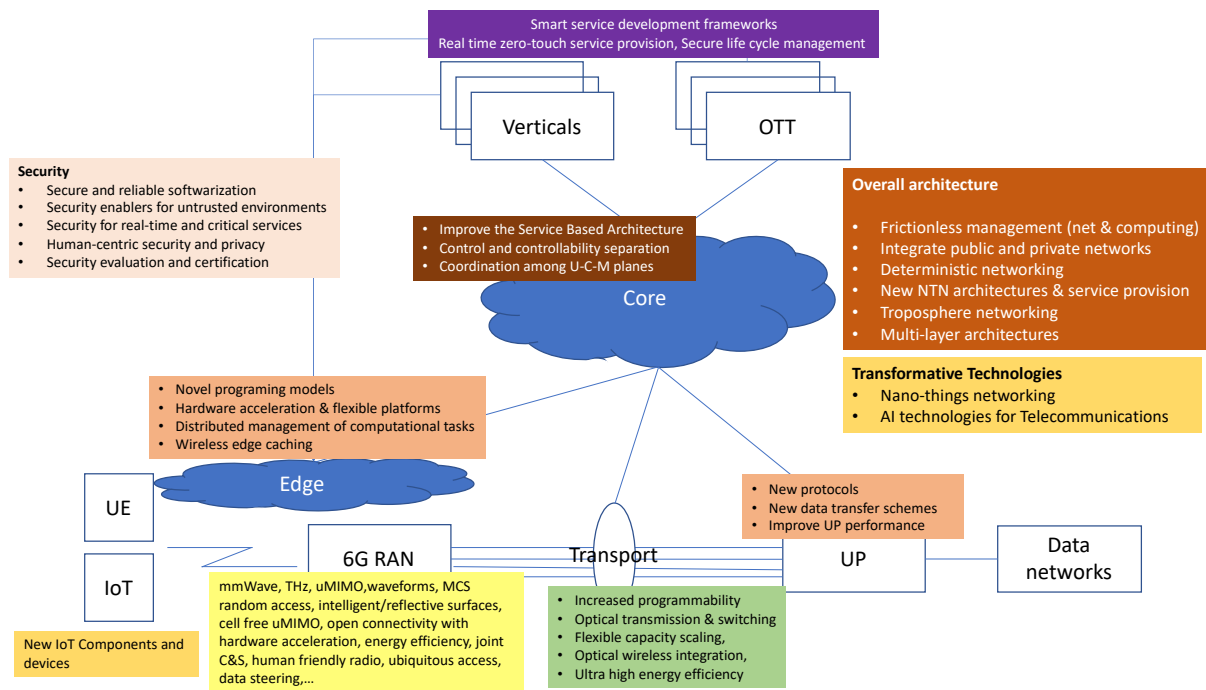




Figure 25: A high level view of SNS JU indicative R&I topics

6G-IA has also actively contributed to the formation of the SNS SRIA. The first launch of projects was successfully completed early 2022 and the first projects are expected to start their research activities early 2023.

Annex 7 – Common Priority Key Performance Indicators

	Key Performance Indicator (KPI)	Value in 2021	Baseline at the start of H2020 (latest available)	Target (for the cPPP) at the end of H2020	Comments																					
1	Mobilised Private Investments	<ul style="list-style-type: none">• 13,58 considering Large Industry and SMEs• 10,93 considering all types of beneficiaries		Between 5 and 10.	The methodology used for this assessment is described in Section 3.2.1.1																					
2	New skills and/or job profiles	<table><tr><th>2014-2020</th><th colspan="2">New jobs/skills</th></tr><tr><th></th><th>Average</th><th>Total projected</th></tr><tr><td>Overall</td><td>7,31</td><td>7.443</td></tr><tr><td>Large Industry</td><td>23,08</td><td>5.910</td></tr><tr><td>SME</td><td>4,06</td><td>570</td></tr><tr><td>Academic Institution</td><td>6,22</td><td>527</td></tr><tr><td>Research Center</td><td>5,33</td><td>437</td></tr></table>	2014-2020	New jobs/skills			Average	Total projected	Overall	7,31	7.443	Large Industry	23,08	5.910	SME	4,06	570	Academic Institution	6,22	527	Research Center	5,33	437			<p>The methodology used for this assessment is described in section 3.2.1.2.</p> <p>Additional considerations (source: The future of work: ICT Professionals⁶⁹):</p> <ul style="list-style-type: none">• Employment for IT professionals is projected to grow by 11% over the period 2018 to 2030, with 395,000 jobs created.• Combined with the number of those leaving the occupation in the same period (an estimated 1.2 million), this growth indicates that 1.6 million jobs in ICT will need to be filled between 2018 and 2030.• The number of ICT professionals who hold medium-level qualifications will remain more or less unchanged at 23% in 2030.• The number of ICT professionals who hold high-level qualifications is expected to increase to 74% in 2030.
2014-2020	New jobs/skills																									
	Average	Total projected																								
Overall	7,31	7.443																								
Large Industry	23,08	5.910																								
SME	4,06	570																								
Academic Institution	6,22	527																								
Research Center	5,33	437																								

⁶⁹ https://ec.europa.eu/eures/public/en/news-articles/-/asset_publisher/QOSmqQGuvdnC/content/the-eu-job-market-and-workplace-in-the-2020s?inheritRedirect=false&redirect=https%3A%2F%2Fec.europa.eu%2Feures%2Fpublic%2Fen%2Fnews-articles%3Fp_id%3D101_INSTANCE_QOSmqQGuvdnC%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3D_118_INSTANCE_U2TwYOTdC3eS_column-1%26p_p_col_pos%3D1%26p_p_col_count%3D4%26_101_INSTANCE_QOSmqQGuvdnC_cur%3D1%26p_r_p_564233524_resetCur%3Dfalse&_101_INSTANCE_QOSmqQGuvdnC_backLabelKey=news.articles.back.to.list&_101_INSTANCE_QOSmqQGuvdnC_showAssetFooter=true

3	Impact of the 5G PPP on SMEs	<table><tr><td></td><td>increase in yearly turnover</td><td>increase in yearly revenues</td><td>increase in staff headcount</td><td>number of new elements of foreground IP</td></tr><tr><td>Reference period</td><td>2020</td><td>2020</td><td>2014 - 2020</td><td>2014 - 2020</td></tr><tr><td>Average values</td><td>10,1%</td><td>11,9%</td><td>16,55</td><td>1,78</td></tr><tr><td>Total projected</td><td>n/a</td><td>n/a</td><td>2.325</td><td>250</td></tr></table>		increase in yearly turnover	increase in yearly revenues	increase in staff headcount	number of new elements of foreground IP	Reference period	2020	2020	2014 - 2020	2014 - 2020	Average values	10,1%	11,9%	16,55	1,78	Total projected	n/a	n/a	2.325	250	<p>The methodology used for this assessment is described in section 3.2.1.3.</p> <p>Note also:</p> <ul style="list-style-type: none">• The number of members SME Working Group has increased by 17% during the year 2020, reaching 200 members, out of which 170 are SMEs.• The SME participation in 5G PPP projects has been increasing in 2020 to reach and even exceed the original objective of 20% participation defined as a KPI of the programme.• According to the H2020 dashboard, the participation of SMEs in the 5G PPP has reached 21.95% of EU funding, representing a total of 156.3 M€
	increase in yearly turnover	increase in yearly revenues	increase in staff headcount	number of new elements of foreground IP																			
Reference period	2020	2020	2014 - 2020	2014 - 2020																			
Average values	10,1%	11,9%	16,55	1,78																			
Total projected	n/a	n/a	2.325	250																			
4	Significant Innovations	<p>The key achievements v3.0 contains the latest information about key achievements from Phase 2 projects (not previously reported) and Phase 3 projects.</p> <p> Key achievements v3.0.docx</p> <p>The key achievements v3.1 is the latest version reporting more than 100 key achievements.</p> <p> Key achievements v3.1.docx</p>		<p>Section 3.2.1.4 presents in more detail the significant innovations</p>																			

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


	KPI domain	Key Performance Indicator (KPI)	Value in 2021	Baseline at the start of H2020 (latest available)	Target (for the cPPP) at the end of H2020	Comments
1	Performance	P1. Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010	Analysis about the KPis (network and verticals) can be found at 2 white papers released in 2021 and two white papers released in 2022			A detailed analysis for the Performance KPis can be found at section 3.2.2.1
2	Performance	P2. Reducing the average service creation time cycle from 90 hours to 90 minutes				
3	Performance	P3. Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people				
4	Performance	P4. Creating a secure, reliable and dependable internet with a "zero perceived" downtime for services provision				
5	Business	B1. Leverage effect of EU research and innovation funding in terms of private investment in R&D for 5G systems in the order of 5 to 10 times	<ul style="list-style-type: none"> • 13,58 considering Large Industry and SMEs • 10,93 considering all types of beneficiaries 		Between 5 and 10	The methodology used for this assessment is described in Section 3.2.1.1.
6	Business	B2. Target SME participation under this initiative commensurate with an allocation of 20% of the total public funding	The SME participation in 5G PPP projects has been increasing in 2020 to reach and even exceed the original objective of 20% (i.e., 21,95%) participation		20%	An analysis of the impact of the 5G PPP on the SME community, including information on the reported KPI can be found in Annex 6.

			defined as a KPI of the programme.																								
7	Business	B3. Reach a global market share for 5G equipment & services delivered by European headquartered ICT companies at, or above, the reported 2011 level of 43% global market share in communication infrastructure	<u>Publicly available reports suggest that EU HQ companies currently have more 30% of total worldwide telecom equipment market.</u>			This KPI is further discussed in section 3.2.2.2																					
8	Societal	S1. Enabling advanced user -controlled privacy				This KPI is presented in Section 3.2.2.3																					
9	Societal	S2. Reduction of energy consumption per service up to 90% (as compared to 2010)				This KPI is presented in Section 3.2.2.3																					
10	Societal	S3. European availability of a competitive industrial offer for 5G systems and technologies				This KPI is presented in Section 3.2.2.3																					
11	Societal	S4. Stimulation of new economically-viable services of high societal value like U-HDTV and M2M applications				For this KPI please refer to section 3.2.2.3																					
12	Societal	S5. Establishment and availability of 5G skills development curricula (in partnership with the EIT)	<table><tr><th>2014-2020</th><th colspan="2">New 5G curricula and/or educational qualifications</th></tr><tr><th></th><th>Average</th><th>Total projected</th></tr><tr><td>Overall</td><td>3,06</td><td>3.120</td></tr><tr><td>Large Industry</td><td>2,00</td><td>926</td></tr><tr><td>SME</td><td>4,33</td><td>1.101</td></tr><tr><td>Academic Institution</td><td>2,89</td><td>442</td></tr><tr><td>Research Center</td><td>4,40</td><td>651</td></tr></table>			2014-2020	New 5G curricula and/or educational qualifications			Average	Total projected	Overall	3,06	3.120	Large Industry	2,00	926	SME	4,33	1.101	Academic Institution	2,89	442	Research Center	4,40	651	The methodology used for this assessment is described in section 3.2.2.3
2014-2020	New 5G curricula and/or educational qualifications																										
	Average	Total projected																									
Overall	3,06	3.120																									
Large Industry	2,00	926																									
SME	4,33	1.101																									
Academic Institution	2,89	442																									
Research Center	4,40	651																									

Annex 9 – Contribution to Programme-Level KPI's

	Key Performance Indicator	Definition/Responding to question	Type of data required	Data [Commission]	Baseline at the start of H2020 (latest available)	Target (for the cPPP) at the end of H2020	Comments
1	Patents	Also, an analysis of the data in the latest publicly available reports such as IPlytics (June 2022), indicates that European headquarter companies share a 15,59% of active and granted 5G US or EP granted patent families. As the report indicates “However, not all self-declared patents are essential and valid, also SEPs vary by value – with some covering core technologies of the standard and others only claiming inventions on minor improvements to the standard”. This is why the same report also examines the number of approved technical 5G contributions of European companies. Their share is 37.04% and brings European	Number of patent applications. Number of patents awarded				Information on IPRs is always difficult to assess as certain time-periods are required from the IPR request submission to the grant of the patent.

		companies in the first place.					
2	<p>Standardisation activities (project level)</p> <p>Contributions to new standards (PPP level)</p>	<p>Online Standards Tracker</p> <p>Tracking activities in the Pre-standardization WG</p>	<p>Number of activities leading to standardisation</p>	<p>In terms of standardization activities, 5G PPP is an active contributor to 5G standardization globally. Overall, the 5G-IA Pre-Standardization WG has tracked 237 inputs based on specific and tangible inputs (e.g. technical reports, study/work item, PoC, new commercial requirements) as opposed to broader inputs collected in previous years. Most inputs have been submitted to 3GPP (96), IETF (50) and ETSI (38), with a growing number of inputs to IEEE, and inputs to sector associations working groups like 5GAA. Twenty-two projects (all Phase 3, except SliceNet) have contributed to two rounds of inputs in Q4-2020 and Q2-2021.</p>			

3	Operational performance	<ul style="list-style-type: none"> • ICT-42 • ICT-53 • ICT-41 • ICT-52 					All operational performance information is available at section 2.1
5	H2020 - LEIT - Number of joint public-private publications	<p>The document hereunder contains available information collected from the public sites Phase 3 projects.</p> <div data-bbox="389 679 593 807">  <p>Worksheet in 5G ppp</p> </div>	Information collected from cordis.europe.eu and project's sites	Phase 3 projects have produced 1249 publications so far (40% of which was published in scientific journals).			