



## Full5G – Fulfilling the 5G Promise

### D3.3: Verticals Cartography

Version: v1.0

Deliverable type	R (Document, report)
Dissemination level	PU (Public)
Due date	31/07/2020
Submission date	30/09/2020
Lead editor	Stephanie Parker (Trust-IT)
Authors	S. Parker, J. Favaro (Trust-IT), A. Kaloxylos (5GIA), D. Bourse (NBLF)
Work package, Task	WP3, T3.2
Keywords	5G, 5G PPP, Use-case experiments, Trials WG, Vertical stakeholders

---

#### *Abstract*

This deliverable describes advances in 5G capabilities through the use-case experiments tracked in the online 5G PPP Verticals Cartography. It covers phase 3 projects (ICT-17-18-19) and active phase 2 projects, analysing types of experiments (e.g. demonstrations, trials and pilots), coverage of ITU functionalities, geographical coverage, vertical clusters and ecosystems of the evolved and updated online tool and analysis.

---

**Document revision history**

<b>Version</b>	<b>Date</b>	<b>Description of change</b>	<b>List of contributor(s)</b>
v0.1	12/06/2020	ToC drafted with sections assigned to partners	S. Parker (Trust-IT)
0.2	26/06/2020	Sections 1, 2	S. Parker, J. Favaro (Trust-IT)
0.3	24/07/2020	Sections 2, 3	S. Parker (Trust-IT)
0.4	21/08/2020	Section 4	S. Parker (Trust-IT)
0.5	31/08/2020	Section 2 and 3	S. Parker, J. Favaro (Trust-IT)
0.6	08/09/2020	Section 2 and 3	S. Parker (Trust-IT), D. Bourse (NBLF)
0.7	21/09/2020	Section 4	S. Parker, J. Favaro (Trust-IT), D. Bourse (NBLF), A. Kaloxylos (5G-I-A)
0.8	28/09/2020	Section 5	S. Parker, J. Favaro (Trust-IT)
0.9	29/09/2020	Sections 4 and 5	S. Parker, J. Favaro (Trust-IT)
1.0	30/09/2020	All Sections, editorial check	S. Parker, J. Favaro (Trust-IT), A. Köhler (Eures)

**Disclaimer**

This report contains material which is the copyright of certain Full5G Consortium Parties and may not be reproduced or copied without permission.

All Full5G Consortium Parties have agreed to publication of this report, the content of which is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License<sup>1</sup>.

Neither the Full5G Consortium Parties nor the European Commission warrant that the information contained in the Deliverable is capable of use, or that use of the information is free from risk and accept no liability for loss or damage suffered by any person using the information.



**CC BY-NC-ND 3.0 License - 2020 Full5G Consortium Parties**

**Acknowledgment**

This report is based in parts on the outcomes of the previous Euro-5G, To-Euro-5G and Global5G.org CSA projects.

---

<sup>1</sup> [http://creativecommons.org/licenses/by-nc-nd/3.0/deed.en\\_US](http://creativecommons.org/licenses/by-nc-nd/3.0/deed.en_US)

## Executive Summary

FULL5G is tracking the use-case experiments on industry verticals in phases 2 and 3, using dedicated blueprints that collect data on the sector, experiment type, country and city location, and the targeted ITU 5G functionalities targeted. This is the basis for developing texts on each use case and feeding them into the online Verticals Cartography tool, where users can search by sector, country and functionality.

Launched in mid-September 2018 by Global5G.org, the tool is now being sustained and extended within FULL5G. Analyses and updates are coordinated through the Technology Board and Trials Working Group as an important showcase for the 5G PPP, also with a view to supporting gap analysis on the 5G technologies, features and functionalities targeted across diverse industry verticals.

Over 180 use-case experiments have been tracked and analysed through the blueprints for phases 2 and 3, and are being fed into the online Verticals Cartography tool.

Phase 2 use-case experiments are now coming to an end, with the final round of updates on the online Verticals Cartography planned for late December 2020.

Phase 3 experiments are now in full swing, bringing a larger portfolio of industry vertical applications and scenarios across a larger pool of countries, including outside EU27. Phase 3 also sees a shift towards use cases on manufacturing, transportation and logistics compared with the focus on broadcasting and media in phase 3.

- Industry (factory processes and automation), transport and logistics, broadcasting and media, smart cities make up 50% of the experiments in Phase 3.
- Use cases on automotive (17 in total) also show an important increase (up from 6 in phase 2), with most being examples of cross-border scenarios.
- Public safety has increased from 6 to 10, health from 3 to 11 and energy from 5 to 9 use cases while farming remains low at just 2 use cases.
- Examples of multiple verticals being tested in individual use cases include smart cities and transportation (smart mobility) and smart cities and new broadcasting and media services.

Phase 3 also marks a significant shift towards demonstrations, trials and pilots compared with phase 2: Only 3 proofs of concept compared with 12 in phase 2. There are no prototypes while demonstrations have increased from 15 to 19; demonstrations combined with trials from 4 to 14; demonstrations combined with trials and pilots from 7 to 10; trials up from 12 to 40; pilots up from 6 to 22.

The online tool has proven to be instrumental in showcasing the results and impacts of the 5G PPP use-case experiments, with the number of views increasing from 55,004 at the end of December 2019 (the Global5G.org delta) to 103,050 at the end of September 2020, with further impacts expected over the next 12 months of FULL5G.

Another highly effective dissemination mechanism is the annual competition organised by the Trials WG, enabling an assessment of 5G PPP results and impacts, including socio-economic impacts and the potential for market uptake and commercialisation. The 2020 competition also shows that the initiative is gaining momentum with 22 applications received and now being evaluated.

## Table of Contents

<b>Executive Summary .....</b>	<b>3</b>
<b>Table of Contents .....</b>	<b>4</b>
<b>List of Figures.....</b>	<b>6</b>
<b>Abbreviations.....</b>	<b>7</b>
<b>1 Introduction.....</b>	<b>9</b>
1.1 Introduction.....	9
1.2 Background and Context .....	9
1.2.1 Cartography Blueprint .....	9
1.2.2 Online Tool.....	10
1.2.3 Work Plan.....	10
<b>2 Phase 2 Project Portfolio Updates .....</b>	<b>12</b>
2.1 Coverage of Industry Verticals .....	12
2.2 Vertical Clustering Updates.....	13
2.2.1 Updated Statistical Overview .....	13
<b>3 Phase 3 Portfolio .....</b>	<b>19</b>
3.1 Phase 3 Portfolio Overview .....	19
3.2 Phase 3 Statistical Overview.....	20
3.2.1 Automotive and Cross-Border Scenarios .....	22
3.2.2 Broadcasting and Media .....	24
3.2.3 Energy.....	25
3.2.4 Health .....	26
3.2.5 Industry .....	28
3.2.6 Public Safety.....	29
3.2.7 Smart Cities and Tourism .....	31
3.2.8 Transportation and Logistics .....	32
<b>4 Trials and Pilots Brochures .....</b>	<b>34</b>
4.1 Brochure 2019 .....	34
4.1.1 5G-CAR.....	34
4.1.2 5G-MEDIA.....	35
4.1.3 5G-MONARCH .....	35
4.1.4 5G-Xcast.....	35
4.1.5 MATILDA.....	35
4.1.6 ONE5G.....	35
4.1.7 SliceNet .....	35
4.2 Brochure 2020 .....	35
4.2.1 5G-ESSENCE: Large-scale stadium .....	36
4.2.2 5G-PICTURE: Railway, Smart City and Stadium Use Cases .....	36

4.2.3	5G TRANSFORMER: eHealth Heart Attack Emergency.....	37
4.2.4	5G-XCast: Object-based Media.....	38
4.2.5	IoRL: Indoor 5G VLC/mmWave System.....	38
4.2.6	MATILDA: Smart City Intelligent Lighting .....	39
4.2.7	MetroHaul: Public Safety and Live Video Streaming .....	39
4.2.8	NRG-5: Predictive Maintenance as a Service .....	40
4.2.9	SliceNet: Smart Grid for self-healing power distribution network.....	41
4.2.10	5G-EVE: Industry 4.0 – Autonomous Vehicles in Manufacturing Environments .....	41
4.2.11	5G-VINNI: Remote Robotic Control with 360° VR-based Telepresence.....	42
<b>5</b>	<b>Impacts Achieved.....</b>	<b>43</b>
5.1	Sample of Website Updates.....	43
5.2	Impacts of online Tool.....	43
<b>6</b>	<b>Main Findings, Results and Next Steps .....</b>	<b>45</b>
	<b>References .....</b>	<b>46</b>

## List of Figures

Figure 1: Phase 2 Industry Vertical Mapping .....	12
Figure 2: Distribution of verticals across Phase 2.....	12
Figure 3: Phase 2 Country Coverage.....	13
Figure 4: Experiment Type Distribution in Phase 2.....	13
Figure 5: Distribution of 5G Functionalities .....	14
Figure 6: Phase 3 Industry Vertical Mapping .....	19
Figure 7: Phase 3 Distribution of Industry Verticals in Phase 3 .....	19
Figure 8: Icons for the Online Verticals Cartography .....	20
Figure 9: Country Coverage EU27.....	20
Figure 10: Country Coverage outside EU27 .....	21
Figure 11: Experiment Type in Phase 3 .....	21
Figure 12: Targeted 5G functionalities in Phase 3 .....	22
Figure 13: Automotive by experiment type .....	22
Figure 14: Automotive - Targeted 5G Functionalities .....	23
Figure 15: Broadcasting and Media by Experiment Type .....	24
Figure 16: Targeted 5G Functionalities for Broadcasting and Media.....	24
Figure 17: Experiment Type for Energy .....	25
Figure 18: Targeted 5G functionalities for energy .....	26
Figure 19: Experiment type for Health .....	27
Figure 20: Targeted 5G Functionalities for Health .....	27
Figure 21: Experiment Type for Industry .....	28
Figure 22: Targeted 5G Functionalities for Industry.....	28
Figure 23: Experiment Type for Public Safety .....	30
Figure 24: Targeted 5G Functionalities for Public Safety .....	30
Figure 25: Experiment Types for Smart Cities .....	31
Figure 26: Targeted 5G Functionalities for Smart Cities.....	31
Figure 27: Experiment Type for Transport and Logistics.....	32
Figure 28: Targeted 5G Functionalities for Transport and Logistics.....	32
Figure 29: 5G PPP Trial and Pilot Brochure 2019.....	34
Figure 30: Sample of Phase 2 Updates.....	43
Figure 31: Sample of Phase 3 entries on the online tool .....	43
Figure 32: Views of the Online Tool since December 2019 .....	44
Figure 33: Views of the Online Tool in FULL5G Year 1.....	44

## Abbreviations

<b>3GPP</b>	Third Generation Partnership Project
<b>5G</b>	Fifth Generation
<b>ACCA</b>	Anticipated Cooperative Collision Avoidance
<b>AGV</b>	Autonomous Guided Vehicles
<b>5G-ACIA</b>	5G Alliance for Connected Industries and Automation
<b>5GC</b>	5G Core Network
<b>5G PPP</b>	5G Infrastructure Public Private Partnership
<b>5G PPP Phase 2</b>	21 projects on the research and validation of 5G technologies and convergent technologies funded under H2020 ICT-07-2017 and ICT-08-2017.
<b>5G PPP phase 3</b>	3 projects on implementing and testing advanced 5G infrastructures funded under ICT-17-2018; 3 projects on implementing and testing advanced cross-border 5G infrastructures; 8 projects (including FULL5G) on advanced 5G validation trails across multiple vertical industries
<b>AR</b>	Augmented Reality
<b>CCAM</b>	Cooperative, connected and automated mobility
<b>CDN</b>	Content Distribution Network
<b>CMM</b>	Coordinate Measuring Machine
<b>COCOM</b>	Communications Commission
<b>DER</b>	Distributed Energy Resource
<b>DSS</b>	Decision Support System
<b>EM</b>	Electromagnetic (exposure)
<b>eMBB</b>	Enhanced Mobile Broadband
<b>ETP</b>	European Technology Platform
<b>ETSI</b>	European Telecommunications Standardisation Institute
<b>EV</b>	Electric Vehicle
<b>EU</b>	European Union
<b>GPS</b>	Global Position System
<b>IEC</b>	International Electrotechnical Commission
<b>IETF</b>	Internet Engineering Task Force
<b>IMT-2020</b>	International Mobile Telecommunications 2020
<b>IoT/IIoT</b>	Internet of Things/Industrial Internet of Things
<b>ITU</b>	International Telecommunications Union
<b>ITU-R</b>	ITU Radiocommunication Sector
<b>L4</b>	Level 4 automation for vehicles
<b>LV</b>	Low Voltage
<b>mMTC</b>	Massive Machine Type Communications
<b>MRL</b>	Market Readiness Level

<b>MV</b>	Medium Voltage
<b>NGMN</b>	Next Generation Mobile Networks
<b>OEM</b>	Original Equipment Manufacturer
<b>PPDR</b>	Public Protection & Disaster Recovery
<b>PSCE</b>	Public Safety Communications Europe
<b>Predictive QoS</b>	Predictive Quality of Service
<b>RAN</b>	Radio Access Network
<b>RRHLs</b>	Remote Radio Lightheds
<b>ToD</b>	Tele-operated Driving
<b>TRL</b>	Technology Readiness Level
<b>TSG</b>	Technical Specification Group
<b>UAS</b>	Unmanned Aerial System
<b>UAV</b>	Unmanned Aerial Vehicle
<b>UHD</b>	Ultra-high definition
<b>URLLC</b>	Ultra-Reliable and Low-Latency Communications
<b>UTM</b>	UAS Traffic Management
<b>VLC</b>	Visible Light Communications
<b>VR</b>	Virtual Reality
<b>VRU</b>	Vulnerable Road User
<b>V2X</b>	Vehicle-to-Everything
<b>ZDM</b>	Zero Defect Manufacturing



# 1 Introduction

## 1.1 Introduction

The online Verticals Cartography was conceived and developed within the Global5G.org Coordination and Support Action (July 2017-December 2019) with a view to tracking progress of 5G use-case experiments within 5G PPP phase 2 projects. In the latter part of Global5G.org, phase 3 projects (ICT-17-18-19) were incorporated and analysed.

FULL5G is a key opportunity to sustain and expand on these efforts. The purpose of this deliverable is to show how FULL5G is building on the outcomes reported in Global5G.org D2.4 Verticals Cartography, Final Version (March 2020), its inputs to the 5G-IA Trials WG and the impact created.

The rest of this document is structured as follows:

- Background and context for the online cartography, cartography blueprint: An analysis of all use case experiments, a brief history of the tool, status and future plan summaries.
- Portfolio of Use-case experiments with a comparative analysis (phases 2 and 3), with an assessment of phase 3 and newcomers to 5G PPP.
- Phase 2 updates based on the outcomes of demonstrations, trials etc.
- Impacts achieved.
- Main findings, results and future plans.

## 1.2 Background and Context

The Verticals Cartography was triggered by the Technical Board (TB) with a view to collecting a set of data points that would help classify and analyse use-case experiments targeting industry verticals in the 5G PPP, starting with phase 2 projects and progressing towards the integration of phase 3. The first step was the development of a blueprint to define data sets common across all projects.

### 1.2.1 Cartography Blueprint

The Cartography Blueprint is a spreadsheet that collects data for analysis on the following:

- **Vertical clustering:** The targeted industry vertical. References are harmonised as much as possible with terminology at both the programme level and 5G standardisation, with a few exceptional cases, as explained below.
- **Targeted ITU 5G functionality:** Enhanced Mobile Broadband (eMBB); massive machine type communications (mMTC); ultra-reliable low latency communications (URLLC).
- **Type of Experiment:** Proof of Concept; Prototype, Demonstration; Trial; Pilot, assessing maturity and rollout readiness levels.
- **Location:** City and country. References to dedicated test tracks are also included wherever relevant, e.g. automotive (5GCAR); cross-border corridors (5GCroCo, 5G-MOBIX, 5G-CARMEN).
- **Date of experiment:** Expressed as “Q-Year”, including multiple testing scenarios and targeted functionalities (as applicable), with possible variations due to the COVID-19 pandemic.
- **Ecosystem:** Summary of stakeholders involved across supply and demand, public and private organisations, helping to identify newcomers to 5G PPP.

## 1.2.2 Online Tool

The online tool covers the above information on the 5G PPP use-case experiments but has the goal of making the information easily digestible to people in the outside world, include the industry verticals that will benefit from R&I advances in coming years.

A brief history:

- Release 1.0 of the online Verticals Cartography was launched in mid-September 2018 (Global5G.org).
- Release 2.0 in April 2019 entailed a revamp of the content and layout of the use cases, integrating inputs received from projects (Global5G.org).
- Release 3.0 starting towards the end of Global5G.org includes the first round of new entries for the integration of phase 3 projects and continuous updates since October 2019 with the inclusion of inputs for the 1<sup>st</sup> 5G PPP Trials and Pilots Brochure (FULL5G).
- Release 4.0 coincides with the competition to select the top ten trials and pilots organised by the Trials WG, which will also feature in the 5G PPP Brochure 2020 on Trials and Pilots.

## 1.2.3 Work Plan

### 1.2.3.1 Current Status

FULL5G has picked up on the activities formerly undertaken by Global5G.org, updating entries to the online tool and the analysis of the use case experiments in phases 2 and 3. FULL5G is a member of the Trials WG and the Evaluation Committee for the annual competition, represented by 5G-I-A, NBLF, Trust-IT. Cartography updates are also shared with the Trials WG, where annual competitions take place to select the top ten trials and pilots in 5G PPP. A key criterion for the competition is having completed a trial or pilot with main outcomes and impacts. Hence, phase 2 projects are mostly targeted in that phase 3 projects are still under development, with trials and pilots also affected by delays due to COVID-19.

Activities have focused on:

- Collecting data to update the cartography from phase 2 and phase 3 projects.
- Tracking any demos, trials and pilots through dedicated email requests, and updating the content on the online tool.
- Adding new city locations, countries and icons to the online tool to reflect the data collected for phase 3 projects.
- Promoting the 2020 competition on the top trials and pilots across phase 2 and phase 3 projects. The 2020 competition is on-going with an application submission deadline for 09.09.2020.
- Monitoring impacts of the online tool, e.g. number of monthly views.

### 1.2.3.2 Future Steps

Future steps include:

- Assessing and selecting the top trials and pilots through the WG Evaluation Committee.
- Publishing the successful applications as a graphically designed brochure.
- Feeding the content from the brochure applications and other updates into the online tool.
- Promotional campaigns through WP2.
- Impact reporting, including outcomes of the promotional campaigns.

The activities for the period M13-24 (September 2020-July 2021) will be reported in D3.5 (Verticals

Cartography) in July 2021. It will report on content updates, outcomes of the 2020 and 2021 showcase brochures, promotion and impact creation, highlighting how European businesses, public-sector organisations and place cases can benefit from 5G applications. In this context, place cases refer to unserved or underserved sectors and communities, e.g. rural areas with multiple types of businesses and also SMEs.

## 2 Phase 2 Project Portfolio Updates

### 2.1 Coverage of Industry Verticals

The image below shows the distribution of industry vertical coverage across phase 2.



Figure 1: Phase 2 Industry Vertical Mapping

19 projects (13 research and innovation projects; 6 innovation actions) were funded under Phase 2, running between **June 2017** and **December 2020**. Collectively, 62 use-case experiments have been analysed in the Cartography Blueprint and uploaded on the online tool. The figure below shows the distribution across verticals, where the highest distribution is broadcasting and media (28%), smart cities (21%), automotive (10%) and the lowest on farming and agriculture (1.5%), industry (industrial processes and automation) (6.5%) and health (6.5%).

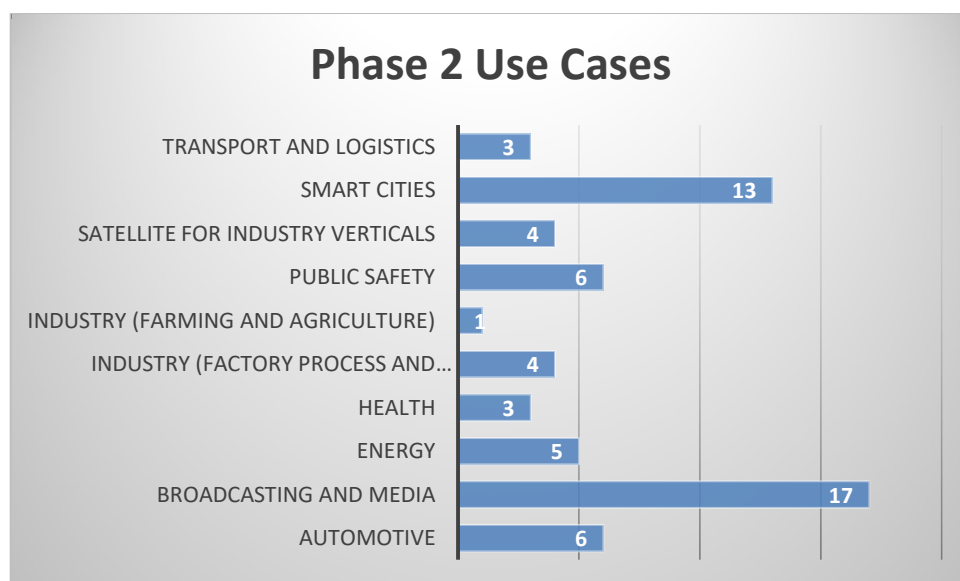


Figure 2: Distribution of verticals across Phase 2

## 2.2 Vertical Clustering Updates

### 2.2.1 Updated Statistical Overview

Updates on use-case experiments have been triggered and tracked through the Trials WG. The main differences compared to the data reported in Global5G.org D2.4 refer to on-going testing activities in 2020, such as IoRL, MetroHaul, SliceNet, as well as projects that have reported changes to their testing timelines and in some cases, changes to the locations.

The updated country coverage is showed in the figure below.

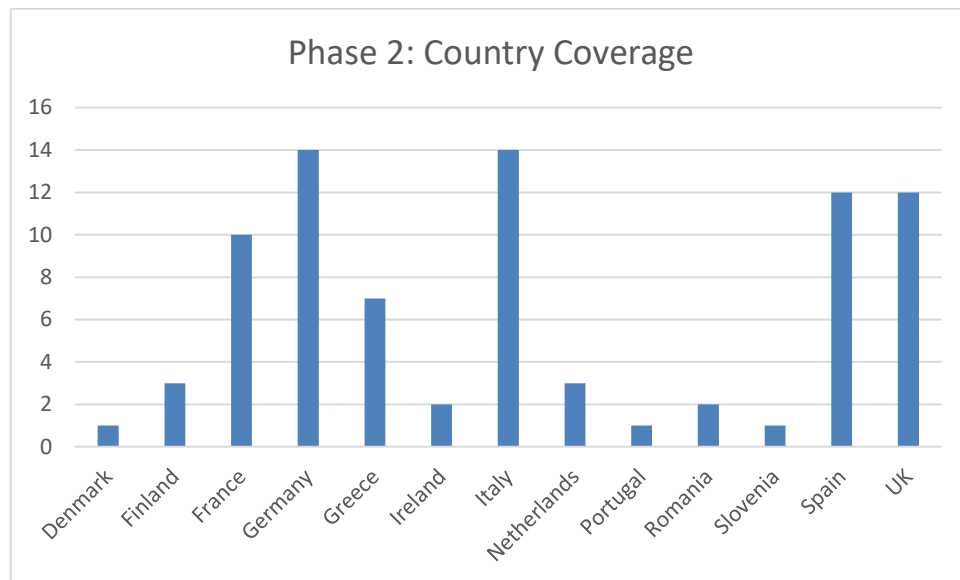


Figure 3: Phase 2 Country Coverage

The figure below shows the distribution by experiment type for phase 2 (61/62 use cases).

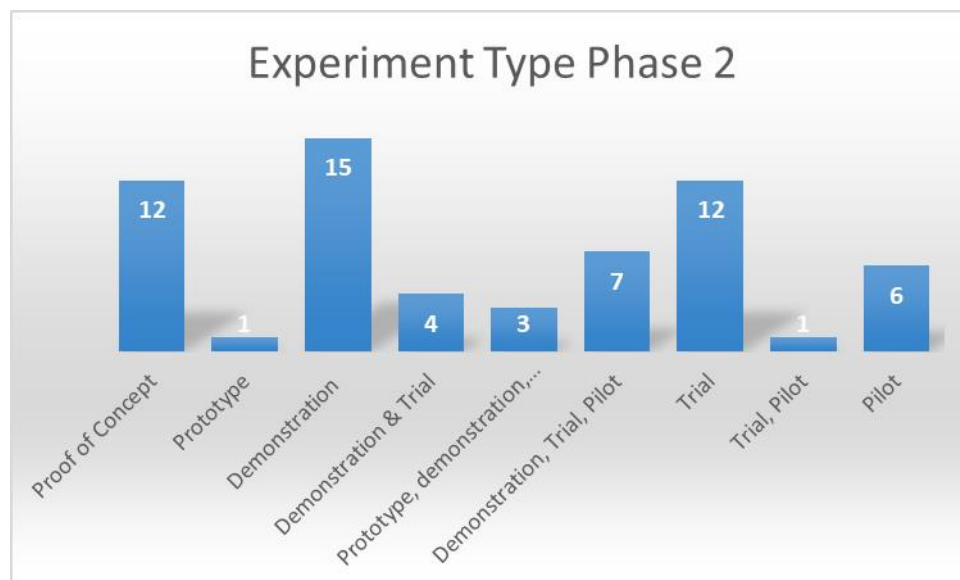


Figure 4: Experiment Type Distribution in Phase 2

The final distribution of 5G functionalities is showed in the graph below, where eMBB is the most targeted.

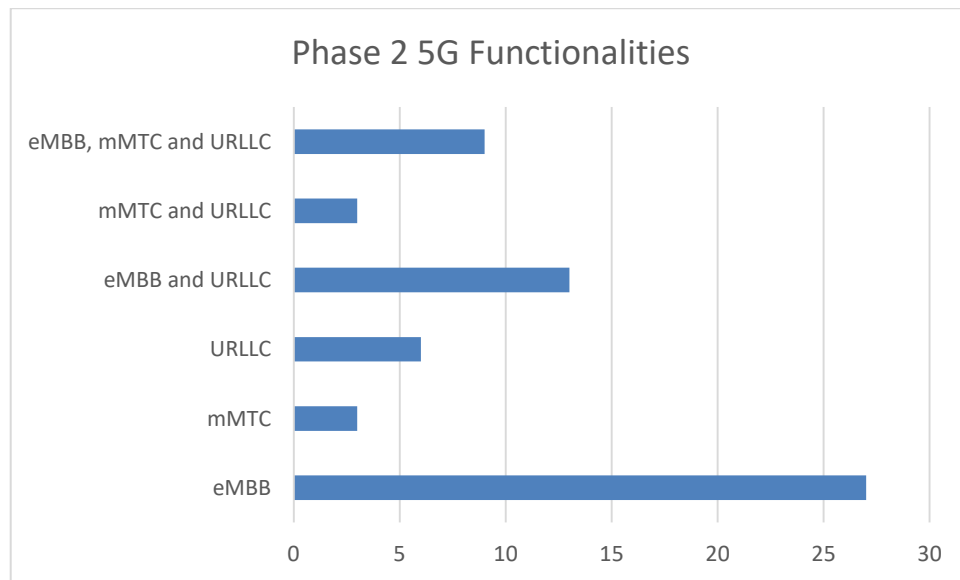


Figure 5: Distribution of 5G Functionalities

**Automotive:** 6 use-case experiments. The only change to previously reported analyses regards MATILDA.

- **5GCAR:** Demonstrations on lane merge coordination; cooperative perception (see-through); vulnerable road user protection, all targeting eMBB and URLLC and all conducted at the test track, UTAC-CERAM test track in Linas, France, in June 2019. 5G functionalities and technologies include edge computing, network slicing, low latency side link communication and NR positioning. See-through and VRU Protection demonstrations are featured in the 5G PPP Brochure on Trials and Pilots 2019.
- **5G-TRANSFORMER:** A proof of concept on intersection avoidance, targeting eMBB, URLLC and mMTC with testing in Q4-2018 in Italy. 5G functionalities and enablers include low latency, high availability, positioning accuracy, energy reduction, service creation time.
- **MATILDA:** A demonstration on remote control and monitoring of automobile electrical systems targeting URLLC. 5G functionalities and enablers include end-to-end orchestration mechanisms. The testing took place only in Bremen and not also in Bristol as originally planned and in Q2-2020, not in Q1-2020, with updates published on the online tool.
- **ONE5G:** A proof of concept on tele-operated and assisted autonomous driving, targeting eMBB, URLLC. 5G functionalities and enablers include ultra-reliable low latency communications for V2X services.

**Broadcasting and Media:** 17 use-case experiments with no major changes with testing taking place between Q4-2018 and Q1-2020. Updates are mostly changes in timelines and locations, which have been tracked through the Trials WG. The cancellation of the Mobile World Congress 2020 also affected a few final piloting activities, e.g. 5GCity.

- **5GCity:** Demonstration, trial and pilot on video Acquisition and Production with Community media engagement in live events targeting eMBB and URLLC between Q4-2018 and Q4-2019 in Barcelona and Bristol. Demonstration, trial and pilot on UHD Video Distribution and Immersive Services targeting eMBB, URLLC, mMTC between Q4-2018 and Q4-2019 in Bristol and Lucca. Demonstration, trial and pilot on real-time transmission with mobile backpack unit targeting eMBB, URLLC, mMTC between Q4-2018 and Q4-2019 in Barcelona. 5G functionalities and enablers include edge computing (e.g. video production); core edge computing coordinated orchestration; reliable and high bandwidth 5G connections; low latency.
- **5G-ESSENCE:** Demonstration, trial and pilot on 5G Edge network acceleration for a stadium targeting eMBB at the stadium in Egaleo (Greece) in Q4-2019. Demonstration, trial and pilot on integrated in-flight connectivity and entertainment systems targeting eMBB, URLLC in

Q4-2019 in Munich. 5G functionalities and enablers include multitenancy; low latency and increased backhaul capacity.

- **5G-MEDIA:** Pilot on remote production in Madrid in Q4-2019 targeting eMBB and URLLC, which featured in the 5G PPP Trials and Pilots Brochure 2019. Demonstrations on ultra-high definition over content delivery network targeting eMBB, URLLC between Q4-2018 and Q4-2019. Demonstrations on immersive applications and VR targeting eMBB with the final demo in Q2-2019. 5G technology coverage includes low latency; high throughput; edge computing (e.g. compressing and re-encoding content, edge and serverless computing (improved service levels through user proximity); optimised network resources.
- **5G-PICTURE:** A trial on mega-event in stadium targeting eMBB, mMTC, URLLC and taking place in Q1-2020 in Bristol. 5G functionalities and enablers include ultra-high density and seamless service provisioning. This is one of the applications for the 5G PPP Trials and Pilots Brochure 2020.
- **5GTANGO:** A pilot on immersive media targeting eMBB and URLLC and taking place in Q4-2018 in Cologne. A communication suite also targeting eMBB/URLLC and taking place Q4-2018 in Vigo (Spain). 5G functionalities and enablers include QoS; latency; high throughput; dynamic monitoring and service chaining; integration of physical equipment; verification of service functionalities, performance and scalability.
- **5G-TRANSFORMER:** A proof of concept on live streaming targeting eMBB and taking place in Q3-2019 during the Spanish Golf Open tournament. 5G functionalities and enablers include low latency; high availability; resilience; high device density; service creation time and energy reduction.
- **5G-XCast:** A trial on distribution of media content at scale in future 5G networks in Q3-2019 in Munich targeting eMBB, featuring in in the 5G PPP Trials and Pilots Brochure 2019. A trial on object-based media over 5G in Q3-2019 targeting eMBB, which is one of the applications for the 2020 Brochure. 5G functionalities and enablers include eMBMS, Multilink.
- **MATILDA:** A demonstration on high-resolution media on demand targeting eMBB and taking place in Q2-2019 in Genoa and Milan (not in Bristol as originally planned). 5G functionalities and enablers include end-to-end orchestration mechanisms and policy enforcement mechanisms.
- **Metro-Haul:** A demonstration on crowdsourced video broadcast targeting eMBB, taking place in Q3-2020 (instead of Q1) and only in Bristol (not in Ipswich). Edge computing, end-to-end SDN controller (orchestrator), high-capacity re-configurable and flexible optical metro network, low-latency (real-time) connections. The use case is one of the applications for the Brochure 2020.
- **ONE5G:** A proof of concept on enhanced massive MIMO, targeting eMBB and taking place in Q2-2019 in Berlin. 5G functionalities and enablers include potential performance gains of massive MIMO technology in a multi-user and multi-cell environment.

**Energy:** 5 use-case experiments. Updates are changes in targeted dates and locations, as well as information collected through the brochure competition.

- **NRG-5:** Demonstrations on decentralised, secure and trusted plug and play, targeting mMTC/URLLC between Q4-2018 and Q4-2019 in Italy, France and Germany. Demonstrations on resilience and high availability via dispatchable demand response targeting URLLC between Q4-2018 and Q4-2019 in Italy and Germany. A trial on aerial predictive maintenance as a service in Stublach (UK) in Q4-2019 with intermittent testing in Arganda, Madrid and Quisimondo, Toledo. This use case is one the applications for the 2020 Brochure. 5G functionalities and enablers span mMTC via a vast number of smart meters and real-time control; eMBB communications for video streaming from drones with analysis to xMEC and the utilities control centre.
- **SLICENET:** A trial on 5G-enabled smart grid for self-healing power-distribution network, targeting URLLC in Q2-2020 in Aveiro. A trial on 5G-enabled smart lighting in smart cities in



Q4-2019 and Q2-2020 in Bucharest, targeting mMTC. Both are applications for the 2020 brochure.

**Health:** 3 use-case experiments, with a new one coming from SliceNet in 2020 in response to the COVID-19 crisis.

- **5G-TRANSFORMER:** A proof of concept on eHealth Heart Attack Emergency, targeting eMBB with live demonstrations in Q3-2019; Q1-2020. 5G functionalities and enablers include low latency; high availability; service creation time. The use case is among the applications for the 2020 Brochure.
- **SLICENET:** A trial on 5G smart health – connected ambulance targeting eMBB with testing in Q4-2019, Q2-2020 in Cork and featured in the 2019 brochure. A new trial in Q2-2020 called the BlueEye Project, which is part of the applications submitted for the 2020 Brochure. 5G functionalities and enablers include edge computing with customised network slicing for secure, real-time, ultra-reliable and low-latency broadband; QoS and QoE through intelligently managed sensors and actuators.

**Industry (factory process and automation):** 4 use-case experiments. Updates relate to some minor changes to testing timelines and locations.

- **5GTANGO:** A pilot on smart manufacturing targeting URLLC taking place in Q4-2018 in Detmold. 5G functionalities and enablers include function placement; QoS; low latency; network slicing; integration of physical equipment.
- **5G-TRANSFORMER:** A proof of concept on cloud robotics for industrial automation, targeting eMBB, mMTC, URLLC with testing in Q4-2018 in Italy. 5G functionalities and enablers include low latency, high availability, positioning accuracy.
- **MATILDA:** A demonstration on Industry 4.0 smart factory, targeting eMBB with testing in Q2-2020 (not Q1) and only in Bremen (not Bristol). 5G functionalities and enablers include end-to-end orchestration mechanisms.
- **ONE5G:** A proof of concept tested in Q2-2019 at a trial industrial environment in Aalborg. It targeted URLLC and mMTC (e.g. high number of low-end devices). 5G functionalities and enablers include stringent requirements for latency and reliability, e.g. wireless control and monitoring in factories; small cell 5G multi-connectivity schemes for enhanced reliability in URLLC services. The trial is featured in the 2019 brochure.

**Industry – Farming and Agriculture:** 1 proof of concept. No updates apply.

- **ONE5G:** A proof of concept on agriculture and basic connectivity as an example of underserved areas, targeting mMTC; URLLC, taking place in Q2-2019 in Athens and Rennes. Low-cost networks and long-range connectivity.

**Public safety:** 6 use-case experiments with minor updates to timelines and information from the 2020 brochure competition.

- **5G-ESSENCE:** Demonstration, trial and pilot on mission critical applications, targeting eMBB, URLLC and taking place in Q4-2019. 5G functionalities and enablers include end-to-end network slicing.
- **5G-XCast:** A trial on Public warning system (PWS), targeting eMBB and taking place in Q2-2019 in Turku. A trial on spectrum for 5G bands, also targeting eMBB and also in Turku. 5G functionalities and enablers include eMBMS.
- **MATILDA:** A trial on public protection and disaster relief (PPDR) and services orchestration with SLA Enforcement, targeting URLLC. 5G functionalities and enablers include end to end orchestration mechanisms, fault tolerance aspects. The trial is featured in the 2019 Brochure.
- **Metro-Haul:** A demonstration on network slicing for improving public safety, targeting URLLC and taking place in Berlin in Q3-2020. 5G functionalities and enablers include edge computing, end-to-end SDN controller (orchestrator), high-capacity re-configurable and flexible optical metro network, low-latency (real-time) connections. It is one of the



applications for the 2020 Brochure.

- **NGPaaS:** A prototype on Mission Critical Push to Talk (MCPTT), targeting eMBB and taking place in Q2-2018 with a focus on flexibility, scalability and resiliency.

**Satellite for industry verticals:** 4 demonstrations from. No updates apply.

- **SAT5G:** A demonstration on 5G cellular backhauling in rural areas targeting eMBB and taking place in Q4-2019 in Munich. 5G functionalities and enablers include satellite access for self-backhaul; network slicing, edge computing, multi-tenancy.
- **SAT5G:** A demonstration on 5G in homes and offices in rural areas targeting eMBB and taking place in Q4-2019 in Guildford. 5G functionalities and enablers include dual connectivity for self-backhaul (satellite and cellular); network slicing; edge computing; traffic steering between unicast and multicast resources.
- **SAT5G:** A demonstration on edge delivery and offload via satellite multicast targeting eMBB and taking place in Q4-2019 in Guildford. 5G functionalities and enablers include network slicing, edge computing (e.g. edge MEC as part of MNO delivery); traffic steering between unicast and multicast resources; secure multicast delivery with caching.
- **SAT5G:** A demonstration on 5G NR over satellite link targeting and taking place in Q4-2019 in Guildford.

**Smart cities and indoor spaces:** 13 use cases experiments, divided across smart-city applications; multiple verticals and indoor spaces, including hotspot areas; ultra-dense city areas; broadband access in crowded areas, e.g. 5G-PHOS, Bluespace, and indoor spaces such as video streaming, video communications and location based services, ultra-high broadband access, e.g. IoRL, Bluespace. Updates mostly apply to several on-going projects and projects ending in 2020.

- **5GCity:** Demonstration, trial and pilot on unauthorised waste dumping prevention targeting eMBB and URLLC and taking place between Q4-2018 and Q1-2020 in Lucca. Demonstration, trial and pilot on neutral host, targeting eMBB, URLLC, mMTC in Barcelona, Bristol, Lucca between Q4-2018 and Q1-2020. 5G functionalities and enablers include edge computing (video analytics; coordinated orchestration); end-to-end network slicing; reliable and high bandwidth 5G connections; multi-tenancy.
- **5G-MONARCH:** A trial on Touristic City targeting eMBB and taking place in Q2-2019 in Turin. 5G functionalities and enablers include service creation time, low latency, cost efficiency through resource elasticity. The trial is featured in the 2019 brochure.
- **5G-PHOS:** Demonstration and trial on PON-overlaid Dense City Area, targeting eMBB with testing in Q1-2020. Demonstration and trial on ultra dense city area and hot spot area targeting eMBB with testing in Q3-2020. Prototype, demonstration and trial on hot-spot areas and also with final testing in Q3-2020. 5G functionalities and enablers include high bandwidth fibre Wireless 5G C-RAN fronthaul deployed over existing PONs; ultra-capacity 5G Fibre Wireless C-RAN fronthaul for highly dense city areas; Gbps-grade mm-wave 5G fibre wireless C-RAN for massively dense hotspot areas.
- **5G-PICTURE:** Smart City demonstration using a test-bed targeting mMTC and taking place in Bristol in Q1-2020. The use case is one of the applications for the 2020 brochure. 5G functionalities and enablers include density and static-to-low mobility.
- **Bluespace:** Proofs of concept on broadband access in crowded areas; Indoor ultra-high broadband Access; co-existence with PONs, all targeting eMBB with testing in Q2-2020.
- **IoRL:** Concluding trials on indoor 5G visible light communication (VLC) and mmWave system in Q3- and Q4-2020 at the Building Research Establishment (Integer House) in Watford, UK. The use case is applicable to diverse indoor settings, such as homes, train stations, museums, supermarkets. It is one of the applications for the 2020 brochure.
- **MATILDA:** A joint trial with SliceNet on smart city intelligent lighting system targeting mMTC, taking place between June 2019 and June 2020. 5G functionalities and enablers include end-to-end orchestration mechanisms, IoT management. It is one of the applications

for the 2020 brochure.

- **ONE5G:** A trial on serving megacities through 5G technologies, targeting eMBB, mMTC, URLLC and taking place in Q2-2019. 5G functionalities and enablers include end-to-end network management with KQI-based monitoring; E2E latency. The trial is featured in the 2019 brochure.

**Transport and Logistics:** 3 use-case experiments. No updates apply apart from additional insights coming from one of the 2020 brochure applications.

- **5G-MoNArch:** A pilot on sea port targeting eMBB, URLLC, mMTC and taking place in Hamburg in Q2-2019. The pilot is featured in the 2019 brochure.
- **5G-PICTURE:** A trial on Railway testbed, targeting eMBB, URLLC, mMTC and taking place in Barcelona in Q4-2019. It is one of the applications for the 2020 brochure.
- **SaT5G:** A demonstration on 5G on board commercial airplanes targeting eMBB and taking place in Weissling (Bavaria) in Q4-2019.

## 3 Phase 3 Portfolio

### 3.1 Phase 3 Portfolio Overview

Phase 3 covers three different types of projects from calls ICT-17 (5G End to End Facilities for KPI validation); ICT-18 (cross-border corridor trials); ICT-19 (advanced 5G validation trials). The figure below shows the distribution of industry verticals.



Figure 6: Phase 3 Industry Vertical Mapping

The 13 projects analysed for phase 3 bring 124 use-case experiments running between **Q1-2020** and **Q3-2022**. As the use cases are detailed, they are uploaded on the online tool using a simplified version of the 2020 brochure competition template, that is, without results, except for those projects submitting an application.

The figure below shows the distribution by vertical.

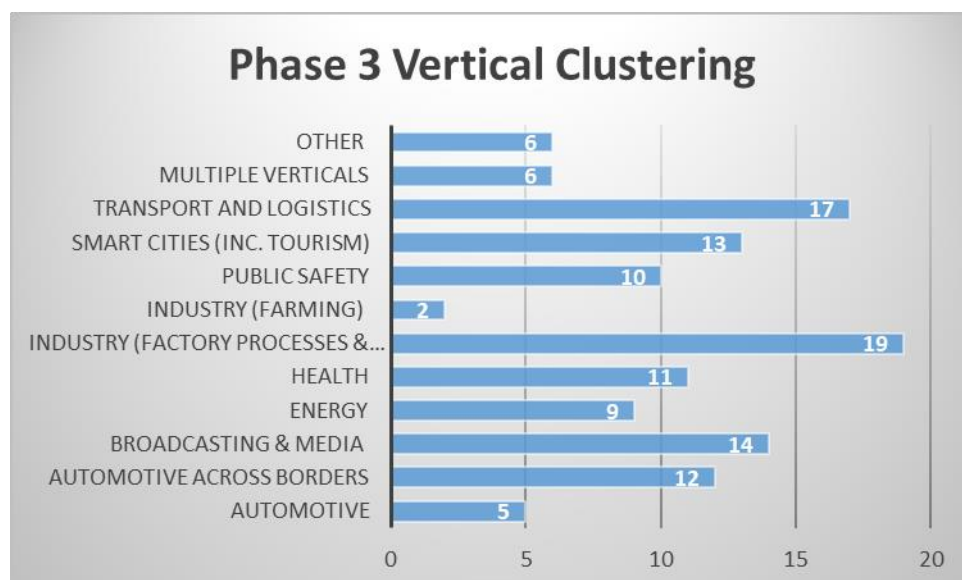


Figure 7: Phase 3 Distribution of Industry Verticals in Phase 3

Industry (factory processes and automation), transport and logistics, broadcasting and media, smart cities make up 50% of the experiments, marking a significant increase for the first two sectors compared with phase 2 (4 and 3 use cases respectively). Use cases on automotive (17 in total) also show an important increase (up from 6 in phase 2), with most being examples of cross-border

scenarios. Public safety has increased from 6 to 10, health from 3 to 11 and energy from 5 to 9 use cases while farming remains low at just 2 use cases. Examples of multiple verticals being tested in individual use cases include smart cities and transportation (smart mobility) and smart cities and new broadcasting and media services.

New icons have been created to capture the breadth of use cases. The figure below shows the full set of icons for the online tool.



Figure 8: Icons for the Online Verticals Cartography

### 3.2 Phase 3 Statistical Overview

The blueprint for phase 3 keeps track of the same core set of data as the phase 2 blueprint to enable a comparative analysis of progress towards 5G deployments across industry verticals.

The figures below show the country coverage of the use-case experiments in and outside EU27.

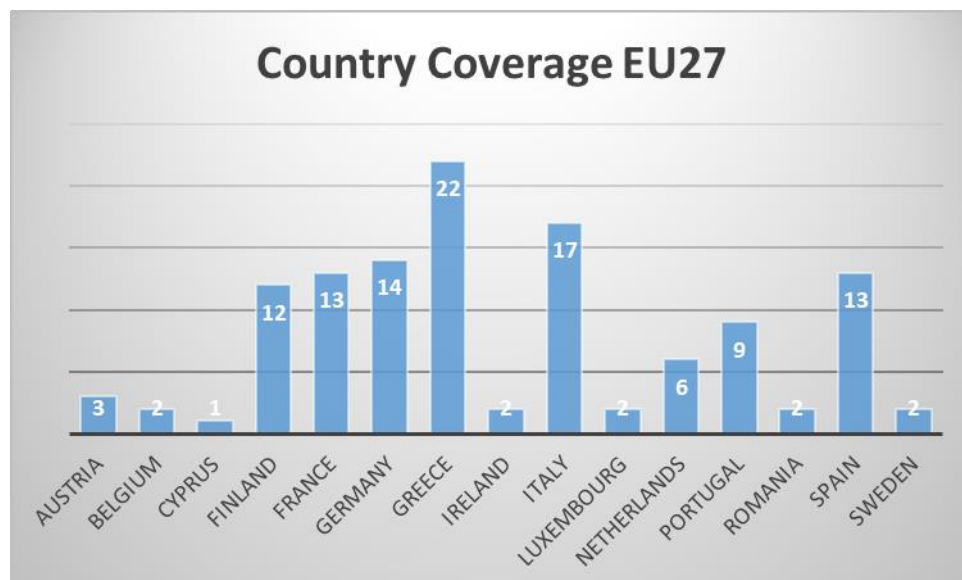


Figure 9: Country Coverage EU27

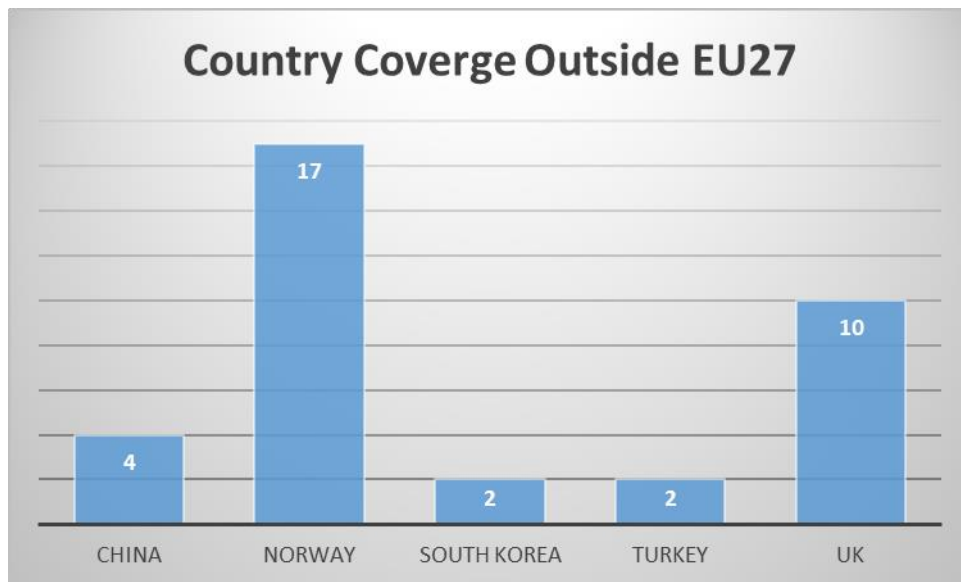


Figure 10: Country Coverage outside EU27

Compared with phase 2, there are two trends to note. Firstly, the number of EU27 participation has increased from 12 to 15 (120 use-case locations), where Greece, Italy, Germany, Spain and France have the highest number of use cases. Secondly, there is new coverage from countries outside the EU (35 use-case locations), notably Norway (48.5%) followed by the UK (28.5%), with China, South Korea and Turkey taking part in the cross-border automotive trials.

The figure below shows the distribution by experiment type (111/124 use cases reported by projects to date).

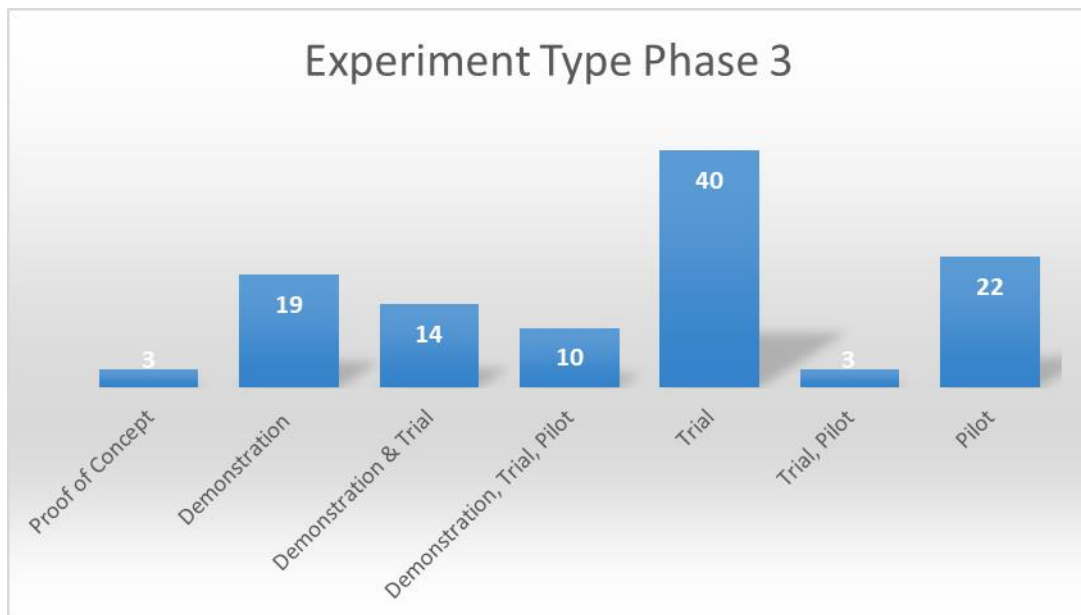


Figure 11: Experiment Type in Phase 3

Phase 3 marks a significant shift towards demonstrations, trials and pilots compared with phase 2: Down from 12 to 3 proofs of concept; no prototypes; demonstrations up from 15 to 19; demonstrations and trials up from 4 to 14; demonstrations, trials and pilots up from 7 to 10; trials up from 12 to 40; pilots up from 6 to 22.

Percentage comparison:

- **Proofs of concept:** Phase 2: 19.5%. Phase 3: 2.5%. **17% decrease.**
- **Prototypes:** Phase 2: 1.5%. Phase 3: 0%.

- **Demonstrations.** Phase 2: 24.5%. Phase 3: 17%. **7.5% decrease.**
- **Demonstrations and Trials:** Phase 2: 6.5%. Phase 3: 12.5%. **6% increase.**
- **Prototype, Demonstration and Trials:** 6.5%. Phase 3: 0%.
- **Demonstration, Trial and Pilot:** 11%. Phase 3: 9%. **2% decrease.**
- **Trials:** Phase 2: 19.5%. Phase 3: 36%. **16.5% increase.**
- **Trial and Pilots:** Phase 2: 1.5%. Phase 3: 2.5%. **1% increase.**
- **Pilots:** Phase 2: 9.5%. Phase 3: 19.5%. **10% increase.**

The figure below shows the targeted 5G functionalities for phase 3 projects.

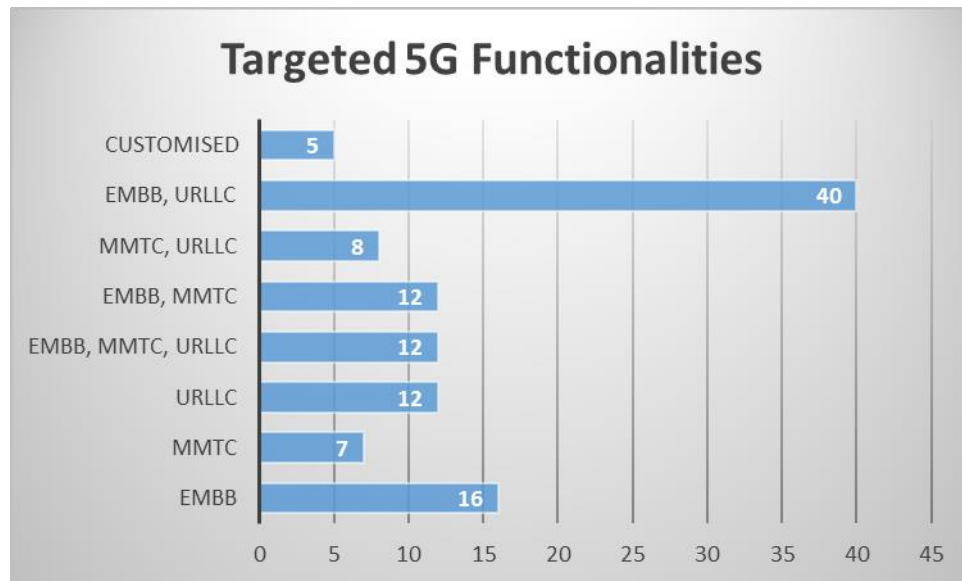


Figure 12: Targeted 5G functionalities in Phase 3

### 3.2.1 Automotive and Cross-Border Scenarios

There are 5 automotive and 12 automotive cross-border use cases, which are distributed by experiment type and targeted 5G functionalities as shown in the figures below.

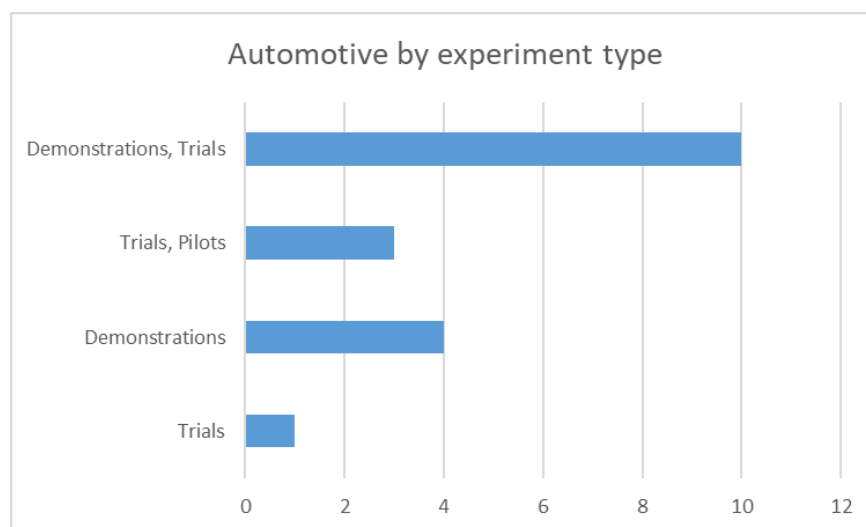


Figure 13: Automotive by experiment type



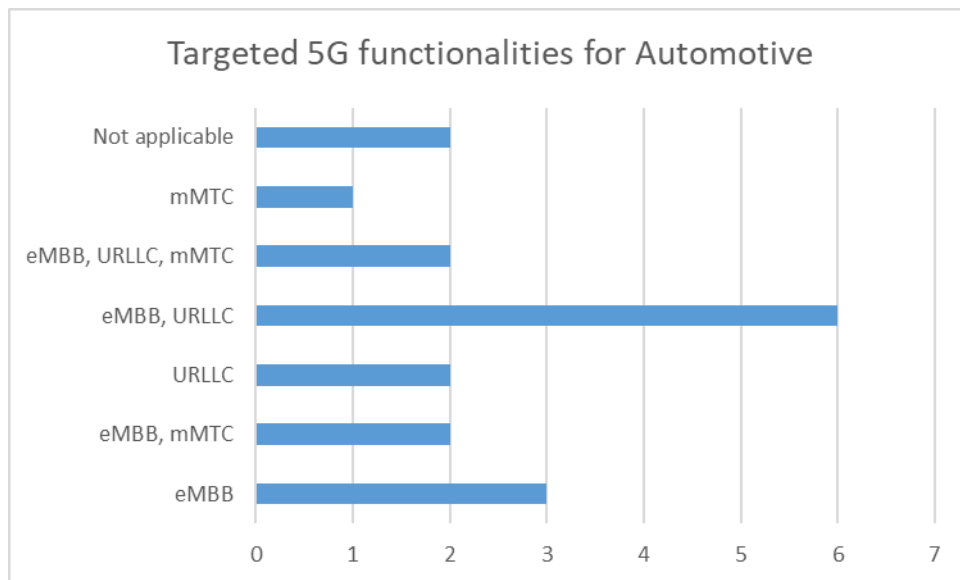


Figure 14: Automotive - Targeted 5G Functionalities

Automotive use cases:

- **5G-HEART:** Demonstrations and trials on platooning (eMBB, URLLC), autonomous/assisted driving (URLLC), remote driving (eMBB, URLLC) and remote diagnosis (mMTC) planned for Q1-2021 and Q3-2022 in the UK (Surrey), Finland (Oulu), Netherlands (Groningen).
- **5G-VINNI:** Trial on autonomous edge on-board satellite connected vehicle (eMBB, mMTC) planned for Q1-2022, Q3-2022 (location independent).

Concurrent testing across verticals:

- **5G-HEART:** multiple slices associated with different vertical applications, e.g. Automotive and Health on a single 5G infrastructure (eMBB, URLLC, mMTC) planned in Q1-2022, Q3-2022 in the UK (Surrey).

The cross-border scenario use cases are:

- **5GCARMEN:** Four demonstrations on Cooperative Manoeuvring; Situation Awareness; Video Streaming; Green Driving, targeting eMBB (e.g. video streaming) and URLLC (e.g. cooperative manoeuvring). Demonstrations are carried out along the 600-km road corridor from Bologna to Munich linking the regions of Bavaria, Tirol and Trentino. Examples of its investigations include mobile network synergies between LTE, 5G, C-V2X and other technologies with the aim of guaranteeing not only data rate requirements but also the coverage needed at all times.
- **5GCroCo:** Three trials and pilots on Teleoperated Driving (ToD); Generation and Distribution of High Definition Maps; Anticipated Cooperative Collision Avoidance, targeting eMBB and URLLC. Its R&I activities focus on distributed computing enabled by mobile edge computing, Predictive Quality of Service (QoS), functional safety and security. Small-scale test sites include the UTAC test track in Montlhéry (South of Paris), a 5G-connected mobility test-site (Germany), a section of the A9 motorway between Nuremberg and Greding, a test-site in Munich city centre, the AstaZero test track (near Gothenburg). Corridor cross-border sites are located between Germany and Luxembourg; France and Germany. Small-scale testing started in June 2020.
- **5G-MOBIX:** Five demonstrations and trials for each use case, with testing planned for Q1-2021 and Q3-2021. Advanced Driving (lane merge, overtaking, collision avoidance), targeting eMBB and URLLC. Vehicles Platooning (see-what-I-see, L4 platooning), targeting eMBB + mMTC. Extended sensors (assisted border crossing, cooperative perception / HD maps), targeting eMBB, URLLC, mMTC. Remote Driving (automated shuttle, tele-operation, remote manoeuvre), targeting eMBB and URLLC. Vehicle QoS support (public transport scenarios,

tethering via vehicle), targeting eMBB. EU27 country coverage: Finland, France, Germany, Greece, Netherlands, Portugal, Spain. International/outside EU27: China, South Korea, Turkey.

### 3.2.2 Broadcasting and Media

There are 18 use cases on broadcasting and media, including multiple vertical scenarios. These are distributed by experiment type and targeted 5G functionalities as shown in the figure below.

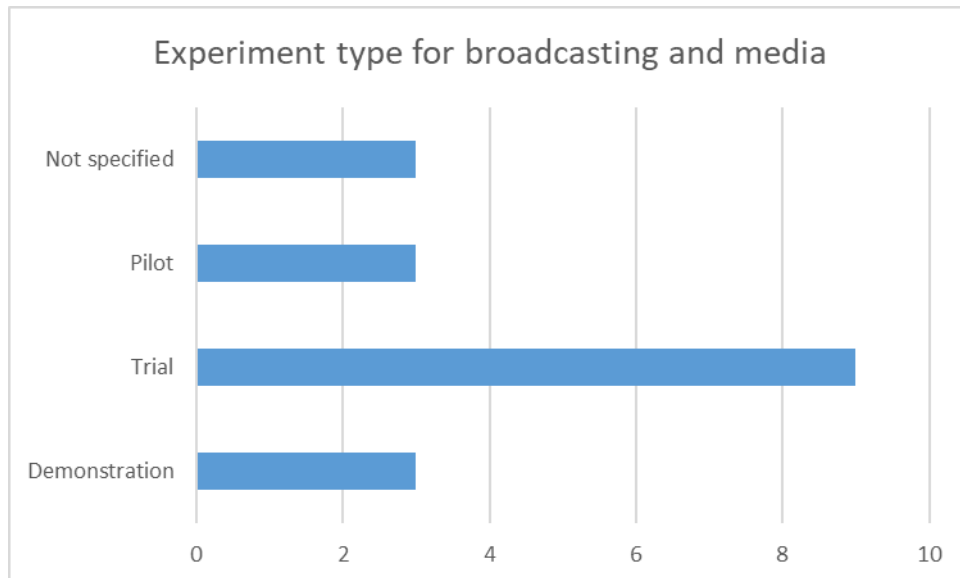


Figure 15: Broadcasting and Media by Experiment Type

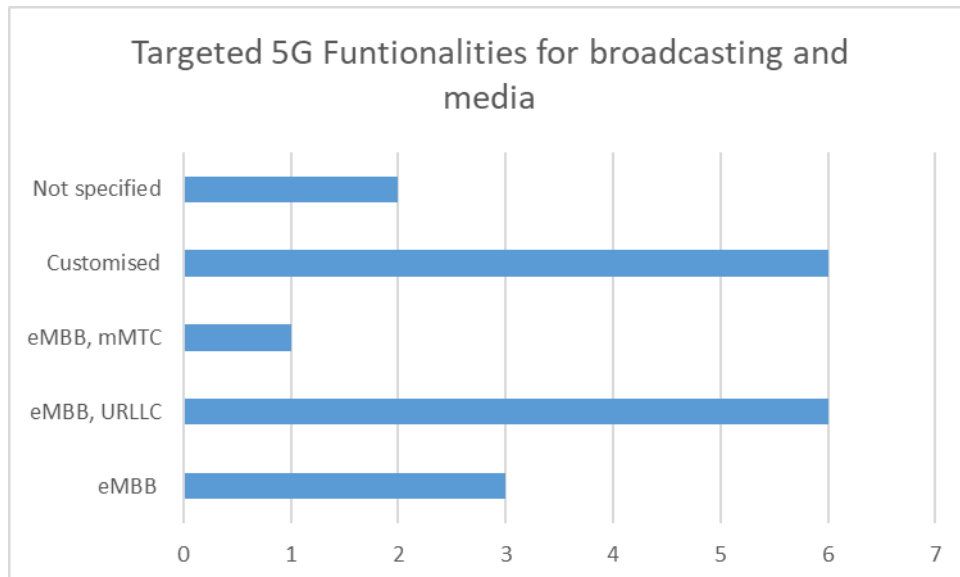


Figure 16: Targeted 5G Functionalities for Broadcasting and Media

In phase 3, this vertical is one of the most impacted by COVID-19 due to the lack of live events (e.g. sports, concerts etc.) as reported by several projects. Timelines may therefore change depending on how the pandemic evolves.

- **5G-EVE:** Pilot on UHF Media, On-site Live Event Experience and Immersive and Integrated Media targeting eMBB with testing planned for Q3-2020 and Q2-2021 in Madrid.
- **5GENESIS:** A demonstration, Festival of Lights, targeting eMBB, URLLC in Q3-2020 in Berlin. A trial at a large-scale public event targeting eMBB, mMTC in Athens planned for Q2-



2020 (small-scale) and Q4-2020 (full-scale).

- **5G-SOLUTIONS:** A trial on ultra-High-Fidelity Media planned for Q4-2020, Q2-2021 and Q2-2022. An experiment on onsite live event experience planned for 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 with first-phase testing completed in Q3-2020 with further testing planned for 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 with customised slicing.
- **5G-TOURS:** Two experiments, one on high quality video services distribution and one on remote and distributed video production, both in Turin in 2022.
- **5G-VICTORI:** One pilot on CDN services in dense static and mobile environments, targeting eMBB, where the only confirmed testing date is Q3-2021 with earlier testing being dependent on the evolution of COVID-19.
- **5G-VINNI:** A trial on media production and distribution use cases targeting eMBB and URLLC planned for Q3-2020 and Q4-2021 in Oslo. A trial on QoS Management for Media Broadcast in Martlesham, UK in Q1-2020.

Examples of multiple verticals with broadcasting and media include:

**5GENESIS** (public safety): Sport event in Surrey targeting eMBB, URLLC in 2020/2021.

**5G-VINNI** (smart cities – tourism): Pilot with 5G-SOLUTIONS on 360° immersive experience (including ultra-high-fidelity media and multi CDN selection), targeting eMBB in Patras and planned for Q3-2020 and Q2-2022. A trial (smart cities) on 360° immersive experience in Martlesham (UK) and Leganés (Spain) targeting eMBB, URLLC and planned for Q1-2020, Q2-2021. A trial on efficient edge content delivery via satellite multicast/broadcast targeting eMBB, URLLC (location independent) planned in Q2-2021.

Several of the 5G-VINNIs trials and pilots will take place with 5G-SOLUTIONS.

### 3.2.3 Energy

There are 9 use case experiments on energy, distributed by experiment and 5G functionalities as follows:

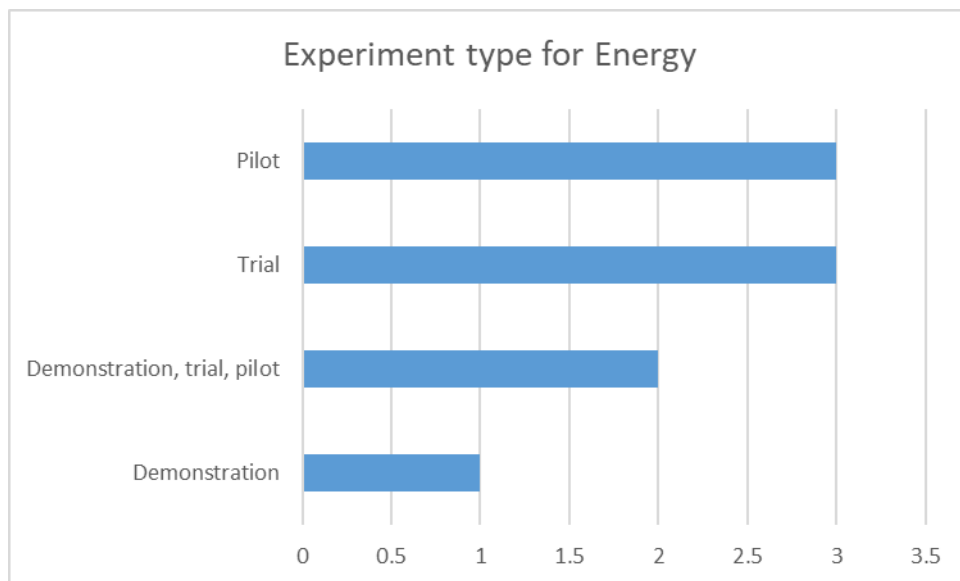


Figure 17: Experiment Type for Energy

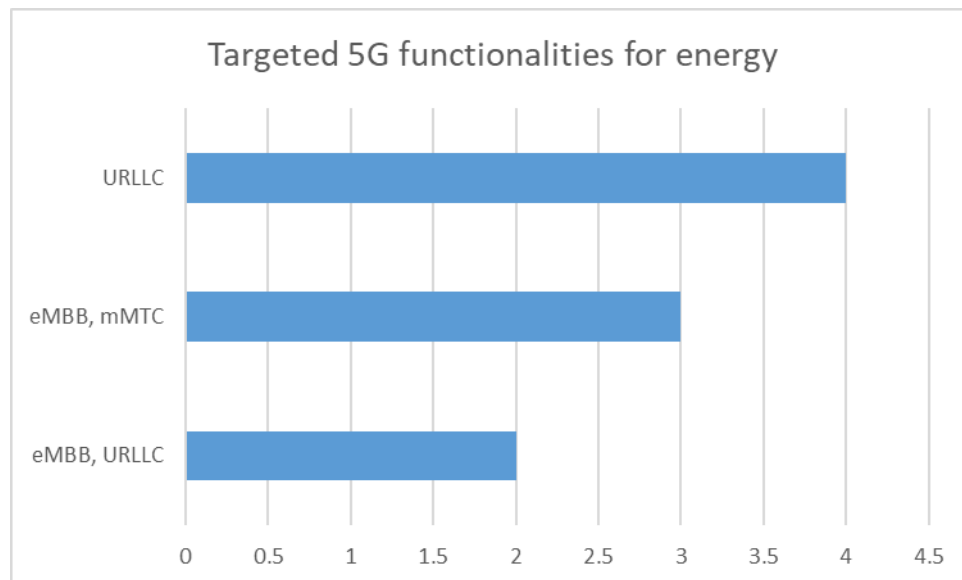


Figure 18: Targeted 5G functionalities for energy

- **5G-EVE:** A pilot on fault management for distributed energy generation in Smart Grids targeting URLLC, mMTC and planned for Q3-2020 and Q2-2021 in Paris. A demonstration on smart electricity management for power grid control and one on fault management for distributed energy generation in smart grids, both targeting URLLC/mMTC in Q1-2020 and Q2-2021.
- **5G-GROWTH:** A demonstration, trial and pilot on advanced monitoring and maintenance support of secondary substation - Medium Voltage/Low Voltage (MV/LV) distribution substation in Q2-2021 and Q4-2021 targeting eMBB and URLLC. A demonstration, trial and pilot on advanced critical signal and data exchange across wide smart metering and measurement infrastructures in Q2-2021 and Q4-2021 targeting URLLC.
- **5G-SOLUTIONS:** A trial on industrial demand side management in Q4-2020, Q2-2021 and Q2-2022 targeting URLLC. A trial on electrical vehicle (EV) smart charging in Q4-2020, Q2-2021 and Q2-2022 targeting URLLC. A trial on electricity network frequency stability in Q4-2020, Q2-2021 and Q2-2022 targeting URLLC.
- **5G-VINNI:** A pilot on Energy Metering for HV and LV targeting URLLC, mMTC and planned for Q2-2020 in Patras with 5G-VICTORI. A pilot on critical signal and data exchange for smart grids targeting eMBB, URLLC and planned for Q4-2020 in Aveiro.

### 3.2.4 Health

The figure below shows the experiment type for health with a mix of demonstrations and trials, with four use cases still to define the specifics.

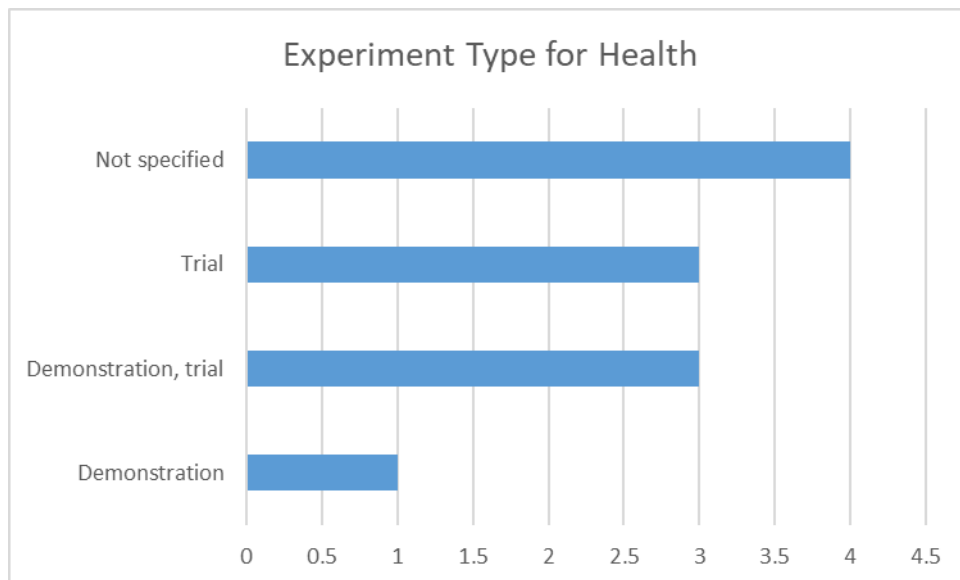


Figure 19: Experiment type for Health

The figure below shows the distribution of 5G functionalities targeted.

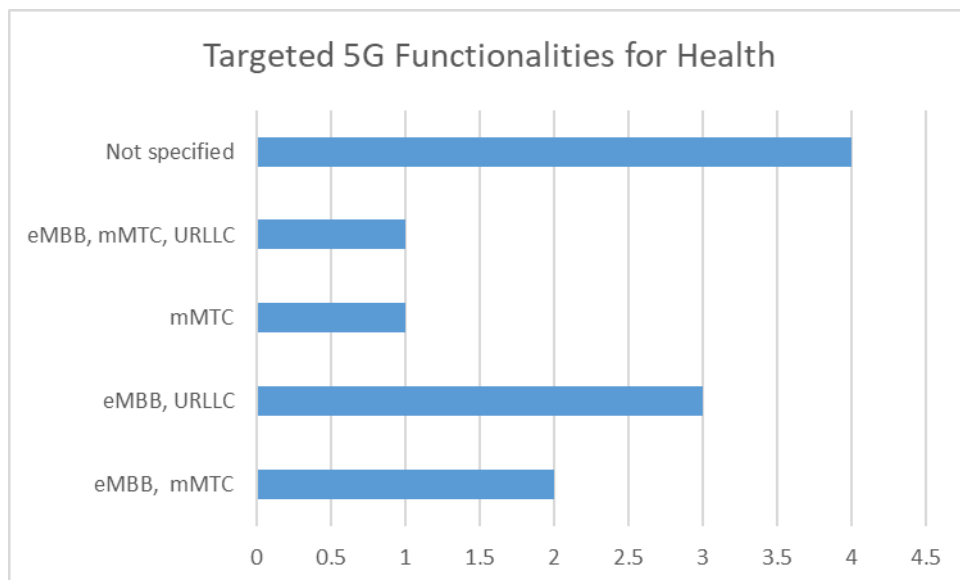


Figure 20: Targeted 5G Functionalities for Health

- **5G-EVE:** A demonstration on connected ambulance targeting eMBB and mMTC, Q3-2020 and Q2-2021. A trial on remote eHealth monitoring and forecasting, targeting eMBB, mMTC and URLLC, Q1-2020 and Q2-2021.
- **5G-HEART:** A demonstration and trial on vital-sign patches with advanced geo-localisation in Q1-2021 and Q3-2022 targeting mMTC. A demonstration and trial on remote interventional support in Q1-2021 and Q3-2022 targeting eMBB and URLLC. A demonstration and trial on automatic polyp detection in Q1-2021 and Q3-2022 targeting eMBB and URLLC.
- **5G-TOURS:** Four experiments on remote health monitoring and emergency situation notification; teleguidance for diagnostics and intervention support; wireless operating room and optimal ambulance routing planned for 2022 in Rennes with more details expected in October 2020.
- **5G-VINNI:** A joint trial on eHealth use cases with 5G-HEART targeting eMBB and URLLC in Q3-2020 in Oslo and Martlesham. A trial on sensor network for use in Healthcare targeting eMBB and mMTC in Martlesham.

The example for multiple verticals comes from **5G-HEART** and **5GENESIS**. Concurrent testing on multiple verticals, e.g. automotive and health. Demonstration and trial in Q1-2022 and Q3-2022 targeting eMBB, URLLC and mMTC.

### 3.2.5 Industry

The figure below shows the types of experiments for industry, both factory processes and automation and farming and agriculture. Trials are the most common type.

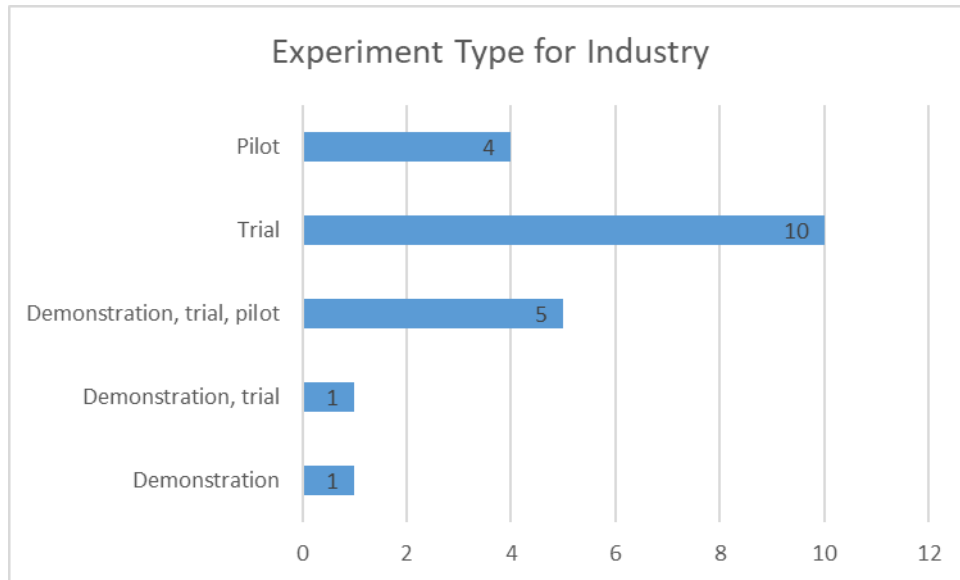


Figure 21: Experiment Type for Industry

The figure below shows the distribution of targeted 5G functionalities for the industry experiments.

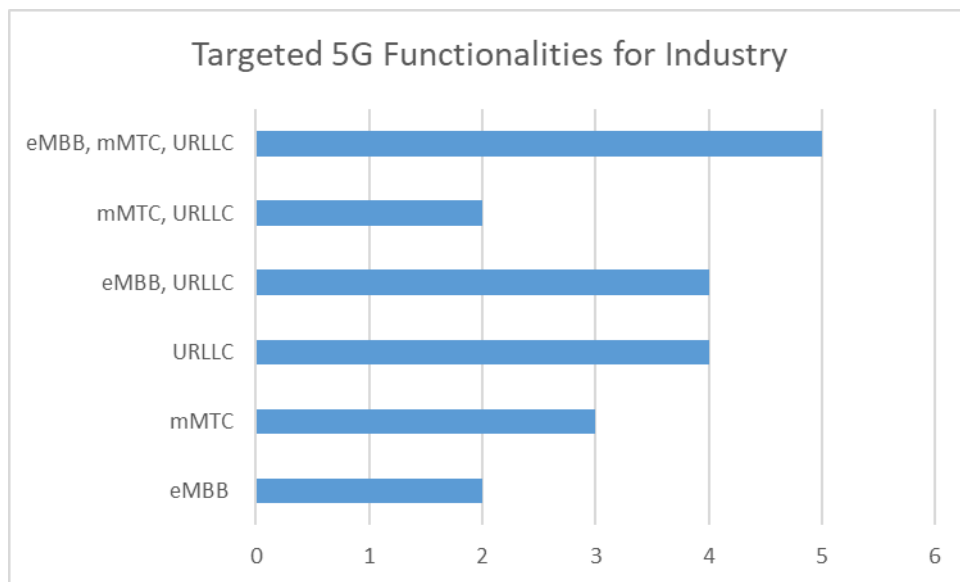


Figure 22: Targeted 5G Functionalities for Industry

#### 3.2.5.1 Farming and Agriculture

**5G-HEART**: A demonstration and trial on the remote monitoring of water and fish quality in Q1-2021 and Q3-2022 in Athens and Trondheim targeting eMBB, mMTC and URLLC.

**5G-VINNI and 5G-HEART**: A joint trial on the aquaculture use case in Q3-2020 targeting eMBB, URLLC.

### 3.2.5.2 Factory Processes and Automation

Examples include functionalities, such as slices for eMBB (live streaming) and URLLC to control the synchronisation of the video stream and the virtual joystick. M2M communications.

- **5G-EVE:** A pilot on Autonomous Vehicles in Manufacturing Environments (Spain), targeting URLLC. The first implementation of the pilot took place at the 5GTonic lab, where a circuit for Autonomous Guided Vehicles (AGVs) was deployed. The trial results were showed at EuCNC 2019 and to verticals such as PSA, Volkswagen, Innovalia and Gestamp Group. Further piloting is planned for Q2-2020 in Madrid.
- **5GROWTH:** A demonstration, trial and pilot on connected worker remote operation of quality equipment, targeting eMBB and URLLC in Q2-2021 and Q4-2021. A demonstration, trial and pilot on connected worker augmented zero defect manufacturing (ZDM) and decision support system (DSS) in Q2-2021 and Q4-2021 targeting eMBB. A demonstration, trial and pilot on digital twin apps, targeting URLLC in Q2-2021 and Q4-2021. A demonstration, trial and pilot on telemetry/monitoring apps in Q2-2021 and Q4-2021 targeting mMTC. A demonstration, trial and pilot on digital tutorials and remote support in Q2-2021 and Q4-2021 targeting eMBB.
- **5G-SOLUTIONS:** A trial on time-critical process optimisation in digital factories in Q3-2020 and Q2-2022 targeting eMBB, mMTC and URLLC. A trial on non-time critical communication in factories in Q3-2020 and Q2-2022 targeting mMTC. A trial on remotely controlling digital factories in Q3-2020 and Q2-2022 targeting eMBB, mMTC and URLLC. A trial on connected goods in Q3-2020 and Q2-2022 targeting URLLC. A trial on rapid deployment, auto/re-configuration, testing of new robots in Q3-2020 and Q2-2022 targeting eMBB, mMTC and URLLC.
- **5G-VICTORI:** A pilot on factories of the future digital utilities targeting mMTC and URLLC, with testing in Q2-2020 and Q3-2021. A pilot on energy metering for HV (150Kv/20Kv) and LV, targeting URLLC (pilot in Greece) and mMTC (pilot in Romania).
- **5G-VINNI:** A pilot on Digital Utilities with 5G-VICTORI targeting mMTC and planned for 2020 in Patras. A trial on UAV multiuser indoor remote control and operation targeting eMBB/URLLC and planned for Q1-2021 in Leganés (Spain).
- **5GROWTH:** A demonstration, trial and pilot on Connected Worker Remote Operation of Quality Equipment, targeting URLLC and eMBB, planned for Q2-2021 and Q4-2021 in the Basque Country. A demonstration, trial and pilot on Connected Worker Augmented Zero Defect Manufacturing (ZDM) Decision Support System (DSS) targeting eMBB and planned for Q2-2021 and Q4-2021 in the Basque Country. A demonstration, trial and pilot on Digital Twin Apps targeting URLLC in Turin in Q2-2021 and Q4-2021. A demonstration, trial and pilot on Telemetry/Monitoring Apps targeting mMTC in Turin in Q2-2021 and Q4-2021. A demonstration, trial and pilot on digital tutorials and remote support targeting eMBB in Turin in Q2-2021 and Q4-2021.

### 3.2.6 Public Safety

The figure below shows the distribution by experiment type for public safety with trials dominating.

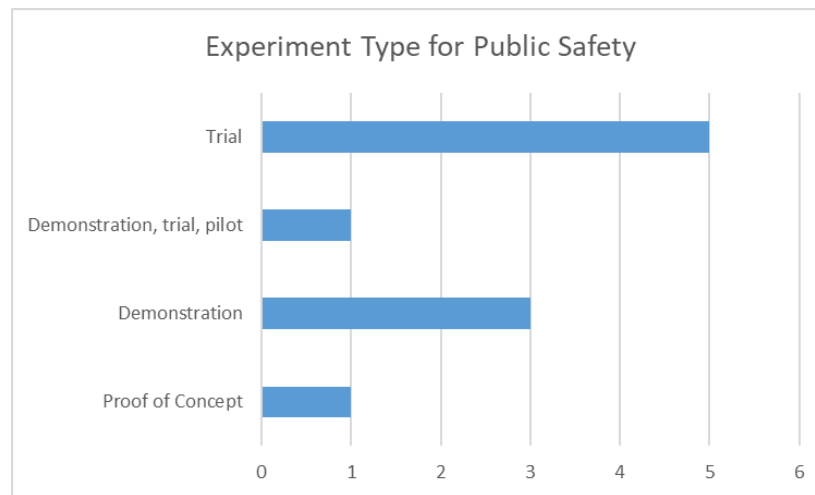


Figure 23: Experiment Type for Public Safety

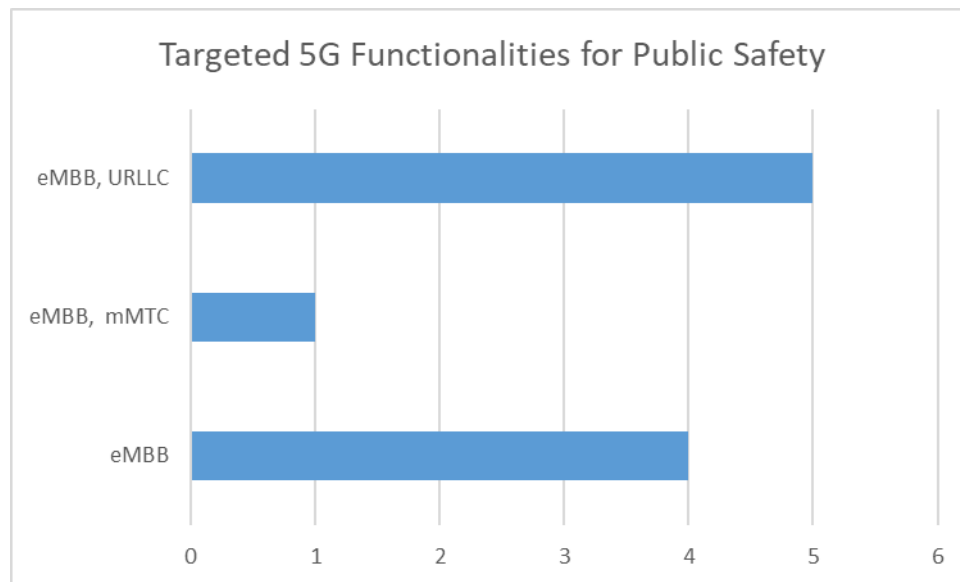


Figure 24: Targeted 5G Functionalities for Public Safety

- 5G-VINNI:** A trial on dedicated slice for Norwegian defence targeting eMBB in Q1-2020 in Oslo. This trial is complete and published on the online tool. A trial on autonomous edge, targeting eMBB in Q3-2020 in Oslo. A trial on satellite backup for backhauling targeting eMBB in Q3-2020 in Oslo. A trial on UAV multiuser remote control and operation (Outdoor) targeting eMBB and/or URLLC planned for Q1-2021 in Leganés. A location-independent trial on PPDR use cases using resilient satellite backhauling targeting eMBB and/or mMTC with a timeline up to Q2 2021.
- 5GENESIS:** A demonstration, trial and pilot on 3GPP MCS & video for surveillance targeting eMBB, planned for Q2-2020 in Malaga.
- 5G!DRONES:** A demonstration on the monitoring of a wildfire targeting eMBB and/or URLLC and planned for Q2-2021 in Sophia Antipolis (Eurecom premises). A demonstration on disaster recovery targeting eMBB and/or URLLC and planned for Q2-2021 in Sophia Antipolis (Eurecom premises). A demonstration on police (incl. counter-UAS) targeting eMBB and/or URLLC and planned for Q2-2021 in Oulu. A proof-of concept on network extension in disaster situations targeting eMBB and/or URLLC and planned for Q2-2021.

### 3.2.7 Smart Cities and Tourism

The figure below shows the experiment types for smart cities, including tourism, where pilots and trials prevail though four use cases still need to be defined.

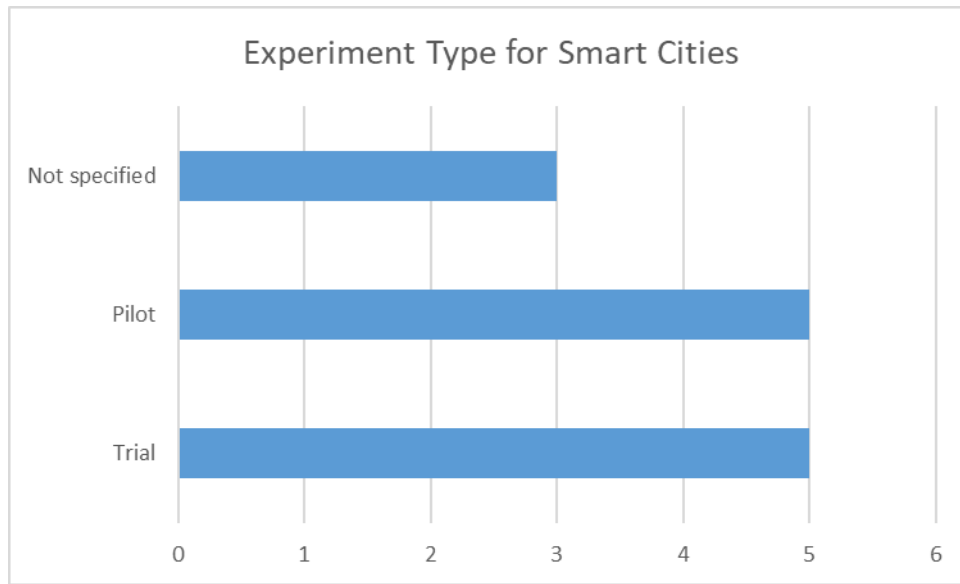


Figure 25: Experiment Types for Smart Cities

The figure below shows the distribution of targeted 5G functionalities for smart cities.

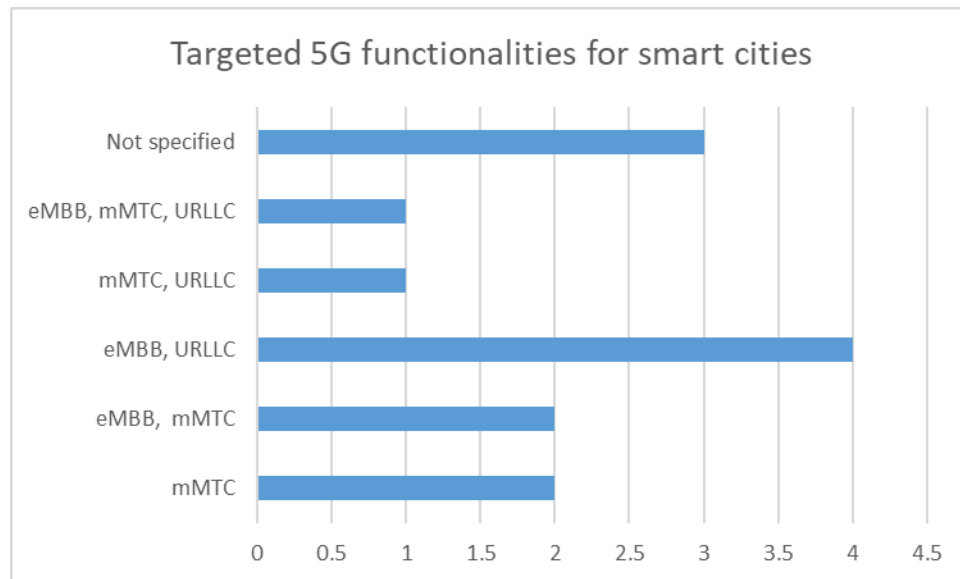


Figure 26: Targeted 5G Functionalities for Smart Cities

- 5G-EVE:** A pilot on safety and environment, targeting URLLC and/or mMTC planned for Q3-2020, Q2-2021 in Turin. The first piloting phase took place at the OTE Academy premises in Athens in Q2-2020 (July) with a demo webinar available. A pilot on augmented reality for smart tourism targeting eMBB and/or URLLC planned for Q3-2020, Q2-2021 in Turin. A pilot on Video 360° 5G - Virtual Tickets (On-demand) targeting eMBB and/or URLLC and planned for Q1-2020, Q2-2021 in Madrid. A pilot on Video 360° 5G Immersive Experience (Live) targeting eMBB and/or URLLC and planned for Q1-2020, Q2-2021 in Madrid. A pilot on Video 360° 5G virtual visit targeting eMBB and/or URLLC and planned for Q2-2020, Q2-2021 in Paris.
- 5G-SOLUTIONS:** A trial on intelligent street lighting in Q4-2020, Q2-2021 and Q2-2022 targeting mMTC in Trondheim. A trial on smart parking in Q4-2020, Q2-2021 and Q2-2022

targeting mMTC in Trondheim. A trial on smart city co-creation in Q2-2021 and Q2-2022 targeting eMBB and mMTC in Trondheim. A trial on smart buildings – smart campus in Q4-2020, Q2-2021, Q2-2022 targeting eMBB, mMTC and URLLC in Dublin.

- **5G-TOURS:** Three experiments on augmented tourism experience; telepresence; robot-assisted museum guide and monitoring planned for 2022 in Turin with more details expected in October 2020.
- **5G-VINNI:** A location-independent trial on eMBB and IoT use cases using satellite backhauling (Smart Villages & Rural Areas) targeting eMBB, mMTC with a timeline up to Q2 2021.

The example of multiple verticals with smart cities is the **5G-EVE** pilot on urban mobility flow management targeting URLLC and/or mMTC and planned for Q3-2020 and Q2-2021 in Turin.

### 3.2.8 Transportation and Logistics

The figure below shows the types of experiments for transport and logistics, with a high number of pilots and trials and some still to be defined.

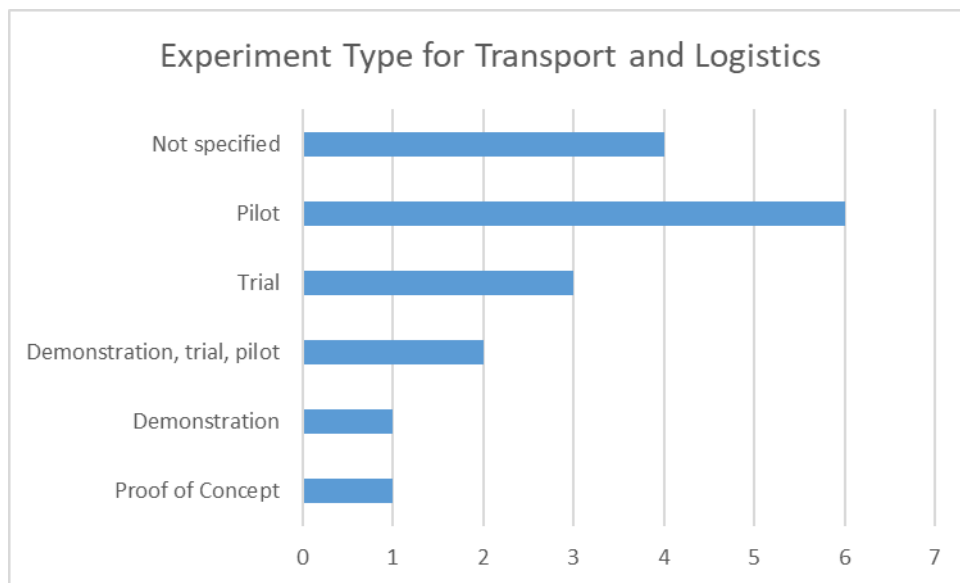


Figure 27: Experiment Type for Transport and Logistics

The figure below shows the distribution of targeted 5G functionalities.

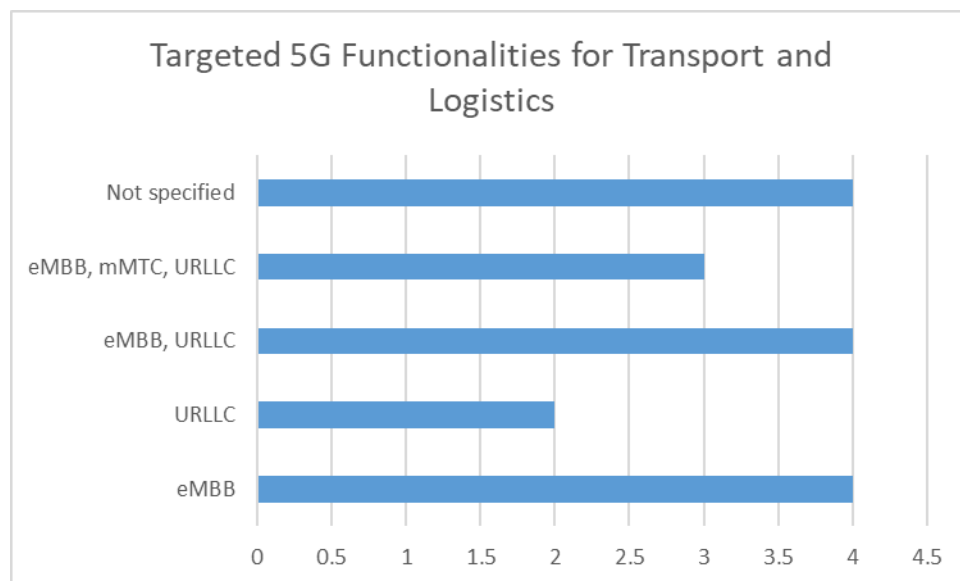


Figure 28: Targeted 5G Functionalities for Transport and Logistics



- **5G-EVE:** A pilot on media content in high-speed trains targeting eMBB and planned for Q3-2020 and Q2-2021 in Turin.
- **5G-GROWTH:** A demonstration, trial and pilot on safety critical communications targeting URLLC and planned for Q4-2020 (partner lab demo) with trial and pilots at the Port of Aveiro in Q2-2021 and Q4-2021. A demonstration, trial and pilot on non-safety critical communications targeting eMBB and URLLC with the partner lab demonstration planned for Q4-2020 and trials and pilots at the Port of Aveiro in Q2-2021 and Q4-2021.
- **5G-SOLUTIONS:** A trial on autonomous assets and logistics for smart harbour/port in Q4-2020, Q2-2021 and Q2-2022 in Herøya (NO) targeting eMBB, mMTC, URLLC. A trial on port safety: monitor and detect irregular sounds targeting eMBB, mMTC, URLLC and planned for Q2-2021 and Q2-2022 in Herøya (NO).
- **5G-TOURS:** Four experiments on smart airport parking management; video-enhanced ground-based moving vehicles; emergency airport evacuation; excursion on an AR/VR-enhanced bus planned in 2022 in Athens with more details expected in October 2020.
- **5G-VICTORI:** A pilot on eMBB under high speed mobility in Rail environments, targeting eMBB, planned for Q2-2020 and Q3-2021 in Patras. A pilot on digital mobility (short-lived application specific networks (or pop-up ‘network on-demand’), targeting mMTC, eMBB, URLLC in Bristol, Berlin and Alba Iulia Municipality (RO), with testing moved to Q2-2021 and Q3-2022 due to unpredictability of COVID-19 evolutions for this specific use case. A pilot on critical services for railway systems, targeting URLLC and planned for Q2-2020 and Q3-2021 in Berlin.
- **5G-VINNI:** A joint pilot with 5G-VICTORI on enhanced mobile broadband under high speed mobility in rail environments targeting eMBB and planned for Q2-2020 in Patras. A trial on Safety critical communications for railway signalling systems targeting eMBB, URLLC and planned for Q4-2020 in Aveiro.

## 4 Trials and Pilots Brochures

The 5G-IA Trials WG has set up the annual competitions with a view to selecting and showcasing the best trials and pilots in the 5G PPP. The evaluation committee within the WG is tasked with defining the selection criteria, the process document, the flyer form and criteria form, keeping track of the applications during the foreseen period (stored in a dedicated BSCW area) before scoring each application. The scores are then weighted and the final selection made.

The next step is the editorial process and design of the brochures, where members of the evaluation committee also contribute.

Launched in 2019, the competition is now in its second iteration, with the added value of enabling the 5G PPP to take stock of results and impacts created through the trials and pilots, zooming in on advances towards 5G deployments in vertical industries, socio-economic impacts, market and commercialisation potential.

### 4.1 Brochure 2019

The first brochure on the top 5G PPP trials and pilots was produced and published in September 2019, as illustrated in the figure below.

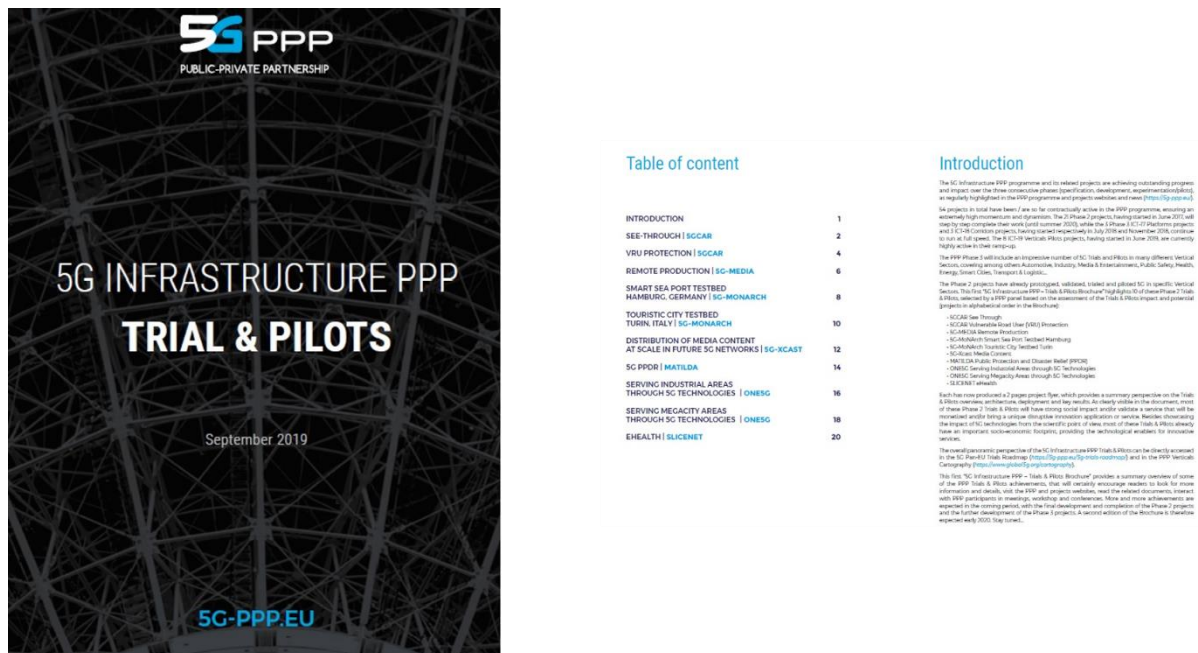


Figure 29: 5G PPP Trial and Pilot Brochure 2019

The brochure is available at:

[https://5g-ppp.eu/wp-content/uploads/2019/09/5GInfraPPP\\_10TPs\\_Brochure\\_FINAL\\_low\\_singlepages.pdf](https://5g-ppp.eu/wp-content/uploads/2019/09/5GInfraPPP_10TPs_Brochure_FINAL_low_singlepages.pdf).

A summary of the selected trials and pilots is given below.

#### 4.1.1 5G-CAR

<b>Title:</b> See-Through (automotive test track in Linas Monthléry)
<b>Overview:</b> Cooperative perception assisting drivers and automated vehicles during overtaking manoeuvres.
<b>Title:</b> Vulnerable Road User (VRU) Protection (automotive test track in Linas Monthléry)
<b>Overview:</b> Alerts about imminent dangerous situations to reduce the risk of accidents.

#### 4.1.2 5G-MEDIA

**Title:** Remote Production (Madrid)

**Overview:** Implementing remote and smart production over 5G networks for low-latency and high-bandwidth media streaming.

#### 4.1.3 5G-MONARCH

**Title:** Smart Seaport Testbed (Hamburg)

**Overview:** 5G network slicing, reliability, resilience and security concepts.

**Title:** Touristic City Testbed (Turin)

**Overview:** Interactive Virtual Reality (VR) visit to the Palazzo Madama Museum in Turin.

#### 4.1.4 5G-Xcast

**Title:** Distribution of Media Content at scale in future 5G networks

**Overview:** 5G-Xcast Content Distribution Framework using multicast and broadcast capabilities as internal network optimisation features.

#### 4.1.5 MATILDA

**Title:** PPDR (Public Protection and Disaster Relief)

**Overview:** Tailored services and applications for public safety teams (5G emergency infrastructure and service orchestration).

#### 4.1.6 ONE5G

**Title:** Serving industrial areas through 5G

**Overview:** 5G technologies supporting the requirements in industrial areas with large factories.

**Title:** Serving megacity areas through 5G

**Overview:** E2E Network management for 5G infrastructures using Key Quality Indicator based monitoring and characterisation of E2E performance.

#### 4.1.7 SliceNet

**Title:** eHealth (testbed in Cork)

**Overview:** Pre-hospital emergency medical services (EMS) for treatment of acute strokes through network slicing and prioritised quality of service.

### 4.2 Brochure 2020

Twenty-two applications have been received for the 2<sup>nd</sup> 5G PPP Trials and Pilots Brochure (2020) with the evaluation in progress at the time of writing.

The applications received are: 5GESSENCE: Large Scale Stadium; 5G-PICTURE: Railway use case; 5G-PICTURE: Smart City use case; 5G-PICTURE: Stadium use case; 5G TRANSFORMER: eHealth Heart Attack Emergency; 5G-XCast: Multimedia Public Warning; 5G-XCast: Object-based Media

over 5G (OBM); IoRL: Indoor 5G VLC/mmWave System - Building Research Establishment – Integer House; MATILDA: Smart City - Intelligent Lighting Pilot; MetroHaul: Network Slicing for Improving Public Safety; MetroHaul: Crowdsourced Live Video Streaming; NRG-5: PMaaS / Storengy plantin StublachUK; SliceNet: 5G powered Smart Lighting in Smart Cities; SliceNet: 5G powered smart Grid for self-healing power distribution network; SliceNet: BlueEye Pilot; Clear5G: Closed-loop control of industrial AGV with UE relaying support; 5G-EVE: Experiential tourism through 360-degree video and VR over 5G; 5G-EVE: Industry 4.0: Autonomous vehicles in manufacturing environments; 5G-EVE: Media and Entertainments: Virtual 360° immersive visit; 5G-EVE: Smart City: Safety and Environment; 5G-VINNI: Remote Robotic Control with 360° VR-based Telepresence; 5GROWTH: Industry 4.0 Low Latency use cases on shared Network.

A sample of the brochure applications is given below, including examples of criteria parameters, such as targeted KPIs, monetisation and commercialisation potential. This is not intended to reflect the selection process or final version of the brochure but rather to give a flavour of results and impacts from phases 2 and 3.

#### 4.2.1 5G-ESSENCE: Large-scale stadium

<b>Overview:</b> Highly interactive fan experience and operation optimisation for evolved multimedia broadcast/multicast services (eMBMS) with optional multi-tenancy support by small cells to ease the coverage and capacity pressure on the multimedia infrastructure while increasing security by keeping content local. Enabling media producers and mobile operators to offer highly interactive fan experiences and optimised operations with several new capabilities to existing 3GPP architectural functionalities and new functions.
<b>5G KPIs:</b> Service deployment time < 2min.
<b>5G technologies and/or services:</b> Lower latency, due to shortening the data transmission path. Maintained backhaul capacity, due to playing out the live feeds and replays locally that avoids additional strain on the backhaul network and upstream core network components.
<b>Impacts:</b> Benefits of lower latency with no strain on the backhaul network and upstream core network components for operators and venue owners.
<b>Maturity:</b> TRL 6 or 7.
<b>Potential for monetised services/commercialisation:</b> The pilot has validated the SmartStreamApp and EVO from Smart Mobile Labs, which is a commercial product in the company's production line.

#### 4.2.2 5G-PICTURE: Railway, Smart City and Stadium Use Cases

<b>Railway Use Case Overview:</b> Making bandwidth available to passengers to broadcast emergency information efficiently; providing secure personalised services to passengers when needed.
<b>5G KPIs:</b> Contributing to 10 to 100 times more connected devices; 10 times to 100 times higher typical user data rate; 10 times lower energy consumption; ubiquitous 5G access including in low density areas.
<b>5G technologies and/or services:</b> End-to-end performance up to 2 Gbps duplex to the moving train with an average latency of about 2 ms and power consumption per km of 200 W.
<b>Impacts:</b> Shared network for effective critical, operational and business communication services integrated with railway infrastructures at lower total cost of ownership, service flexibility and deployment speed. High-data rate wireless connectivity using mmWave from the stanchions located at the trackside to the mmWave units attached to the roof at the rear and at the front of the train.
<b>Maturity:</b> Overall TRL of 7.
<b>Potential for monetised services/commercialisation:</b> Monetisation from customer services as well as investment reduction and railway infrastructure management. Early adopters (i.e. stakeholders deploying the solution or asking from infrastructure providers to deploy the solution) would be

those infrastructure customers facing critical technology communications phase-out, or being forced by liberalisation pushing the need for new services, or seeking/planning deep operational improvement.
<b>Smart City Use Case Overview:</b> Two use cases. One on smart city safety. One on virtual reality. Deployment of a single network infrastructure to support a variety of services, e.g. emergency/safety services, especially critical communications.
<b>5G KPIs:</b> (Use case 1) Radio Network node capacity: Equipment, specific to the access technology - Expected to be greater than 50 Mbit/s. Throughput: Equipment – specific to the cameras used. Expected to be greater than 3 Mbit/s per device. Latency: Between the Device and the Cloud serving node - Expected < 50 ms. (Use case 2) Radio Network node capacity: Equipment – Specific to the Access Technology Expected to be greater than DL ~ 30 Mbit/s & UL ~ 1 Mbit/s. Throughput: Equipment – specific to the cameras used. Expected to be less than DL ~ 3 Mbit/s & UL ~ 100 kbit/s. Latency: Between the Device and the Cloud serving node. Expected < 35 ms.
<b>5G technologies and/or services:</b>
<b>Impacts:</b> Applications for citizens, e.g. broadcasting and media; enhanced citizen quality of life through advanced emergency, safety or information services; service flexibility and speed of deployment of novel services; detecting problems related to pandemics in urban, as well as rural areas, supported by video and audio services.
<b>Maturity:</b> TRL 6.
<b>Potential for monetised services/commercialisation:</b> New revenue streams reliant on business models for infrastructure ownership and agreements, the sharing of responsibility for deployment and operation of the telecom infrastructure, operation of the communication services, provisioning and/or selling entertainment services to citizens. Indicative revenue streams include: telecom operations for infrastructure usage; collaboration with service providers and revenue sharing from services for citizens.
<b>Stadium Use Case Overview (Broadcasting and Media):</b> Showcasing how an existing production network in a stadium can be augmented with 5G network technologies and validated how 5G-OS can enable seamless creation of value-added network services in less than 1 minute and provide elasticity to both network- and application-level services.
<b>5G KPIs:</b> Quality of Experience (QoE) of application user via the Media KPIs. Network Metrics that were evaluated are jitter, latency, utilisation, congestion and service deployment time. The target KPIs are: Low jitter, low latency and low instances of congestion and service deployment time.
<b>5G technologies and/or services:</b> Application aware, programmable network over heterogeneous hardware. Differentiated treatment of the application traffic using slices. Service resilience using slices in a multi-connectivity link scenario for Wi-Fi and high capacity wireless access technologies, such as Massive MIMO.
<b>Impacts:</b> Bringing digitisation to society through diverse new services and devices that are becoming available to them. Increased coverage, ultra-fast, low latency, high density and reliable connectivity that 5G can support is an essential enabler for a variety of services that will improve citizens' way of living.
<b>Maturity:</b> TRL 7. MRL 3.

#### 4.2.3 5G TRANSFORMER: eHealth Heart Attack Emergency

**Overview:** besides using the capabilities of 5G networks from physical layer (high throughput) to management layer (automated orchestration and deployment of NFV-NSs in multiple administrative domain), the “eHealth Heart Attack” PoC shows an automated service deployment to improve emergency reaction time and on-site medical assistance.



<b>5G KPIs:</b> Service Creation Time.
<b>5G technologies and/or services:</b> Reduced NFV-NS creation time (in the order of 5 minutes). Possibility of automatically creating NFV-NS in multiple administrative domains while satisfying vertical requirements, improving emergency response time. Latency reduction derived from the selective location of the deployed NFV-NS, improving medical on-site assistance, and enabling innovative AR solutions.
<b>Impacts:</b> On-demand automatic deployment of NFV-NSs implementing ehealth emergency services helping to reduce emergency response time (including network service federation among different administrative domains). Improved emergency on-site medical assistance due to a latency reduction enabling AR innovative solutions.
<b>Maturity:</b> TRL of 5-6. MRL of 4.
<b>Potential for monetised services/commercialisation:</b> Emergency services could pay to have this service available to reduce emergency response time and enhance the on-site medical assistance. Currently, there is not a plan to commercialize the service, it is still in Proof of Concept (PoC) stage.

#### 4.2.4 5G-XCast: Object-based Media

<b>Object-based Media Overview:</b> Multicast and unicast objects are seamlessly combined into a single experience on the user equipment. To achieve this (and with the added benefit of keeping the coding complexity of the app low) 5G-Xcast has ensured that the delivery method (multicast or unicast) of the objects is transparent to the mobile app (e.g., The BBC has developed the Forecaster5G app). This is achieved by allowing the Dynamic Adaptive Streaming Over IP Multicast (DASM) system to handle the multicast through the use of a proxy, while the app concentrates solely on delivering an object-based experience.
<b>5G KPIs:</b> Throughput, such as the bit rate against the number of user devices.
<b>5G technologies and/or services:</b> Enabling functionalities e.g. software defined networks (SDN), network function virtualisation (NFV) and mobile edge computing (MEC) in the UNIS 5G test-bed, the intention of the OBM trial is to add the flexibility and ability to the 5G network so that it can deliver object-based media content. For example, multicast can be used to deliver commonly used and bandwidth-heavy objects to the edge to overcome scarcity of resources in the network. This can either be to a MEC node to overcome bandwidth limitations within the core or directly to the handset to reduce the use of radio resources. Meanwhile, more bespoke, personalised and/or less bandwidth-expensive objects can be delivered over unicast.
<b>Impacts:</b> Going beyond the traditional approach for delivering media services with added value in the COVID-19 context with a new rendering approach, which also opens the door to new content experiences and more immersive forms of experience in 5G, such as online conference/webinar with virtual and augmented reality and 360-degree video.  5G-Xcast has used the Forecaster5G app developed by the BBC to test both the assumption that delivering common and bandwidth-heavy objects over multicast can reduce the network load, and the assumption that an object-based approach is feasible to deliver whilst improving the user's experience.
<b>Maturity:</b> TRL 3 experimental proof of concept. Parts of the trialed system have higher readiness level, e.g. 5G Core, 5G CPE (commercial device), Forecaster5G app.
<b>Potential for monetised services/commercialisation:</b> The OBM is ready to deliver the promised features in a production network. The Forecaster5G app is on the testing phase but has shown a stable run on some off-the-shelf mobile devices.

#### 4.2.5 IoRL: Indoor 5G VLC/mmWave System

<b>Overview:</b> The Internet of Radio Light is successfully conducting performance tests of a hybrid Visible Light Communications (VLC) and 40GHz mmWave 5G compliant system in the Integer
--

House lab at the Building Research Establishment, August – December 2020.
Demonstrating how to solve the problem of broadband wireless access in buildings and promote 5G global standard.
Indoor Location based services allows intelligent services to be designed around it, namely: location based data access, follow me, monitoring and guiding etc
<b>5G KPIs:</b> Coverage, latency, location, accuracy, EM exposure.
<b>5G technologies and/or services:</b> Mobile edge cloud location services; mobile edge cloud network management services; security and privacy services.
<b>Impacts:</b> COVID-19 has highlighted the need for high performance homes, such as improved location estimation of smart phones indoors to enable the development of a whole new generation of location-based services, including monitoring social distancing in pandemics. High resolution location services can be used for aligning graphics with real world in tetherless augmented reality systems. The impact of this is that guidance and training can more easily be provided to workers thus improving productivity.
<b>Maturity:</b> In general, VLC parts of the system are at TRL 5 with further development is needed to increase bandwidth, propagation distance and beam angle. The mmWave parts of the system are at TRL 6 with a viable working system built and demonstrated. Both systems are at MRL 4 with small-scale stakeholder campaigns being undertaken.
<b>Potential for monetised services/commercialisation:</b> Hardware sub-systems have monetisable value, namely: mmWave PCB 40 GHz antenna, distributed RAN, Remote Radio Light Head lighting system & location systems; and software systems, namely: security monitoring VNF and Multi Source Streaming VNF.

#### 4.2.6 MATILDA: Smart City Intelligent Lighting

<b>Overview:</b> The demonstrator comes with 6 different components deployed as an application graph. In terms of application, it offers several functionalities for the customer, like full monitoring of lamps and electricity consumptions, smart dashboards, ticketing and billing. The key innovation stems from the provisioning and in life management of the service which shall be fully automated, except for the installation of the lamps.
<b>5G KPIs:</b> Contributing to energy efficient KPI, reducing with 60% the energy consumption; reducing the service creation for under 5 min (excluding lamps installations), service availability of 99.99%.
<b>Impacts:</b> Decreased annual energy consumption with 60% due to use of LED lamps but also by using the optimal infrastructure resources in the Datacenter. Enhanced public safety by actively monitoring the status of the lighting lamps and fixing any fault that could lead to a malfunctioning of the system. Created new business opportunities, e.g. incubate start-ups within the marketplace as Application Developers, etc.
<b>Maturity:</b> TRL7.
<b>Potential for monetised services/commercialisation:</b> Two different approaches to deliver MATILDA developments to the customer have been proposed. Option 1: Commercialising only the application (all or part of the components); Option 2: Commercialising the End to End Solution.

#### 4.2.7 MetroHaul: Public Safety and Live Video Streaming

<b>Public Safety Overview:</b> A multi-layer network slice that allows the allocation of computational resources to perform the modules of the video management and analytics on remote servers and provide the optical connection to satisfy the bandwidth and delay requirements of public safety video surveillance. The impact in the vertical is a higher number of customers and richer service.
<b>5G KPIs:</b> Contributing to targets such as 10 times to 100 times higher typical user data rate; end-to-

end latency of < 1ms; scalable management framework enabling fast deployment of novel applications.
<b>5G technologies and/or services:</b>
<b>Impacts:</b> Meeting need for improved and widespread public safety services as a growing societal concern by outsourcing computational tasks to a remote edge computing node and making analytics available more quickly to the surveillance zone.
<b>Potential for monetised services/commercialisation:</b> The intelligent video surveillance using the network operators' infrastructure can be commercialised as a service, extending the reach of current systems covering large areas. Operators can also monetise network slices with stringent QoS requirements
<b>Crowdsourced Live Streaming Overview:</b> Allowing users to create their own multi-camera productions by combining smartphones, professional cameras, or external video streams; adding graphics and overlays, changing shots, creating PinP layouts, or mixing audio tracks. They can share them on social media, custom destinations, or web players.  Performing cuts from video streams, files stored in the Media Library, or uploads from their mobile and easily sharing them on social media.  Creating multi-clip compositions from multiple live cuts or files stored in the Media Library; adding graphics, setting up transitions between clips, and easily sharing them on social media.
<b>5G KPIs:</b> Contributing to 1000 times higher mobile data volume per geographical area; end-to-end latency of < 1ms; scalable management framework enabling fast deployment of novel applications.
<b>5G technologies and/or services:</b> 5G network orchestration utilising SDN and NFV technologies to leverage programmable networks and network functions on generic compute servers. This allows flexibility and agility in network service deployment. A network service deployment which may take hours/days using legacy technology can now be deployed in minutes.
<b>Impacts:</b> Crowdsourced video streaming applications enable easy collaboration between teams, fans and communities, turning them into a film crew anywhere, anytime empowering them to create videos quickly and affordably. Despite the COVID-19, which made live crowdsourcing demonstrations impossible, multiple video streams can be generated from VLC media player instances in a server from pre-recorded video and streamed to another server hosting OBS studio.
<b>Maturity:</b> TRL 6, with the technology validated in an industrially relevant environment for key enabling technologies. The vertical application is built on top of a commercially mature product.
<b>Potential for monetised services/commercialisation:</b> The Crowdsourced Live Video Streaming is a network service that can be monetised. The operator can gain revenue from the advanced connectivity and network slice offered by the smart optical network.

#### 4.2.8 NRG-5: Predictive Maintenance as a Service

<b>PMaaS/Storengy plant in Stublach UK Overview:</b> Allowing the autonomous navigation, obstacle avoidance, landing, and flight formation in the context of Predictive Maintenance, considering system design and constraints from several factors: accurate positioning, sensor fusion, sensing arbitrary terrain, and real-time operation with the objective to off-load the on-board computer, migrate the visual and ultra-sonic analysis at the MEC using relevant media analysis VNFs.
<b>5G KPIs:</b> Mobility, traffic type, user data rate and latency.
<b>5G technologies and/or services:</b> Overcoming limitations current drone technology is affected by low-range flying control, low camera quality, onboard storage of data, no encryption mechanisms and data transmission bandwidth limited to 10Mb/s in the best case.
<b>Impacts:</b> Very low latency able to secure the flight control and the transmission of real-time HD videos, simultaneous control and data transmission and registration of events in a secure and non-disputable fashion.
<b>Potential for monetised services/commercialisation:</b> The use of drones will lead to more frequent



and efficient surveys at no additional costs, and to faster access areas that were not previously reachable by maintenance personnel. Good monetisation potential.

#### 4.2.9 SliceNet: Smart Grid for self-healing power distribution network

**Overview:** Electrical power grid Fault Detection Isolation and Restoration (FDIR). Using the 5G technology URLLC capabilities it will be possible to implement the Self-Healing Smart Grid scenarios. The electrical power utilities need this solution in order to prevent/reduce the frequency and duration of outages to the consumers. This will have a direct impact in the economy and in the consumer satisfaction.

##### 5G KPIs:

- 1) SliceNet's northbound API, called One-Stop API, provide mission-critical service providers to adopt 5G slice-based/enabled services in a rapid and cost-efficient way, thereby contributing to "reducing the average service creation time cycle from 90 hours to 90 minutes".
- 2) SliceNet's Smart Grid use case provides "Proof-of-Concept (PoC) and demonstrators beyond phase one and validating core functionalities and KPIs in the context of specific use cases with verticals closely associated to the demonstrations and validation".
- 3) A key SliceNet objective for the Smart Grid use case is to offer to the vertical an E2E network slice (NS) that fulfil his requirements and that is capable of predict and prevent network failures by replacing faulty NS with healthy NS.
- 4) Eurecom, a SliceNet partner, has designed a novel low-latency edge feature, called the LL-MEC, for the Smart Grid use case, and thereby offers "Improved architectural support for diverse types of terminals and RANs".

**5G technologies and/or services:** Adopting 5G technology will make it possible to guarantee the necessary low latency communication to trigger the Powerline Protection Devices (PPDs) in the Smart Grid network. Besides this, the proposed architecture, based on AI/ML techniques, can do the prediction of a faulty behaviour on one of the network slices (NS) and make the necessary actions to replace that faulty NS by a healthy NS.

**Impacts:** The implementation of dynamic 5G slicing, with Ultra-Reliable Low Latency Communications (URLLC) capabilities that will help Smart Grid self-healing solutions to reduce the frequency and duration of outages to the consumers. Besides this, the electric power utilities will improve their reliability indicators reducing their financial impact. Contributing to the "global competitiveness of European 5G systems" through innovative solutions in the Smart Grid area.

**Maturity:** The pilot is being implemented and demonstrated at the Altice Labs laboratories in Aveiro, Portugal, using power grid devices provided by Efacec. Since the pilot will be validated in the lab, the target TRL is 4.

**Potential for monetised services/commercialisation:** Smart Grids will make significant use of 5G capabilities to improve their services for the customers. SliceNet has trialled and validated business opportunities relying on the main 5G features like: network slicing, flexible network management and provision of mMTC and URLLC services. It implemented and trialled a fully closed-loop cognition-based autonomous network slice control, management and orchestration.

#### 4.2.10 5G-EVE: Industry 4.0 – Autonomous Vehicles in Manufacturing Environments

**Overview:** A first step towards an operational model that can be disruptive in manufacturing and other economic activities. 5G provides the latency and reliability that allow this application to be feasible from a technical and economic viewpoint.

**5G KPIs:** Energy efficiency. AGV should, initially, not consume more energy than the traditional operating model. In the future, it should help to reduce energy consumption by means of better

coordination of vehicles, route optimisation
<b>Impacts:</b> The use of AGVs, taking advantage of a centralised and virtualised control, can facilitate several activities with a significant impact in a pandemic context: Disinfecting areas with UV light; Moving materials in contaminated areas; Use of AGVs for temperature control.
<b>Maturity:</b> TRL 4. MRL 4.
<p><b>Potential for monetised services/commercialisation:</b> The economic impact of the evolution of the operational model tested may allow several monetisation opportunities:</p> <ul style="list-style-type: none"> <li>- Reduce the operational costs with respect the current operational model.</li> <li>- Facilitate new business models for the use of AGVs by verticals, like the robot as a service model.</li> <li>- Facilitate new operational conditions in factories, allowing for greater flexibility and reconfigurability.</li> </ul>

#### 4.2.11 5G-VINNI: Remote Robotic Control with 360° VR-based Telepresence

<p><b>Overview:</b> The disruptive aspect of this demo is the low latency interactivity between robot and controller – this can massively increase operational efficiency, and allow real-time reactivity to the situation the robot encounters. 5G enables this trial because of the availability of very high bandwidth and very low latency support simultaneously on the used links. Other technologies would not allow the immersive video experience and real-time control and interactivity to be achieved.</p>
<p><b>5G KPIs:</b> The trial validates high bandwidth connectivity through the use of high-definition 360-degree immersive video to an AR/VR headset, and ultra-low-latency by allowing real-time control of the robot through both a ULL video path, and ULL controller path. The use of robotic control in the industrial environment can drastically reduce production times. Equipment is only used when required, providing a low energy factory solution.</p>
<p><b>Impacts:</b> The use of robotics can transform the factory environment. This reduces costs for goods and improves time to production, providing low cost goods into the market. The principles on display in this demo could be applied to any form of disaster response, search and rescue or hazardous environment where human presences may be dangerous, but a robot could be used. In addition, rapid response production methods could support pandemic relief (e.g. with personal protective equipment).</p>
<b>Maturity:</b> TRL4 and MRL4.
<p><b>Potential for monetised services/commercialisation:</b> The trial demonstrates a remote-control capability with extensive applicability to IIoT/Industry 4.0, and for remote control and assessment in any industrial setting. It could also be used for security services or actions in hazardous environments, including disaster response. Plans are in place to bring this innovation directly to market.</p>

## 5 Impacts Achieved

### 5.1 Sample of Website Updates

New entries and updates are published on the online tool whenever they become available through the blueprints for phases 2 and 3. Below a sample for the period between September 2019 and August 2020.

The figure below shows a sample of phase 2 new entries (e.g. SliceNet) and updates (e.g. IoRL).

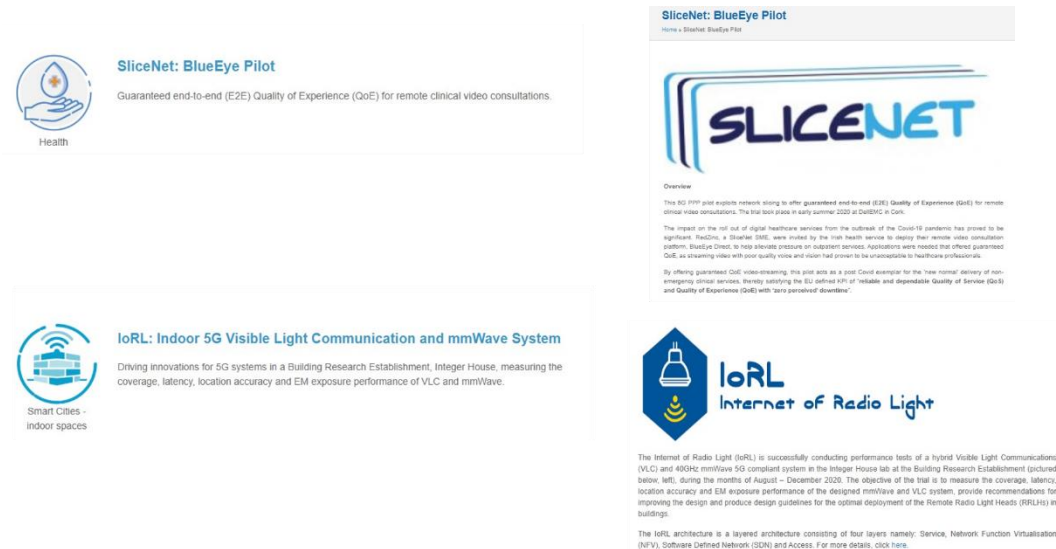


Figure 30: Sample of Phase 2 Updates

The figure below gives a snapshot of updates to the online tool on Phase 3 experiments.

More updates are part of Release 4.0 of the tool and as phase 3 projects work on planning their experiments.



Figure 31: Sample of Phase 3 entries on the online tool

### 5.2 Impacts of online Tool

The Verticals Cartography online tool is a very popular tool and important showcase for the 5G PPP and its funded projects.

Now in Release v4.0 with the fully updated phase 2 project experiments and continuous integration of phase 3, it has now reached the important milestone of 103,050 views since its launch in mid-September 2018.

The figure below shows the trajectory taking the Global5G.org delta as December 2019, showing the

milestone reached.

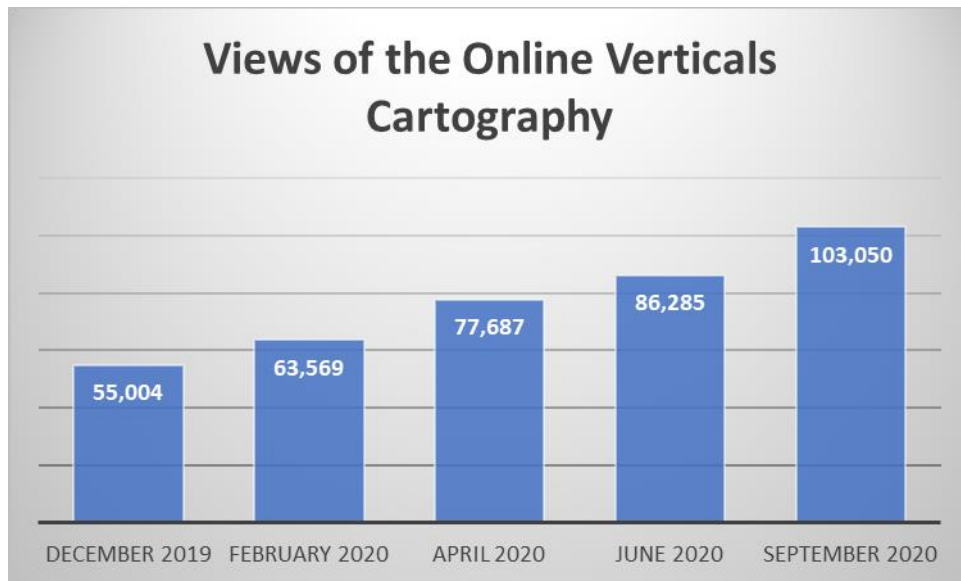


Figure 32: Views of the Online Tool since December 2019

The figure below shows the evolution over the first year of FULL5G.

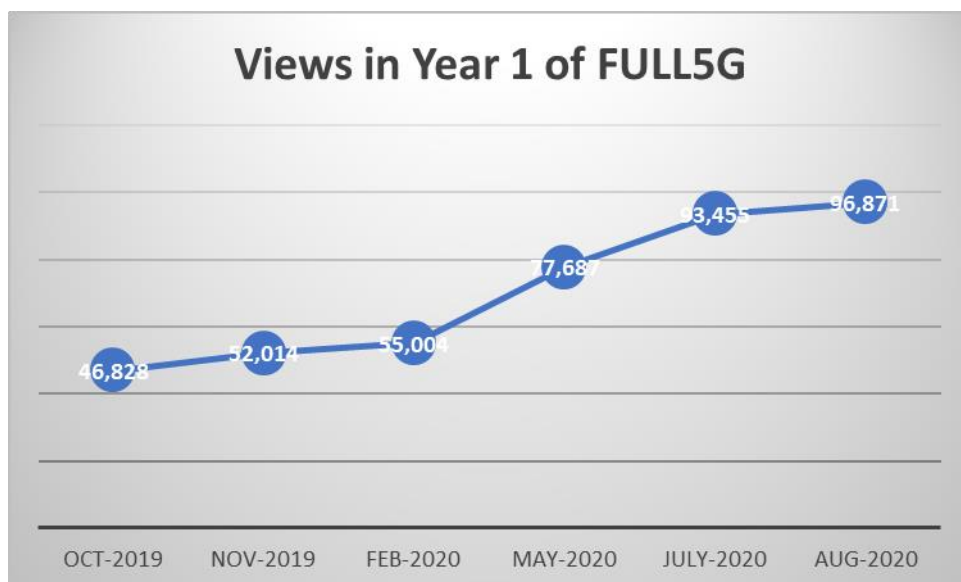


Figure 33: Views of the Online Tool in FULL5G Year 1

## 6 Main Findings, Results and Next Steps

Over 180 use-case experiments have been tracked and analysed through the blueprints for phases 2 and 3, and are being fed into the online Verticals Cartography tool.

Phase 2 use-case experiments are now coming to an end, with the final round of updates on the online Verticals Cartography planned for late December 2020.

Phase 3 experiments are now in full swing, bringing a larger portfolio of industry vertical applications and scenarios across a larger pool of countries, including outside EU27. Phase 3 also sees a shift towards use cases on manufacturing, transportation and logistics compared with the focus on broadcasting and media in phase 3.

- Industry (factory processes and automation), transport and logistics, broadcasting and media, smart cities make up 50% of the experiments in Phase 3.
- Use cases on automotive (17 in total) also show an important increase (up from 6 in phase 2), with most being examples of cross-border scenarios.
- Public safety has increased from 6 to 10, health from 3 to 11 and energy from 5 to 9 use cases while farming remains low at just 2 use cases.
- Examples of multiple verticals being tested in individual use cases include smart cities and transportation (smart mobility) and smart cities and new broadcasting and media services.

Phase 3 also marks a significant shift towards demonstrations, trials and pilots compared with phase 2: Only 3 proofs of concept compared with 12 in phase 2. There are no prototypes while demonstrations have increased from 15 to 19; demonstrations combined with trials from 4 to 14; demonstrations combined with trials and pilots from 7 to 10; trials up from 12 to 40; pilots up from 6 to 22.

The online tool has proven to be instrumental in showcasing the results and impacts of the 5G PPP use-case experiments, with the number of views increasing from 55,004 at the end of December 2019 (the Global5G.org delta) to 103,050 at the end of September 2020, with further impacts expected over the next 12 months of FULL5G.

Another highly effective dissemination mechanism is the annual competition organised by the Trials WG, enabling an assessment of 5G PPP results and impacts, including socio-economic impacts and the potential for market uptake and commercialisation. The 2020 competition also shows that the initiative is gaining momentum with 22 applications received and now being evaluated.

The next steps will include the production and promotion of the new brochure based on the top ten trials and pilots chosen, helping to further highlight the online tool and overall achievements of 5G PPP in terms of its focus on industry verticals.

The revised and updated blueprints for phases 2 and 3 and the related analyses will assist the 5G PPP, EC and prospective proposal writers in conducting a gap analysis on the coverage of use cases, 5G ITU functionalities, country and city locations, as well as the results achieved. The new versions of the blueprints will also assist the on-going phase 2 and phase 3 projects in keeping track of their use cases through coordination with the Technology Board and Trials WG.

## References

- [1] <https://global5g.org/cartography>.
- [2] [https://5g-ppp.eu/wp-content/uploads/2019/09/5GInfraPPP\\_10TPs\\_Brochure\\_FINAL\\_low\\_singlepages.pdf](https://5g-ppp.eu/wp-content/uploads/2019/09/5GInfraPPP_10TPs_Brochure_FINAL_low_singlepages.pdf).