5G PAN-EUROPEAN TRIALS ROADMAP VERSION 3.0

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The 5G Pan-European Trials Roadmap Version 3.0 has been elaborated and is supported by the Trials Working Group (WG) Members organizations listed on Page 14. It is coordinated by the 5G Infrastructure Association (5G-IA), expanding the work initiated by the Industry and the European Commission (EC) in the context of the 5G Manifesto[1] and of the 5G Action Plan (5GAP)[2].

1. Introduction

This document addresses the 5G Pan-European Trials Roadmap Version 3.0 and its implementation. It is produced for public release at the 5th Global 5G Event[3] and extends the Roadmap Version 2.0[4] made public at the 4th Global 5G Event[5] and highlighted during MWC 2018[6].

The main objectives of the Roadmap are to:
- Support global European leadership in 5G technology, networks deployment and profitable business.
- Validate benefits of 5G to vertical sectors including public sector, businesses and consumers.
- Stimulate a clear path to successful and timely 5G deployment in Europe.

To that end, it expands commercial trials and demonstrations as well as national initiatives.

Most of the Roadmap implementation is driven by the Industry on a private basis. Through the 5GAP, the EC supports the setting up of framework conditions for 5G deployment in Europe, notably the identification of the relevant harmonized spectrum and of the regulatory conditions, whilst additional financial support for trials and pilots is made available from the 5G Infrastructure PPP[7], specific National programmes of Member States (MSs) as well as from specific programmes such as the European Space Agency (ESA) Satellite for 5G Initiative[8].

The Roadmap strategy hereafter described builds on several pillars: (1) 5G Private Trials, (2) 5G Vertical Pilots, (3) 5G Pan-EU Flagship event - 5G for UEFA EURO 2020 and (4) 5G Trials Cities.

The Roadmap Version 4.0 is planned for public release at the 6th Global 5G Event.

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[1] http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc_id=16579
[2] http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=17131
[3] 5th G5GE on 16-17.05.18 in Austin - http://5gnewhorizons.com/home/
[4] https://5g-ppp.eu/wp-content/uploads/2017/05/5GInfraPPP_TrialsWG_Roadmap_Version2.0.pdf
[5] 4th G5GE on 22-24.11.17 in Seoul - https://www.4th-g5ge.org/
[6] https://5g-ppp.eu/wp-content/uploads/2018/02/flyer-trials-roadmap-MWC18_v0.1.pdf
[7] www.5g-ppp.eu
[8] https://artes.esa.int/satellite-5g

2. 5G Pan-EU Trials Strategy and Roadmap

Fast and successful 5G adoption depends on two key pillars: Technical and business validations. 5G trials and pilots have to help clarifying key questions and notably: (1) What are the business benefits of 5G?, (2) How does 5G provides these benefits?, (3) Why can this not be achieved now?, (4) What is 5G bringing that makes this possible? and (5) How is the transition done from 4G to 5G? Validation trials and pilots hence have to cover large scale deployment scenarios, under various vertical use-cases and business conditions, with their respective technology and business Key Performance Indicators (KPIs). In this document, the term pilot is differentiated from the term trial as follows: In a trial, activities are conducted (outside a laboratory environment) to verify the functionality of a system or parts of it, e.g. when the correct functionality is still the primary interest. Pilot is the execution of a trial including business relationship conditions aimed at validating the business added value of a product or service for the end-user.

The core part of the 5G trials and pilots is and will be achieved through private trials (commercial and pre-commercial) between network operators and manufacturers/vendors and is increasingly involving vertical stakeholders (as detailed in the 5G Private Trials section). The acceleration of 5G in Europe is happening thanks to a specific joint strategy between Industry (hand in hand with Research Centers, Academics and local communities), EC and MSs and Domains specific initiatives. In line with the European 5G strategy targeting large scale adoption of 5G by vertical sectors[9], and considering the public interest and the public sector role for a multiplicity of verticals like energy, healthcare or automotive, additional trials and pilots will also be supported from the public sector through "public" trials. Expanding bilateral and multilateral private trials, the strategy hence relies on the development of initiatives addressing 5G vertical pilots and 5G platforms, 5G UEFA EURO 2020 as major 5G Pan-EU Flagship event and the 5G Trials Cities programme. The 5G Pan-EU roadmap also leverages a multiplier effect of the cooperation between ecosystem partners over different European countries. In that context, the EC is fostering the provision of a number of pan-European Corridors[10] from MSs, made available to industry and stakeholders to test and validate 5G in the context of Connected and Automated Driving (CAD), which is considered as a 5G flagship use-case in Europe. This will support 5G CAD projects engaging stakeholders at large, notably network operators, manufacturers/vendors, chipset providers, car makers and road administration. The 5G Infrastructure PPP Phase 3 provide opportunities to support such early projects. The Roadmap strategy including its main building blocks is depicted in Figure 1.

The running 21 5G PPP Phase 2 projects (2017-2019) already contribute to the prototyping, experimentation and trialling of 5G technologies and components for specific uses-cases including vertical use-cases developed with vertical stakeholders[11] (as detailed in the Verticals Pilots Section). 5G Infrastructure PPP Phase 3 projects (2018-2021) starting in July 2018 will allow to scale up these experimentations through at least an additional 3 projects providing a pan-European large-scale end-to-end 5G validation network infrastructure, covering about 20 European sites and nodes on a pan-European basis. This infrastructure will provide the adequate level of openness to make it possible for vertical industries to test their innovative 5G business cases using ad-hoc network resource control in an end-to-end interoperability framework. In addition, about 3 projects addressing vertical pilots for connected mobility implemented through CAD corridors in partnership with the MSs, to start in October 2018 will support advanced 5G trials for connected mobility. These

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[9] https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf
[10] https://ec.europa.eu/digital-single-market/en/news/new-5g-cross-border-corridors-connected-and-automated-driving-announced-digital-day-2018
[11] https://5g-ppp.eu/5g-ppp-phase-2-projects/

will be complemented by 6-9 projects addressing vertical pilots, to start in May 2019, and leveraging the pan-European 5G end-to-end facilities in priority. 5G Infrastructure PPP Phase 3 projects will thus target large scale trials and pilots including complete end-to-end 5G systems, demonstrating 5G KPIs and key distinguishing features and notably end-to-end network slicing, service based architecture, integration of diverse access technologies, and proving 5G technology capability to address and integrate requirements of a multitude of vertical industries. From a European perspective, it is also important to leverage the multiple developments and investments supported at MS level. The 5G platforms projects and their interworking with the verticals pilots projects will be detailed in the Roadmap Version 4.0 for public release at the 6th Global 5G Event. An inventory of 5G available platforms in the EU and their related functionalities is currently under development and should be available in July 2018. It is particularly important to describe the supported technologies and functions of platforms compared to the complete 5G target landscape. This inventory will boost the access to 5G platforms, by helping the different stakeholders (research, public sector, industry…) identifying the right platform (common classification and documentation) for their interests.
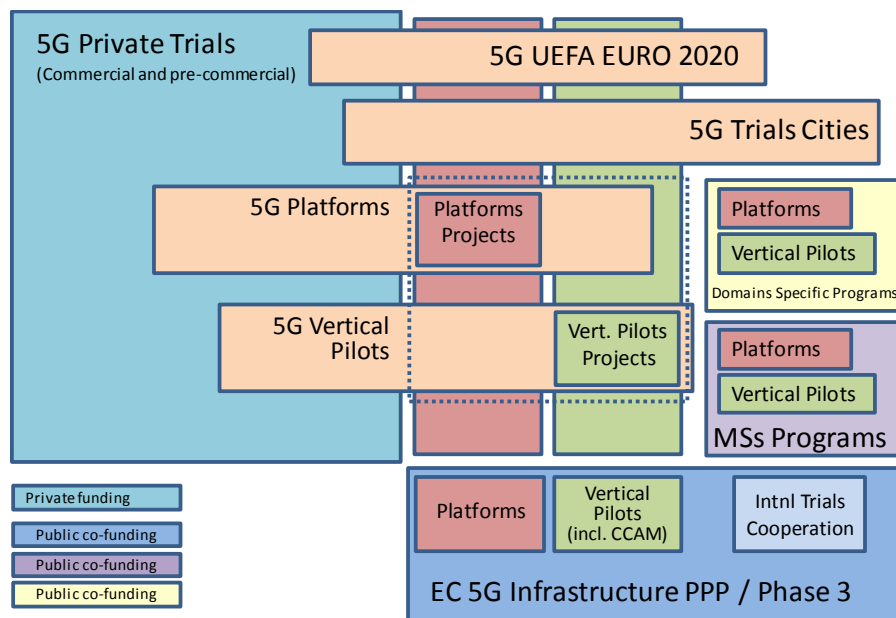

Figure 1: 5G Pan-EU Trials Roadmap - Strategy

During MWC 2018[12], EC Commissioner for Digital Economy and Society Mariya Gabriel announced two new initiatives: The European 5G Observatory and the 5G Pioneer Award. The European 5G Observatory[13] aims to provide up-dates on market developments, as well as plans and actions undertaken by both the private and public sectors, in the field of 5G. All developments will be analyzed in view of their strategic implications on the objectives of the 5GAP and other public policy objectives. The Observatory will focus primarily on developments in Europe, along with major international developments that could impact the European market. The European 5G Pioneer Award initiative in partnership with GSMA, aims to single out the front runners in Europe adopting 5G, whether they are key partnerships with vertical sectors, innovative 5G cities, region, or any

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[12] https://ec.europa.eu/digital-single-market/en/news/european-5g-observatory-and-5g-pioneer-award-mobile-world-congress-2018

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

other initiative enabling to identify 5G deployment best practices to stimulate 5G ecosystems. The first award is planned during MWC 2019.

In addition, specific programmes like the "ESA Satellite for 5G Initiative"[14] aims to support space sector integration in the 5G Pan-EU trials. The intention is to accelerate the integration of Satellite in 5G through relevant projects, in particular 5G Infrastructure PPP Phase 3 projects, with ESA funding providing a complementary "multiplier" effect[15] to the satellite elements in those projects.

The overall 5G Pan-EU Trials Roadmap time plan and relevant standardization, regulatory and ecosystems time plan are summarized in Figure 2.
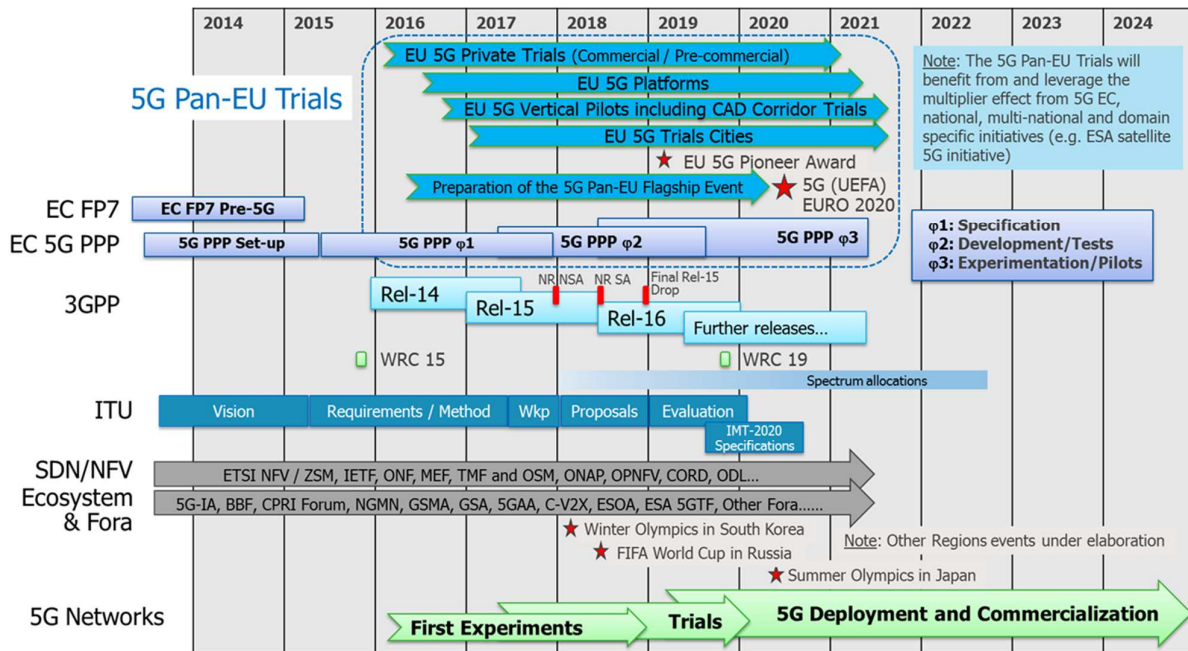

Figure 2: 5G Pan-EU Trials Roadmap – Time Plan

The involvement of Vertical sectors stakeholders is also developed through the 5G-IA Verticals Task Force. Verticals sectors and related Associations (e.g. Industry, Media, Automotive, Health, Public Safety, Energy…) are currently prioritized and specific interactions are targeted, as depicted in Figure 3. Vertical industries have different levels of 5G readiness and in some vertical sectors, large industry alliances or consortia exist, e.g. EATA[16] and 5GAA[17] in the automotive sector. These will be instrumental to foster 5G adoption within their verticals.

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[14] https://artes.esa.int/satellite-5g

[15] The primary objective is to incentivize collaborations within 5G Infrastructure PPP projects (for example the inclusion of a relevant satellite element) by providing the opportunity to further enlarge their scope. A secondary objective could be to implement individual complementary activities, in a coordinated manner, typically to extend the scope of selected 5G Infrastructure PPP projects in areas specific to satellite technology and use cases.

[16] http://www.acea.be/press-releases/article/connected-and-automated-driving-eata-presents-deployment-roadmap-submits-pr
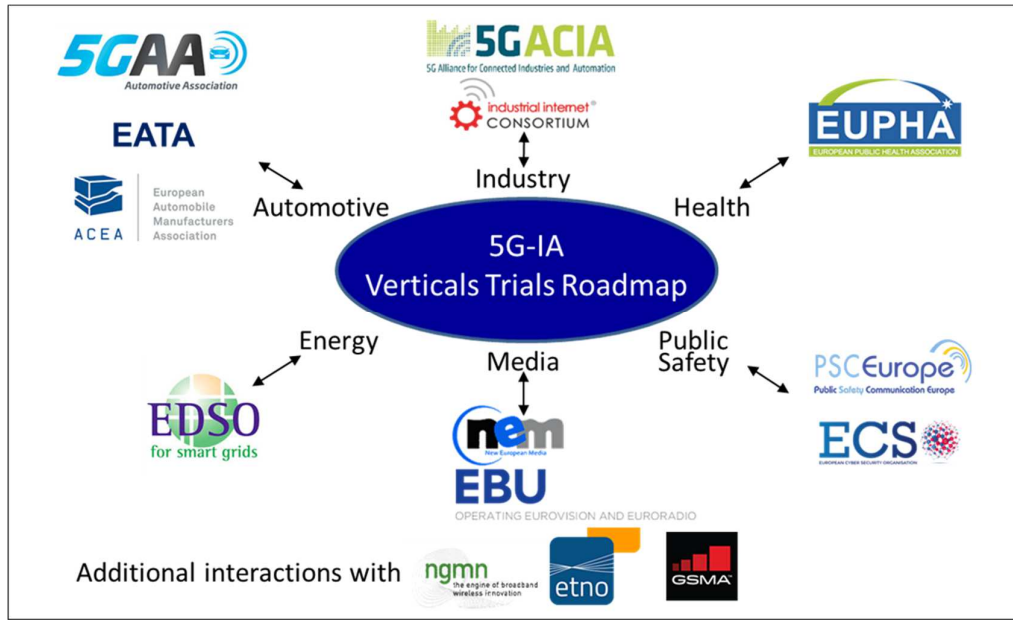
[17] http://5gaa.org/

Figure 3: 5G Verticals Strategy – Verticals Sectors and Associations

5G Pan-EU Trials are implemented within a global context where deployment initiatives are already taking place in other countries and regions. Avoiding premature "5G" launch announcements should be a common industry objective, as risks of potential fragmentation among the different countries may hurt both industry and consumers. In that sense, the adoption of the first version of a 5G New Radio (NR) standard, completed by 3GPP by the end of 2017, is a major milestone towards global 5G adoption and the 5G Infrastructure PPP will continue to support globally harmonized standards through the implementation of relevant trial results in subsequent 3GPP releases. This will also leverage the results of trials implemented through European research collaboration with third countries currently including: (1) Japan, with a focus on spectrum and interoperability at different bands, (2) South Korea, with special emphasis on mmWave and integration of 5G vertical testbeds in heterogeneous environments (e.g. connected car), (3) China, where the main use cases will be Vehicular to Everything (V2X) communications and enhanced Mobile Broadband (eMBB) applications, (4) Taiwan, where trials will be conducted on end-to-end testbeds for specific applications in shopping malls, high-speed trains, and connected cars and (5) Brazil, with a focus on spectrum and standards cooperation (e.g. via field tests in the VHF and UHF bands) targeting the provision of high speed access in low density areas.

3. Building Europe 5G readiness through 5G Private Trials

Multiple 5G private trials and pilots (pre-commercial and commercial) have been achieved or are currently on-going/planned in Europe. Today, more than 80 such initiatives[18] are publicly announced in the different EU countries, involving a multiplicity of stakeholders, notably network operators, manufacturers/vendors and some vertical industries. Major network operators in Europe have already announced their first results of experimentations and plans for further demonstrations of specific 5G features, either bilaterally with a single manufacturer/vendor or multilaterally with a number of manufacturers/vendors.

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[18] https://5g-ppp.eu/5g-trials-2/

Most of the current trials and pilots target the demonstration of high data rates and low latency communications performance of 5G technology. Trials have been so far mainly focused on enabling technologies related to the radio interface (e.g. high throughput, millimetre-waves and other new wide spectrum bands, antenna technologies…), the network architecture (e.g. virtualization, cloudification, network slicing, edge computing…) and the introduction of new technologies dedicated to specific use cases (e.g. technologies for IoT, for automotive…). Until now, only a few 5G Private trials include vertical stakeholders. As the maturity level of 5G features increases, more direct vertical stakeholders will be engaged in the trials. Some of the announced 5G trials include joint work on experimentation platforms that could become open to new vertical ecosystems, in order to develop 5G applications and services in the context of the digital transformation of vertical industries.

The running trials and demonstrations are already today building concrete know-how and readiness of the European industry to benefit from an early 5G launch when the standards will be fully stable. Figure 4 depicts the number of trials publicly announced/achieved in the different MSs.
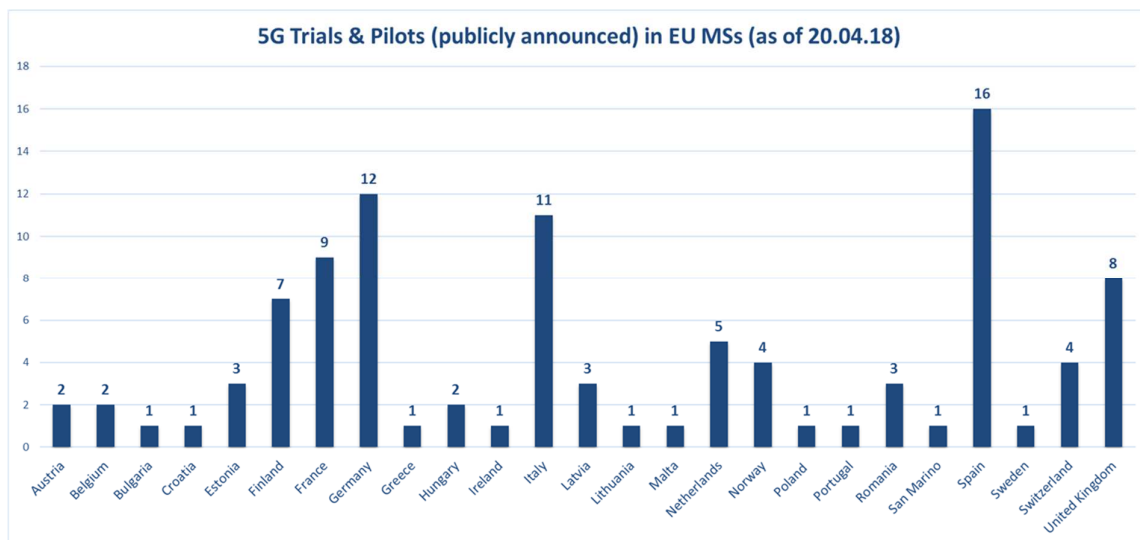

Figure 4: 5G Private Trials in EU, publicly announced as of April 2018

From 2018 onwards, European stakeholders will develop detailed trials specifications (use-cases, scenarios, interfaces, agreement to transfer use-cases across trial networks) valid for Pan-European trials, mostly based on standard-compliant systems. These trials will take advantage of the first 5G release of the 3GPP Standard (Rel-15) with compliant equipment, which will include a small set of 5G features and will be based on non-standalone LTE assisted NR. This will be followed by full 5G System (5GS) trials, featuring standalone NR after June 2018. Trials will use some of the additional frequency spectrum proposed for identification in WRC 2019 (e.g. 5G Pioneer bands), enabling the full performance capabilities of 5G in terms of capacity and speed. These trials will aim at demonstrating a wider interoperability (5G and legacy systems) and the support for vertical use-cases, so as to validate new business models.

Some of these initiatives will also reflect the Trial and Testing Initiative (TTI)[19], approved by NGMN in June 2016, which aims at: (1) Enabling a global collaboration on testing activities to support a

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[19] https://www.ngmn.org/news/ngmn-news-and-press-releases/ngmn-news-and-press-releases-details/ngmn-is-leading-the-way-to-a-healthy-5g-ecosystem-5g-trial-and-testing-initiative.html

successful and timely 5G introduction, (2) Consolidating contributions and report on industry progress in order to ensure the development of globally aligned 5G technology and service solutions and (3) Testing 5G use-cases with industry stakeholders (e.g. from vertical industries) for identifying and promoting new business opportunities. The 5G-IA Trials WG is developing a connection with the TTI WG. The tests and trials conducted by NGMN TTI partners in the framework of EC 5GAP are naturally entitled to be shared within the framework of this global initiative.

4. 5G for Vertical Industries - Building the case through Pilots Projects

In the context of the European 5G strategy for vertical industries, validating the stability and performance of 5G technologies in specific vertical environments and across vertical industries is key to bring 5G to the market. This approach can prevent the development and deployment of platforms that each is specialized for one sector and supports the development of a generic platform that can flexibly accommodate and support multiple verticals requirements. From a business point of view, pilots that embrace several verticals are needed. For example, a company in the manufacturing sector requires links to companies in the transport/logistics sector and/or companies in the smart grid/energy sector.

Making the above a reality and to attract verticals, the 5G-IA has defined the following strategy:
- Identification of priority vertical sectors: (1) Media, Automotive and Smart Manufacturing, (2) eHealth, Energy and Public Safety and (3) Smart Cities. It is understood that Smart Cities is more a horizontal sector, covering many vertical sectors.
- Definition of a governance structure to coordinate the activities, considering vertical stakeholders engagement.
- Encouraging an active engagement of vertical stakeholders, supported by an active awareness and promotion strategy.

Various organizations[20] already identified diverse application-specific requirements and usage scenarios for 5G. At a high level these are eMBB, Ultra-Reliable and Low-Latency Communication (URLLC) and massive Machine Type Communication (mMTC). These requirements stem from an analysis of business aspects and applications driven by verticals. eMBB, URLLC and mMTC, to a larger or smaller extent, can be found in the following six vertical clusters:
- Consumer and Professional Services cluster embracing media & entertainment (B2C, B2B2C), personal communications, emergency communications, smart buildings, smart health and on the move services.
- Automotive embracing connected and autonomous cars, vehicle-to-infrastructure, entertainment and media services.
- Industry Cluster embracing factory and process automation, energy, logistics/transport and Farming technology.
- Digital Health (eHealth) cluster embracing smart pharmaceuticals, smart pharmaceuticals augmented with supply chain and cost clearing and medical emergency management.
- Public Safety & Digital divide resorption embracing rapid disaster response, public event management, Critical asset protection and Remote area coverage.
- Smart City cluster embracing public administration, tourism, assisted living, people mobility and residential energy management and provisioning.

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[20] https://www.itu.int

The vertical clusters structure the development of concrete plans for trials. Note that the clusters cover the above-mentioned priority vertical sectors. In addition, there are already agreed and planned pilots announced for smart cities and communities[21]. The currently running Phase 2 of the 5G Infrastructure PPP also includes significant participation from verticals[22]. The table below exemplifies some of the experimentations, trials and pilots from a selection of 5G Infrastructure PPP Phase 2 projects across different vertical categories.

Vertical Category	Project	Verticals Stakeholders	Project Trial / Pilot Focus	ITU Service Type	Location
Connected and Automated Mobility	5GCAR	Volvo, PSA, and Bosch	End-to-end V2X network connectivity for highly reliable and low-latency V2X services.	eMBB, URLLC	Montlhéry (FR)
Smart City	5GCity	City councils of Barcelona, Bristol and Lucca	Distributed cloud and radio platform for municipalities and infrastructure owners acting as 5G neutral hosts.	eMBB, URLLC (mMTC)	Barcelona (ES), Bristol (UK), Lucca (IT)
	IoRL	BRE, Issy Media and Ferrovial	Indoor delivery of very high bandwidth, low latency and location based services.	eMBB	Watford (UK), Paris (FR), Madrid (ES)
Consumer and Professional Services	5G-Xcast	BBC, EBU and LiveU	5G network architecture for large-scale immersive media delivery.	eMBB	Surrey (UK), Munich (DE), Turku (FI)
	5G ESSENCE	Smart Mobile Labs GmbH	5G Edge network acceleration for a stadium.	eMBB	Egaleo (GR)
	5G-MEDIA	CERTH/ITI, IRT and RTVE	Tele-immersive applications, mobile contribution, remote and smart production in broadcasting.	eMBB	Athens (GR), Thessaloniki (GR), Madrid (ES), Rome (IT)
	5GTANGO	Nurogames	Immersive media application showing added value of 5G service network programmability, automatic testing and NFV orchestration.	eMBB, URLCC	Aveiro (PT), Athens (GR)
Transport	5G-Transformer	CRF and SAMUR	Transforming today's mobile transport network into an SDN/NFV-based Mobile Transport and Computing Platform (MTP) which brings the "Network Slicing" paradigm into mobile transport networks.	URLLC	Turin (IT), Pisa (IT), Madrid (ES), Nice (FR)
Industry	5G-MoNArch	Hamburg Port Authority and Turin Palazzo Madama	A flexible, adaptable, and programmable architecture for 5G brought into practice in two testbeds: Hamburg for	mMTC, URLLC (eMBB)	Hamburg (DE), Turin (IT)

Vertical Category	Project	Verticals Stakeholders	Project Trial / Pilot Focus	ITU Service Type	Location
			network resilience and Turin for resource elasticity.		
	NRG-5	Ineo Energy & Systems, Romgaz, Emotion and ASM Terni	Smart Energy-as-a-Service: Making the operation and management of communications and energy infrastructures easier, safer, more secure and resilient.	mMTC, URLLC (eMBB)	Terni (IT)
	5GTANGO	Weidmüller	Smart manufacturing showing added value of 5G service network programmability, automatic testing and NFV orchestration.	mMTC (URLLC)	Detmold (DE)
	VirtuWind (PPP Phase 1)	Siemens Wind Power	SDN/NFV to lower CAPEX/OPEX in control network infrastructure in an operational wind energy park.	URLLC	Brande (DK)
	5G-Picture	FGC Ferrocarrils de la Generalitat de Catalunya and Comsa Industrial	Adoption of the 5G disaggregated RAN (DA-RAN) architecture for demonstration of 5G rail services in a real railway testbed.	mMTC, URLCC, eMBB	Barcelona (ES), Bristrol (UK)
	NGPaaS	Vertical M2M and Virtual Open Systems	"Build-to-order" IoT Platform as a Service: Isolation of two devices (Health vs Temperature) using a single virtual IoT gateway component.	mMTC, URLCC	Paris, Grenoble (FR)
Public Safety & Digital Divide Resorption	5G-ESSENCE	Thales Communications & Security SAS	Demonstrate and evaluate the cloud-integrated multi-tenant small cell network customisable on a per vertical basis.	URLLC, eMBB	Coventry (UK)
	MATILDA	ININ Internet Institute	5G-enabled emergency response for real time intervention monitoring and critical infrastructure protection, showing Services Orchestration with SLA Enforcement.	URLLC (eMBB)	Genova (IT), Ljubljana (SL)

Table 1: Vertical Experimentation and Trials in EC H2020 5G Infrastructure PPP Projects

Vertical industries prioritized by the ESA Satellite for 5G Initiative include several segments in the identified clusters, for example, within the Industry Cluster Energy, Marine 4.0, Transportation/logistics incl. railway, aeronautical, motor coaches, i.e. inter city buses and holiday buses, media & entertainment, public safety and last mile 5G broadband connectivity in remote

European regions. Integrated satellite terrestrial vertical trials under the ESA Satellite for 5G Initiative address the complementarity of SatCom solutions offering ubiquitous coverage, global mobility support and broadcast/multicast delivery. These trials are scheduled to use existing and/or planned satellite capacity including mega-constellations and complement the vertical segments considered in 5G Infrastructure PPP pilots.

Within the European 5G vertical strategy, CAD is considered as a flagship use case for 5G deployment along European transport paths, in view of creating complete ecosystems around vehicles, beyond the safety services targeted by the Cooperative-Intelligent Transport System (C-ITS) roadmap of Europe. This has led to a high-level agreement between the EC and MSs at ministerial level, where MSs agree to make available pan European corridors to test 5G technology for vehicular applications. These corridors included initially Metz-Merzig-Luxembourg, Rotterdam-Antwerp-Eindhoven, Porto-Vigo and Merida-Evora (corridor Lisbon – Madrid), the E8 "Aurora Borealis" corridor between Tromsø and Oulu and the "Nordic Way" between Sweden, Finland and Norway. These have been expanded during the EC Digital Day in April 2018 with announcements[23] to work to develop corridors between Spain and Portugal, to expand the corridor Thessaloniki – Sofia – Belgrade with Greece, Bulgaria and Serbia, to develop the 5G Corridor on the Brenner pass motorway towards Italy... The 5G corridors make Europe the biggest experiment area rolling out the 5G technology.

5. 5G for UEFA EURO 2020 – An opportunity for a Pan-European Showcase Event

In order for 5G to be truly successful, high profile trial(s), accessible to large public audiences are planned. The target flagship event has to get widespread media attention and serve as a milestone for industry, governments and the general public showing that 5G is coming now and is beneficial for individuals and society.

The UEFA EURO 2020 football championships will be played in 12 different cities in Europe (Glasgow, Dublin, Copenhagen, Budapest, Bucharest, Bilbao, Amsterdam, Saint Petersburg, Rome, Munich, Baku and London). This makes the EURO 2020 an excellent opportunity for a 5G Pan-European trial, also because of the media attention it will get. The timing of EURO 2020, summer 2020, just before the 2020 Olympics in Japan, fits well with the EC 5GAP.

The intention is that the EURO 2020 acts as the "launching event" for 5G in Europe with a number of 5G services that will be trialed around the EURO 2020 football cup.

In each of the cities, a consortium is needed of local governments, playing stadiums, operators, infrastructure vendors and application providers. Local funding through private trials or/and national or/and regional initiatives will be used to develop the trials. The City of Amsterdam, with the Amsterdam Arena as EURO 2020 host stadium publicly announced at the MWC 2017 in Barcelona that they are committed to participate in 5G trials and to get as many playing cities on board. For each playing city, an agreement with (at least one) operator is targeted to ensure there will be a 5G coverage on which the intended 5G services can be trialled. There will need to be a trade-off between what coverage specific trials need and what local operators and manufacturers/vendors can deliver. Sufficient spectrum (at least 100 MHz per operator across the 3.4-3.8 GHz band, several hundreds of MHz in the 26 GHz band) is targeted for availability from the

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[23] https://ec.europa.eu/digital-single-market/en/news/new-5g-cross-border-corridors-connected-and-automated-driving-announced-digital-day-2018

related MSs, in order to allow demonstrating the full performance capabilities of 5G. Cities that are not a playing city can participate with 5G augmented and virtual reality applications at local fan zones, which will also reduce the requirements on coverage and spectrum. The trial services will be developed together with the local partners, e.g. public safety trials will need collaboration with local governments. Though the different local governments and local initiatives may lead to differences in the trials, replication of 5G trial services across multiple cities is aimed for as far as possible. A Pan-European steering committee, including representatives of the cities, the playing stadiums and telco partners, will ensure a consistent coordination of trial objectives and implementation. It will also address the marketing and communications aspects of this profile event across Europe and the world.

The first 5G UEFA EURO 2020 Trial meeting was organized in Amsterdam in February 2018, collocated with the Innovation Summit 2020[24] organized at Amsterdam Arena, and attended by government and non-governmental organizations, from different cities. The city of Amsterdam presented its sustainable 5G program and 5G use-cases were addressed, including Multimedia, Public Safety and Automated Driving.

The City of Amsterdam, with the Amsterdam Arena as host stadium, together with several other playing cities, are forming a Vanguard group of EURO 2020 playing cities that not only execute a 5G trial around UEFA EURO 2020, but also develop a trial program towards the events itself that can link to several verticals. They are committed to getting as many of playing cities and stadiums involved as possible. For each of the playing cities, an operator, with one or more vendors, needs to be involved to provide 5G network coverage for the 5G trials. For each playing city, an agreement with (at least one) operator needs to be found to ensure there will be 5G coverage on which the intended 5G services can be trialled. The concept of trialling the same 5G services in different cities demands for test infrastructure that can be easily replicated in the different cities.

A Vanguard Group, which consist of hosting cities is now being formed. The aim of this Vanguard Group is to further define the initiative that describes the use-cases and launch of 5G in 2020 during UEFA EURO 2020. The following cities are now included in the discussions: Amsterdam, Dublin, London, Copenhagen, Munich and Roma. Hosting cities currently describe the 5G use-cases as discussed during the first 5G UEFA EURO 2020 Trial meeting. The initiative is further developing and will be signed and communicated to EC for further development. The description and focus of the hosting cities will formulate a focus to launch 5G as a Pan-European Service.

A relation with UEFA will be established in order to investigate the rights and constraints associated with using EURO 2020 as a flagship event and to ensure the trials add to the success of UEFA as well. A win-win-win perspective between 5G Infrastructure PPP, EC and MSs (and related Cities) and other stakeholders is sought.

Although 5G coverage at the EURO 2020 event is going to be requirement for the trial, it is not going to be the focus of the 5G Pan- European Trial event. The focus should be on the 5G services tailored to the UEFA EURO 2020 event (e.g. multimedia, automated driving, public safety, adaptive buildings), that are provided across multiple different cities. It is the intention that the same service will be provided in the same way in each participating city to prove the European Single Digital Market validity.

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[24] http://amsterdaminnovationarena.com/summit/

6. 5G Trials Cities

A number of European cities have already announced their plans to become 5G Trials Cities, at the forefront of 5G trials and pilots. The different involved stakeholders come together to enable societal infrastructure benefits to the public, as new technology provided by 5G is seen as an opportunity to enhance and enrich the public services, increase the cities attractiveness and streamline the cities functions. There is also a clear need to modernize city governance and processes and to deploy disruptive technologies enabling further digitization in public service delivery.

The private trials, lay the foundation to city trials, forming the basis of commercial 5G deployment and use in city environment. In addition to private trials, the large scale publicly supported open test networks and trial environments are foreseen as the first platforms to conduct the city trials and public service piloting. These test network environments (such as 5G Barcelona, 5G Test Network Finland, UK 5G Hub…), bring together both commercial technology vendors, operators and service providers as well as public authorities and academia, setting the initial ecosystem for further commercial deployment of 5G networks and services.

A non-exhaustive list of 5G Trials Cities include Amsterdam, Aveiro, Barcelona, Bari, Berlin, Bristol, Espoo, Ghent, L'Aquila, London, Madrid, Malaga, Matera, Milan, Oulu, Patras, Prato, Stockholm, Tallinn and Turin. These trial cities aim to provide support for variety of technology and service demonstrations carried out during the 5G trialling phase, and provide valuable vertical use cases especially for Smart City concept to validate the trials in real user environments. When compared to the private sector, public entities such as cities usually have different interests even in similar use cases focusing e.g. on eHealth, energy, transport, smart buildings or digital service portals. In all of these domains, shared technology platforms, free access, open data and interfaces as well as the maximal involvement of local ecosystems and residents are common priorities.

The example cities are aiming especially to boost the industry and services for the citizens and become key actors within the 5G ecosystem. For example, the city of Barcelona is determined to transcend the "smart city" concept and deploy a program that integrates and coordinates local initiatives related to a truly digital transformation of the services the city offers to its citizens. Barcelona has just launched the 5GBarcelona strategy towards facilitating the deployment of trials and pilots across the city and so, become a 5G smart city. The city of Berlin aims to stipulate research and development of 5G technologies, and one of the city's main strategic interest is to enable an innovation-stipulating environment and technology infrastructure which can eventually provide the 5G experience to the public on the streets of Berlin. The City of Oulu is challenged to modernize the city governance and processes in the framework of constrained public expenditure and demand for deploying disruptive technologies enabling digitization, automation and robotization in public service delivery. One of the main strategic priorities is to enhance innovation led economic growth and competitiveness of the local economy and companies to create employment outcomes for the people of Oulu, in order to ensure sustainable and healthy living environment. Arranging broadband connectivity (eMBB) and providing local free 5G network services network for mobile IoT based experiments is the first step to adopt the 5G technologies for citizens and city administration. City also targets people mobility related service trials and offers e.g. traffic-light data as open data for service development… Similarly, the City of Patras is aiming at organizing, transforming and finally extending its current digital infrastructure into an open platform that will interconnect 5G related technologies. This digital transformation is performed in order to address e-administration issues related to the City of Patras while enhancing the quality of life of its citizens. City of Bristol as one of

the main UK 5G Hub sites, together with University of Bristol, aims especially to demonstrate the 5G technologies for public. The Bristol target has been mainly to show the potential of 5G in shaping the future of social interaction, entertainment, urban planning and public safety. The similar events as "Layered Realities - Weekend", arranged in March 2018[25], are planned for near future. The promotional video from the event is also available[26].

In addition to the previous city examples, there are 5G Research & Innovation Programs running in several MSs, including the development of specific labs and experimentation and trials platforms. These platforms, being generally anchored in specific labs / cities (before their replication), contribute to the 5G momentum in these specific areas. For example, some of the 12 cities where the UEFA EURO 2020 competition will be organized already work on the possible 5G demonstrations and showcases. These different actions clearly create a strong momentum on 5G from cities and countries perspectives.

5G cities may benefit from the "5G Pioneering Award" contest, organized as a call for interest towards interested 5G initiatives at city, regional or else level, with the aim of supporting the development of 5G deployment best practices and sharing of lessons learnt. 5G Trials Cities are also encouraged to contribute and support the end-to-end facility trials and joint vertical industry pilots in order to expand the coverage and public visibility of the activities related to the 5G Infrastructure PPP Phase 3. Here again, the availability of sufficient amounts of spectrum will be sought to deliver the full benefits of the large-scale 5G city trials.

7. Future Updates

The release of the Roadmap Version 4.0 is planned for November 2018 in conjunction with the 6th Global 5G Event to be organized on 21-23.11.18 in Rio. It will notably provide updates on the Roadmap implementation, on the availability of end to end 5G platforms available in Europe and their interworking with the initiatives of vertical sectors.

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[25] http://www.bristol.ac.uk/engineering/research/smart/events/layered-realities-weekend/
[26] https://vimeo.com/260787851/79f696c47c

Trials WG Members organizations contributing to the Trials Roadmap Strategy
ABB, ADVA Optical Networking, Ahlers, Airbus, Altice Labs, Atos, Avanti Communications Group plc, BMW, Bosch, BT, COMSA, Deutsche Telekom, DOCOMO Communications Laboratories Europe, Engineering, Ericsson, Eurescom, Eutelsat, Fastweb, Fiat, Huawei Technologies, IBM Research, IDATE, Indra Sistemas, Inmarsat, Intel Mobile Communications, KPN, Leonardo, LiveU, Mitsubishi Electric R&D Centre Europe, NEC Laboratories Europe, Netaş Telecommunication, Nokia, OpenFiber, Orange, Philips, Proximus, QinetiQ, Samsung Electronics Research Institute, SES, Siemens, SIGOS, Telecom Italia, Telefónica I+D, Telenor, Tele2, Telespazio, Telia Company, Thales Alenia Space, Thales Communications & Security, Trenitalia, Turkcell, Turk Telekomünikasyon, Vodafone, ZTE Wistron Telecom, European Broadcasting Union (EBU), ECTA, ETNO, T-REGS, AICO Software, AMBEENT WiRELESS YAZILIM, CityPassenger, Ingeniería y Soluciones Informáticas, Integrasys, InterInnov, M.B.I., Nextworks, Quobis, Sequans Communications, WINGS ICT Solutions, CEA-LETI, Centre Tecnologic de Telecomunicacions de Catalunya (CTTC), Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Cork Institute of Technology (CIT), DLR (German Aerospace Center), Fraunhofer Gesellschaft zur Foerderung der angewandten Forschung e. V., Fundació Privada i2CAT, Internet i Innovació Digital a Catalunya, Fundacion IMDEA Networks, IMEC, Institut Mines-Télécom, Instituto de Telecomunicações, IHP, IRT, TNO, Universidad de Málaga, Universidad Politecnica de Madrid, Universitat Politècnica de Catalunya, University of Bologna, Universität Paderborn, University of Sussex, University of Oulu/CWC, University of Patras, VTT Technical Research Centre of Finland, Universidad Carlos III de Madrid, Amsterdam CTO.

Note: Specific comments / questions can be communicated to the 5G-IA Trials WG @ TrialsRoadmap@5g-ppp.eu.