



The 5G Infrastructure Public-Private Partnership

5G research in Europe

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Chair of the board of 5G Infrastructure Association

<http://5g-ppp.eu/>

Outline



- 5G PPP in Horizon 2020 of the European Union
- 5G Vision and Requirements
- 5G PPP research projects
 - Radio-related cluster
 - Fronthaul/backhaul
 - Hardware implementation
 - Network automation
 - SDN, NFV, Cloud and Virtualisation
 - Security
- Conclusions

Major milestones towards the 5G PPP implementation



- Commissioner Kroes asked Industry in Europe to cooperate on 5G PPP at Mobile World Congress 2013 in Barcelona
- First Call for Proposals published on December 11, 2013
- 5G PPP Contractual Arrangement signed between EU Commission and private side on December 17, 2013
- Budget for 2014 – 2020 time frame
 - Up to 700 million € public funding
 - Matched by private side including leveraging factor 5 of additional private investment results in private value of about 3.5 billion €
- 5G PPP industry launch at Mobile World Congress on February 24, 2014
- Submission deadline of proposals on November 25, 2014
- Project start on July 1, 2015
- 5G Vision EU – CTO Press Event at Mobile World Congress on March 3, 2015
- 5G Infrastructure Association vision paper published

<http://5g-ppp.eu/wp-content/uploads/2015/02/5G-Vision-Brochure-v1.pdf>



- From left to right:
- Marcus Weldon, Chief Technology Officer and President Bell Labs, Alcatel-Lucent
 - Li Yingtao, President of 2012 Laboratories, Huawei
 - Kyungwhoon Cheun, Executive Vice President, Samsung Electronics
 - Hermann Eul, Corporate Vice President General Manager, Mobile and Communications Group, Intel
 - Mari-Noëlle Jégo-Laveissière, Senior Executive Vice President of Innovation, Marketing and Technologies, Orange
 - Günther H. Oettinger, Commissioner for Digital Economy and Society
 - Hossein Moïni, Executive Vice President, Chief Technology Officer, Nokia Networks
 - Didier le Boulch, Chief Technology Officer, Thales Alenia Space
 - Mr Seizo Onoe, Executive Vice President, Chief Technical Officer, and Member of the Board of Directors, Docomo
 - Ulf Ewaldsson, Chief Technology Officer, Ericsson

19/06/2015

Source: 5G Infrastructure Association.



Key challenges



- PPP Program that will deliver solutions, architectures, technologies and standards for the ubiquitous 5G communication infrastructures of the next decade
- Program Ambitions: Key Challenges / High level KPIs
 - Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010
 - Saving up to 90% of energy per service provided. The main focus will be in mobile communication networks where the dominating energy consumption comes from the radio access network
 - Reducing the average service creation time cycle from 90 hours to 90 minutes
 - Creating a secure, reliable and dependable Internet with a “zero perceived” downtime for services provision
 - Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people
 - Enabling advanced User controlled privacy

5G PPP Vision and Requirements

5G new service capabilities



USER EXPERIENCE CONTINUITY

INTERNET OF THINGS

MISSION CRITICAL SERVICES



- 5G needs to support efficiently three different types of traffic profiles
 - high throughput for e.g. video services
 - low energy for e.g. long-living sensors
 - low latency for mission critical services
- 5G covers network needs and contributes to digitalization of vertical markets
 - automotive, transportation, manufacturing, banking, finance, insurance, food and agriculture
 - education, media
 - city management, energy, utilities, real estate, retail
 - government
 - healthcare
- Sustainable and scalable technology to handle
 - anticipated dramatic growth in number of terminal devices
 - continuous growth of traffic (at a 50-60% CAGR)
 - heterogeneous network layouts
 - without causing dramatic increase of power consumption and management complexity within networks

19/06/2015

Source: 5G Infrastructure Association: Vision White Paper, February 2015.

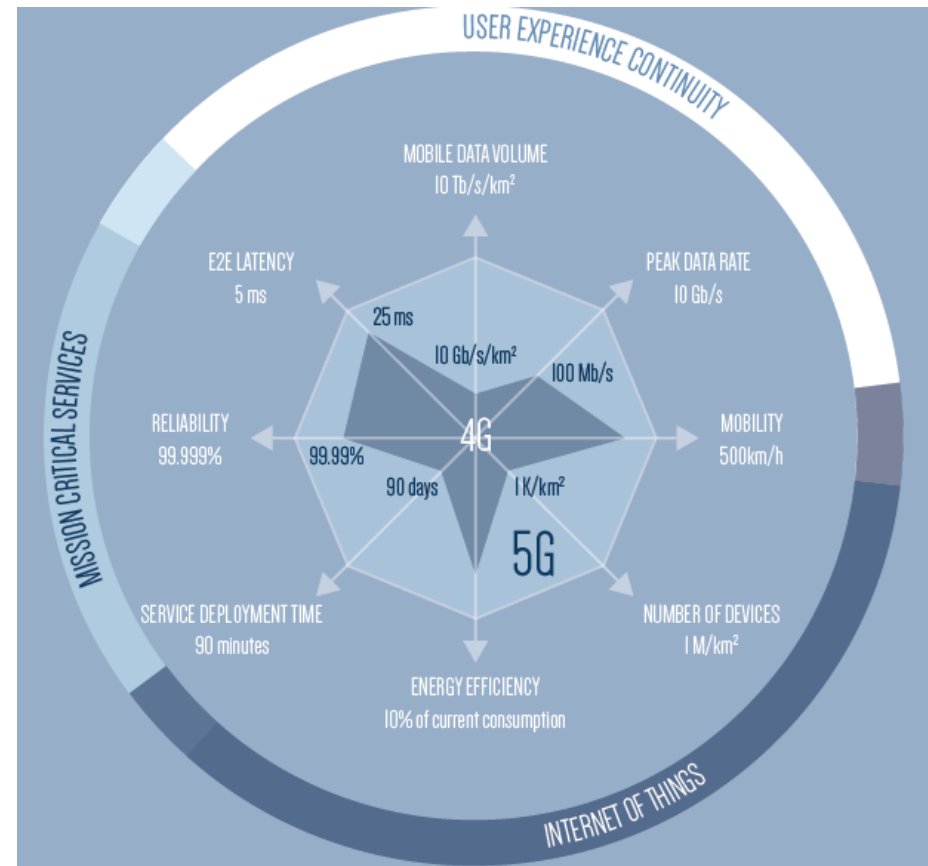
5G PPP Vision and Requirements

5G will have disruptive capabilities



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- 5G will provide an order of magnitude improvement in performance in the areas of more capacity, lower latency, more mobility, increased reliability and availability
- 5G infrastructures will be also much more efficient in terms of
 - energy consumption
 - service creation time
 - hardware flexibility



5G PPP Vision and Requirements

Key requirements



1000 TIMES



20 BILLION
HUMAN-ORIENTED TERMINAL



1 TRILLION



90%



<5MS LATENCY



99.999%



- 1,000 X in mobile data volume per geographical area reaching a target ≥ 10 Tb/s/km²
- 1,000 X in number of connected devices reaching a density ≥ 1 M terminals/km²
- 100 X in user data rate reaching a peak terminal data rate ≥ 10 Gb/s
- Guaranteed user data rate >50 Mb/s
- 1/10 X in energy consumption compared to 2010
- 1/5 X in end-to-end latency reaching 5 ms for e.g. tactile Internet and radio link latency reaching a target ≤ 1 ms for e.g. Vehicle to Vehicle communication
- 1/5 X in network management OPEX
- 1/1,000 X in service deployment time reaching a complete deployment in ≤ 90 minutes
- Mobility support at speed ≥ 500 km/h for ground transportation
- Accuracy of outdoor terminal location ≤ 1 m

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Source: 5G Infrastructure Association: Vision White Paper, February 2015.

5G PPP Vision and Requirements

Key technological components



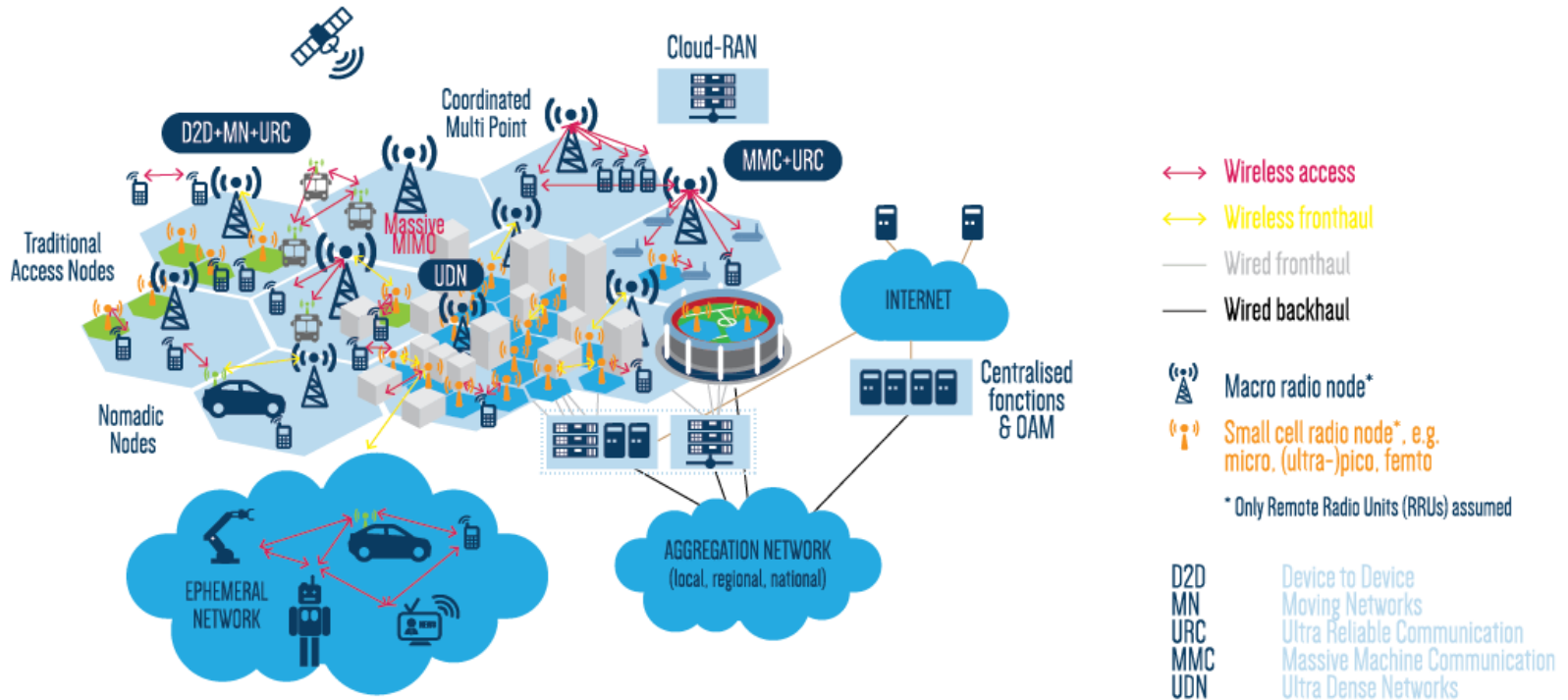
- 5G wireless will support a heterogeneous set of integrated air interfaces
 - from evolutions of current access schemes
 - to brand new technologies
- 5G networks will encompass cellular and satellite solutions
- Seamless handover between heterogeneous wireless access technologies
- Simultaneous radio access technologies to increase reliability and availability
- Deployment of ultra-dense networks with numerous small cells requires new interference mitigation, backhauling and installation techniques
- 5G will be driven by software and will heavily rely on emerging technologies
 - Software Defined Networking (SDN)
 - Network Functions Virtualization (NFV)
 - Mobile Edge Computing (MEC)
 - Fog Computing (FC)to achieve required performance, scalability and agility
- Easier and optimised network management by means of exploitation of Data Analytics and Big Data techniques
 - to monitor users Quality of Experience
 - while guaranteeing privacy



5G PPP Vision and Requirements

5G networks and services vision

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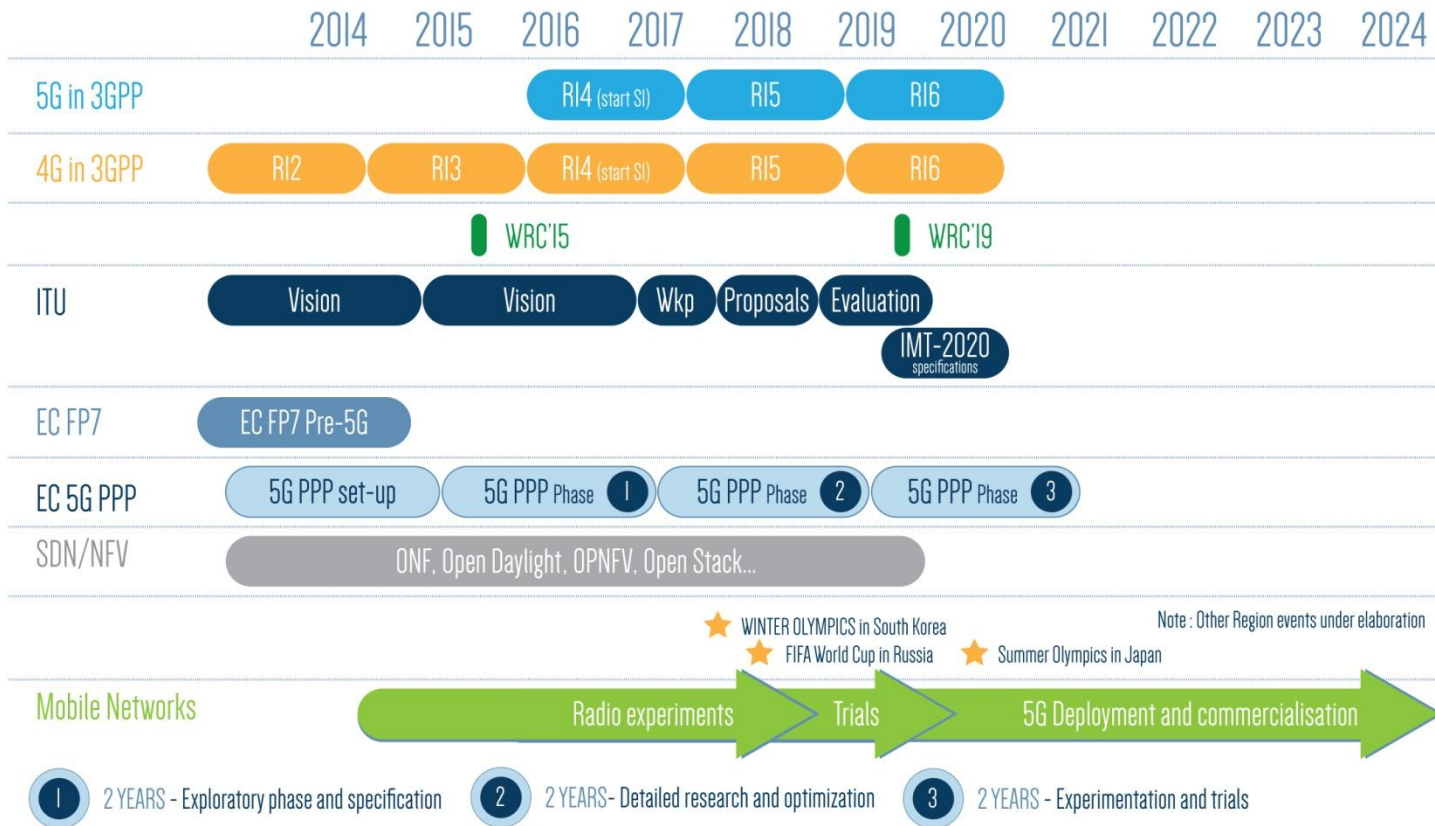


5G PPP Vision and Requirements

5G roadmap



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Objectives

- Radio interface below 6 GHz
- Radio interface above 6 GHz
- Overall RAN design
- Heterogeneous radio access networks (RAN)
- Novel adaptive 5G mobile network architecture
- Spectrum access

Objectives

- **5G integrated backhaul and fronthaul transport network**
- Fronthaul and backhaul solutions between RAN and packet core
- Demonstration and validation of xHaul technology components will be integrated into a software-defined flexible and reconfigurable 5G Test-bed
- **Flexible backhaul/fronthaul network** for serving current and future RAN deployments in a dynamic, service oriented, and cost-effective way
- **Seamless integration of future-proof technologies** in the optical and wireless (Sub-6 GHz, mm-Wave) metro/access domains, through a converged software-based control plane

Hardware implementation



Objectives

- Increasing the HW versatility and reconfigurability
- Providing HW-agnostic, flexible and cost-effective SW platforms
- Increasing the overall capacity of 5G communication platforms
- Decreasing the energy consumed by 5G communication platforms
- Identifying and prototyping key building blocks

Areas to be addressed

- RF front-ends and antennas (versatility, TRX > 6 GHz, antennas, ...)
- Mixed-signal technology (broadband DAC/ADC, full duplex, ...)
- Digital front-end + HW/SW split (HW for new waveforms, MIMO ...)
- SW modules and functions (SW re-configurability, energy savings)

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Objectives

- **Automated and fast provisioning** of infrastructure services in a multi-domain/multi-operator 5G environment
- Innovative framework for the **automated management** and rapid deployment **of self-configuring next-generation networks and services**
- Extending the state-of-the-art network management within the Software-Defined Networking and Network Function Virtualization (SDN/NFV) arena
- Network Management at the **5G/IOT** scale

Objectives

- **Network Functions Virtualisation (NFV)** and **Edge Cloud Computing**;
- Substantial evolution of the Small Cell concept
- Consolidation of **multi-tenancy** in communications infrastructures, allowing several operators/service providers to engage in new sharing models of both access capacity and edge computing capabilities.
- **Reduce time to market for networked services** by shortening service development (Programming model and SDK)
- Optimizing resource utilization and reduce cost of service deployment and operation
- Converged cloud-based 5G concept that will enable innovative use cases in the mobile edge, empower new business models, and reduce investment and operational costs
- To develop a **SDN & NFV ecosystem for industrial domains**, based on open, modular, and secure communication framework, leading to a prototype demonstration for intra-domain and inter-domain scenarios in real wind parks as a representative use case of industrial networks, and quantify the economic benefits of the solution

Security



Objectives

- End-to-end security across all layers of the converged and virtualised open access network
- Physical layer low-latency security for both wireless and optical, in open, dynamic, multi-user, highly connected and decentralized 5G networks
- Build two secure end-to-end pilot demonstrators

Conclusions



- 5G research started already in EU Framework Program 7
- 5G research is getting momentum globally
- In Europe 5G PPP launched in December 2013 as part of new research program Horizon 2020
- 5G PPP is addressing the complete future communication network including support of vertical sectors
- 5G PPP published its Vision and Requirements White Paper in Barcelona at MWC 2015
- Horizon 2020 Call 1 projects will start on July 1, 2015 and will address major components of future communication network

Acknowledgement: The author would like to thank his colleagues for their contributions.





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**Thank you for your
attention!**

