The 5G Infrastructure Public-Private Partnership

5G Visions and Requirements

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Chair of the board of 5G Infrastructure Association

http://5g-ppp.eu/

Outline

- 5G research projects in Framework Program 7
- International activities
- 5G PPP in Horizon 2020 of the European Union
- Indicative time plan
- Implementation of 5G PPP and Call 1
- 5G Vision and Requirements
- Conclusions

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EU Framework Program 7
System and radio projects

- **METIS** — **M**obile and wireless communications **E**nablers for **T**wenty-twenty (2020) **I**nformation **S**ociety
  - **Overall objective**

    https://www.metis2020.com/

    Lay the foundation & Ensure a global forum & Build an early global consensus for beyond 2020 “5G”mobile & wireless communications.
- **5GNOW** — **5**th **G**eneration **N**on-**O**rthogonal **W**aveforms for Asynchronous Signalling

  http://www.5gnow.eu/node/5
  - **Overall objective**

    5GNOW will develop new PHY and MAC layer concepts being better suited to meet the upcoming needs with respect to service variety and heterogeneous transmission setups.
- **iJOIN** — **I**nterworking and **JOIN**t Design of an Open Access and Backhaul Network Architecture for Small Cells based on Cloud Networks

  http://www.ict-ijoin.eu/
  - **Overall objective**

    iJOIN introduces concept RAN-as-a-Service (RANaaS), where RAN functionality is centralised through an open IT platform based on cloud infrastructure. Joint design and optimisation of access and backhaul, operation and management algorithms and architectural elements, integrating small-cells, heterogeneous backhaul and centralised processing.

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EU Framework Program 7
Radio and security projects

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- **Tropic** DisTributed computing, storage and radio resource allocation over cooperative femtocells

  http://www.ict-tropic.eu/

  - **Overall objective**

    The project aims at exploiting the convergence of pervasive femto-network infrastructure and cloud computing paradigms for virtualisation/distribution of applications and services.

- **MiWaveS** Beyond 2020 **Heterogeneous Wireless Networks** with **Millimeter-Wave Small Cell** Access and Backhauling

  http://www.miwaves.eu/index.html

  - **Overall objective**

    Demonstrate how low-cost or advanced millimetre-wave (mmW) technologies can provide multi-Gigabits per second access to mobile users and contribute to sustain the traffic growth. Hence, spectrum flexibility and the exploitation of the available mmW spectrum will be key strategies to build high-throughput and low-latency infrastructures for next generation heterogeneous mobile networks.

- **PHYLAWS** **PHY**sical **LA**yer **W**ireless **S**ecurity

  http://www.phylaws-ict.org/

  - **Overall objective**

    Design and prove efficiency of new privacy concepts for wireless communications that exploit propagation properties of radio channels. Search for realistic implantations in existing and in future Radio Access Technologies.

EU Framework Program 7
Network and Internet projects

- **combo** **CO**nvergence of fixed and **M**obile **B**r**O**adband access/aggregation networks

  http://www.ict-combo.eu/

  - **Overall objective**

    Propose and investigate new integrated approaches for Fixed / Mobile Converged (FMC) broadband access / aggregation networks for different scenarios (dense urban, urban, rural)

- **MOTO** Evolving **MO**bile internet with innovative terminal-**T**o-terminal **O**ffloading technologies

  http://www.fp7-moto.eu/

  - **Overall objective**

    Design an integrated operator-managed offloading system and combined offloading algorithms.

- **MCN** **M**obile **C**loud **N**etworking

  http://www.mobile-cloud-networking.eu/site/

  - **Overall objective**

    Extend the Concept of Cloud Computing beyond data centres towards Mobile End-User. One Service: Mobile Network + Computing + Storage. On-Demand, Elastic, and Pay-As-You-Go. Enable a Novel Business Actor, the Mobile Cloud Provider. Mobile Network Architecture for Exploiting and Supporting Cloud Computing. Deliver and Exploit the Concept of End-to-End Mobile Cloud for Novel Applications.

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International activities on 5G getting momentum

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ITU-R Visions Group

EU

- Framework Program 7, e.g. METIS and 5GNow projects
- 5G PPP in Horizon 2020

Germany – 5G Lab Germany at TU Dresden

UK – 5G Innovation Centre (5GIC) at University of Surrey

US

- Intel Strategic Research Alliance (ISRA)
- NYU Wireless Research Center
- 4G Americas

China

- 863 Research Program
- Future Forum
- IMT-2020 (5G) Promotion Group

Japan – The 5G Mobile Communications Promotion Forum

Korea – 5G Forum

Taiwan – TAICS, Ministry of Science and Technology, Ministry of Economic Affairs

Russia – 5GRUS by Russia's Icom-Invest

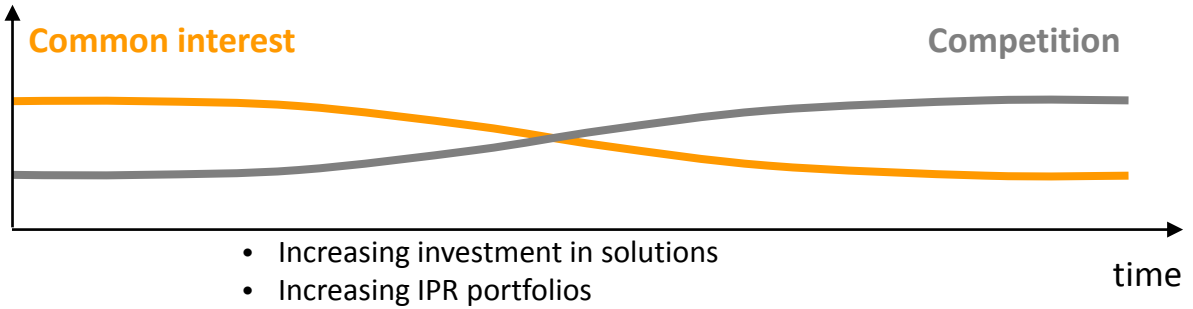
CJK White Paper

NGMN – White paper on future requirements

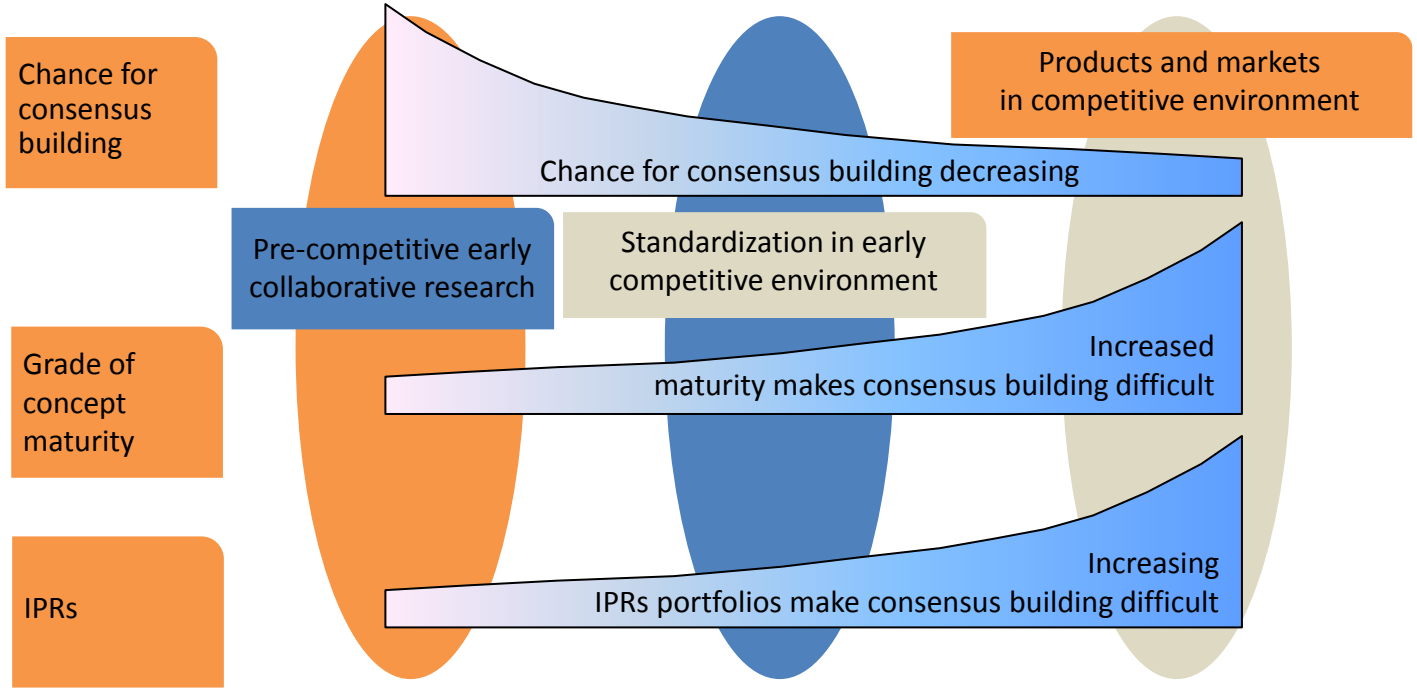
- Company internal research

Source: 5G Infrastructure Association.

Why Collaborative research?
International consensus building at an early stage



- Increasing investment in solutions
- Increasing IPR portfolios

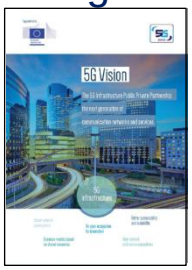


- Horizon 2020 is open for organizations from outside of Europe

Source: NetWorld2020.

Major milestones towards the 5G PPP implementation

- 5G PPP is a new instrument in Horizon 2020
- First Call for Proposals published on December 11, 2013
- Contractual Arrangement on 5G PPP signed between EU Commission and private side on December 17, 2013
- Budget for 2014 – 2020 time frame
  - 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

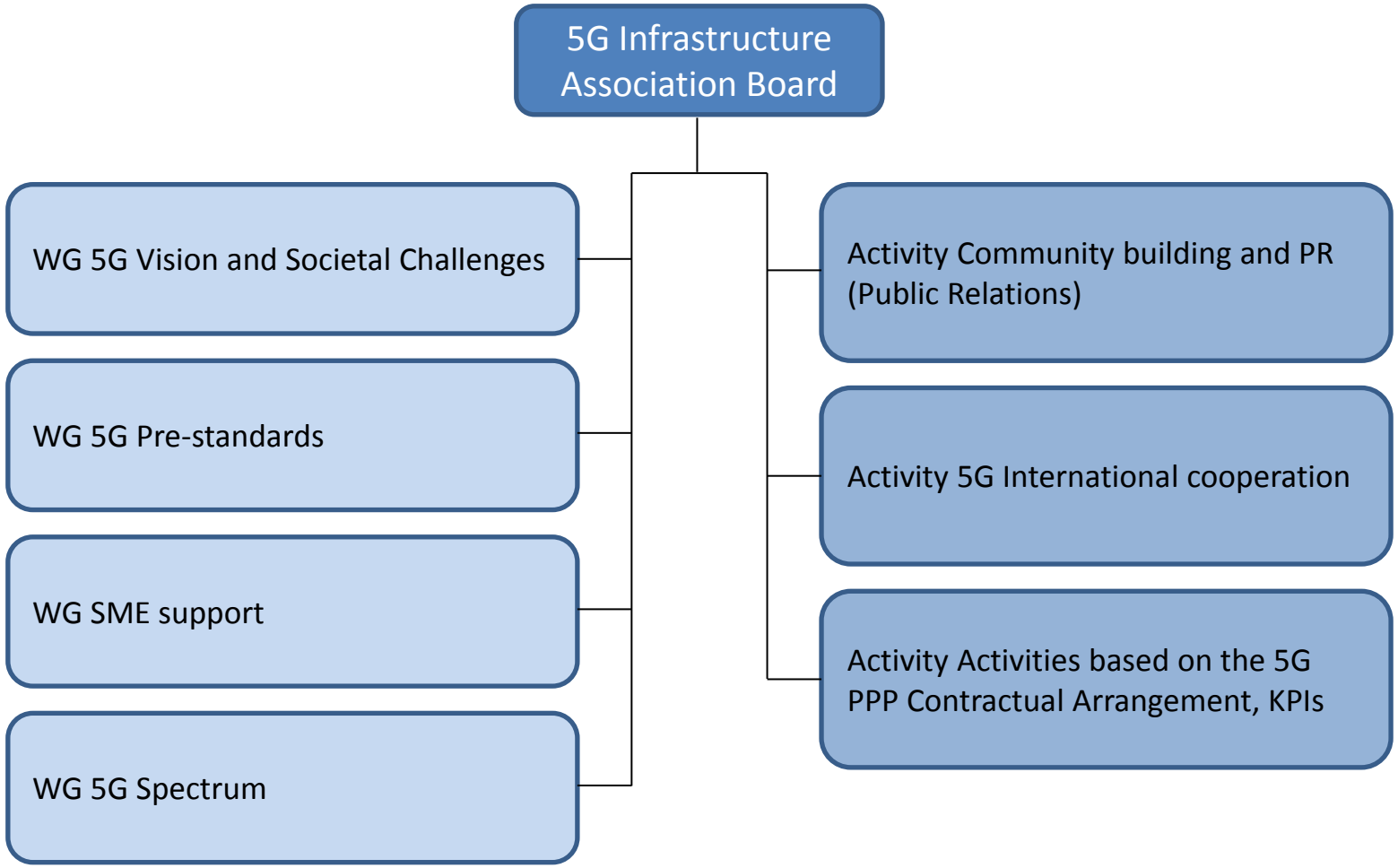


http://5g-ppp.eu/wp-content/uploads/2015/02/5G-Vision-Brochure-v1.pdf

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 Jego-Laveissière , Senior Executive Vice President of Innovation, Marketing and Technologies, Orange
- Günther H. Oettinger, Commissioner for Digital Economy and Society
- Hossein Moiin, Executive Vice President, Chief Technology Officer, Nokia Networks
- Didier le Boulc'h, 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

Source: 5G Infrastructure Association.

5G Infrastructure Association Working Groups and Activities



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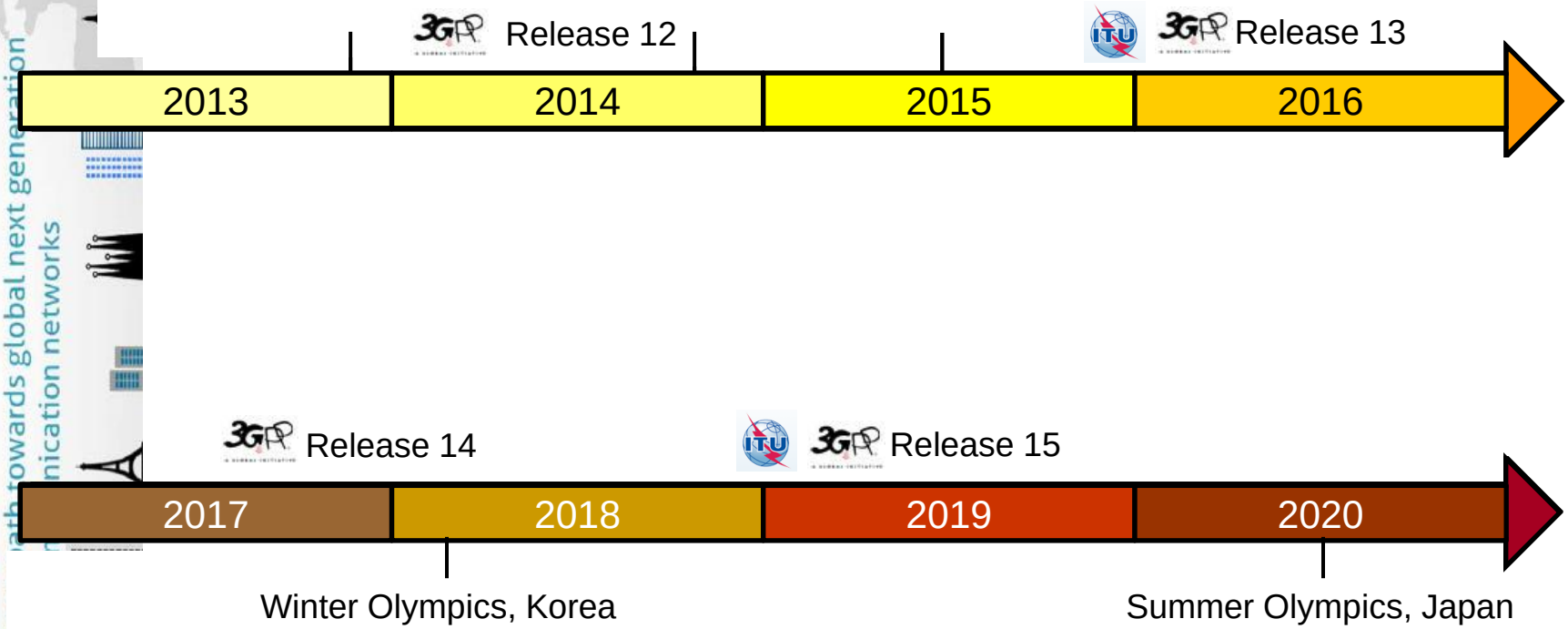
Source: 5G Infrastructure Association.

Indicative time plan



5G Infrastructure PPP

Horizon 2020 5G PPP Call 1 objectives
125 million € Funding

Radio network architecture and technologies

Support anticipated 1000 fold mobile traffic increase and very different classes of traffic/services

- Network architecture, protocols and radio technologies capable of at least a ten times increase in frequency reuse and new frequency ranges above 3,6 GHz
- Versatile low cost ubiquitous radio access infrastructure equally supporting low rate IoT and very high rate (>> 1 Gbit/s) access
- Flexible and efficient radio, optical or copper based backhaul/fronthaul with low latency
- Innovative architectures for 5G transceivers and micro-servers
- Experiment based research preparing for large scale demonstrator and test-beds

Convergence beyond last mile

Support integration of a ubiquitous access continuum composed of cooperative, cognitive fixed and heterogeneous wireless resources, with fixed optical access reaching at least the 10 Gb/s range

- Solving the management heterogeneity of different fixed and heterogeneous wireless networks
- Architectures to optimize reuse and sharing of functionality across heterogeneous access technologies and networks

Network management

Challenge to radically decrease network management Opex through automation whilst increasing user perceived quality of service, of experience and security

- Novel simplified (low Opex) approaches to overall management of the network (e.g. Self-organizing networks –SON) and service level management
- Combination of software defined network implementations with autonomic management of resources
- Network security across multiple virtualized or SDN domains

Network virtualization and Software Networks

Highly flexible, manufacturer-independent model of controlling reconfigurable resources supporting changing/emerging application requirements

- Virtualization of network functionalities at infrastructure level and implementation of network services
- Orchestration logic (SDN), enabling network programmability, automation of cross domain network configuration, simplification and programmability of devices
- Tighter integration between application/service layers and networking layers
- Support of open network functionalities for dynamic integration with third party and OTT cloud environments

Source: EU Commission Work Program 2014-2015 / 5G Infrastructure Association.

Horizon 2020 5G PPP
Call 1 selected projects

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CHARISMA
Converged Heterogeneous Advanced 5G Cloud-RAN Architecture for Intelligent and Secure Media Access

SESAME
Small cEllS coordinAtion for Multi-tenancy and Edge services

SPEED-5G
quality of Service Provision and capacity Expansion through Extended-DSA for 5G

CogNet
Building an Intelligent System of Insights and Action for 5G Network Management

SELFNET
Framework for SELF-organized network management in virtualized and software defined NETworks

VirtuWind
Virtual and programmable industrial network prototype deployed in operational Wind park

SONATA
Service Programing and Orchestration for Virtualized Software Networks

5GEx
5G Exchange

SUPERFLUIDITY
Superfluidity: a super-fluid, cloud-native, converged edge system

METIS-II
Mobile and wireless communications Enablers for Twenty-twenty (2020) Information Society-II

5G-Norma
5G NOvel Radio Multiservice adaptive network Architecture

FANTASTIC-5G
Flexible Air iNTerfAce for Scalable service delivery wiThin wIreless Communication networks of the 5th Generation

5G-Xhaul
Dynamically Reconfigurable Optical-Wireless Backhaul/Fronthaul with Cognitive Control Plane for Small Cells and Cloud-RANs

COHERENT
Coordinated control and spectrum management for 5G heterogeneous radio access networks

Flex5Gware
Flexible and efficient hardware/software platforms for 5G network elements and devices

mmMAGIC
Millimetre-Wave Based Mobile Radio Access Network for Fifth Generation Integrated Communications

Xhaul
The 5G Integrated fronthaul/backhaul

Research projects
Innovation projects

Euro-5G
5G PPP Coordination and Support Action

Source: 5G Infrastructure Association.

5G PPP Vision and Requirements
5G key drivers

- The start of commercial deployment of 5G systems is expected in years 2020+
- 5G is an **opportunity for the European ICT sector** which is already well positioned in the global R&D race
- 5G will bring **new unique network and service capabilities**
  - user experience continuity
  - Internet of Things
  - mission critical services (low latency, high reliability)
- 5G targets a **unified and programmable infrastructure**
- 5G will support **multi tenancy models**
- 5G will be designed to be a **sustainable and scalable technology**
- 5G will create an **ecosystem for technical and business innovation**

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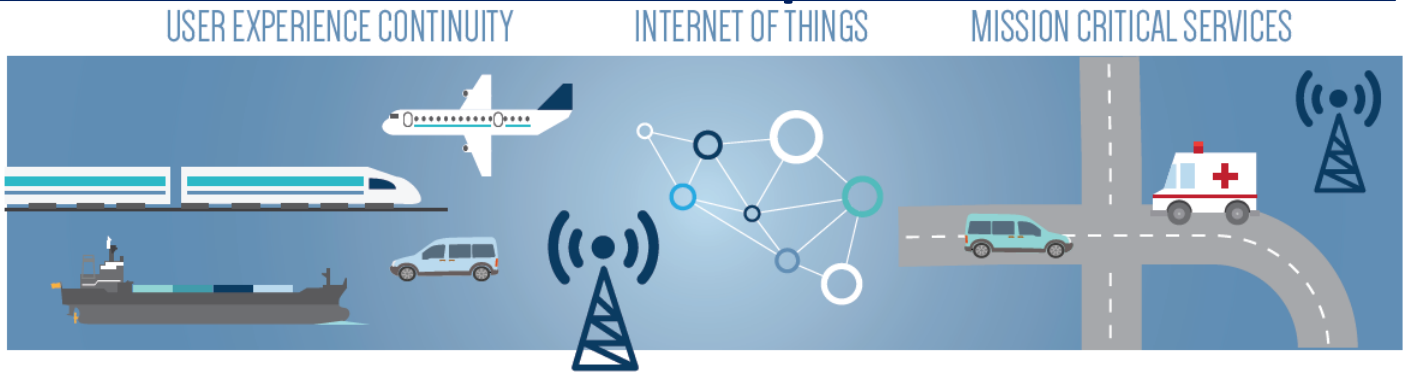
Source: 5G Infrastructure Association: Vision White Paper, February 2015.

5G PPP Vision and Requirements
5G new service capabilities

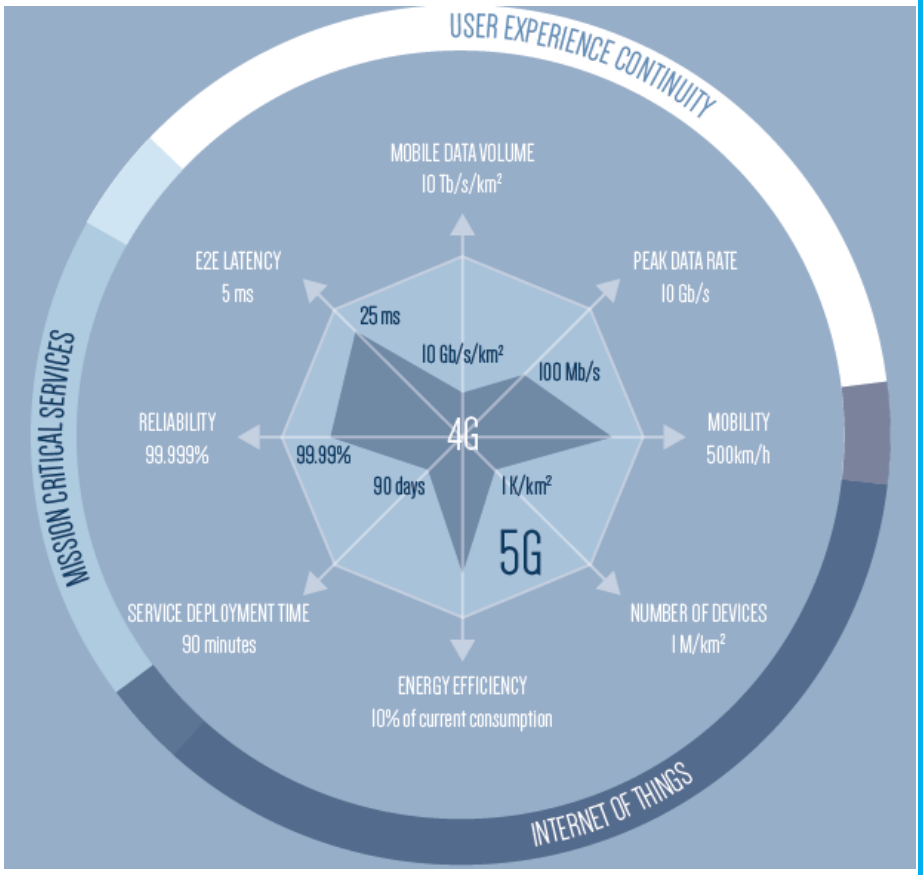


- 5G needs to support efficiently three different types of traffic profiles
  - high throughput for e.g. video services
  - low energy for e.g. long–living sensors
  - low latency for mission critical services
- 5G covers network needs and contributes to digitalization of vertical markets
  - automotive, 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

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

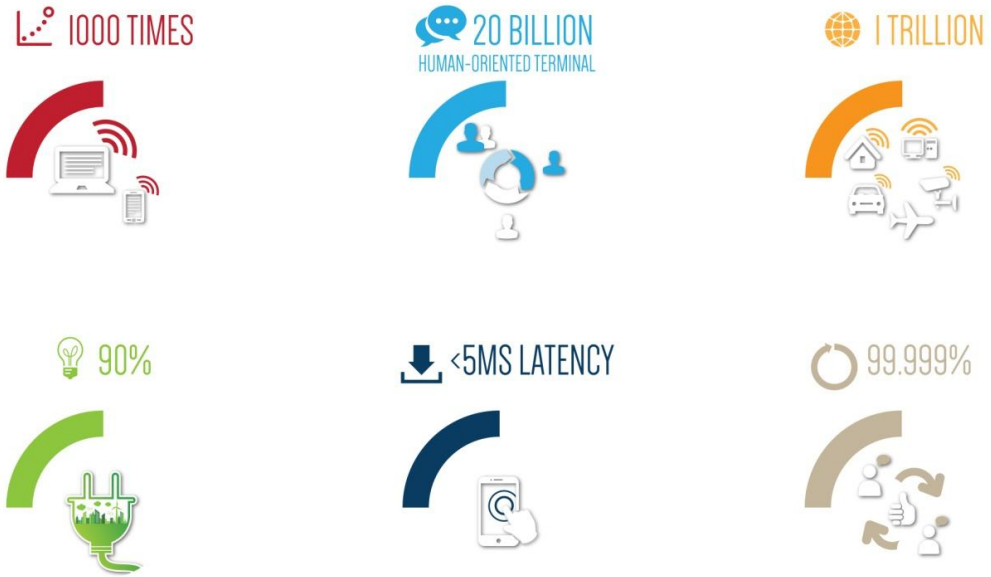
5G PPP Vision and Requirements
5G will have disruptive capabilities

- **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



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

5G PPP Vision and Requirements
Key requirements



- 1,000 X in mobile data volume per geographical area reaching a target ≥ 10 Tb/s/km^2
- 1,000 X in number of connected devices reaching a density ≥ 1M terminals/km2
- 100 X in user data rate reaching a peak terminal data rate ≥ 10Gb/s
- Guaranteed user data rate >50Mb/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 ≥ 500km/h for ground transportation
- Accuracy of outdoor terminal location ≤ 1m

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
- Easer and optimised network management by means of exploitation of Data Analytics and Big Data techniques
  - to monitor users Quality of Experience
  - while guaranteeing privacy

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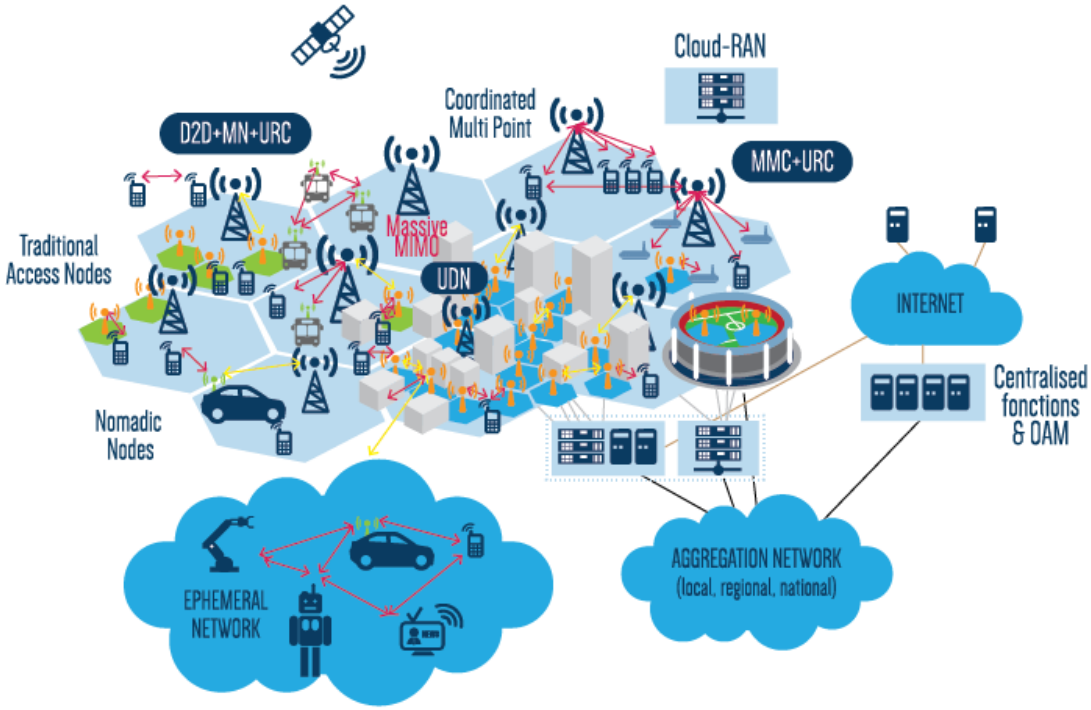
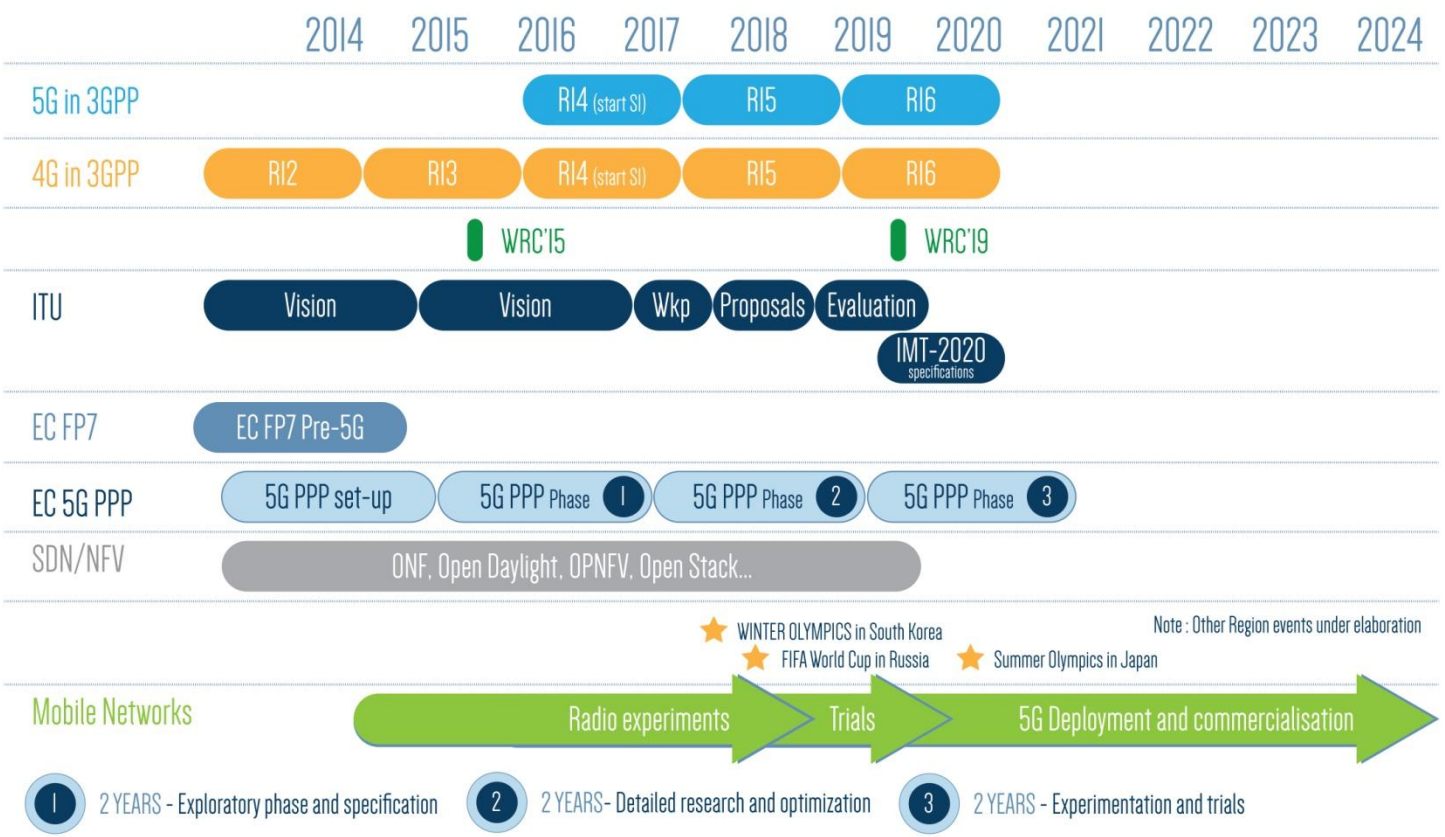
Source: 5G Infrastructure Association: Vision White Paper, February 2015.

5G PPP Vision and Requirements
5G networks and services vision



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

5G PPP Vision and Requirements
5G roadmap



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

Conclusions

- 5G research started in EU Framework Program 7
- 5G research is getting momentum globally
- Collaborative research as means for consensus building even between competitors to prepare future standards
- In Europe 5G PPP launched in December 2013 as part of new research program Horizon 2020
- 5G PPP is addressing the future communication network including support of vertical sectors
- In addition to system and technology development support of policy objectives
- Horizon 2020 Call 1 projects are currently under implementation
- Big bunch or research projects will start on July 1, 2015
- 5G PPP published a Vision and Requirements White Paper at MWC 2015
- Horizon 2020 is open for international participation

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

http://5g-ppp.eu

Thank you for your attention!