



# 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

# EU Framework Program 7 System and radio projects



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

- **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** 5th Generation **Non-Orthogonal Waveforms** for Asynchronous Signalling



- **Overall objective**

<http://www.5gnow.eu/node/5>

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** Interworking and **JOINT** Design of an Open Access and Backhaul Network Architecture for Small Cells based on Cloud Networks

**iJOIN**

- **Overall objective**

<http://www.ict-ijoin.eu/>

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.

# EU Framework Program 7 Radio and security projects



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## Tropic

DisTributed computing, storage and radio resource allocation over cooperative femtocells



- **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.

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

## MiWaveS

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



- **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.

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

## PHYLAWS

**PHYsical LAYer Wireless Security**



- **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.

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



# EU Framework Program 7 Network and Internet projects



## • **combo**

**CO**nvergence of fixed and **MO**bile **BrO**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-**To**-terminal **Of**floading technologies



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

### • **Overall objective**

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

## • **MCN**

**MO**bile **Cl**oud **Ne**tworking



### • **Overall objective**

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

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.

# 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

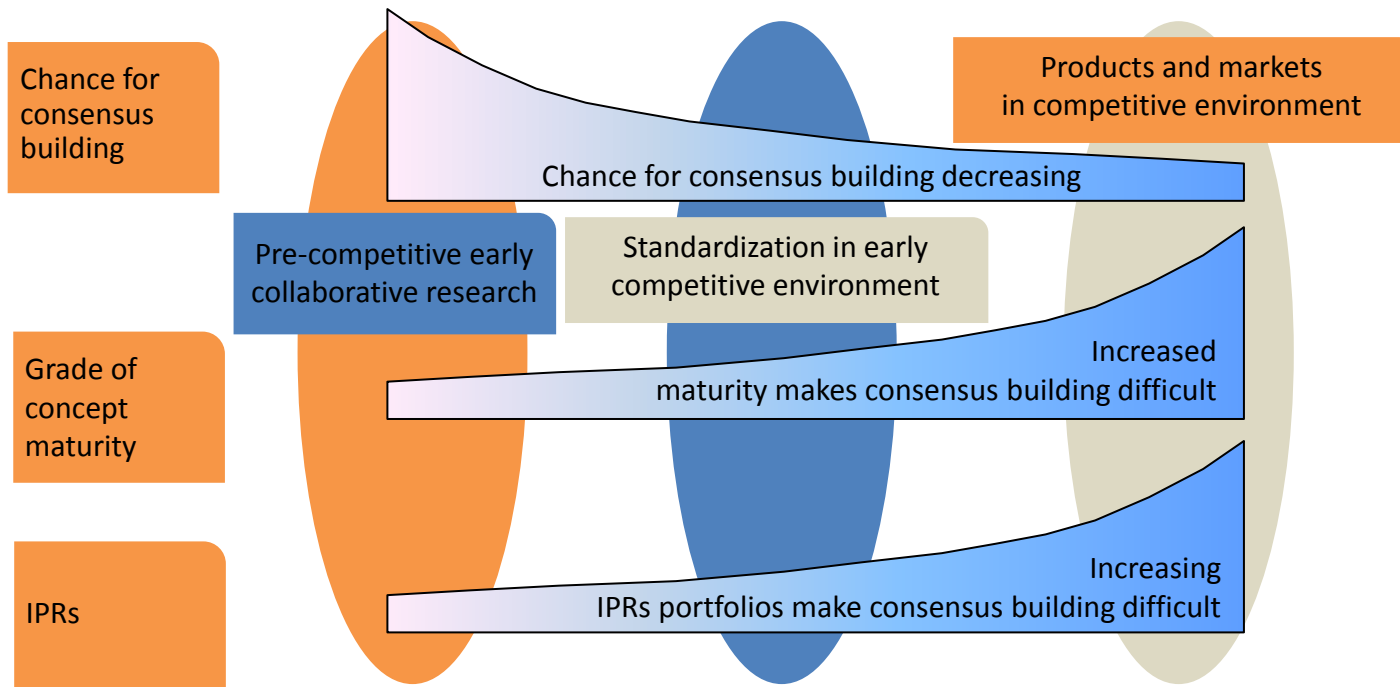
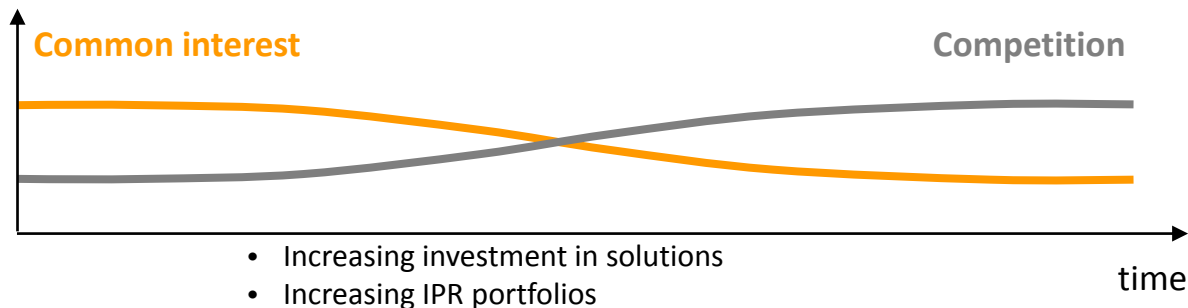
- Company internal research

23/06/2015

Source: 5G Infrastructure Association.

# Why Collaborative research?

## International consensus building at an early stage



- Horizon 2020 is open for organizations from outside of Europe

# 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>

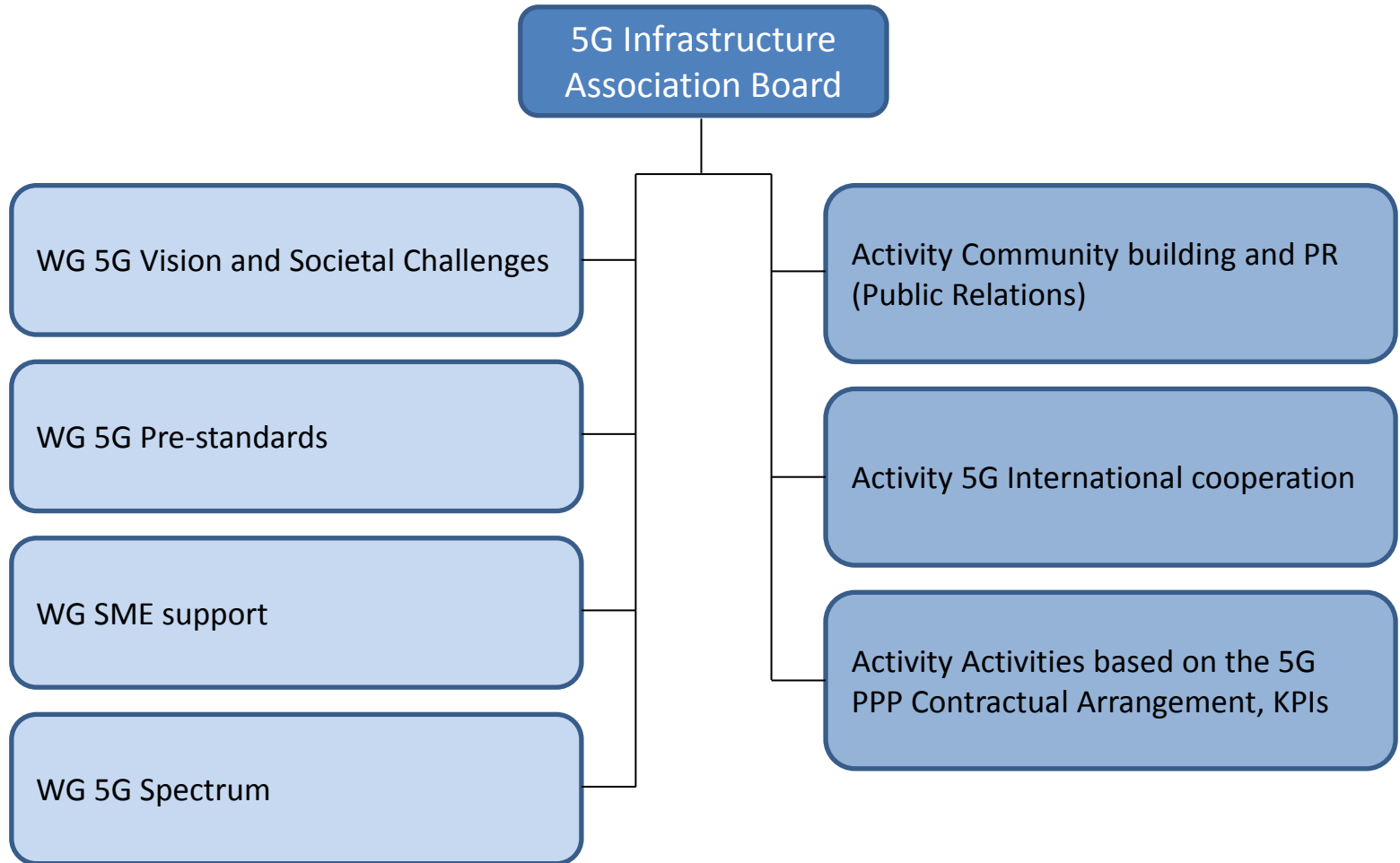


- From left to right:
- Marcus Weldon, Chief Technology Officer and President Bell Labs, Alcatel-Lucent
  - Li Yingtao, President of 2012 Laboratories, Huawei
  - Kyungwhoon Cheun, Executive Vice President, Samsung Electronics
  - Hermann Eul, Corporate Vice President General Manager, Mobile and Communications Group, Intel
  - Mari-Noëlle 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





# 5G Infrastructure Association Working Groups and Activities



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# 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

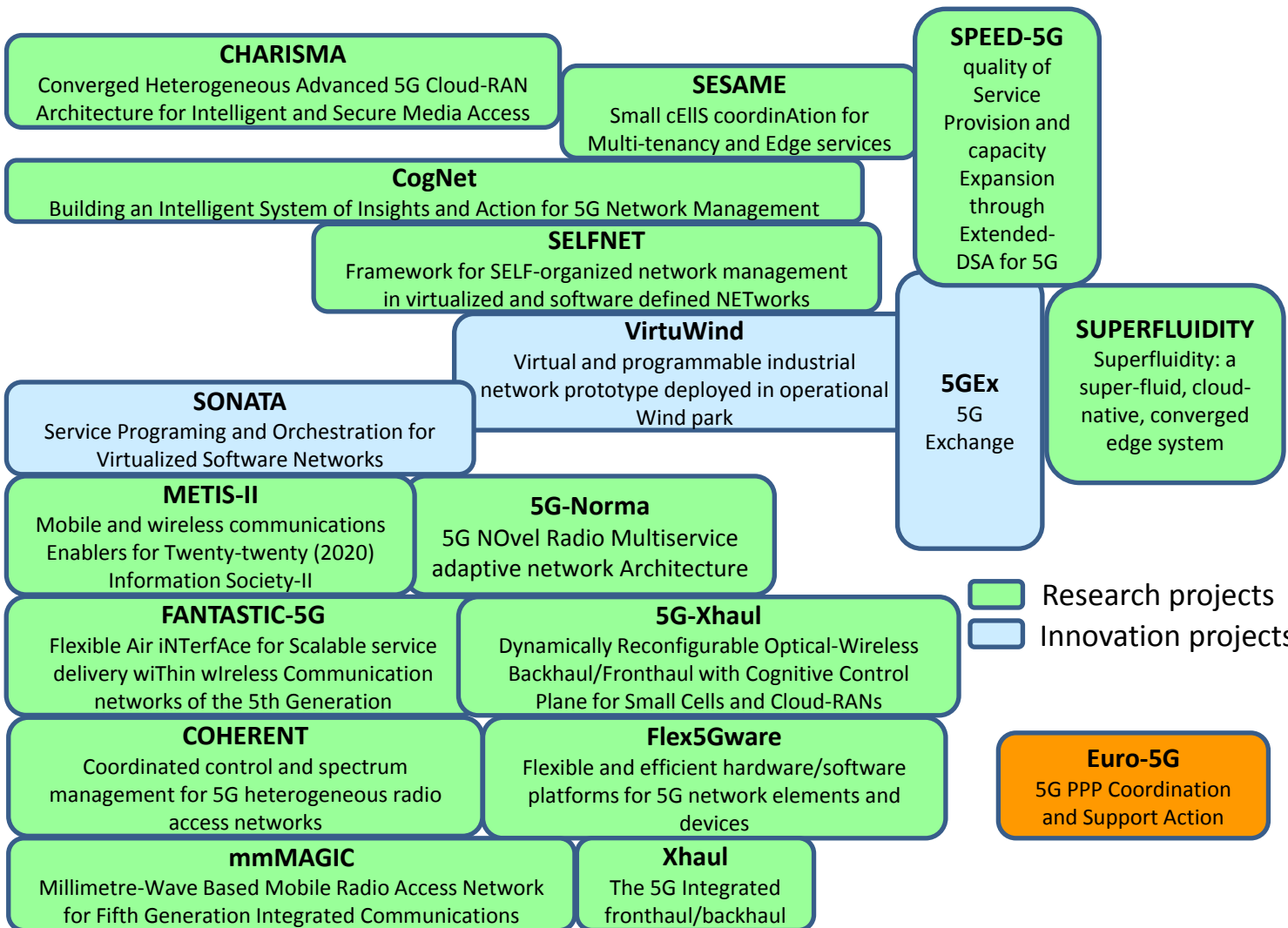
### Network virtualization and Software Networks

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

# Horizon 2020 5G PPP Call 1 selected projects

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# 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**

# 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

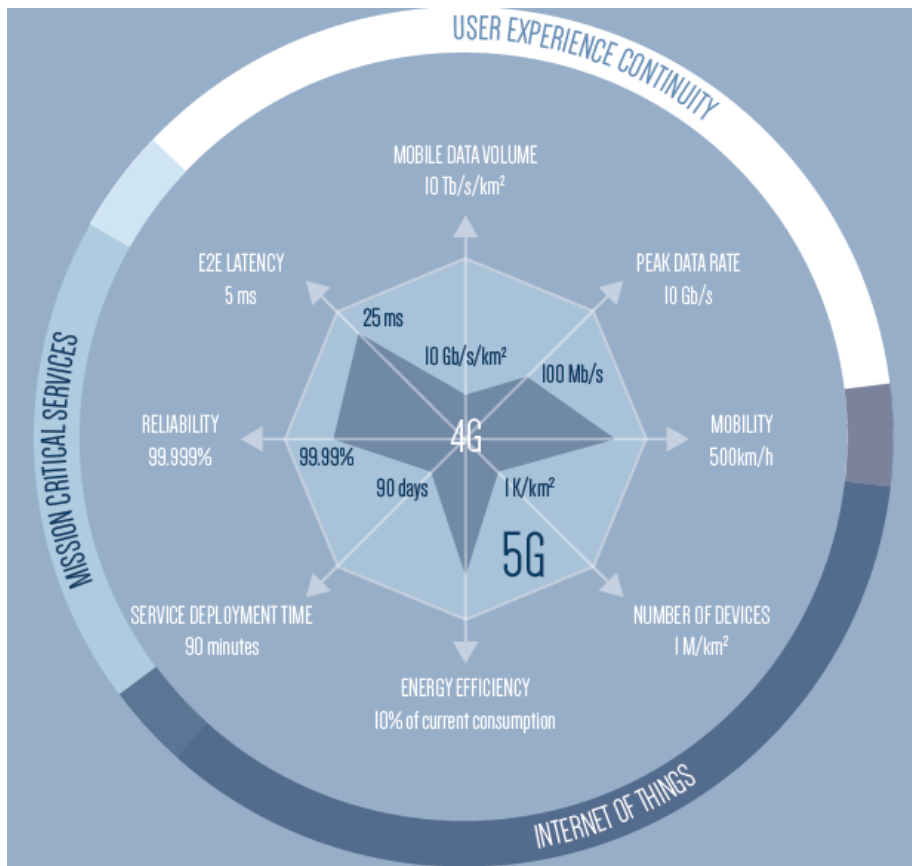
# 5G PPP Vision and Requirements

## 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  $\geq 10$  Tb/s/km<sup>2</sup>
- 1,000 X in number of connected devices reaching a density  $\geq 1$ M terminals/km<sup>2</sup>
- 100 X in user data rate reaching a peak terminal data rate  $\geq 10$ 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  $\leq 1$  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  $\leq 90$  minutes
- Mobility support at speed  $\geq 500$ km/h for ground transportation
- Accuracy of outdoor terminal location  $\leq 1$ m

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

# 5G PPP Vision and Requirements

## Research on technology building blocks



### Wireless Networks

- Advanced Multi Antenna Transceiver techniques
- mmWave RATs
- Channel Models for 5G (new bands)
- Novel RAN Architectures
- Machine type Communications
- Intelligent Radio Resource Management
- Integrating satellite networks

### The Software Network

- Novel Views on Network Architecture
- The Software Network: Interface Abstractions and Layering
- “On the fly” Virtualization and Adaptability
- Efficient RAN Sharing for Multi-Tenancy
- Cloud Orchestration

### Optical Networks

- Programmable, elastic and high capacity optical networking
- Optical networking for converged and ubiquitous 5G access

### Network Management and Automation

- Smart Orchestration and Use of Network Analytics and Big Data for network management
- Agile Management Frameworks

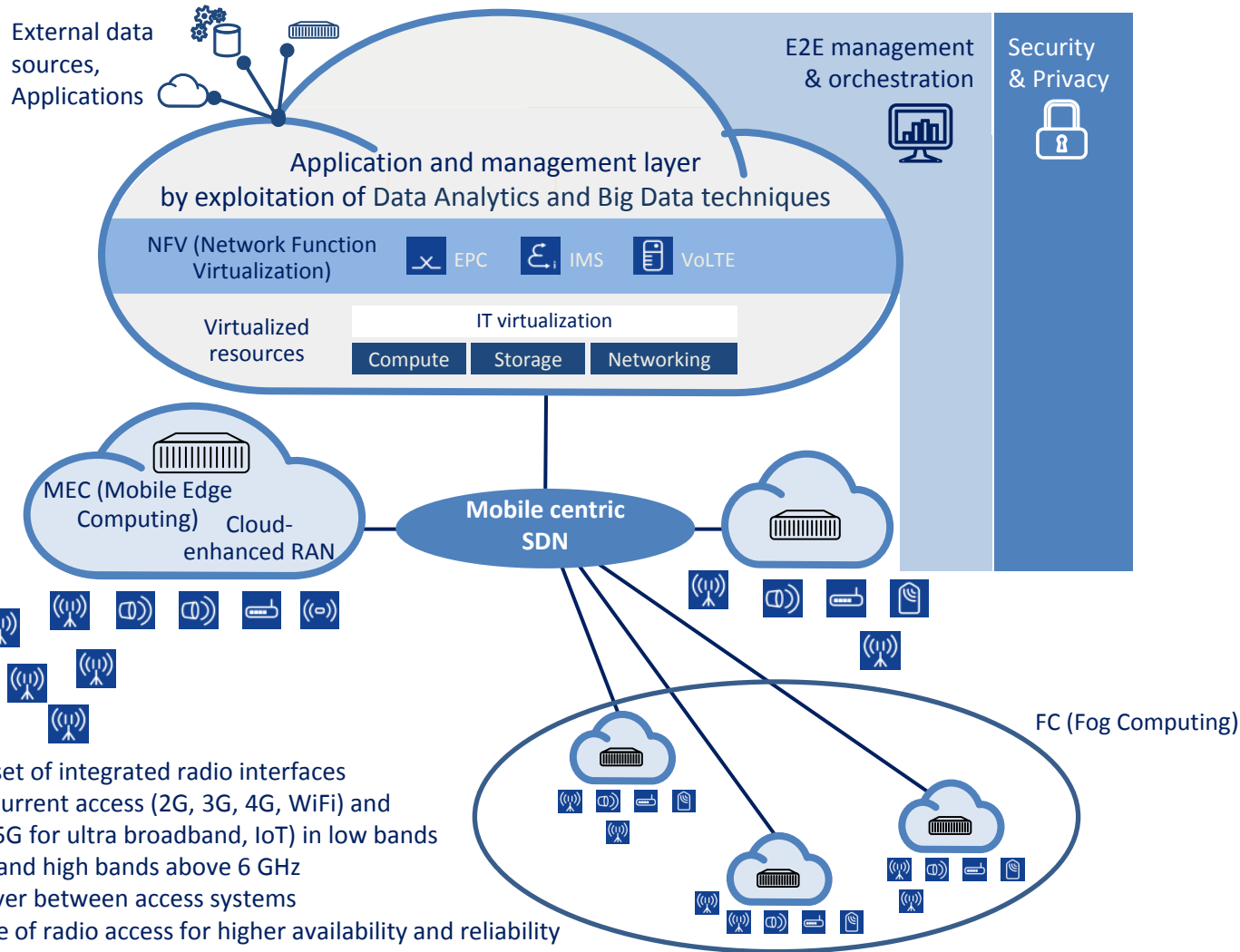
### Effective Systems and Networks

- Energy Efficient Devices and Networks
- Highly Flexible Communication Systems
- Security, privacy and trust



# 5G PPP Vision and Requirements

## Architecture for software driven networks

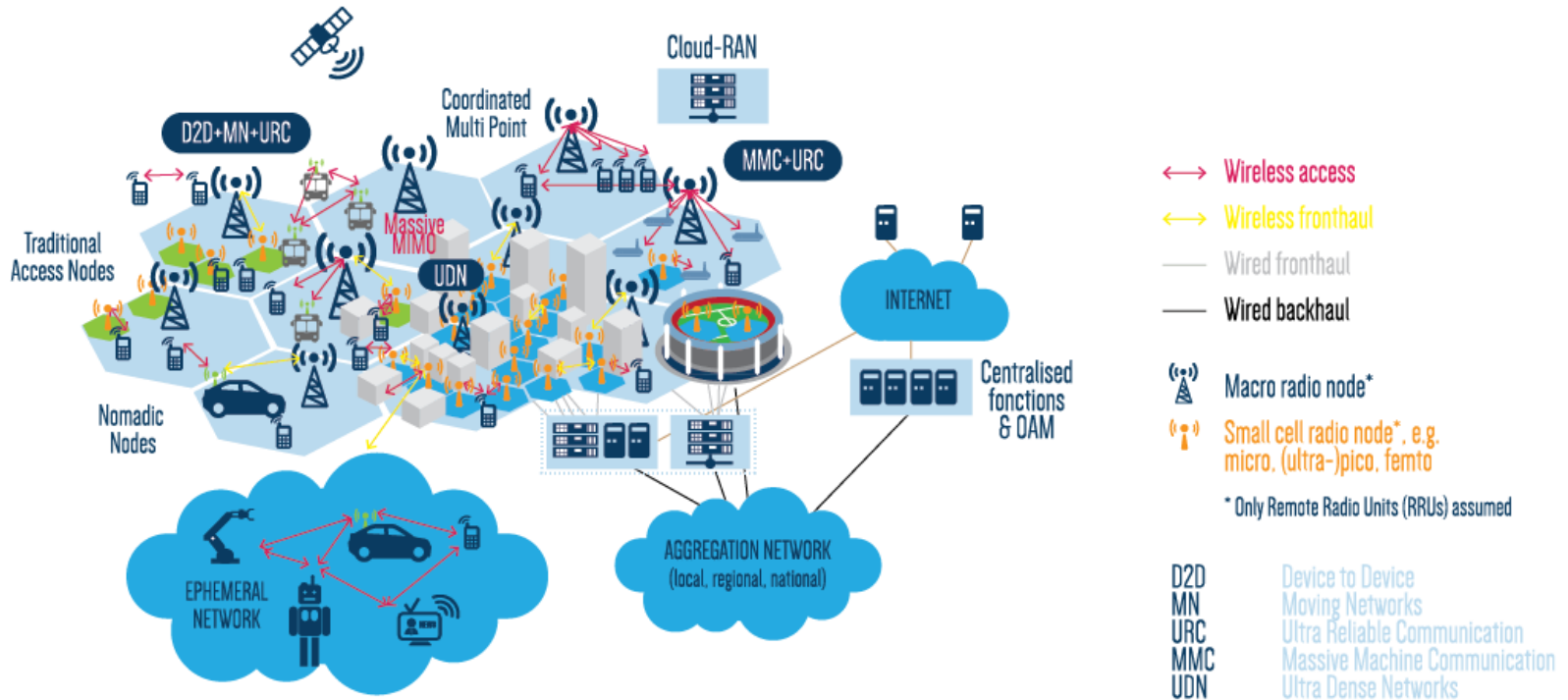


- Heterogeneous set of integrated radio interfaces
  - Evolution of current access (2G, 3G, 4G, WiFi) and
  - New access (5G for ultra broadband, IoT) in low bands below 6 GHz and high bands above 6 GHz
- Seamless handover between access systems
- Simultaneous use of radio access for higher availability and reliability
- Ultra-dense deployment with new backhaul concepts
- Encompass cellular and satellite systems

# 5G PPP Vision and Requirements

## 5G networks and services vision

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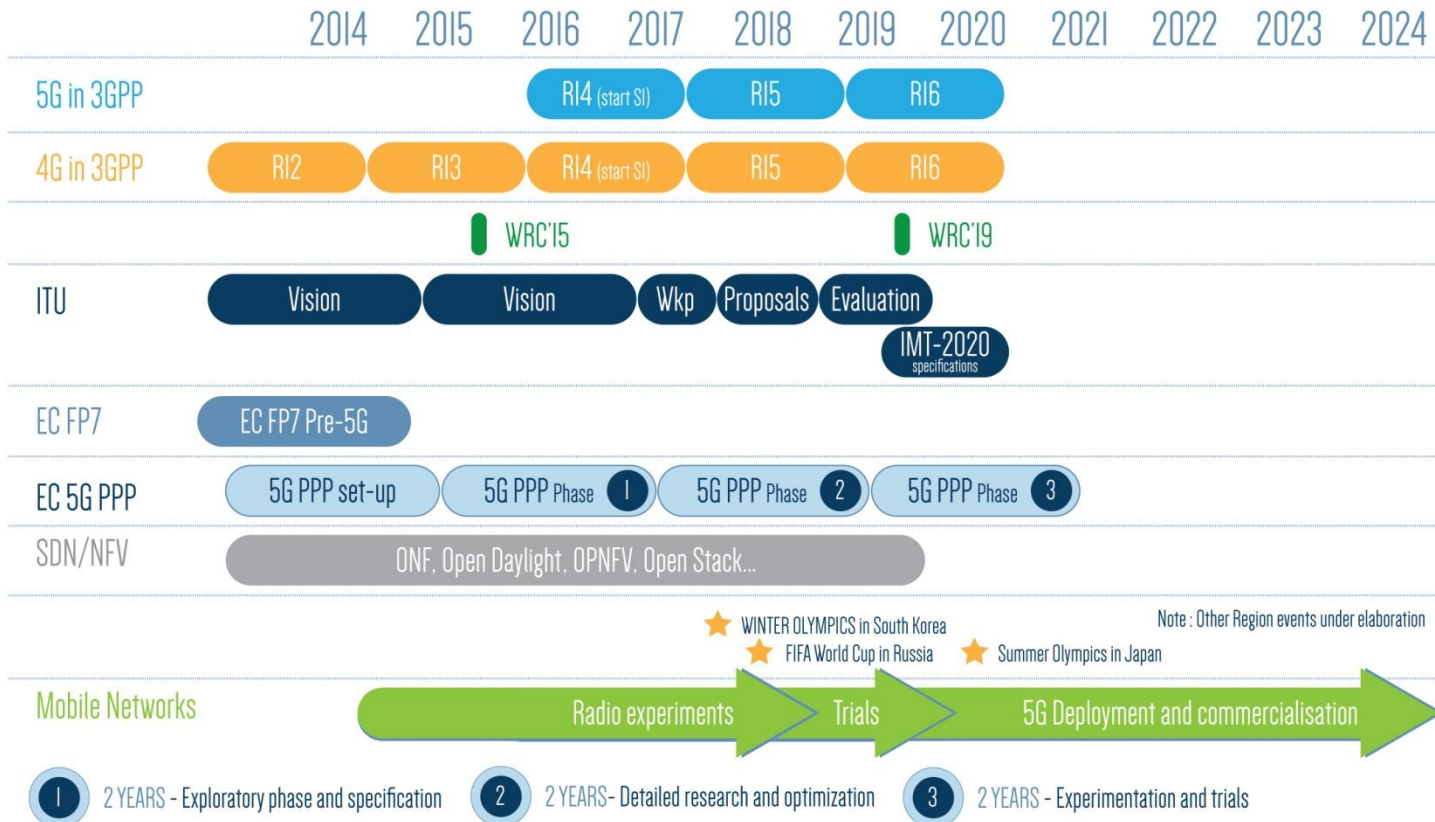


# 5G PPP Vision and Requirements

## 5G roadmap



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# 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.

23/06/2015

Source: 5G Infrastructure Association.





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

**Thank you for your  
attention!**

