



The 5G Infrastructure Public-Private Partnership

5G research in Europe Werner Mohr

The 5G Huddle – Towards a global 5G vision
London, September 22 and 23, 2014

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

Outline



- 5G research projects in Framework Program 7
- International activities
- Example view on 5G
- 5G PPP in Horizon 2020 of the European Union
- Indicative time plan
- 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**

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



- **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.

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

EU Framework Program 7 Radio and security projects



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The European path towards global next generation
communication networks

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

PHYsical LAYer Wireless Security



<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 **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 **Off**loading 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



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 – 2020 and Beyond Ad-Hoc Group under ARIB's Advanced Wireless Communications Study Committee



Korea – 5G Forum



Taiwan – Ministry of Economic Affairs, National Science Council



Russia – 5GRUS by Russia's Icom-Invest



CJK White Paper

NGMN – White paper on future requirements

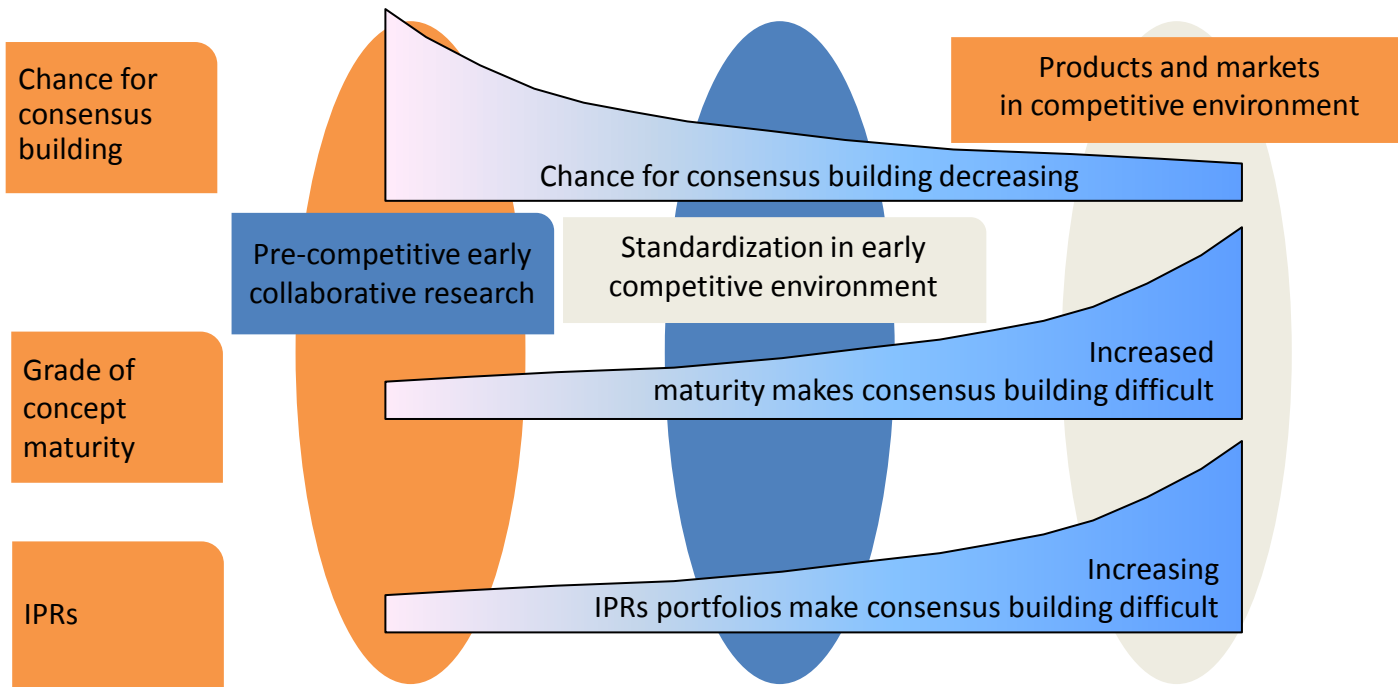
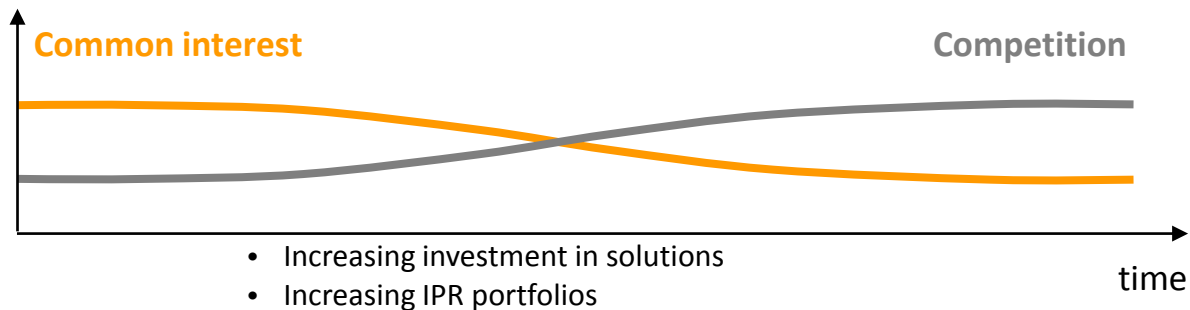
- Company internal research

Source: 5G Infrastructure Association.

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Why Collaborative research?

International consensus building at an early stage



- Horizon 2020 is open for organizations from outside of Europe

Source: NetWorld2020.

The 2020+ experience



5G Infrastructure PPP

My home ecosystem



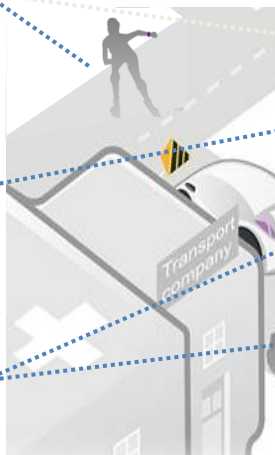
HD to go



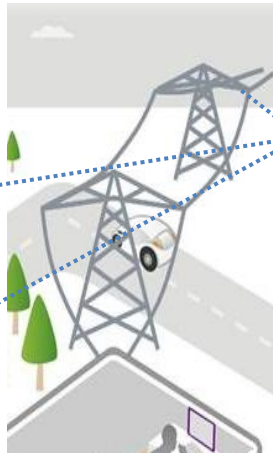
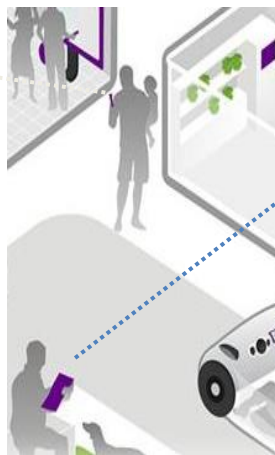
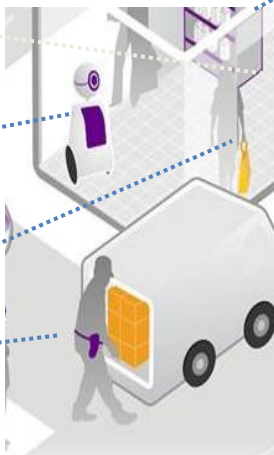
Real-time virtual overlay



Remote control of robot



Things 2.0



Sensor networks



Movie in a minute



Tactile internet



Autonomous driving



Source: Nokia.

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Example view on 5G



Next generation Wide Area
Scalable service experience
anytime and everywhere

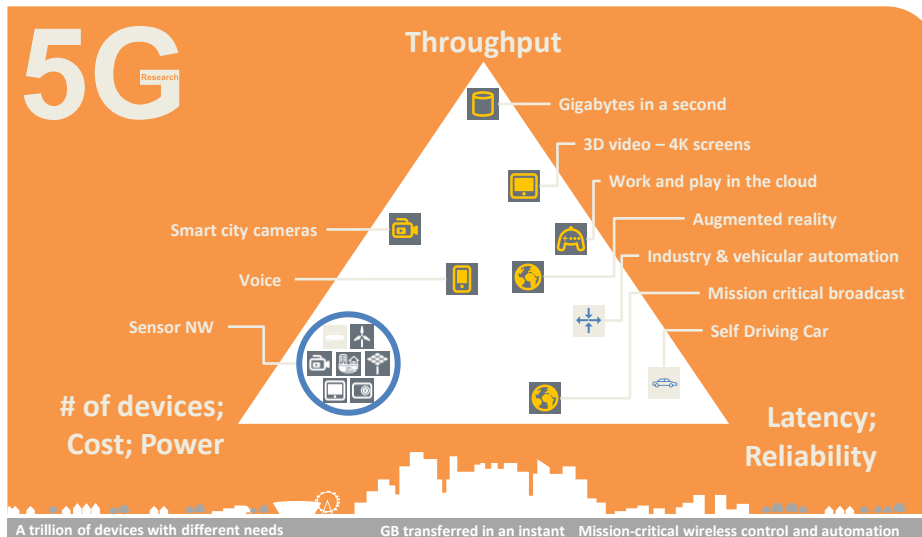
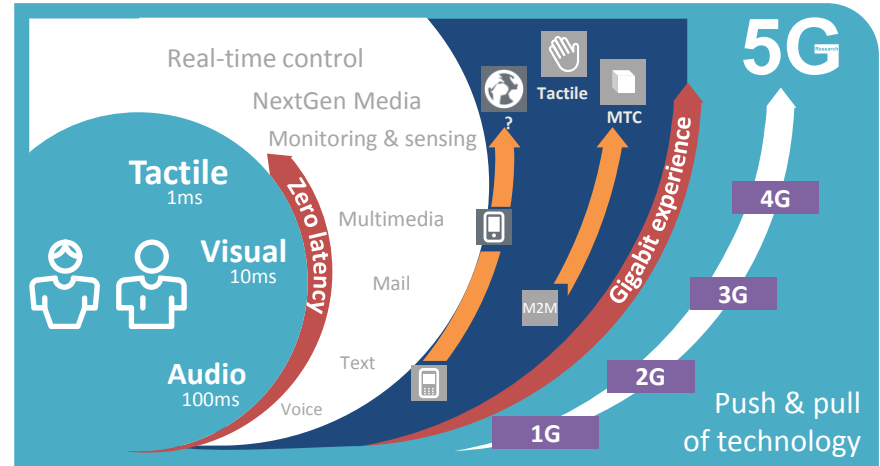
- 4G 'massive mobile data'
- 3G 'voice, video and data'
- 2G 'high quality voice or'
- Wi-Fi 'best effort data'
- PAN 'short range and low power'

Ultra dense deployments

Zero latency and GB experience –
when and where it matters

5G

**Integrated, harmonized and
complementing each other**



Source: Nokia.

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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 first half of 2015



From left to right:

- Ulf Ewaldsson, Chief Technology Officer, Ericsson
- Neelie Kroes, Vice-President of the EU Commission, Digital Agenda
- Mari-Noëlle Jégo-Laveissière, Senior Executive Vice President of Innovation, Marketing and Technologies, Orange
- Hossein Moïn, Executive Vice President Technology and Innovation, Nokia
- Luis Sanchez Merlo, CEO SES Astra Ibérica
- Marcus Weldon, Chief Technology Officer and President Bell Labs, Alcatel-Lucent

Source: 5G Infrastructure Association.

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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

Source: 5G Infrastructure Association.

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Proposed research program



- Faster, More Powerful and More Energy Efficient Solutions for integrated High Capacity Access and Core Networks for a Wider Range of Services
 - Wireless Networks
 - Optical Networks
 - Automated Network Organisation - Network Management and Automation
 - Implementing Convergence Beyond the Access Last Mile
- Re-Designing the Network
 - Information Centric Networks
 - Network Function Virtualisation
 - Software Defined Networking
 - Networks of Clouds
- Ensuring availability, robustness and security
- Ensuring efficient hardware implementations

Source: 5G Infrastructure Association.

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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

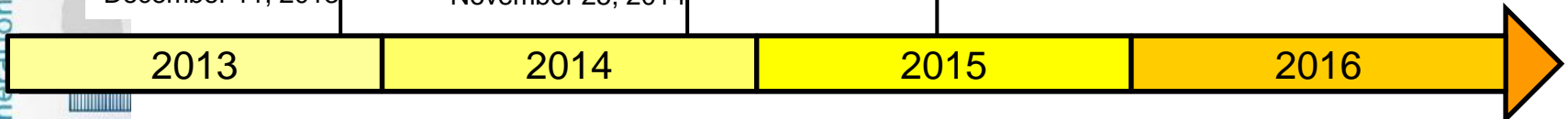
Indicative time plan



Call 1 published
December 11, 2013

Submission deadline
November 25, 2014

Start of first projects mid 2015

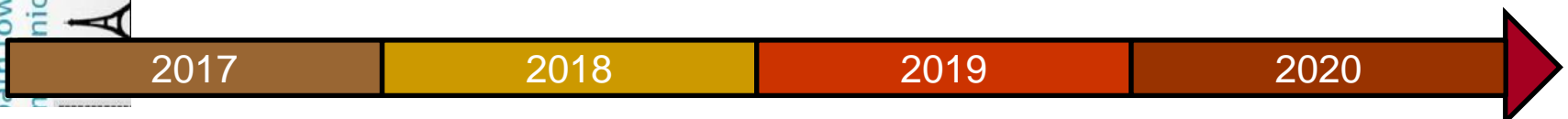


Exploratory phase:

- Detailed requirements
- Identify most promising functional architectures and technologies
- Build on previous research work

- Detailed **system research and development**
- Basis for Pan European experimental infrastructure

- **Detailed system optimization**
- Consensus building on globally to be identified frequency bands (consider result of WRC15)
- Validation of concepts and early trials
- Contributions to **initial global standardization** activities
- **Preparation of WRC18/19**



- Support of **initial international standardization**
- Support of regulatory bodies for allocation of newly identified frequency bands
- Implementation of large trials for validation under close to real world conditions

- Extension of trials to non ICT stakeholders
- **Detailed standardization process**

Large scale demonstrations and trials, scalability testing, etc.

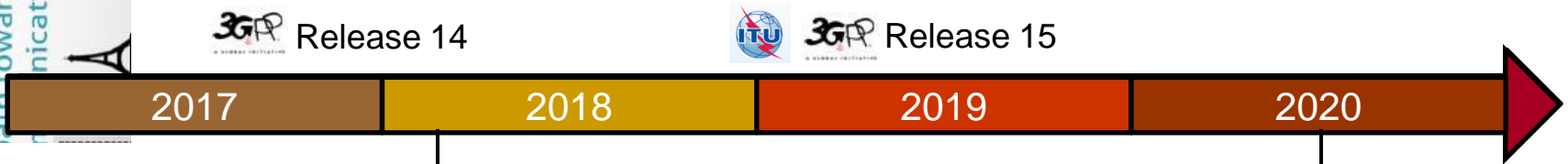
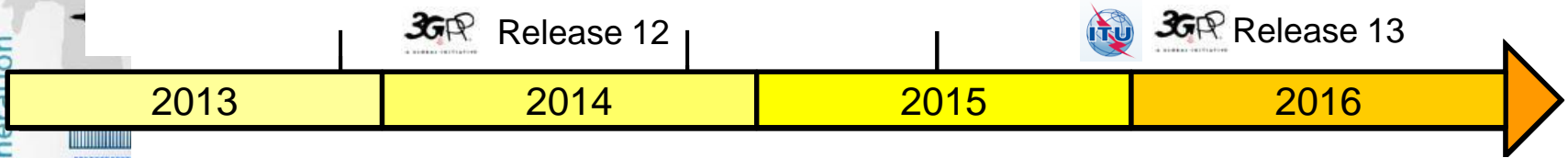
- **New frequency bands available** for trial network deployment and initial commercial deployment
- **Close to commercial systems deployment** under real world conditions to prepare economic exploitation on global basis

Source: 5G Infrastructure Association.

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Indicative time plan



Winter Olympics, Korea

Summer Olympics, Japan

FIFA World Cup, Qatar 2020

Source: 5G Infrastructure Association.

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Conclusions



- 5G research started in EU Framework Program 7
- 5G research is getting momentum globally
- Demand for advanced data services and support of vertical sectors is increasing with challenging requirements on throughput, latency and user experience
- 5G will be a combination of existing and evolving systems, like LTE-Advanced and Wi-Fi, coupled with new, revolutionary technologies designed to meet new requirements, such as virtually zero latency to support tactile Internet, machine control or augmented reality
- In Europe 5G PPP launched in December 2013 as part of new research program Horizon 2020
- Horizon 2020 is open for international participation

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

Source: 5G Infrastructure Association.



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

**Thank you for your
attention!**

