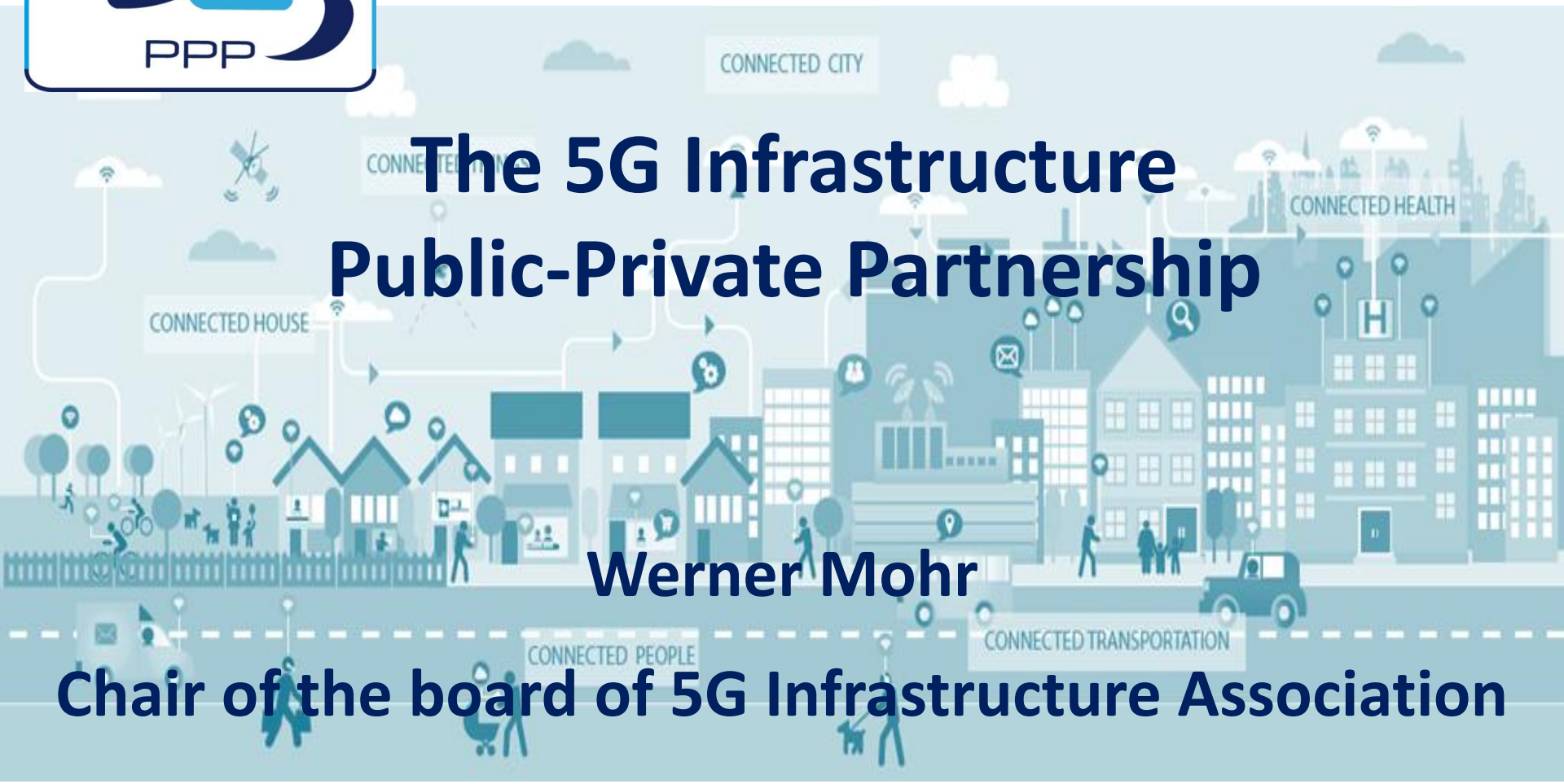

The 5G Infrastructure Public-Private Partnership

Werner Mohr

Chair of the board of 5G Infrastructure Association

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
- Implementation of 5G PPP and Call 1
- 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**society

  https://www.metis2020.com/

  - **Overall objective**

    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

- **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-**To**-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

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 Association

Japan – 2020 and Beyond Ad-Hoc Group under ARIB's Advanced Wireless Communications Study Committee, now transformed to 5G Promotion Forum

Korea – 5G Forum

Taiwan – 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.

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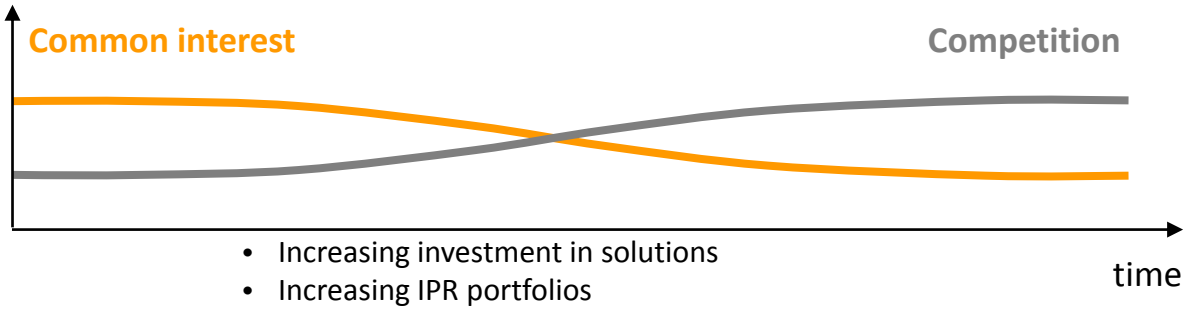
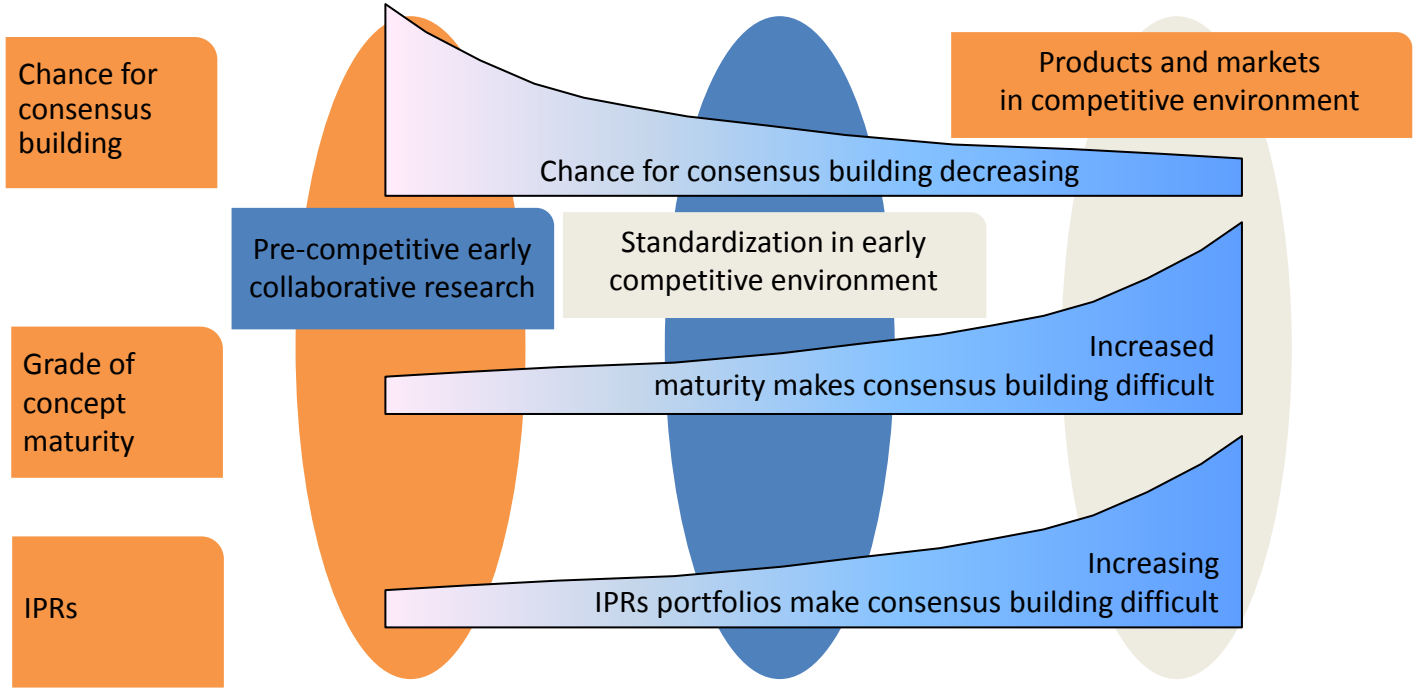
Why Collaborative research?
International consensus building at an early stage



- Increasing investment in solutions
- Increasing IPR portfolios



- Horizon 2020 is open for organizations from outside of Europe

Source: NetWorld2020.

Socio-technical evolution requirements for beyond 2020

Broadband Internet connectivity widely available

Need for a strong limit on energy dissipation and CO_2 footprint per capita

More context-related information (e.g. augmented reality)

Increased amount of remote virtual collaboration

Increasing average age and higher importance of health care

Need for more efficient and safer transportation means

Personal data stored in the cloud and transmitted over wireless channels

'Internet of things': Smart Homes, Smart Cites, Smart Society

Source: Nokia.

The 2020+ experience

5G Infrastructure PPP

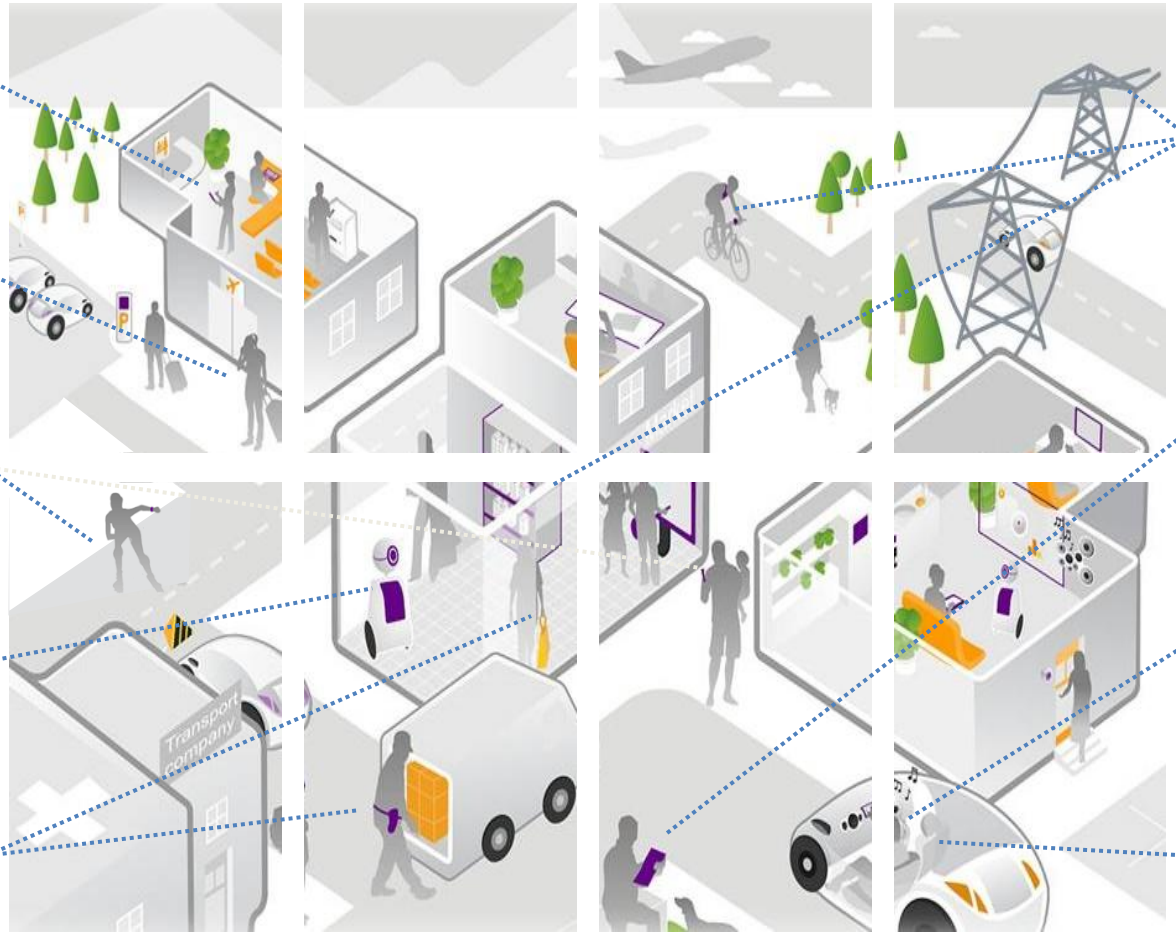
My home ecosystem

HD to go

Real-time virtual overlay

Remote control of robot

Things 2.0



Sensor networks

Movie in a minute

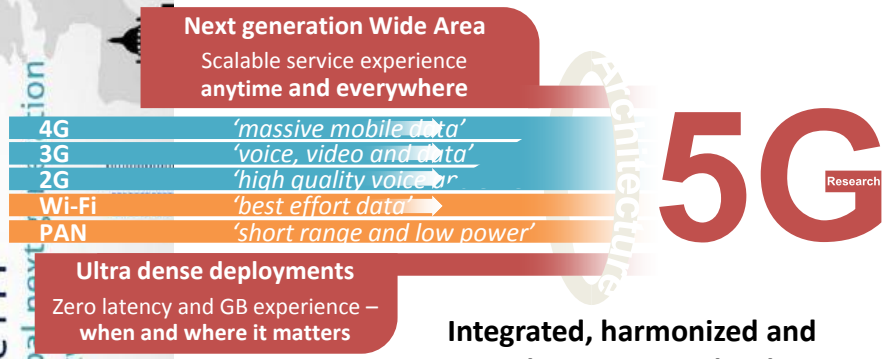
Tactile internet

Autonomous driving

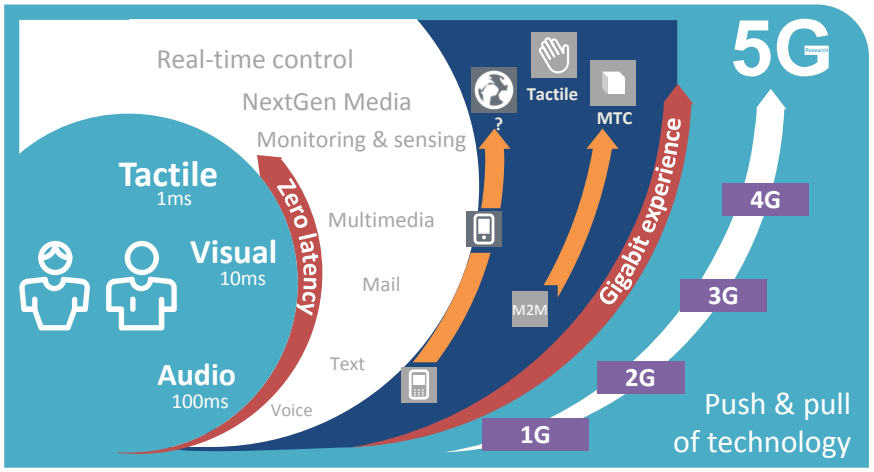
Source: Nokia.

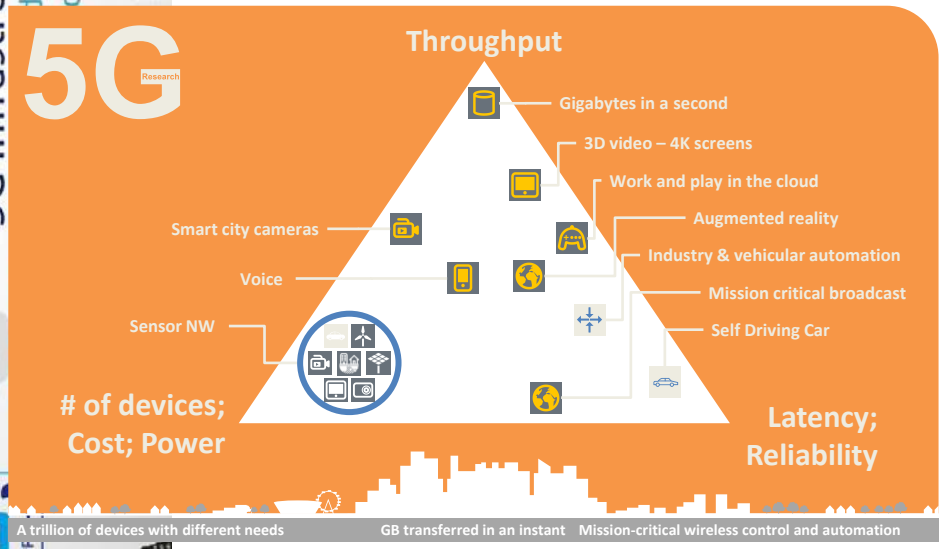
Source: Nokia.

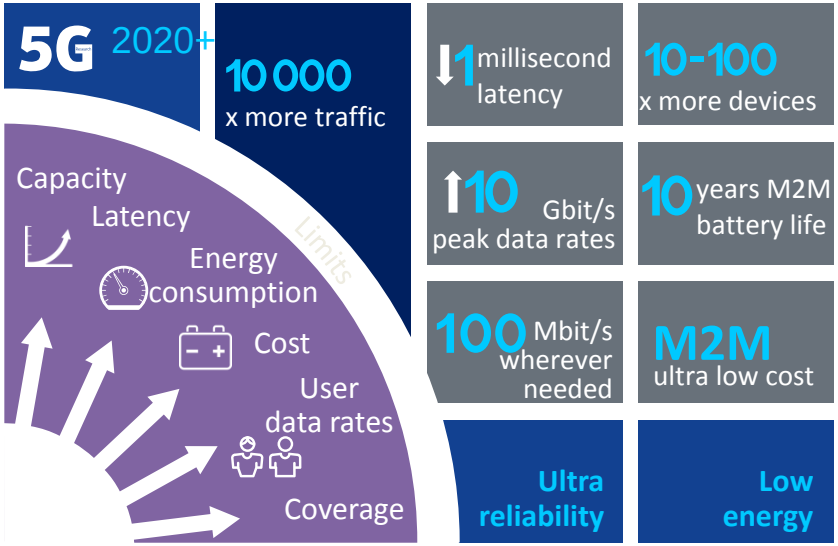
Example view on 5G



Integrated, harmonized and complementing each other







Source: Nokia.

EU Commissioner Kroes called industry to join EU Commission in a PPP on 5G

- Commissioner Kroes called industry at Mobile World Congress 2013 in Barcelona, Spain

  "… And today I call on EU industry and other partners to join us in a Public-Private partnership in this area. An open platform that helps us reach our common goal more coherently, directly, and quickly. European 5G is an unmissable opportunity to recapture the global technological lead. And I hope you will be able to support and join us. …"

Scoure: Commissioner Neelie Kroes, Smashing barriers and thinking big. Address at Mobile World Congress, 26 February 2013, Barcelona, Spain, http://europa.eu/rapid/press-release_SPEECH-13-159_en.htm?locale=en.

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 Jego-Laveissière , Senior Executive Vice President of Innovation, Marketing and Technologies, Orange
- Hossein Moiin, 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.

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

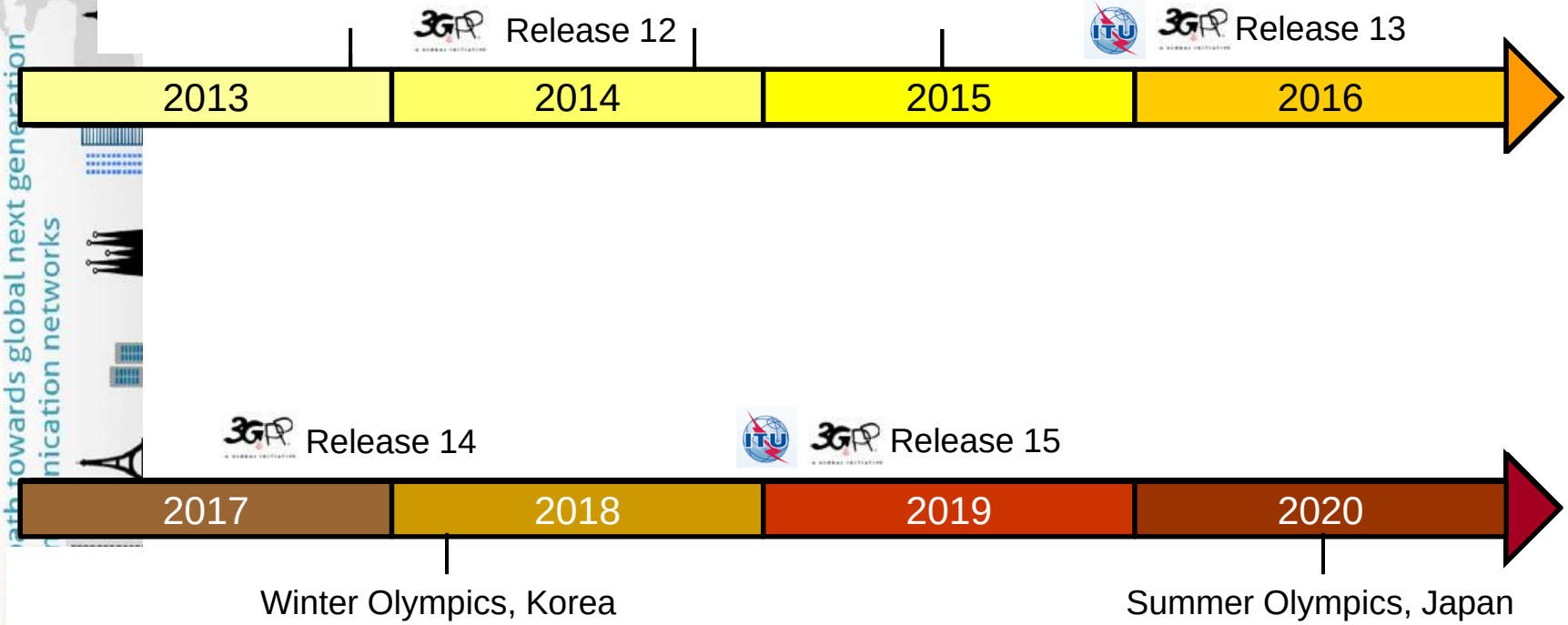
Source: 5G Infrastructure Association.

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.

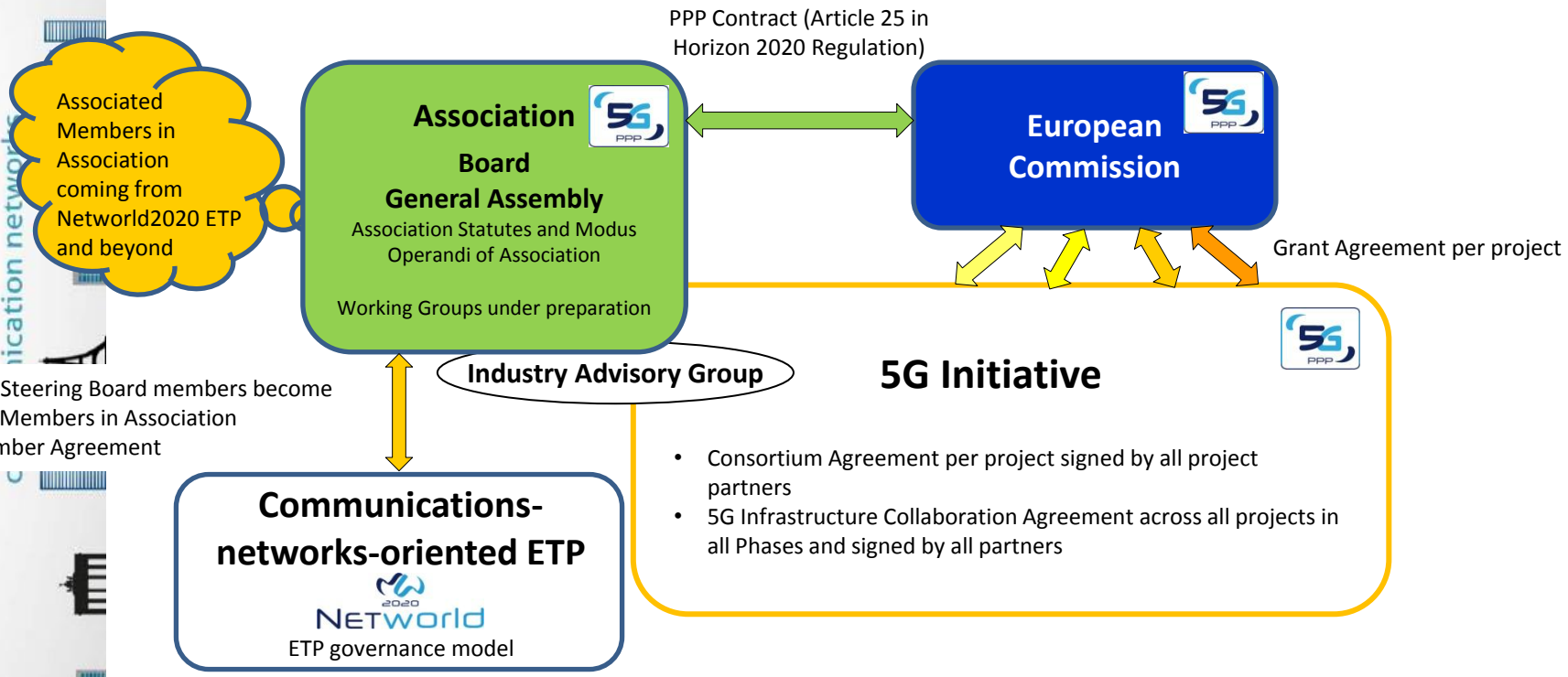
Indicative time plan



Source: 5G Infrastructure Association.

Governance model – Basic approach
Relation of new ETP to 5G PPP

- NetWorld 2020 will support the 5G PPP by
  - the direct relation to the PPP Association and
  - the development of the SRAI for the 5G-PPP



- The Association is an international non-profit association, named "The 5G Infrastructure Partnership" under Belgian law. It is the contractual counterpart of the European Commission for signing the 5G-PPP contract, done on 17 December 2013, see http://europa.eu/rapid/press-release_IP-13-1261_en.htm.

Source: NetWorld2020 ETP and Annex to 5G PPP Contractual Arrangement.

Members of 5G Infrastructure Association including international dimension

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Industry

- ADVA Optical Networking SE
- Alcatel-Lucent
- Airbus
- Atos
- Deutsche Telekom
- DOCOMO Communications Laboratories Europe GmbH
- Ericsson
- Huawei Technologies Düsseldorf GmbH
- IBM Research
- Intel Mobile Communications
- NEC Europe Ltd., NEC Laboratories Europe
- Nokia
- Orange Labs
- Portugal Telecom
- Samsung Electronics Research Institute Ltd.
- SES
- Telecom Italia
- Telefónica I+D
- Telenor ASA
- Telespazio
- Thales Alenia Space
- Turk Telekomünikasyon A.Ş.

Research

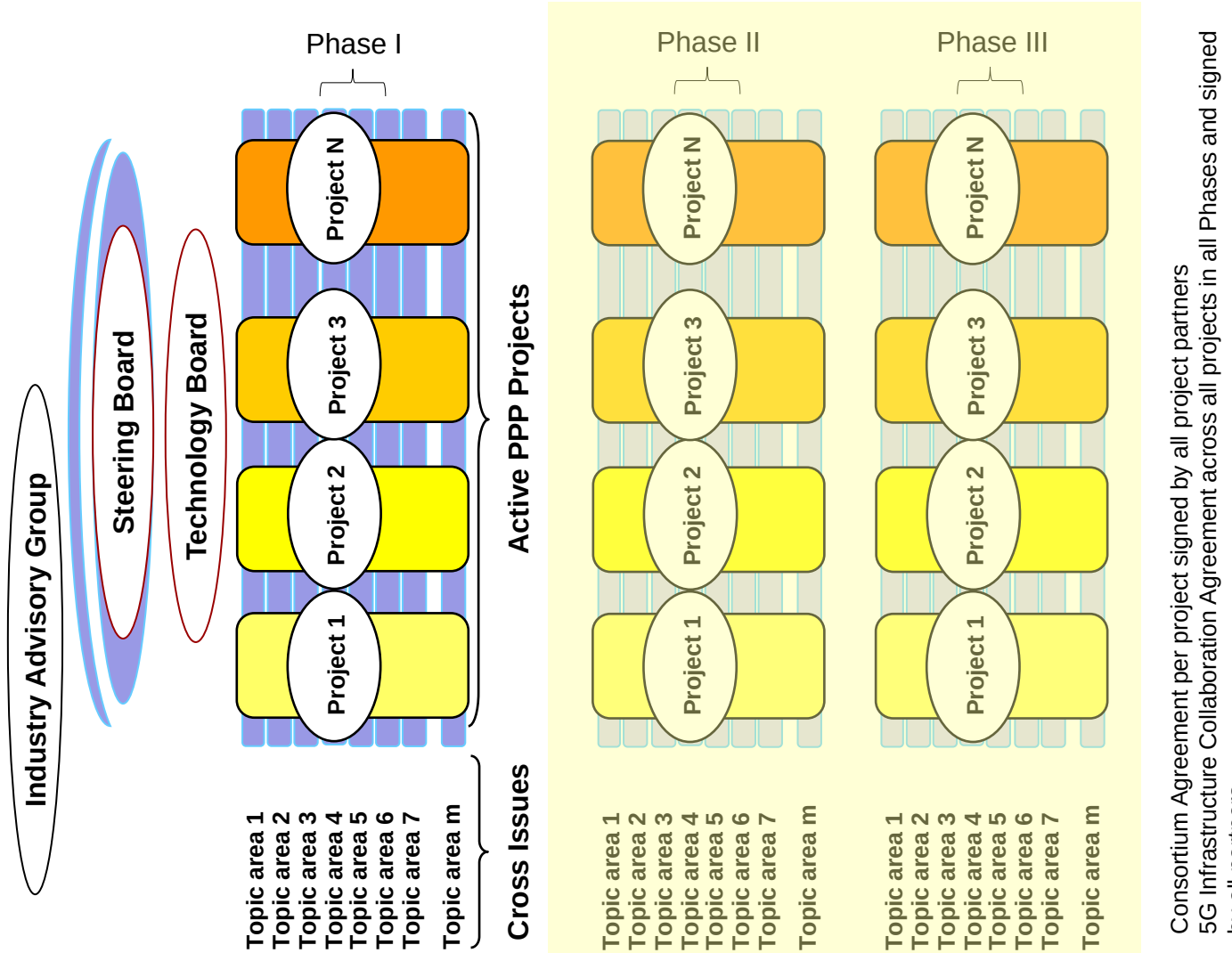
- CEA-LETI
- Centre Tecnologic de Telecomunicacions de Catalunya (CTTC)
- Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT)
- Fundacion IMDEA Networks
- Instituto de Telecomunicacoes
- IST – University of Lisbon
- TNO
- University of Bologna – DEI

SMEs

- Integrasys SA
- INTERINNOV
- M.B.I. S.R.L.
- Nextworks s.r.l.
- Quobis
- Sequans Communications

Source: 5G Infrastructure Association.

Governance model – Basic approach
Project Implementation



Source: 5G PPP Annex to contractual arrangement.

- Consortium Agreement per project signed by all project partners
- 5G Infrastructure Collaboration Agreement across all projects in all Phases and signed by all partners

5G Infrastructure PPP
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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

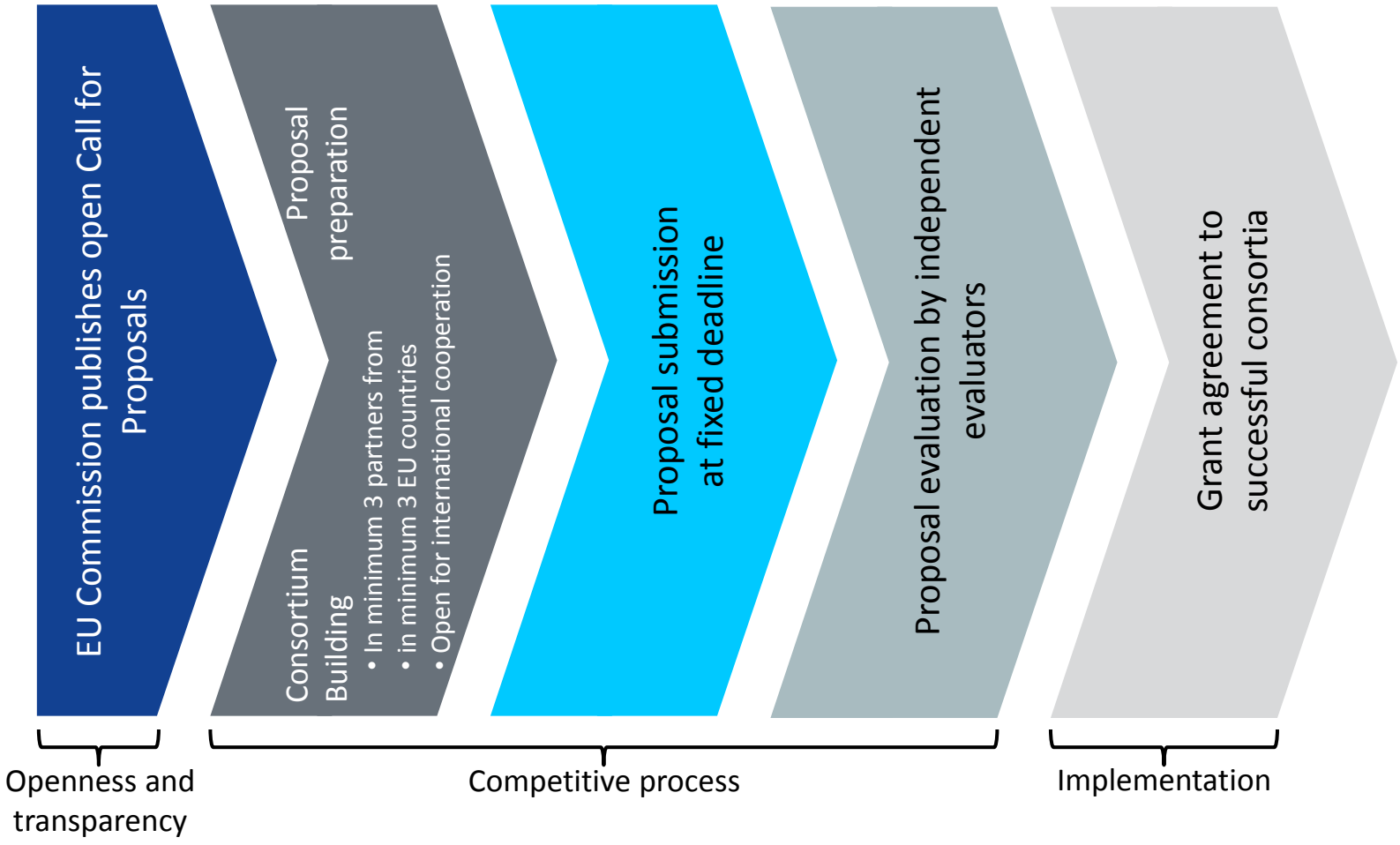
Network virtualization and Software Networks

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

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

How to start a project?
Major steps



Source: 5G Infrastructure Association.

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!