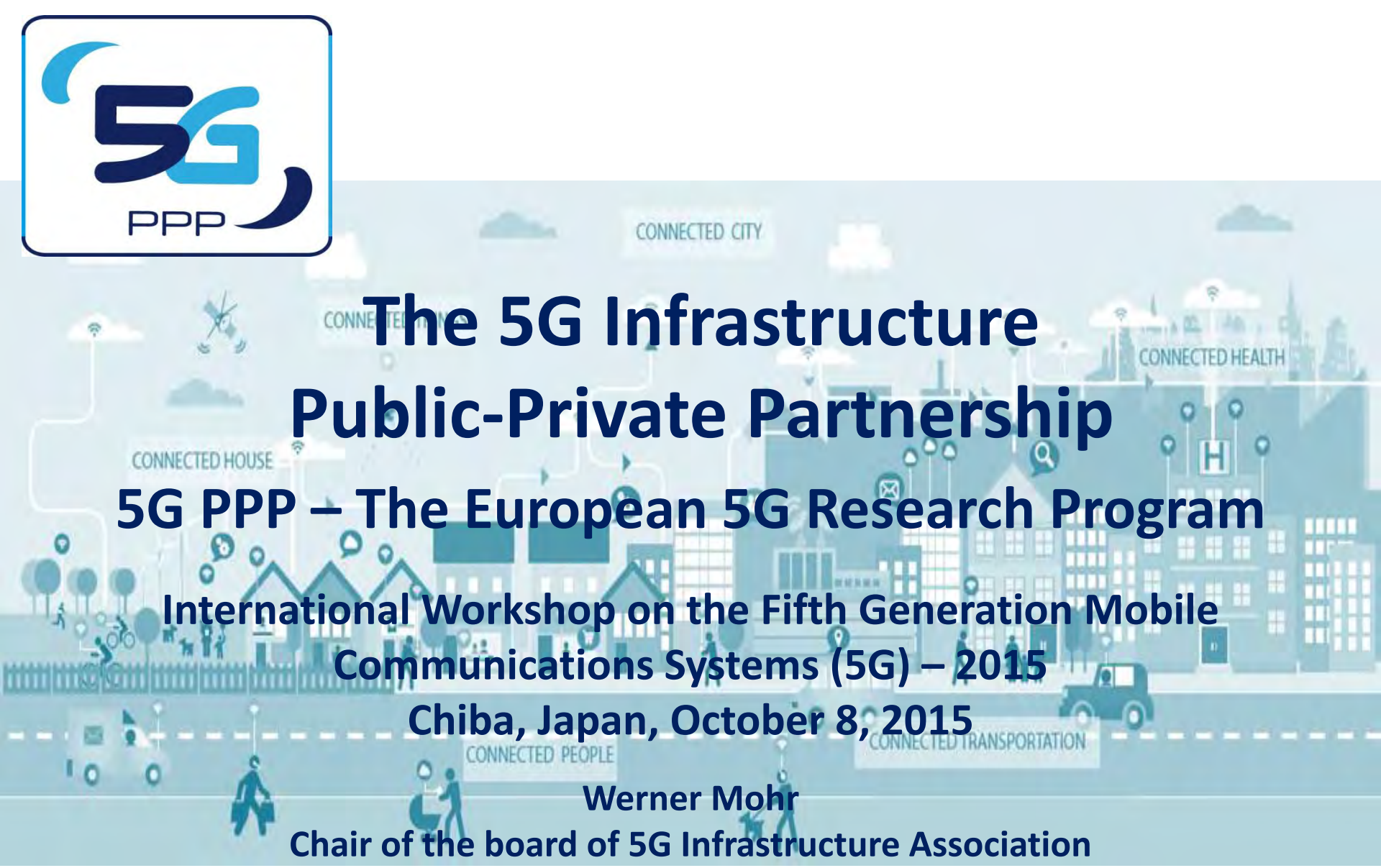

The 5G Infrastructure Public-Private Partnership

5G PPP – The European 5G Research Program

International Workshop on the Fifth Generation Mobile Communications Systems (5G) – 2015

Chiba, Japan, October 8, 2015

Werner Mohr

Chair of the board of 5G Infrastructure Association

http://5g-ppp.eu/

Outline

- 5G PPP overview
- 5G PPP vision
- Time plan
- 5G PPP research project portfolio
- Exploitation of results
- Conclusions

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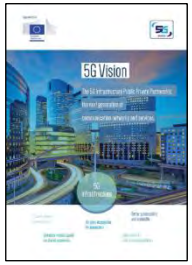
5G PPP in Horizon 2020 of the EU

- 5G PPP is a research program in Horizon 2020 of the EU dedicated to 5G system research
- 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 €
- Research program is addressing all building blocks of a future communication network and a huge number of huge cases from vertical sectors
- 5G Infrastructure Association vision paper published at Mobile World Congress 2015 in Barcelona
  http://5g-ppp.eu/wp-content/uploads/2015/02/5G-Vision-Brochure-v1.pdf
- First set of projects started on July 1, 2015



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International activities on 5G getting momentum
MoUs signed

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, MoU - signed

China

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

Japan – The 5G Mobile Communications Promotion Forum, MoU - signed

Korea – 5G Forum, MoU - signed

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

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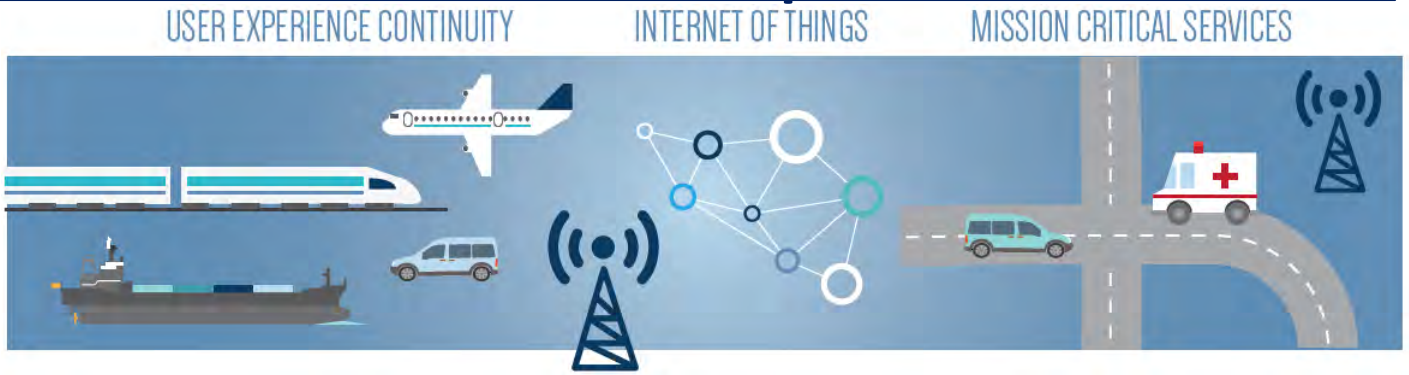
Source: 5G Infrastructure Association.

5G PPP Vision and Requirements
5G new service capabilities

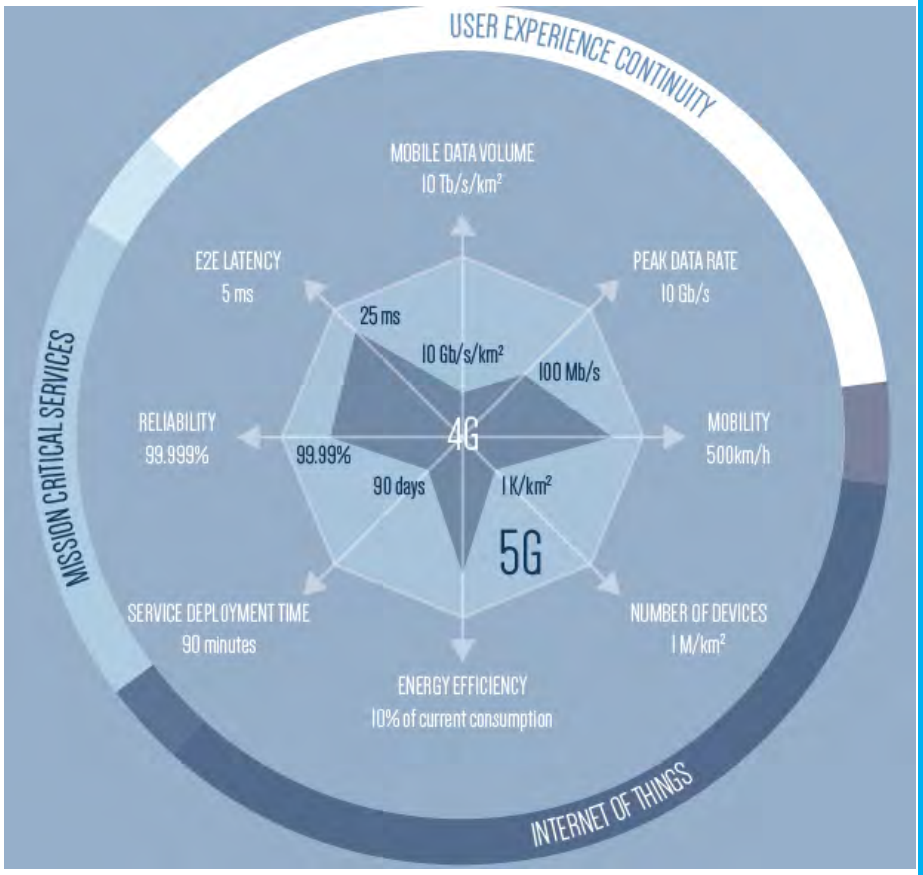


- 5G needs to support efficiently three different types of traffic profiles
  - high throughput for e.g. video services
  - low energy for e.g. long–living sensors
  - low latency for mission critical services
- 5G covers network needs and contributes to digitalization of vertical markets
  - automotive,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

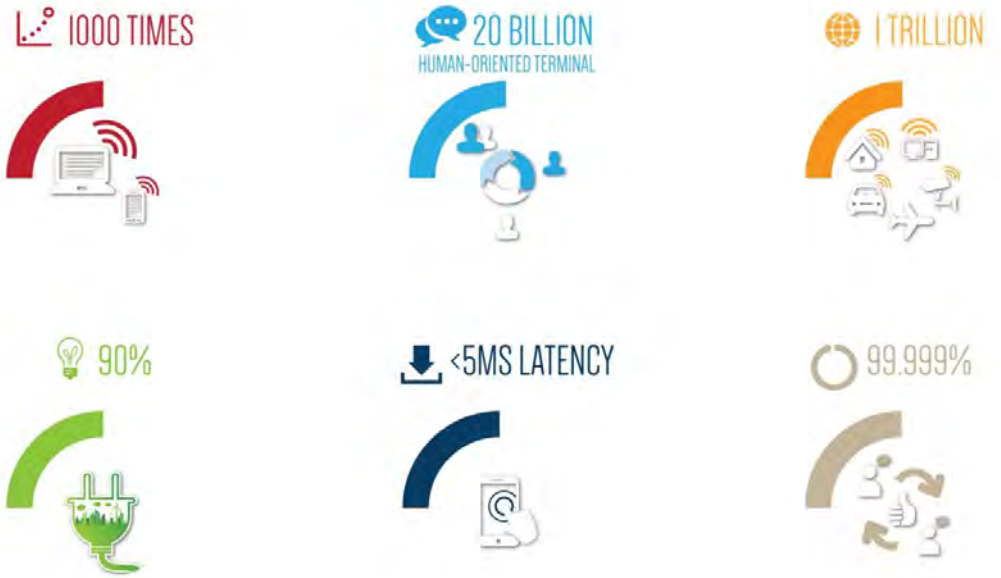
5G PPP Vision and Requirements
5G will have disruptive capabilities

- **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.

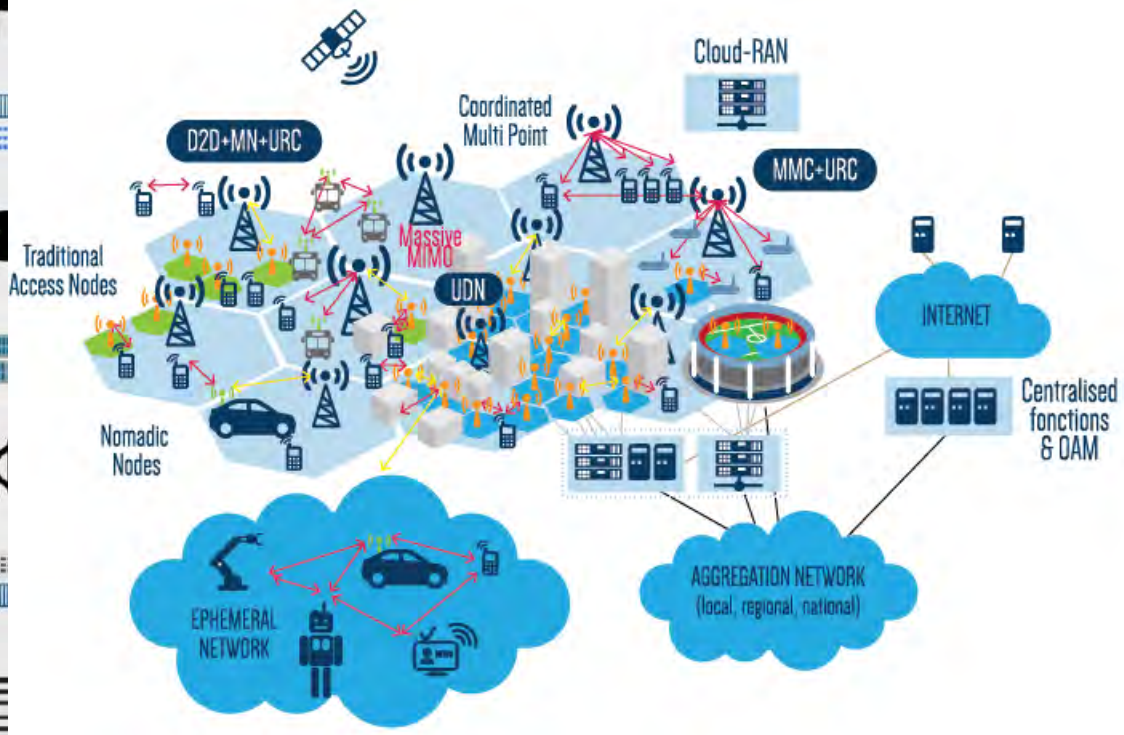
5G PPP Vision and Requirements
Key requirements



- 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

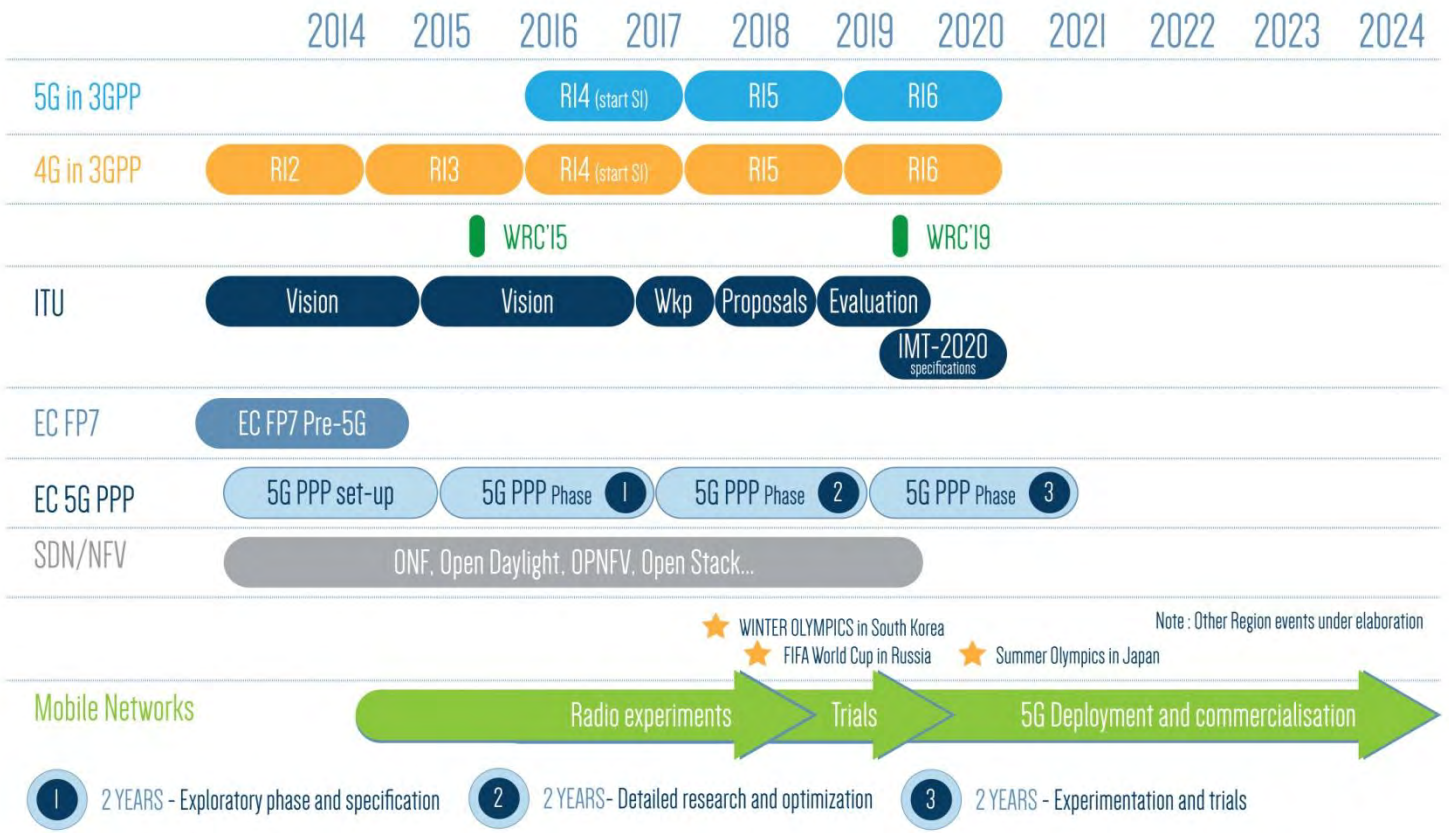
Source: 5G Infrastructure Association: Vision White Paper, February 2015.

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



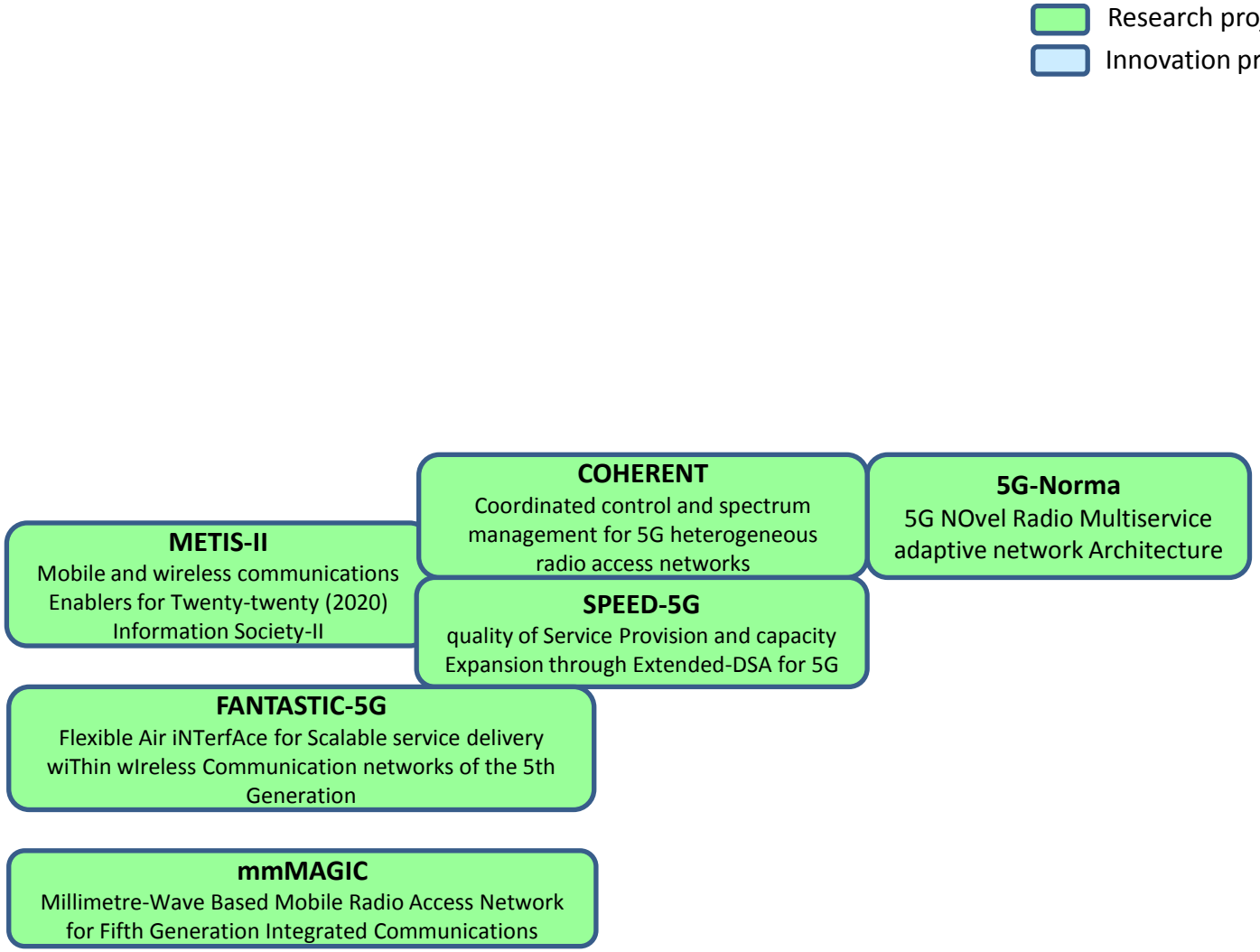
Source: 5G Infrastructure Association: Vision White Paper, February 2015.

5G PPP Vision and Requirements
5G roadmap



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

Radio-related cluster



Source: COHERENT, FANTASTC-5G, Metis-II, mmMAGIC, 5G-NORMA, SPEED-5G.

Radio-related cluster

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

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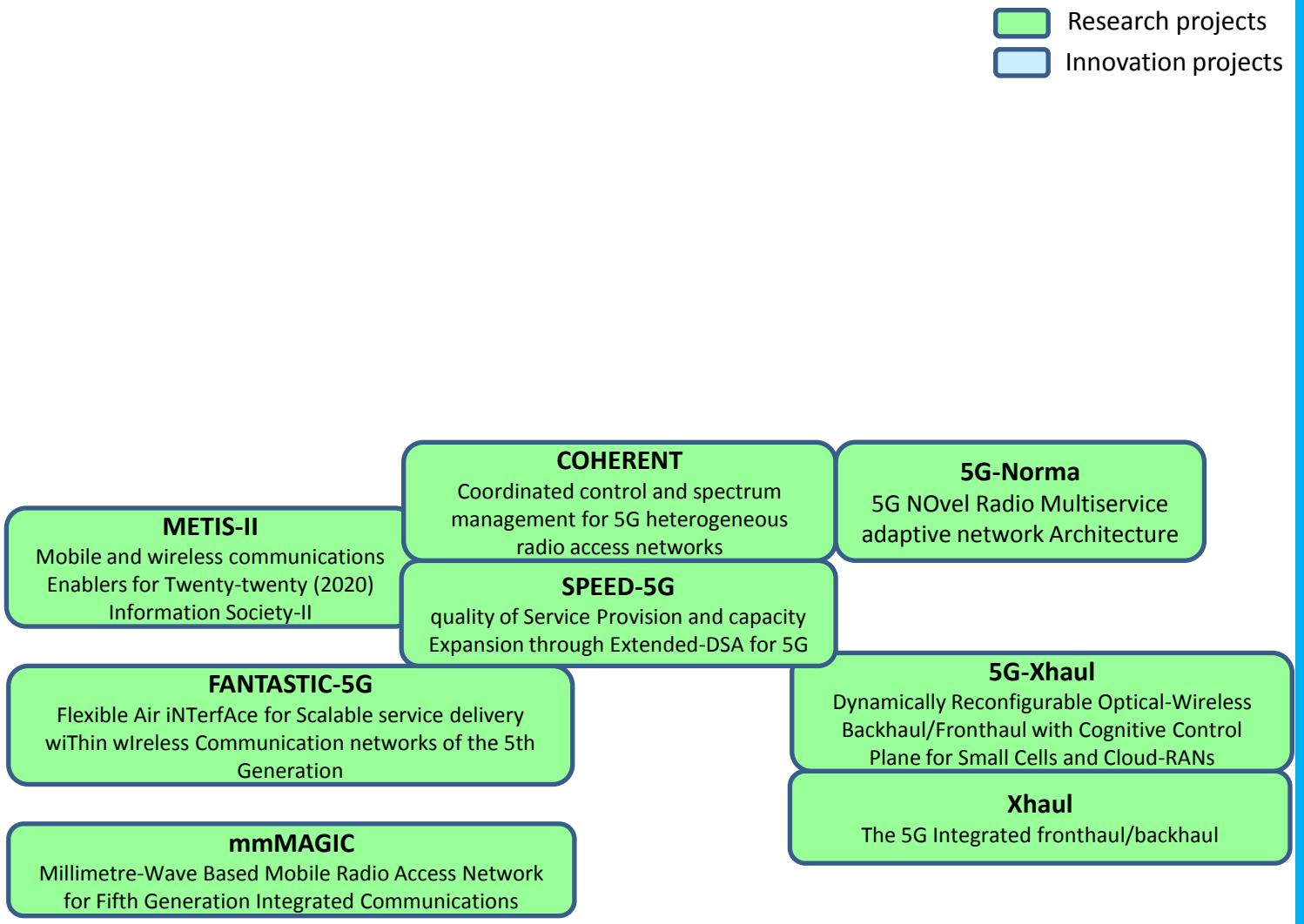
Source: COHERENT, FANTASTC-5G, Metis-II, mmMAGIC, 5G-NORMA, SPEED-5G.

Fronthaul/backhaul



Source: xHaul, 5G-xHaul.

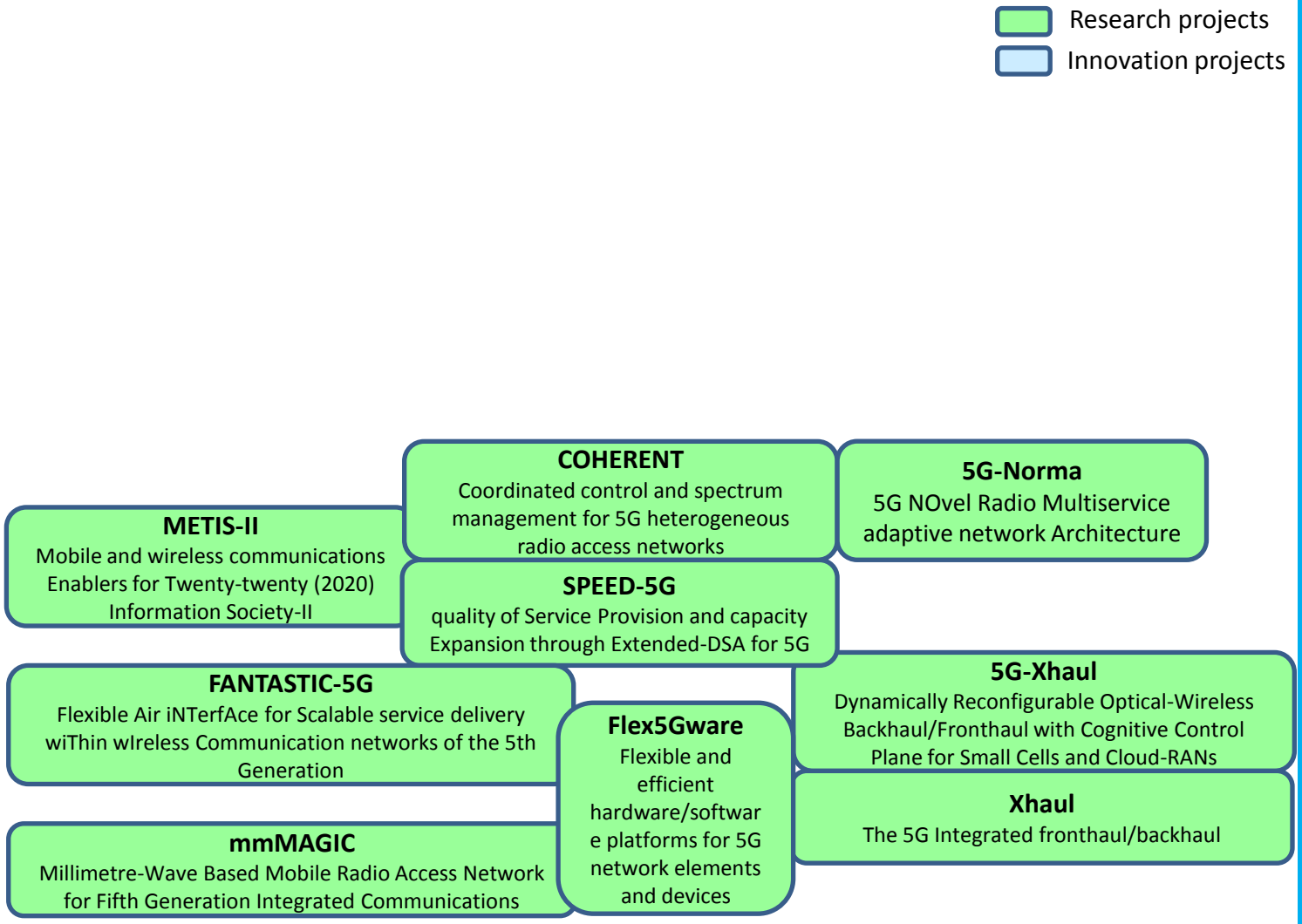
Fronthaul/backhaul

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

Source: xHaul, 5G-xHaul.

Hardware implementation



Source: Flex5Gware.

Hardware implementation

Objectives

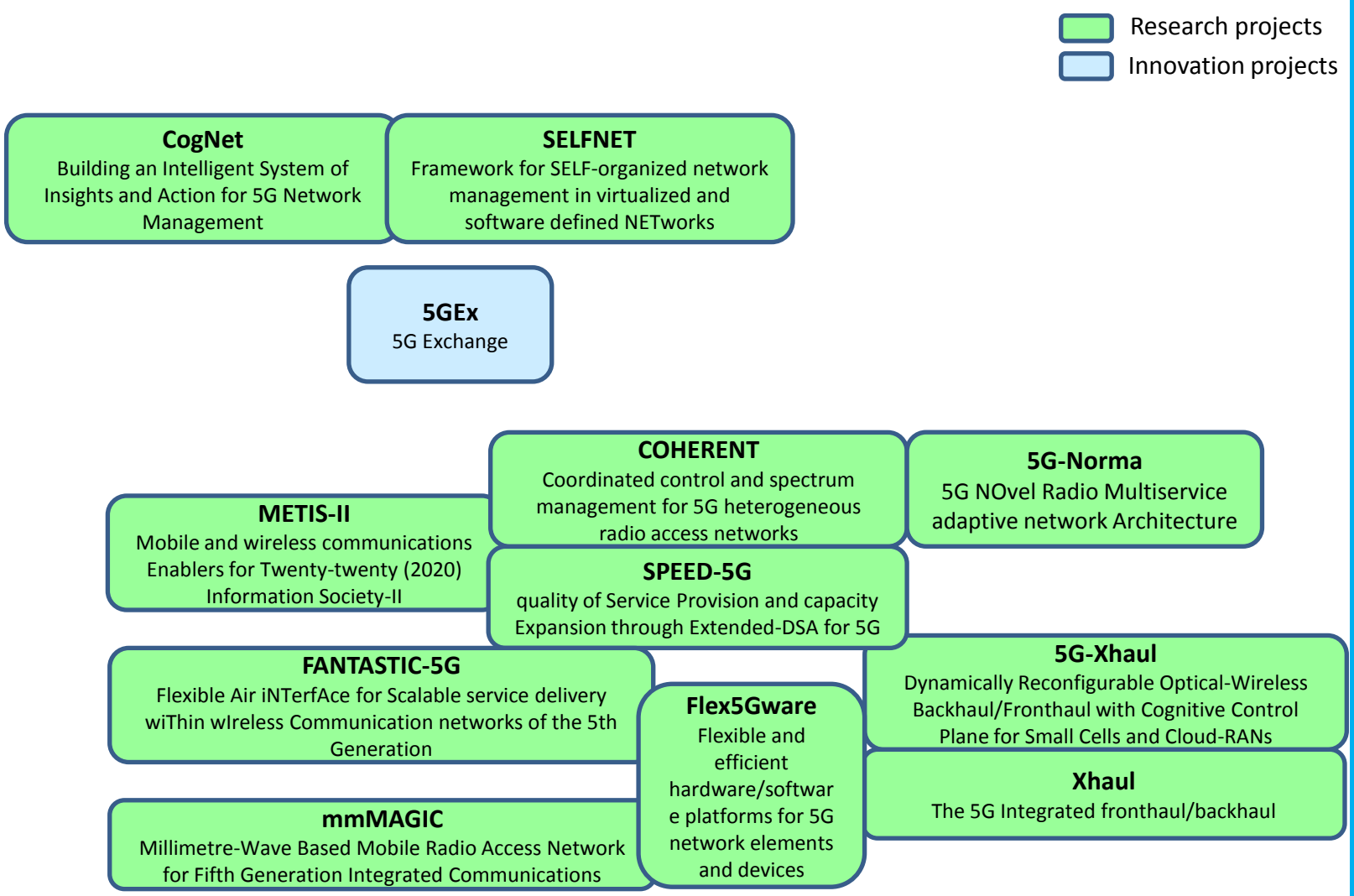
- Increasing the HW versatility and reconfigurability
- Providing HW-agnostic, flexible and cost-effective SW platforms
- Increasing the overall capacity of 5G communication platforms
- Decreasing the energy consumed by 5G communication platforms
- Identifying and prototyping key building blocks

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)

Source: Flex5Gware.

Network automation



Source: CogNet, SELFNET, 5GEx.

Network automation

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

Source: CogNet, SELFNET, 5GEx.

SDN, NFV, Cloud and Virtualisation

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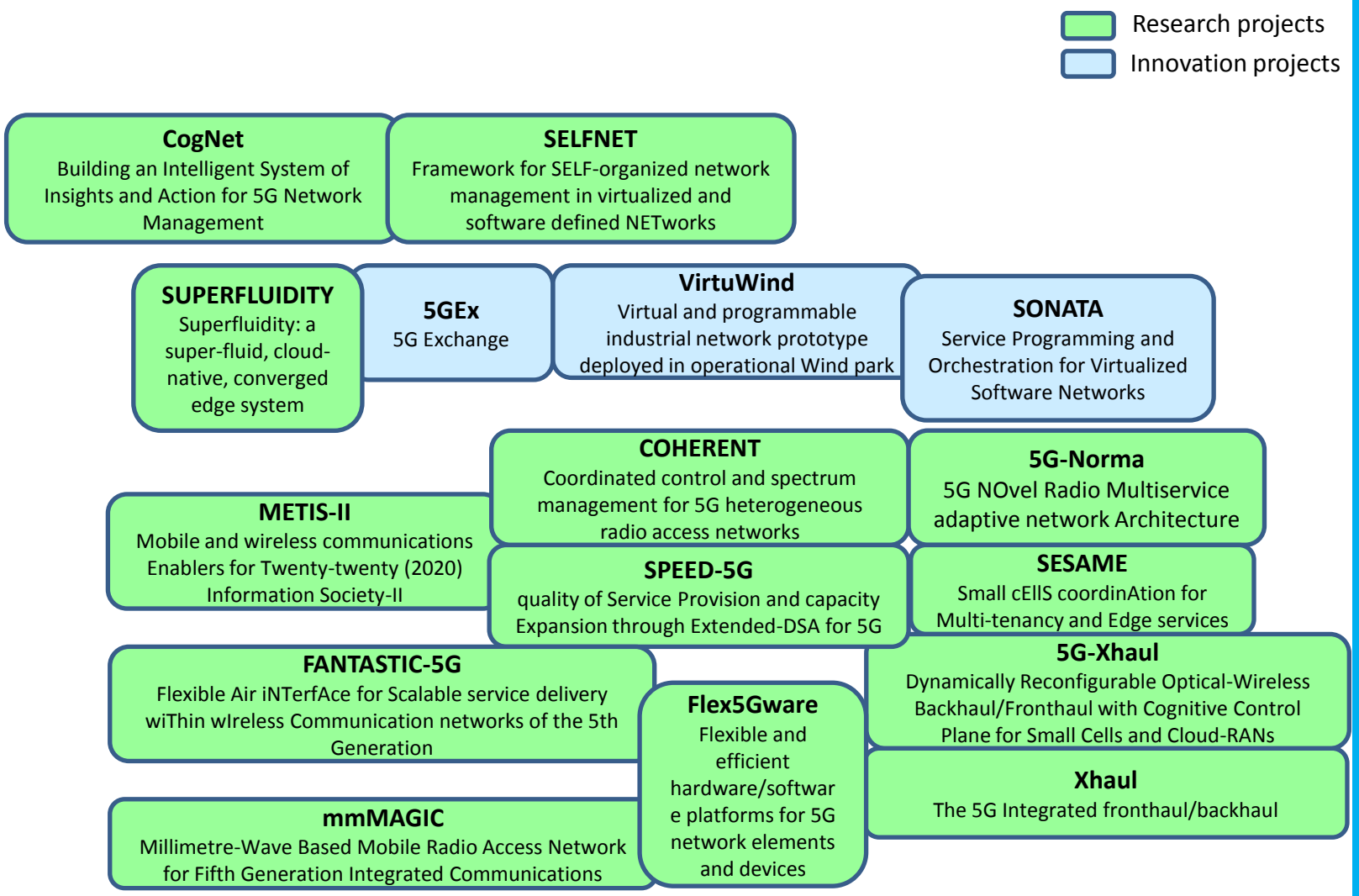

Source: SESAME, SONATA, SUPERFLUIDITY, VirtuWind.

SDN, NFV, Cloud and Virtualisation

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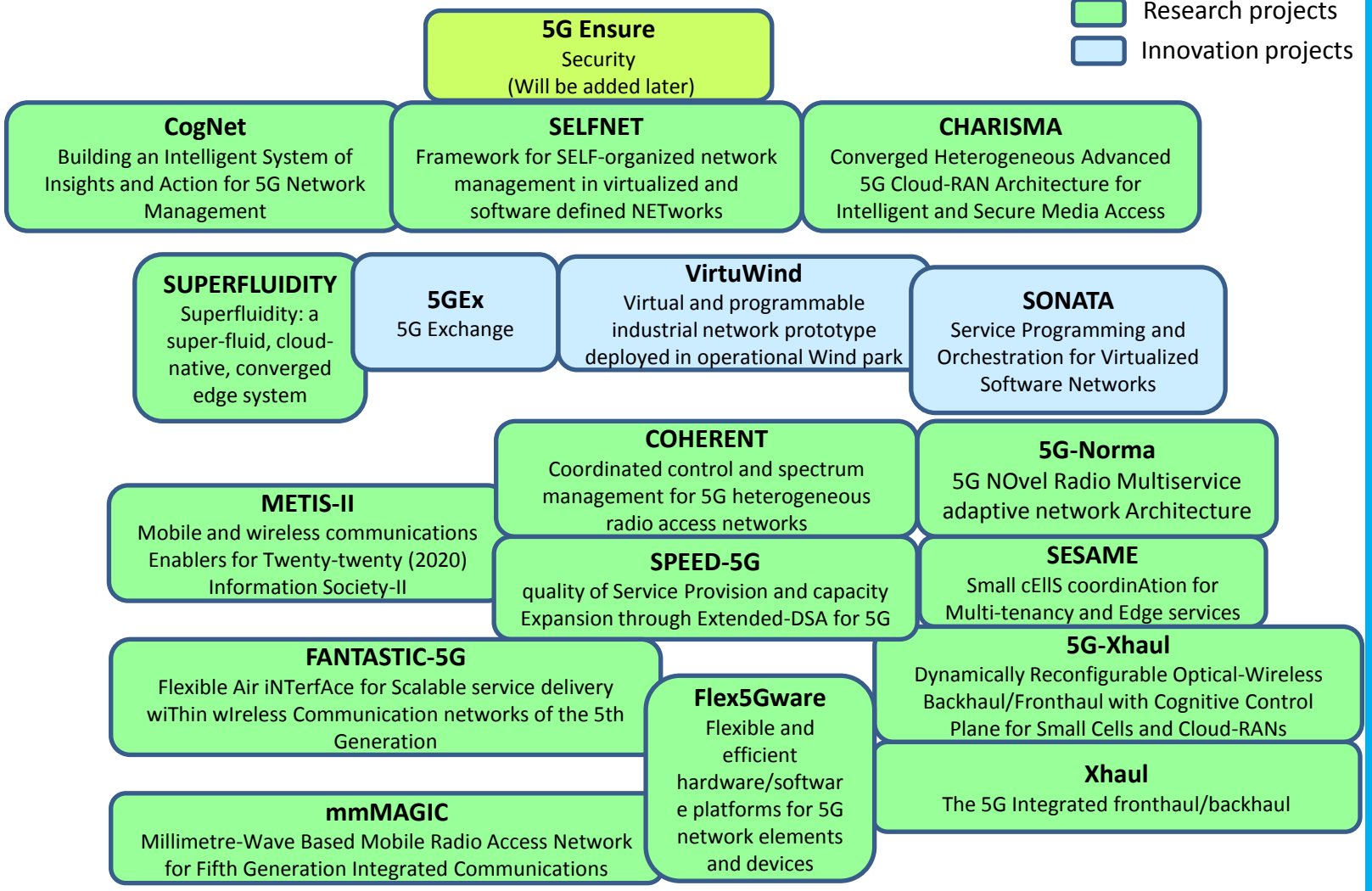
Objectives

- **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

Source: SESAME, SONATA, SUPERFLUIDITY, VirtuWind.

Security



Source: CHARISMA, 5G-ENSURE.

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

Source: CHARISMA, 5G-ENSURE.

5G Infrastructure Association Working Groups and Activities

5G Infrastructure PPP
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5G Infrastructure Association Board

WG 5G Vision and Societal Challenges
- Vision and requirements
- Vertical sectors
- Definition of research program
- Assessment of research portfolio
- Monitoring of performance KPIs (system capacity, energy consumption, privacy and security, reliability and availability, service creation time

WG 5G Pre-standards
- Roadmaps of relevant standards and specification bodies
- Identify topics for research and timing of availability of results
- Provide means for coordinated contributions across projects

WG SME support
- SME participation of at least 20 %
- Stimulate SME involvement

WG 5G Spectrum
- Support preparation of WRC 2019 on future spectrum requirements
- Identification new means of spectrum access based on research results

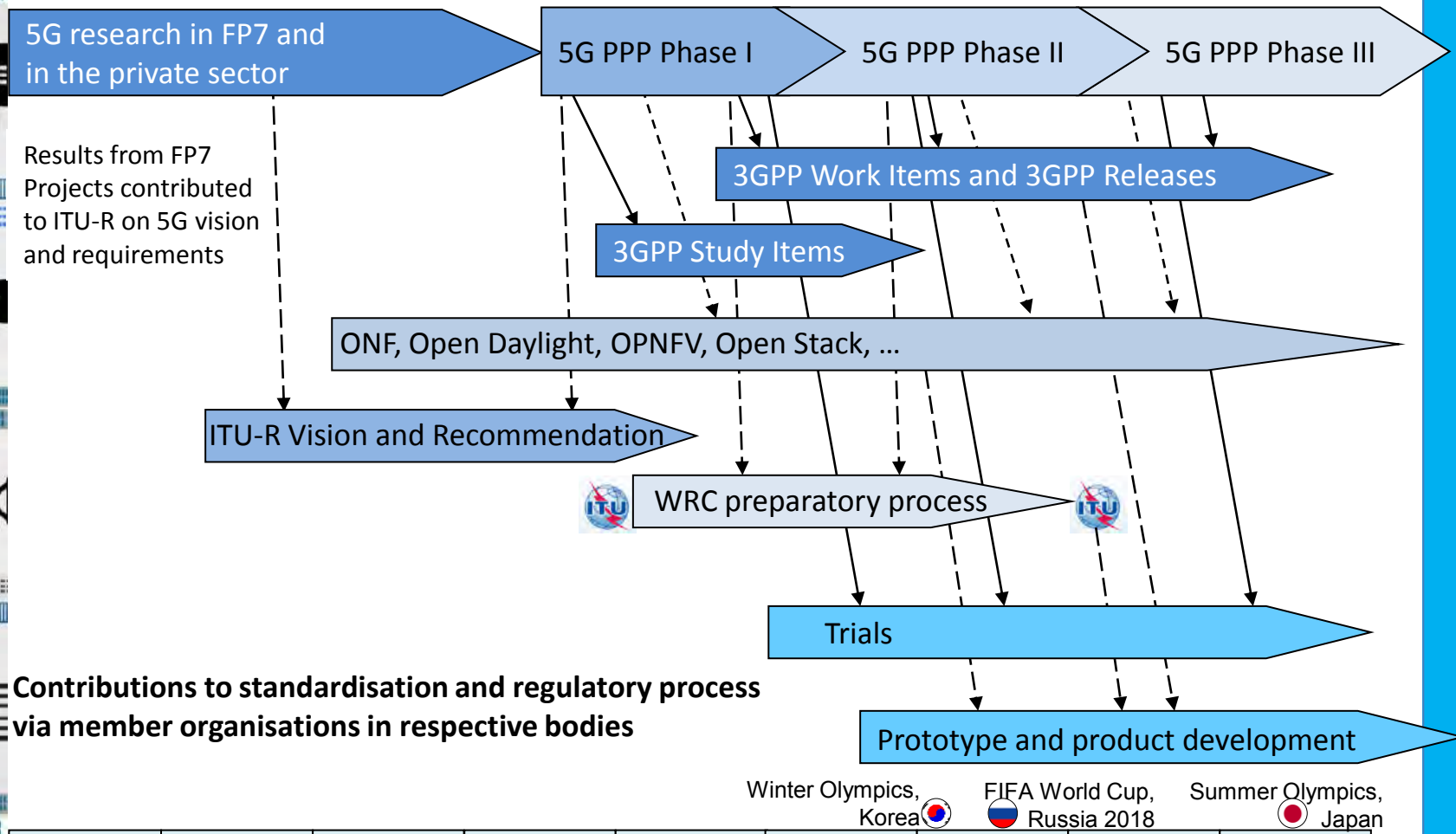
Activity Community building and PR (Public Relations)
- Dissemination of results and communication strategy
- Website and press releases
- Public consultation

Activity 5G International cooperation
- International cooperation strategy with counterparts in other regions
- Establishment of relations
- Joint events across regions

Activity Activities based on the 5G PPP Contractual Arrangement, KPIs
- Leveraging factor of additional private investment
- Monitor market share from European perspective
- Monitoring of generated IPR base
- Support adaptation of curricula for education of skilled personnel (e.g. via EIT ICT Labs.)

Source: 5G Infrastructure Association.

Exploitation of results



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Source: 5G Infrastructure Association.

Conclusions

- 5G PPP is a research program in Horizon 2020 of EU Commission dedicated to 5G system research and development
- Collaborative research as means for consensus building to prepare future standards
- 5G PPP vision and requirements similar to views in other regions and international bodies and associations
- Large project portfolio or cooperating projects, which are addressing major elements and building blocks of a future communication network
- 5G PPP Working Groups and Activities support project cooperation and contributions to international standardisation and the regulatory process
- Research results are expected to be contributed by project participants to the international standardisation and regulatory process

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

http://5g-ppp.eu

Thank you for your attention!