# EMERGING 5G TECHNOLOGIES AND INSIGHTS FROM EXPERIMENTS WITH SELECTED VERTICAL DOMAINS

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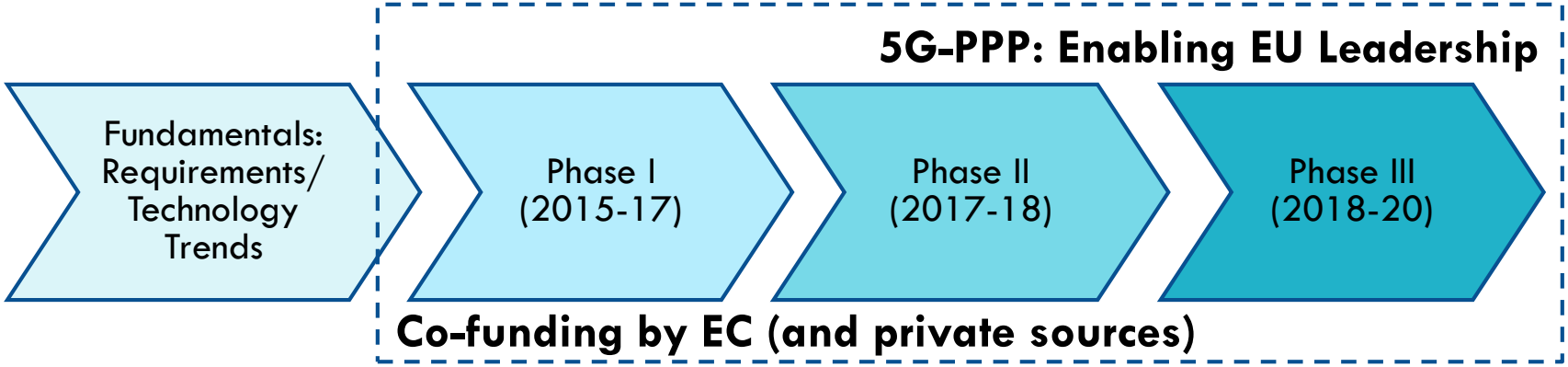
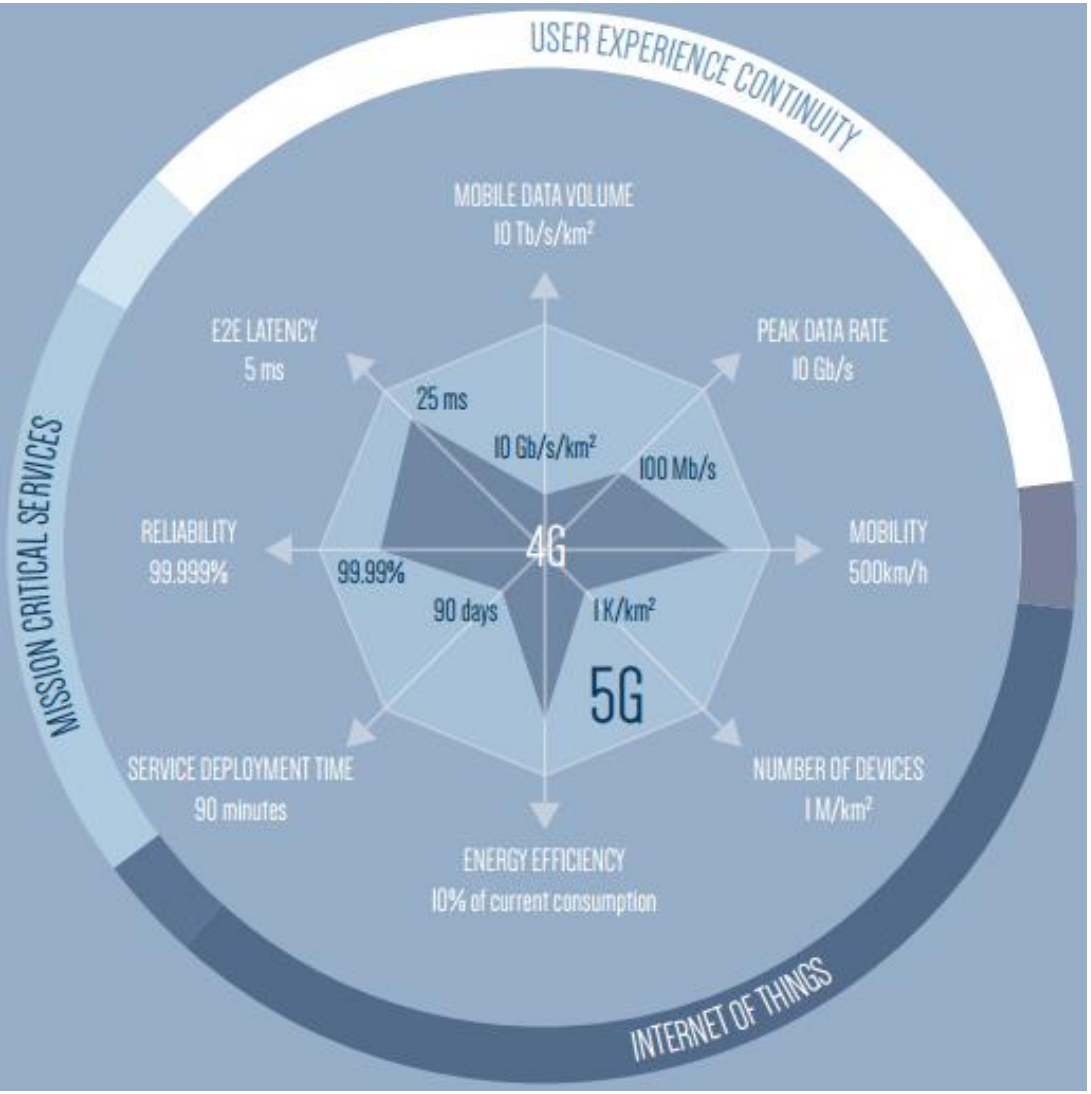
5G Summit, Thessaloniki, 11 July 2017

# Outline




- **A.** Fundamentals
  - Requirements
  - Technology Trends
- **B.** Current technology enablers
  - Ongoing projects
- **C.** Emerging technology activities
  - New projects
- **D.** Future Evolution-Experiments-Pilots-Trials
  - Technology fine-tuning

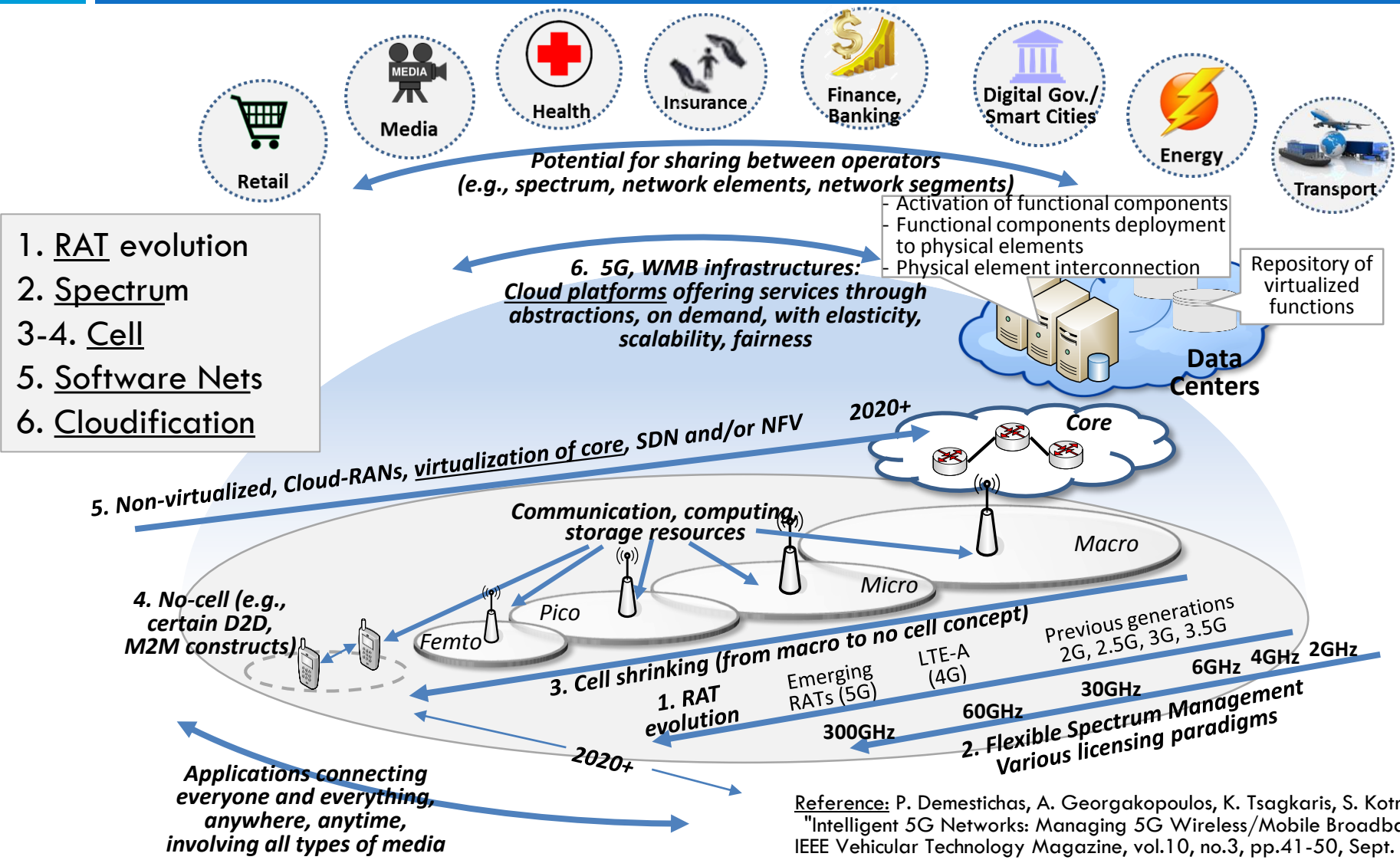
# Fundamentals: Requirements on 5G




- **1000x** more capacity and data rates
- Towards **0-5ms** E2E latency
- **1M/km²** devices
- **500km/h** high mobility
- **99.999%** reliability
- **<90mins** service deployment time
- **90%** energy efficiency

Source: 5G-PPP (https://5g-ppp.eu/)

# Fundamentals: 5G Technology Trends

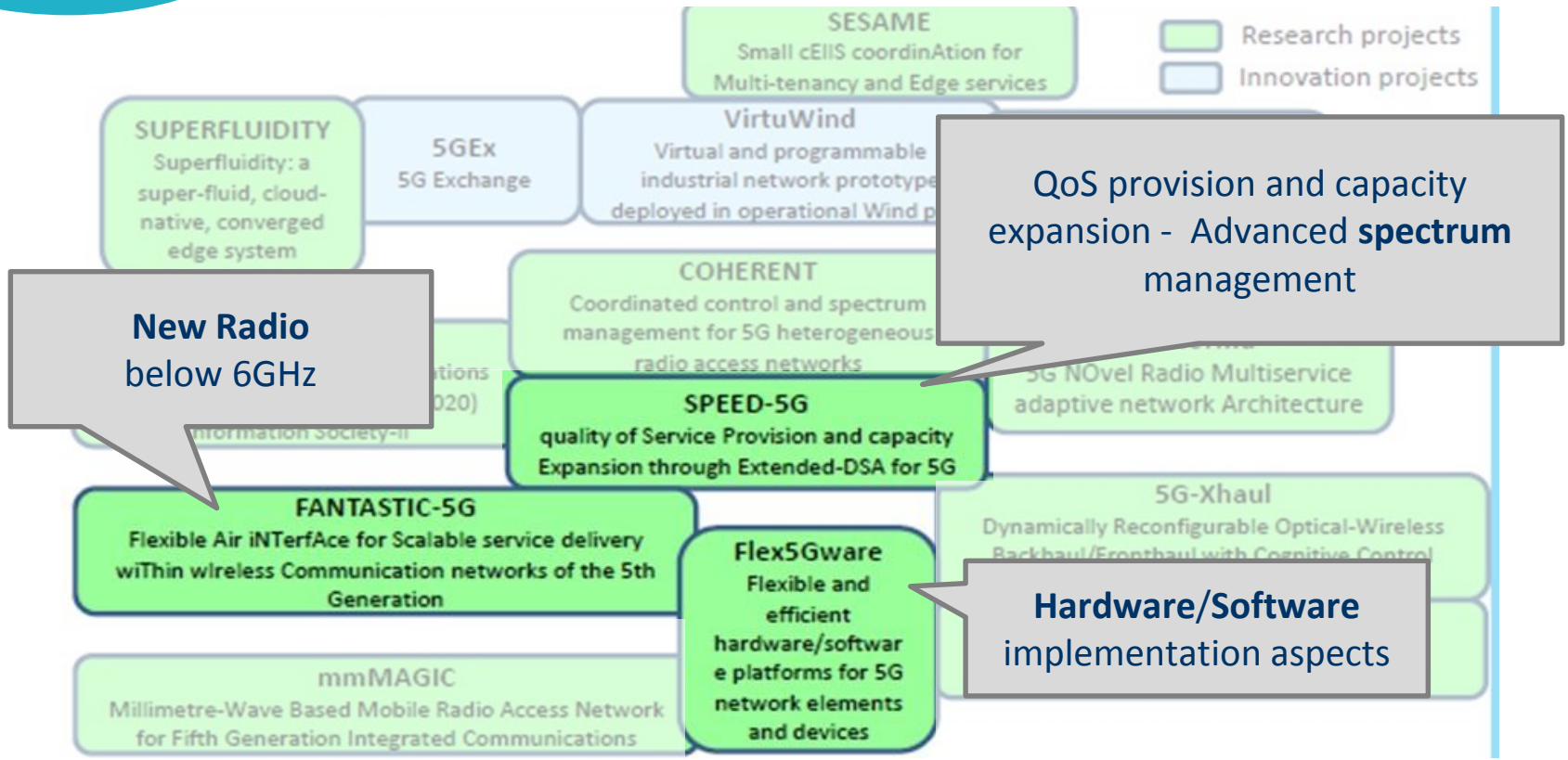



Reference: P. Demestichas, A. Georgakopoulos, K. Tsagkaris, S. Kotrotsos, "Intelligent 5G Networks: Managing 5G Wireless/Mobile Broadband," IEEE Vehicular Technology Magazine, vol.10, no.3, pp.41-50, Sept. 2015

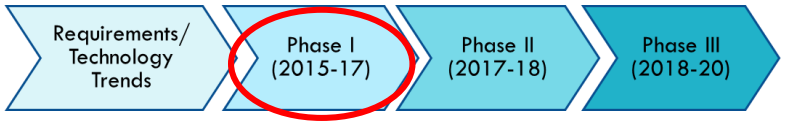
# 5G-PPP Phase 1: Selected achievements

**35+ projects funded by EC for 5G research**

Requirements/ Technology Trends → Phase I (2015-17) → Phase II (2017-18) → Phase III (2018-20)



# FANTASTIC-5G: New Air Interface below 6GHz



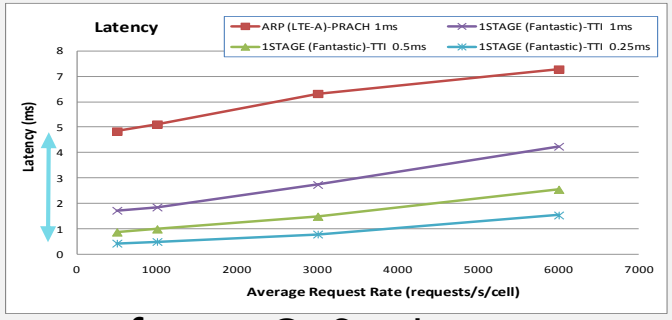

## Features

- New waveforms
- Frame design
- Advanced coding
- Advanced modulation
- Massive MIMO
- Enhanced RRM

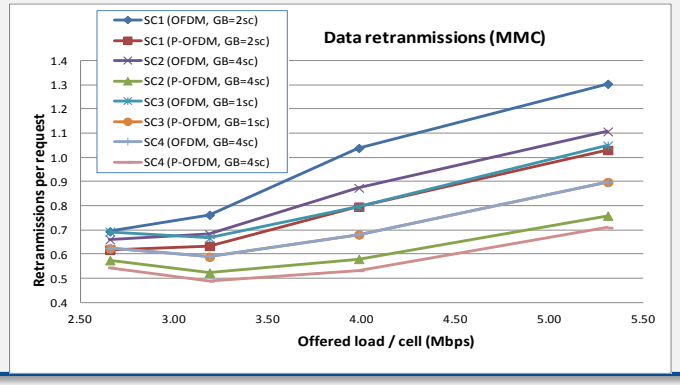
WINGS system-level simulator

## Evaluation

**Flexible frame:** ~50% reduced latency compared to LTE-A

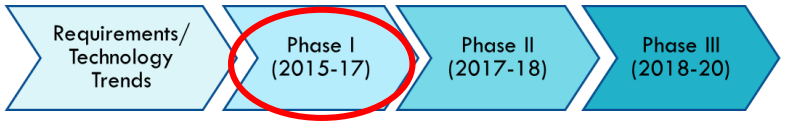



**New waveforms:** QoS achievement with 30-50% less cost (e.g. retransmissions) compared to OFDM




**Sample achievements**: Over 20 patents filed, standardization etc.

# SPEED-5G: Spectrum optimization

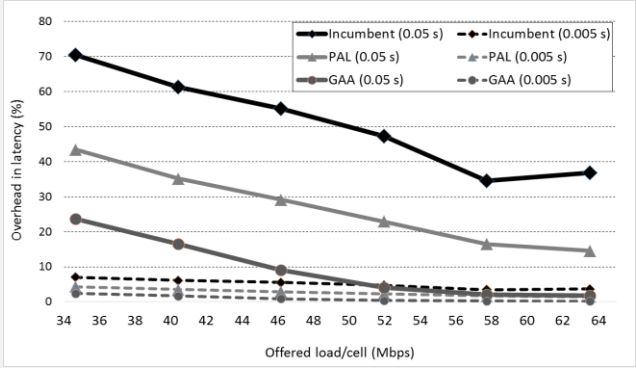



## Features

- Novel spectrum management
- Extended Dynamic Spectrum Assignment (eDSA)
- Lightly-licensed spectrum ***and*** licensed/unlicensed
- New MAC/RRM

## Evaluation

Achievement of 5G performance with up to 70% less cost (signalling due to hierarchical RAT/spectrum management)

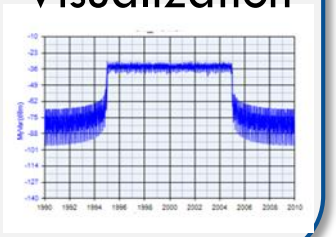



**Hardware evaluation– Hardware in the loop**

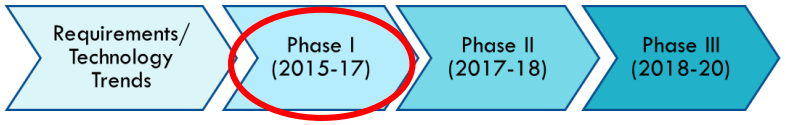
Traffic generator

USRPs

Results/ Visualization



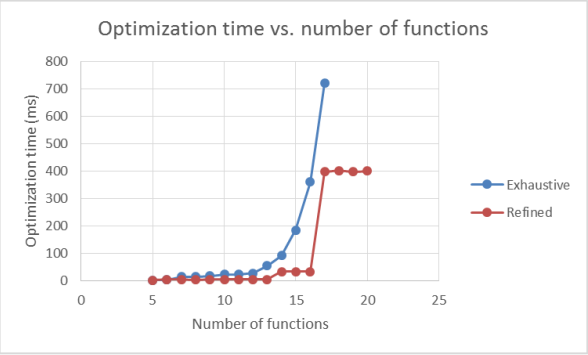
# Flex5Gware - Flexible and efficient HW/SW



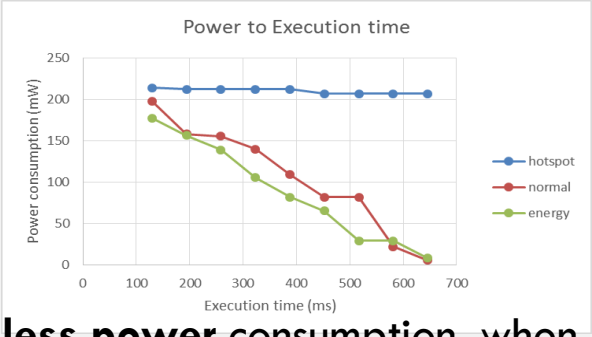

## Features

- HW versatility and reconfigurability
- HW-agnostic, flexible and cost-effective SW platforms
- More capacity of 5G communication platforms
- Less energy consumed by 5G communication platforms

## Evaluation



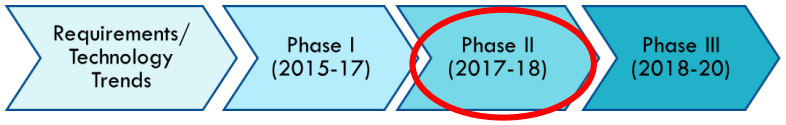

**20 ms, up to 300 ms less reconfiguration** time, in terms of optimization execution, compared to current optimization solutions




**10% less power** consumption, when moving more functions to SW implementation

# 5G-PPP Phase 2

## Verticals and technology




### One5G

- Megacities and Under-served areas
- E2E-aware optimizations
- Advanced link technologies and enhancements beyond Rel.15
- Multi-service operation
- Advanced massive MIMO and RRM

### Clear5G

- Factories of the Future (FoF)
- Towards "zero" latency
- Ultra-reliable services
- Configure and optimize radio network architectures
- Energy and spectral efficiency
- Protocol enhancements

### MATILDA

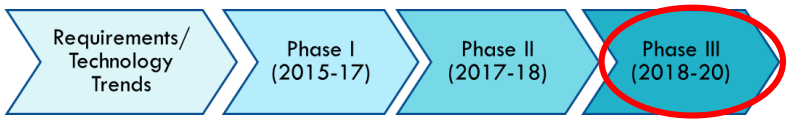
- Operational framework where software for 5G-ready applications
- Supporting virtual and physical network functions
- Development of micro-services & VNFs
- Automotive, Smart cities, Industry 4.0, Media

### 5G-PHOS

- Integrated optical technologies
- Enhancing Fiber-Wireless (FiWi) convergence
- Joint optical/wireless network optimization
- Cost-effective & energy-efficient 5G network solutions
- Media delivery in smart venues

# 5G-PPP Phase 3

## Evolution-Experiments-Pilots-Trials




- **Verticals**
  - Advanced automation
  - Energy management
  - Water management
- **Trials**

- **Beyond Phase 3**
  - Exploitation
  - Innovation Management
  - Funding instruments in conjunction with market forces

# Acknowledgment-References

- 5G-PPP: https://5g-ppp.eu/
- One5G: https://5g-ppp.eu/one5g/
- FANTASTIC-5G: http://fantastic-5g.eu/
- SPEED-5G: http://speed-5g.eu/
- Flex5Gware: http://www.flex5gware.eu/

The work is supported by the European Commission and 5G Public-Private Partnership (5G-PPP) and received funding from the EC H2020/5G-PPP programme One5G, FANTASTIC-5G, SPEED-5G, Flex5Gware projects

# Thank You!