



# 5G Mobile Networks

A revolutionary evolution towards  
the Wireless Internet of Things

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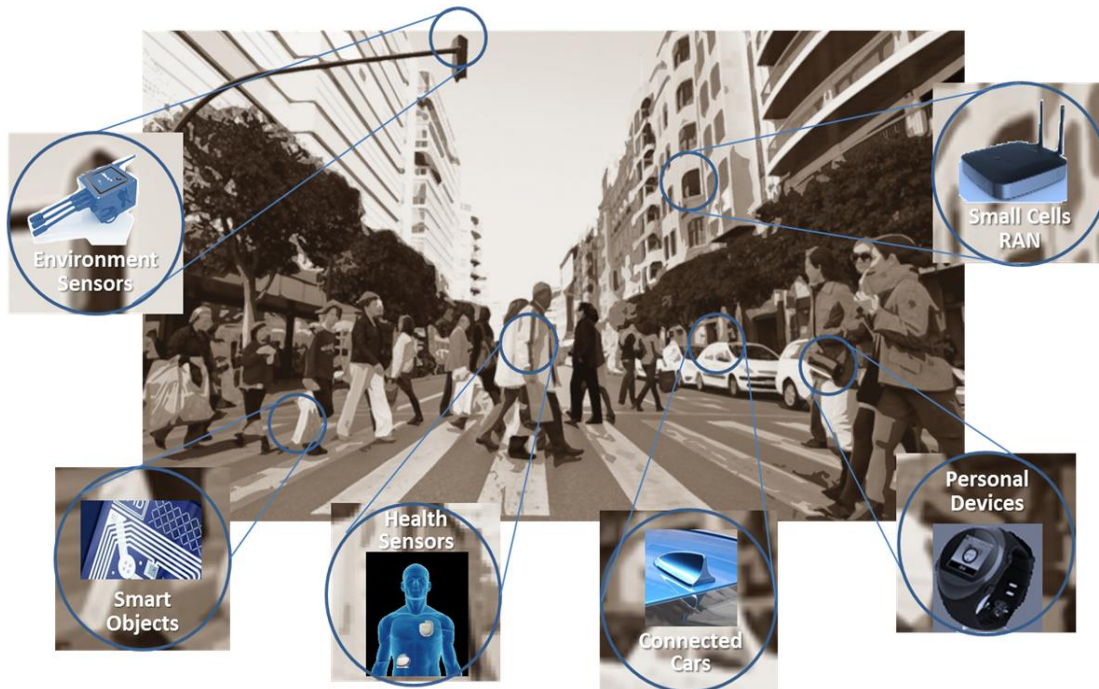
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[www.iteam.upv.es](http://www.iteam.upv.es); [www.ic1004.org](http://www.ic1004.org)

2020s 'hyper-connected society' in which mobile will play an ever more important role in people's lives.



Mobile Networks traffic boosted by the evolution of terminals, mainly the user interfaces.

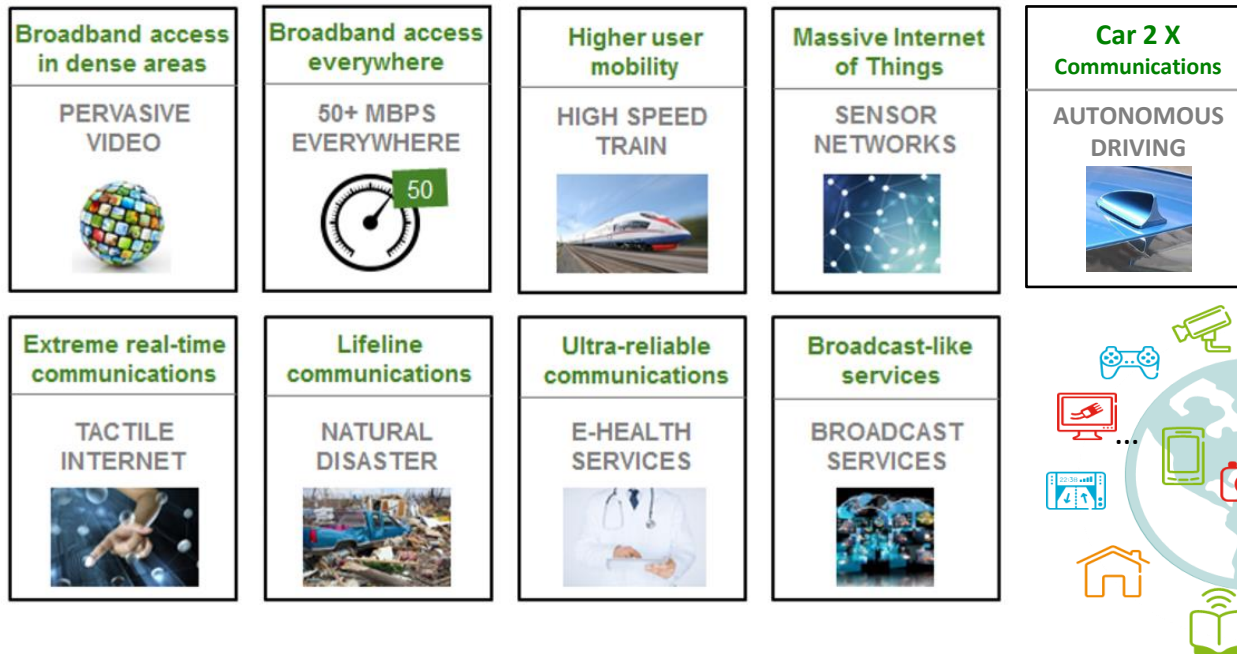
Terminals become active in the network procedures, taking roles of sense the local environment, relay to other devices, link to the access network, coordinate, ...

Access Networks are to change their architectural basis, evolve to terminal- (user-) (service-) centric.

*A second terminals' revolution could be expected by 2020*

Wireless Internet of Things to ramp up in ... 5(?) years

# Mobile Services Scenarios for 2020+

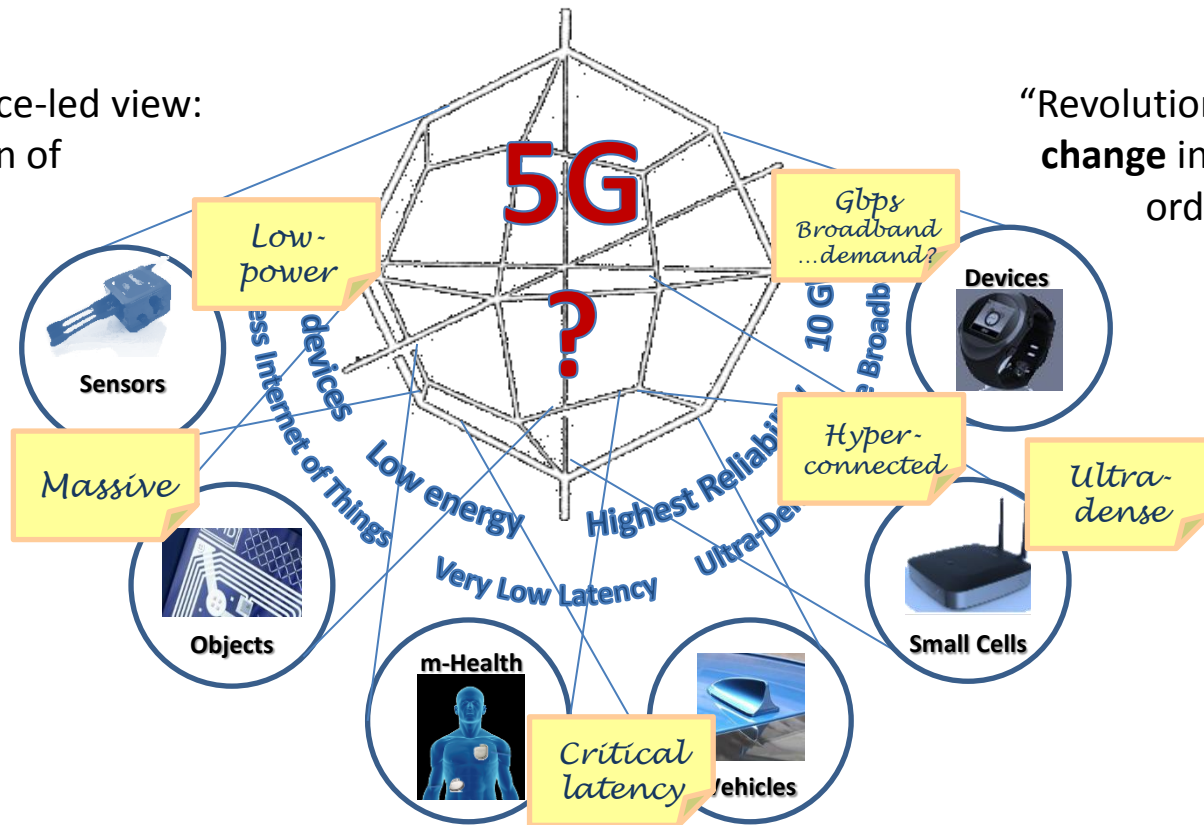


New “users”, devices, business models, applications, new players,... all taking positions

[ref.] “5G White Paper” NGNM Alliance Public deliverable

# What is (and what isn't) 5G ?

“Evolutionary” service-led view:  
5G as a consolidation of  
**harmonised** 2G, 3G,  
4G, Wi-fi and other  
innovations  
providing far  
greater coverage  
and always-on  
reliability



“Revolutionary” view: **step change** in data speed and  
order of magnitude  
reduction in  
end-to-end  
latency

# H2020 – 5G PPP ongoing projects



The 5G Infrastructure Public Private Partnership





# 5G requirements according to 5G-PPP

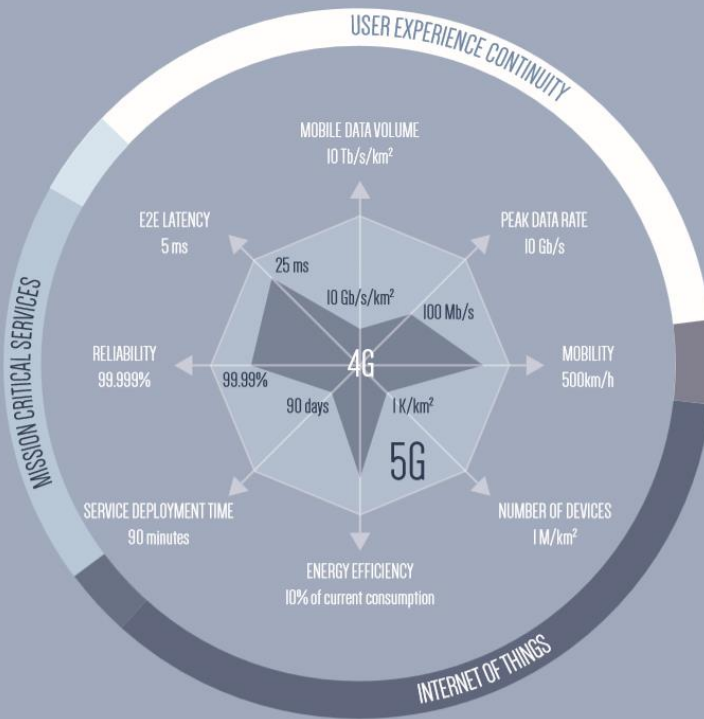


FIGURE 2. Radar diagram of 5G disruptive capabilities

1,000 X in mobile data volume per geographical area reaching a target  $\geq 10 \text{ Tb/s/km}^2$

1,000 X in number of connected devices reaching a density  $\geq 1 \text{ M terminals/km}^2$

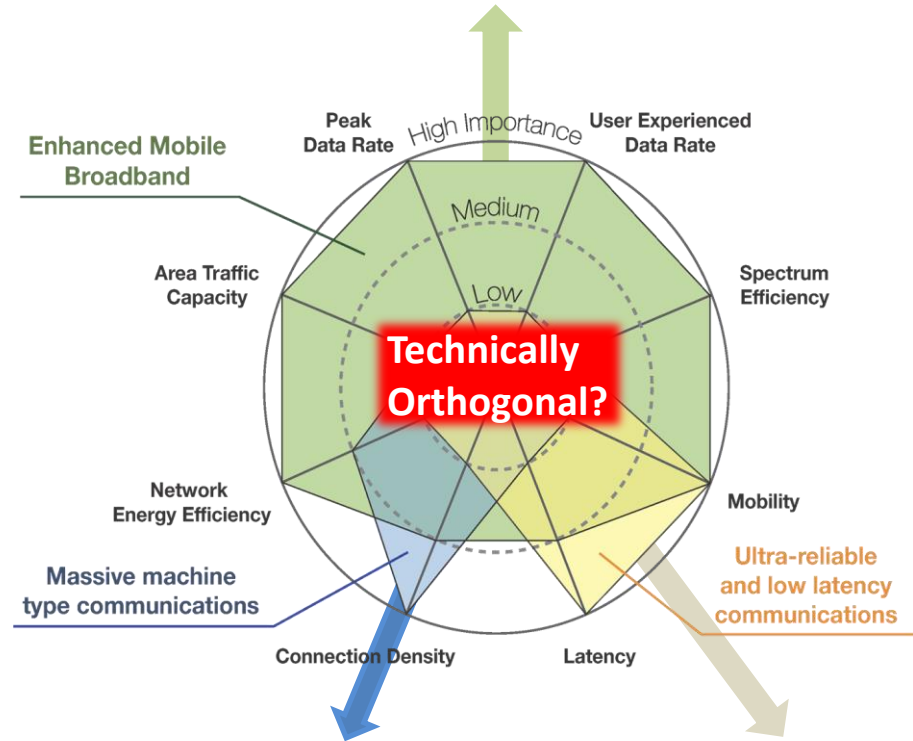
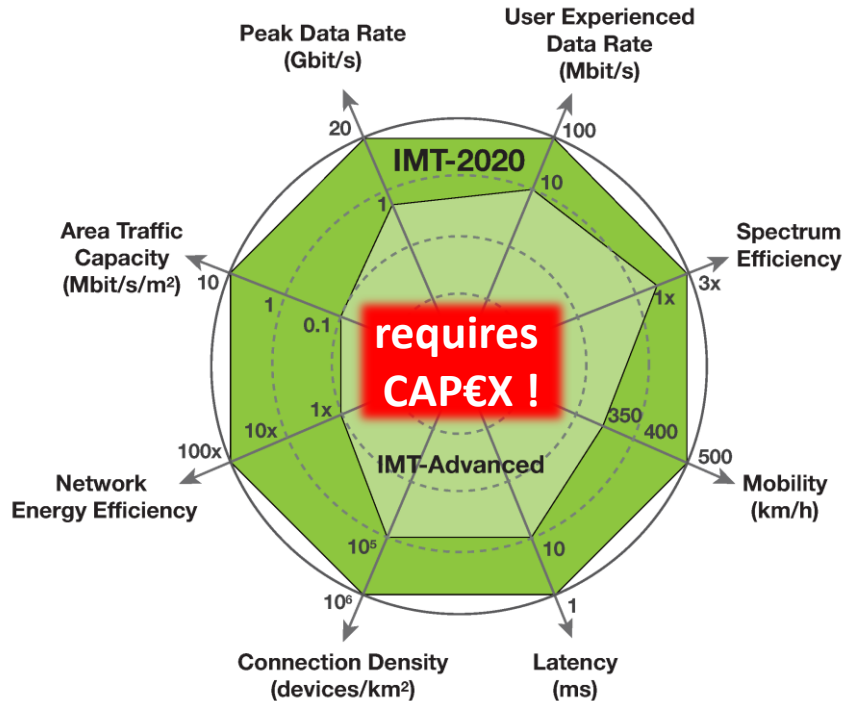
100 X in user data rate reaching a peak terminal data rate  $\geq 10 \text{ Gb/s}$

1/10 X in energy consumption compared to 2010

1/5 X in end-to-end latency<sup>4</sup> reaching 5 ms for e.g. tactile Internet and radio link latency reaching a target  $\leq 1 \text{ ms}$  for e.g. Vehicle to Vehicle communication

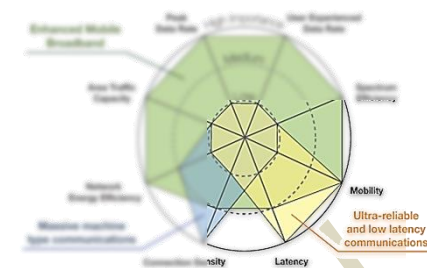
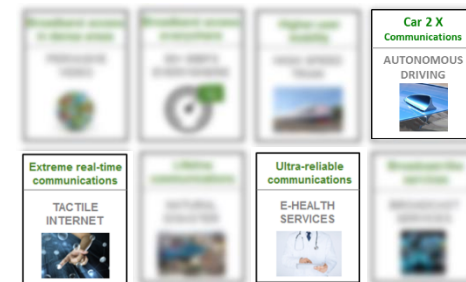
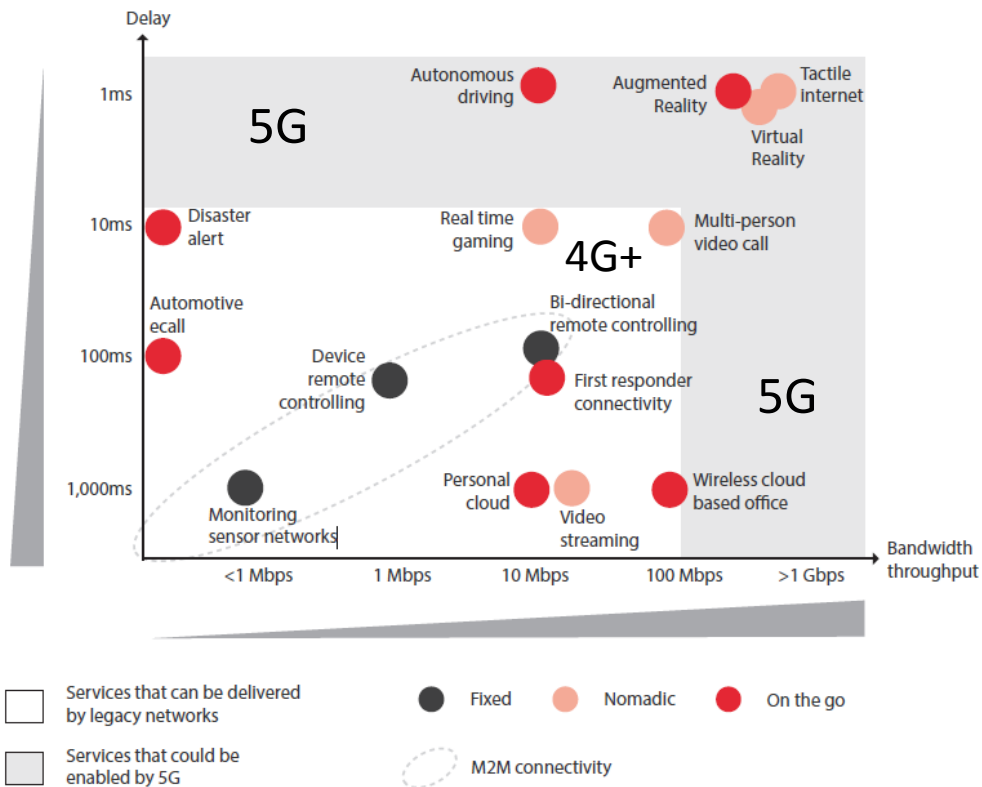
1/5 X in network management OPEX

1/1,000 X in service deployment time reaching a complete deployment in  $\leq 90 \text{ minutes}$



[Ref. ] Recommendation ITU-R M.2083-0(09/2015) IMT Vision—Framework and overall objectives of the future development of IMT for 2020 and beyond

# GSMA view: 5G is as step change, latency(+)Gbps

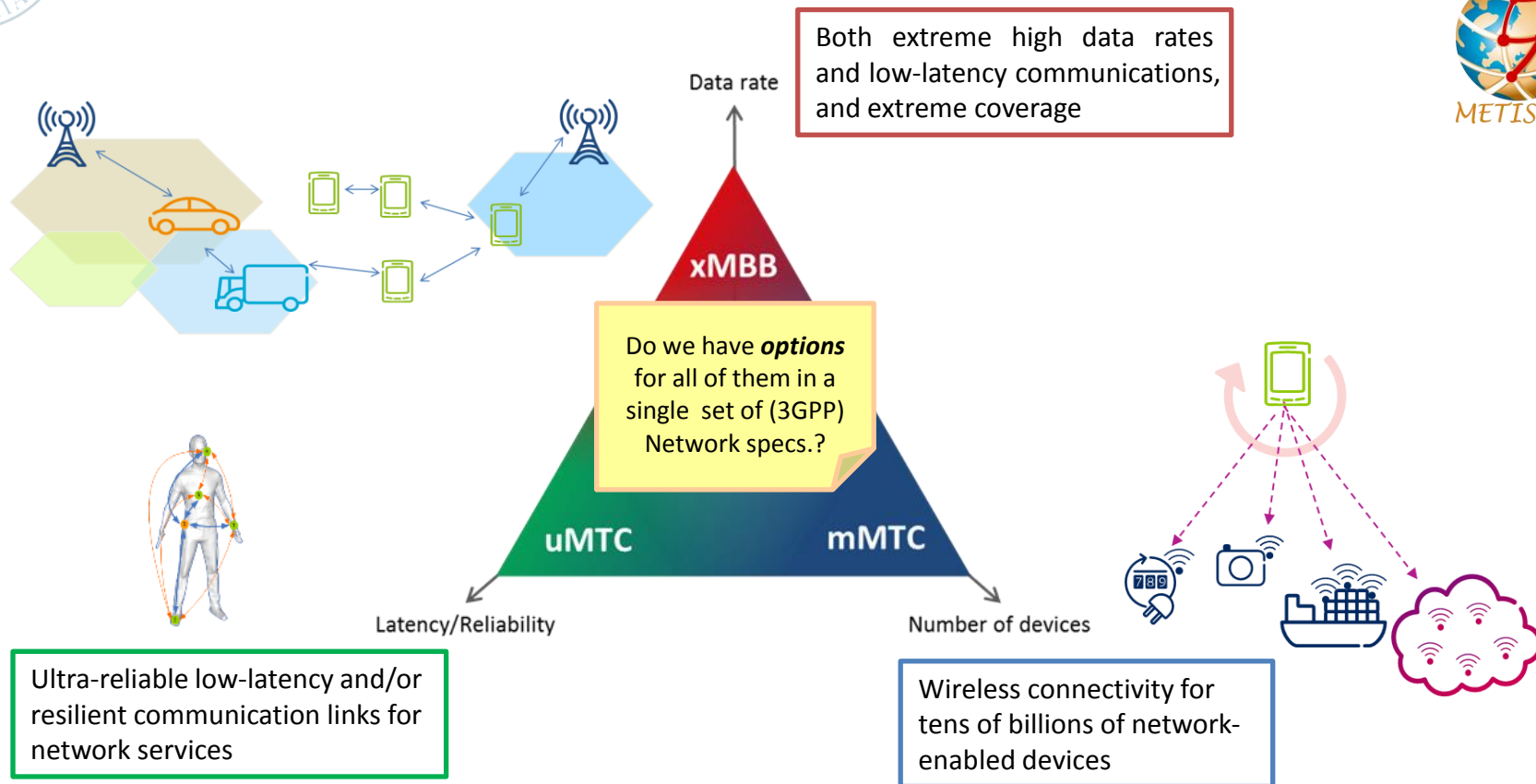


5G only

[ref.] "Understanding 5G: Perspectives on future technological advancements in mobile". GSMA intelligence ([gsmaintelligence.com](http://gsmaintelligence.com))



# 5GPPP projects view: 5G inclusive flexible network



Both extreme high data rates and low-latency communications, and extreme coverage

Data rate

xMBB

5G services

uMTC

mMTC

Latency/Reliability

Number of devices

Ultra-reliable low-latency and/or resilient communication links for network services

Wireless connectivity for tens of billions of network-enabled devices

Use Case Set

METIS-I

ITU-R

3GPP

NGMN

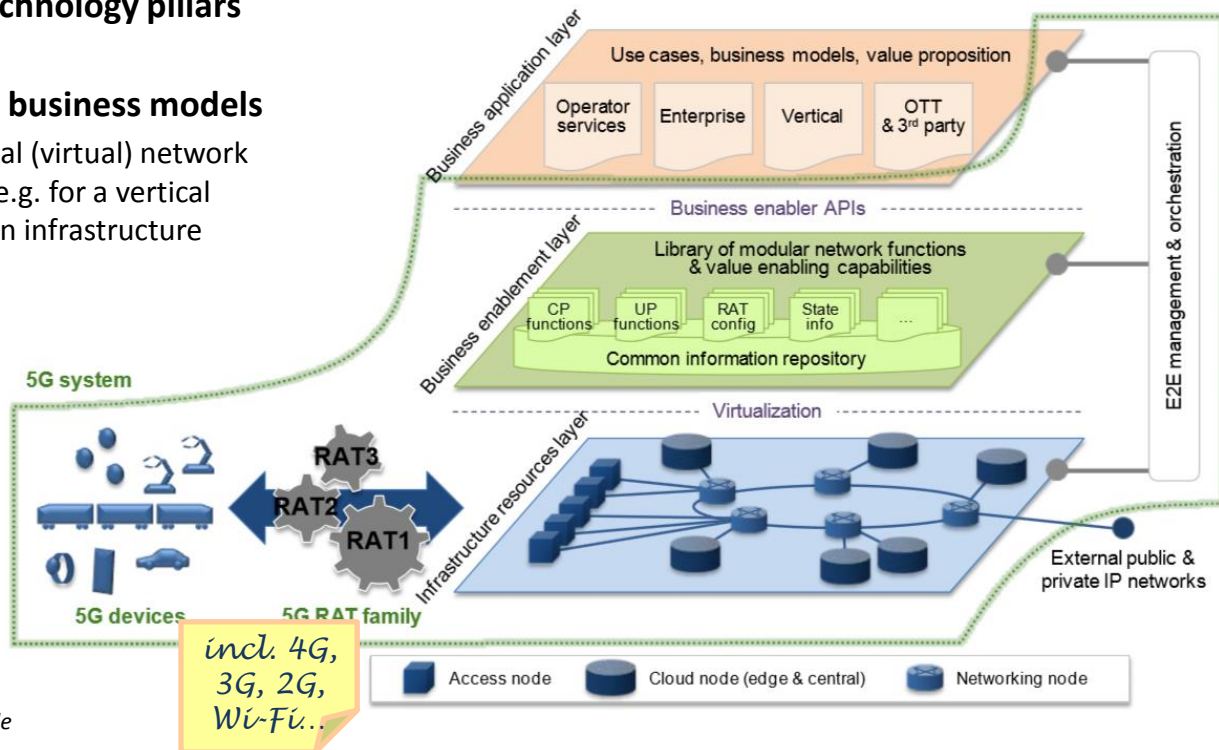
Other EU projects

## 5G Use Cases in METIS-II

Use case		Scope of Requirements (Network/User Perspective)	Scope of Services (Service Perspective)
xMBB mMTC	Dense Urban Information Society	Experienced user data rate / Traffic vol. per subscriber / Nb. of users & devices / Energy efficiency	Broad range of communication services covering needs related to both indoor and outdoor urban daily life (excl. office and factory)
xMBB	Virtual Reality Office	Experienced user data rate/Traffic volume per subscriber/Latency	Broad range of communication services in in the (indoor) office context
xMBB	Broadband Access Everywhere	Experienced user data rate / Availability / Mobility / Energy efficiency	Full coverage topic addressing outdoor/indoor communication needs especially in rural areas
mMTC	Massive Distribution of Sensors and Actuators	Availability / Number of devices / Energy efficiency	Broadest range of IoT services covered
xMBB uMTC	Connected cars	Latency / Reliability / Mobility	Strong expectation from the (automotive) industry Belong to the first uMTC services expected to be commercialized

# 5G Networks to evolve to Ultra-flexible, Sliced ...

- SDN, NFV, convergence are **key technology pillars** for the “inclusive” approach
- Network Slicing will facilitate **new business models**
  - A NW slice instance is a dedicated logical (virtual) network with customer specific functionalities (e.g. for a vertical industry company) hosted on a common infrastructure with other slices
  - Network slicing will help to optimize virtualized radio access/core network to deliver a different network experience for different kinds of traffic: Video, Autonomous driving, Internet of Things data
  - High economy of scale can be achieved

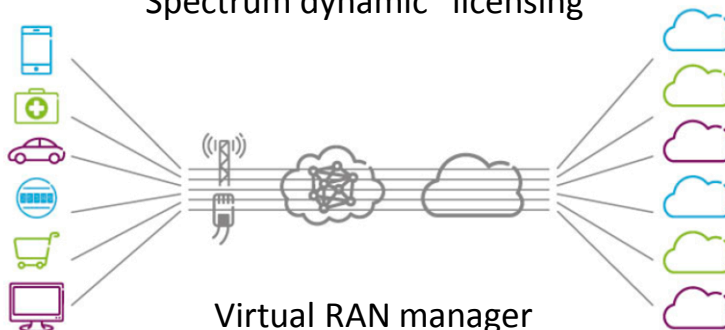


[ref.] “5G Energy Performance” White Paper, Ericsson  
 [ref.] “5G White Paper.” NGNM Alliance Public deliverable

# New business models & opportunities to explore

From an operator's perspective, this paradigm change [Cloud, SDN, VFN, Slicing,...] means facing **new business model**, since slicing opens OPPORTUNITIES for **new players** or alternative incomes for the current ones:

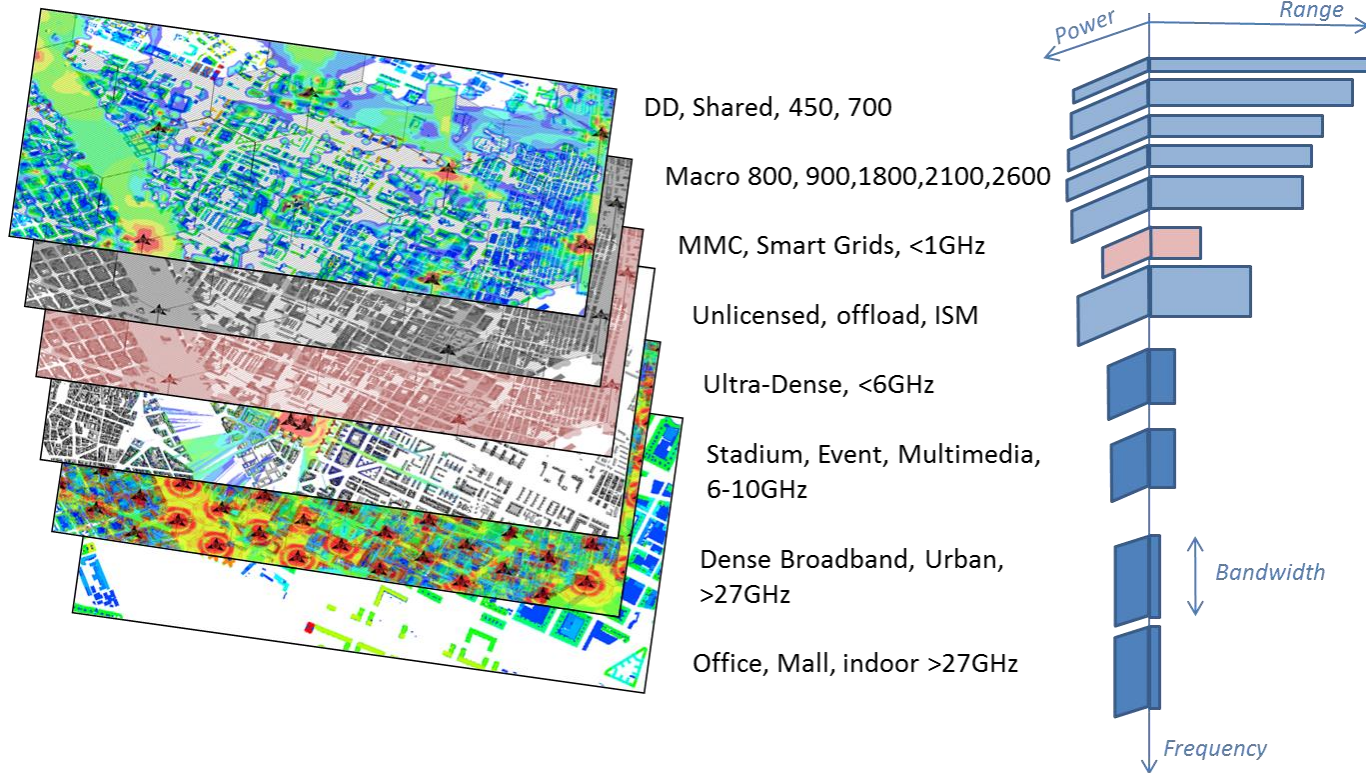
Connectivity as a service (rent-a-RAN)  
 Location or/and MM as a service ! (objects track, D2Ds mgm, ...)  
 Transport /backhaul as a service  
 Spectrum dynamic "licensing"



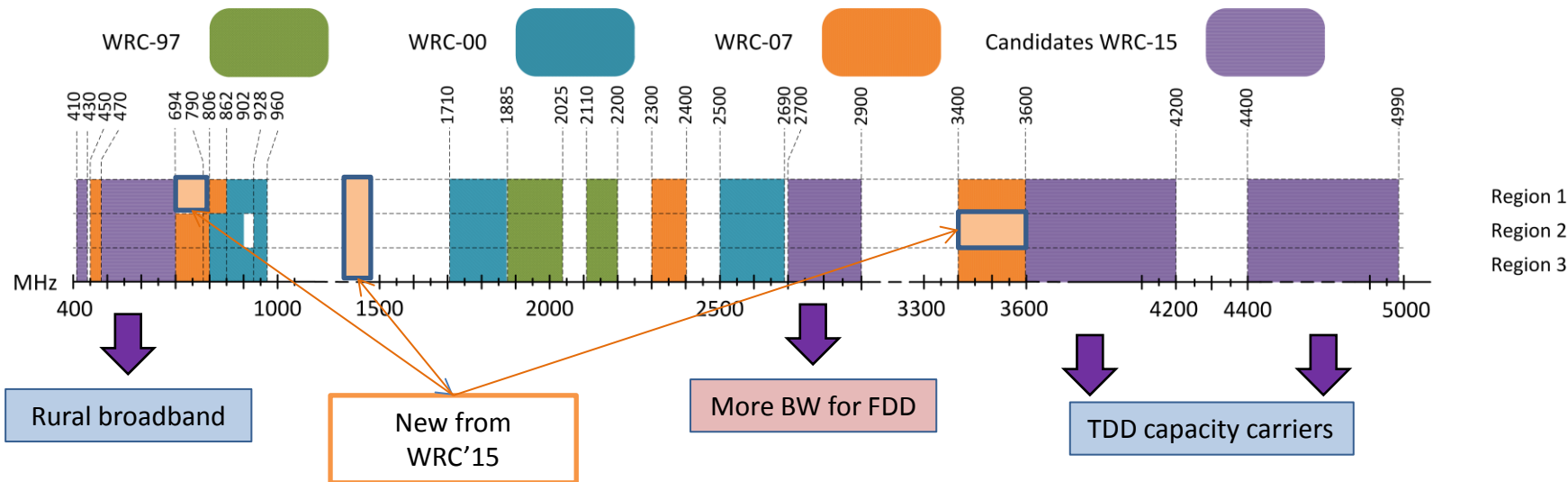
Virtual RAN manager  
 Physical RAN provider  
 Moving nodes / Moving Nets / D2D coordination  
 Soft- (virtual-) SIMs licensing and authentication

...

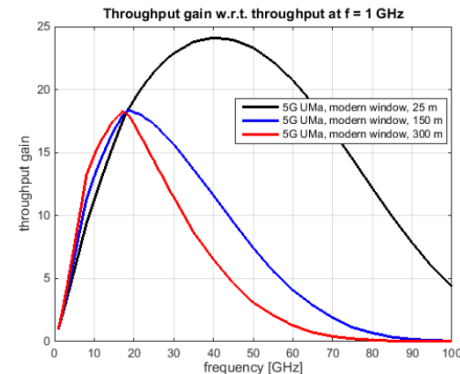
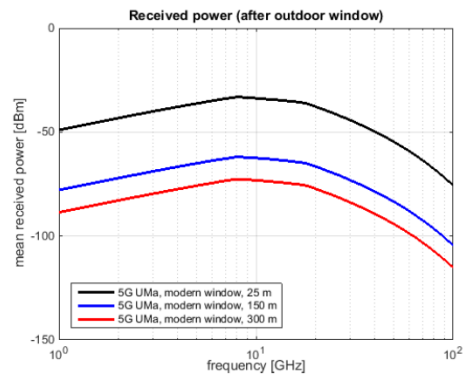
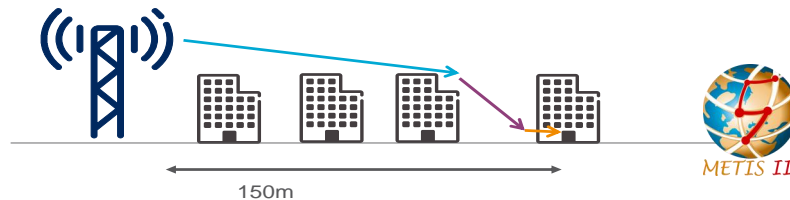
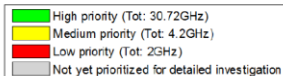
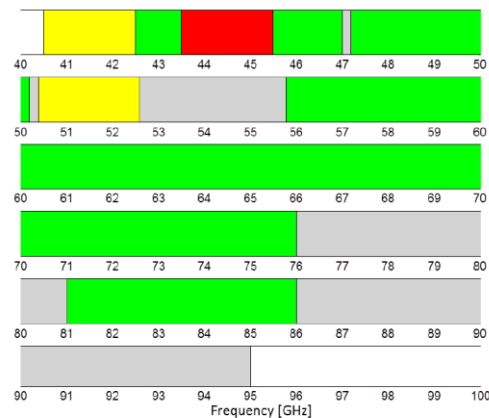
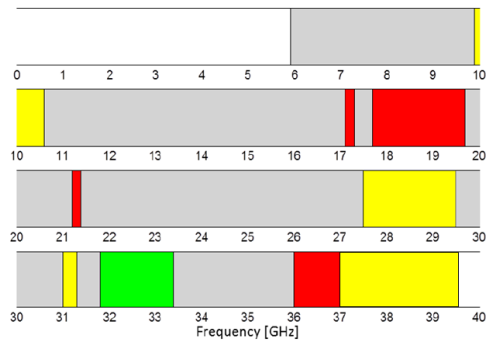
# Ultra-densification, new RATs, ...new spectrum !?



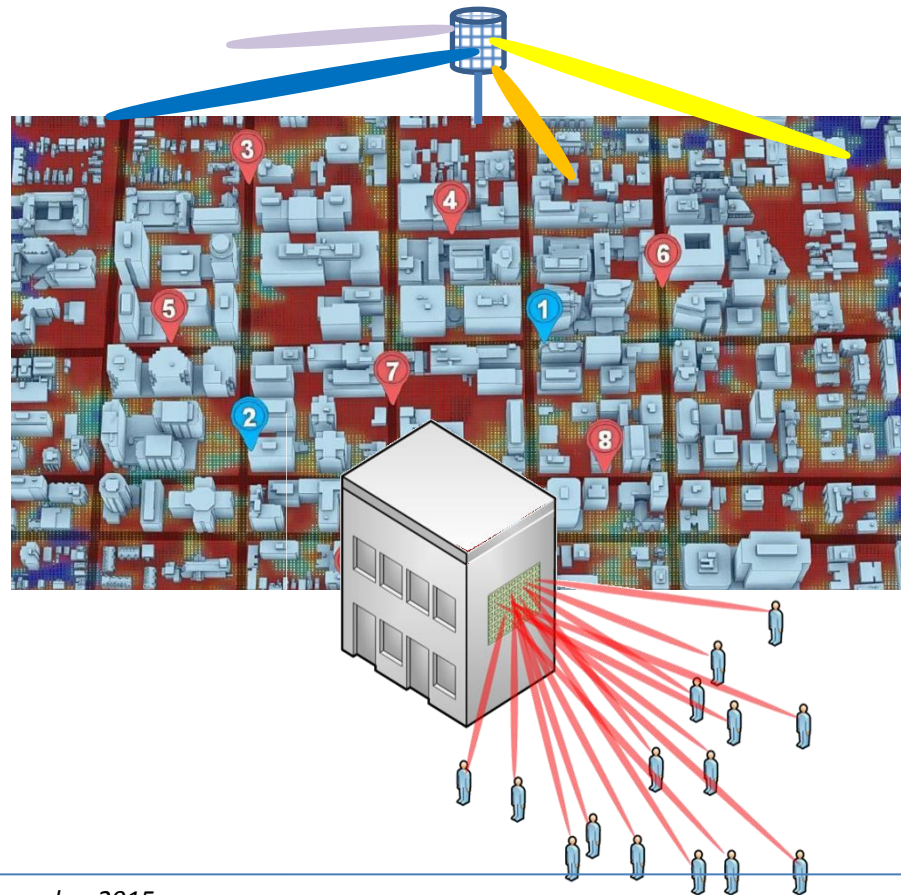
# Spectrum discussions below 6GHz...



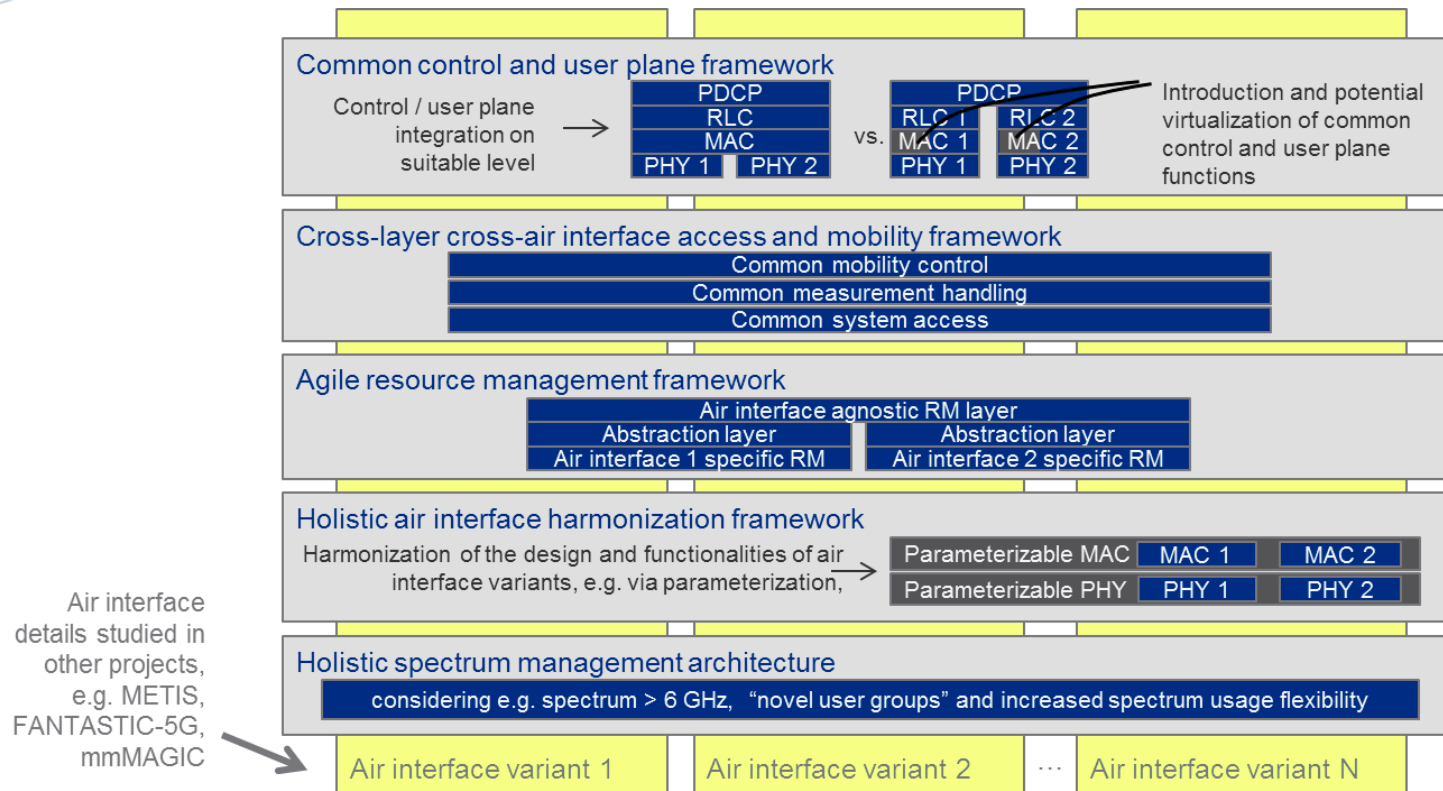


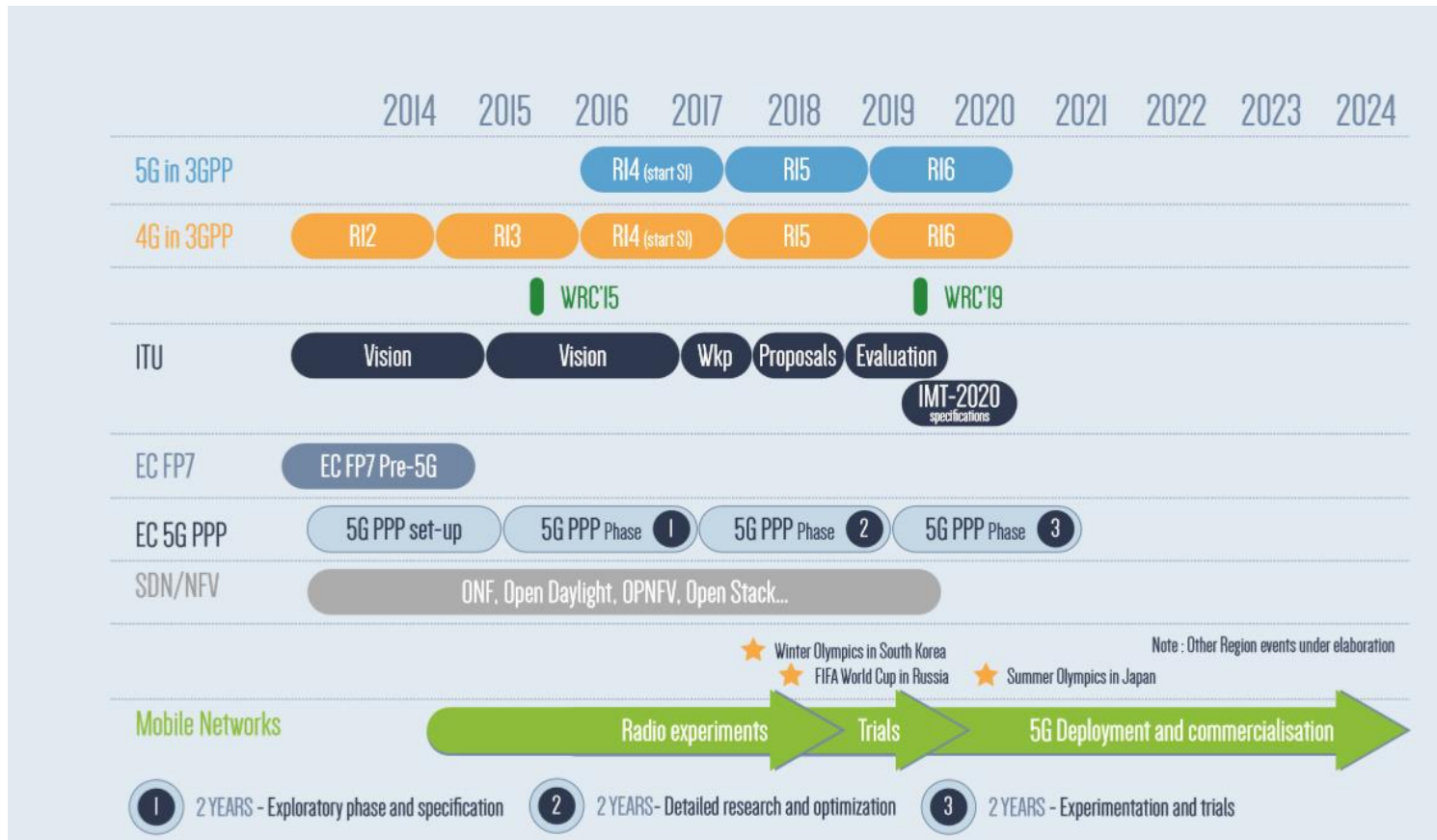


- Need of **Massive MIMO** antennas (feasible)
  - Beam track problem  $\rightarrow$  reduced speeds  $< 30$  km/h
  - ISD  $< 200$ m; Preference LoS  $\rightarrow$  high degradation for NLoS cell edge users
- *Cells* are no longer a proper concept to describe the area/service offered, no strict “boundaries”. **mmWaves “cells”** may be sets of coordinated MMIMO APs
- Wireless **Backhaul** (up to 73 GHz)
  - Nomadic nodes
  - Wireless relays
  - LoS/Near LoS conditions
  - Increased latency!



# + innovation pillars for 5G (METIS-II)





- Need of new generation of Mobile Networks to support the 2020s 'hyper-connected society', with "mobile" being crucial in people's lives.
- 5G identified by some new scenarios, not covered by 4G evolution, mainly those requiring very low latency (1ms) and very high mobile broadband (1Gbps).
- Network evolution from the legacy 3GPP RATs, on the basis of SDN, NFV and slicing, does not require a formal 5G brand, but investments on top of the ongoing deployments (4G).
- New business models will arise, from the new types of terminals, scenarios and network topologies. Operators to pursue 5G as an opportunity to develop a more sustainable investment model.
- Additional spectrum will be necessary, below and above 6GHz, but it is still unclear if mm-waves can serve mobile links under the 5G actual requirements of latency, mobility and energy efficiency.

Look beyond RAN, beyond cells, ...



...and 5G





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