

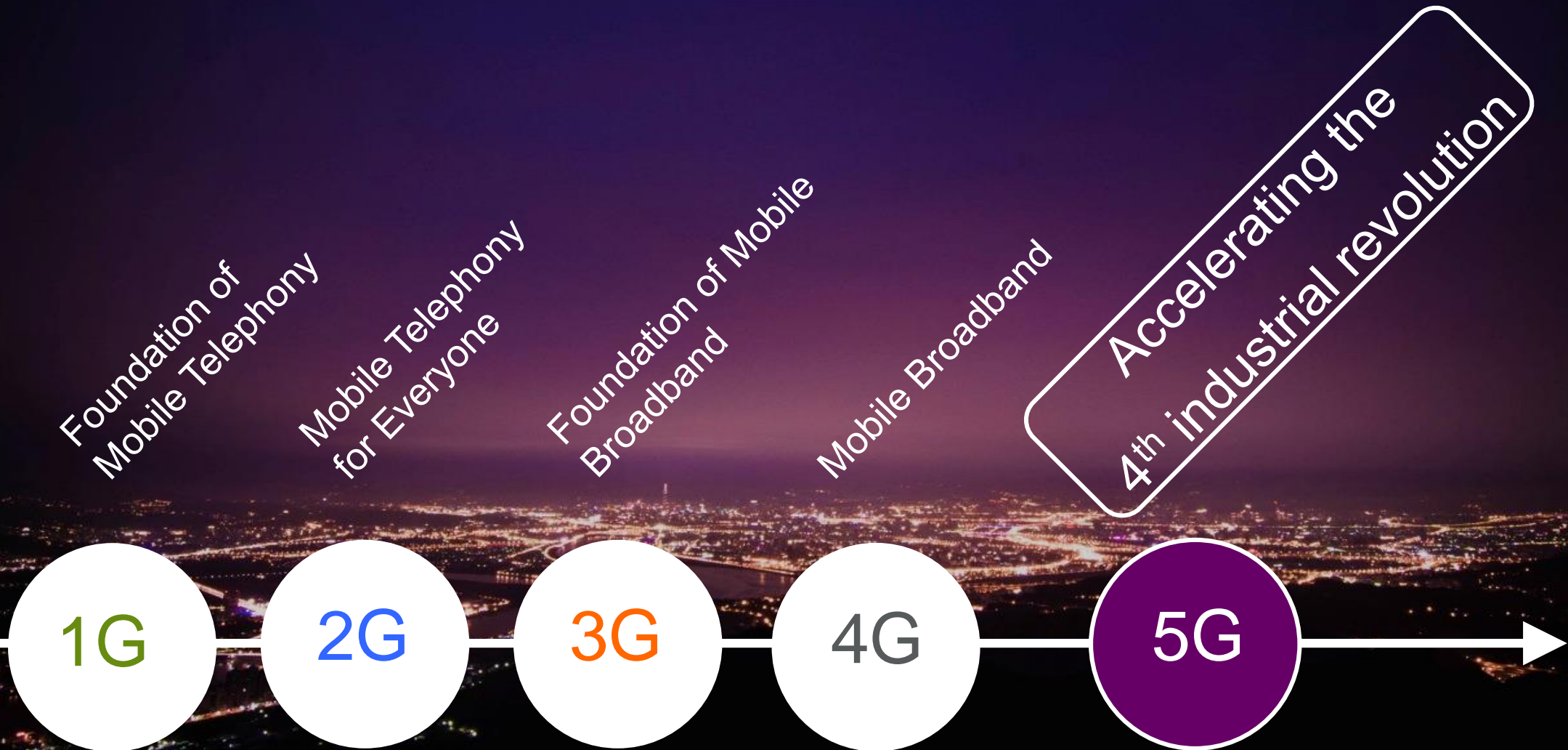


5G

READY FOR INDUSTRY CONVERGENCE

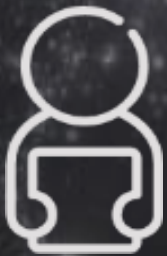
Kyoungin Kwon
Head of NEP, CTO, Ericsson-LG

MOBILE SYSTEM GENERATIONS

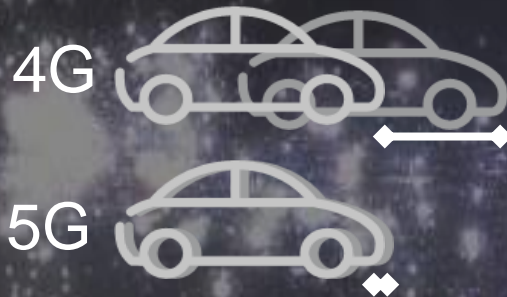


5G

ONE NETWORK FOR MILLIONS OF THINGS



Full-length HD
movie in seconds



Smart Vehicles &
Autonomous Cars



Fixed wireless
broadband



Drone Control &
Communication



Virtual Reality /
Augmented Reality



10 Year Battery Life
for Remote Sensors



Remotely
Operate Robots

Latency . Capacity . Mobility

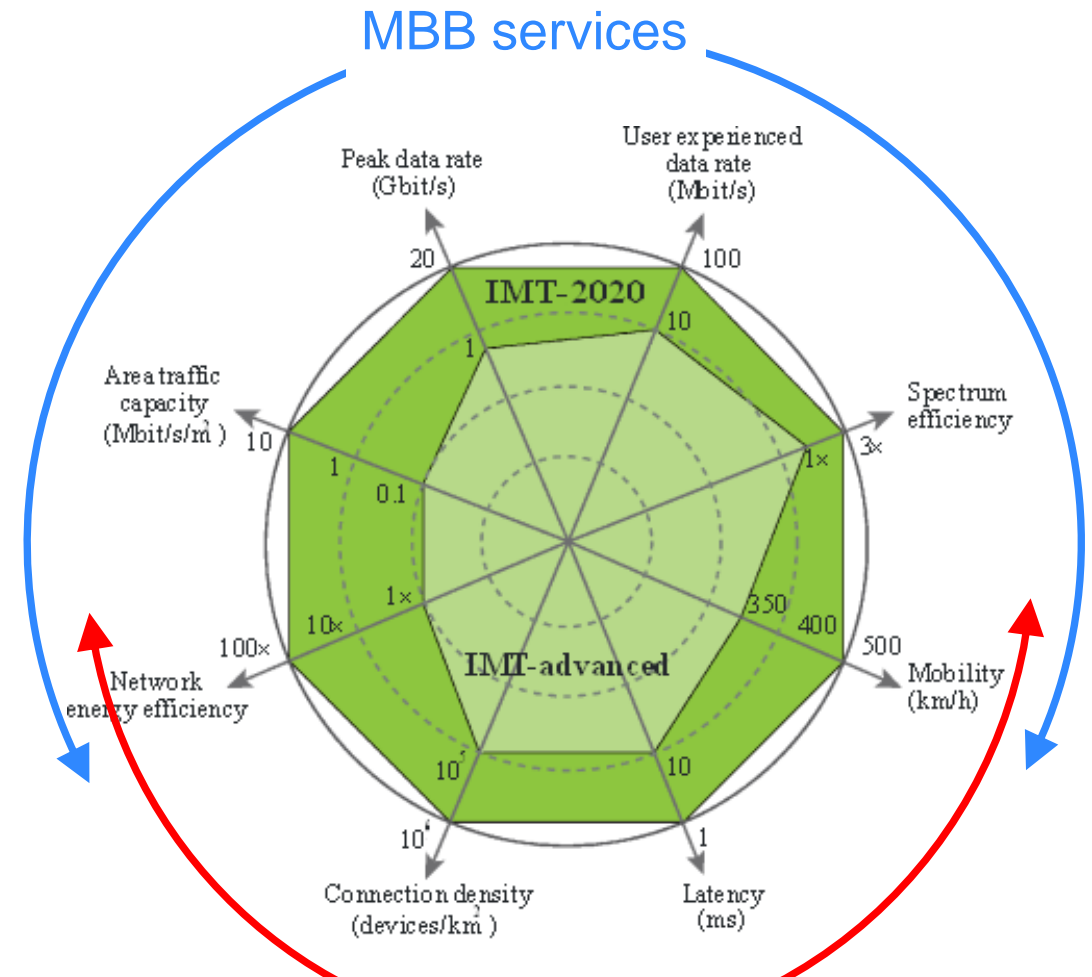
WHAT DOES 5G BRING?

› Enhancing current MBB services

- Massive capacity, very high end-user data rates, low latency, improved energy performance, ...

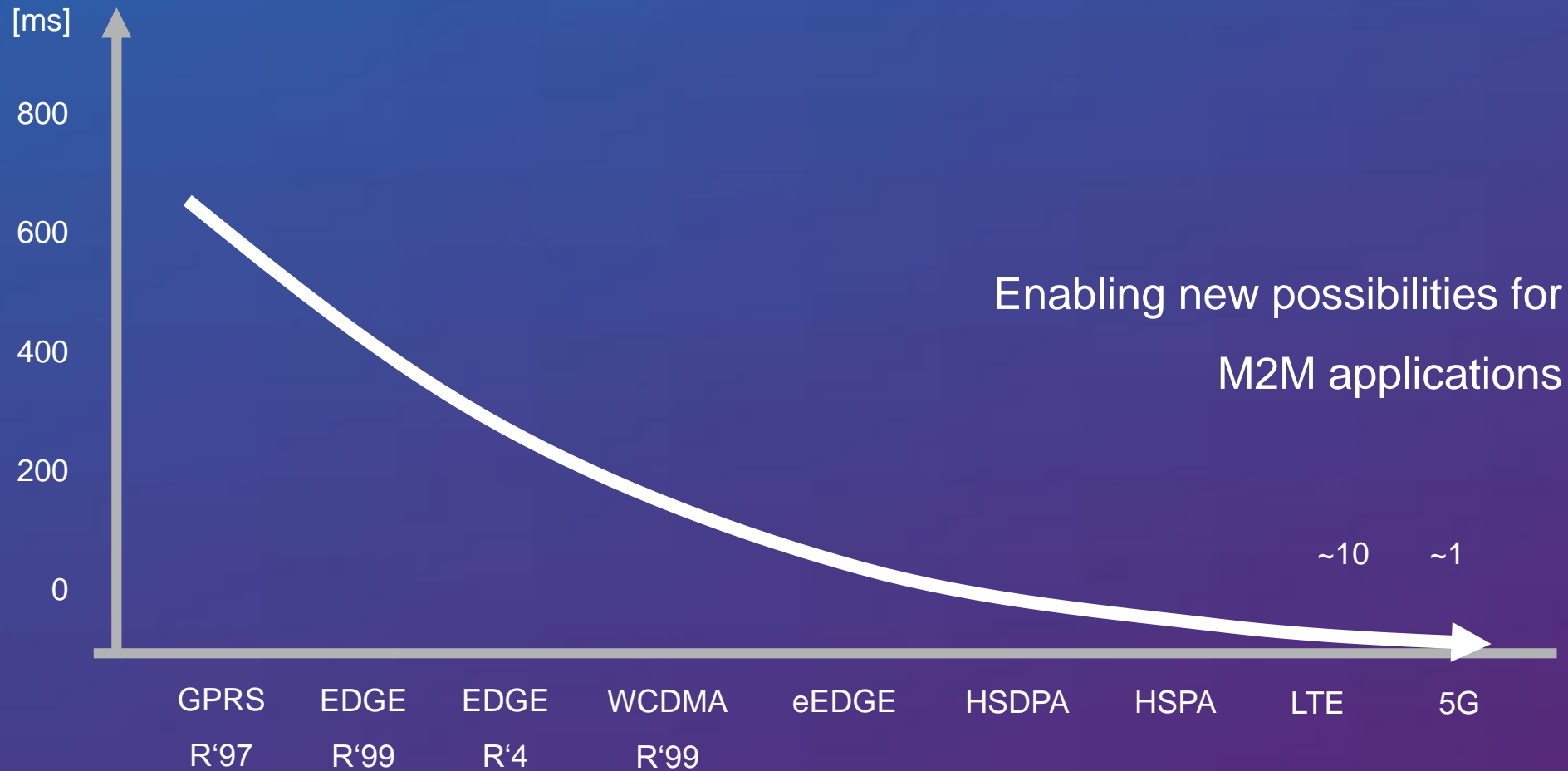
› New use cases – “Machine-Type Communication”

- Massive MTC, Mission-critical MTC, ...



Massive MTC, Mission-Critical MTC

LATENCY REDUCTIONS



5G - ENABLING INDUSTRY TRANSFORMATION AND NEW BUSINESS



MASSIVE MTC

SMART BUILDING | **LOGISTICS, TRACKING AND FLEET MANAGEMENT**

SMART METER | **SMART AGRICULTURE** | **CAPILLARY NETWORKS**

CRITICAL MTC

TRAFFIC SAFETY & CONTROL

INDUSTRIAL APPLICATION & CONTROL

REMOTE MANUFACTURING, TRAINING, SURGERY

LOW COST, LOW ENERGY
SMALL DATA VOLUMES
MASSIVE NUMBERS

ENHANCED BROADBAND

Smartphones | **Home, Enterprise, Venues, Mobile/Wireless/Fixed**

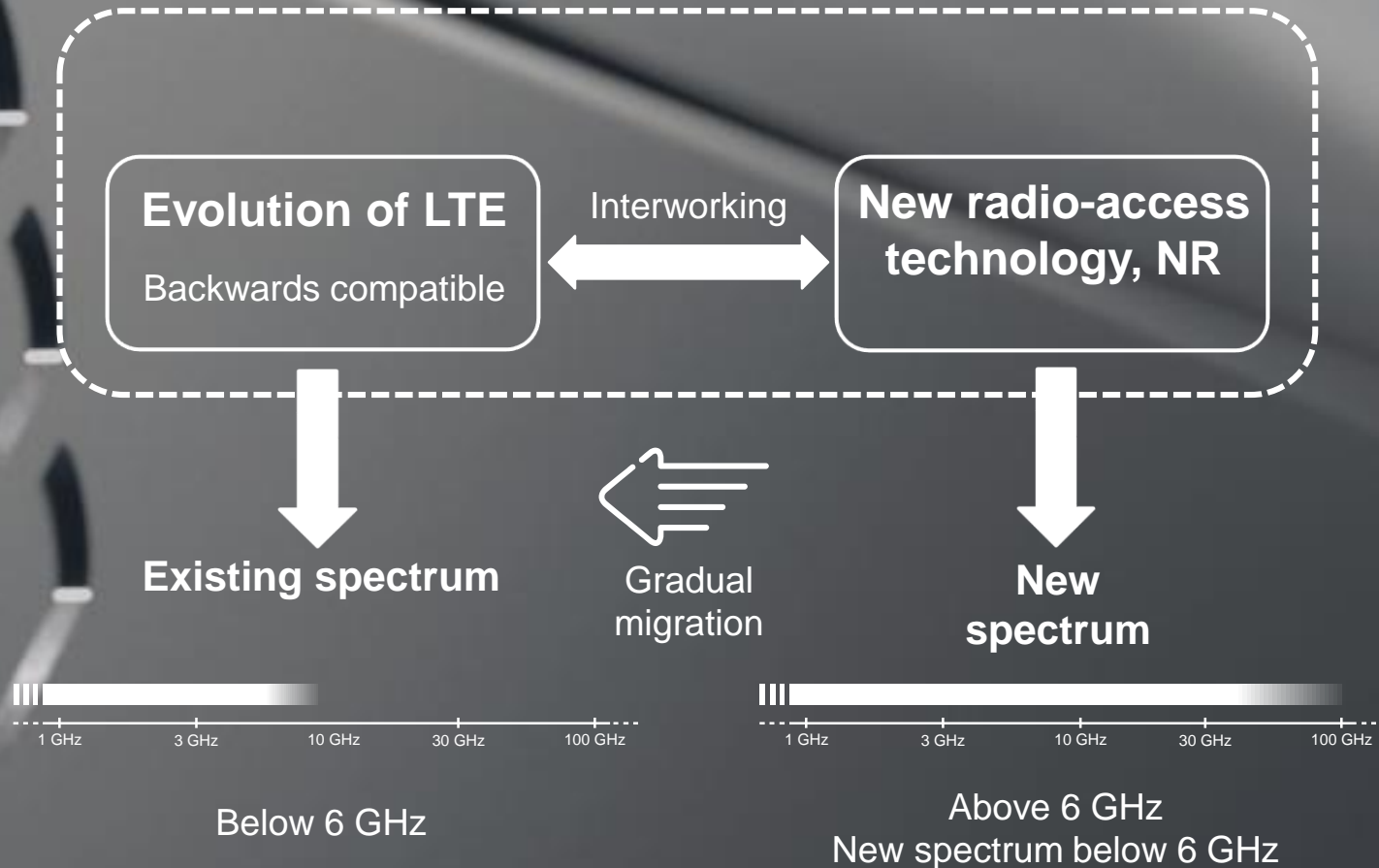
SIM less devices | **4k/8k UHD, Broadcasting, VR/AR,**

ULTRA RELIABLE
VERY LOW LATENCY
VERY HIGH AVAILABILITY

5G RADIO ACCESS TECHNOLOGIES



Overall 5G solution

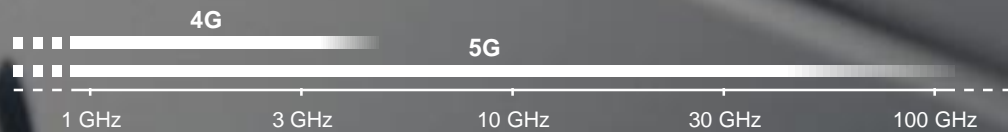


- > 5G radio access consists of LTE evolution and NR
 - Evolved mobile broadband and new use cases such as massive-MTC and critical-MTC
 - Fulfill all 5G requirements, commercial and ITU

NR – KEY TECHNOLOGY FEATURES

MANY ALSO APPLY TO LTE EVOLUTION

Extension to higher frequencies and wider band widths



Ultra-lean design

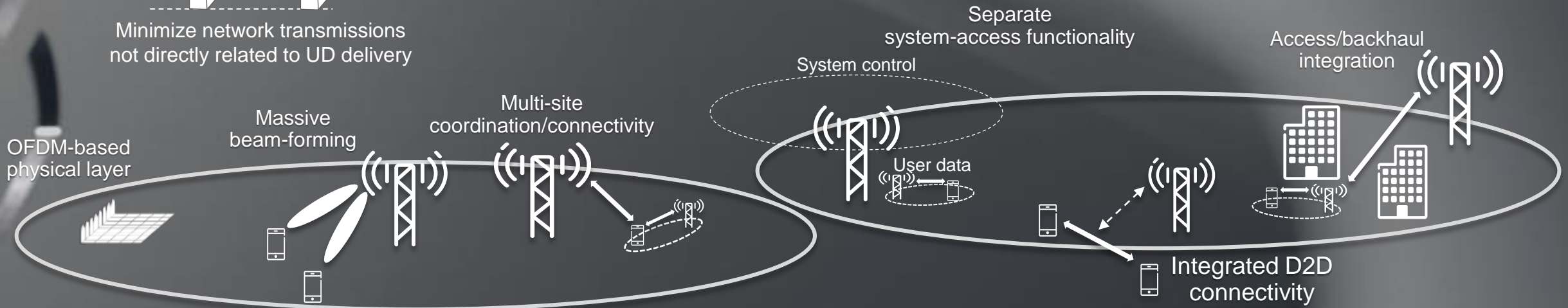


Minimize network transmissions not directly related to UD delivery

Flexible and scalable Layer 1 design



- OFDM with flexible numerology
- Multiplexing of wideband and narrowband devices on the same radio resource
- Filtering and shaping by digital processing
- Support for various spectrum allocation schemes



3GPP 5G TIME PLAN



IMT-2020

ITU

Requirements

Proposals

Specifications

SI: Channel mod.

SI: Requirements

NR SIs Phase 2

NR WIs Phase 2

NR Study Item

NR WI Phase 1

LTE evo

Rel-14

LTE evo

Rel-15

LTE evo

Rel-16

2015

2016

2017

2018

2019

2020



Full IMT-2020

NR PHASE 1 WORK ITEM

APPROVED IN [RP-170847](#)



- › Targeting eMBB and URLLC
 - Requirements in TR38.913
- › Frequency ranges up to 52.6 GHz
 - 3.5GHz, 28GHz,
 - 39GHz (US), 4.4GHz (Asia)
- › Standalone
 - LTE-NR Dual Connectivity
 - NR-NR Carrier Aggregation
- › (dynamic) TDD & FDD
 - full/flexible duplex
- › NR/LTE co-channel coexistence
 - DL & UL
- › OFDM waveform
- › Mini-slots
- › Multi-antenna
- › 3-state state machine
- › Higher layer CU/DU split
- › Network slicing

NR PHASE 2

APPROVED STUDY ITEMS

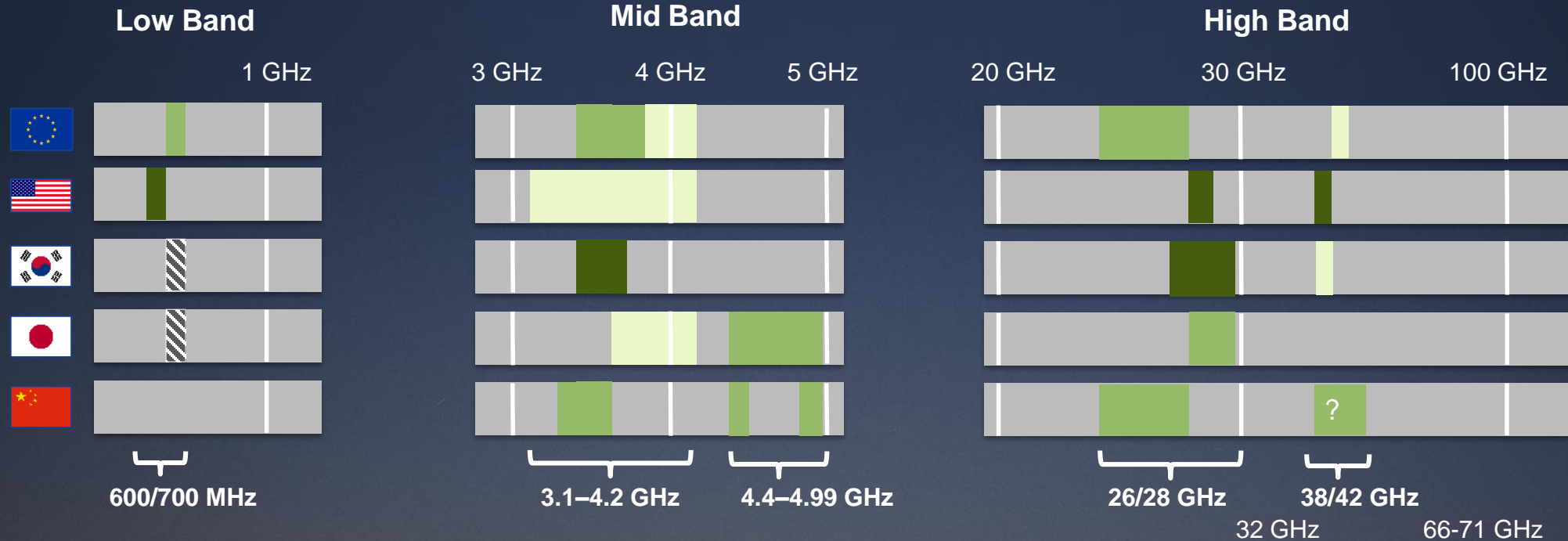
To start in Q3:

- › Unlicensed spectrum ([RP-170828](#))
 - Standalone and licensed-assisted
 - 5GHz, 3.5GHz, 60GHz
- › Multiple access ([RP-170829](#))
 - Study NOMA more in detail
- › Lower Layer CU/DU Split
 - ([RP-170818](#))
 - › Identify functionalities and create evaluation
- › Non-Terrestrial Networks
 - ([RP-170717](#))
 - › Satellite link channel modeling
 - › Deployment scenario
 - › NR impact

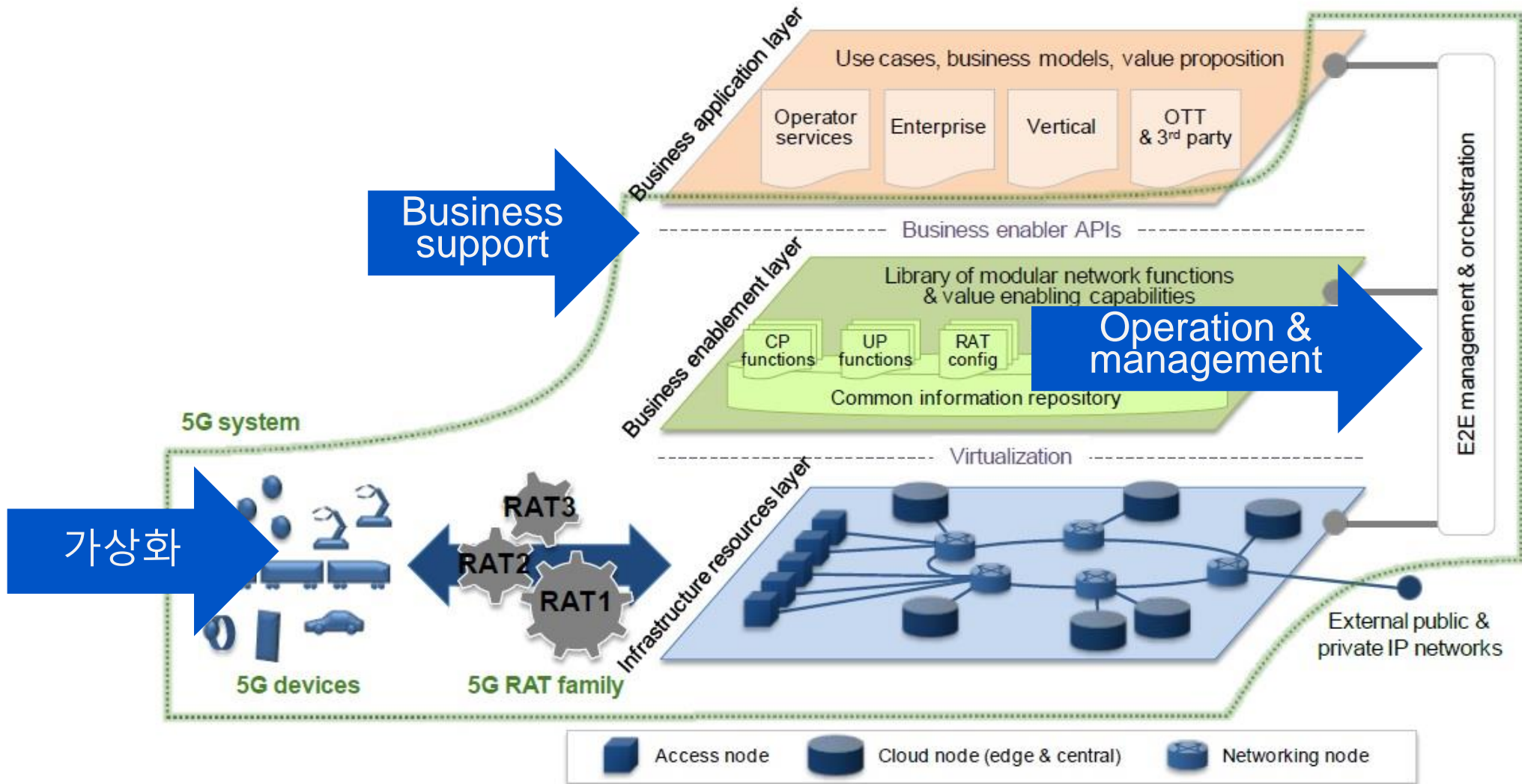
To start in Q4:

- › eV2V evaluation ([RP-170837](#))
 - Sidelink channel modeling for >60GHz
- › Integrated Access Backhaul
 - ([RP-170831](#))
 - › Efficient and flexible operation for both in-band and out-band relaying in indoor and outdoor scenarios
 - › Multi-hop and redundant connectivity
 - › End-to-end route selection and optimization
 - › Support of backhaul links with high spectral efficiency
 - › Support of legacy NR UEs

MOMENTUM FOR 5G SPECTRUM CONVERGENCE

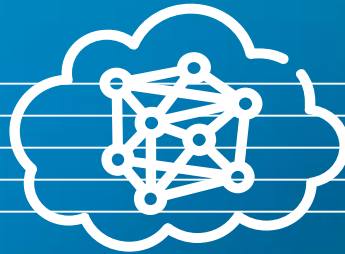


5G NETWORK EVOLUTION



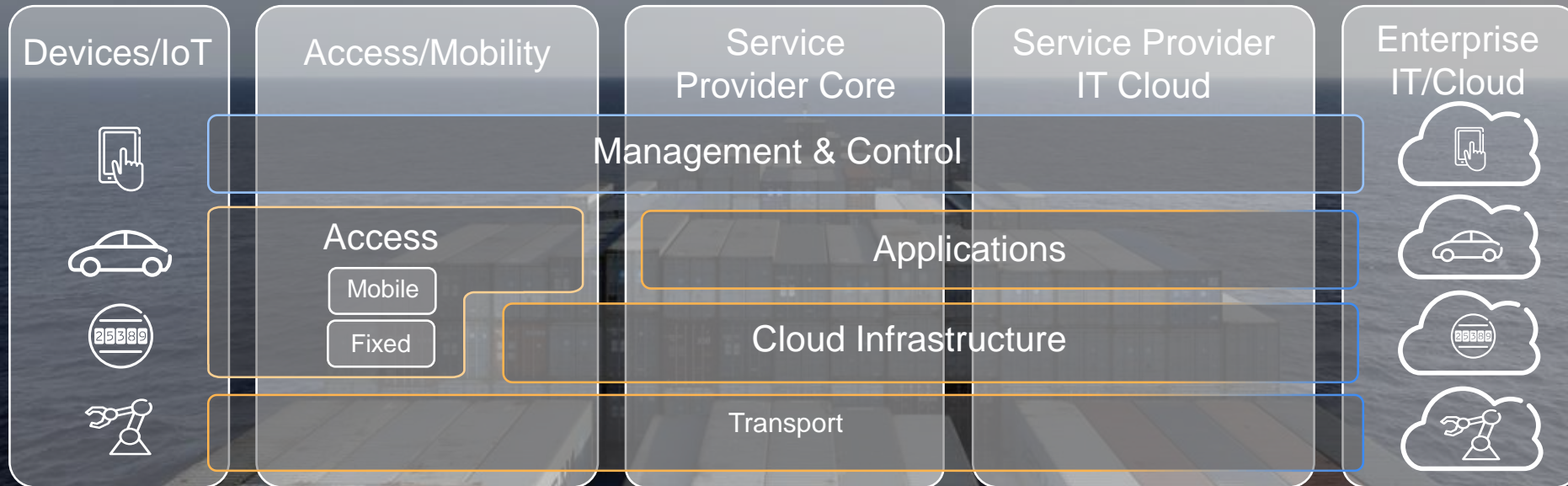
Source : NGMN 5G white paper, 2015

ONE NETWORK – NETWORK SLICING



A common network platform with
dynamic and secure Network Slices

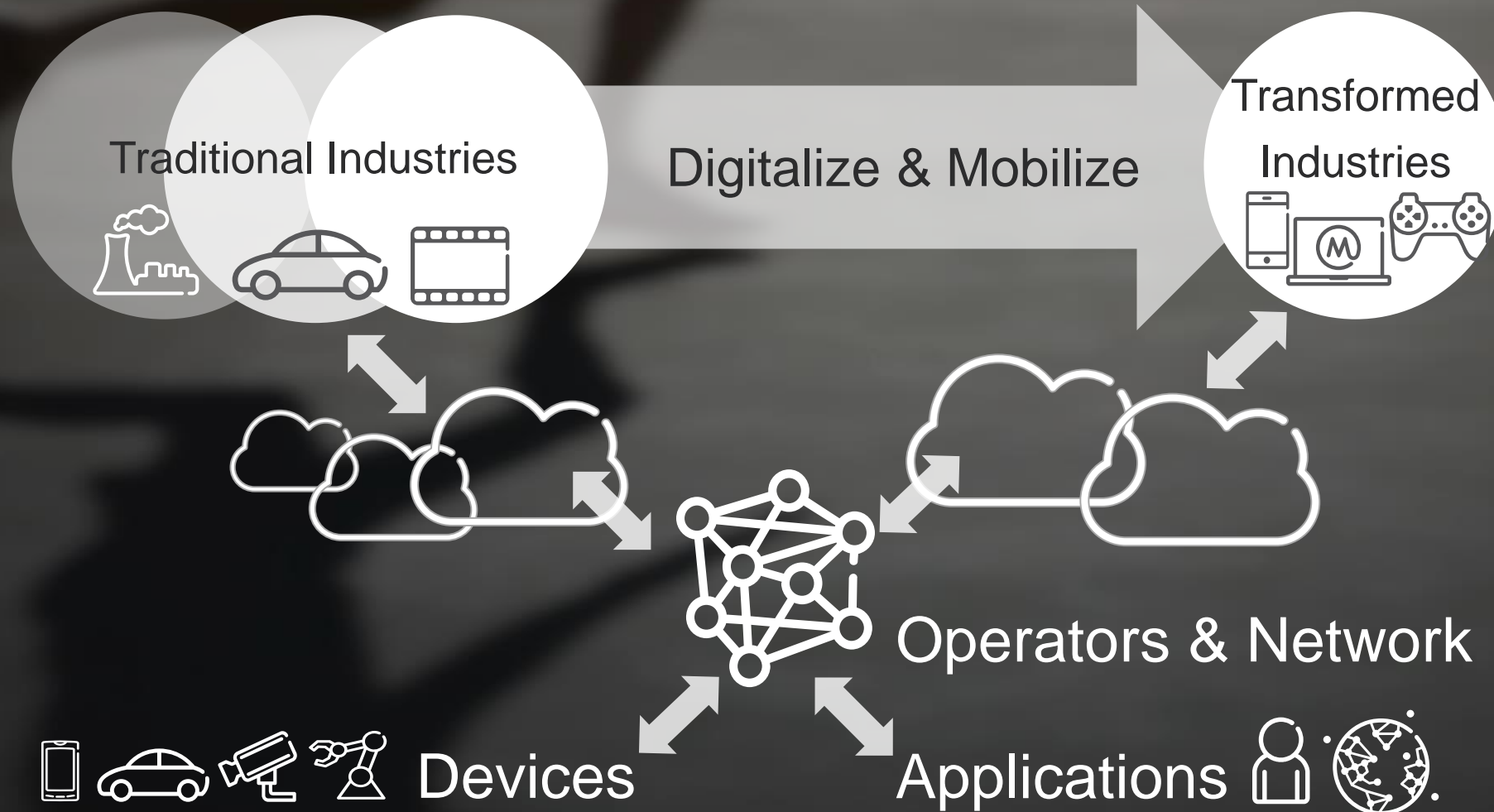
5G, ONE ARCHITECTURE MULTIPLE INDUSTRIES



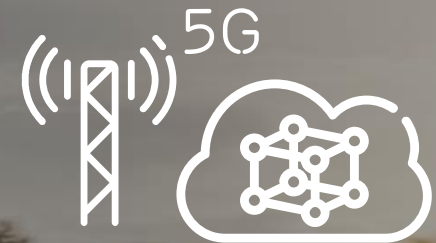
Business support

Virtualization with SDN/NFV/Cloud

INDUSTRY TRANSFORMATION



SECURE THE BEST CONNECTED CAR CUSTOMER EXPERIENCE



- EXPONENTIAL GROWTH IN VEHICLE CONNECTIVITY
- SOFTWARE DEFINED VEHICLES ARE HERE

- NEW CONNECTED SERVICES REVENUES
- SOFTWARE RELATED RECALLS INCREASING

- ADAS, AUTONOMOUS V2V, V2X AND C-ITS
- SOFTWARE DEFINED NETWORKS



MOBILE COMMUNICATION IN C-ITS



2G (EDGE)

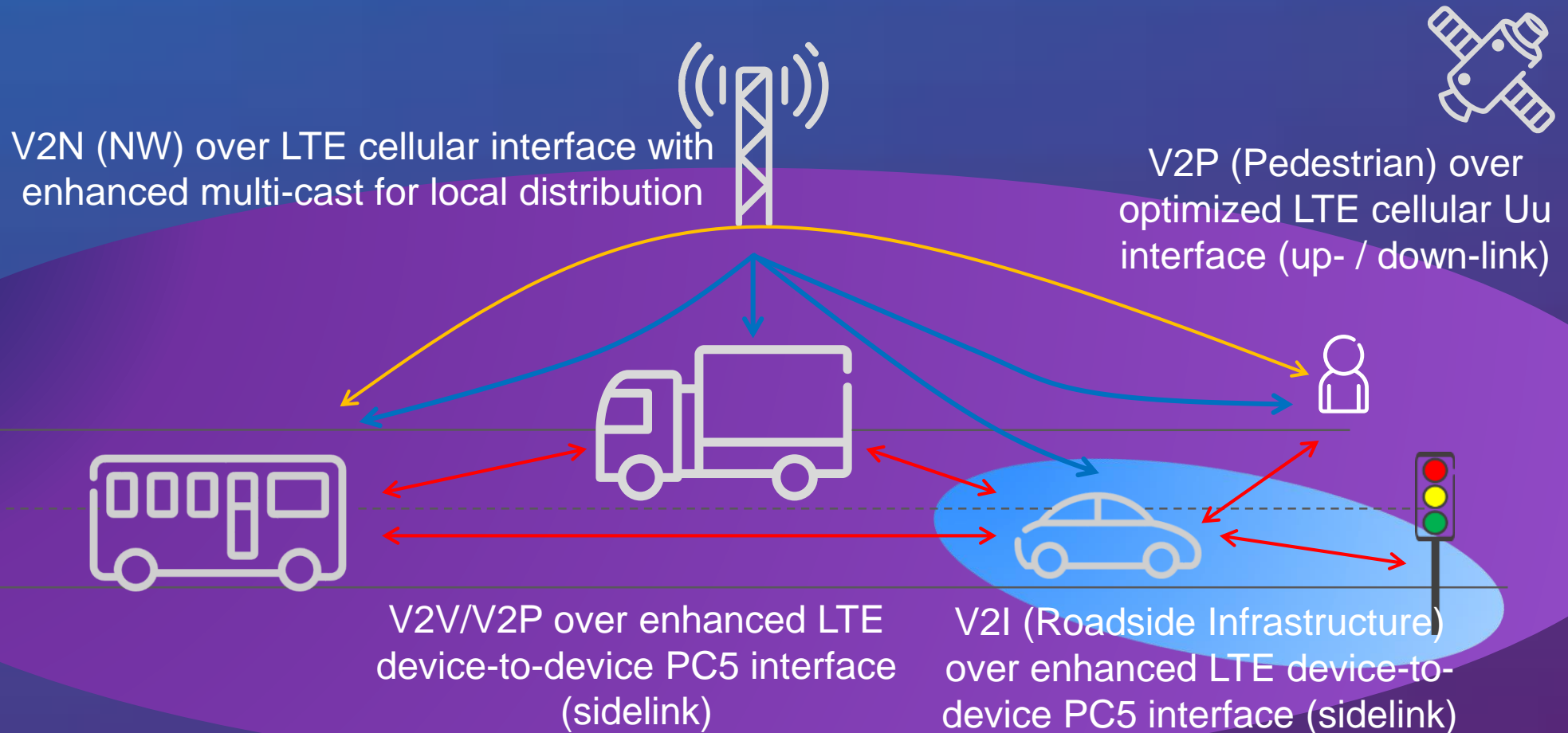
Ad-hoc radio (ITS-G5, DSRC, etc)

3G (HSPA, WCDMA)

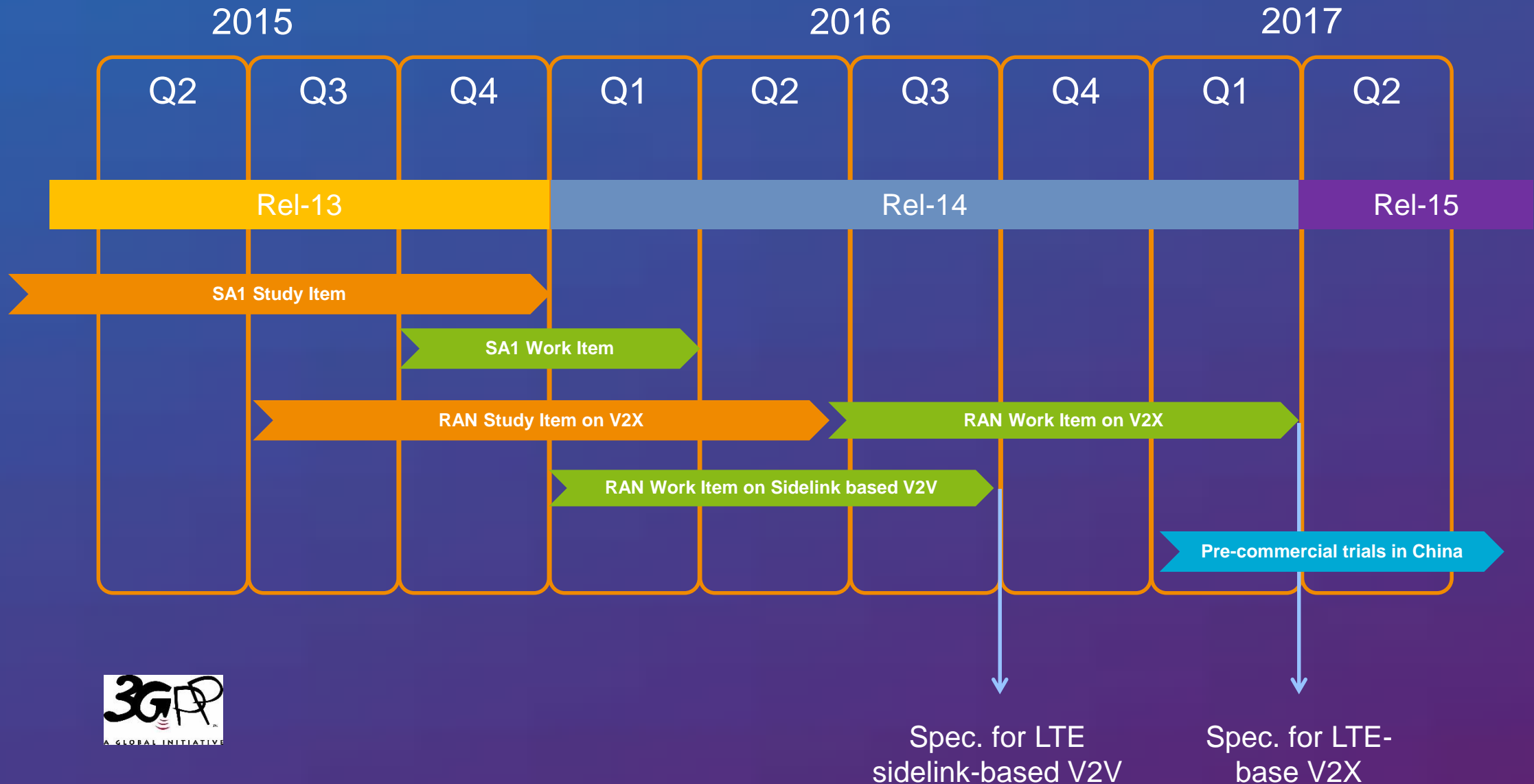
4G (LTE)

5G

LTE-V2X OVERVIEW



3GPP LTE-V2X TIMELINE



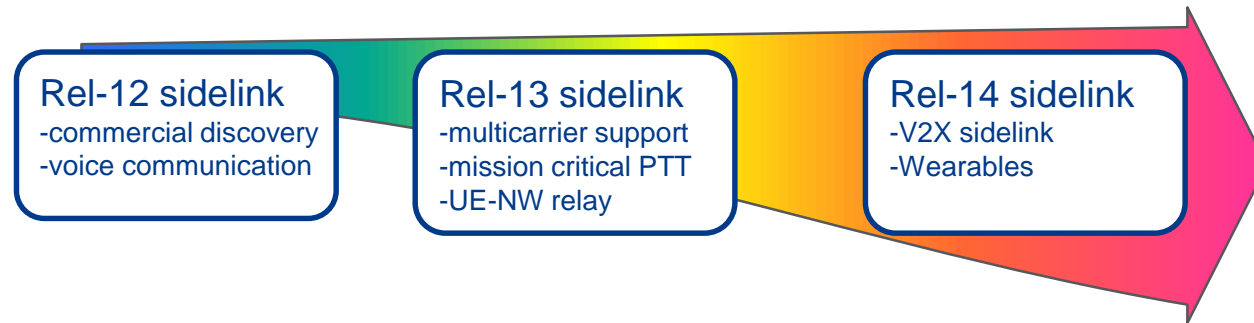
3GPP LTE-V2X

> LTE-based V2X

- LTE transport for V2X services considering
 - > WAN based communication (Uplink / Downlink) → *Uu Interface*
 - > Device-to-Device (D2D) direct communication (**Sidelink**) → *PC5 Interface*
- ITS services and associated message sets are defined outside of 3GPP



LTE-V2X SIDELINK

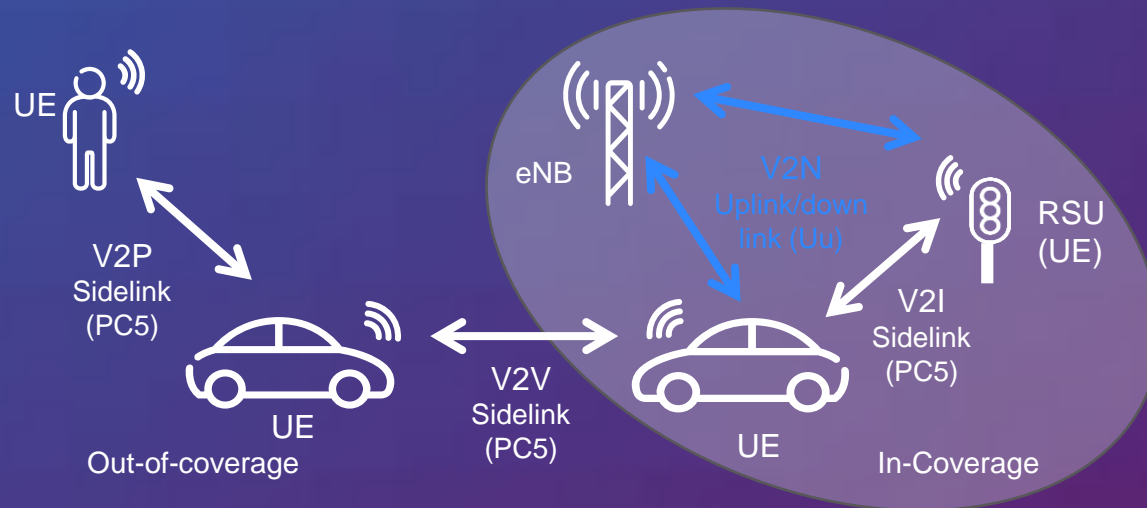


- > Sidelink introduced in LTE Rel-12 and enhanced in Rel-13
 - In/out of coverage operation
 - Targeting public safety and commercial discovery
- > Sidelink enhancements for V2X in Rel-14
 - PHY and RRM enhancements targeting improved system capacity, higher Doppler, lower latency

LTE V2X SIDELINK ENHANCEMENTS

› Operating conditions:

- High UE density (2500+ vehicles/km²)
- Relative Speeds up to 250+250 km/h
- In and out of network coverage
- Operating frequency up to 6 GHz



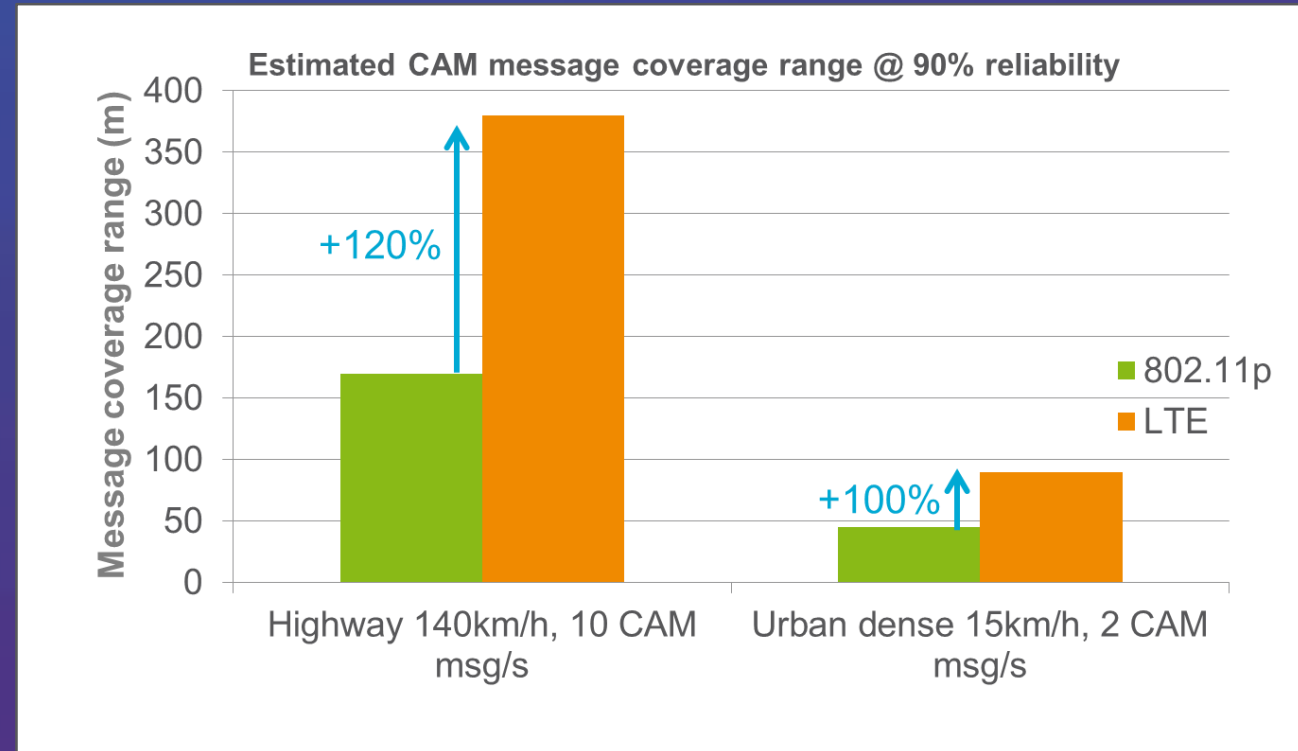
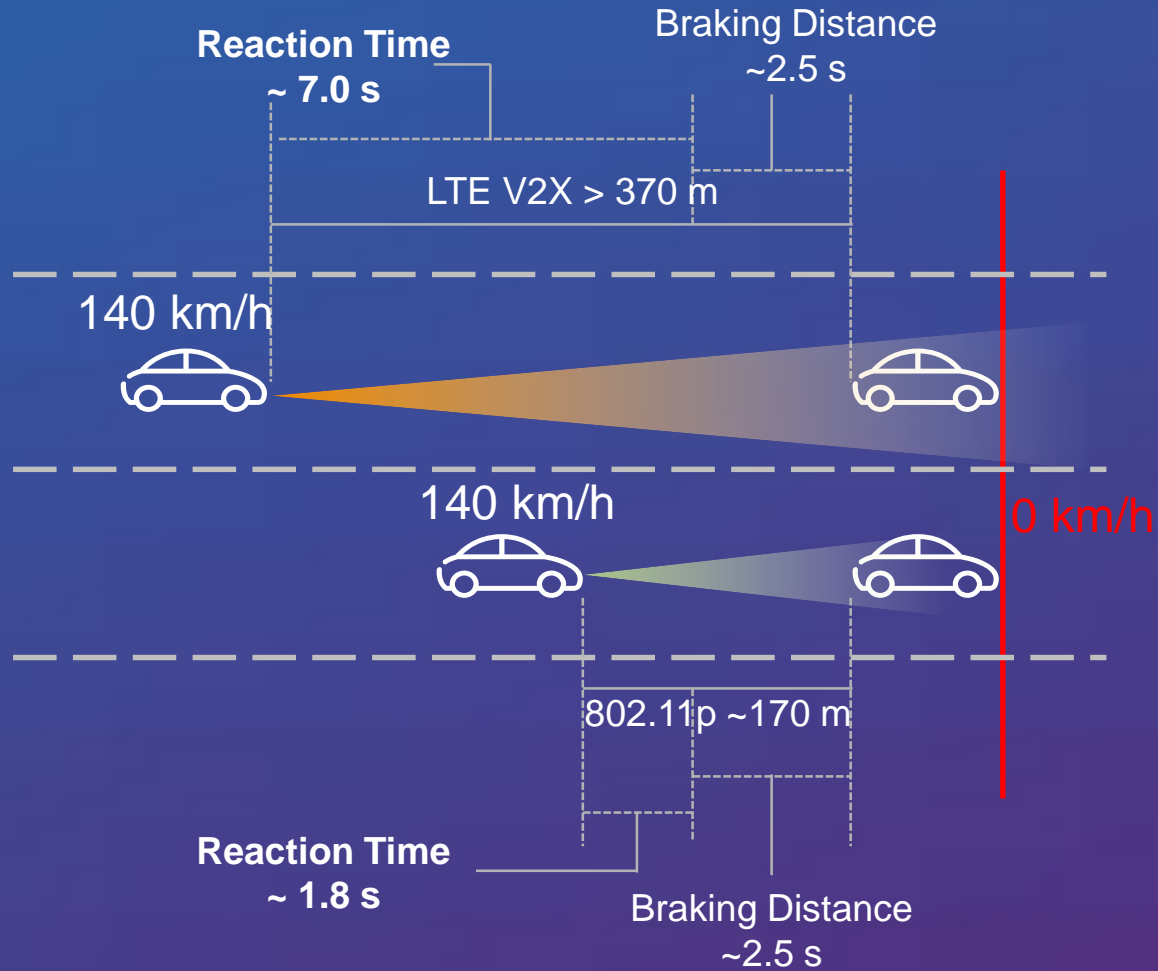
› Physical layer

- New Demodulation and Reference Signal (DMRS)
- Improved synchronization for out of coverage operation

› Radio resource allocation based on time and frequency division multiplexing

- Distributed autonomous resource allocation in and outside network coverage
- Centralized resource allocation
- Semi-Persistent Scheduling (SPS) for periodic messages

V2V PERFORMANCE LTE-V2X SIDELINK VS. IEEE 802.11P



*R. Blasco, H. Do, S. Shalmashi, S. Sorrentino, Y. Zang, "3GPP LTE Enhancements for V2V and Comparison to IEEE 802.11p", EU ITS Congress 2016

COMPARISON OF DSRC/ETSI ITS-G5 AND LTE-V2X



DSRC / ETSI ITS-G5

- Radio technology from 1999 (IEEE 802.11a)
- Flat architecture for short range comm.
- No direct V2N support
- Full protocol stack
- Mature technology but no future evolution

Hybrid Comm. Solution

- DSRC for short range / Cellular for WAN
- Over the top solution for cellular system
- Suboptimal performance

LTE-V2X

- Based on LTE radio technology with enhancements for V2X
- Integrated local (PC5) and WAN (Uu) comm. providing optimal performance
- Reusing upper layer V2X standards
- Reuse existing cellular coverage
- Future proof technology

– **Time to market**

3GPP: evolving technology

THE CONNECTED ECO SYSTEM





5G FOR INDUSTRIES



Drive 5G Requirements, Insights and Readiness

5G CAR TRIALS AND POC



5G CONNECTED MOBILITY

Test track of approx. 30 km along the A9 motorway and a high speed railway track. Partners include BMW Group, DB, MNOs, BAST, BNetzA, and TU Dresden.



NORDIC WAY

EU Connecting Europe Facility (CEF) project – kicked off 2015

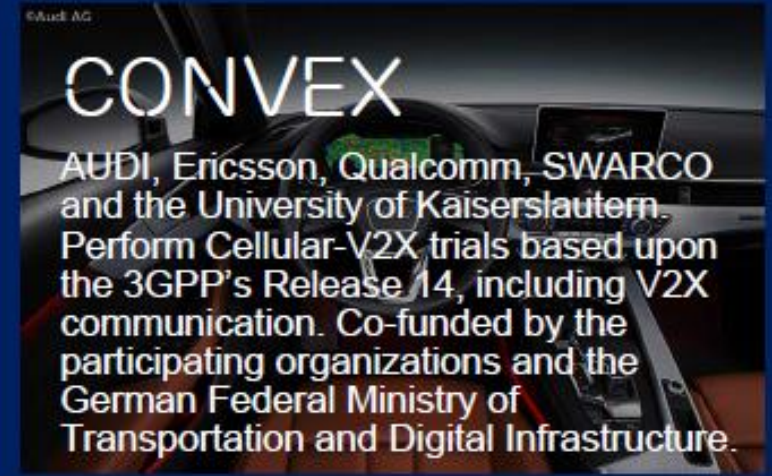
Finish, Danish, Norwegian and Swedish road/traffic authority are signing partners.

Project goal: Show Cooperative-ITS over cellular (for some use cases) that are interoperable in the Nordic countries.



CONVEX

AUDI, Ericsson, Qualcomm, SWARCO and the University of Kaiserslautern Perform Cellular-V2X trials based upon the 3GPP's Release 14, including V2X communication. Co-funded by the German Federal Ministry of Transportation and Digital Infrastructure.



TOWARDS 5G CONNECTED CAR

Partnership between Ericsson, Orange and PSA Group.

Aims to leverage 4G to 5G technology evolution to address connected vehicle requirements, such as ITS, improve road safety, and enable new automotive and in-car services.



KISTA 5G TEST NETWORK

Nobina AV Buses

5G RDV / KTH Concept car



BMW DRIVING CENTER SEOUL

SK Telecom, BMW and Ericsson Providing 5G coverage of BMW driving center to test multiple Vehicle Connectivity related use cases. High speed mobility, high data rate connectivity demonstrated



ERICSSON & BMW TRIALING 5G ON THE RACE TRACK



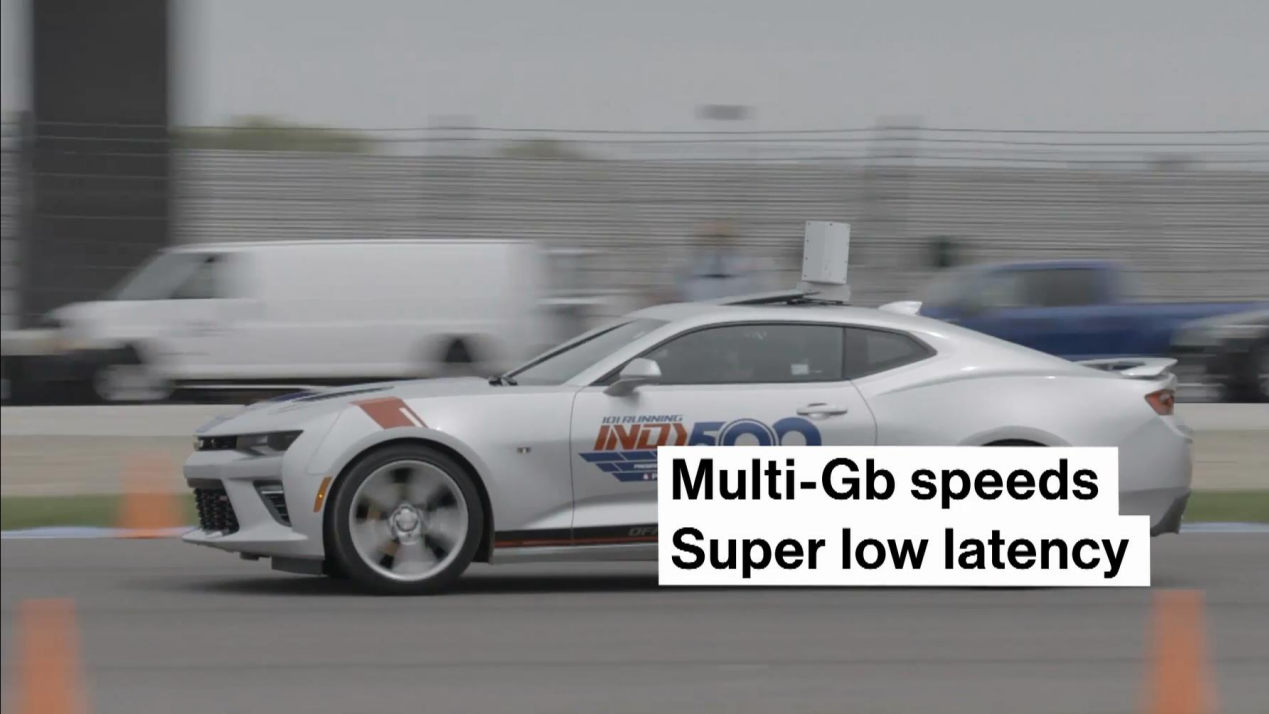
- › Consistent Gigabit-level bi-directional throughput for multiple use cases
- › Uninterrupted connectivity at speeds exceeding 100 kilometers per hour
- › Beam tracking and beam mobility between different 5G access points at high mobility

Ericsson, SK Telecom and BMW Group Korea reach new world record speed with 5G

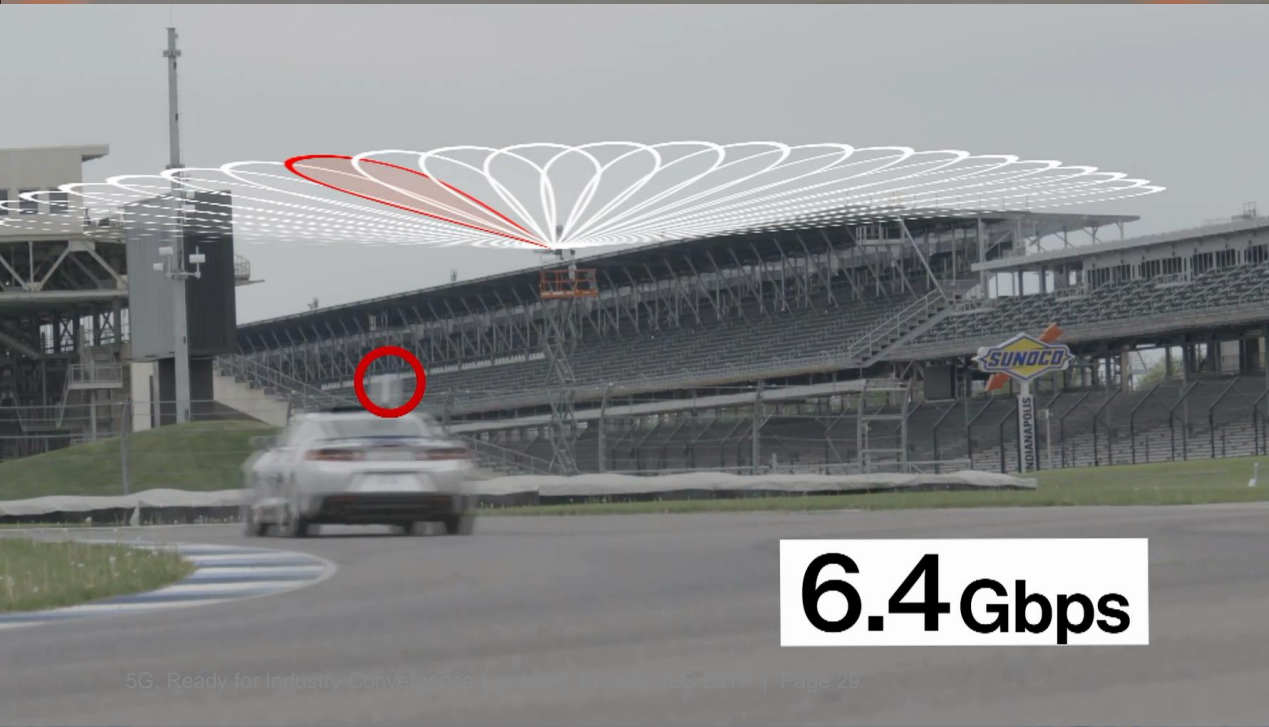
2017-02-07 Categories: Industry



Ericsson, SK Telecom and BMW Group Korea have broken a world record for 5G speeds in a follow-up to the 5G trials announced in November 2016. On a racetrack in Yeonjong-do, South Korea, a high-performance network connection supported data transmission from point-to-point from a car driving up to 170 kilometers per hour.



**Multi-Gb speeds
Super low latency**



6.4Gbps

THE 5G RACE IS ON



- › Ericsson and Verizon tested a 5G network at the historic Indianapolis Motor Speedway
- › The tests prove what's possible when you combine super low-latency with download speeds that exceed 6Gbps.



Ericsson and Verizon test the limits of 5G



Verizon and Ericsson test 5G technology in a home in the shadow of Indianapolis Motor Speedway

CMA CONNECTED MOBILITY ARENA STOCKHOLM



- Create Europe's leading test site for connected mobility
 - Open innovation platform
 - Open cellular radio connectivity
 - Management and control platform
 - Efficient management of test activities (system configuration, road authority, etc.)



- Emergency vehicle prioritization
- Remote-controlling of platoons
- Automatic service orchestration
- ...and more



**ITRL — INTEGRATED TRANSPORT
RESEARCH LAB**

KTH ROYAL INSTITUTE OF TECHNOLOGY



ERICSSON ACCELERATING 5G



First movers are starting



Working with leading markets

5G Use cases possible now

5G Core & Radio Trials in 2017

28

SIGNED 5G PARTNER AGREEMENTS



5G

Empowering people,
transforming industries,
advancing society

