

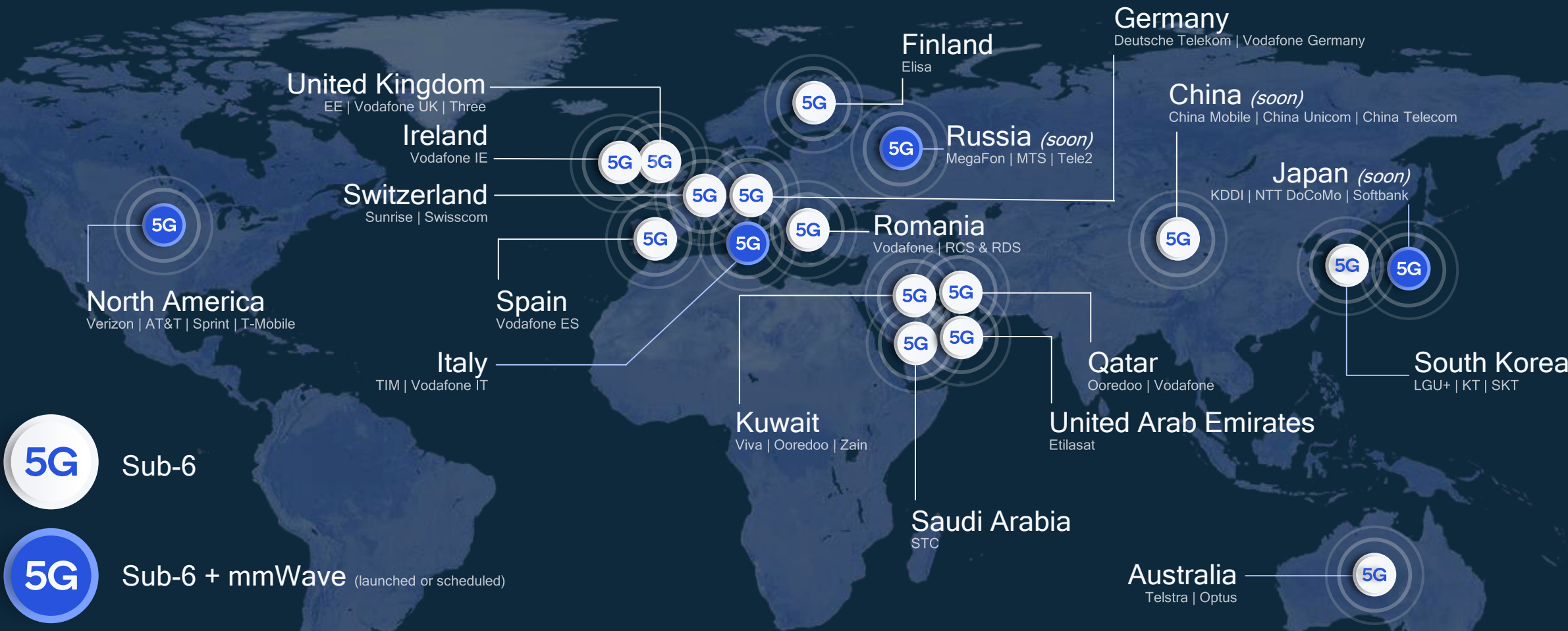
# 5G eMBB is Here! More 5G is Coming!

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Senior Vice-President, Engineering  
Qualcomm Technologies, Inc.

2nd Workshop on 5G Technologies for Tactical and  
First Responder Networks  
The Johns Hopkins University Applied Physical  
Laboratory  
7 October 2019







5G global rollout

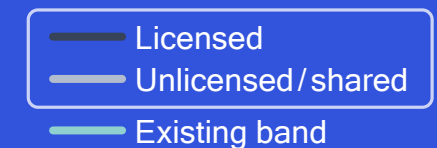
30+ launched in 6 months  
Faster than 4G



# Designed for diverse spectrum bands/types

Global snapshot of 5G spectrum bands allocated or targeted

New 5G band



## 5G smartphones



Lenovo  
Z6 Pro 5G



LG  
V50 ThinQ  
5G



Motorola  
moto z4/z3  
+ 5G moto mod



Nubia  
Mini 5G



OnePlus  
7 Pro 5G



OPPO  
Reno 5G



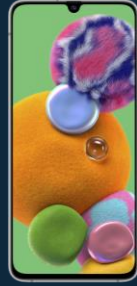
Samsung  
Galaxy  
S10 5G



Samsung  
Galaxy Fold



Samsung  
Galaxy  
Note10+ 5G



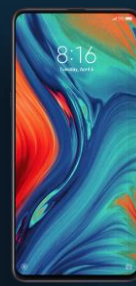
Samsung  
A90 5G



Vivo  
iQOO  
5G Edition



Vivo  
NEX 3 5G



Xiaomi  
Mi MIX 5G



ZTE  
Axon 10 Pro  
5G

## Hotspots and CPEs



Askey

Inseego

HTC

Netcomm

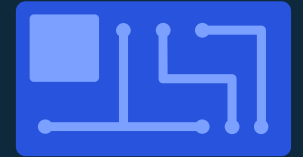
Netgear

Nokia

WNC

ZTE

## 5G modules



Compal

Fibocom

Longsung

Quectel

Sierra

Wireless

SIMcom

Telit

**150+** 5G devices launched  
or in development

Qualcomm  
snapdragon



# Comprehensive 5G modem-RF solutions

**Qualcomm**  
snapdragon   
X50 5G modem-RF system

1<sup>st</sup> gen

- Sub-6 and mmWave
- NSA, TDD, Multi-SIM
- Qualcomm® 5G PowerSave
- Qualcomm® Smart Transmit
- Qualcomm® Signal Boost

Early 2019

**First wave of devices**

**Qualcomm**  
snapdragon   
X55 5G modem-RF system

2<sup>nd</sup> gen

Added features

- Integrated 5G to 2G
- Standalone (SA), FDD
- Dynamic Spectrum Sharing
- Qualcomm® Wideband Envelope Tracking
- Platforms for PC, fixed wireless access, automotive, and more

Late 2019

**Second wave**

**Snapdragon 8,7,6  
Series Mobile Platforms**



1<sup>st</sup> half 2020

**Broader, faster adoption**

**System-level integration delivers best-in-class power-efficiency and performance**



Qualcomm  
snapdragon

X55 5G modem-RF system



Qualcomm®  
mmWave modules

QTM525

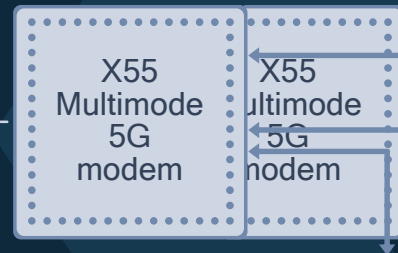
mmWave

Qualcomm®  
Smart Transmit

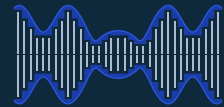
Support for all radios  
5G-2G, Wi-Fi



Qualcomm®  
5G PowerSave



RF Front End RF Front End



Qualcomm®  
Wideband  
envelope tracking



Sub-6 GHz  
(5G,LTE)

Qualcomm®  
Signal Boost  
antenna tuning



# Optimization through co-design of hardware and software



A technology; a state of mind  
A platform for new applications  
and innovations



Multi-gigabit  
speed



Scalable to  
extreme simplicity



Ultra-low  
latency



Virtually  
unlimited  
capacity



Extreme  
reliability

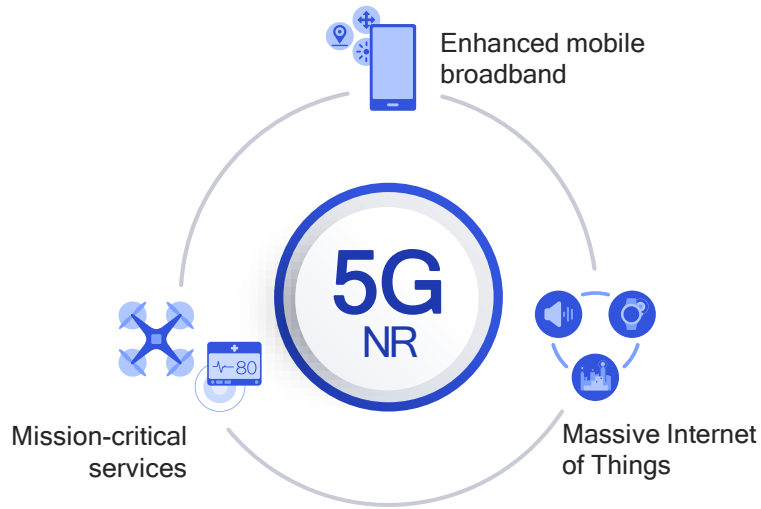


On-device  
intelligence

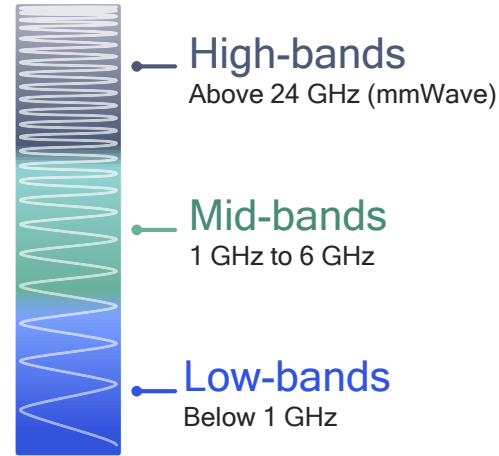




# Designing a unified, more capable 5G air interface



Diverse services



Licensed/shared/unlicensed

Diverse spectrum



Diverse deployments


Existing, emerging, and unforeseen services - a platform for future innovation



# The 5G expansion


Rel.15  
eMBB expansion

Private networks 


 Industrial IoT with eURLLC


Laptops 

Automotive 

 5G NR C-V2X, smart transportation


5G massive IoT 

 Future verticals, services, devices


5G broadcast 

 Shared / unlicensed spectrum

mmWave evolution, indoor, enterprises 

New device classes like tethered XR 

Fixed wireless access 

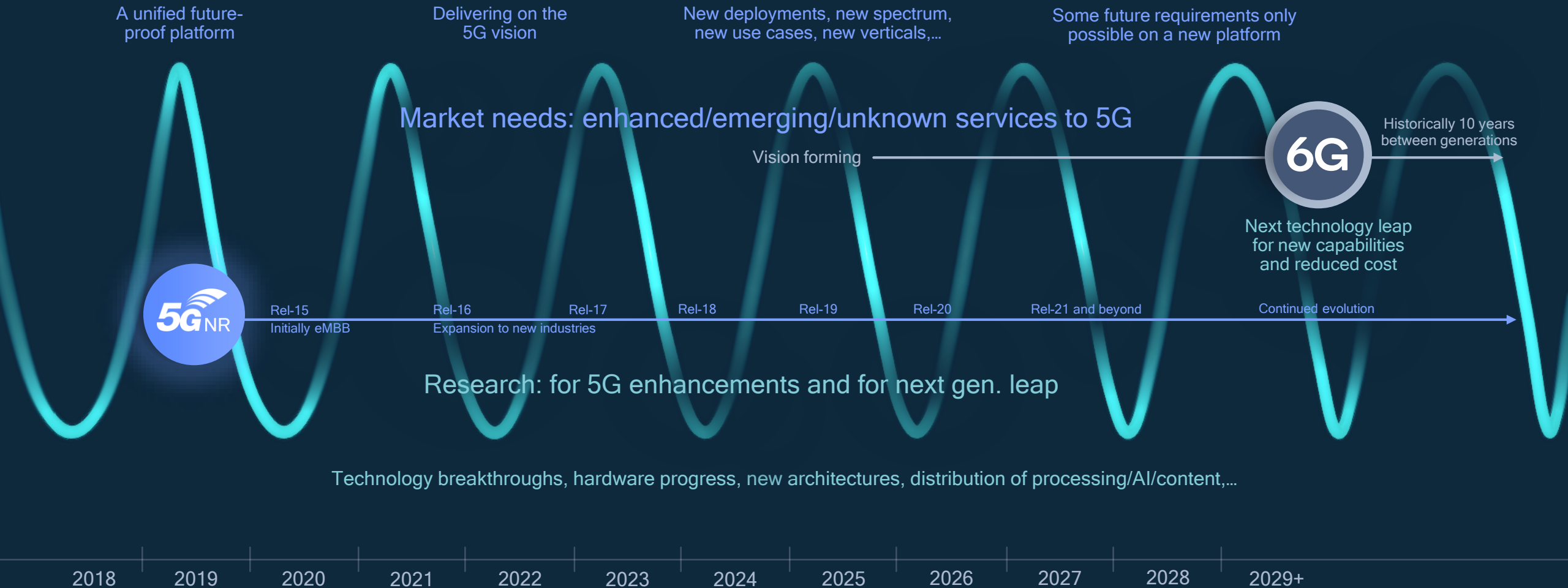
 New device classes like boundless XR

Sub-6 GHz evolution, new use case 

Smartphones 

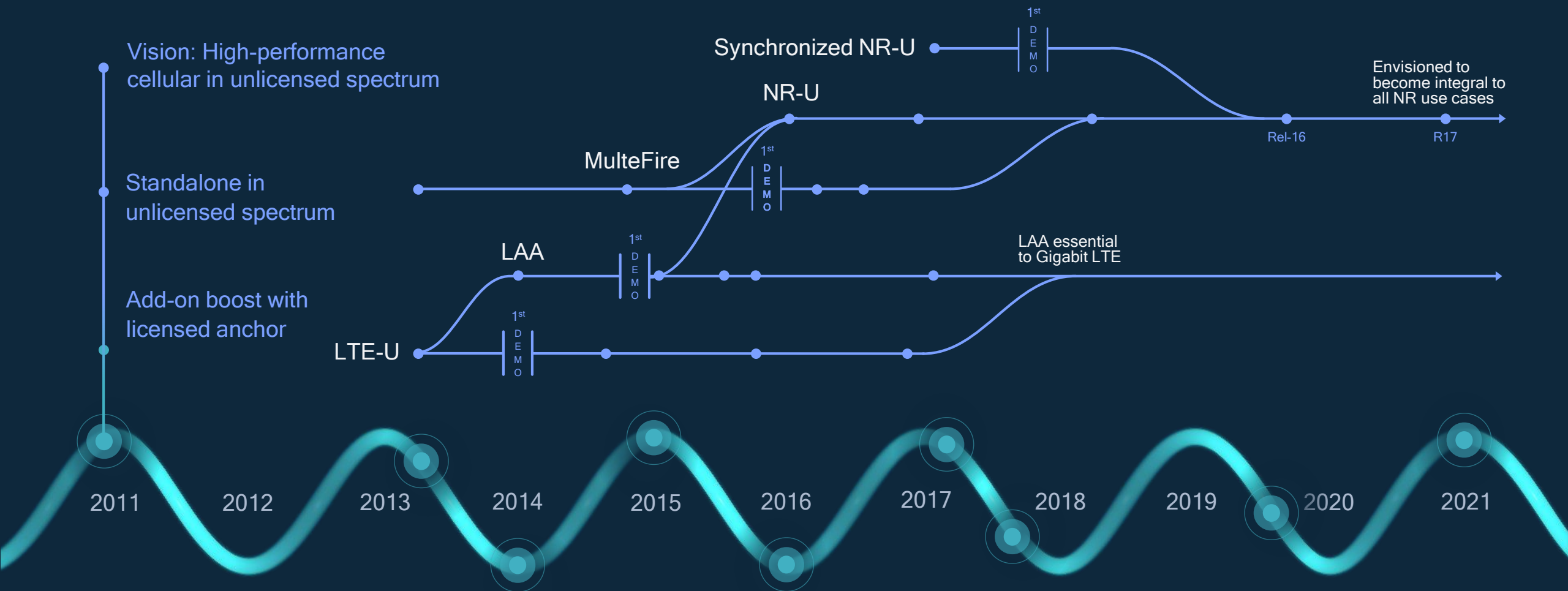
Rel.16-17

# 5G is the innovation platform for the next decade





# Using 3GPP-technologies for unlicensed spectrum



Continuous research, industry first over-the-air LAA, eLAA, MulteFire demos, interoperability with Wi-Fi

# Multiple spectrum options

For private 5G networks



## Licensed spectrum by mobile operators

Operators can allocate spectrum in a specific area



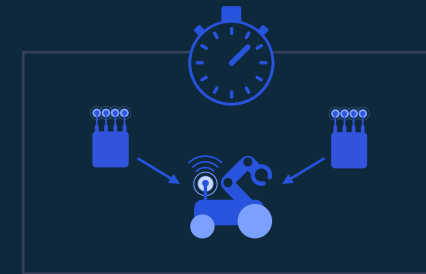
## Unlicensed spectrum with async sharing

NR-U with asynchronous sharing work for many applications



## Dedicated regional spectrum

Regional spectrum such as 3.7GHz in Germany for IIoT



## Unlicensed spectrum with synch sharing

Synchronized sharing can provide reliability and eURLLC for IIoT



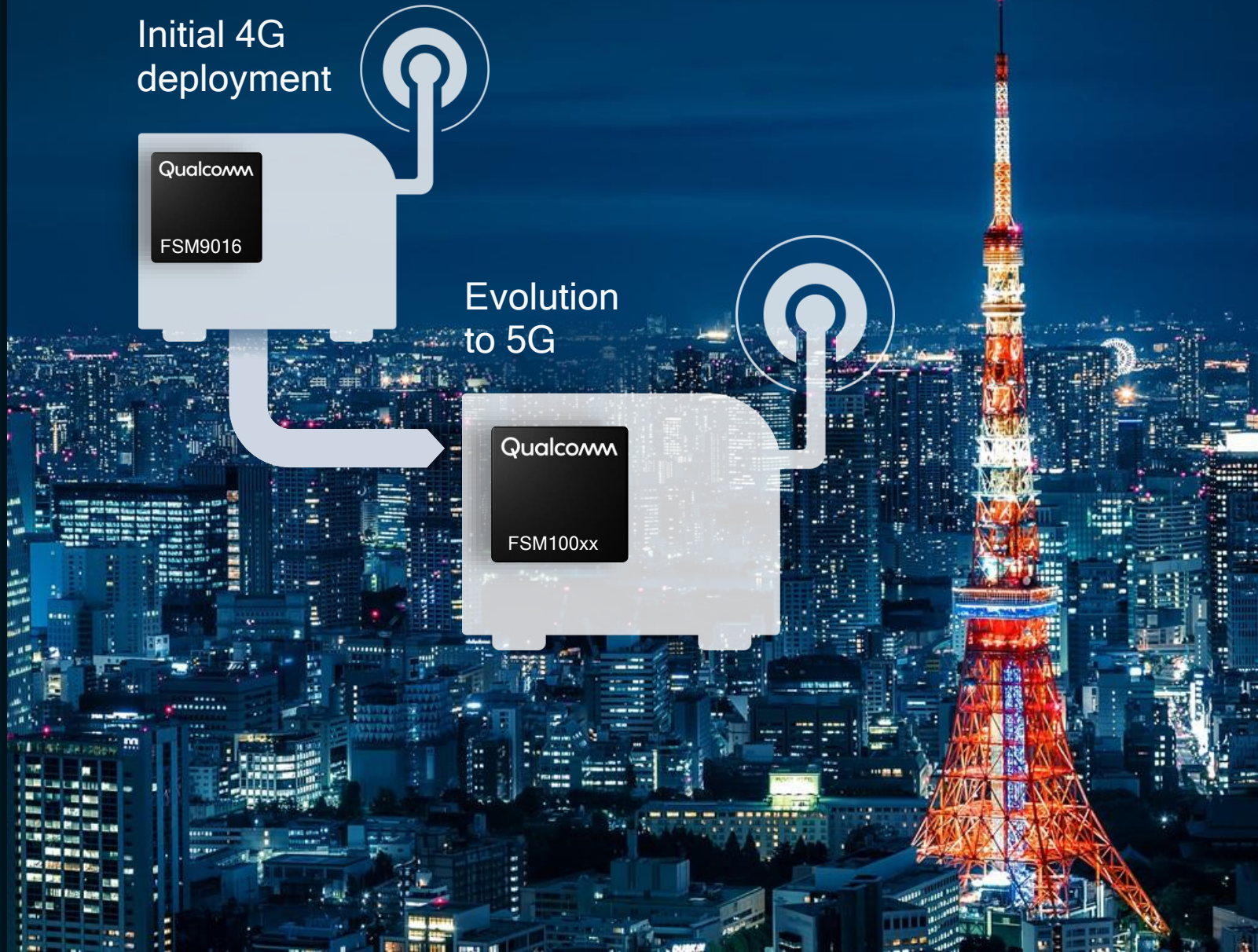
# Accelerating the expansion of 5G network with small cells

Powered by Qualcomm® FSM™ small cell platforms

Capable of being developed to utilize mmWave and sub-6 GHz

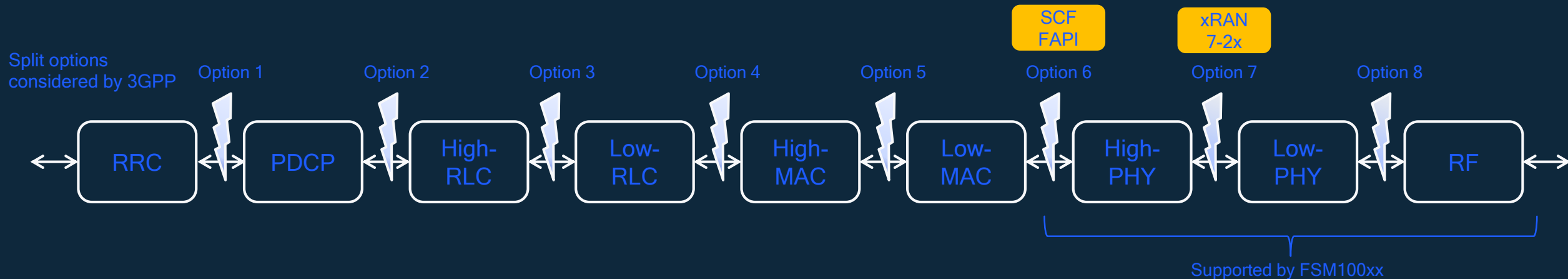
Supporting uniform 5G speeds and experiences, indoors and outdoors

Expected to begin sampling in 2020



# Disaggregated Radio Access Networks

- Industry focused on **disaggregation of the radio access network** for 4G+5G
- Goals are to lower cost of network and lessen dependence on traditional infrastructure suppliers
  - Encouraging new suppliers + open source development
- **RAN disaggregation:**
  - Monolithic RAN functions moved to a new disaggregated design allowing the underlying RAN to be more efficiently and flexibly deployed. e/gNB software decoupled from white box hardware.
  - Open standardized interfaces with multiple vendor support.
- Key industry groups are 3GPP, Open RAN Alliance (O-RAN), Telecom Infra Project (TIP) and the Small Cell Forum (SCF)





# 3GPP and Public Safety

What happened so far, what will happen next..

- 3GPP did extensive work developing public safety related enablers since Rel.12 (for LTE/EPS):
  - New QoS parameters for public safety application
  - Group communication using MBMS
  - Sidelink communication/Proximity Services inc. sidelink relays
  - Mission critical applications (MC PTT, MC Data, MC Video)
- NR and 5G system already supports the related QoS framework for unicast Mission critical applications (since Rel.15) but does not yet support any of the more “advanced” enablers
- For the Rel.17 package which is currently being scoped in 3GPP several of the more advanced enablers required for public safety are considered, namely sidelink communication using NR, multicast/broadcast architecture using NR and 5GS, various forms of sidelink relays
  - Work on sidelink done for V2X in rel.16 will be used as baseline
- 3GPP already has an ongoing activity to adapt existing MC applications to 5GS and potentially expand to new ones also



## Enhanced network communication

Faster access to cloud for in-vehicle experiences, car OEM services and telematics



## New direct communication

V2V, V2I, and V2P communications for latency-sensitive use-cases, e.g. collision avoidance



## Massive Internet of Things

Deeper coverage to connect road infrastructure (e.g. sensors and traffic cameras)



V2N



V2N



Road hazard warning

V2I

RSU

Speed harmonization



Smart city



Sensors



Utilities



Connected car services



In-vehicle experiences



Road safety



Transportation efficiency



Connected road sensors

# 3GPP is Enhancing C-V2X (Rel. 14/15 LTE-V2X) by NR-V2X

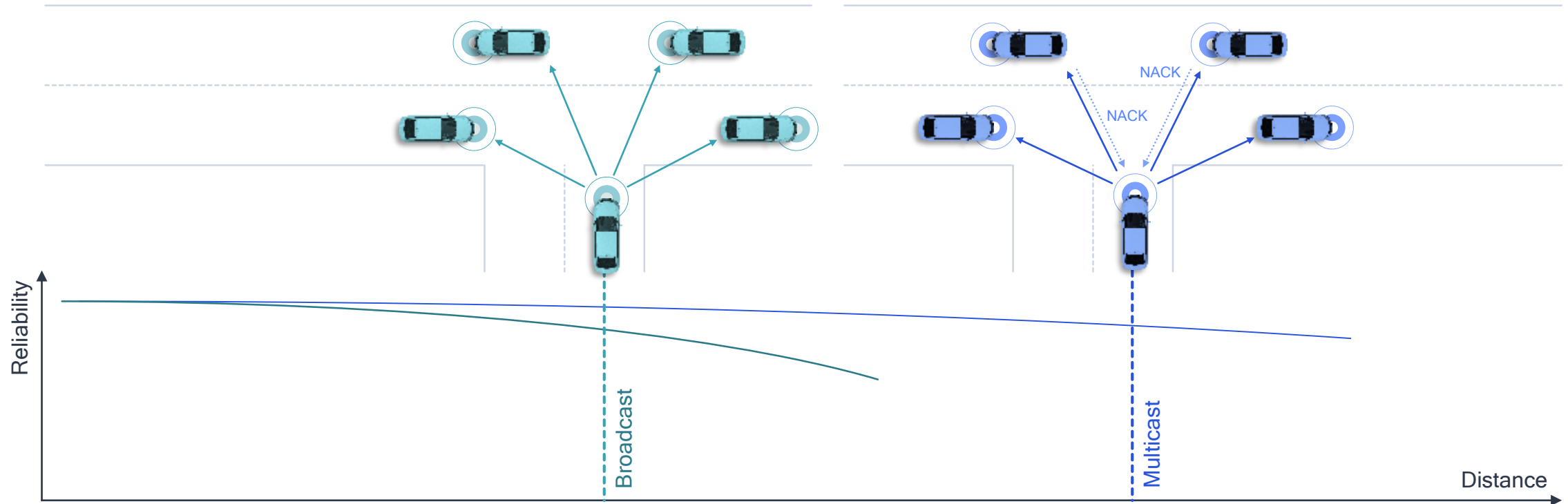


## Rel-14 C-V2X

Broadcast without feedback, which can't ensure reliability

## Rel-16 5G NR C-V2X

Multicast with feedback for higher reliability; if signal can't be decoded, NACKs are sent on the same radio resources (SFN-like approach)



# Multicast support for higher reliability

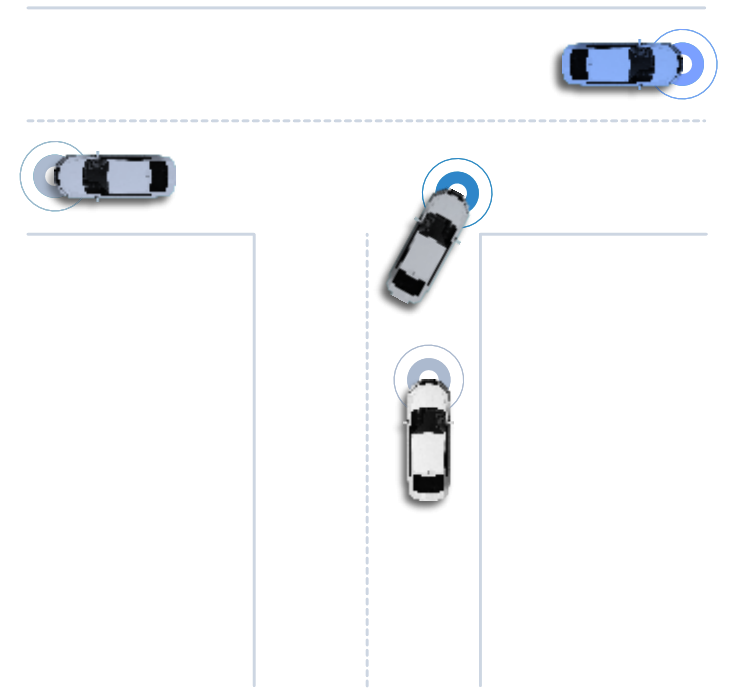
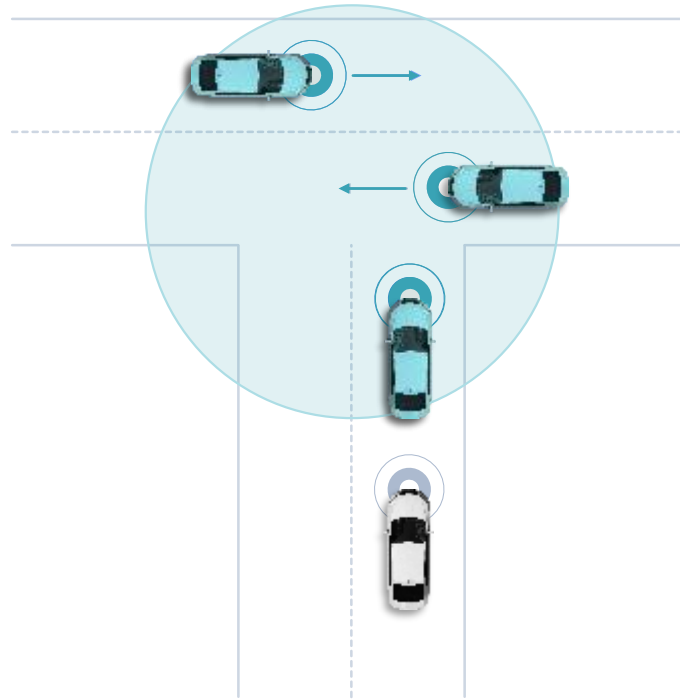
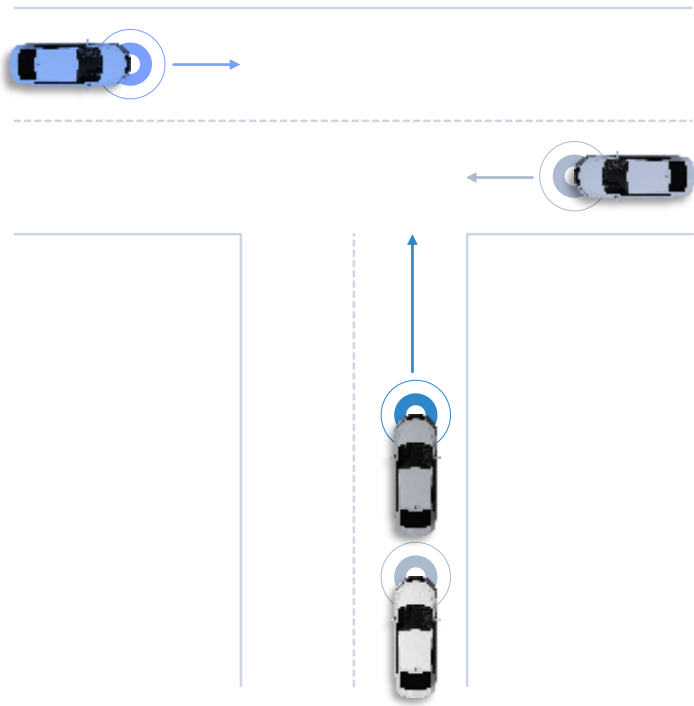
HARQ feedback to achieve higher reliability | Introducing efficiency by sending only NACKs using SFN



Vehicles approaching intersection

Group formed among vehicles for coordinated intersection management

Group disbanded after intersection is navigated

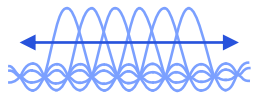


# Connectionless 'on-the-fly' distance-based groups

Vehicles within a certain distance and interested in same services form a group

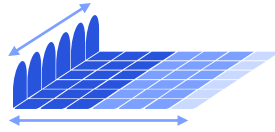
## Adapting R15 5G NR flexible framework to vehicles

Scalable OFDM-based air interface



Such as wideband carrier support (>20 MHz) and different sub-carrier spacing

Flexible slot-based framework



Such as adding sidelink and dynamic reference signal for various speed

Advanced channel coding



State of the art LDPC/polar coding to deliver performance

## Building on R14/15 C-V2X framework with backward compatibility

Such as frequency division multiplexing, guaranteed latency performance and prioritization support



# 5G NR C-V2X

## Facilitating a new paradigm of communication design

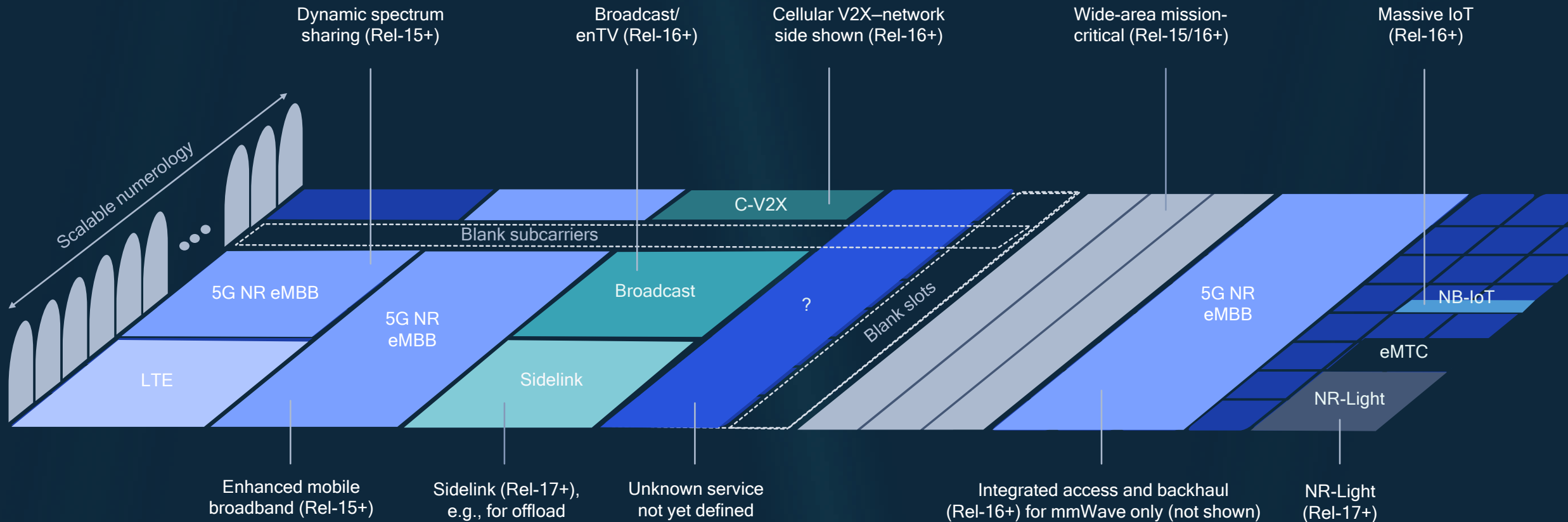
Efficient sidelink link level design for optimized performance at all speeds

Connectionless 'on-the-fly' distance-based groups

Multicast with distance-based reliability and application relevancy

# 5G NR C-V2X builds on existing frameworks and facilitates a new paradigm of communication design





# Expanding 5G with the flexible slot-based framework







# Thank you

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