Qualcomm

June 2020

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Propelling 5G forward

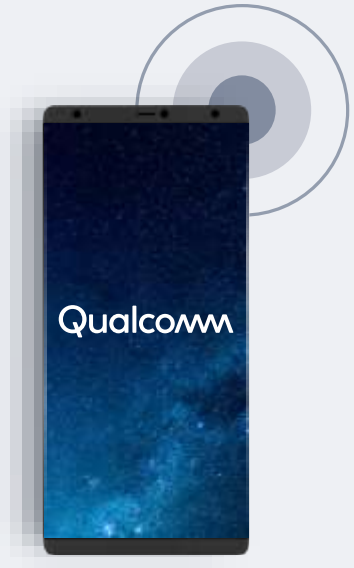
Key 3GPP Release 16 inventions

5G

Leading mobile innovation for over 30 years

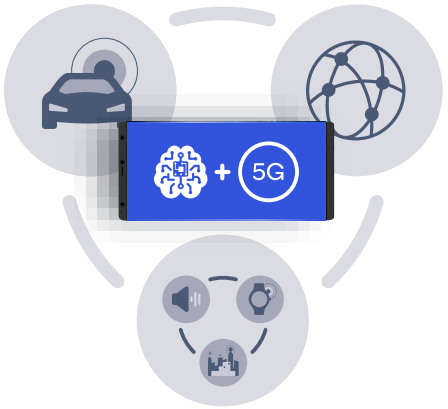
Digitized mobile communications

Analog to digital



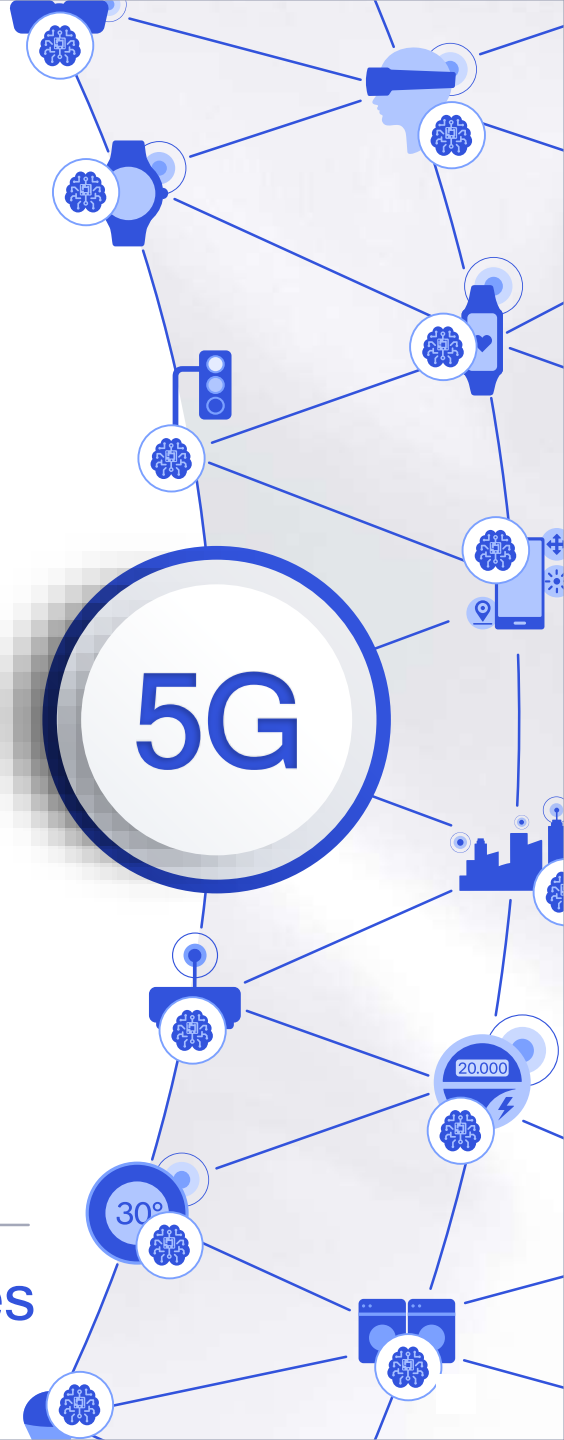
Redefined computing

Desktop to smartphones



Transforming industries

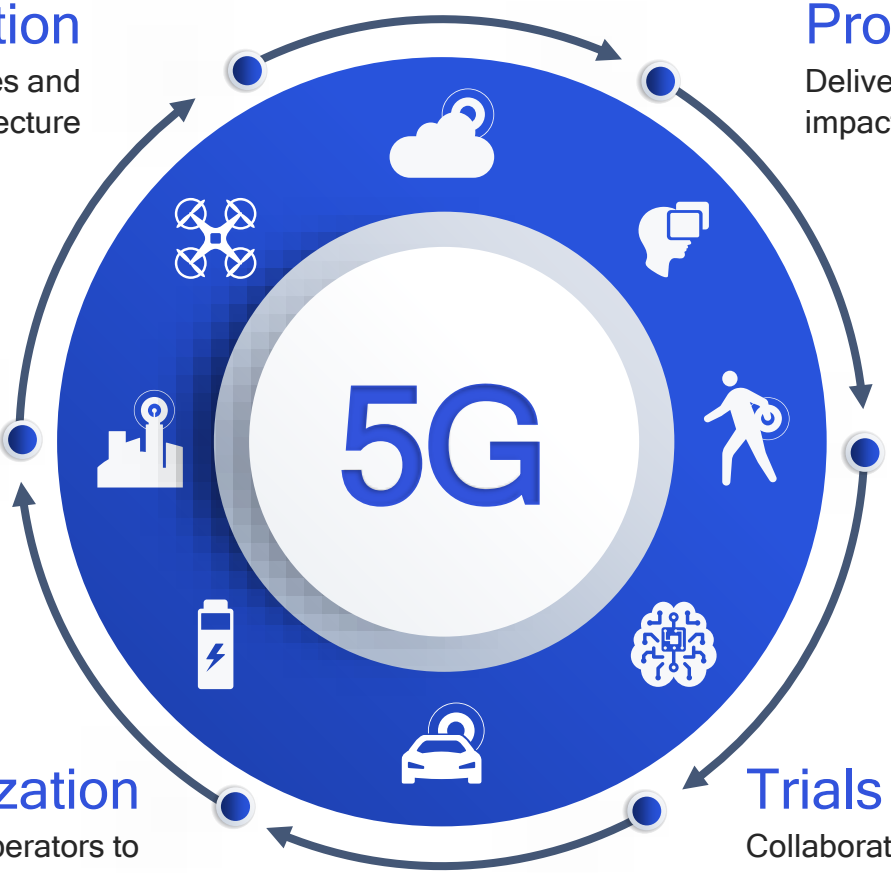
Connecting virtually everything at the wireless edge



Transforming how the world connects, computes and communicates

Foundation to 5G leadership is technology leadership

Early R&D and technology inventions essential to leading ecosystem forward



Invention

Invent new technologies and e2e system architecture

Proof-of-concept

Deliver end-to-end prototypes and impactful demonstrations

Vision

Identify a problem or need; establish requirements

Standardization

Drive e2e design with ecosystem and through standards process

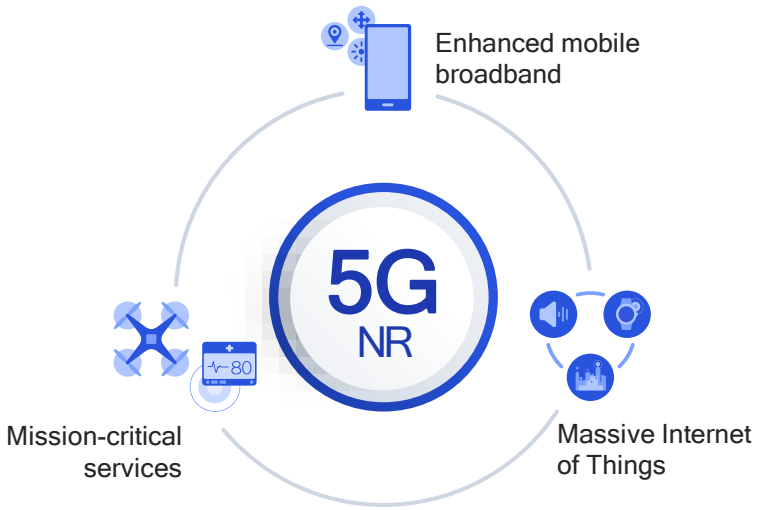
Commercialization

Engage with global network operators to deploy new features with standards-compliant infrastructure and devices

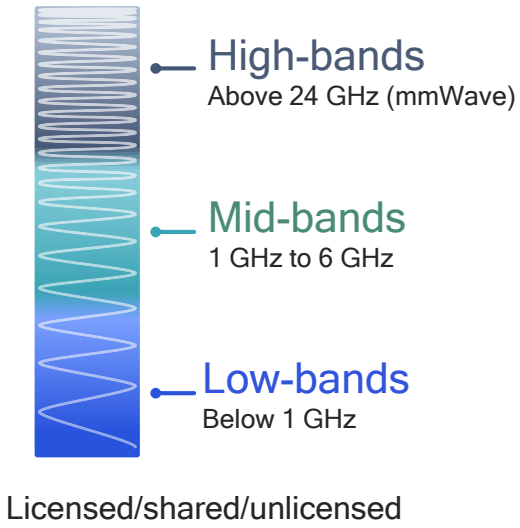
Trials

Collaborate on OTA field trials that track 3GPP standardization and drive ecosystem towards rapid commercialization

5G NR is a unified, more capable air interface



Diverse services



Licensed/shared/unlicensed

Diverse spectrum

Diverse deployments

10x Decrease in end-to-end latency

10x Experienced throughput

3x Spectrum efficiency

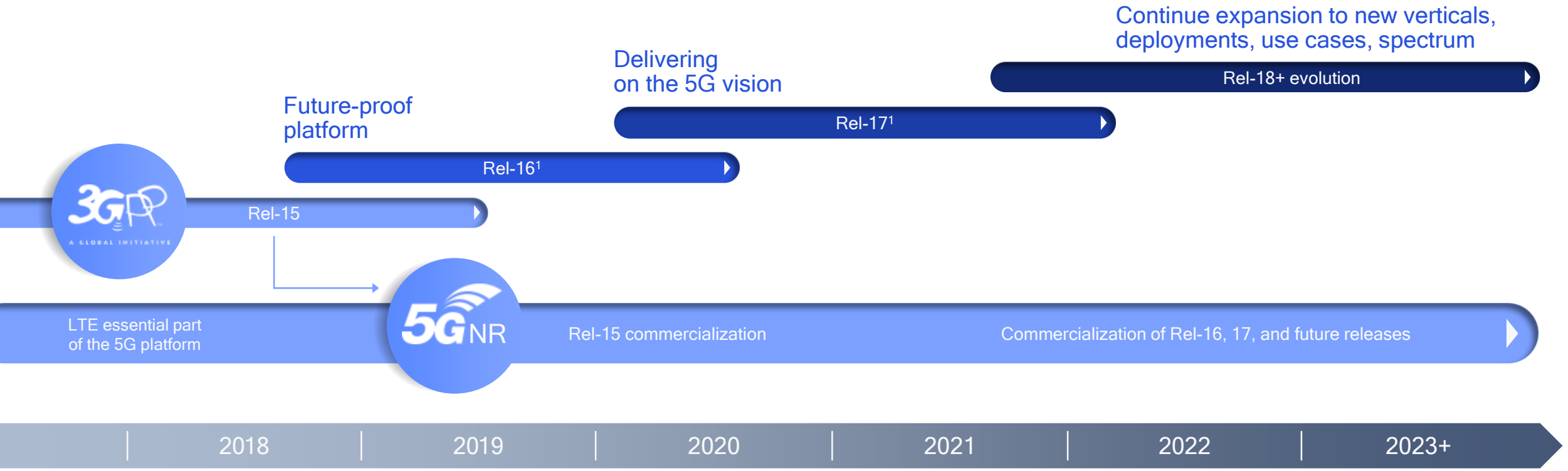
100x Traffic capacity

100x Network efficiency

10x Connection density

Based on ITU vision for IMT-2020 compared to IMT-advanced; URLLC: Ultra Reliable Low Latency Communications; IAB: Integrated Access & Backhaul

Driving the 5G technology evolution



Rel-15 eMBB focus

- 5G NR foundation
- Smartphones, FWA, PC
- Expanding to venues, enterprises

Rel-16 industry expansion

- eURLLC and TSN for IIoT
- NR in unlicensed (NR-U)
- Positioning
- 5G V2X sidelink multicast
- In-band eMTC/NB-IoT

Rel-17+ long-term expansion

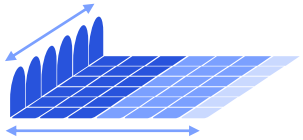
- Lower complexity NR-Light
- Boundless extended reality (XR)
- Higher precision positioning and more…

1 3GPP start date indicates approval of study package (study item → work item → specifications), previous release continues beyond start of next release with functional freezes and ASN.1

Our technology inventions drove 5G Rel-15 specifications

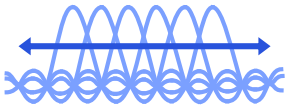
Flexible slot-based framework

For forward compatibility and ultra low-latency



Scalable OFDM-based air interface

For diverse services, spectrum, deployments

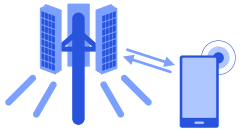


Advanced channel coding

For more efficient delivery of multi-Gbps throughput

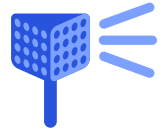
Massive MIMO

For increased network coverage and capacity



Mobile mmWave

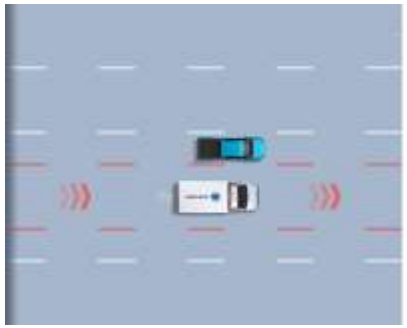
For extreme capacity and throughput



5G NR air interface foundation is analogous to new road and vehicle designs

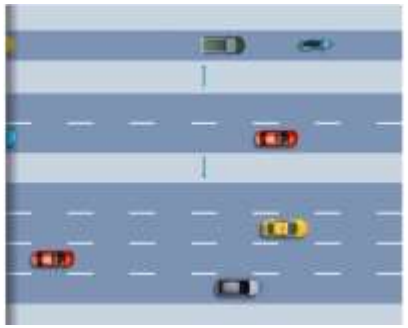
Flexible road framework

Dynamically and efficiently adapt to all traffic types and situations



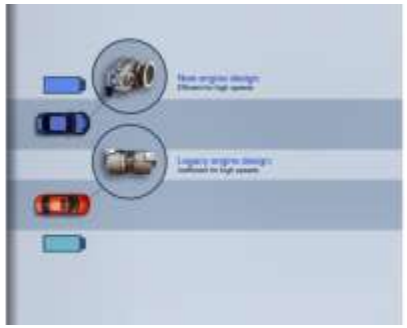
Modular road design

Exponentially scalable from single to multi-lane; common design for all configurations



Better engine efficiency

Ability to achieve high speeds with lower energy consumption

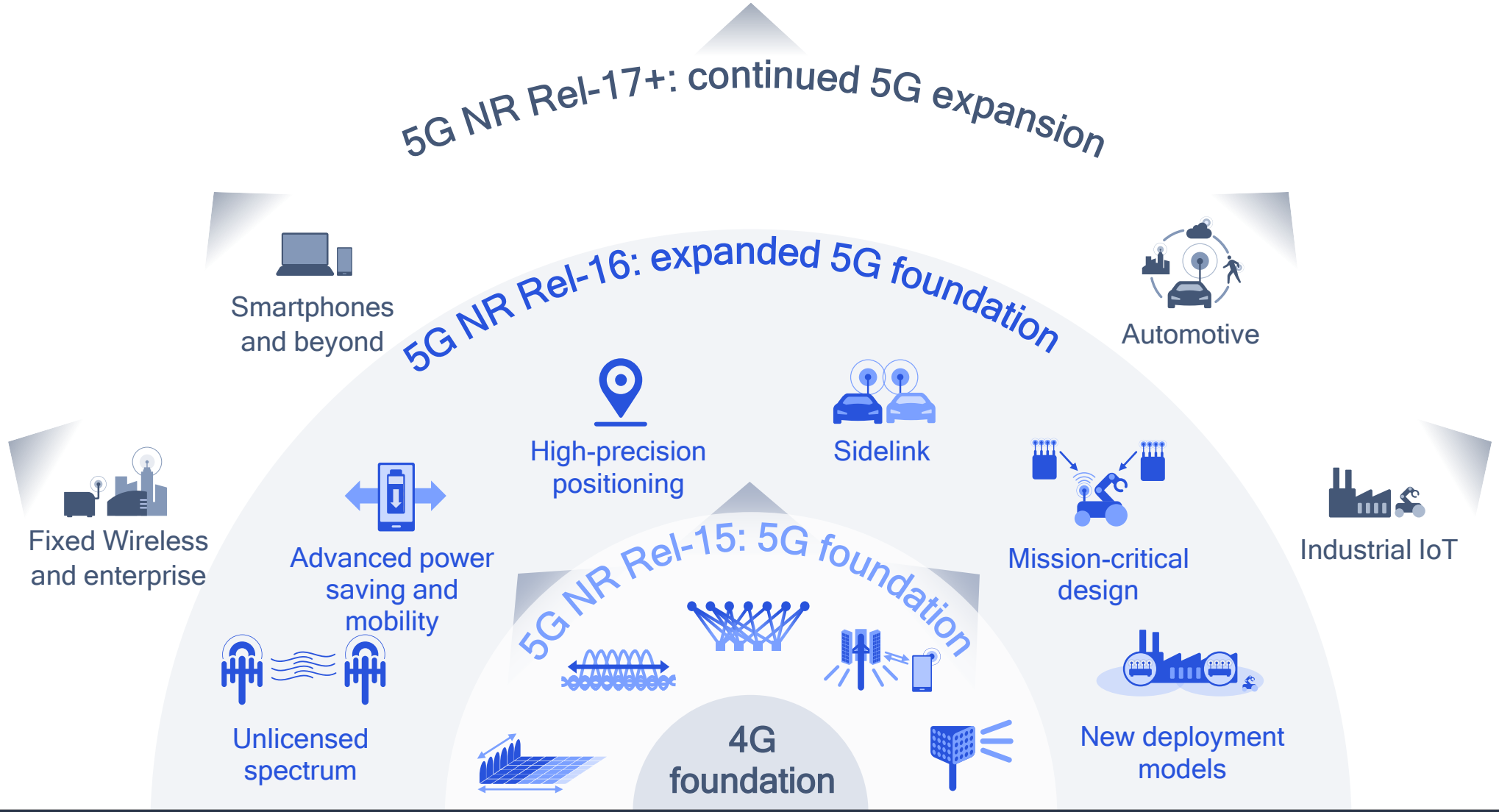


Multi-deck road

Stacking roads to allow more cars to travel faster

Roads in the sky

New types of high-speed roads based on resources that were previously thought unusable



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Our wireless inventions are leading the 5G evolution

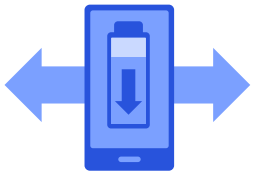
Qualcomm Technologies' Release 16 inventions expand the 5G NR foundation

Unlicensed spectrum

Shared spectrum, LAA[1], standalone operation

For improved capacity and new use cases

Advanced power saving & mobility



WUS[2], faster CA[3], full-power UL[4], dual connectivity

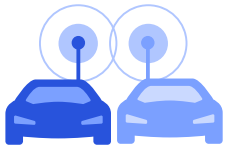
For better device performance and coverage

High-precision positioning

OTDOA[5], PRS[6], device-based positioning, multi-cell RTT[7]

For more accurate indoor and outdoor positioning

Sidelink



Basis for cellular V2X[8], public safety

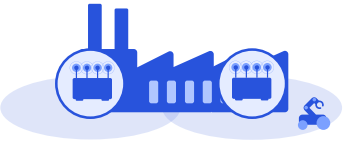
For advanced automotive use cases

Mission-critical design

Multi-TRP[9], CoMP[10], service multiplexing & preemption

For meeting ultra-high reliability of up to 99.9999%

New deployment models



Non-public network, TSN[11], IAB[12], in-band eMTC/NB-IoT[13]

For new deployments such as IIoT and enterprise

Early R&D investments | Cutting-edge prototypes | Fundamental innovations in 3GPP

1 Licensed assisted access; 2 Wakeup signal; 3 Carrier aggregation; 4 Uplink; 5 Observed time difference of arrival; 6 Positioning reference signal; 7 Roundtrip time; 8 Vehicle to everything; 9 Multiple transmission or reception point; 10 Coordinated multipoint; 11 Time sensitive networking; 12 Integrated access and backhaul; 13 Enhanced machine-type communication and narrowband IoT

Accelerating the expansion of 5G

New services, deployments, and spectrum bands

Continued eMBB enhancements, e.g., mobility, coverage, more[1]

New spectrum above 52.6 GHz

More capable, flexible IAB

Enhancements to 5G NR IIoT

Expanded sidelink, e.g., V2X reliability, P2V

5G

3GPP Rel-17

Unlicensed spectrum across all use cases

NR-Light for wearables, industrial sensors, and enhanced massive IoT[2]

Positioning with cm-level accuracy

Extended reality

Rel-15 deployment learning, others[3]

1. Further improvements to capacity, power consumption, spectral efficiency; 2. NR-Light refers to Reduced Capability in 3GPP, including eMTC and NB-IoT in 5G NR; 3. mixed-mode multicast, small data transmission, multi-SIM, satellite, multimedia

Intelligently connecting

our world in the 5G era

A unified connectivity fabric this decade

5G

Strong 5G momentum sets the stage for the global expansion

Continued evolution

Rel-15
eMBB focus

Rel-16 and 17
Expanding to new industries

Rel-18, 19. 20 and beyond
Continued 5G proliferation

Next technology leap for new capabilities and efficiencies

6G

Historically 10 years between generations

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Thank you!

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