QUALCOMM®

Towards 5G NR Commercialization

Accelerating 5G NR for Enhanced Mobile Broadband

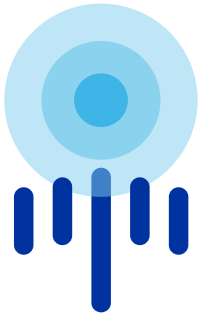
May 25 2017

5G NR will deliver new levels of capability and efficiency

For enhanced mobile broadband and beyond

Fiber-like speeds

Multi-Gbps peak rates for both download (consumption) and upload (sharing)

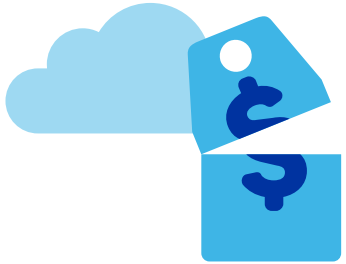


Uniform experience

Reliable performance, e.g. 100+ Mbsps, even in challenging environments or at the cell edge

Lower latency

As low as 1ms for interactive content, as well as reduced buffering requirements and lag



Lower cost-per-bit

Significantly lower than today's networks to efficiently support cost-effective data plans

10x experienced throughput

10x decrease in end-to-end latency

10x connection density

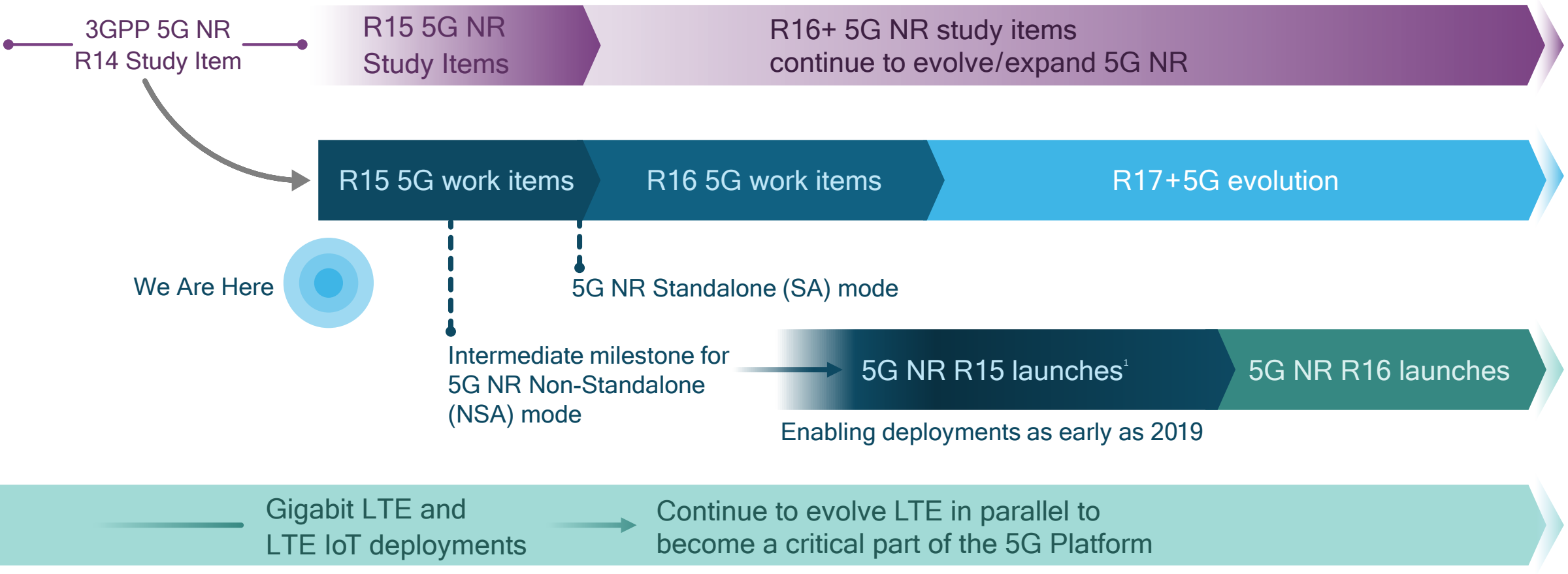
3x spectrum efficiency

100x traffic capacity

100x network efficiency

Based on ITU vision for IMT-2020 compared to IMT-advanced

Accelerating 5G NR, the global standard for 5G



1. Forward compatibility with R16 and beyond

Approved way forward on overall 5G NR eMBB workplan

RP-170741 agreed upon at 3GPP RAN #75 in March 2017

Stage 3 completion for 5G NR NSA by December 2017 (RAN#78)[1]

Stage 3 completion for 5G NR SA by June 2018 (RAN #80)[2]

Broad support to meet increasing mobile broadband needs with global 5G NR standard

AT&T NTT DOCOMO SK Telecom Vodafone Ericsson Nokia Qualcomm

Alcatel-Lucent Shanghai-Bell Alibaba Apple British Telecom Broadcom CATT China Telecom China Unicom China Mobile Cisco

Convida Wireless Deutsche Telekom Etisalat Fujitsu Huawei Intel Interdigital KDDI Korea Telecom LG Electronics

LGU+ MediaTek NEC Ooredoo OPPO Samsung Sierra Wireless Sony Sprint Swisscom TCL

Telecom Italia Telefonica TeliaSonera Telstra Tmobile USA Verizon vivo Xiaomi ZTE

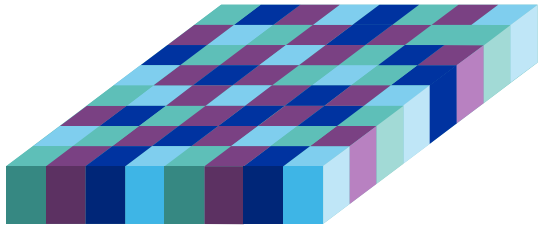
1 NSA Option 3 family ASN.1 by March 2018; 2 Release-15 ASN.1 for 5G NR NSA and SA by September 2018

5G NR R15 will establish the 5G foundation

For enhanced mobile broadband and beyond

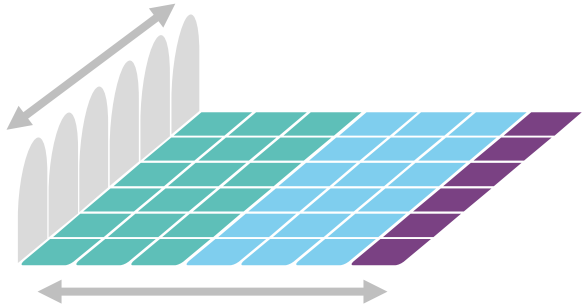
Optimized OFDM-based waveforms

With scalable numerology and TTI, plus optimized multiple access for different use cases



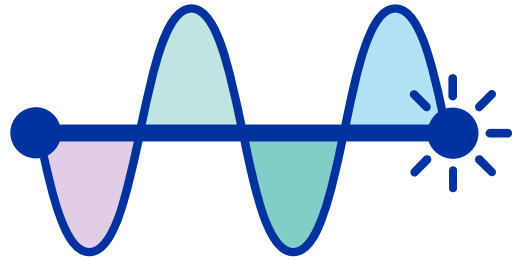
A flexible, forward compatible framework

To efficiently multiplex services and features with a dynamic, low-latency TDD/FDD design



Advanced wireless technologies

Such as massive MIMO, robust mmWave, advanced channel coding, and device-centric mobility



Unified design across spectrum types and bands

For licensed and shared / unlicensed spectrum bands both below 6 GHz and above 6 GHz[1]

1. 3GPP R15 focused on spectrum bands up to ~40 GHz; R16+ will bring support for bands up to ~100 GHz

Our technology inventions are driving the 5G NR standard

- Scalable OFDM numerology
- Multi-user Massive MIMO
- Advanced LDPC channel coding
- Self-contained TDD sub-frame
- Low-latency slot structure design
- Adaptive beamforming/tracking (mmW)

5G NR

R&D leadership

First successful 5G NR connection based on 3GPP

3GPP A GLOBAL INITIATIVE

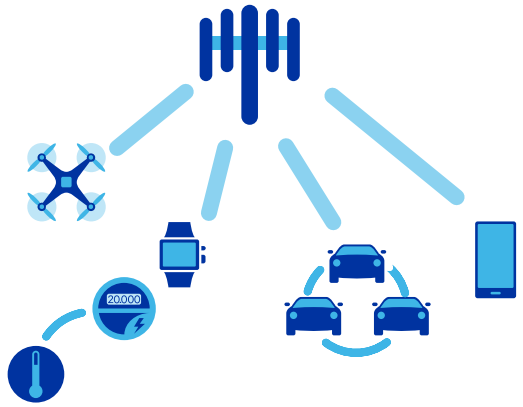
Standards leadership

Technologies part of ongoing 5G NR Study Item

Qualcomm Research 5G NR end-to-end prototype systems

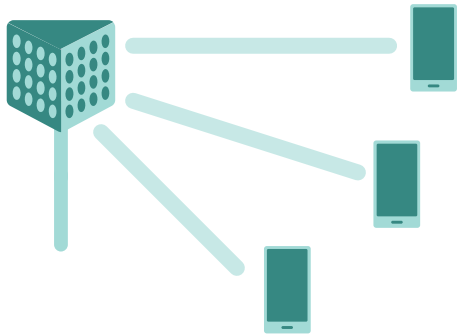
Sub-6 GHz

Ubiquitous coverage and capacity for a wide-range of 5G use cases



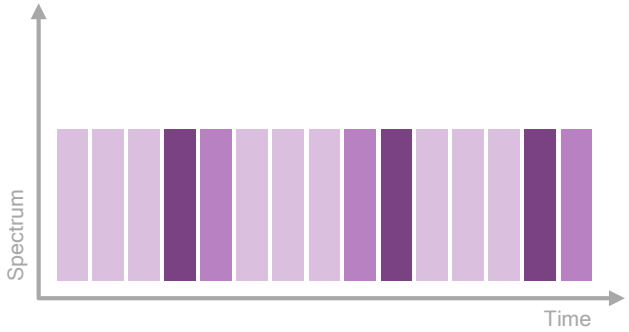
Mobilizing mmWave

Large bandwidths for extreme throughput and capacity



Spectrum sharing

More efficient utilization of, and access to, scarce resources



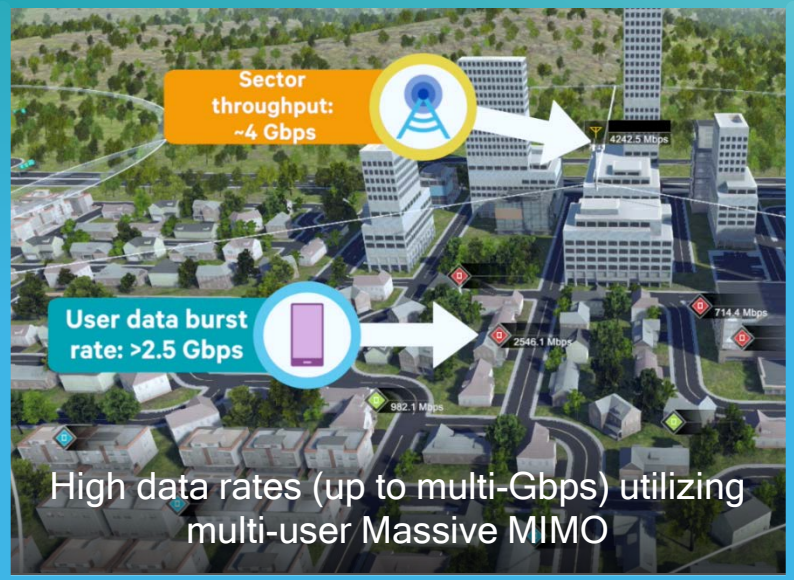
Accelerating 5G NR commercialization

Test, demonstrate and verify our 5G designs | Drive and track 3GPP 5G NR standardization | Achieve impactful trials with network operators | Drive timely commercialization

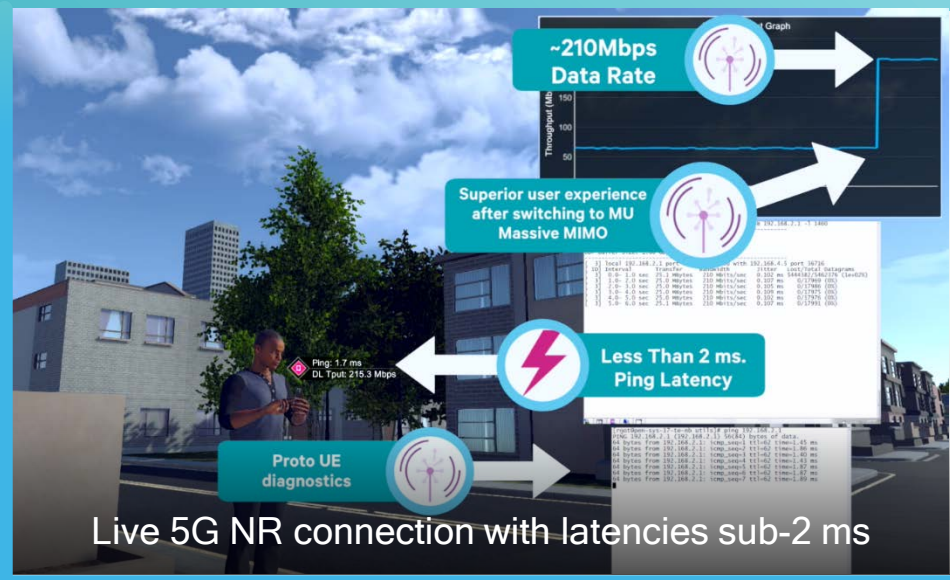
Bringing new capabilities and efficiency to sub-6 GHz

Demonstrating advanced 5G NR technologies

Wide area coverage at 3.3-3.8 GHz band with multiple simultaneous users



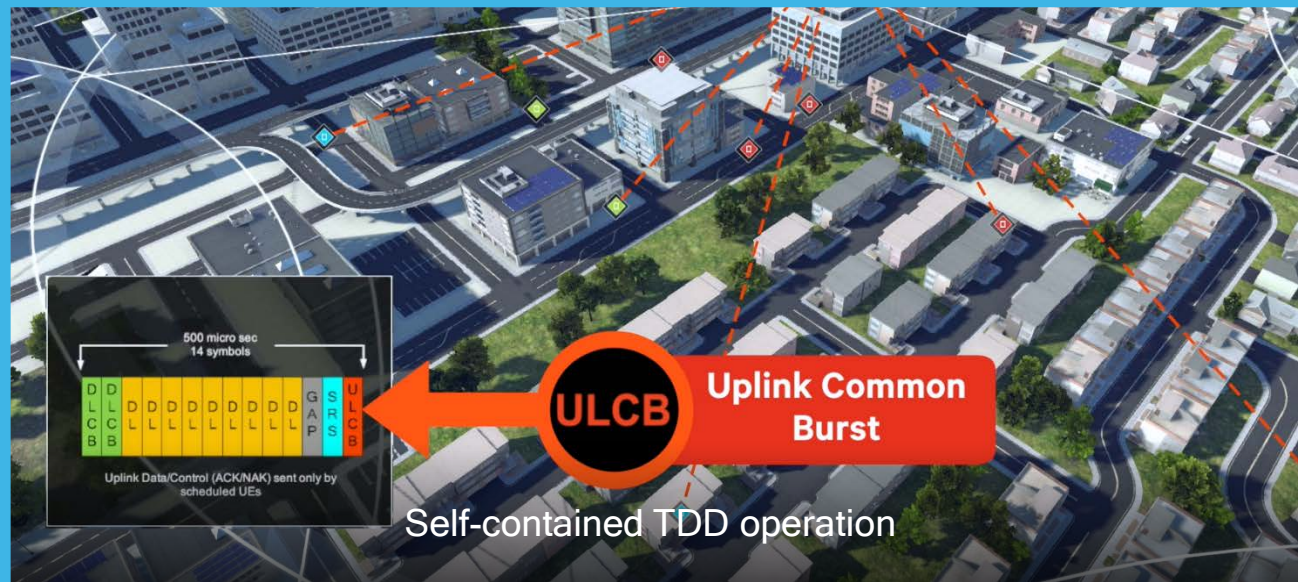
High data rates (up to multi-Gbps) utilizing multi-user Massive MIMO



Live 5G NR connection with latencies sub-2 ms

Kpis	MIMO	MU-MIMO
Downlink Datarate (Gain %)	12.84 Mbps	32.47 Mbps (+152.88 %)
MIMO SINR	3.46 dB	4.97 dB
Modulation Order	QPSK	QPSK
Base Station Rank	2	11

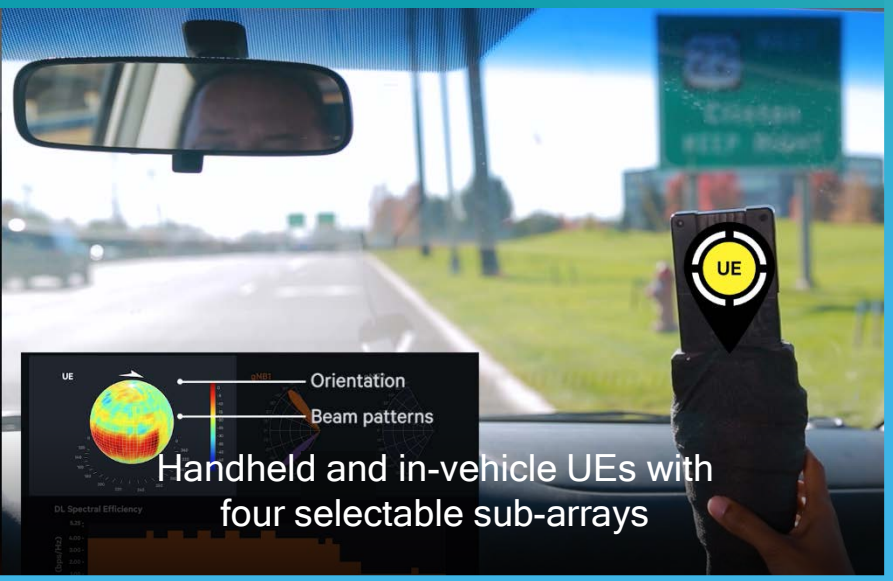
Faster, more uniform data rates both outdoor and indoor



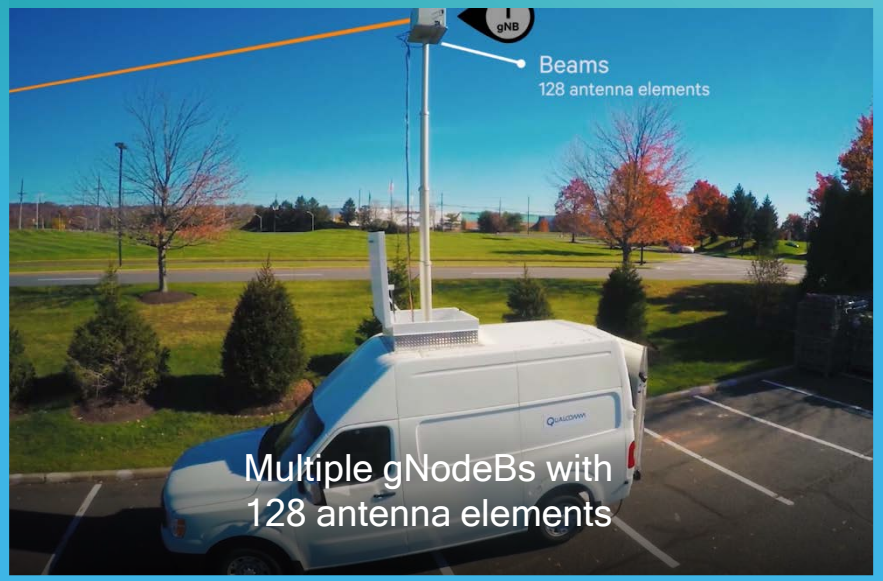
Self-contained TDD operation

Mobilizing 5G mmWave in real-world environments

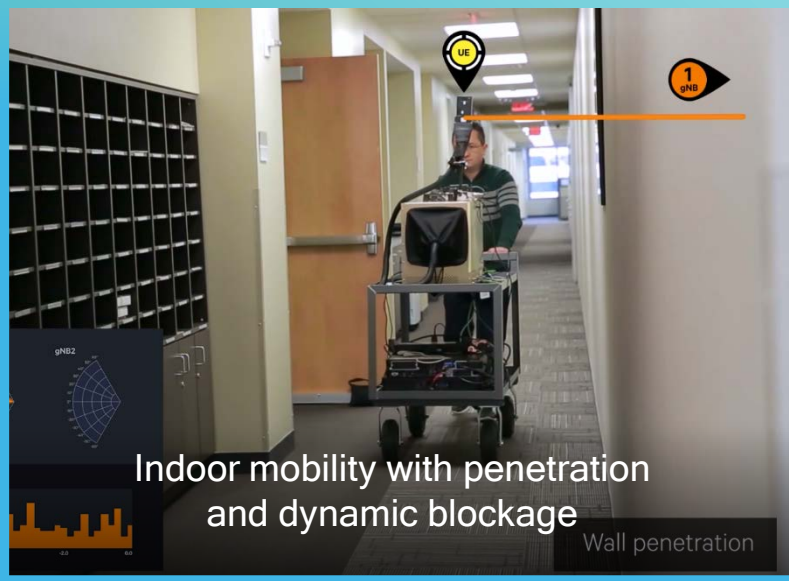
Demonstrating NLOS operation and robust mobility



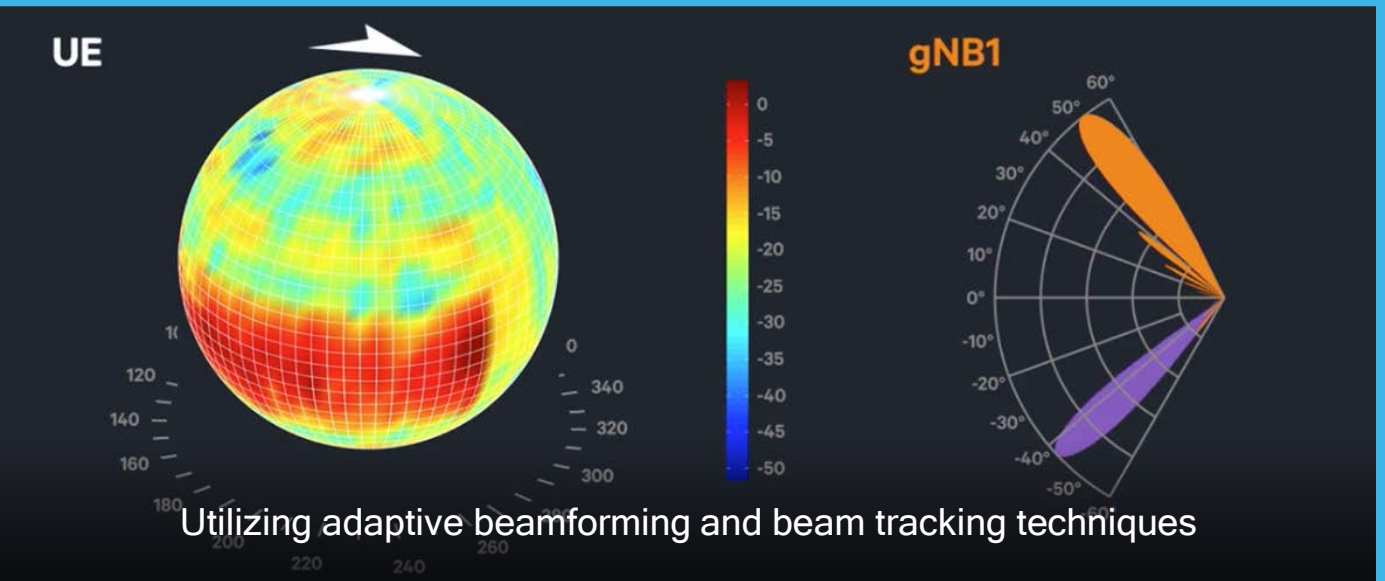
Handheld and in-vehicle UEs with four selectable sub-arrays



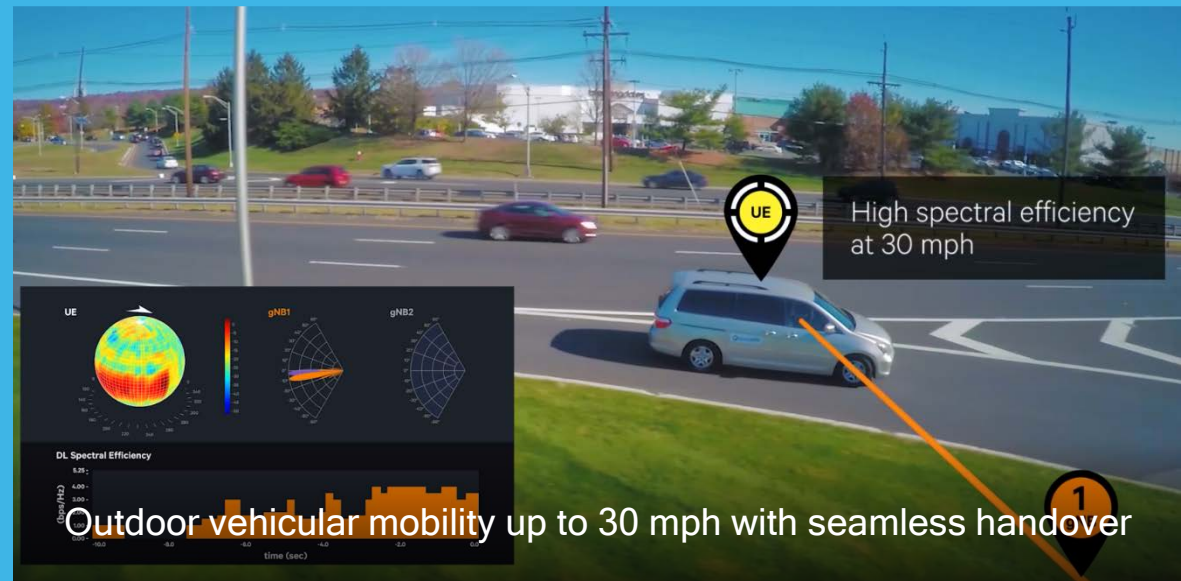
Multiple gNodeBs with 128 antenna elements



Indoor mobility with penetration and dynamic blockage



Utilizing adaptive beamforming and beam tracking techniques



Outdoor vehicular mobility up to 30 mph with seamless handover

Leading the way on 5G NR trials to accelerate deployments

Starting 2nd half of 2017 in collaboration with operators and infrastructure vendors

3GPP-compliant trials
and interoperability testing
at sub-6 GHz & mmWave

5G
NR

In collaboration with...

at&t

中国移动 China Mobile

NTT docomo

SK telecom

vodafone

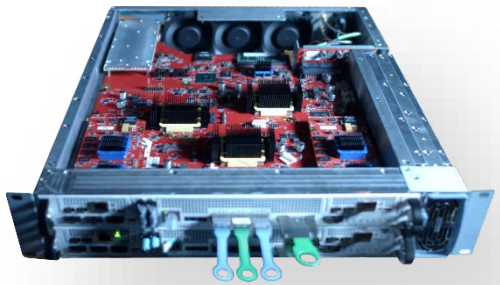
ERICSSON

ZTE中兴

...and more to come

We are accelerating the path to 5G NR

Best-in-class 5G prototype systems and testbeds



Test, demonstrate and verify our innovative 5G designs to contribute to and drive standardization

5G standards, technology and research leadership

3GPP™ A GLOBAL INITIATIVE

Such as advanced channel coding, self-contained subframe, mobilizing mmWave, …

Impactful trials and early deployments with network operators

Over-the-air interoperability testing leveraging prototype systems and our leading global network experience

Modem and RFFE leadership to solve 5G complexity

Qualcomm Snapdragon X50 5G Modem Family

Announced the world's first 5G NR multimode modems for premium smartphones in 2019

Learn more at www.qualcomm.com/5G

Thank you

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