



# Making 5G NR a reality

Silicon Valley 5G Summit

Mountain View, CA | October 19<sup>th</sup>, 2017

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**Tingfang Ji**

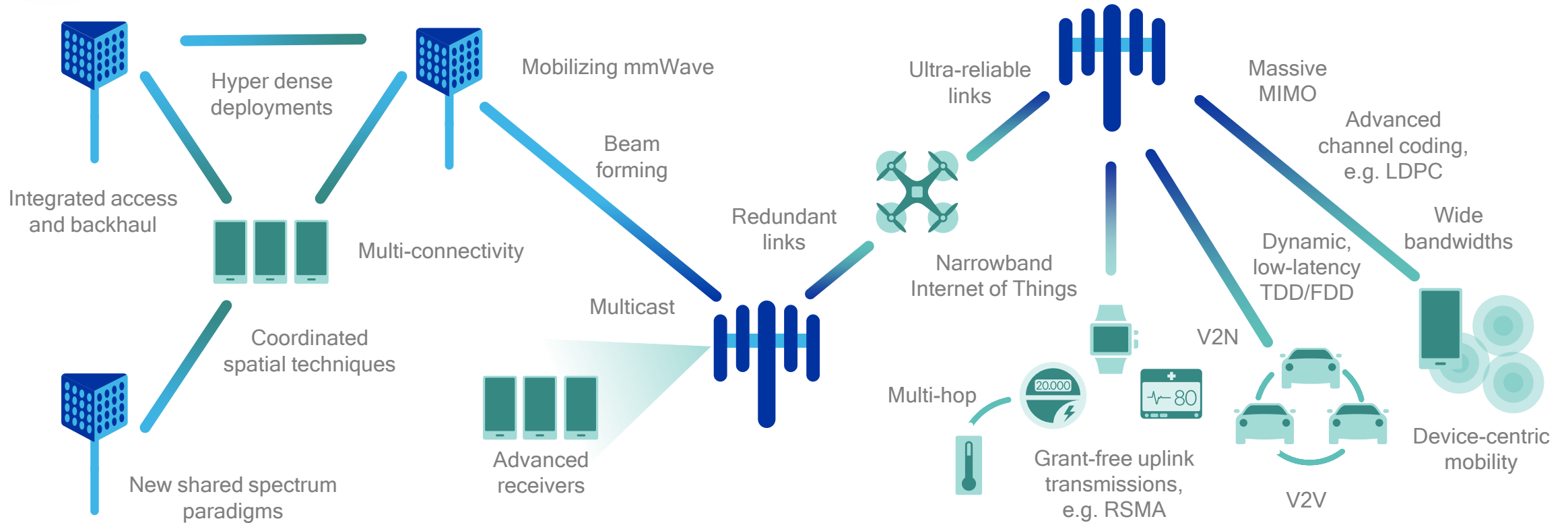
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# Designing a unified, more capable 5G air interface for the next decade & beyond



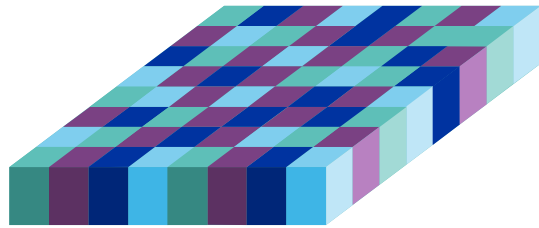
Scalability to address diverse services & devices

Unified design across diverse spectrum bands & types

Adaptable to diverse deployments & topologies

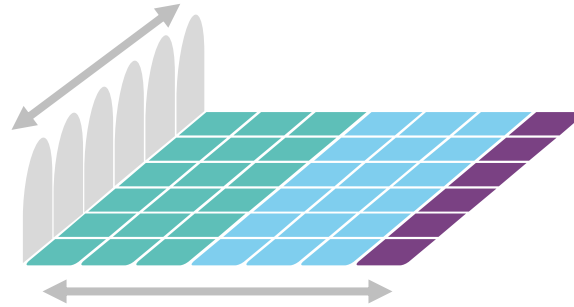
# 5G NR R15 is establishing the 5G foundation

For enhanced mobile broadband and beyond



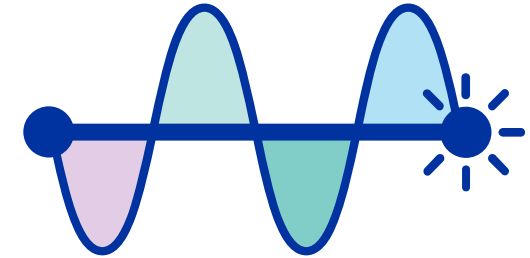
## Optimized OFDM-based waveforms

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

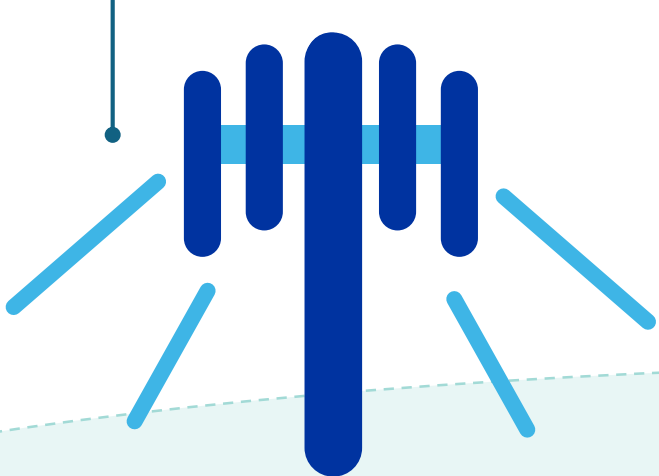
Unified design across spectrum types and bands

For licensed and shared / unlicensed spectrum bands both below 6 GHz and above 6 GHz<sup>1</sup>

# 5G NR Massive MIMO to increase coverage and capacity

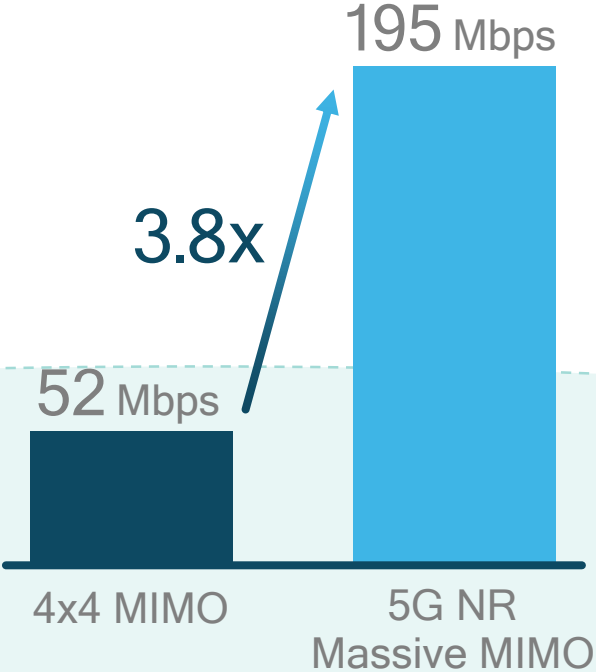
Allows reuse of existing sites and same transmit power at e.g. 4 GHz

Exploit 3D beamforming with up to 256 antenna elements

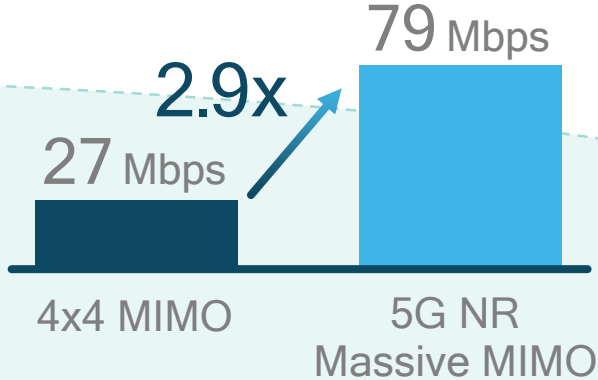


200m inter-site distance  
48 dBm transmit power

Median user perceived throughput



Cell edge user perceived throughput

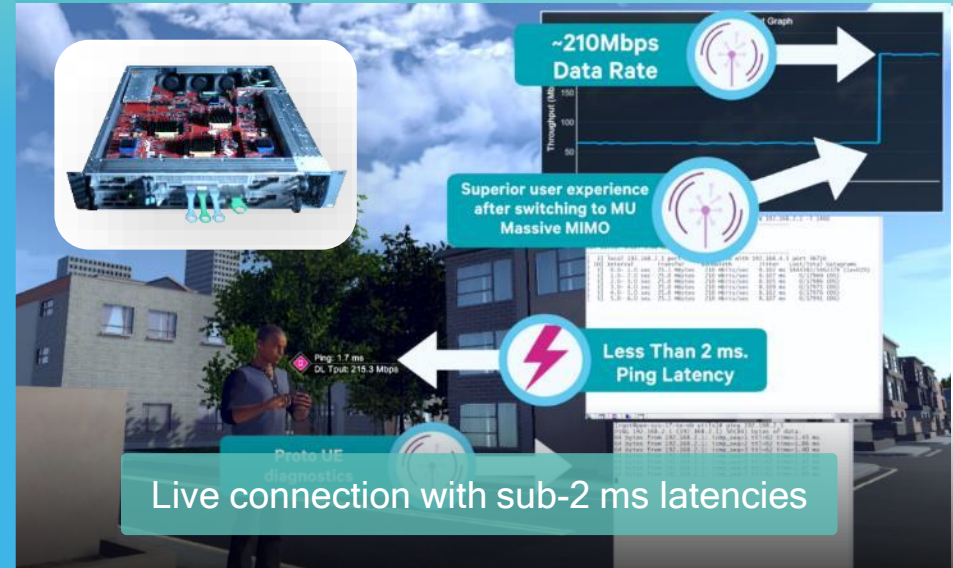
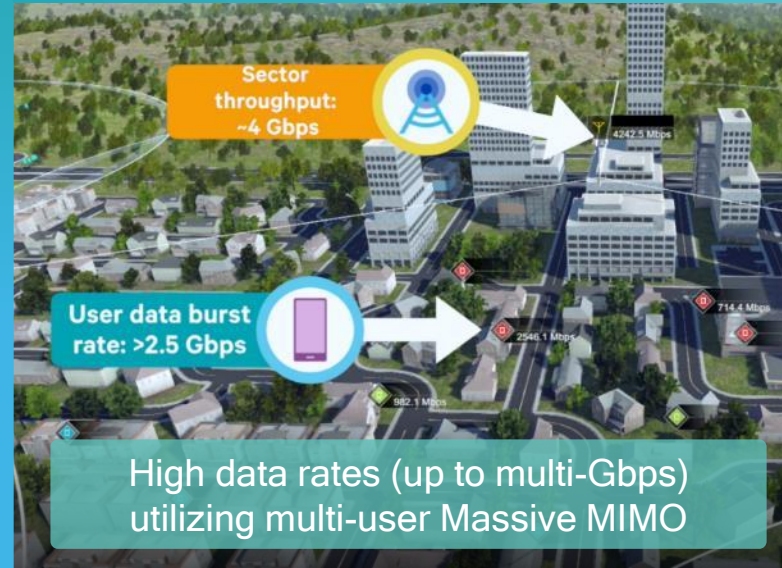


Assumptions: carrier frequency 4GHz; total bandwidth: 200MHz; base station: 256 antenna elements (x-pol), 48dBm Tx power over 200MHz; UE: 4 Tx/Rx antenna elements, 23dBm max. Tx power; full buffer traffic model, 80% indoor and 20% outdoor UEs.



# Qualcomm Research 5G NR Sub-6 GHz Demonstration

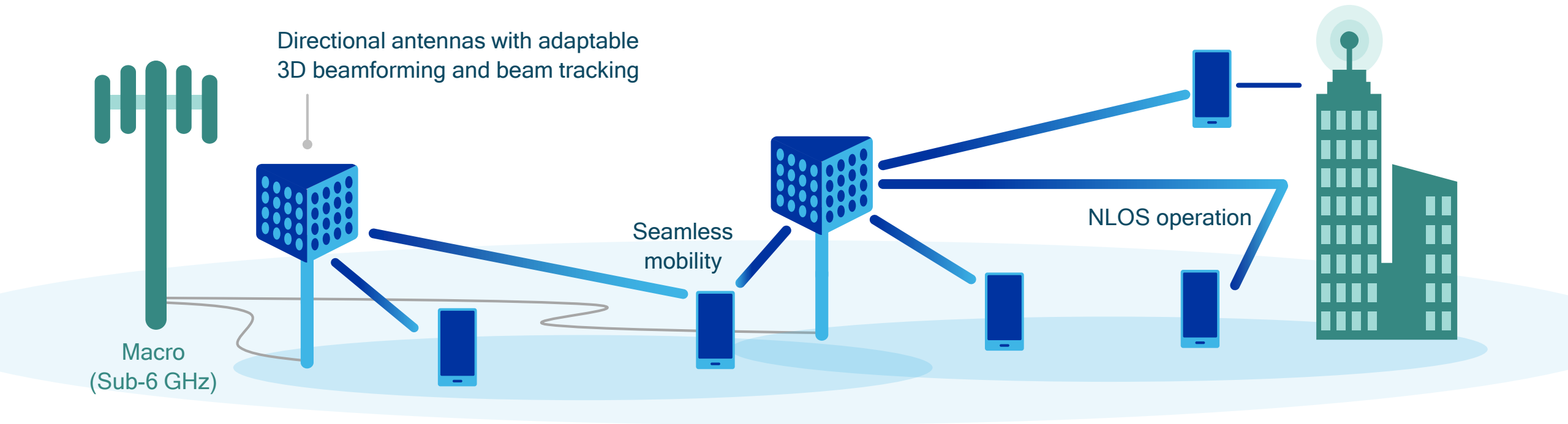
Showcasing 5G NR technologies to achieve multi-Gbps at ultra-low latency





# Mobilizing mmWave with 5G NR technologies

## Key properties for robust mmWave operation in a NLOS mobile environment



Very dense network topology and spatial reuse (~150-200m ISD)

Fast beam steering and switching within an access point

Architecture that allows for fast beam switching across access points

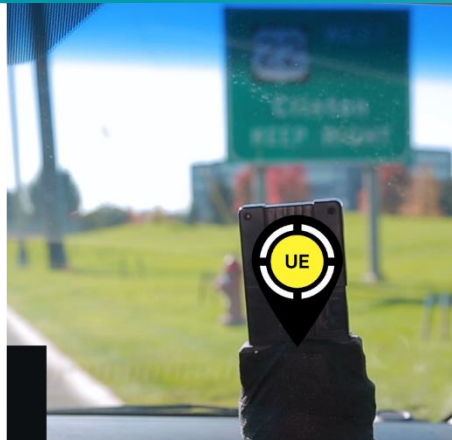
Tight integration with sub-6 GHz (LTE or NR)

# Qualcomm Research 5G mmWave OTA testing

Showcasing robust mobile communications in real-world environments



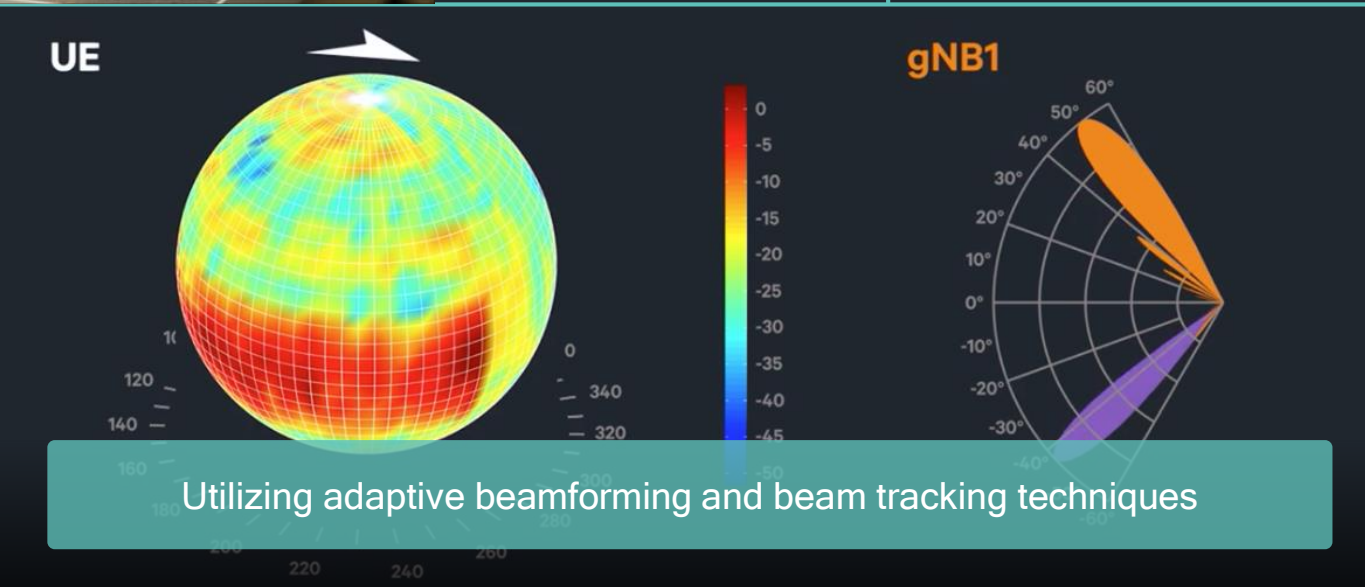
Handheld and in-vehicle UEs with hand-blocking



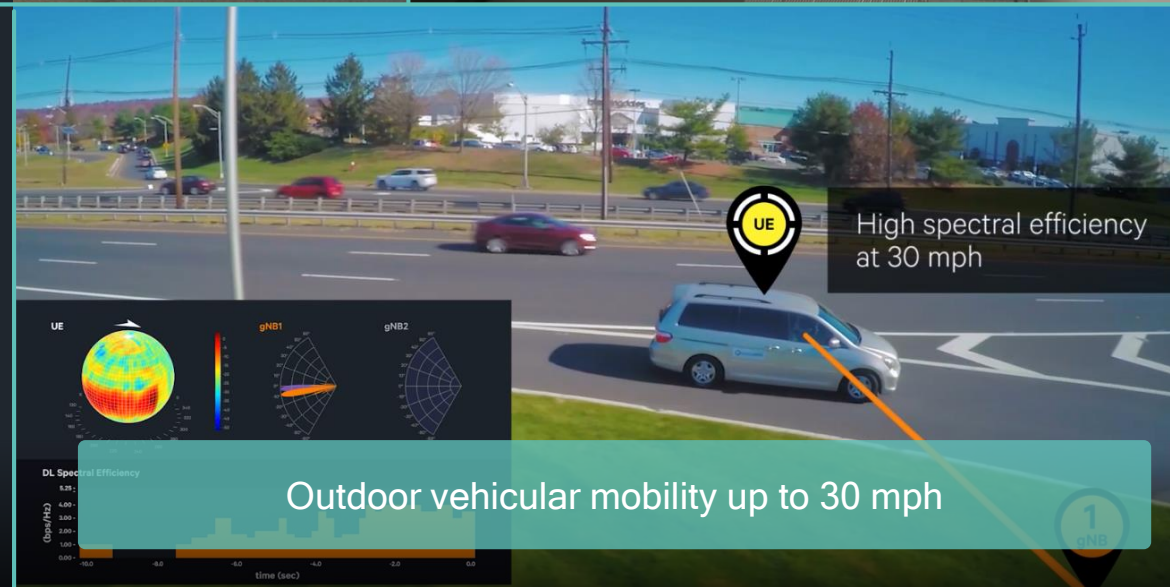
Multiple gNodeBs with seamless handovers



Indoor mobility with wall penetration and dynamic blocking



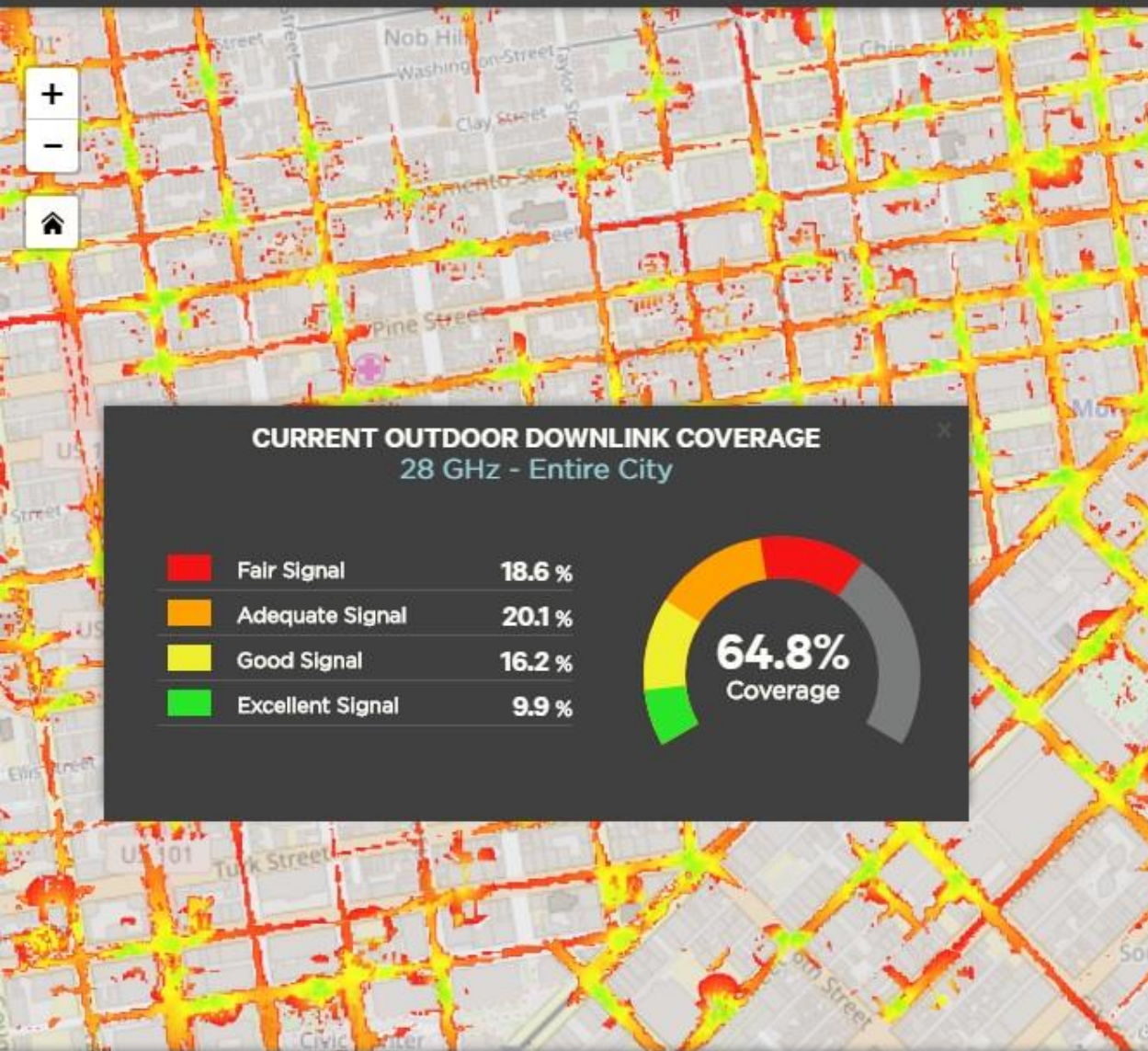
Utilizing adaptive beamforming and beam tracking techniques



High spectral efficiency at 30 mph

Outdoor vehicular mobility up to 30 mph





Working with global network operators to simulate 5G NR mmWave network coverage

Showcases significant outdoor coverage possible utilizing existing LTE sites (10+ global cities)

Outdoor coverage only; frees up sub-6 GHz resources for out-to-indoor capacity

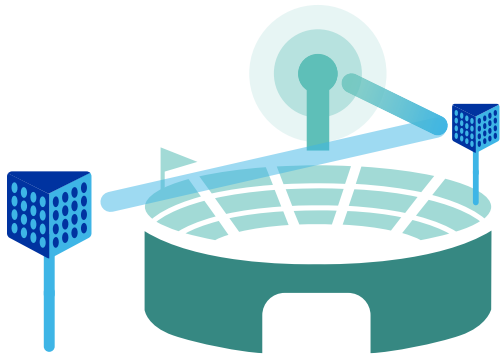
San Francisco simulation demoed at MWC Americas 2017

Outdoor coverage can be complemented with targeted indoor deployments – stay tuned for upcoming study



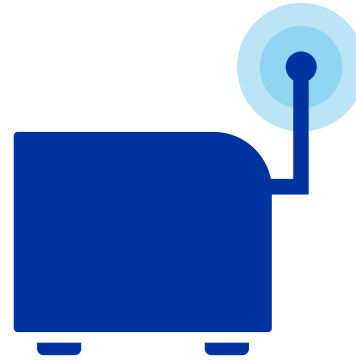
# 5G NR mmWave continuing to evolve beyond R15

Bringing new capabilities, new spectrum bands and new deployment opportunities



## Integrated Access & Backhaul

Rel-15 Study Item on enabling easy/low-cost deployment of small cells using mmWave spectrum for access and backhaul



## Unlicensed Spectrum

Rel-15 Study Item for both LAA and standalone operation (aka 5G MulteFire™) in sub-6 GHz and mmWave spectrum bands



## Higher spectrum bands

Exploring the use of spectrum bands above ~40 GHz, including unlicensed spectrum in the 57 GHz to 71 GHz band

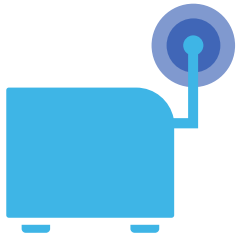
# 5G NR evolution and expansion beyond eMBB

URLLC part of Rel-15 Work Item; also new Rel-15 5G NR Study Items approved



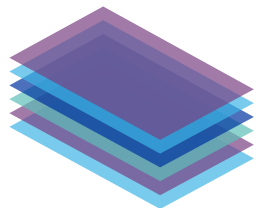
## Work on 5G NR Ultra-Reliable Low Latency Communications<sup>1</sup>

For mission-critical control services like industrial automation, incl. efficient multiplexing with mobile broadband



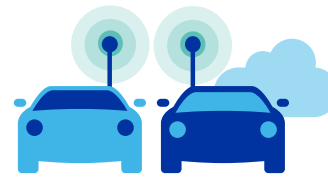
## Study on 5G NR operation in unlicensed spectrum

For both licensed-assisted access (aka LAA) and standalone operation (aka MulteFire™) in sub-6 GHz and mmWave spectrum bands



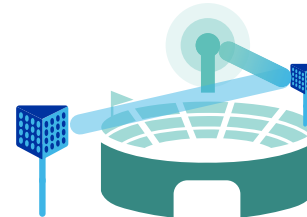
## Study on 5G NR non-orthogonal multiple access, e.g. RSMA<sup>2</sup>

For grant-free uplink transmissions that can be utilized e.g. for small data exchanges in IoT communications



## Evaluation of 5G NR for C-V2X communications

For augmenting today's C-V2X technology with use of high-frequency ITS bands



## Study on 5G NR Integrated Access & Backhaul

For enabling easy/low-cost deployment of small cells with integrated access and backhaul



## Study on 5G NR for non-terrestrial networks

Explore deployment scenarios and channel models for utilizing 5G NR for satellite operation



# Making 5G NR a commercial reality in 2019

Best-in-class 5G prototype systems and testbeds



5G standards, technology and research leadership



Interoperability testing and trials with network operators



Modem and RFFE leadership to solve 5G complexity



Qualcomm Snapdragon X50 5G Modem Family

To test, demonstrate & verify our innovative 5G NR designs

Our technology inventions are driving the 5G NR standard

Leading the way on 5G NR IoTs and trials starting 2H-17

Announced world's first 5G NR multimode modems for 2019



# Thank you

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