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MWC Shanghai  
5G Network Forum

Qualcomm

# A deep dive into 5G NR mmWave's commercialization in 2019 and beyond

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# A unifying connectivity fabric for future innovations

Like electricity, you will just expect it everywhere



Multi-gigabit speed



Scalable to extreme simplicity



Ultra-low latency



Virtually unlimited capacity



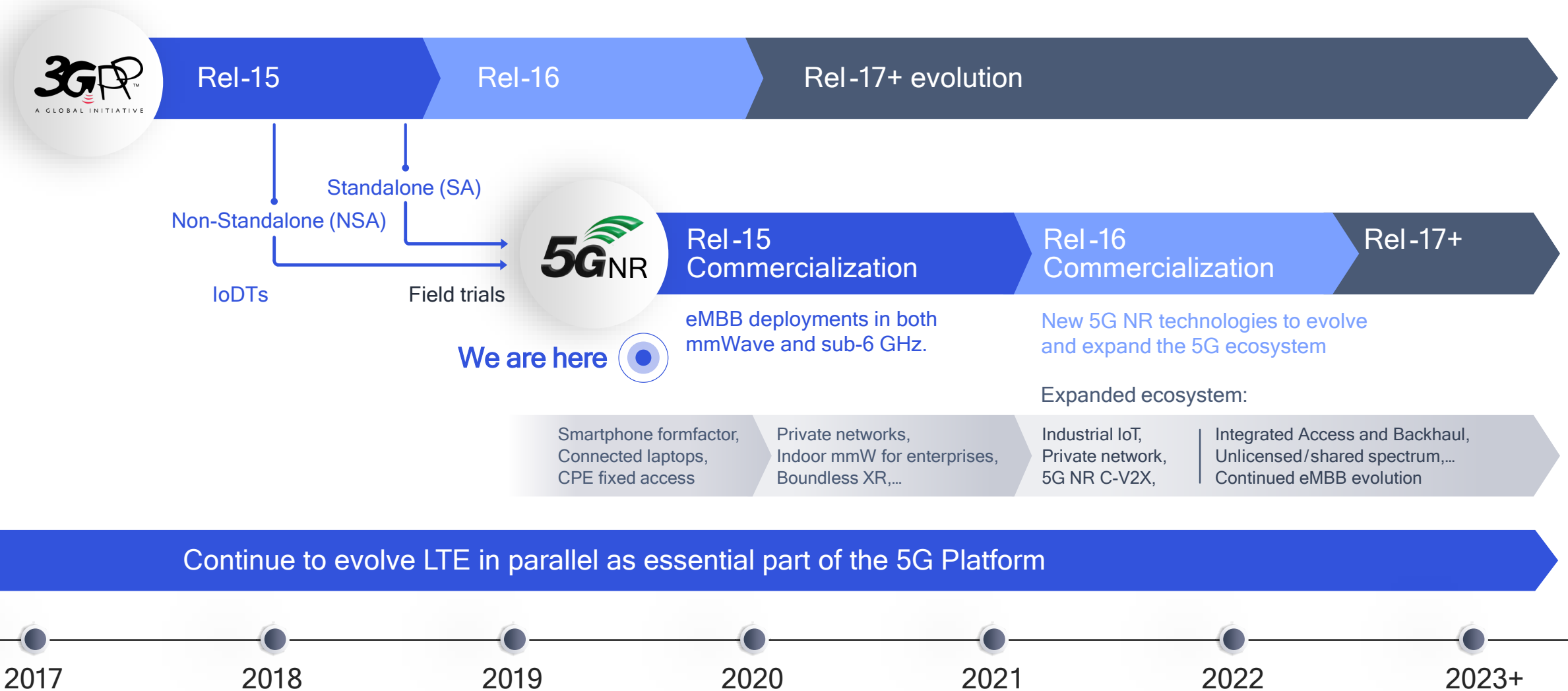
Extreme reliability

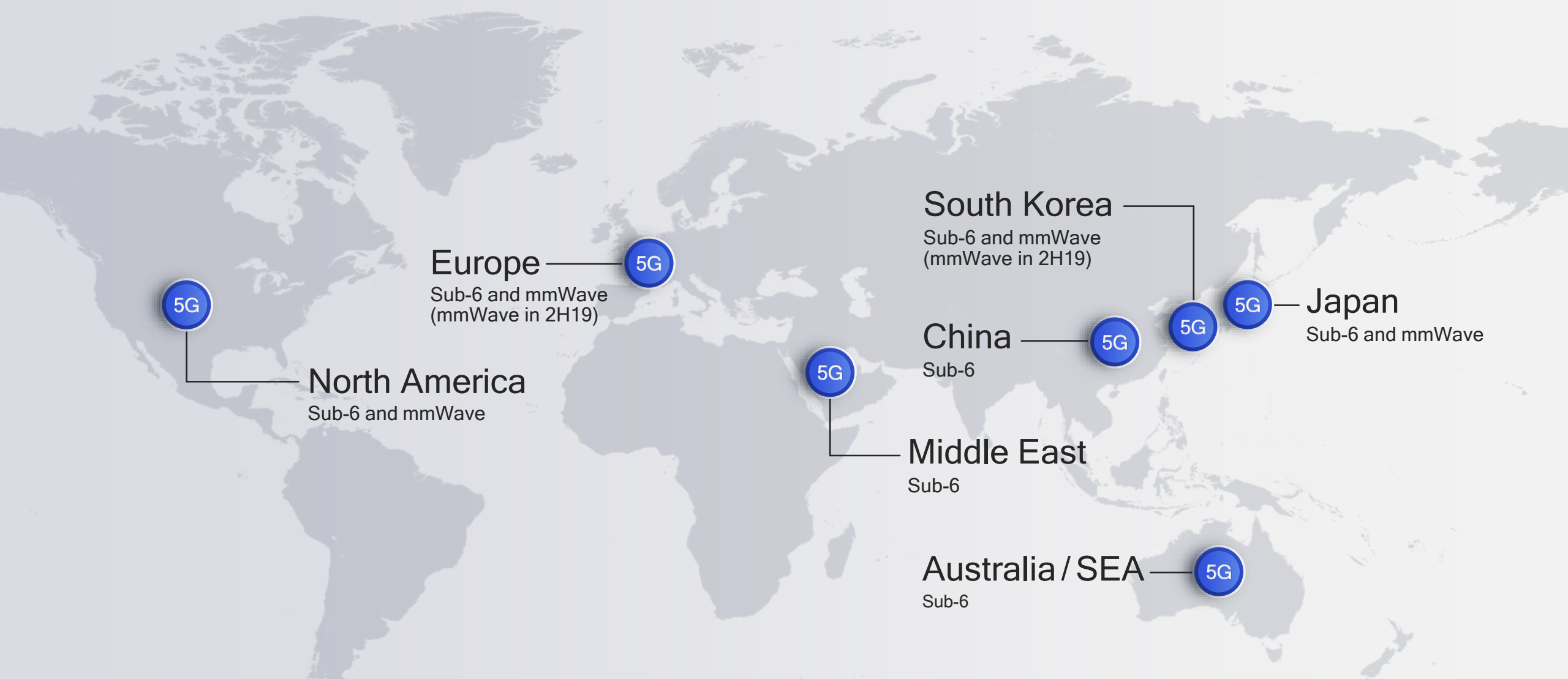


On-device intelligence



# Driving the 5G roadmap and ecosystem expansion





2019 is the year of 5G

Deployments happening in regions across the globe



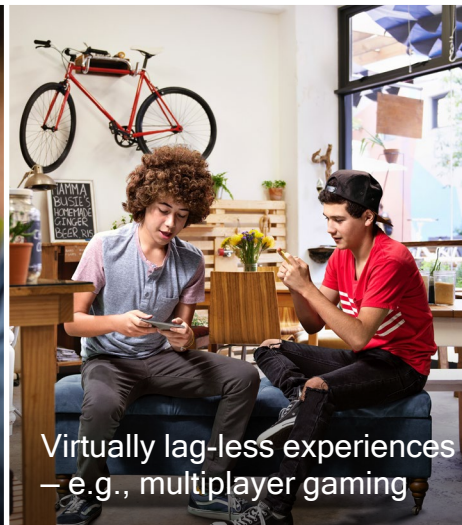
Rich media and entertainment for outdoor – augmenting lower bands



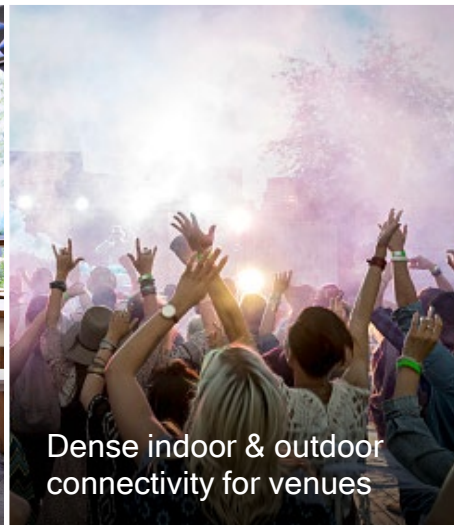
More indoor capacity as outdoor mmWave offloads outdoor lower bands



Massive bandwidth for cloud computing



Virtually lag-less experiences – e.g., multiplayer gaming



Dense indoor & outdoor connectivity for venues



New indoor opportunities – e.g., connected enterprises



Fiber-like broadband to the home – fixed mmWave



Beyond smartphones – e.g., smart manufacturing



# 5G NR mmWave will support new and enhanced mobile experiences

- Fiber-like data speeds
- Low latency for real-time interactivity
- Massive capacity for unlimited data plan
- Lower cost per bit

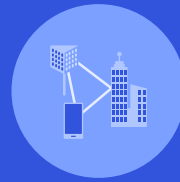
# We are overcoming the mobile mmWave challenge

Proving the skeptics wrong about mmWave can never be used for mobile



## Limited coverage and too costly

Significant path loss means coverage limited to just a few hundred feet, thus requiring too many small cells



## Significant coverage with co-siting

Analog beamforming w/ narrow beam width to overcome path loss. Comprehensive system simulations reusing existing sites.



## Works only line-of-sight (LOS)<sup>1</sup>

Blockage from hand, body, walls, foliage, rain etc. severely limits signal propagation



## Operating in LOS and NLOS<sup>1</sup>

Pioneered advanced beamforming, beam tracking leveraging path diversity and reflections.



## Only viable for fixed use

As proven commercial mmWave deployments are for wireless backhubs and satellites



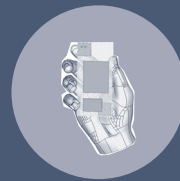
## Supporting robust mobility

Robustness and handoff with adaptive beam steering and switching to overcome blockage from hand, head, body, foliage.



## Requiring large formfactor

mmWave is intrinsically more power hungry due to wider bandwidth with thermal challenges in small formfactor



## Commercializing smartphone

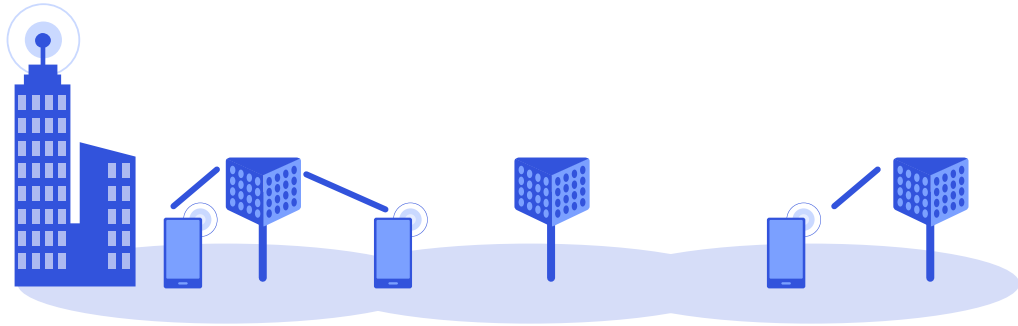
Announced modem, RF, and antenna products to meet formfactor and thermal constraints, plus device innovations.

<sup>1</sup> LOS: Line of sight, NLOS: Non-line-of-sight

# 5G NR mmWave is bringing new waves of opportunities

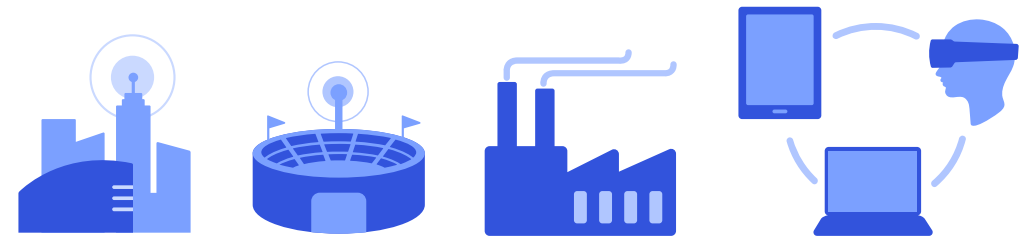
## For outdoor deployments...

- Significantly elevate today's mobile experiences – initially focusing on smartphones
- Deployments predominantly driven by mobile operators – initially focusing on dense urban



## For indoor deployments...

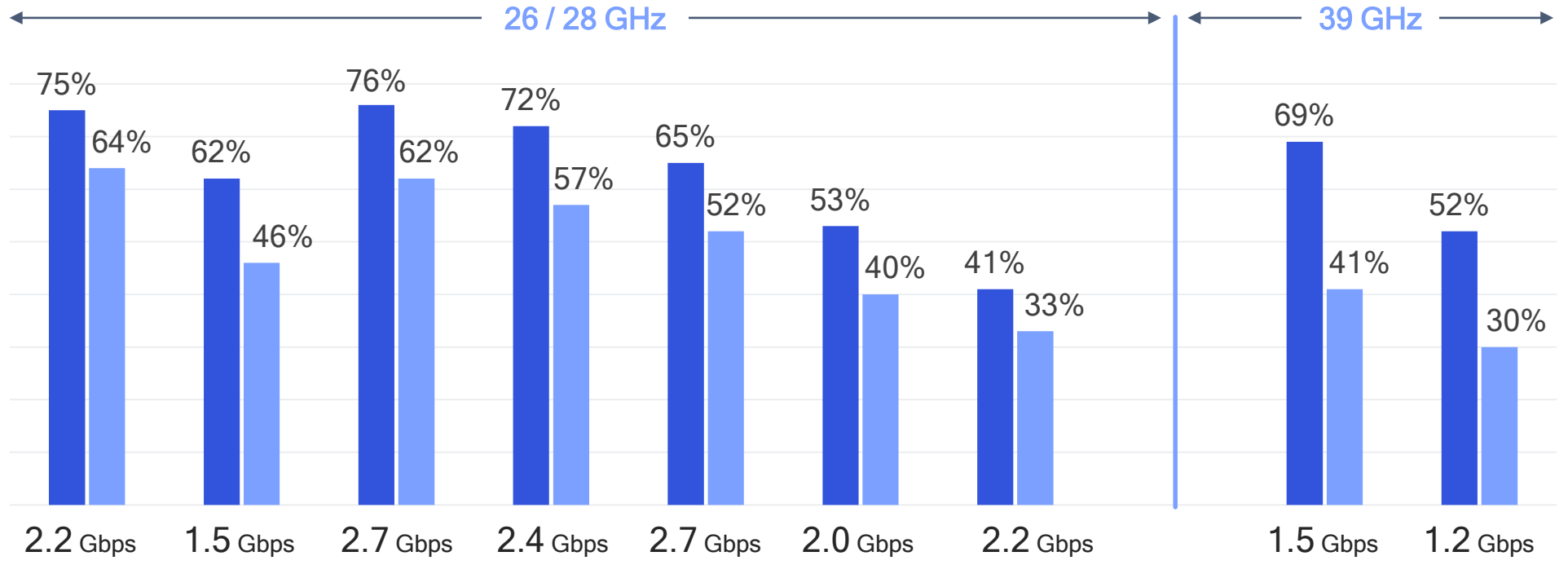
- Complementing existing wireless services provided by Wi-Fi – also expanding to new device types
- Bringing superior speeds and virtually unlimited capacity for enhanced experiences



Creating value for the mobile ecosystem

Operators, service providers, venue owners, infra vendors, device OEMs, ...

Downlink  
Uplink  
Coverage %  
Co-siting with LTE



Median Downlink  
Burst Rate (Gbps)

Site density  
(per km<sup>2</sup>)

Total  
Macro  
Small

City	US City 1	US City 2	Korean City 1	Hong Kong	Japan City 1	Russia City 1	Europe City 1	US City 1	US City 2
Total	48	36	41	39	28	26	28	48	36
Macro	0	8	33	39	28	26	7	0	8
Small	48	28	8	0	0	0	21	48	28

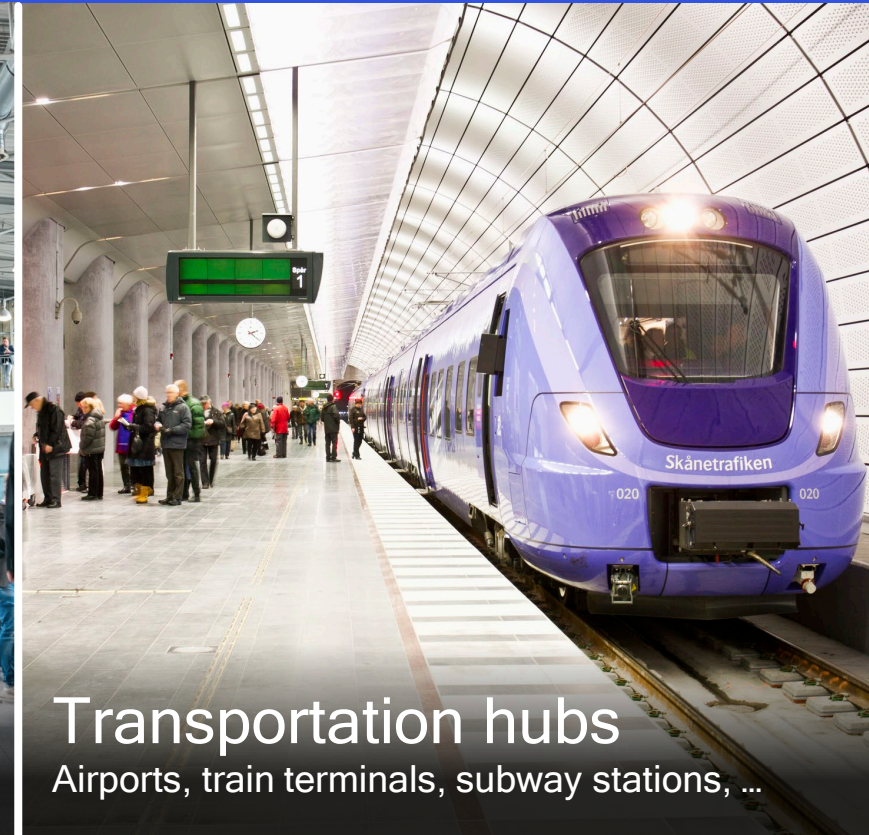
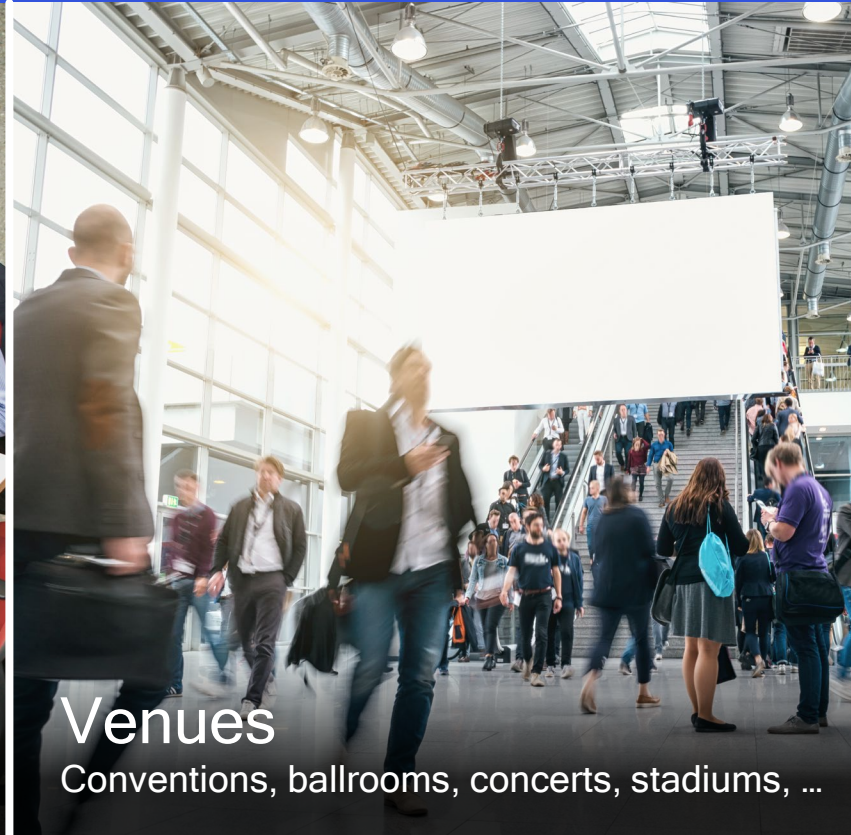
Simulations assumptions: Based on MAPL (maximum allowable path loss) analysis with ray tracer propagation model and city/area specific models; minimum 0.4 bps/Hz and 0.2 bps/Hz for downlink data and control, out-to-out coverage only; Using 800 MHz DL bandwidth and 100 MHz uplink bandwidth with 7:1 DL:UL TDD

Significant 5G NR mmWave outdoor coverage via co-siting  
Simulations based on over-the-air testing and channel measurements



# Extending 5G NR mmWave to indoor deployments

For new and enhanced experiences complementing existing Wi-Fi services



Bringing multi-Gigabit speed, low latency, and virtually unlimited capacity



Supporting devices beyond smartphones – tablets, XR, always-connected laptops



Leveraging existing Wi-Fi or cellular infrastructure by co-siting small cells

# 5G NR mmWave boosts performance in Enterprise networks



Downlink/uplink coverage  
comparable to Wi-Fi with 1:1  
or partial co-site



Realize multi-Gigabit burst rate  
with wider bandwidths  
(e.g., 800 MHz)



Complement indoor Wi-Fi  
deployments

Coverage simulation based on MAPL (maximum allowable path loss) analysis with ray tracer propagation model and measured material and propagation loss; minimum 0.4/0.1 bps/Hz for downlink/uplink data and control; 2 Maximum Allowable Path Loss; DL: 115 dB, UL 117 dB 3 Using 800 MHz DL bandwidth and 100 MHz uplink bandwidth with 7:1 DL:UL TDD



Total Area: ~27.6k ft<sup>2</sup>



Existing Wi-Fi access point locations – co-sited with 5G NR mmWave antenna locations

## Complete coverage at 28 GHz<sup>1</sup> at Qualcomm headquarters

- ~98% Downlink coverage with 1:1 co-siting
- ~99% Uplink coverage with 1:1 co-siting
- 5 Gbps downlink median burst rate<sup>3</sup>

# 5G NR mmWave for convention centers

Co-siting 5G NR mmWave gNodeB antennas with existing Wi-Fi access points

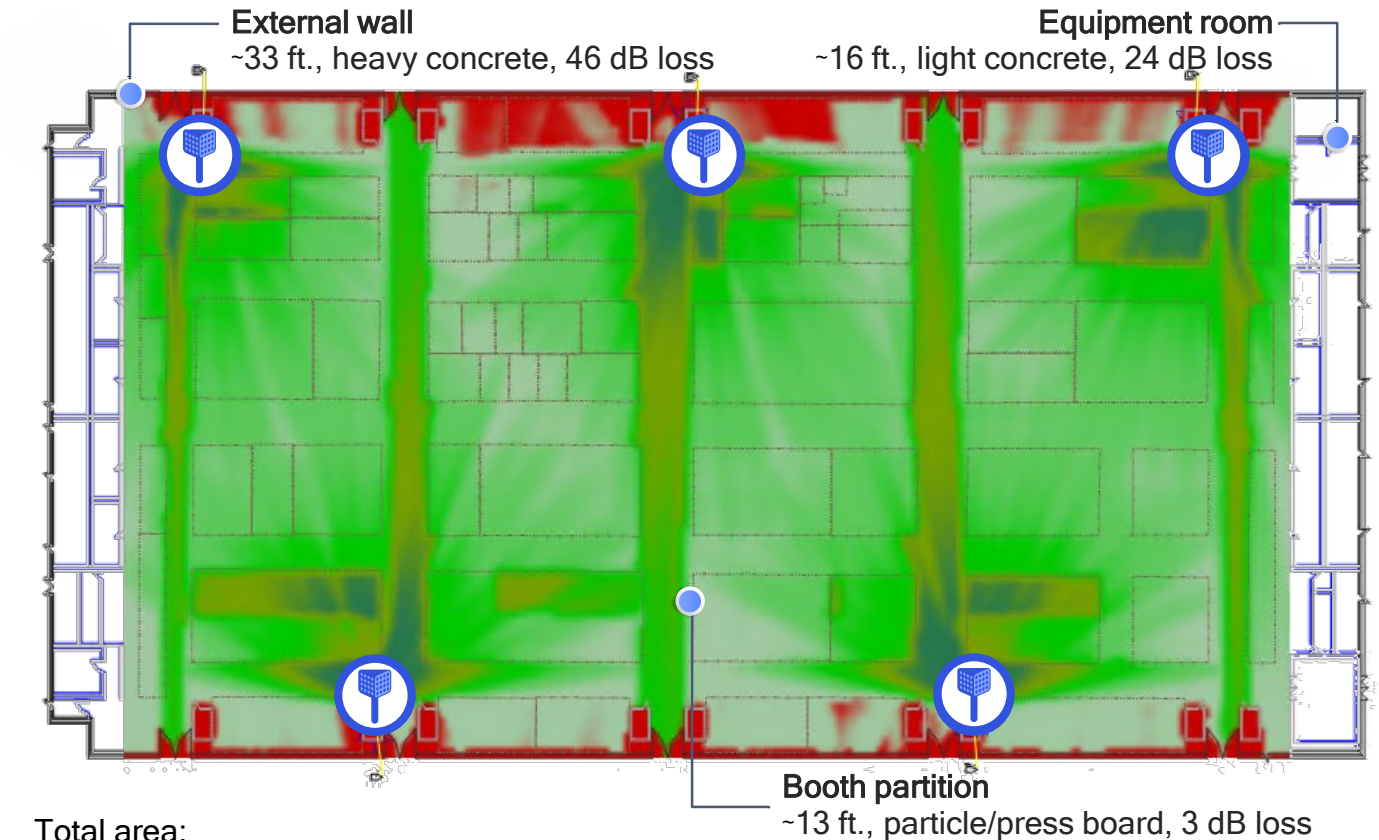
Achieving significant coverage at 28 GHz<sup>1</sup>

- Downlink coverage of ~87% with 115 dB MAPL<sup>2</sup>
- Uplink coverage of ~92% with 117 dB MAPL

Realizing multi-gigabit user experience<sup>3</sup>

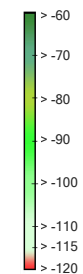
- Downlink median burst rate of 1.5 Gbps

<sup>1</sup> Coverage simulation based on MAPL (maximum allowable path loss) analysis with ray tracer propagation model and measured material and propagation loss; minimum 0.4/0.1 bps/Hz for downlink/uplink data and control; <sup>2</sup> Maximum Allowable Path Loss; <sup>3</sup> Using 400 MHz DL bandwidth and 100 MHz uplink bandwidth with 7:1 DL:UL TDD



Total area:  
~180k sq. ft.

Path loss (dB)



Existing Wi-Fi APs mounted on ceiling at 20 ft.



Co-sited 5G NR mmWave antenna locations  
(each 128 x 2 elements & 16 horizontal beams)

# 5G NR mmWave for underground subway stations

Co-siting 5G NR mmWave gNodeB antennas with existing LTE DAS or Wi-Fi access points

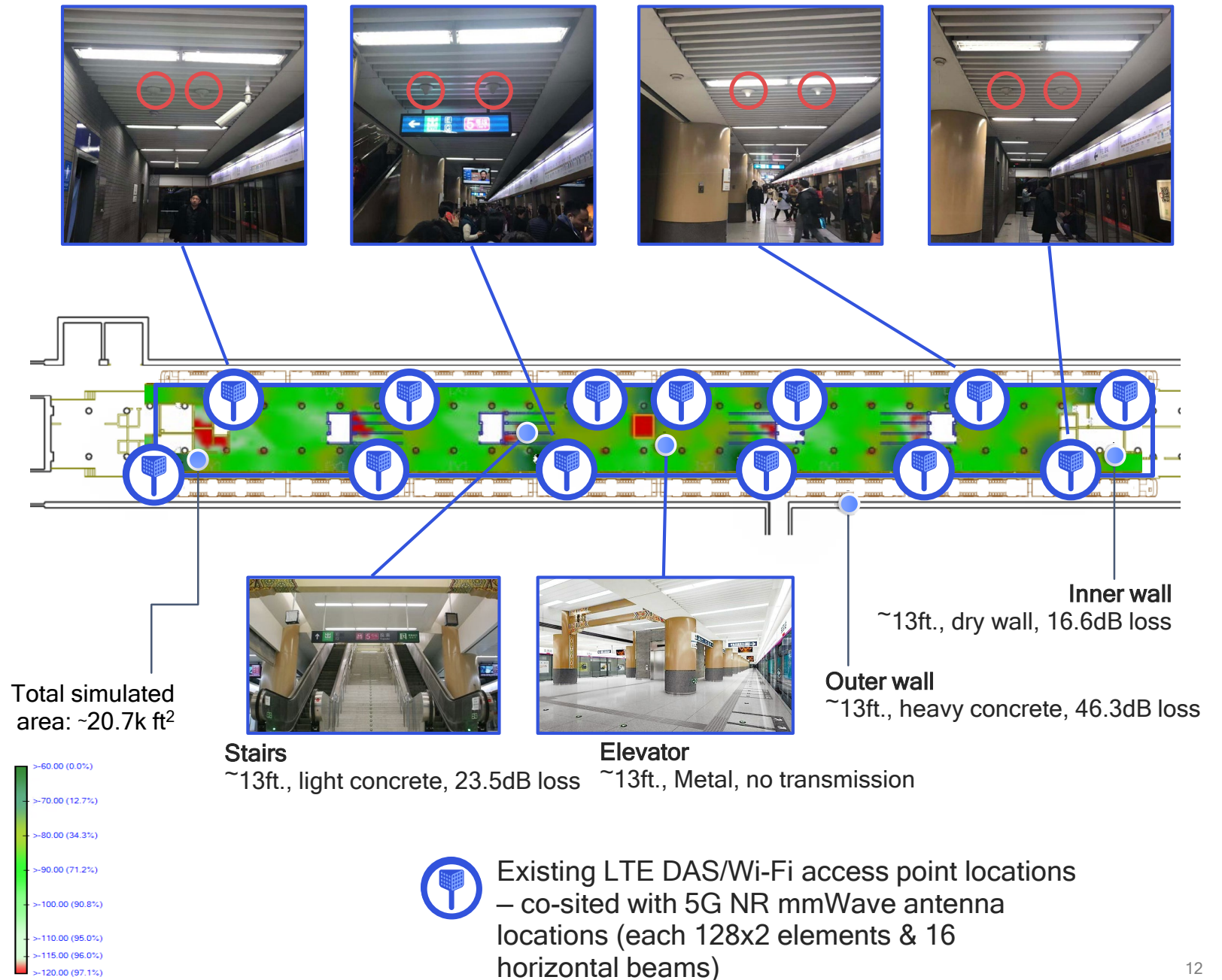
Achieving significant coverage at 28 GHz<sup>1</sup>

- Downlink coverage of ~96% with 115 dB MAPL<sup>2</sup>
- Uplink coverage of ~97% with 117 dB MAPL

Realizing multi-gigabit user experience<sup>3</sup>




- Downlink median burst rate of ~4.6 Gbps

1 Coverage simulation based on MAPL (maximum allowable path loss) analysis with ray tracer propagation model and measured material and propagation loss; minimum 0.4/0.1 bps/Hz for downlink/uplink data and control; 2 Maximum Allowable Path Loss; 3 Using 800 MHz DL bandwidth and 100 MHz uplink bandwidth with 7:1 DL:UL TDD





# Thank you!

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