

eBRIEF

Mobile mmWave Is Here — and Indoor Deployment Opportunities Abound



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In the mobile industry, 4G is on the threshold of giving way to much-anticipated next-generation 5G mobile experiences. Fiber-like data speeds, ultra-low latency for real-time interactivity, more consistent performance, and massive capacity for unlimited data plans await wireless operators.

Consumers' insatiable appetite for mobile broadband has put significant demands on mobile networks that only 5G can answer. To deliver on the full potential of 5G, mobile operators not only need to use spectrum more efficiently, but they also need access to new spectrum. This is where 5G New Radio (NR) Millimeter Wave (mmWave) comes in. It opens up a large-bandwidth opportunity that is an order of magnitude bigger and wider than what LTE and 5G NR sub-6 GHz spectrum can deliver.

The promise of 5G is indeed becoming a commercial reality in 2019, as global mobile operators and device manufacturers start to launch 5G NR mmWave networks and devices, including smartphones, data cards, laptops, and fixed wireless CPEs. In many regions of the world, 5G NR mmWave deployments are poised to deliver massive capacity and multigigabit-per-second, low-latency connectivity for a wide range of new and enhanced mobile use cases. In the U.S., for example, Verizon switched on its first 5G network in parts of Chicago and Minneapolis in early April and has since then added more cities to its mmWave coverage.

Fixed, line-of-sight (LOS) wireless communications have used mmWave bands for quite some time. But mmWave hasn't traditionally been feasible for mobile communications because of its challenging propagation characteristics, susceptibility to blockage, and power and thermal



constraints. That is, until recently when 5G NR innovations shattered the mmWave limitations. Led by Qualcomm Technologies, the following innovations and deployment techniques made mobilizing mmWave possible:

- **Achieving significant coverage with LTE co-siting.** Analog beamforming compensates for much of the path loss associated with mmWave, and leveraging existing infrastructure helps to drive down network deployment cost.
- **Supporting LOS and non-line-of-sight (NLOS) coverage.** Advances in beamforming and beam tracking that use multiple signal paths and signal reflections overcome hand blocking and other LOS issues.
- **Supporting robust mobility.** Robustness and handoff with adaptive beam steering and switching overcome blockage by hands, head, body, foliage, walls, etc.
- **Commercializing the smartphone.** Qualcomm Technologies has announced modems (Snapdragon™ X50 and X55) and RFFE solutions (QTM052 and QTM525) that support mmWave and meet size, power, and thermal requirements of smartphones and other mobile form factor devices.

In addition to supporting smartphones for wide-area, outdoor use cases, 5G NR mmWave can also complement existing Wi-Fi services for indoor deployments, providing enhanced user experiences for a wider set of use cases and devices, such as connected laptops and tablets. 5G NR mmWave will not only provide these devices a boost in performance but also virtually seamless indoor and outdoor wireless connectivity.

Mobile mmWave Ideal for Indoor Deployments

More than 80% of mobile data traffic originates or terminates indoors, according to a market study conducted by ABI Research. Many of these indoor environments are user- and connectivity-dense with high bandwidth requirements. For wireless operators, service providers, and venue owners, mobile mmWave brings a plethora of indoor business opportunities.

Topping the list of indoor use cases: crowded venues such as convention centers and stadiums, transportation hubs such as airports and train stations, and enterprise spaces such as offices, meeting rooms, and shop floors. With mmWave's significantly wider

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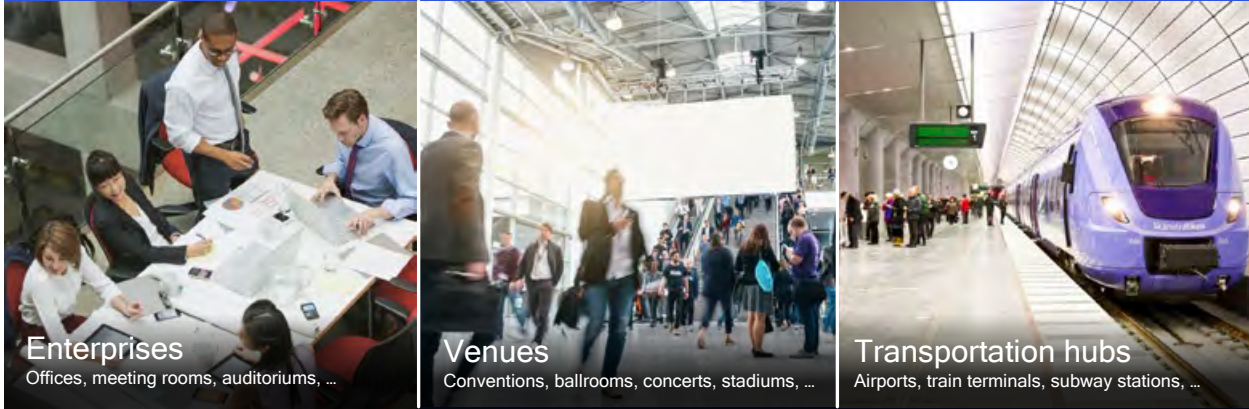
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bandwidth and high spatial multiplexing gains, mobile operators can offer multigigabit, low-latency connectivity to a large number of users.

Extending 5G NR mmWave to indoor deployments


For new and enhanced experiences complementing existing Wi-Fi services





Enterprises
Offices, meeting rooms, auditoriums, ...

Venues
Conventions, ballrooms, concerts, stadiums, ...

Transportation hubs
Airports, train terminals, subway stations, ...

 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

Source: Qualcomm Technologies, Inc.

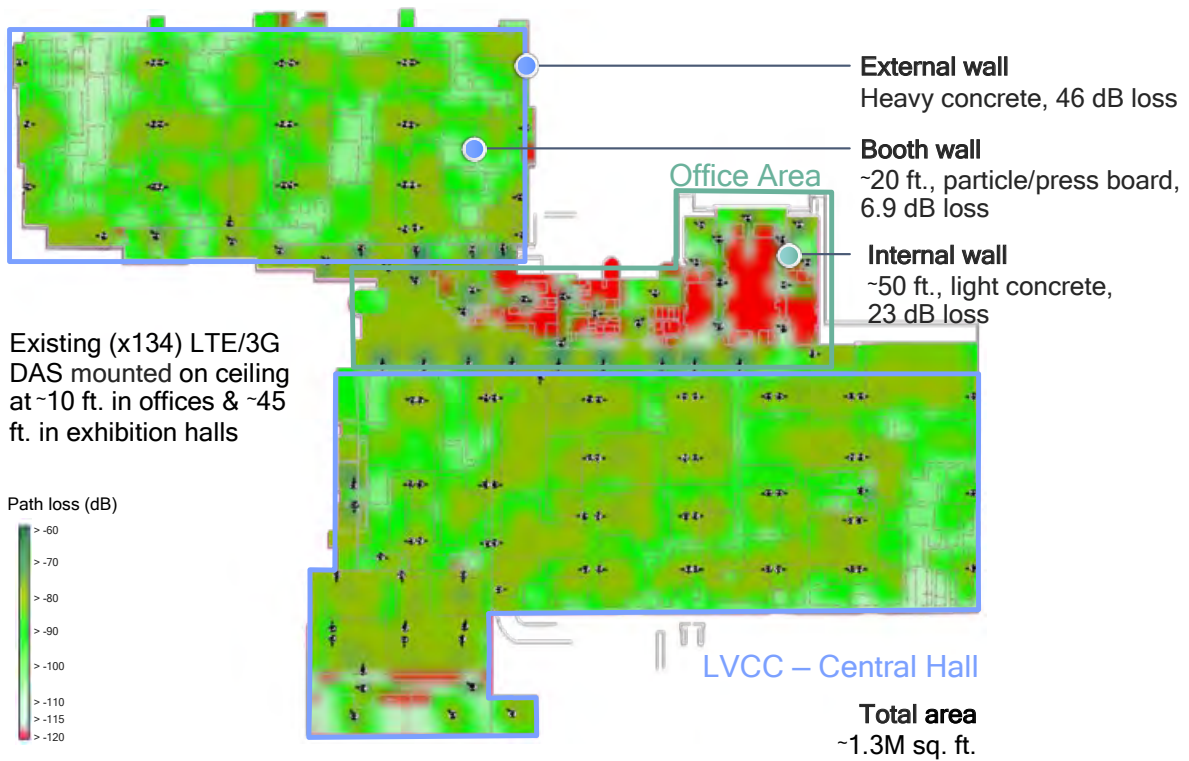
Crowded Venues, Limitless Capacity

Crowded venues, such as convention centers, concert halls, and stadiums, traditionally have limited network capacity and are constrained by slow speeds and unreliable connectivity. In contrast, 5G NR mmWave enables multigigabit speeds with virtually limitless capacity. This performance boost enables new monetization opportunities for operators, such as providing personalized user experiences. Fans at a football game, for instance, can view on-demand instant replays on their smartphones or, in the not-too-distant future, on their extended reality devices and wearables.

In a deployment at the Las Vegas Convention Center, Qualcomm Technologies simulated co-siting of 5G NR mmWave antennas with existing LTE distributed antenna system (DAS) deployments. In this high-density venue, capacity and performance spiked significantly due to wider bandwidths, better antenna directivity, and superior beamforming. Substantial coverage was achieved at 28 GHz: downlink of about 95% with 115 dB maximum allowable path loss (MAPL) and uplink of about 95% with 117 dB MAPL. The downlink median burst rate was 5 Gbps.

5G NR mmWave for High Density Convention Centers

LVCC – North Hall



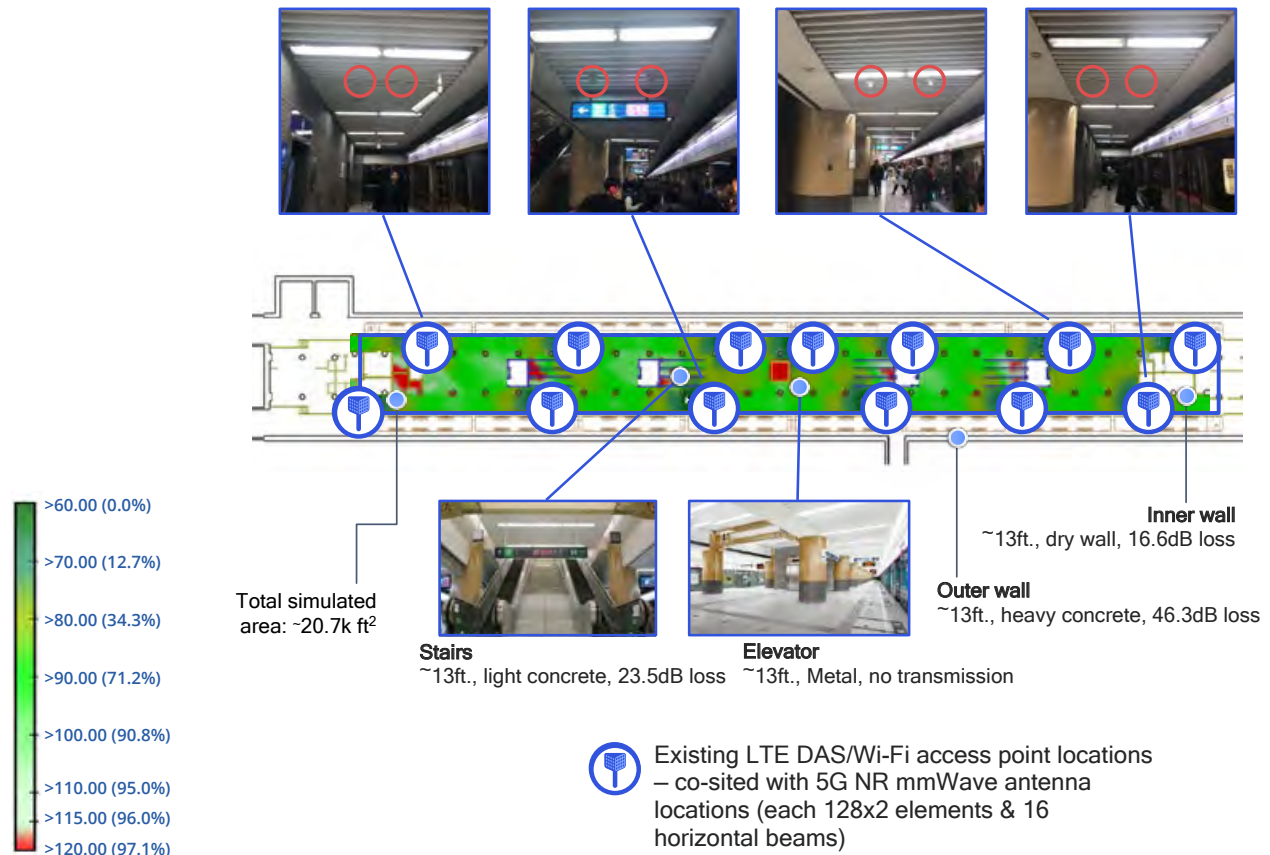
Source: Qualcomm Technologies, Inc.

Superior Coverage at Transportation Hubs

5G NR mmWave is ideal for mobile communications at airports, subways, train stations, and other transportation hubs where there are lots of users and high bandwidth demands from travelers and commuters accessing emails and the Internet, watching ultra-high-definition videos, and gaming.

Qualcomm Technologies simulated mobile mmWave at an international underground subway station, co-siting 5G NR mmWave antennas with existing LTE DAS or Wi-Fi access points. At 28 GHz with similar path loss assumptions as in its convention center simulation, downlink coverage was about 96% and uplink coverage was about 97%. The downlink median burst rate was around 4.6 Gbps.

5G NR mmWave for Underground Subway Stations



Source: Qualcomm Technologies, Inc.

Additionally, Qualcomm Technologies simulated mobile 5G NR mmWave at an airport concourse, operating at 26 GHz. Again, with similar path loss assumptions, this deployment yielded a superior 100% downlink coverage, with a median burst rate around 4.2 Gbps.

Deploying Indoor mmWave for an Airport Concourse



Source: Qualcomm Technologies, Inc.

Unfettered Enterprise Connectivity

Private indoor enterprise locations, mostly served by Wi-Fi and wired connectivity today, also present ideal deployment opportunities for 5G NR mmWave. In locations such as offices, shop floors, and meeting rooms, 5G NR mmWave plus Wi-Fi enables a fiber-like, always-on, always-connected experience for users on laptops, tablets, and other mobile devices.

Qualcomm Technologies has conducted extensive testing and modeling in indoor office enterprise environments to show that significant coverage (greater than 90%), multi-Gbps median speeds, and better user experiences can be achieved simply by co-siting mmWave small cells with existing Wi-Fi access points. Among the uses enabled by mmWave:

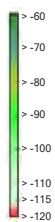
- Instant cloud access to applications and data
- Extreme capacity for heavy-use areas such as auditoriums and conference rooms
- Consistent connection to projectors and screens with immersive content
- Fast, reliable augmented and virtual reality applications

5G NR mmWave for High-Density Indoor Enterprise



Total area:
~27.6k ft²

Path loss (dB)

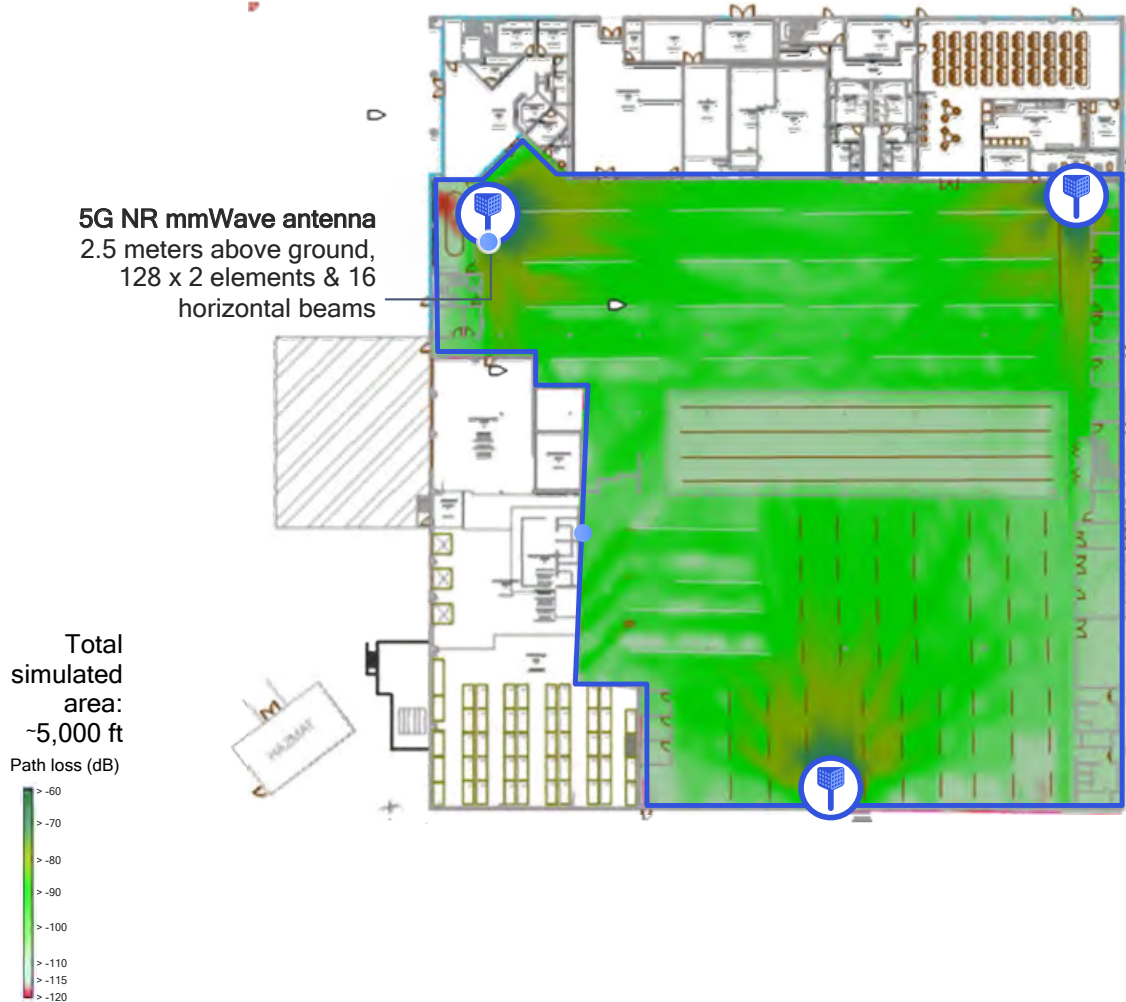


Existing Wi-Fi access point locations
– co-sited with 5G NR mmWave antenna
locations (each 128x2 elements & 16
horizontal beams)

Source: Qualcomm Technologies, Inc.

Qualcomm also simulated 5G NR mmWave on an enterprise shop floor, measuring about 5,000 square feet, and yielded excellent results at 28 GHz: downlink and uplink coverage of 100%. The downlink median burst rate was 4.2 Gbps. The simulation included coverage challenges typically found on a shop floor, such as many metallic structures that can obstruct wireless communications, thereby requiring non-line-of-sight connectivity.

Deploying 5G NR mmWave for Enterprise Shop Floors



Source: Qualcomm Technologies, Inc.

Debunking a mmWave Myth

As Qualcomm Technologies' simulations and live testing demonstrate, mmWave is not a costly proposition that requires many more indoor small cells than Wi-Fi or LTE. A recommended practice for mobile operators is to start their mmWave deployments by co-siting with existing Wi-Fi or LTE infrastructure and adding more small cells, as needed, to fill coverage gaps.

Now that the traditional coverage and performance limitations of mobile mmWave are being shattered by technology and product advances, mobile operators can start to reap the full benefits of 5G. With 5G NR mmWave technology, their ability to deliver exceptional user experience, indoors and outdoors, cost-efficiently and easily is finally within reach.

References

[1] ABI Research

[2] FierceWireless, “Qualcomm driving 5G NR technology evolution forward to unlock the full potential of 5G.”

[3] Qualcomm eBrief, “Unleashing the Full Potential of 5G: Mobilizing mmWave.”

[4] Qualcomm Snapdragon is a product of Qualcomm Technologies, Inc. and/or its subsidiaries.

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Qualcomm

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