Public consultation on Ofcom Plan of Work for 2021/2022

Qualcomm Response

Qualcomm would like to thank Ofcom for the opportunity to provide comments on the public consultation regarding its Plan of Work for 2021/2022.

Qualcomm is pleased to see that Ofcom intend to issue a consultation during 2021/22 about the award of frequencies in 26 GHz. Qualcomm believe that releasing 26 GHz band is key to unlocking the full potential associated with 5G.

As mmWave adoption continues to spread across the world, handsets and a variety of other devices and CPEs supporting mmWave are being introduced into the markets.

In Europe, mmWave momentum is also picking up and an increasing number of countries have made available the 26GHz band (e.g. Germany, Italy, Finland, Greece, Russia) or are planning to make it available in 2021.

Qualcomm recommends Ofcom to take all the possible actions to release this band not later than 2H 2021.

Ecosystem in the 26 GHz band

After more than a decade of advanced R&D and ecosystem trials, commercial 5G mmWave service is now available in 55+ U.S. cities and more than 160 areas in Japan. Consumers now have a wide selection of mmWave-enabled devices — smartphones, laptops, hotpots, fixed wireless access CPEs and more. In the next year or so, we expect 5G mmWave to expand into other territories such as South Korea, Russia, Italy, Singapore, Hong Kong, Taiwan, Thailand, Finland, Germany and others. In Europe, in addition to Italy, UK, Finland, Gemrnay and Greece that have already assigned 26 GHz spectrum, many more countries (such as Denmark, Slovenia, Croatia etc.) will follow in 2021.

Some of the current mmWave activities that Qualcomm is involved in Europe are included in the picture below.

Soon, we will also see 5G mmWave proliferating to new device types and tiers. A list of 5G mmWave commercial devices powered by Qualcomm Snapdragon is provided in the picture below.

Deployment Scenarios, Use Cases and Applications

In a recent economic study conducted by GSMA Intelligence, researchers examined a wide range of 5G mmWave deployment scenarios including different geographical regions, outdoor dense urban networks, indoor enterprises, and fixed wireless access (FWA). The overall findings are encouraging, with all scenarios showing how mmWave can be a cost-effective deployment strategy. Below is a quick summary of this study, with more detailed analysis becoming available in the coming weeks.

- *Dense urban networks:* the study looked at the period between now and 2025, and it finds that mmWave can be deployed cost effectively to deliver an additional capacity layer in dense urban areas in China and Europe.
- *FWA:* similarly, three different FWA deployments were analyzed, including urban China, sub-urban Europe, and rural U.S. The study shows that 5G FWA networks using mmWave spectrum can be cost effective if they are able to capture a significant percentage of the high-traffic residential broadband market.
- *Indoor enterprises:* the study looked at an indoor 5G mmWave deployment in a large office space. It finds that this strategy can also be cost effective and generate cost savings between 5% and 20% when a significant share of data traffic needs to be supported by indoor 5G services.

In line with the findings of the economic study by GSMA Intelligence, Qualcomm expects initial use cases to focus on enhanced Mobile BroadBand (eMBB) and Ultra Reliable Low Latency Communications (URLLC) usage scenarios for indoor hotspots in enterprises and factories and outdoor mobile broadband in dense urban and urban areas as well as Fixed wireless access (FWA)[1] in suburban and rural macro scenarios. Applications such as Mobile Virtual/Augmented Reality and Ultra High Definition Video, 5G fixed wireless access services and smart home, smart manufacturing, autonomous vehicle, Health care will all benefit from 5G deployments.

The multi-gigabit data rates possible with mmWave technology and the wide bandwidths available in 26 GHz will likely enable new use cases benefiting from high instantaneous data rates. On one hand, end users, who could be individual consumers and machines), will be able to download large amounts of data very quickly e.g., a movie before boarding a flight, fiber like services on always on laptops, or a high definition map update to a vehicle. On the other hand, the network will be able to serve a lot of more highly demanding end points as the high instantaneous peak rates combined with Massive MIMO (M-MIMO) will dramatically increase network capacity and hence facilitate traffic offload to the existing 4G networks.

Capacity will be an important metric for 5G, as the amount of traffic will be burgeoning in the coming years with the more widespread adoption of competitive data plans comprising unlimited use of popular apps, video streaming or even full unlimited data usage. The capacity increase will focus on specific hotspots (cafes, venues, public squares, city centers, etc.) and aligned with the strategic deployment of high-capacity small cells covering the hotspot area. mmWave technology brings the benefits of Massive MIMO down to a small-cell scale, hence maximizing small cell

[1] A feasible use case for mmWave that provides expedited and low-cost deployment to replace fiber.

capacity and hotspot coverage. Deployments will encompass venues (e.g., stadiums) and locations within city centers. Depending on traffic patterns, it would cover the main public squares and roads within the city center, as those would be the locations where most traffic is consumed.

One area of focus for 5G NR mmWave mobile deployments will be high-traffic urban areas in large global cities. To help assess this deployment challenge for 5G NR mmWave, Qualcomm conducted an extensive set of 5G NR mmWave network coverage simulation studies in numerous global cities. The results of the simulation studies conducted across ten global cities, show that significant outdoor downlink coverage is possible when co-siting 5G NR mmWave with existing 4G LTE macro and small cell sites. The positive results show that mobile deployments in urban-areas based on existing LTE cell cities is feasible, especially when considering the tight-interworking of 5G NR with 4G LTE. Although mmWave outdoor-to-indoor coverage for mobile is not feasible, the outdoor mmWave coverage will significantly free up resources in the spectrum bands below 6 GHz for outdoor-to-indoor capacity, utilizing either 4G LTE or 5G NR technology. In addition, outdoor mmWave coverage can be complemented with targeted indoor mmWave deployments.

While the initial focus for mobile operators is to quickly expand network capacities by starting deployments of 5G NR mmWave in existing dense urban markets, there are even more opportunities for mmWave beyond traditional macro networks. One area of interest is to bring mmWave indoors to address the exploding demand of fiber-like wireless broadband access in crowded venues, such as convention centers, concert halls, and stadiums. These venues have traditionally been challenged with limited network capacity, thereby constrained with the quality of service (e.g., slow speeds and unreliable connectivity) they can deliver. With mmWave's significantly wider bandwidth and high

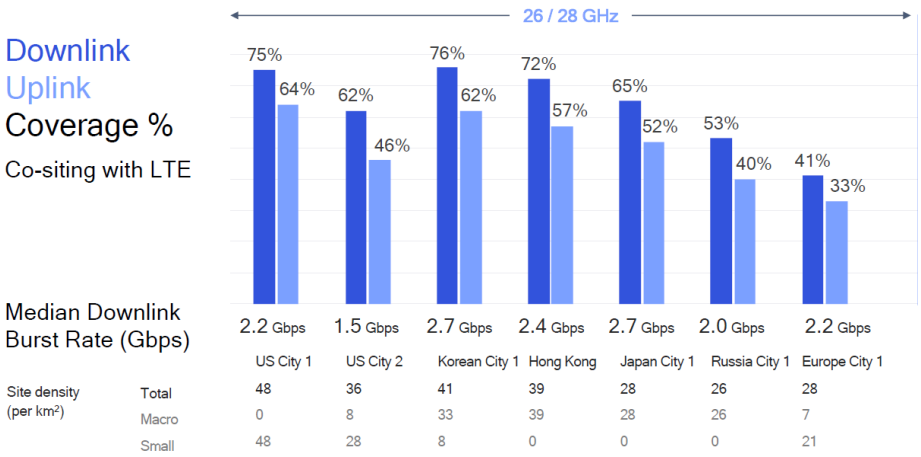
spatial multiplexing gains, mobile operators and service providers could rapidly make multi-Gigabit, low-latency connectivity available to a large number of users.

Qualcomm has simulated a number of usage scenarios – these are presented hereafter:

5G mmWave is expanding into new use cases for indoor and outdoor deployments

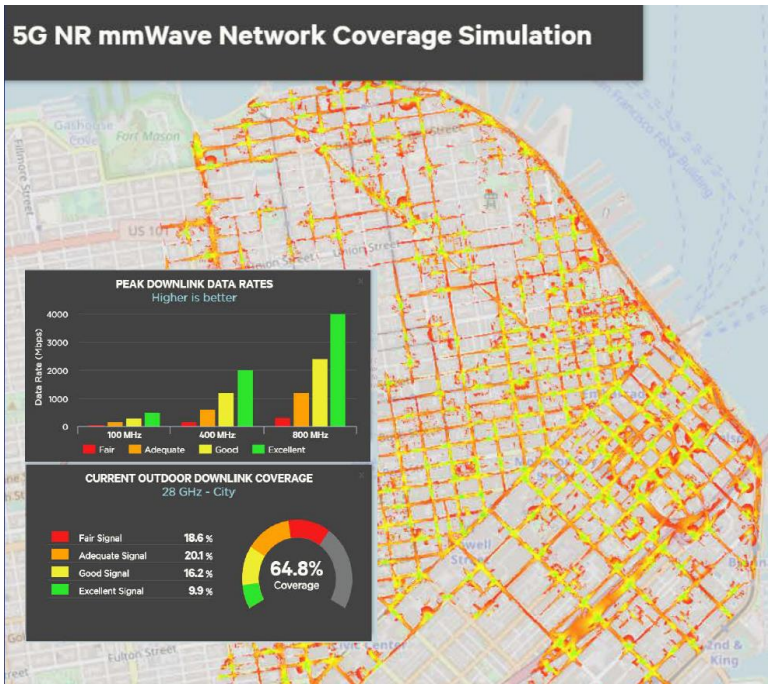
Outdoor Coverage Simulation Study using mmWave Smartphone for Mobility Application

Results of outdoor simulation studies performed at dense urban traffic hotspots across major global cities are reported in the picture below. The studies are based on co-siting mmWave transmission points with current LTE site locations of major tier-1 MNOs, used accurate high-resolution 3D geo-maps, and also factored in additional hand, body and shadowing losses



From the above, it is evident that a significant percentage of outdoor areas could very well be covered by 5G NR mmWave mobility services using smartphone and offer unprecedented experience to the end users.

Following is a more detailed snapshot of a Qualcomm case study performed in 10 sq-km cluster of San Francisco by reusing actual LTE deployment of a major tier-1 service provider. The observations remain the same that just by reusing existing deployment, nearly 70% of the outdoor area could be covered with a user-experience that far-exceeds what existing technologies can offer.



5G NR mmWave outdoor coverage simulation

Fixed Wireless Access (FWA) Coverage Simulation Study

With the evolution to 5G, Fixed Wireless Access (FWA) offers a path to deployments on a massive scale and better services for customers. 5G FWA changes the economics of connecting homes and businesses Today, there is already a strong business case for using FWA as an add-on improvement to mobile broadband (MBB). FWA is particularly attractive in areas where there is no existing copper, fiber, or hybrid infrastructure to deliver wired broadband, or when the current fixed infrastructure is unable to provide sufficient service. The business case for FWA only becomes stronger as LTE continues to advance to 5G.

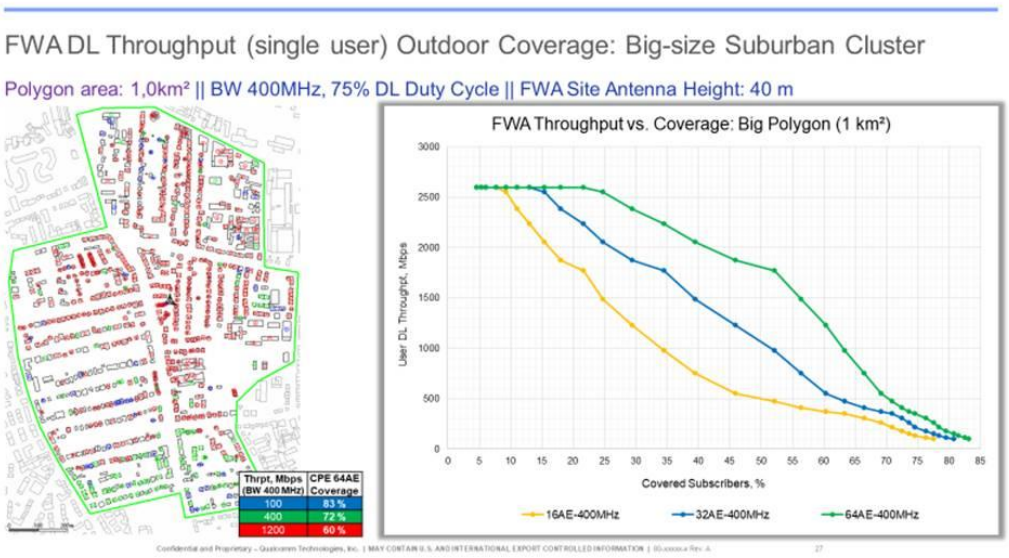
One of the 5G use cases currently gaining momentum around the globe is using FWA to provide broadband service for homes and small and medium-sized enterprises (SMEs). With the help of 5G, Fixed Wireless Access will grow on a massive scale. With 10 to 100 times more capacity than 4G networks, 5G will enable cost-efficient FWA deployments on a massive scale. Using larger ranges of radio spectrum to provide consumers with low latency connectivity (1ms) and major capacity gains, the evolution to 5G will take FWA to a whole new level.

5G FWA is expected to enable robust services at sustainable rates high enough to meet the needs for residential use well into the future. 5G FWA will not only eliminate the need for costly deployment of deep-fiber fixed access infrastructure, it will offer peak rates that few fixed technologies will be able to match.

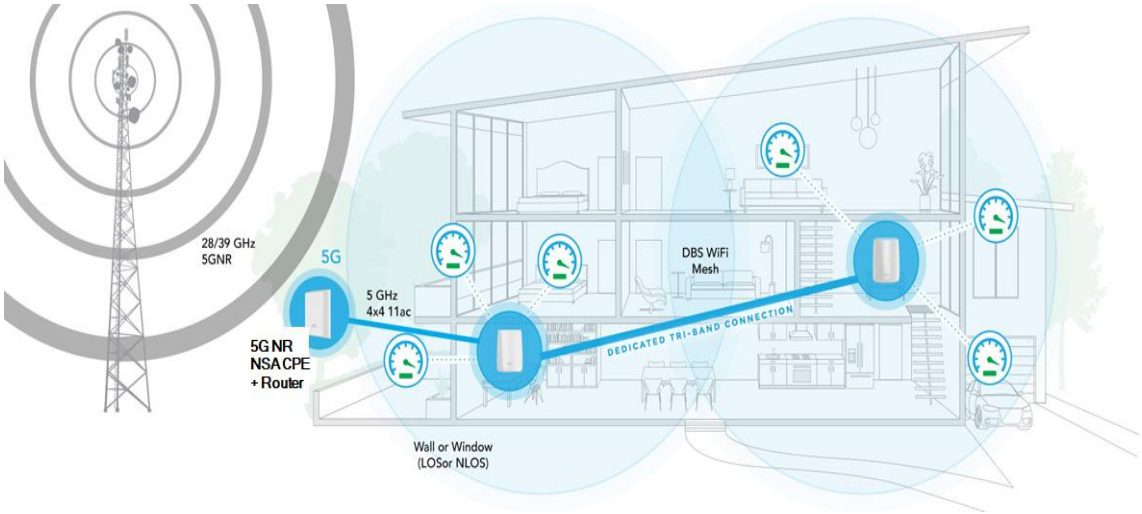
5G mmWave not only brings next-level mobile experiences, it can also deliver high-capacity wireless broadband access to urban, suburban, and rural homes as well as enterprises. The commercial momentum is strong. To date, ~40% of operators with commercial 5G networks (i.e., 37 out of 94) are offering FWA services and 80+ FWA products are in design or development from 30+ OEMs using our 5G modem-RF solutions. In a recent joint announcement with U.S. Cellular and Ericsson, we showcased extended-range 5G mmWave FWA in a commercial network, achieving a 5+ km range while sustaining data rates of 100+ Mbps. This proves that 5G mmWave can be utilized to deliver fast, reliable, and cost-efficient connectivity to rural and often underserved areas — taking a significant stride to bridge the digital divide.

Qualcomm has carried out several coverage simulations studies of 5G NR mmWave Fixed Wireless Access (FWA) deployments at 26.5 – 27.5 GHz. Cluster location used was Hamburg vicinity area with a size of 12.8 km², mostly suburban environment and a high office building was used as the FWA macro-site. Results show a very good FWA coverage for suburban/rural clusters (DL Cell edge throughput = 120 Mbps for carrier bandwidth 400 MHz) obtained for a macro-cluster with cell radius 800m (2 km² = 16% of the full cluster area) which included 850 houses. In general, coverage depends on morphologies, environment type and a number of other factors. Possible solutions for further increasing the coverage include using repeaters, mesh network approach, more sites, gNB antenna height. By modelling FWA throughput in a big size suburban cluster (1 km^2 area, 400 MHz Bandwidth, 40 m FWA site antenna

height, 64 antenna element CPE), results have been also very good with single user throughput reaching 1.2 Gbps for 60% of the area, 400 Mbps in 72% of the area and 100 Mbps in 83% of the area as depicted in the graph below:



In respect of FWA applications, one question that often comes up is how to transfer traffic from outdoor CPEs to serve broadband applications. To facilitate this, Qualcomm has already come up with innovative solutions that already started hitting the markets as commercial product, some examples of which are captured below.



Taking 5G NR mmWave indoors

With more than 80% of mobile data traffic originating or terminating indoors, one enormous opportunity for mobile operators and service providers is to bring mmWave services to indoor locations. Today, we are already seeing deployments of 5G mmWave for fixed wireless access (FWA). On this front, we have analyzed potential deployment scenarios in various dense urban cities, and one example is how a dense metropolitan city with an existing outdoor

LTE network can re-use sites deploying 5G NR mmWave. By using rooftop CPEs, our simulation showed that co-siting 5G NR mmWave with LTE small cells can deliver service speeds of 1.6 Gbps downlink and 150 Mbps uplink to 80% of the buildings in the city.

The fact that mmWave may not propagate well from the outside to inside is beneficial for deploying mmWave indoors as well, since the same mmWave spectrum can be reused indoors with limited coordination with the outdoor deployment. This benefit opens up new possibilities for mobile operators to offer private indoor mmWave networks, in addition to expanding mmWave indoors as part of their public networks.

Complementing existing indoor Wi-Fi services, 5G NR mmWave can elevate user experiences to new heights by bringing multi-Gigabit speed, ultra-low latency, and virtually unlimited capacity to a wide range of devices such as smartphones, tablets, XR (extended reality) headsets, and always-connected laptops.

Qualcomm has been working with indoor venue owners and operators to understand how 5G NR mmWave will perform in a wide range of indoor environments.

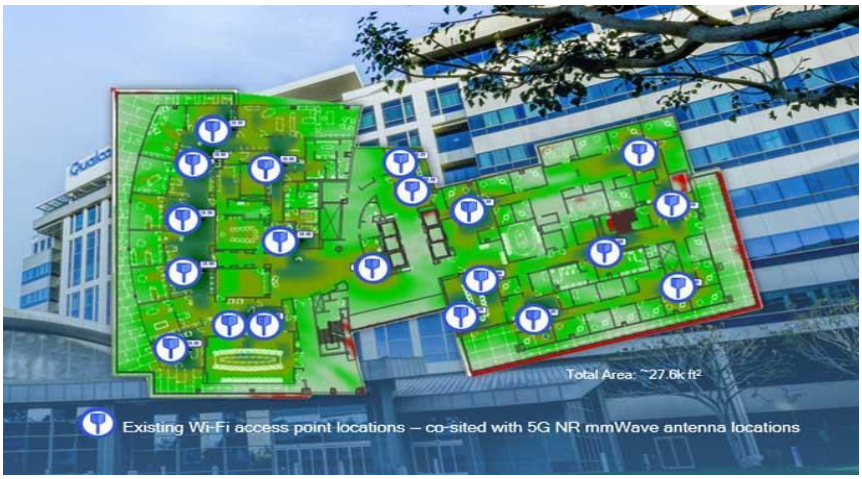
Taking 5G NR mmWave to a wide range of indoor locations

For indoor enterprises

One exciting opportunity for 5G NR mmWave is indoor enterprises. Today, most offices have Wi-Fi connectivity for computers and other enterprise devices. With 5G NR mmWave private networks, enterprises can realize the vision of "mobile office of the future", bringing enhanced performance, convenience, security, and user experiences not possible with today's connectivity solutions.

Opening doors to new and enhanced enterprise user experiences.

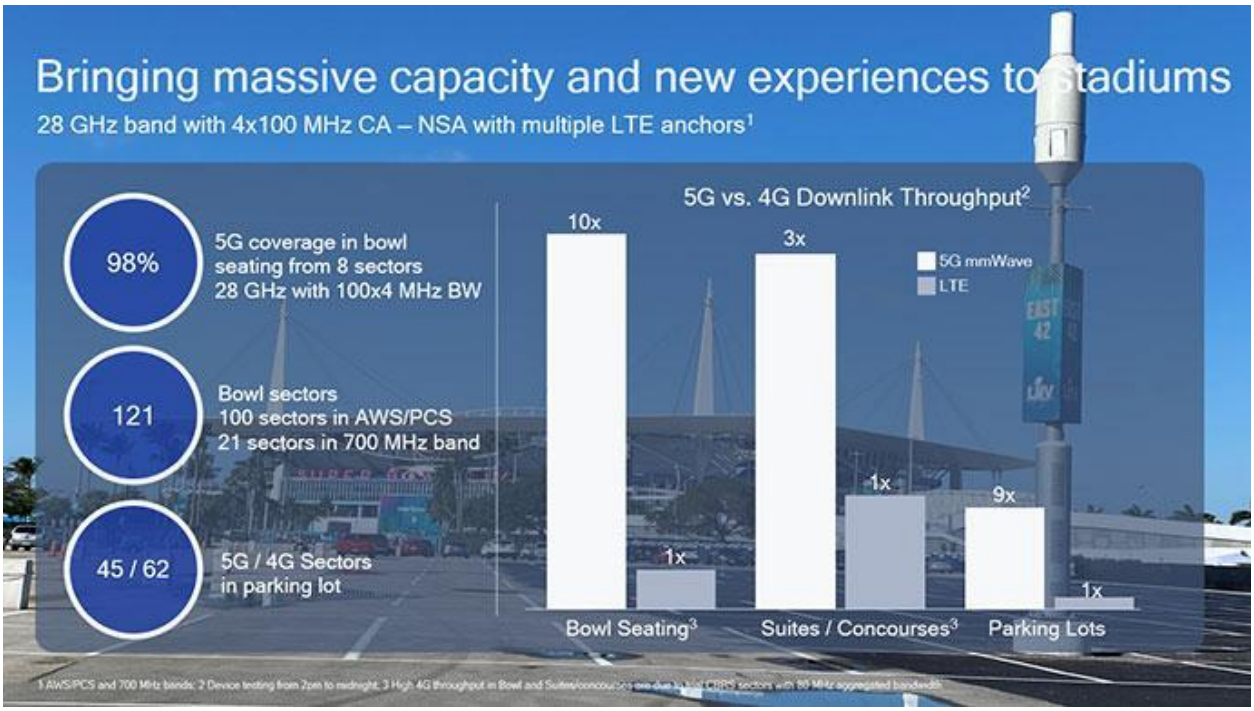
To understand how 5G NR mmWave performs in enterprise settings, we have studied a few different office layouts and performed comprehensive system-level simulations. As an example, we looked at one office floor at our San Diego headquarters and simulated coverage and performance with 5G NR mmWave small cells placed at the same locations as existing Wi-Fi access points. The rationale behind co-siting is that both power supply and wired backhaul connectivity are already available at these locations, and it is the most efficient way to start any 5G NR mmWave deployments. With 1-to-1 co-siting, we were able to achieve ~98% downlink coverage and ~99% uplink coverage. The median throughput achieved with this setup is 5 Gbps. Note that the red outline shown in the figure below are areas not covered by the co-sited mmWave small cells, as they are surrounded by concrete walls (e.g., balcony, stairwell). Such areas could typically be covered with macro sites, or if needed, additional small cells can be deployed to provide a more comprehensive coverage.



Co-siting 5G NR mmWave for higher-density indoor enterprise.

For stadium and dense venues

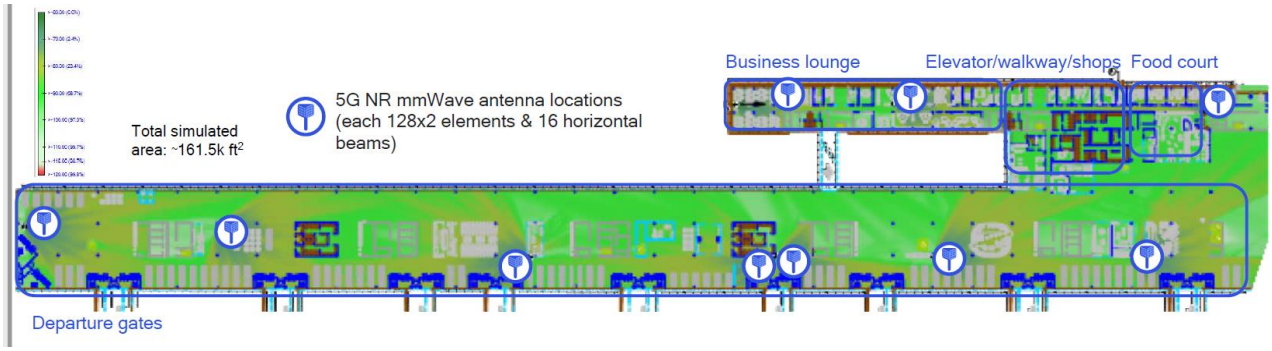
5G mmWave brings a once-in-a-generation opportunity to transform venue experiences, and for many years we have been working with venue owners and event organizers to deploy cutting-edge wireless networks. We recently announced at IFA 2020 our collaboration with Live Nation to bring broader 5G deployments to their venues. On the sporting front, 40+ of the largest stadiums in North America already have commercial mmWave networks, and in China, plans are in place to deploy 5G mmWave at the 2022 Winter Games in Beijing. For the biggest American pro football event in 2020, Qualcomm was tasked to design and test the deployment of a new 5G mmWave network covering the entire stadium, working closely with the venue and mobile operator. Thanks to the large bandwidths available in 28 GHz, we realized much better deployment efficiency — using only eight mmWave sectors to cover 98% of the stadium bowl area, compared to 100+ sectors needed with LTE. At the same time, 5G mmWave can deliver average downlink throughput that is 10x higher than LTE in the bowl seating area, fulfilling the insatiable demand of subscribers who are downloading, streaming, and sharing high-definition videos as well as content from inside the stadium.



5G mmWave more efficiently delivers extreme capacity and throughput for venues

For transportation hubs

Lastly, we also looked at various transportation hubs, such as airports and train stations. For an airport concourse that is about 160 thousand square feet in size, comprehensive coverage and a median throughput of ~4.2 Gbps could be achieved using just ten co-sited 5G NR mmWave small cells.



Delivering 100% 5G NR mmWave coverage and multi-Gbps speeds with at an airport concourse.

For IIoT (Industrial IoT)

One key technology area in 3GPP Release 16 is the expansion of 5G to address high-performance industrial IoT (IIoT) applications — delivering enhanced ultra-reliable and low-latency wireless connectivity. Building on the collaborations with industrial ecosystem leaders to usher in the factory of the future, we have expanded our efforts to utilizing mmWave spectrum for a wide range of high-bandwidth IIoT use cases. We've shown that 5G mmWave can bring great indoor coverage, even in a noisy, industrial settings, as well as provide the high system capacity needed to satisfy bandwidth-demanding use cases, such as high-definition video streaming and extended reality (i.e., VR and AR). Collaborating with an industrial customer and leading mobile operator for our initial deployment, we achieved over 1.5 Gbps and 120 Mbps in downlink and uplink throughput, respectively, which met all initial use case requirements.