Qualcomm

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5G-Advanced mmWave : Opportunities and Challenges

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We overcame the “impossible” mobile mmWave challenge

Challenges

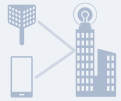
Limited coverage and too costly
Limited to just a few hundred feet, thus requiring many small cells.

Works only line-of-sight (LOS)
Blockage from hand, body, walls, foliage, rain severely limits signal propagation.

Only viable for fixed use
Only commercially proven for wireless backhauls and satellites.

Immature RFIC technology
Power hungry due to wider bandwidth with thermal challenges in small formfactor.

Solutions



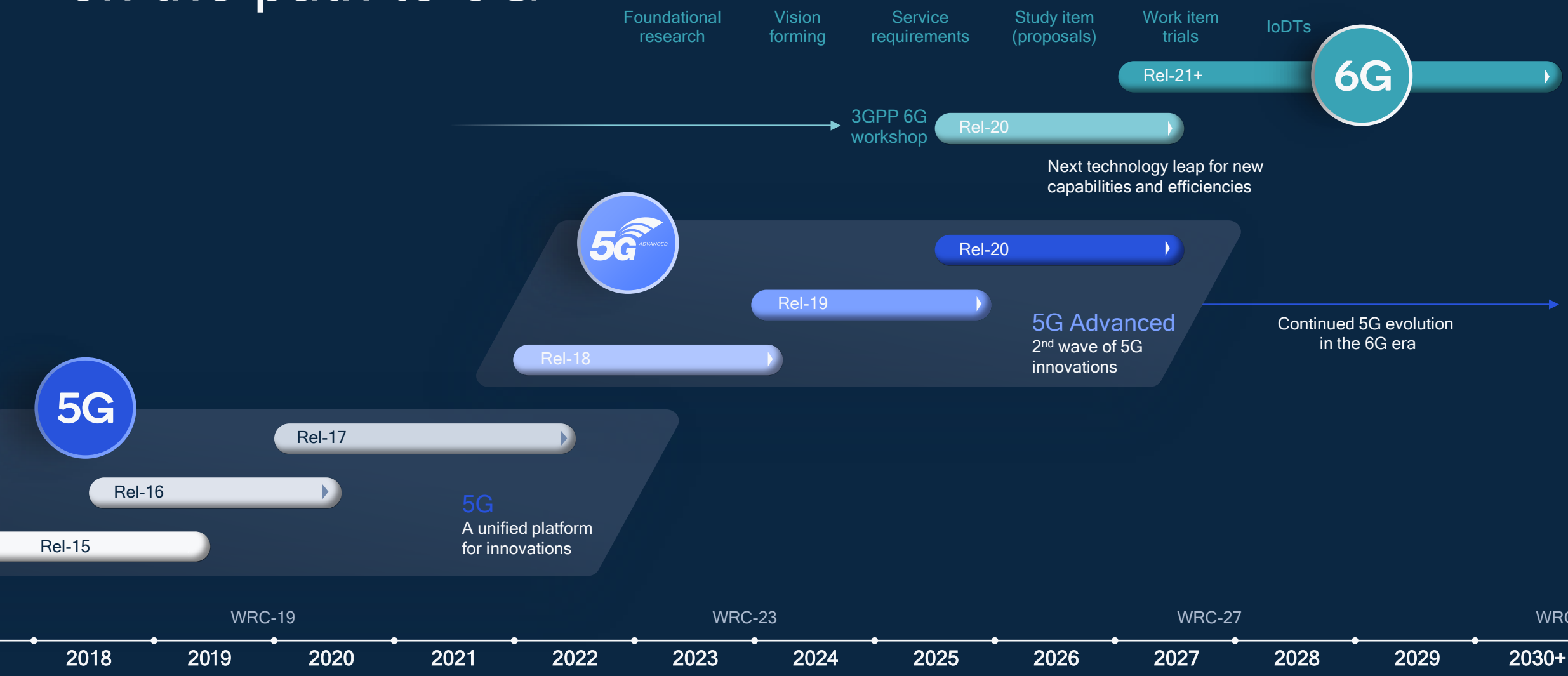
Significant coverage with co-siting
Analog beamforming w/ narrow beam to overcome path loss. Achieving significant coverage when reusing existing sites.

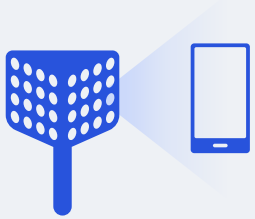
Operating in LOS and Non-LOS
Pioneered advanced beamforming, beam tracking leveraging path diversity and reflections.

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

Commercialized smartphone
Launched modem, RF, and antenna products to meet formfactor, thermal constraints and regulatory compliance.

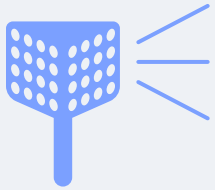
5G Advanced on the path to 6G





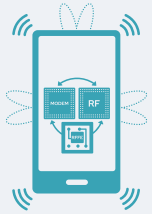
Coverage

Innovations to overcome significant path loss in mmWave bands



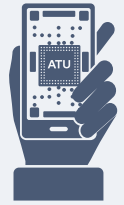
Beam management

Innovations to beam pairing, tracking and recovery



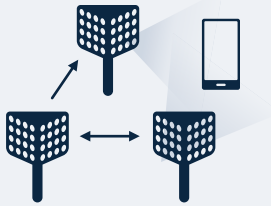
Device size / power

Innovations to optimize mmWave design for smartphone form factor



Robustness

Innovations to overcome blockage from hand, body, walls, foliage, etc.



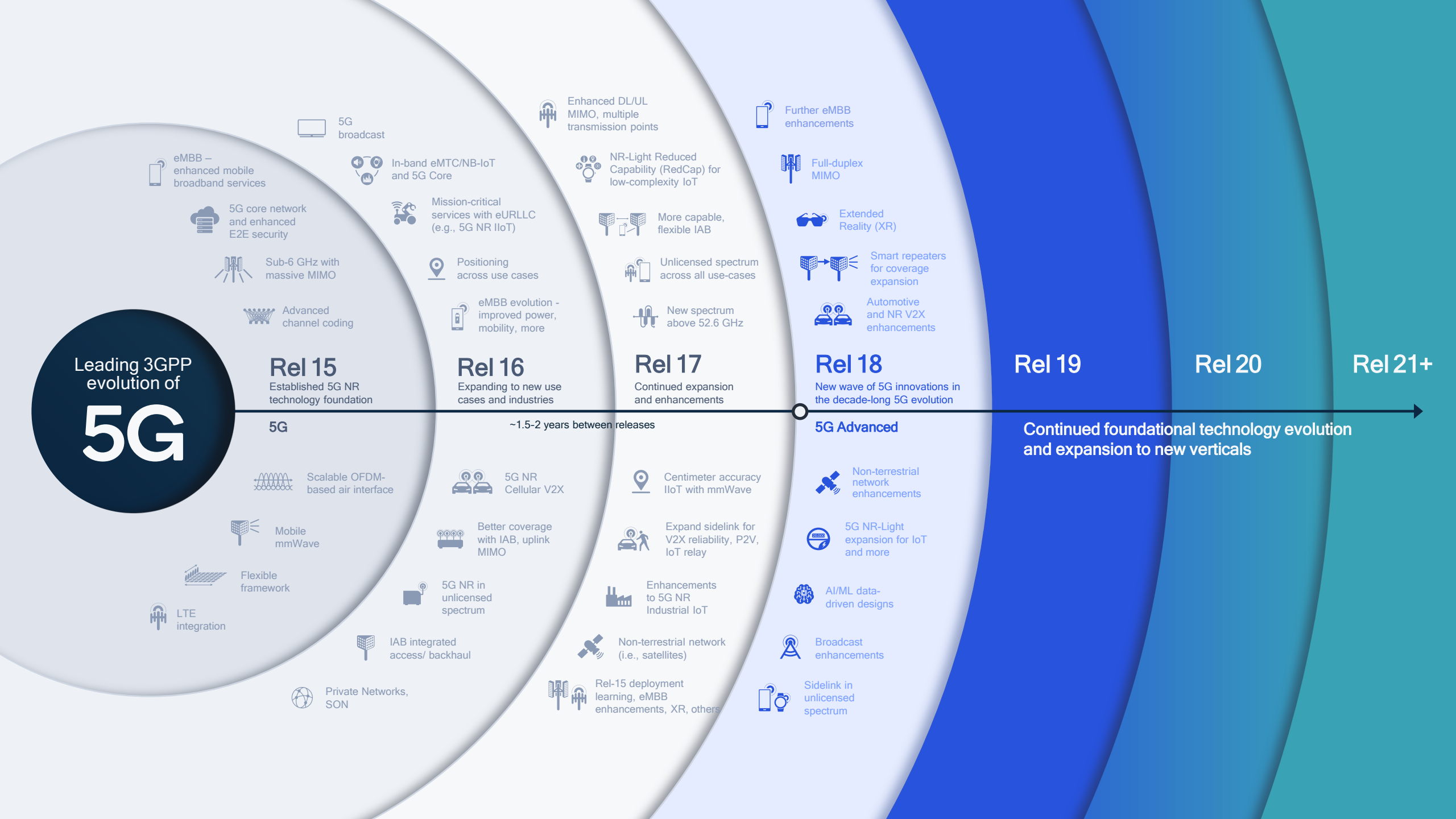
Topology enhancement

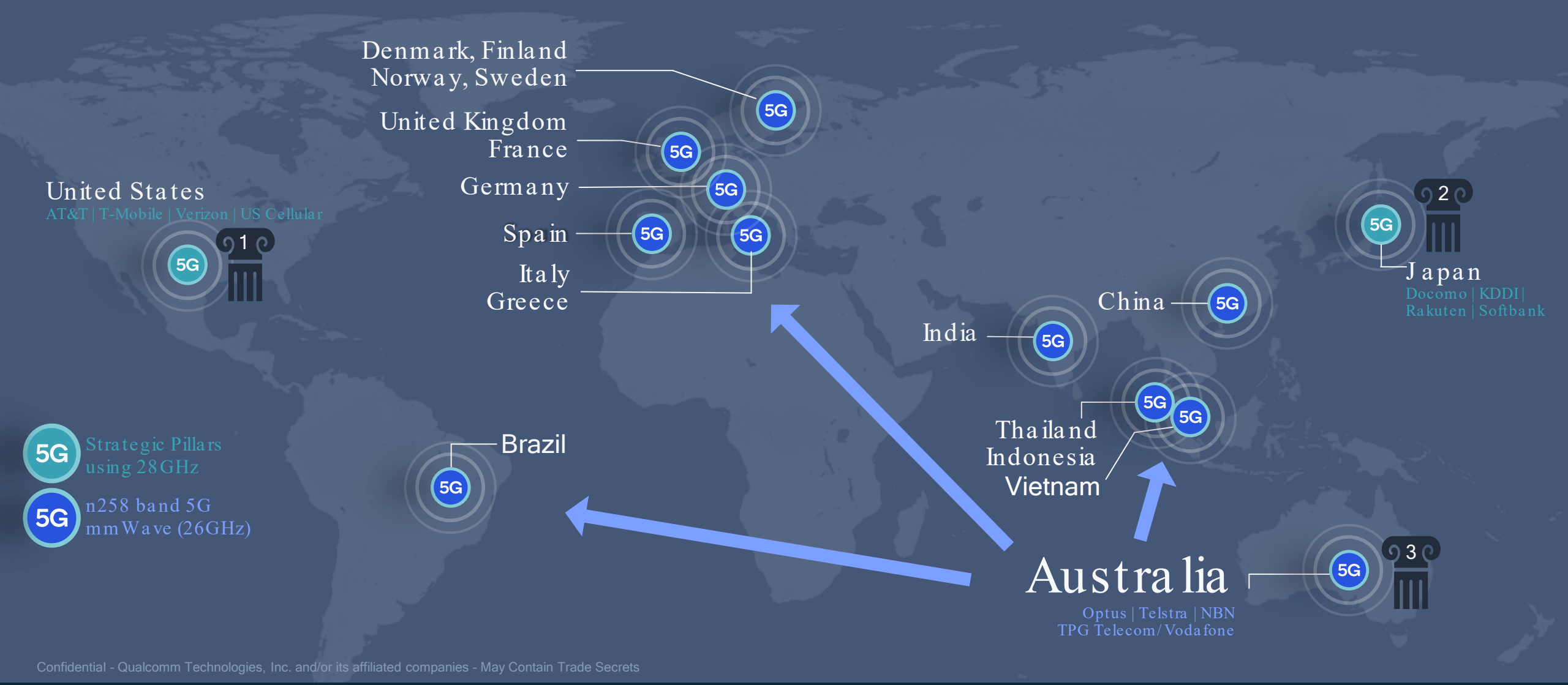
Innovations to efficiently scale and densify the network

CONTINUED EXPANSION AND ENHANCEMENT OF

mobile mmWave technologies

Building on the solid foundation of 5G NR

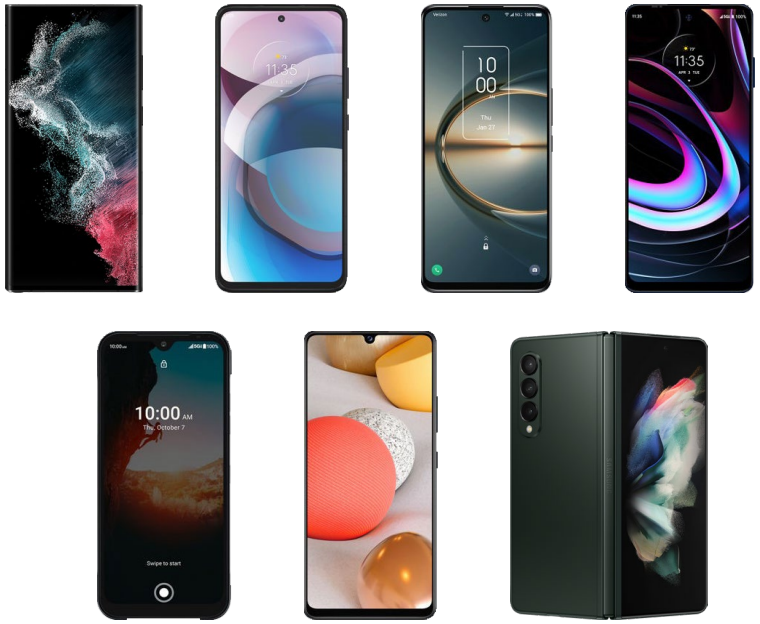

Leading 3GPP evolution of 5G
Rel 15
Established 5G NR technology foundation
5G
Rel 16
Expanding to new use cases and industries
Rel 17
Continued expansion and enhancements
Rel 18
New wave of 5G innovations in the decade-long 5G evolution
5G Advanced
~1.5-2 years between releases
Rel 19
Rel 20
Rel 21+
Continued foundational technology evolution and expansion to new verticals
eMBB – enhanced mobile broadband services
5G core network and enhanced E2E security
Sub-6 GHz with massive MIMO
Advanced channel coding
Scalable OFDM-based air interface
Mobile mmWave
Flexible framework
LTE integration
5G broadcast
In-band eMTC/NB-IoT and 5G Core
Mission-critical services with eURLLC (e.g., 5G NR IIoT)
Positioning across use cases
eMBB evolution - improved power, mobility, more
5G NR Cellular V2X
Better coverage with IAB, uplink MIMO
5G NR in unlicensed spectrum
IAB integrated access/ backhaul
Private Networks, SON
Enhanced DL/UL MIMO, multiple transmission points
NR-Light Reduced Capability (RedCap) for low-complexity IoT
More capable, flexible IAB
Unlicensed spectrum across all use-cases
New spectrum above 52.6 GHz
Centimeter accuracy IIoT with mmWave
Expand sidelink for V2X reliability, P2V, IoT relay
Enhancements to 5G NR Industrial IoT
Non-terrestrial network (i.e., satellites)
Rel-15 deployment learning, eMBB enhancements, XR, others
Further eMBB enhancements
Full-duplex MIMO
Extended Reality (XR)
Smart repeaters for coverage expansion
Automotive and NR V2X enhancements
Non-terrestrial network enhancements
5G NR-Light expansion for IoT and more
AI/ML data-driven designs
Broadcast enhancements
Sidelink in unlicensed spectrum



Australia is the 3rd pillar opening up the "26GHz market"

China, India, Europe being part of 26GHz market (3GPP n258 band)

5G smartphones



PCs

170+

5G mmWave devices launched or announced by 65+ vendors

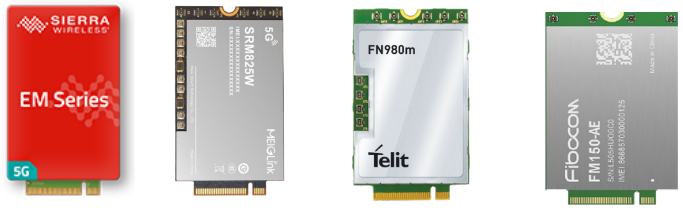
Source: GSA, Dec. 2022

Hotspots & IoT

IP camera

CPEs

Modules



Expanding breadth, availability of 5G mmWave devices

Fixed wireless access

Urban cities, suburban towns, rural villages

Bridge digital divide

Indoor/ outdoor venues

Stadiums, Shopping malls, Busy streets, music venues

Best Quality of Experience in high-density areas

Transportation hubs

Train terminals, subway stations, airports

Indoor enterprises

Offices, auditoriums, education campuses

Free up mobility and power hybrid work

Industrial IoT

Factories, warehouses, logistic hubs

Unleash Industry 4.0

5G mmWave + mid-band = best possible QoE wherever people are

5G mmWave can deliver more uniform user experiences even in congested network

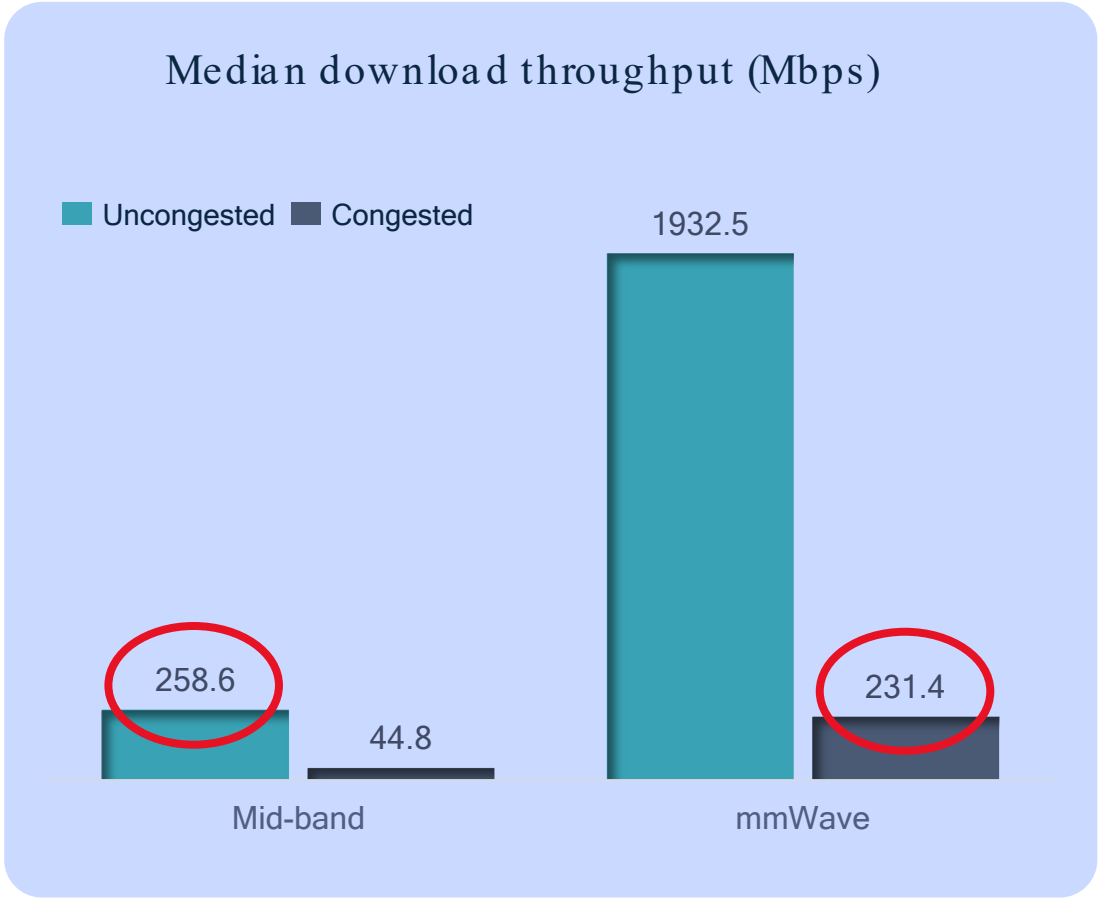
5G mmWave delivers on the promise of extreme capacity and blazing-fast speeds under heavy network loads


Stadiums


Train Stations


Indoor malls


Outdoor hot zones



Source: https://www.rootmetrics.com/en-US/content/mmwave-cutting-through-congestion

5G mmWave in "islands of capacity" positions the operator as a quality leader, cost-efficiently

Stadiums

Train Stations

Indoor malls

Outdoor dense areas

5G mmWave Hot Zones**

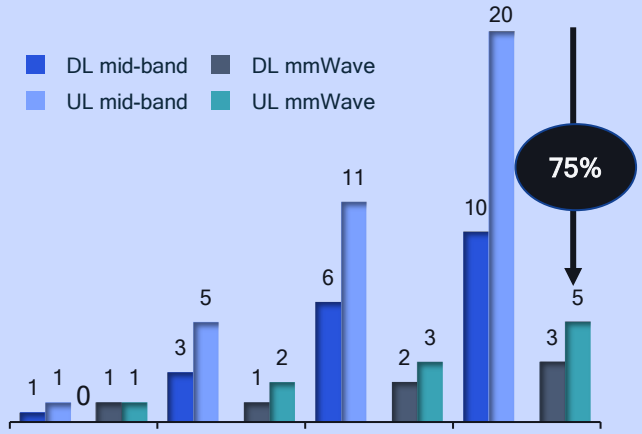
2000

%Subs daily reach*

24%

Requires the most cost-efficient technology, esp. in Uplink

Leads to **up to 70% less power consumption**



mmWave vs. mid-band number of small cells per "hot-zone"

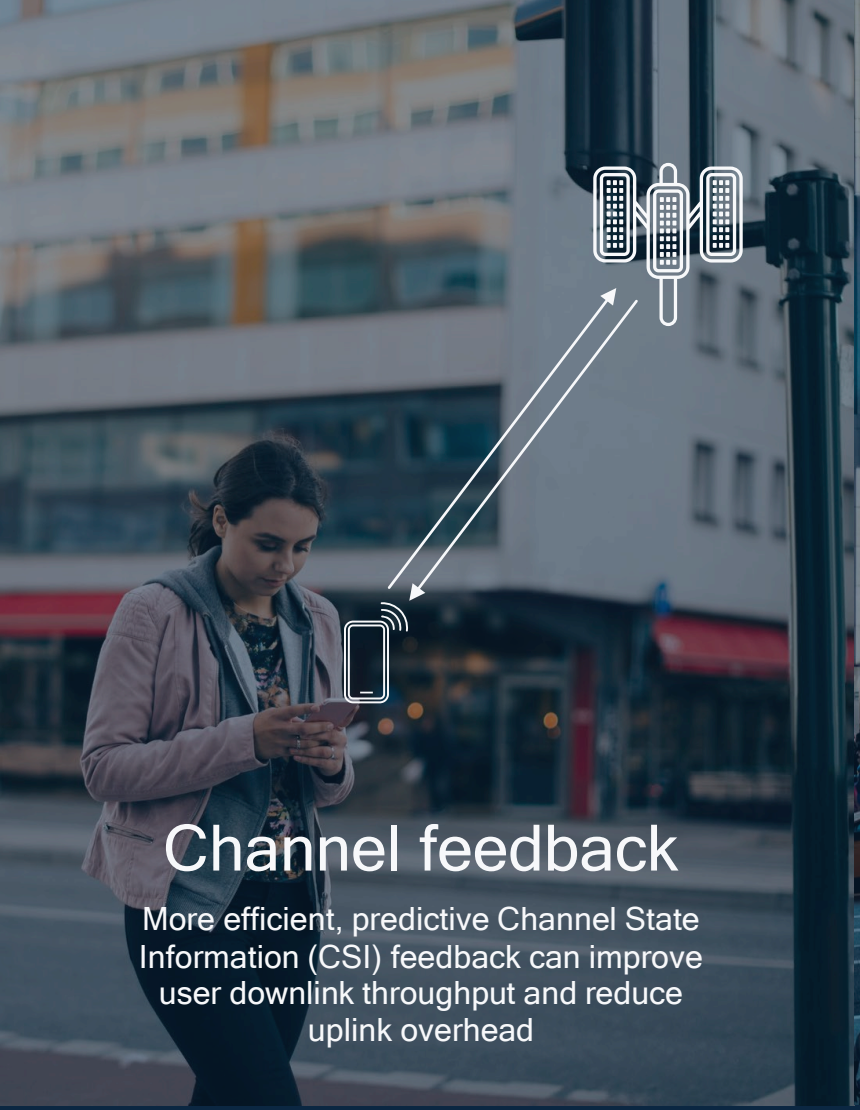
Net-0 Capex

70% less energy

* Subscribers able to experience mmWave daily. ** Hypothetical UK operator with 30% market share

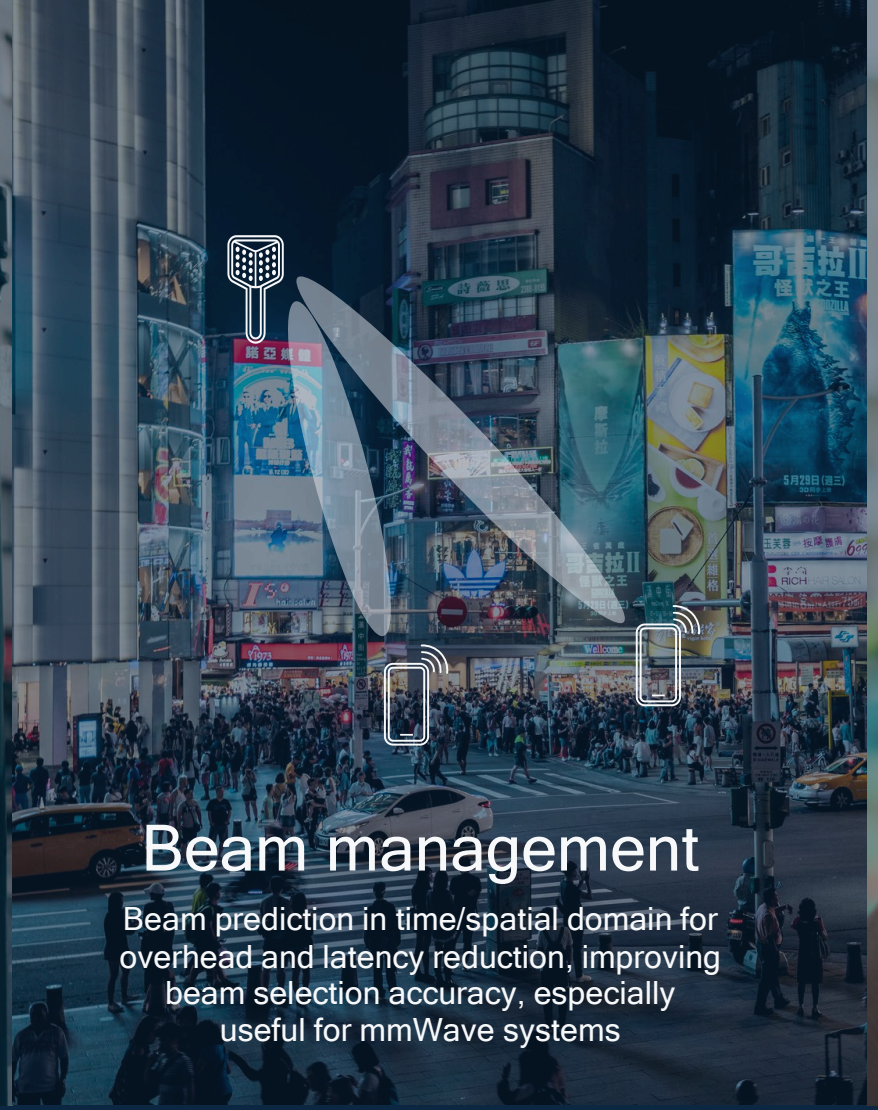
Source: Qualcomm Technologies and Bell Labs Consulting study, April 2022

The rise of AI brings a unique opportunity to revolutionize the future of wireless technology



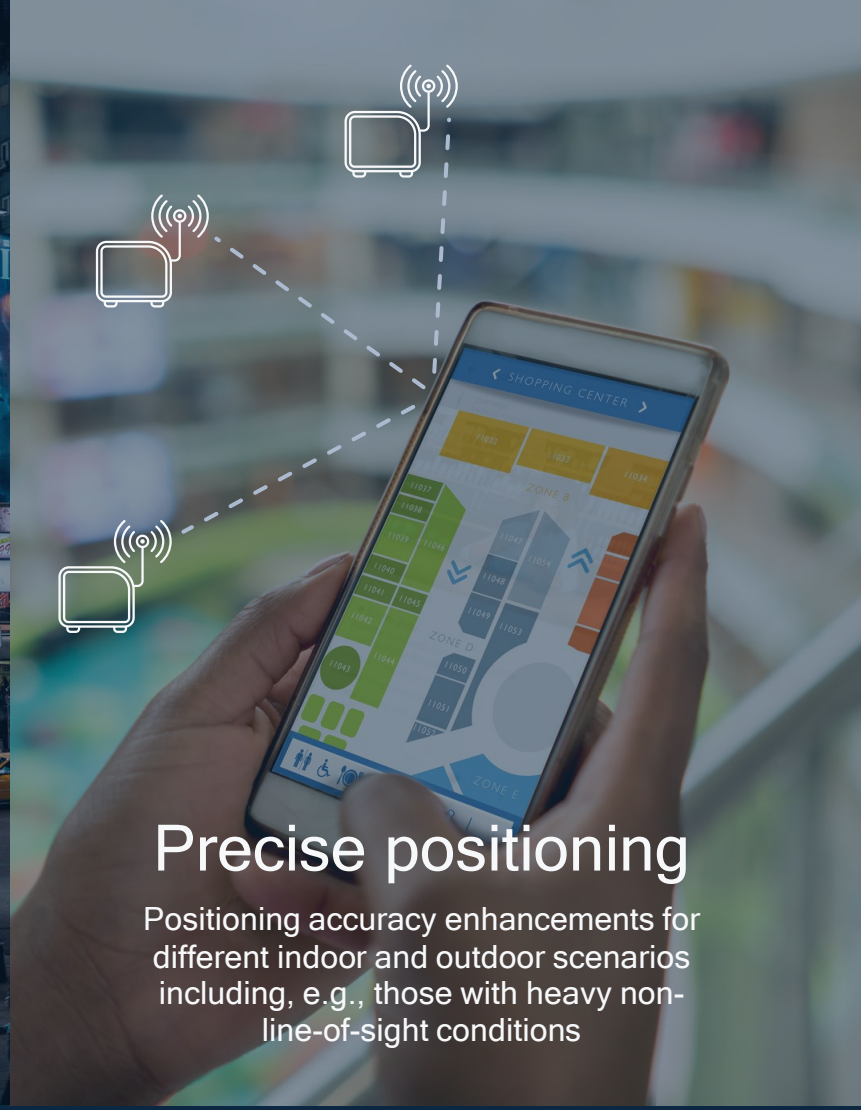
Channel feedback

More efficient, predictive Channel State Information (CSI) feedback can improve user downlink throughput and reduce uplink overhead



Beam management

Beam prediction in time/spatial domain for overhead and latency reduction, improving beam selection accuracy, especially useful for mmWave systems



Precise positioning

Positioning accuracy enhancements for different indoor and outdoor scenarios including, e.g., those with heavy non-line-of-sight conditions

AI in 5G Advanced - Use case examples

Many more potential use cases for the future

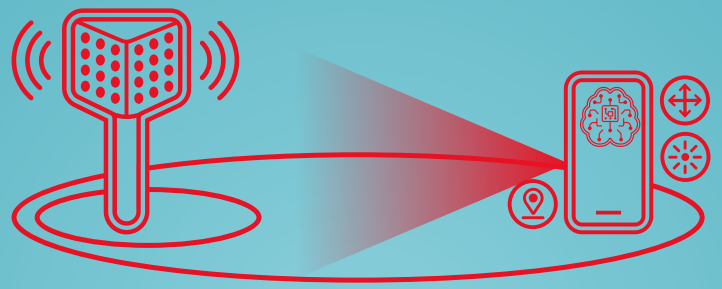
Snapdragon
X75 5G modem-RF

AI hardware acceleration for superior 5G performance

Qualcomm ®
5G AI Processor
Gen 2 with
dedicated tensor
accelerator

Snapdragon®
X75
Qualcomm®
5G AI Processor Gen 2

2.5X
improved AI performance *



AI-based mmWave beam management

1st sensor-modem-RF fusion solution for mmWave beam processing

Up to 25% higher received power* for increased mmWave robustness

AI-enhanced GNSS Location Gen 2

Up to
50%
improved location tracking accuracy [1]

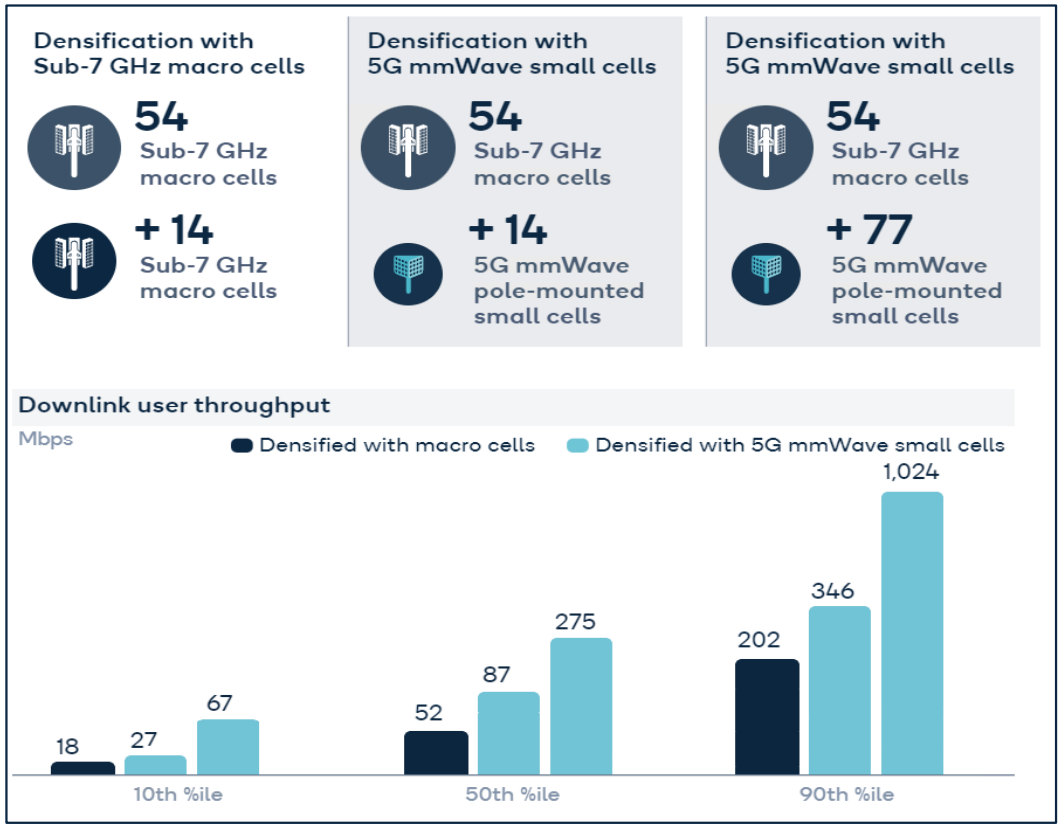
* Compared to Snapdragon X70 Modem -RF System
[1]Compared to non -AI-based location tracking; Under typical GNSS -challenged dense urban canyon environment

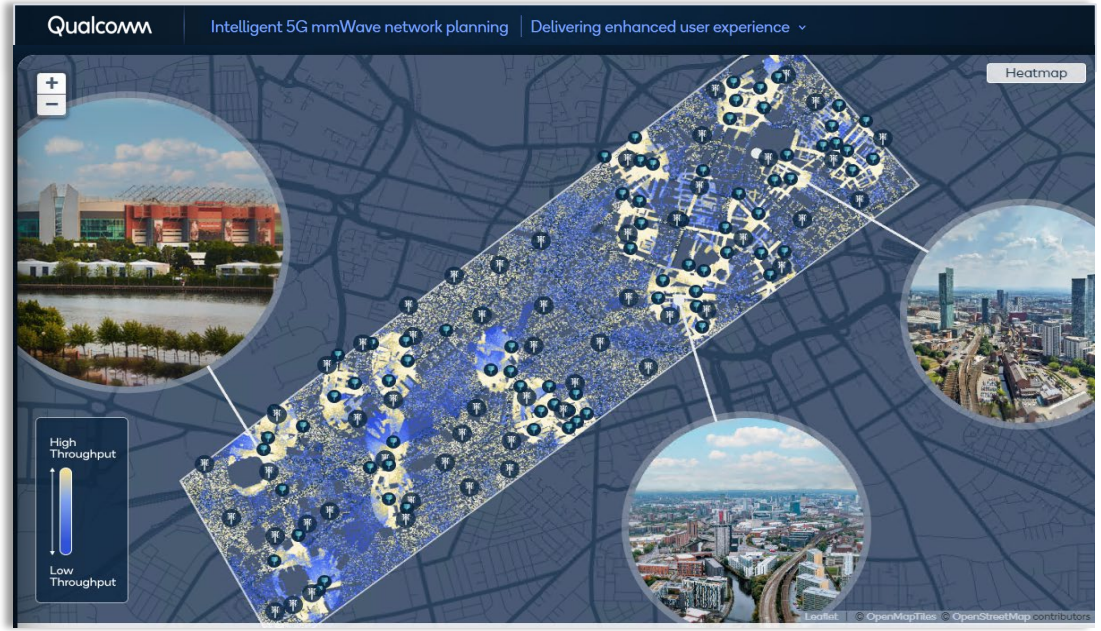
Intelligent 5G mmWave network planning

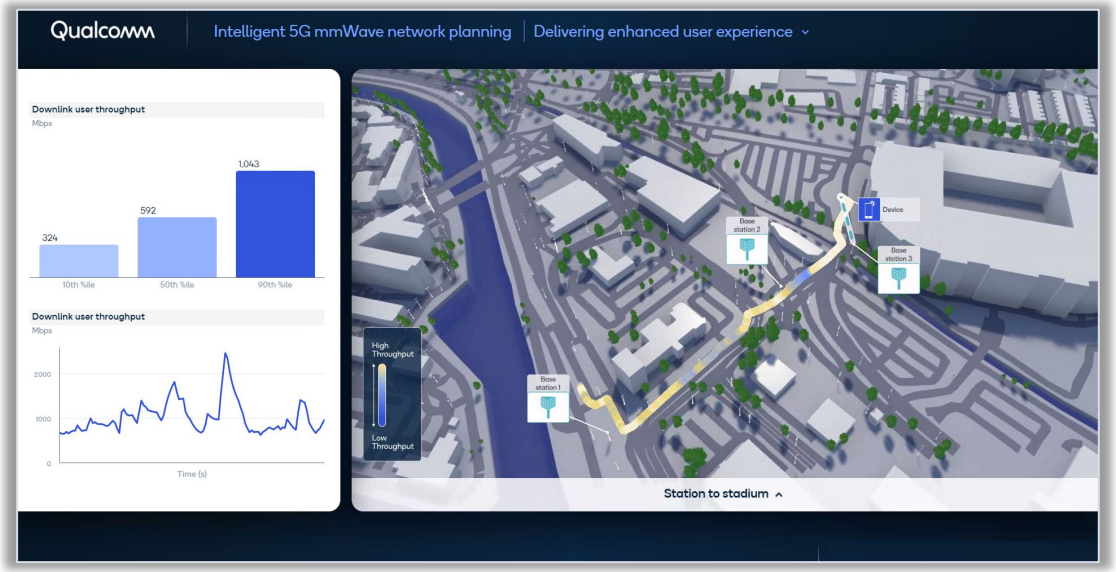
Demonstration at Qualcomm Technologies booth - Hall 3

Manchester, England

Test location: 6.8 sq km








5G
mmwave
A mature ecosystem
1. Commercial in all parts of the world
2. Mature device and infrastructure ecosystem
3. Subscribers want more capacity in crowded locations
4. 5G mmWave is the cheapest solution to cope with it
5. More to come for consumers and businesses

Thank you

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