

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.



Significant coverage with co-siting

Analog beamforming w/ narrow beam to overcome path loss. Achieving significant coverage when reusing existing sites.



Works only line-of-sight (LOS)

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



Operating in LOS and Non-LOS

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



Only viable for fixed use

Only commercially proven for wireless backhubs and satellites.



Supporting robust mobility

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



Immature RFIC technology

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

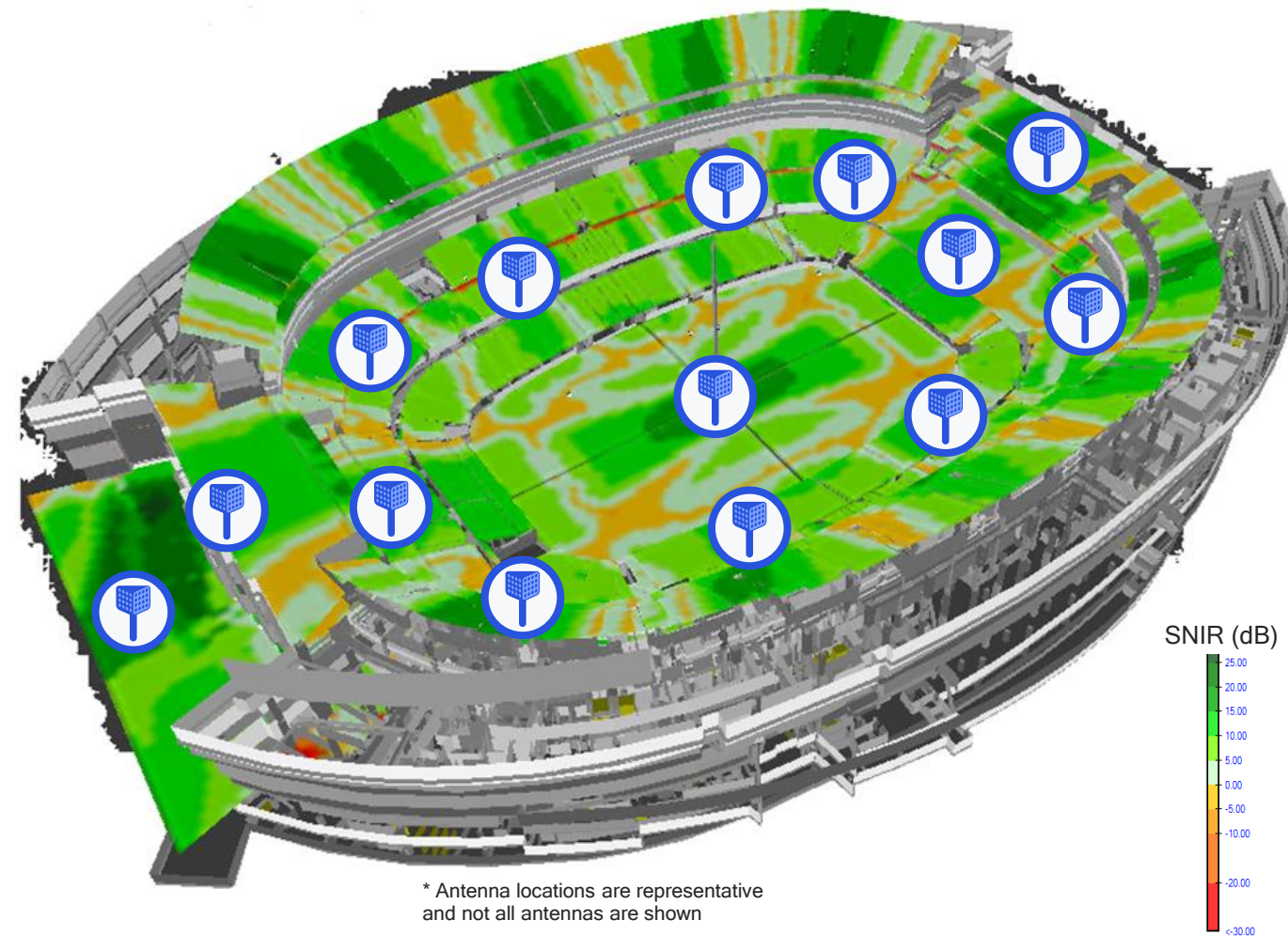


Commercialized smartphone

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

Bringing massive capacity & new experiences to stadiums

Example: NFL stadium with 100,000 seat capacity



Significant coverage

All seating areas can be covered¹ with just 15 antenna sectors

More uniform user experience

Median downlink throughput² at all levels: >700 Mbps
10th percentile (cell edge) throughput: >100 Mbps



Next level of untethering —
the mobile office of future



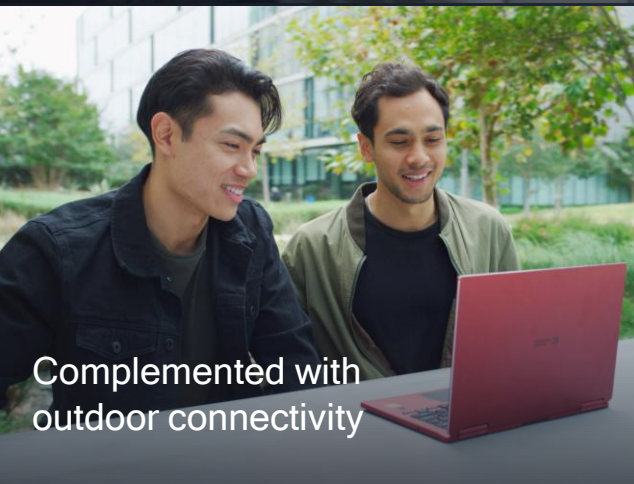
Instant cloud applications,
instant cloud storage access



Extreme capacity for heavy
use areas—conference room



Connect to projectors/screens
with immersive content



Complemented with
outdoor connectivity



Beyond laptops:
Augmented and virtual reality (XR)

Boosting enterprise productivity with 5G private networks

Complement Wi-Fi with mmWave



Multi-Gigabit speeds with
virtually unlimited capacity



Seamless inside-out mobility



Reuse licensed spectrum with
inside-out mmWave isolation



Private 5G NR indoor network
with cellular grade security



Commercially available ACPCs and
smartphones, and soon 5G XR glasses

Expanding
breadth,
availability
of 5G mmWave
devices

150+

5G mmWave devices
launched or announced
by 50+ vendors

5G smartphones



PCs



Hotspots



Modules



CPEs





C-V2X

V2V Vehicle-to-vehicle e.g., collision avoidance safety systems. C-V2X messages on a sidelink channel provide a Non-Line of Sight (NLOS) sensor for vehicles



V2I Vehicle-to-infrastructure e.g., Red light violation warning. Roadside Units (RSUs) broadcast messages on a sidelink channel to enhance safety at intersections



C-V2X



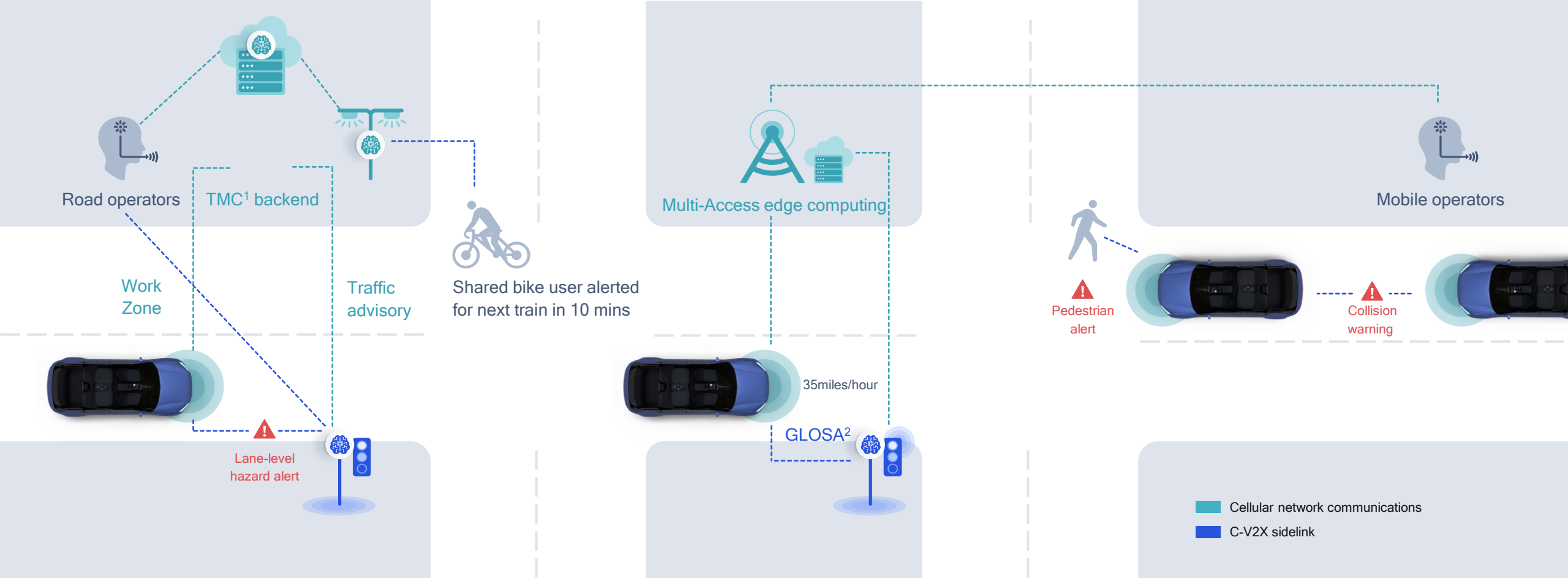
Connects vehicles to everything around them
Enhancing the safety of an intelligent transportation system



V2N Vehicle-to-network e.g., real-time traffic/routing, cloud services. V2N messages enable value-add use cases for drivers, vehicle OEMs and road operators



V2P Vehicle-to-pedestrian e.g., safety alerts to/from Vulnerable Road Users (VRUs) like bicyclists/pedestrians. Vehicles/VRUs broadcast messages on a sidelink channel allowing other actors to take appropriate action



C-V2X sidelink complements 5G networks

Managing intersections combining C-V2X with 5G



C-V2X sidelink
(collision avoidance and safety alerts)



Cellular networks
(TMC-based traffic monitoring and advisory)



Edge AI
(AI-based vision systems for enhanced safety)

Protecting VRUs

A person is riding a red bicycle on a wet street at night. The person is wearing a grey long-sleeved shirt and dark pants. The street is wet and reflective, showing the lights from the bicycle and the car in the background. A car with its headlights on is visible in the background, slightly out of focus.

2019 National Highway Traffic Safety Association stats
for pedestrian and cyclists

6,205 pedestrians were killed in traffic crashes

- ~one person every 85 minutes, up 27% since 2015
- 17% of all traffic fatalities

846 pedal cyclist fatalities, accounting
for 2.3% of all traffic fatalities

~49,000 pedal cyclists were injured,
a 5.4% increase over 2018

Strong momentum in the U.S.



C-V2X is a critical component of our vision

The safety component of the Digital Chassis

Vehicle-to-Infrastructure (V2I)

e.g. Red Light Violation Warning



Vehicle-to-Vehicle (V2V)

e.g. collision avoidance safety systems



Vehicle-to-Network (V2N)

e.g. real-time traffic / routing, cloud services



Vehicle-to-Pedestrian (V2P)

e.g. safety alerts to pedestrians, bicyclists



Enhanced range and reliability
for direct communication without
network assistance



Qualcomm® 9150 C-V2X chipset commercialized starting 2018



Integration of C-V2X into the Qualcomm® Snapdragon™ Automotive 4G (SA415M) and 5G (SA515M) Platforms starting 2019

Augment on-device processing for boundless photorealistic mobile XR



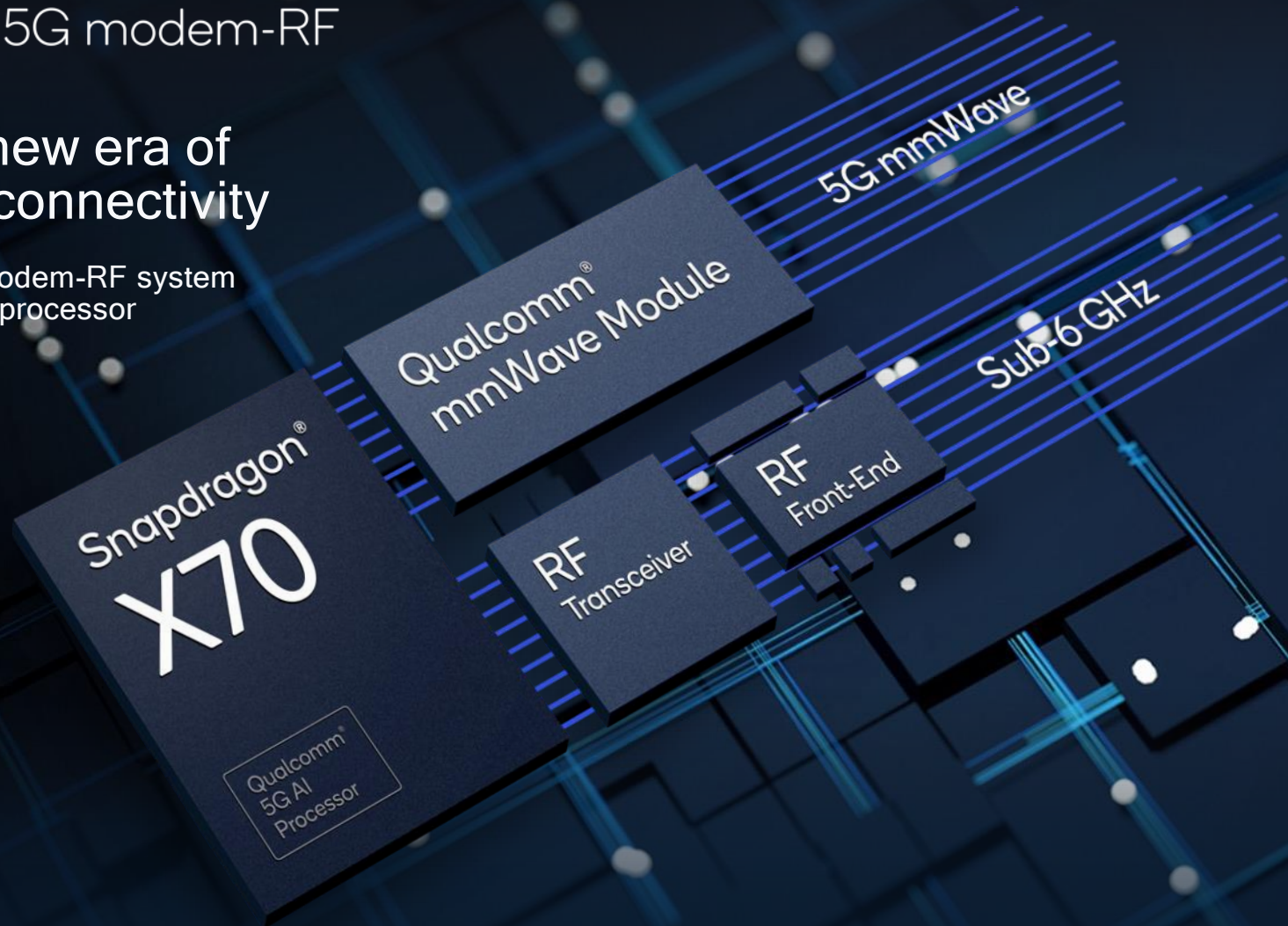


Snapdragon

X70 5G modem-RF

Fueling a new era of
intelligent connectivity

World's first 5G modem-RF system
with integrated AI processor



Improved
speeds

Enhanced
coverage

Improved
stability

A new era of
**connected,
intelligent
devices**



A unifying connectivity fabric

Like electricity, you will just expect it everywhere





Thank you

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