August 25, 2020 San Diego @qualcomm

Qualcomm

Smart Transportation

Jim Misener,

Sr. Director, Product Management and
Global C-V2X Ecosystem Lead,

Qualcomm Technologies, Inc.

Smart transportation can benefit from connected systems — roads, vehicles, and infrastructure

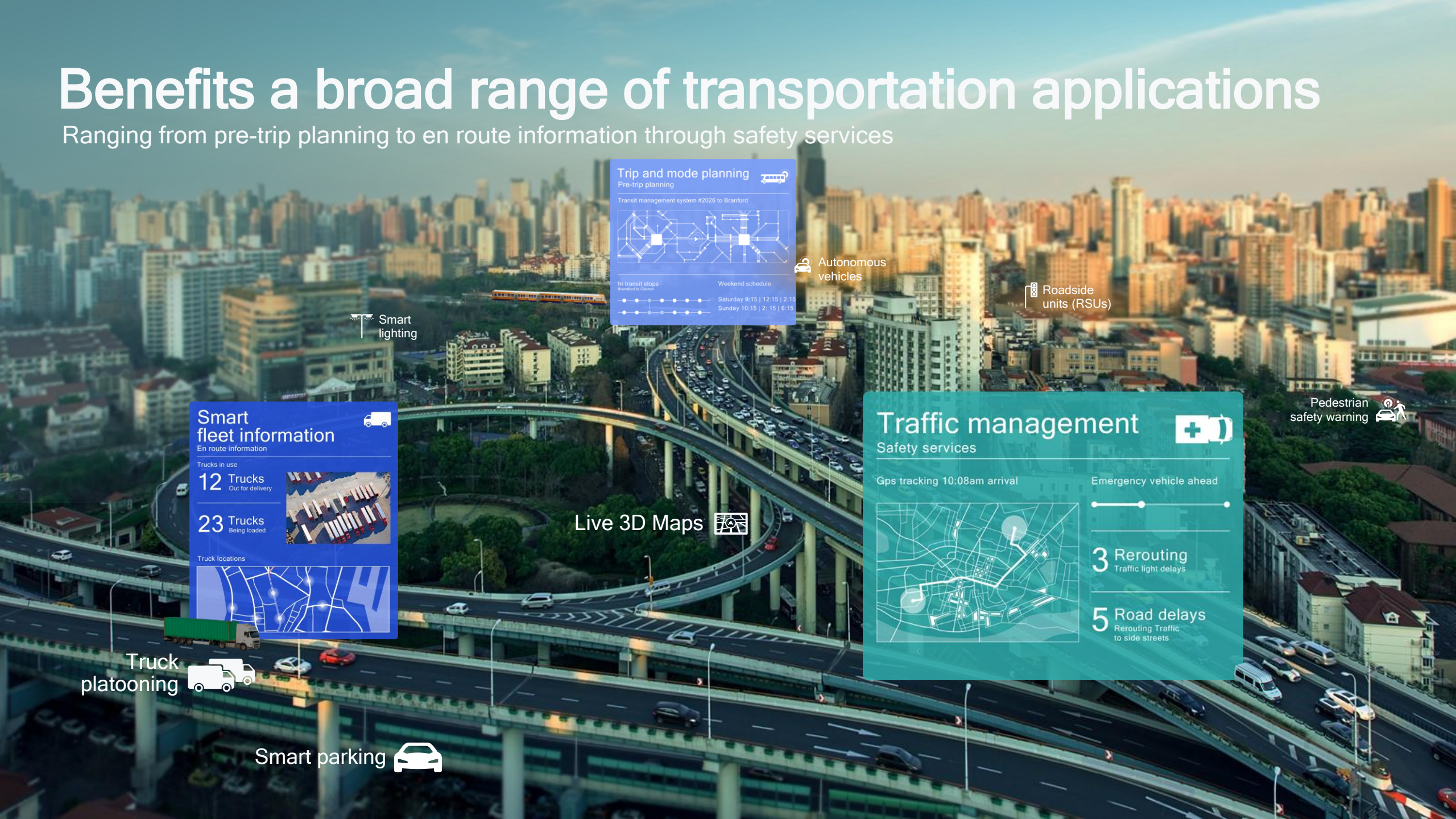
Cellular and transportation networks, in partnership, can deliver efficient smart transportation solutions

Smart transportation can tap quantifiable benefits to for everyone

With our technology leadership, rich 5G roadmap, and proven AI capabilities, we are shaping a new era of smart transportation for a cleaner environment and sustainable future

Benefits a broad range of transportation applications

Ranging from pre-trip planning to en route information through safety services



Evolving technologies

to support key transportation use cases

1 TMC is Traffic Management Center

Reshaping our neighborhoods

Cellular + Transportation networks

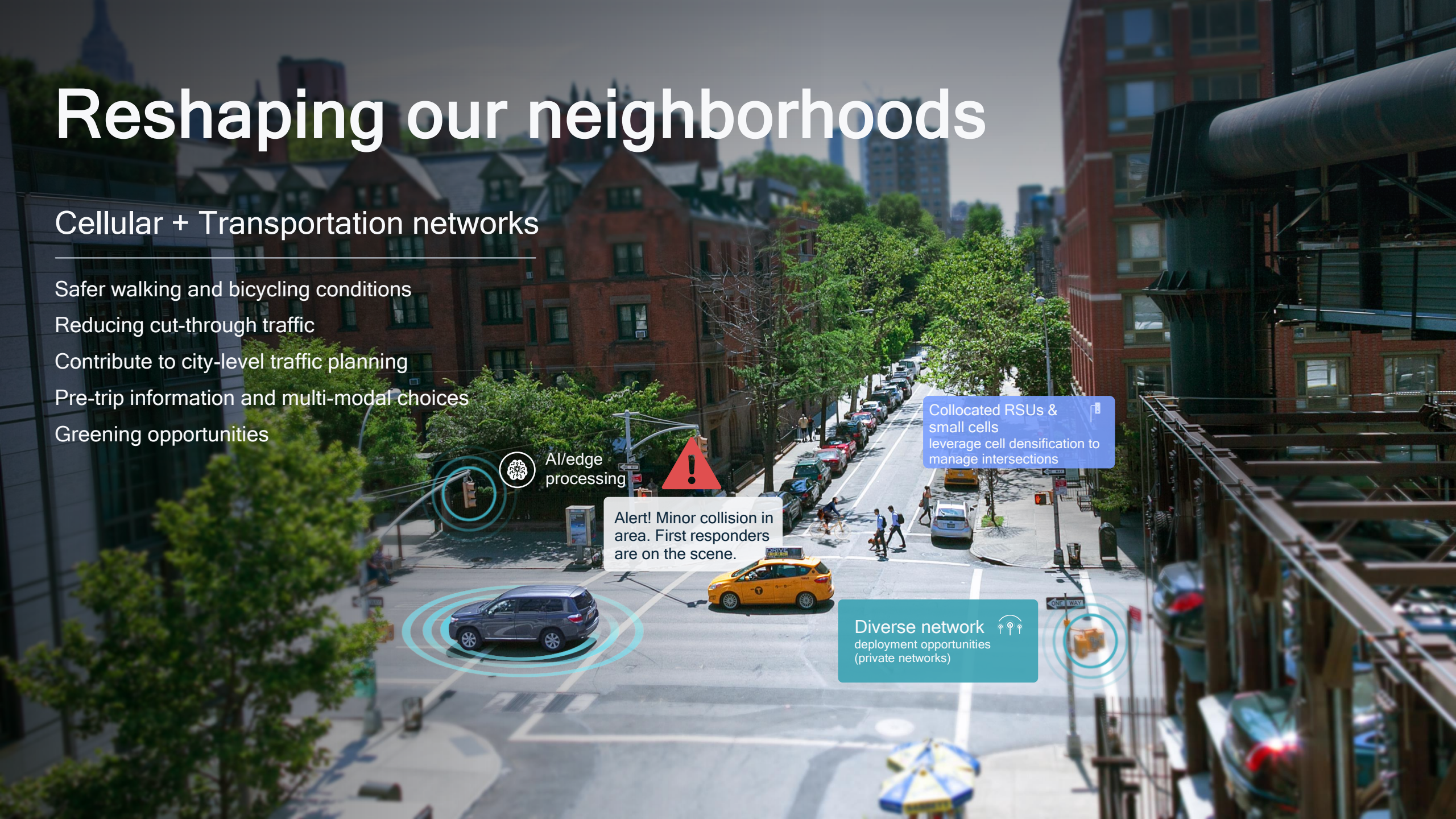
Safer walking and bicycling conditions

Reducing cut-through traffic

Contribute to city-level traffic planning

Pre-trip information and multi-modal choices

Greening opportunities



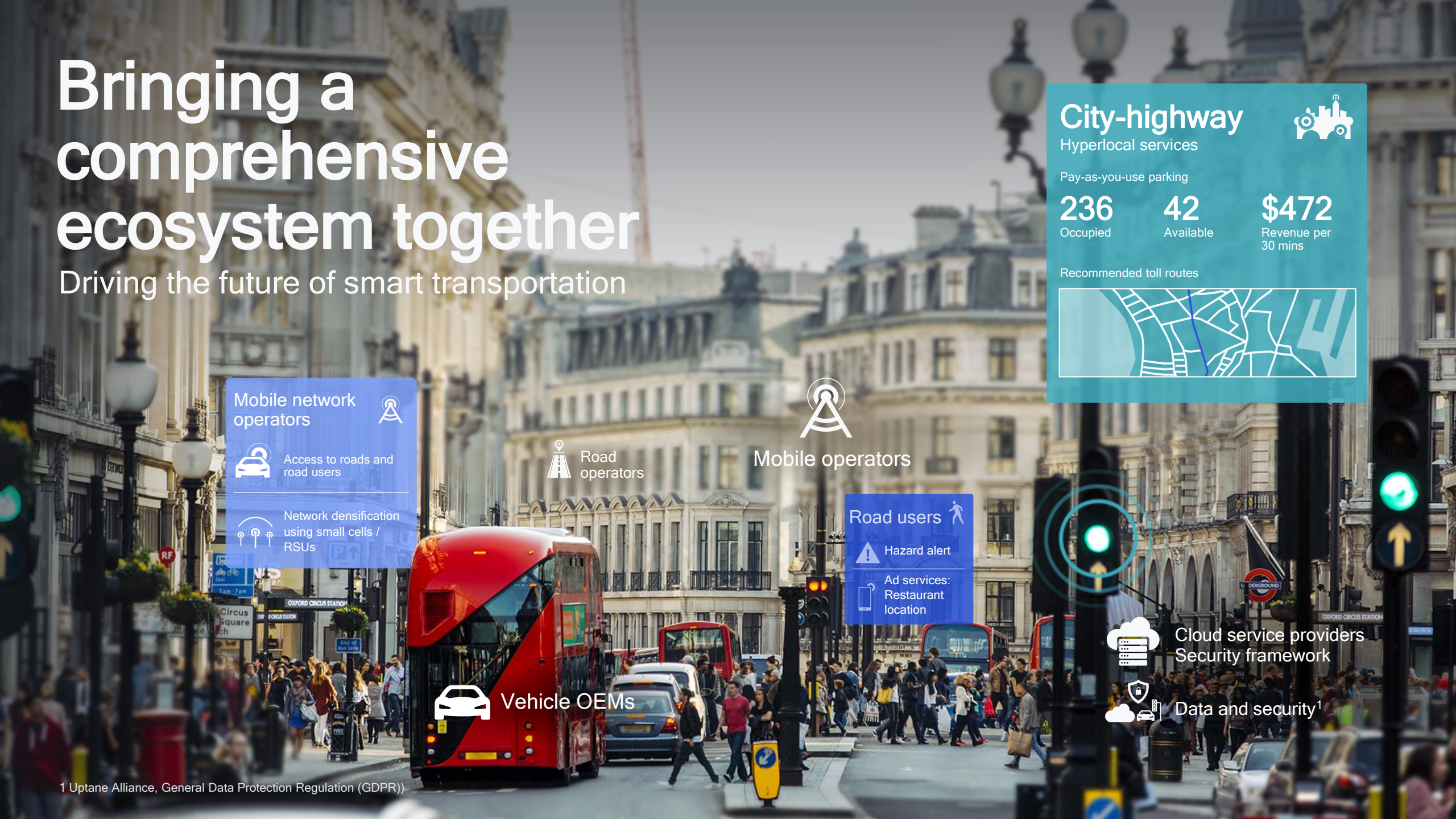
Smart transportation can revolutionize logistics

1 MEC is mobile edge network


Maximizing
Efficiency
with shared transit and mobility on demand
Safety
Affordability
Reliability
Availability to all
Hybrid/
Electric buses
Clean environment
Quieter buses
Reduced
operational costs
Location-based
services
Transit
signal priority
Priority services
BRT
Rideshare
Saved time
00:06:15
Saved time
00:08:00
Integrated with ITS
Location map
77
34
65
52
76
84
86
GRN-AIRPORT
Bus
5
Auto fare
collection
Time left
00:02:10
Seats left
5 / 30

Bringing a comprehensive ecosystem together

Driving the future of smart transportation



1 Uptane Alliance, General Data Protection Regulation (GDPR))

Facilitating multi-tiered services

Pedestrian detection

AR-based navigation

Virtual assistant

Traffic information

Freemium

Feature management

Vehicle features

Your music stations added

Day running lights on

City speed limit set

Premium

On demand unlocking and locking

Context-based personalized information

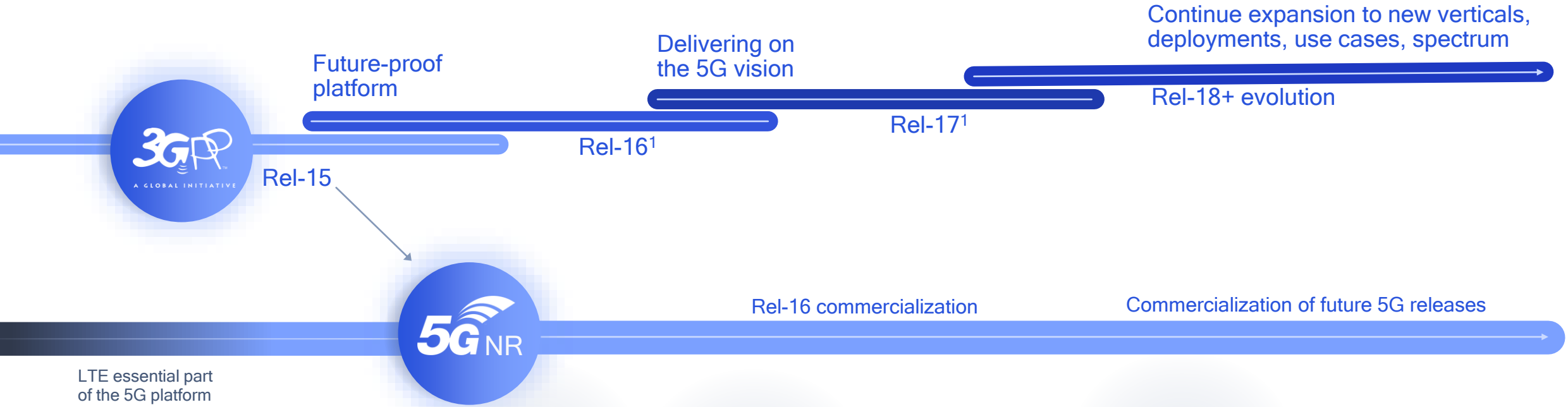
Premium

Road safety comes free

Pedestrian 10ft ahead

Shaping a new era of smart transportation

Driving the 5G technology evolution



2019 eMBB

- Global smartphone launches
- Fixed wireless access

2020 eMBB expansion

- Beyond smartphone (PC, FWA, …)
- New markets/regions
- Nationwide coverage and SA migration

Longer term expansion

- Automotive, Smart City, Industrial IoT,…
- Private networks
- Unlicensed spectrum

2018 | 2019 | 2020 | 2021 | 2022 | 2023+

1. 3GPP start date indicates approval of study package (study item->work item->specifications), previous release continues beyond start of next release with functional freezes and ASN.1

Perceive

Camera, radar sensors

CV2X, localization in maps extended horizon sensors

Low level sensor fusion

Plan

Behavior prediction

Behavior planning

Motion planning

Act

Actuation control

Drive-by-wire smooth maneuver

Connect

Tele-operations

Data analytics

Smart transportation

Simulator and tools

A system approach—autonomy stack

End-to-end system. Active sensing and extend horizon using connectivity and maps

5G brings several features to autonomous driving

Autonomous driving

Perception

Sharing of high throughput sensor data and real world model

Path planning

Intention and trajectory sharing for faster, yet safe maneuvers

Real-time local updates

Real-time sharing of local data with infrastructure and other vehicles (e.g. 3D HD maps)

Coordinated driving

Exchanging intention and sensor data for more predictable, coordinated autonomous driving

Benefits

Safer roads

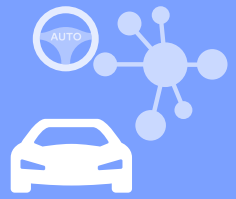
Truck platooning, driver monitoring, minimizing manual operations to substantially human error

Clean environment

Reduced emission and shorter travel time

Enhanced personal mobility

Mobility services, assistive technologies, route planning



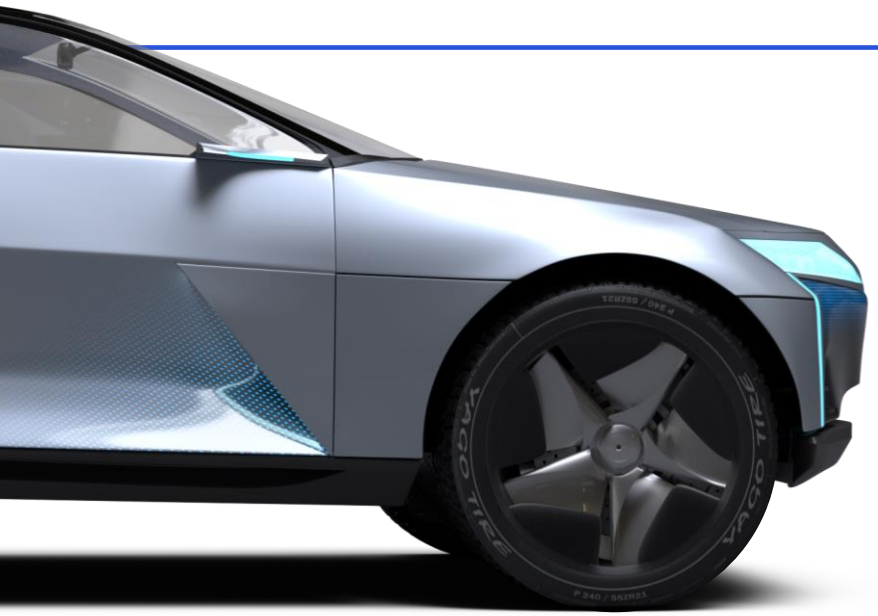
New business opportunities

Parking services, mapping services, fleet management, etc.

C-V2X + Autonomous Driving + Car-to-Cloud

For the next generation of intelligent transportation systems

Bringing richer applications, content, and services management



Car-to-Cloud platform

Future-proof designs

On demand/OTA updates, soft-SKU

Driver monitoring

Improved safety

Expanding the digital ecosystem using data

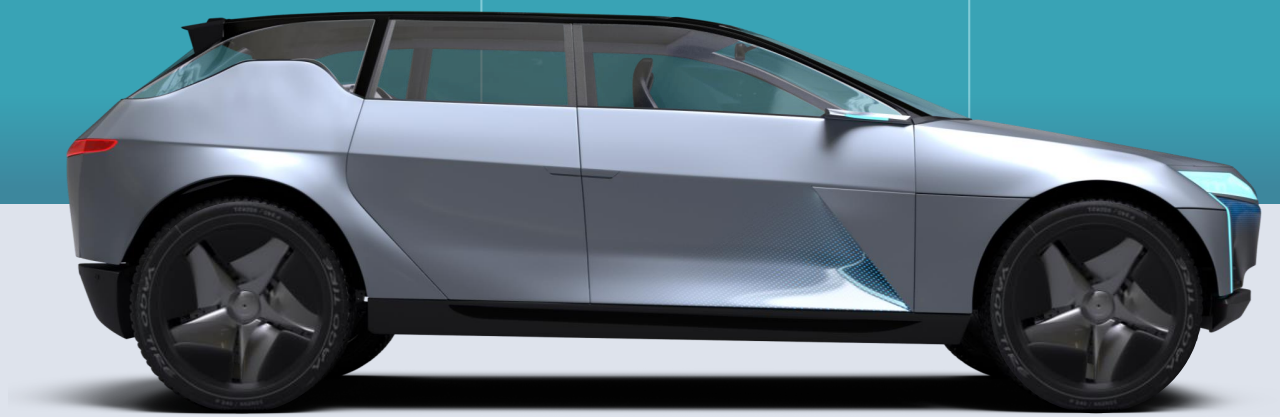
User data apps and behavior

Vehicle data and diagnostics

Actionable insights

New opportunities

Personalized user experience



Car-to-Cloud platform

C-V2X

Standards complete, commercially available, deployment begun

Broad industry support with 5GAA

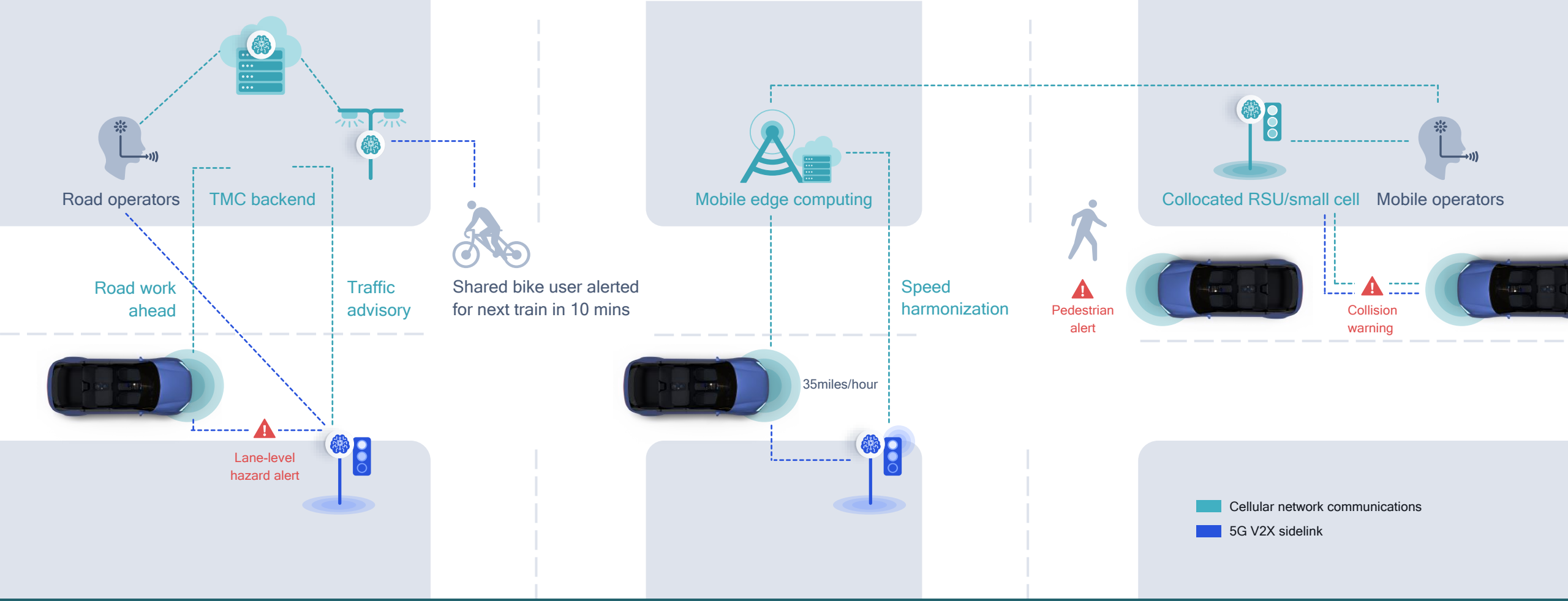
Initial focus on basic safety use cases

5G roadmap expands functionality

Rich sensor sharing
Vehicles share intent and perception

On-the-fly connectionless groups
Enabled by reliable multicast

Benefits in addition to safety
Coordinated driving brings reduced congestion, shorter trip time, and energy savings



5G V2X sidelink can complement wide-area networks

Managing intersections with 5G V2X

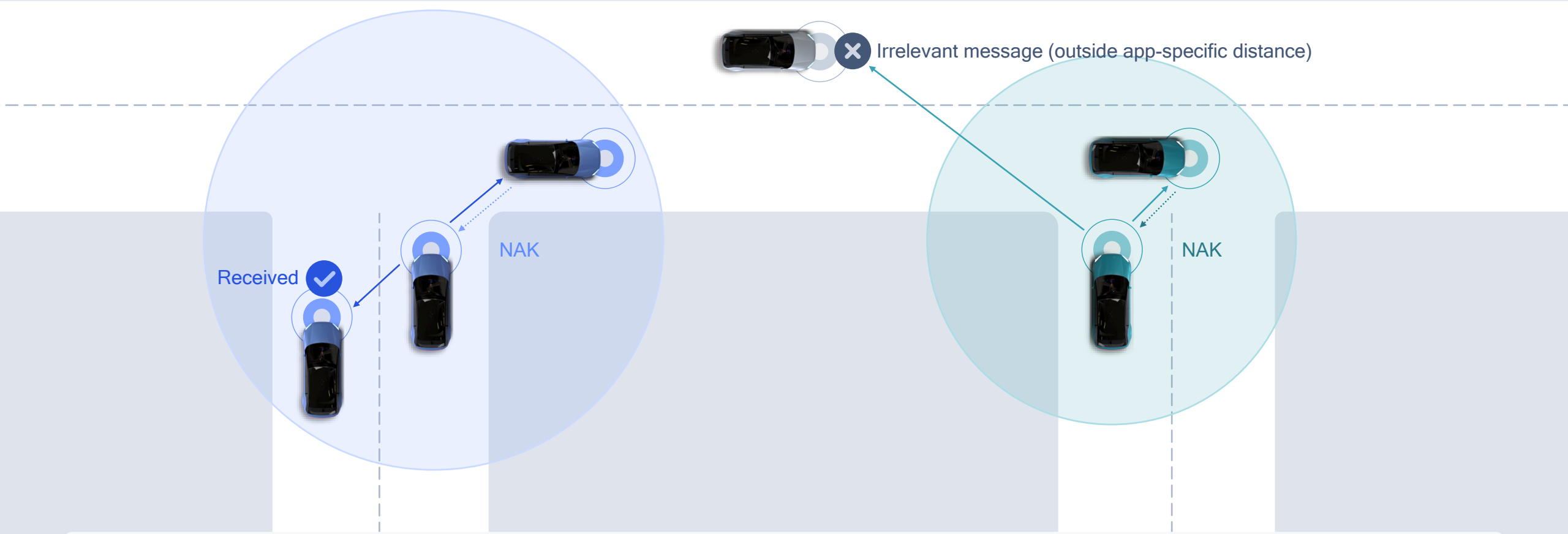
5G V2X sidelink
(collision avoidance and coordinated driving)

Cellular networks
(TMC-based traffic monitoring and advisory)

Edge/on-device AI
(AI-based traffic sensors for speed harmonization)

Application A

Application B



Application-aware, distance-based multicast communication with 5G V2X can assist in intersection management

Application-specific distance is determined based on relevancy
Transmitting vehicles adapt transmission to relevant vehicles within range
Receiving vehicles only acknowledge (NAK) relevant messages

Smart RSUs with on-device processing can complement edge cloud

Central cloud

Traffic management center

Big data, AI training, less delay sensitive content, storage,…

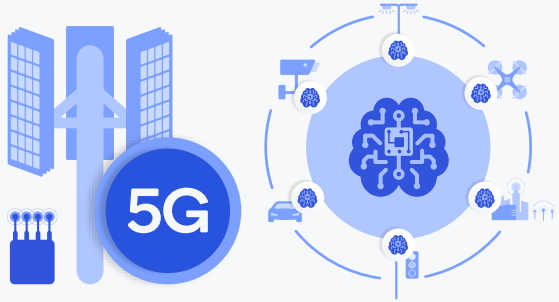
Compute intensive, real-time data

Edge cloud

Neighborhood/city/highway

Compute/processing, context, control, storage, closer to vehicular network

Vehicular networks are highly dynamic



On-device intelligence

Smart RSUs

Sensing, processing, security, intelligence

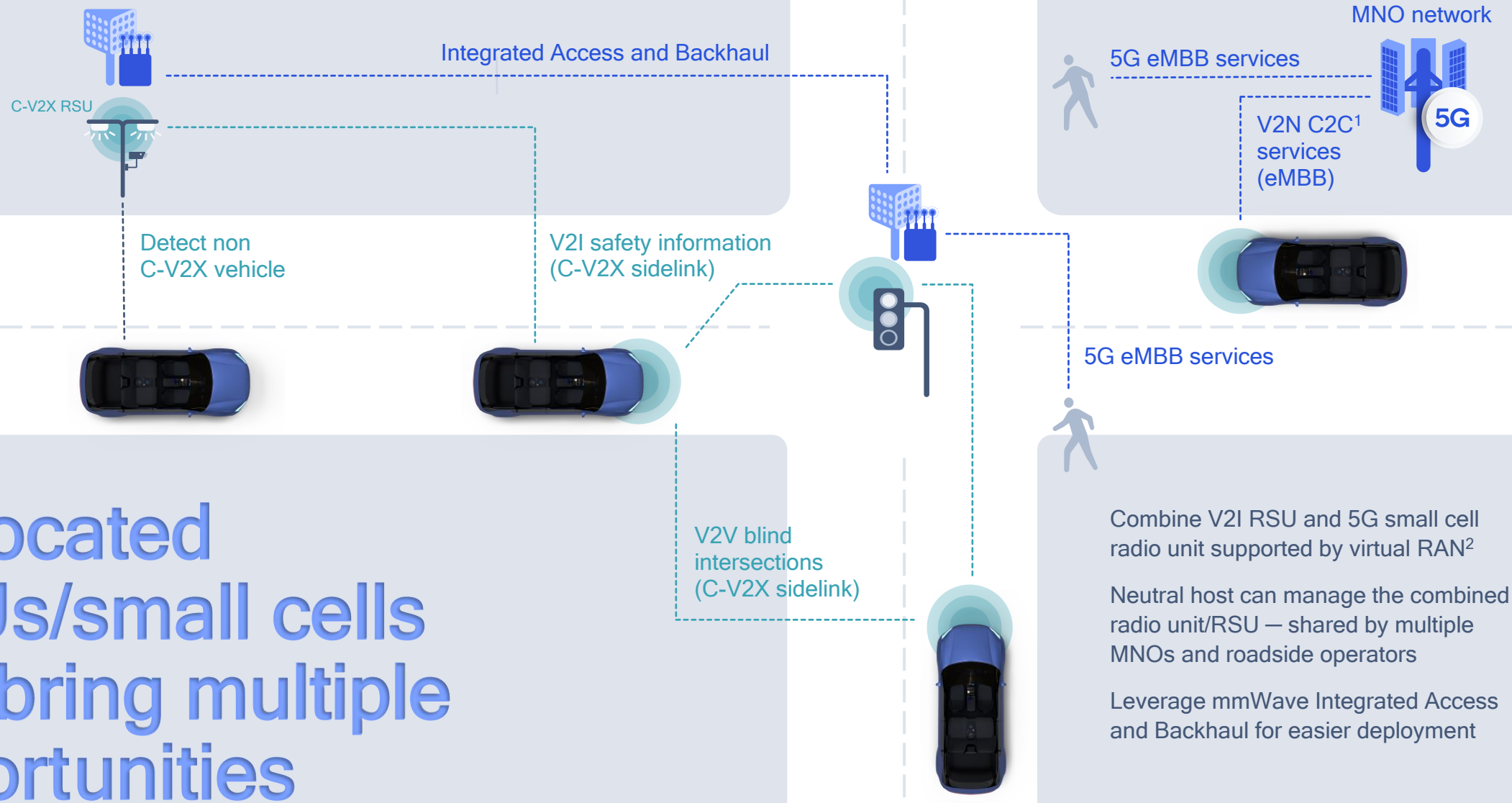
- Realize 5G's low latency
- Scalability
- Performance
- Additional resources
- New deployments, (private networks)

Latency could be over 100s ms today ← Cooperation between road operators, MNOs[1], infra vendors, cloud providers,… → Latency as low as 1 ms

- 5G value maximizes from operators and city services
- Deliver enhanced and new services
- Host, content, processing,.. for 3rd party
- Local analytics, management, security

- Immediacy–tasks on device
- Efficient use of bandwidth
- Scalability

1 MNO is mobile network operator



Collocated RSUs/small cells can bring multiple opportunities

Combine V2I RSU and 5G small cell radio unit supported by virtual RAN[2]

Neutral host can manage the combined radio unit/RSU — shared by multiple MNOs and roadside operators

Leverage mmWave Integrated Access and Backhaul for easier deployment

MNO radio unit
mmWave + sub-7

1 C2C is car-to-cloud 2 RAN is radio access network

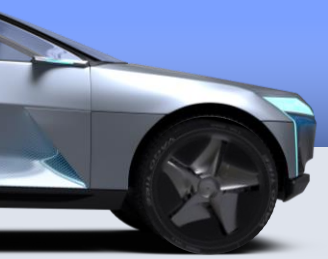
Smarter transportation infrastructure creates new opportunities

Road world model SW stack
Perception, sensor fusion

Compute
Heterogenous computing and AI accelerator for perception/sensor fusion

Communications
V2I (sidelink) via C-V2X
Cellular communication via 4G/5G

C-V2X

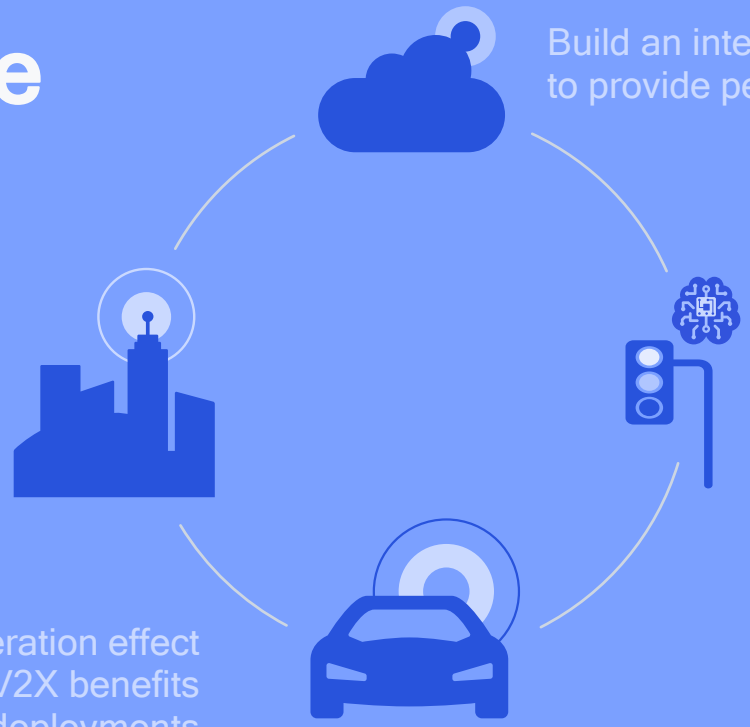


Today
Basic safety and mobility services

Tomorrow
Advanced safety applications
Smarter RSUs, collocated RSUs and small-cells

Future
Roadside access can generate new revenue models

Sharing roadside access can generate additional value for the ecosystem

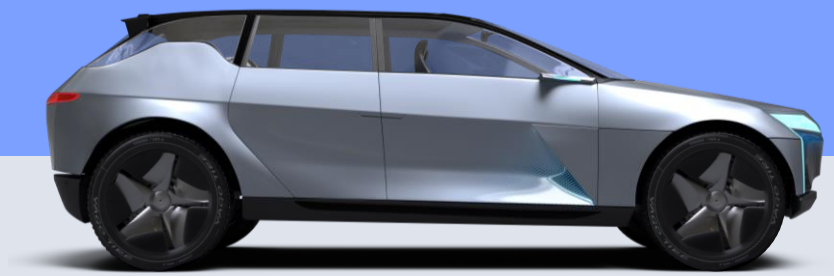


Build an integrated data sharing system to provide personalized services

Leverage collocated smart RSUs/small-cells to expand MNOs cellular coverage

Leverage network acceleration effect to expand C-V2X benefits in initial deployments

Improve collaboration for enhanced road management



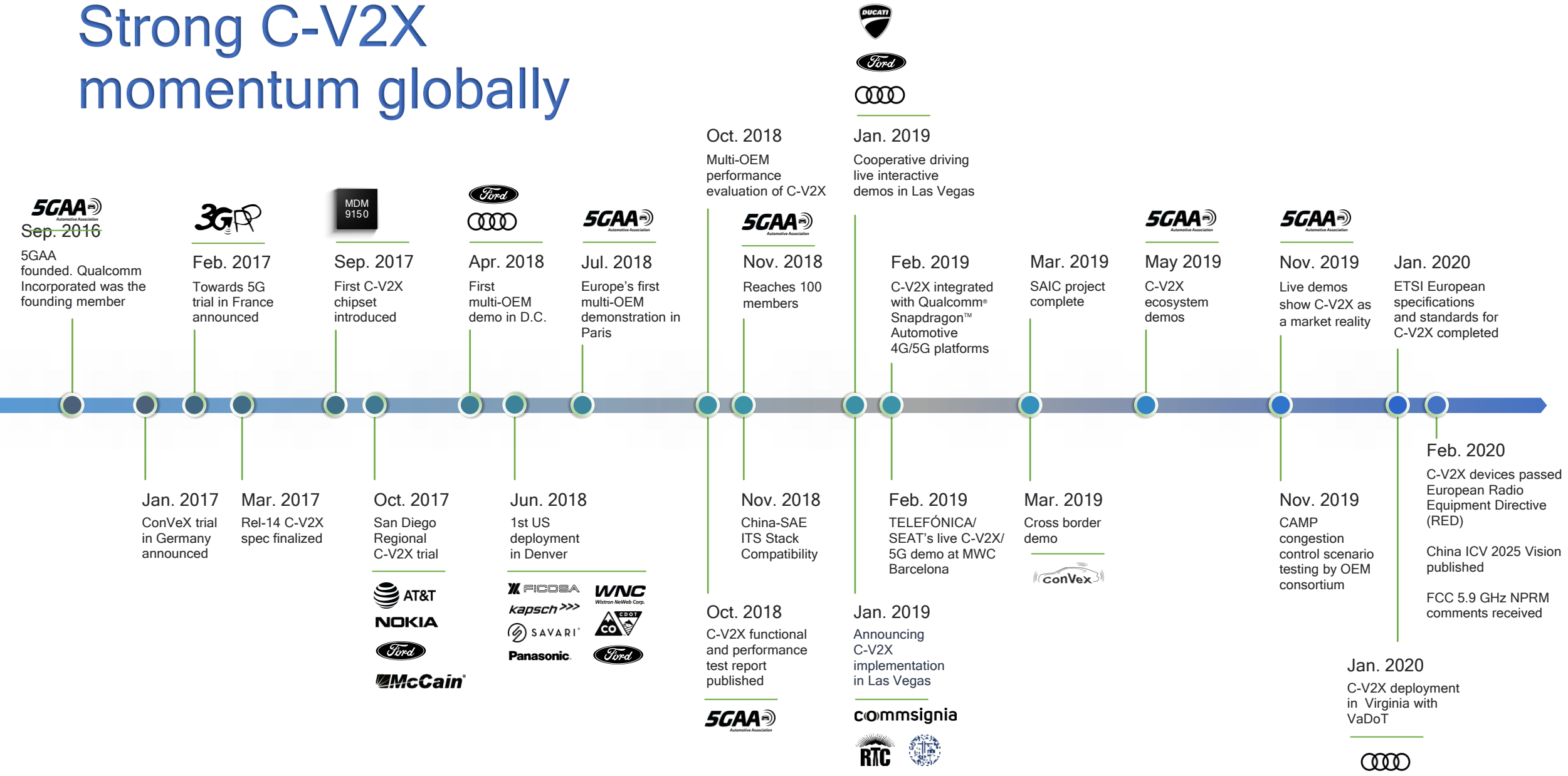
Today

Tomorrow

Future

Driving digitally enabled end-to-end solutions for smart transportation

Strong C-V2X momentum globally



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

Over a decade of innovation and core R&D

Autonomous stack

Investing for multiple years in R&D to develop a comprehensive autonomous highway pilot stack

ADAS SoC and accelerator

Automotive Safety compliant scalable HW – SoCs and Accelerators, with SDK, framework, tool chain

Dimensioning purpose-built IP

Workload and HW sizing for optimized, purpose-built HW, SW, compilers, optimizers and algorithms

HW and SW proof-of-concept

Developed prototypes including camera perception, radar deep learning, localization, sensor fusion, path, maneuver and behavior planning; and related AI/ML, tools

Continuous road and offline testing

Software-In-Loop and Hardware-In-Loop tests, real-world simulations

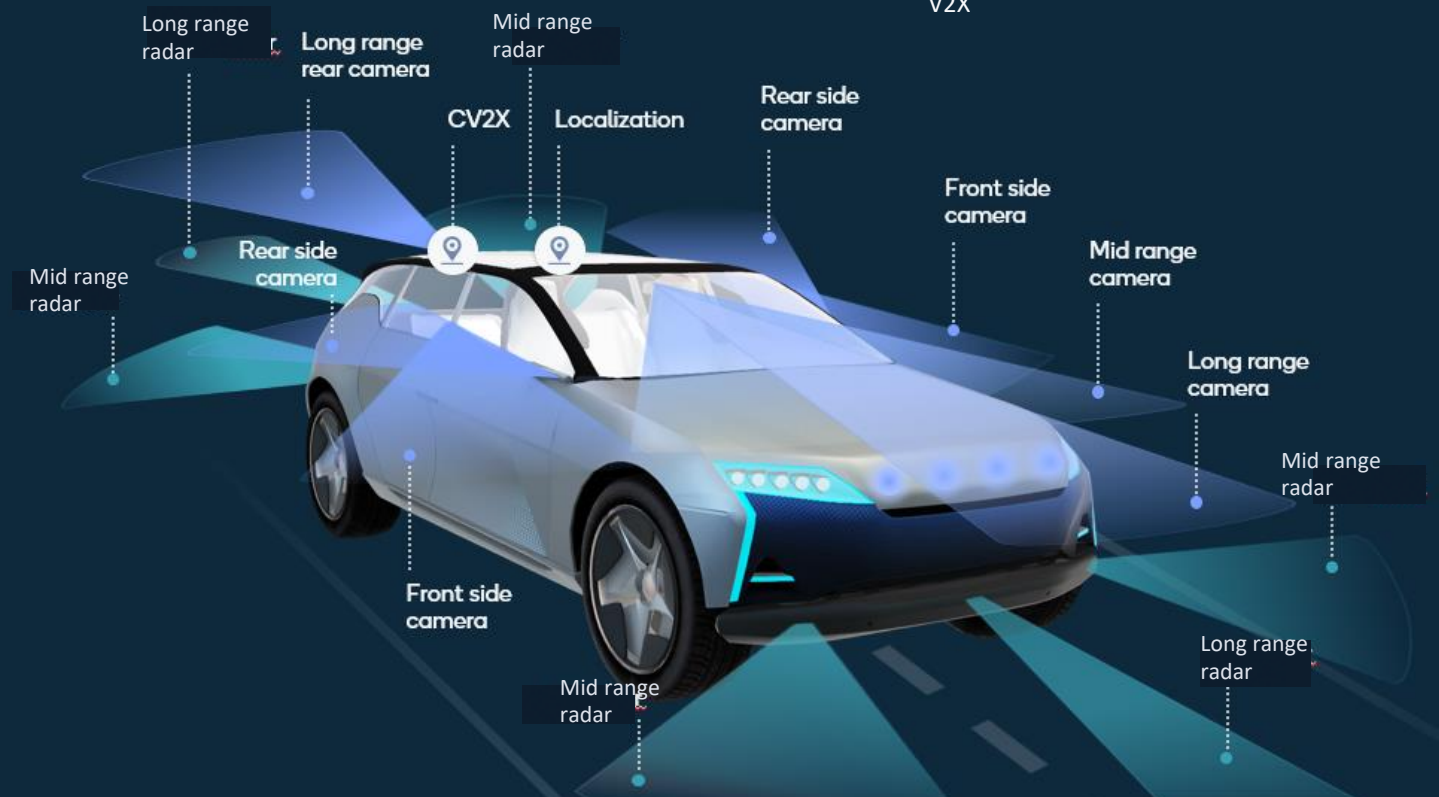
Embedded testing/optimization/tools

Using existing hardware to test and optimize the system on embedded platform

Qualcomm Technologies' holistic approach

to solving autonomous driving system challenges

Sensor coverage for 360° environmental recognition complemented by HD maps and V2X



Traffic light | Traffic sign | Pedestrian | Bicycle | Vehicles | Lane detection

Radar | HD-Map | C-V2X | Lidar

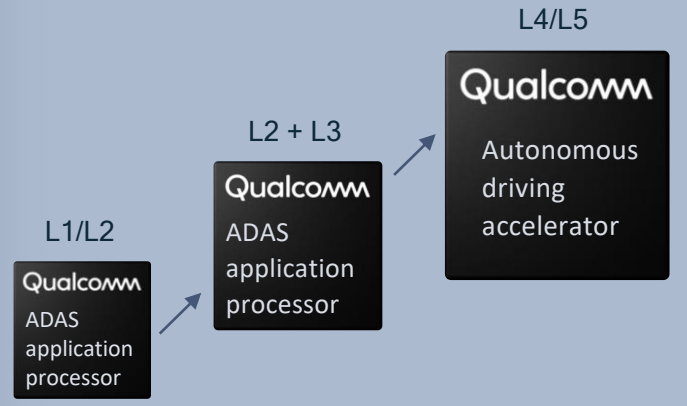
Snapdragon Ride Autonomous Stack

Hybrid Deep learning + Computer Vision approach
30+ Concurrent Deep Learning Networks
Advanced RADAR perception w/ Deep learning
Hybrid RL based Prediction & Planning

Camera | Localization | Ultrasonic

Qualcomm VEPP + Map Fusion

Family of SoCs and Accelerator

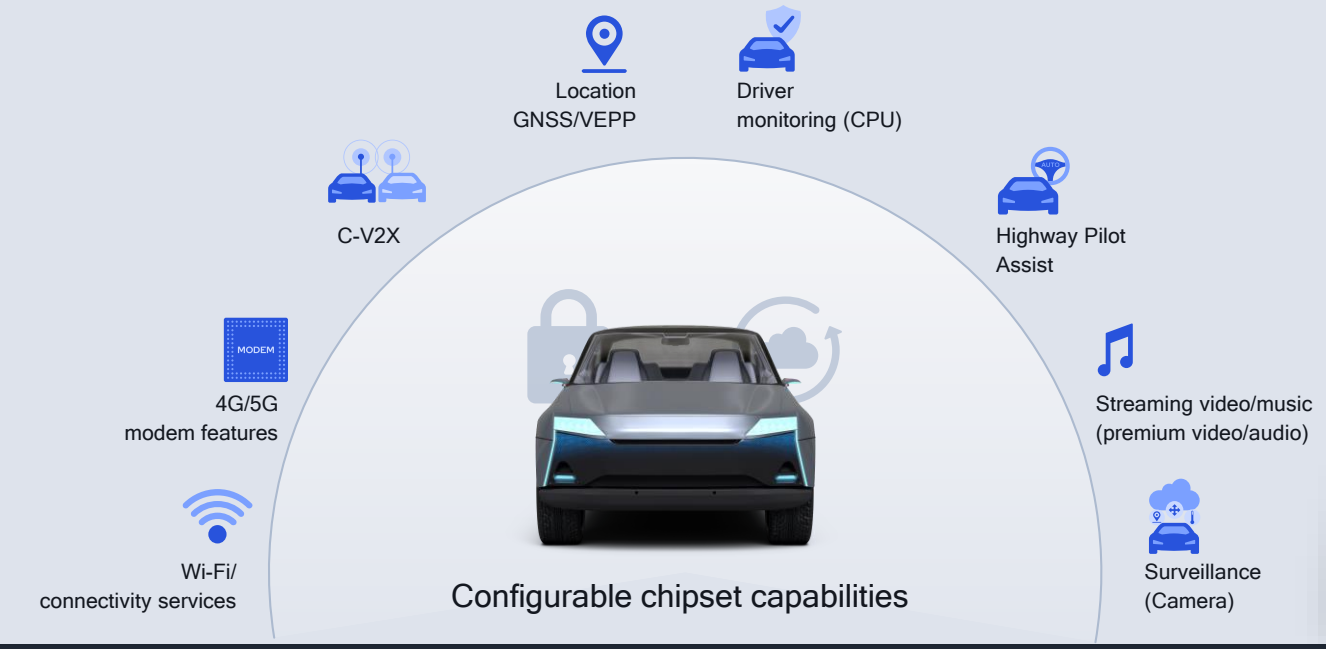


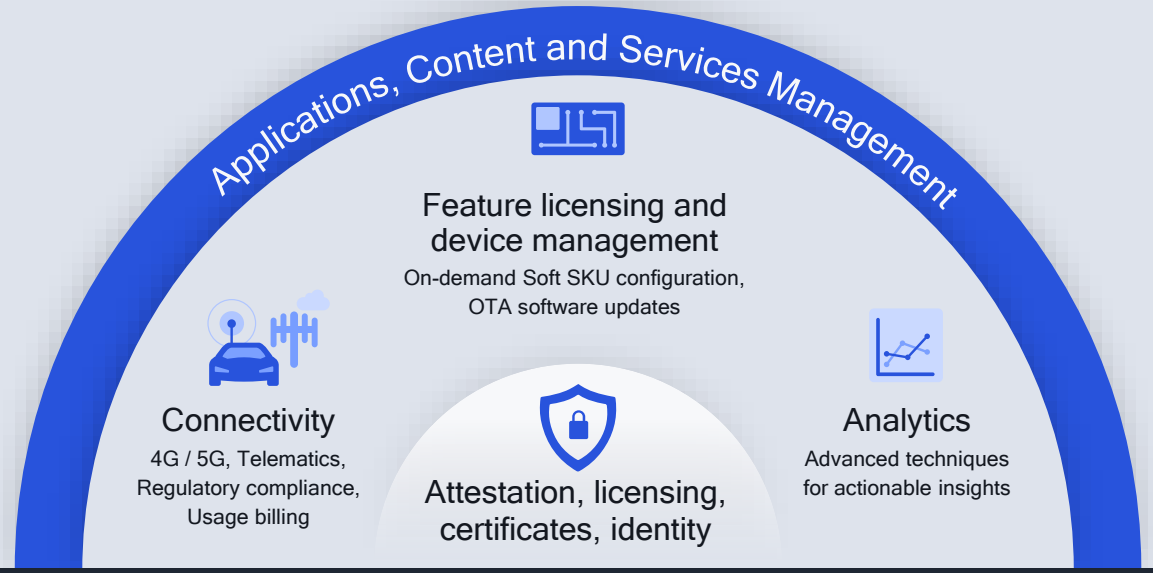
Hardware platforms

Scalable and thermally efficient

Snapdragon Automotive Cockpit, 4G/5G Wireless Platform, ADAS and Car-to-Cloud Platform

Secure, connected-car services and lifecycle management





On-demand hardware/capabilities

Qualcomm® Car-to-Cloud Platform

We provide the enabling technologies for various mobility services

Users	Residents | Drivers | Commuters | Tourists				
Applications	Road safety Parking management	Personalized experiences Traffic efficiency	Shared rides Wallet management	Electronic tolling Location information	Driving experiences Fleet management
Platform	Edge-AI/compute	Automakers	Tier 1 suppliers		
Network	MNO	Enterprises	Internet providers		
Infrastructure	City services	Tower companies	Highway services		

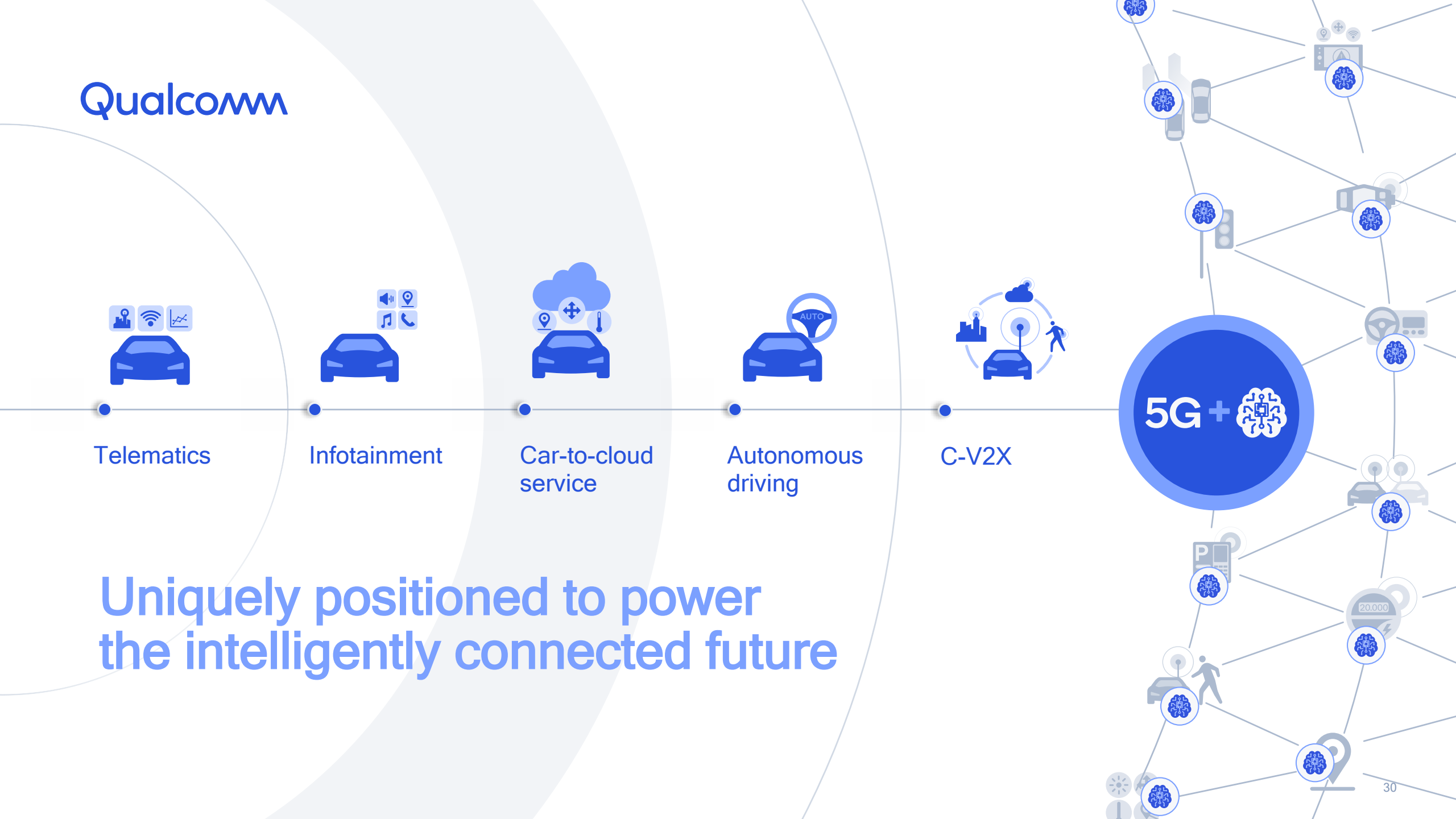
Data

Payment Services

Our Technologies

- Artificial intelligence
- Multi-mode modem + RFFE
- DSDA
- C-V2X
- Extended reality
- Location
- Power management
- Wi-Fi / BT

Qualcomm



Telematics

Infotainment

Car-to-cloud service

Autonomous driving

C-V2X

Uniquely positioned to power the intelligently connected future

Qualcomm

Thank you

Follow us on:

For more information, visit us at:

www.qualcomm.com & www.qualcomm.com/blog