Smart Transportation

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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

**Transportation efficiency**
- Pre-trip route and mode planning
- 00:04:10
- Shared transport
- En route information

**Road safety**
- Forward collision avoidance (via V2V sidelink)
- Hazard warning (via V2I sidelink)

**Connectivity**
- Enhanced cellular network
- New direct communication
- Massive Internet of Things

**Teleoperation**
- via cellular networks

**TMC\(^1\)-based traffic monitoring and advisory**
- (via cellular networks)

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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

Monitoring sensors
- Freight pressure / temperature / Asset tracking

Driver monitoring cloud based management

Smart road technology
- Electronic toll booths

Traffic MEC

Electronic logging devices
- Compliance for road / driver safety

1 MEC is mobile edge network
Maximizing Efficiency with shared transit and mobility on demand

Safety
Affordability
Reliability
Availability to all
Bringing a comprehensive ecosystem together
Driving the future of smart transportation

City-highway
Hyperlocal services
Pay-as-you-use parking
236 Occupied
42 Available
$472 Revenue per 30 mins

Recommended toll routes

Mobile network operators
Access to roads and road users
Network densification using small cells / RSUs

Road operators

Mobile operators

Vehicle OEMs

Cloud service providers
Security framework

Data and security

1 Uptane Alliance, General Data Protection Regulation (GDPR)
Facilitating multi-tiered services

Pedestrian detection
AR-based navigation
Virtual assistant

Traffic information
Fremium

Road safety comes free
Pedestrian 10ft ahead
Shaping a new era of smart transportation
Driving the 5G technology evolution

Rel-16 commercialization
- Delivering on the 5G vision
- Continue expansion to new verticals, deployments, use cases, spectrum

Rel-16 evolution
- Rel-16
- Rel-17
- Rel-18+

Rel-17 evolution
- 5G NR
- 3GPP

Future-proof platform
- LTE essential part of the 5G platform

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

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
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

**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
V2V  Vehicle-to-vehicle  e.g., collision avoidance safety systems

V2P  Vehicle-to-pedestrian  e.g., safety alerts to pedestrians, bicyclists

V2I  Vehicle-to-infrastructure  e.g., roadside traffic signal timing/priority

V2N  Vehicle-to-network  e.g., real-time traffic/routing, cloud services

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
TMC backend

Shared bike user alerted for next train in 10 mins

Traffic advisory

Road work ahead

Lane-level hazard alert

Mobile edge computing

35 miles/hour

Speed harmonization

Pedestrian alert

Collision warning

Road operators

Mobile operators

Collocated RSU/small cell

5G V2X sidelink

Cellular network communications

Edge/on-device AI

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-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...

Edge cloud
- Compute intensive, real-time data
- 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

Latency could be over 100s ms today

- Cooperation between road operators, MNOs, 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

1 MNO is mobile network operator

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

5G value

Cooperation between road operators, MNOs, infra vendors, cloud providers...

Efficient use of bandwidth
Scalability
Immediacy—tasks on device
Collocated RSUs/small cells can bring multiple opportunities

- Detect non-C-V2X vehicle
- V2I safety information (C-V2X sidelink)
- V2V blind intersections (C-V2X sidelink)
- Combining V2I RSU and 5G small cell radio unit supported by virtual RAN
- 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

1 C2C is car-to-cloud  2 RAN is radio access network
Smarter transportation infrastructure creates new opportunities

- Basic safety and mobility services
- Advanced safety applications
  - Smarter RSUs, collocated RSUs and small-cells
- Roadside access can generate new revenue models

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
Tomorrow
Future
Sharing roadside access can generate additional value for the ecosystem.

- Improve collaboration for enhanced road management.
- Leverage network acceleration effect to expand C-V2X benefits in initial deployments.
- Leverage collocated smart RSUs/small-cells to expand MNOs cellular coverage.
- Build an integrated data sharing system to provide personalized services.

Today → Tomorrow → Future
Driving digitally enabled end-to-end solutions for smart transportation
Strong C-V2X momentum globally

- **5GAA** founded. Qualcomm Incorporated was the founding member.
- **3GPP** trial in France announced.
- **MOCA** V2X introduced.
- **5GAA** cooperation announced.
- **ConVeX** trial in Germany announced.
- **Rel-14** C-V2X spec finalized.
- **San Diego** Regional C-V2X trial announced.
- **1st US deployment** in Denver.
- **China-SAE** ITS Stack Compatibility test report published.
- **TELEFÓNICA/SEAT**'s live C-V2X/5G demo at MWC Barcelona.
- **Cross border demo**.
- **CAMP** congestion control scenario testing by OEM consortium.
- **Live demos** show C-V2X as a market reality.
- **ETSU European specifications and standards for C-V2X completed**.
- **C-V2X devices passed European Radio Equipment Directive (RED)**.
- **China ICV 2025 Vision published**.
- **FCC 5.9 GHz NPRM comments received**.

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Over a decade of innovation and core R&D

Qualcomm Technologies’ holistic approach
to solving autonomous driving system challenges
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

Family of SoCs and Accelerator

- L1/L2
- L2 + L3
- L4/L5

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

Configurable chipset capabilities

Applications, Content and Services Management

Feature licensing and device management
On-demand Soft SKU configuration, OTA software updates

Connectivity
4G / 5G, Telematics, Regulatory compliance, Usage billing

Analytics
Advanced techniques for actionable insights

Attestation, licensing, certificates, identity

Streaming video/music (premium video/audio)

Surveillance (Camera)

Highway Pilot Assist

Driver monitoring (CPU)

Location GNSS/VEPP

C-V2X

4G/5G modem features

Wi-Fi/ connectivity services

On-demand hardware/capabilities

Qualcomm® Car-to-Cloud Platform

Qualcomm Car-to-Cloud is a product of Qualcomm Technologies, Inc. and/or its subsidiaries.
We provide the enabling technologies for various mobility services

<table>
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<tr>
<th>Users</th>
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<td>Tower companies</td>
<td>Highway services</td>
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Our Technologies

- Artificial intelligence
- Multi-mode modem + RFFE
- DSDA
- C-V2X
- Extended reality
- Location
- Power management
- Wi-Fi / BT
Uniquely positioned to power the intelligently connected future
Thank you

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