ITU/SAE Workshop on "How communications will change vehicles and transport“:  Communications for Automated Driving, including V2V

# Road to 5G and Autonomous Driving

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Qualcomm

# Major automakers use Qualcomm Technologies

Acura • Audi • BMW • Buick • BYD • Cadillac
Chevrolet • Chrysler • Dodge • Ford • Geely • Hond
Hyundai • Infiniti • Jaguar • Jeep • Kia • Land Rover
Lexus • Lincoln • Mercedes • Mini • Nissan • Opel
Porsche • PSA • Renault • Rolls-Royce • Smart
Subaru • Toyota • Tesla • Volvo • VW

Source: Company data

**#1**
in telematics and connectivity, supplier to all major car OEMs

**Leading**
in premium next-gen infotainment design-wins for production vehicles starting 2019-2020

**14**
automakers have selected Snapdragon for infotainment

**$5B**
design-win pipeline

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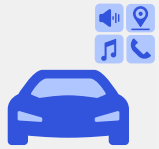
Telematics



Infotainment

In-car connectivity

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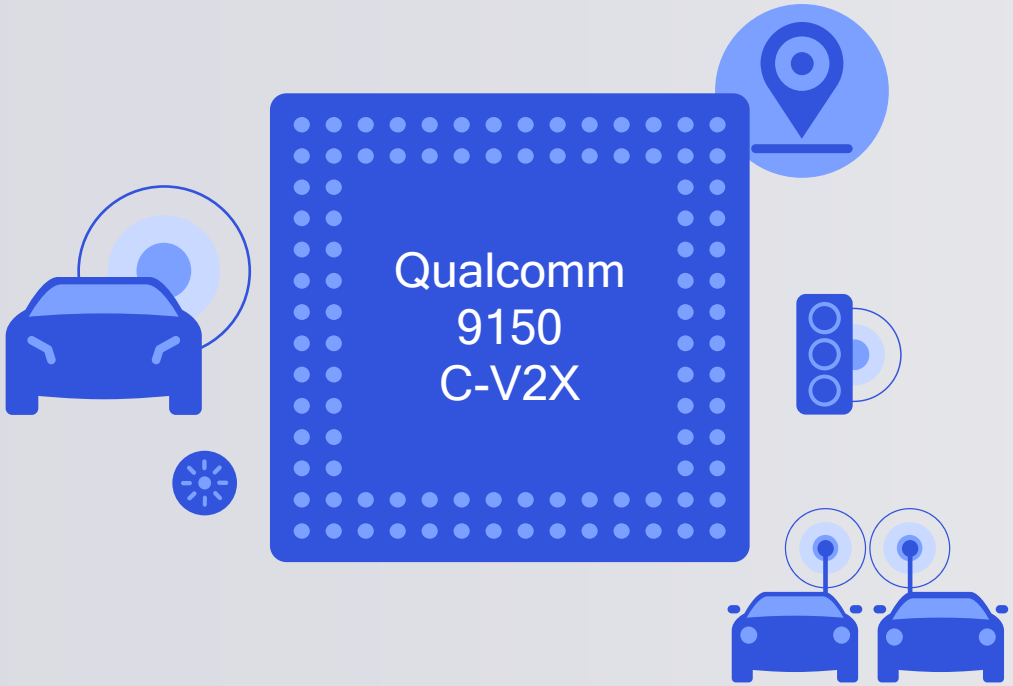
# 9150 C-V2X

Chipset




## Qualcomm is driving C-V2X towards commercialization

Supporting C-V2X Direct Communications (V2V, V2I, V2P) based on 3GPP Rel-14

### Leveraging auto industry investments

Reusing established security, service and upper layers / ITS stacks that have been defined by the auto industry for over a decade

### Public automotive ecosystem support

Audi, Ford, Groupe PSA, and SAIC announced their support of our first C-V2X solution; Continental and LG announced using our C-V2X solutions; testing with R&S

### Healthy cellular ecosystem

C-V2X has key auto and telecom players, including multiple silicon vendors, creating a healthy C-V2X ecosystem

# C-V2X complements other ADAS[1] sensor technologies

## Provides 360° NLOS[2] sensing for higher levels of predictability and autonomy

**ADAS**

Radar

Camera

Lidar

Ultrasonic

C-V2X

3D HD maps

Precise positioning

**Brain of the car to help automate the driving process by using:**

Sensor fusion | Machine learning

1 Advanced Driver Assistance Systems; 2 Non-line of Sight

# 5G NR pioneering advanced 5G NR technologies

## To meet an extreme variation of 5G NR requirements

### Mission-critical services

Cellular Vehicle-to-Everything (C-V2X)

Drone communications | Private Networks

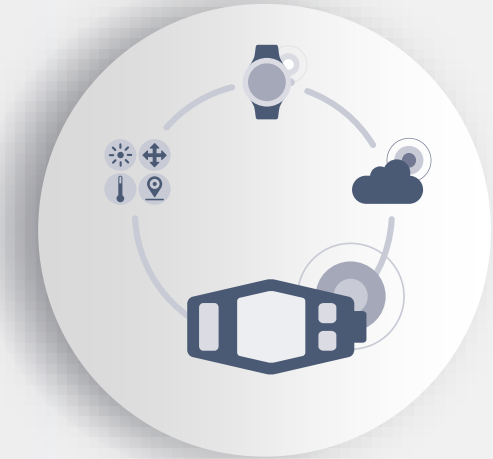
Ultra Reliable Low Latency Comms (URLLC)

### Enhanced mobile broadband

Spectrum sharing | Flexible slot-based framework

Scalable OFDM | Massive MIMO | Mobile mmWave

Dual Connectivity | Advanced channel coding



### Massive Internet of Things

Enhanced power save modes

Deeper coverage | Grant-free UL

Narrow bandwidth | Efficient signaling

**10x** Decrease in end-to-end latency

**10x** Experienced throughput

**3x** Spectrum efficiency

**100x** Traffic capacity

**100x** Network efficiency

**10x** Connection density

Based on ITU vision for IMT-2020 compared to IMT-advanced; URLLC: Ultra Reliable Low Latency Communications; IAB: Integrated Access & Backhaul

# 5G NR C-V2X

## Communication augments 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

# Advanced use cases for autonomous driving

## High throughput sensor sharing

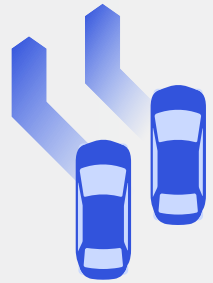
High throughput and reliability to enable the exchange of raw or processed data gathered

## Intent / Trajectory sharing

High throughput and URLLC to enable planned trajectory sharing

## Real-time local updates

High throughput to build local, dynamic maps based on camera and sensor data; and distribute them at street intersections



## Coordinated driving

URLLC and high date rate to exchange path planning information in timely fashion

Wideband carrier support

High throughput

Ultra-low latency

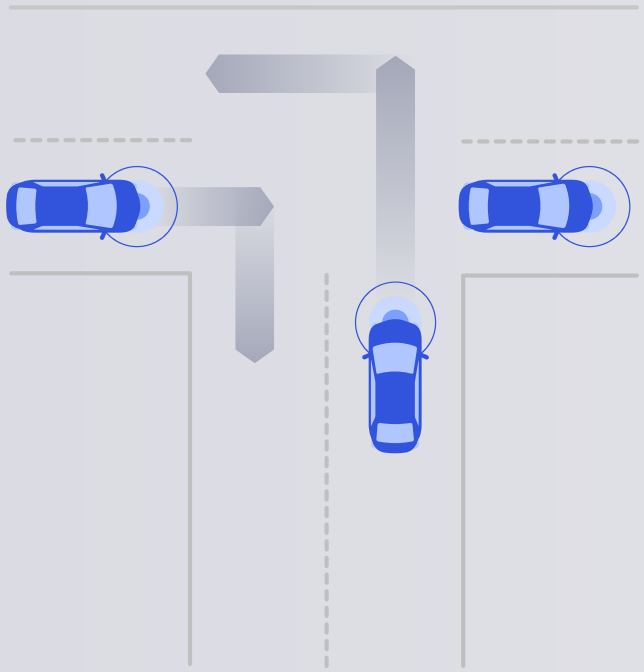
Ultra-high reliability

# Intention/trajectory sharing for autonomous driving

## Providing higher level of predictability and traffic efficiency for advanced path planning

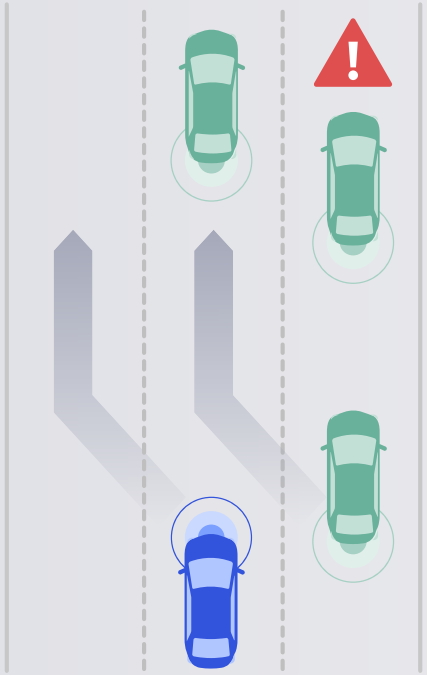
### Efficient maneuvers

Autonomous vehicles are able to make quicker, yet safe maneuvers by knowing the planned movements of surrounding vehicles



### Advanced path planning

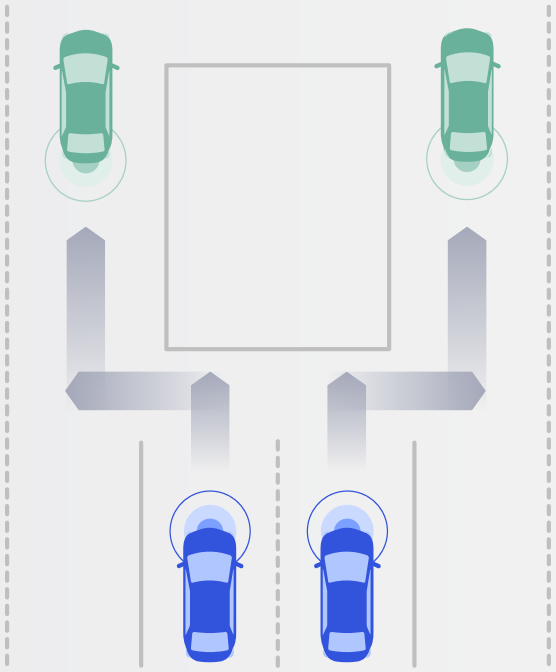
Supporting the level of predictability needed for advanced path planning for autonomous driving



Sudden braking and lane change on a freeway

### Coordinated driving

Autonomous vehicles are able to choose time-efficient paths toward their given destinations as they know the planned movements of other vehicles



# Intent/trajectory sharing for faster yet safe maneuvers

A vehicle trying to do a **left turn** is demonstrated for two scenarios


Scenario 1

## Autonomous vehicle without C-V2X

Safe, but may require significantly longer maneuver time


Scenario 2

## Autonomous vehicle with 5G NR based C-V2X

Enables vehicles to select faster yet safe path

https://sharepoint.qualcomm.com/corp/Tech-Marketing/TechMessaging/Published%20Content/5G/Cellular%20V2X/Video_MWC_5G_CV2X_useCase2_leftTurn.mp4

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# Thank you

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