

C-V2X Technology

Tech Marketing

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

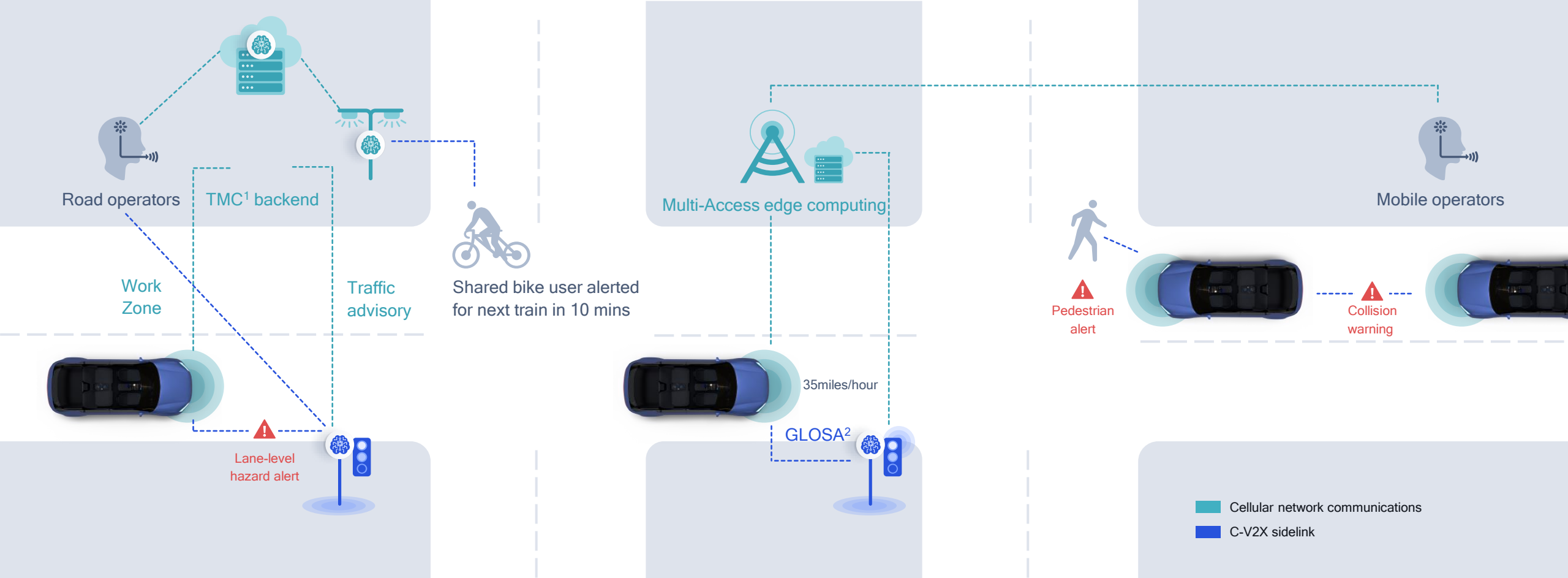
Introduced in 3GPP Rel 14

Operates in dedicated spectrum at 5.9 GHz

Distributed operation with no infrastructure and SIM required

C-V2X already deployed commercially in China; U.S. deployment targeted in 2022

Broad industry support with 5GAA, GSMA and 5G Americas



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)

Smart RSUs with on-device processing form a connected intelligent edge



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

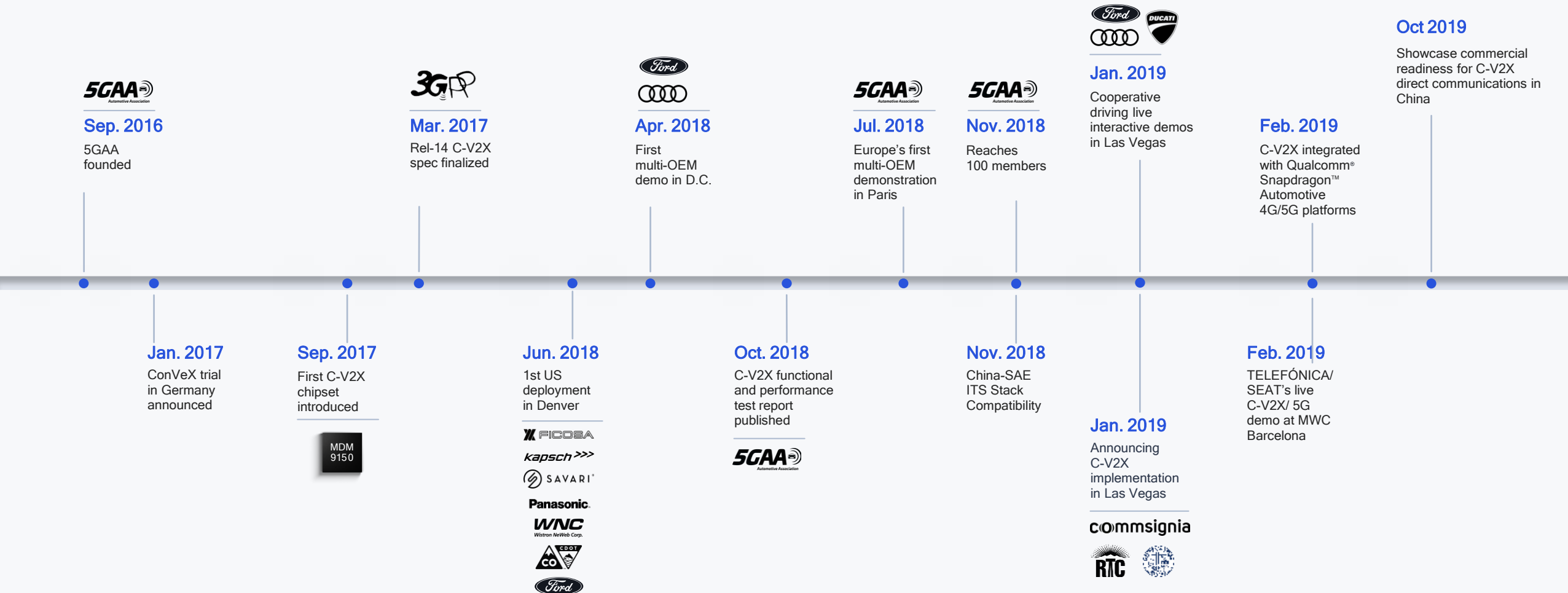
Cooperation between road operators, MNOs¹, infra vendors, cloud providers,...

Latency as low as 1 ms

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

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

Strong global momentum and ecosystem support



Strong global momentum and ecosystem support



Nov. 2019

Live demos show C-V2X as a market reality

Jan. 2020

ETSI European specifications and standards for C-V2X completed

Oct. 2020

40 OEMs complete interoperability testing at China-SAE's IoT event

Hongqi E-HS9

Dec. 2020

First commercial vehicle launched with Qualcomm C-V2X solution

Feb. 2021

ANAS announces Smart Road project in Italy



May 2021

VRU demos with school buses

Aug. 2021

Spoke/Qualcomm C-V2X for bike VRU protection

Dec. 2021

Multi-stakeholder petition to FCC for petition to deploy

Jan. 2020

C-V2X deployment in Virginia with VaDoT



Feb. 2020

C-V2X devices passed European Radio Equipment Directive (RED)



Nov. 2020

FCC assigns 30 MHz in 5.9 GHz spectrum to C-V2X



NOKIA



McCain

Nov. 2019

CAMP congestion control scenario testing by OEM consortium

May 2021

Publication of the FCC R&O¹ and FNPRM²

Human Horizons launches with 5G & C-V2X



Oct. 2021

China 4-layers event showing Day deployments with OEMs

Working with regional standards to define applications globally

SAE International for North America, ETSI ITS for Europe, C-SAE/C-ITS/NTCAS/CCSA for China; IEEE & ISO globally

Supporting emerging
use cases



Standardizing messages for new use cases (e.g., sensor data sharing among vehicles)

Providing
interoperability



Allowing vehicles from different automakers to benefit from new use cases

Specifying minimum
requirements



Defining application layer-specific minimum requirements for new messages

Reshaping our neighborhoods

Cellular + C-V2X 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



AI/edge
processing



Alert! Crash in
area. First responders
are on the scene.

Diverse network
deployment opportunities
(private networks)



Safer and smarter arterials and other urban roads

Combining C-V2X RSUs and cellular networks

Transportation efficiency



Pre-trip route and mode planning

Predictive maintenance
00:04:10

Shared transport

En route
information

3.2 / 8 miles

50% Congestion
8% Road work



TMC¹-based traffic
monitoring and advisory
(via cellular networks)



Road safety
Hazard warning
(via V2I sidelink)

Road safety
Forward collision
avoidance
(via V2V sidelink)

Trip and mode planning

Pre-trip planning



Transit management system #2026 to Branford



In transit stops

Weekend schedule



Saturday 9:15 | 12:15 | 2:15
Sunday 10:15 | 2:15 | 6:15

Smart parking



AI/edge
processing

Connectivity

5G



Enhanced
cellular network



New
direct communication



Massive
Internet of Things



Pedestrian
safety warning

Advanced traffic management

Smooth traffic flow delivered by C-V2X

Truck
platooning



Smart fleet information

En route information

Trucks in use

12 Trucks
Out for delivery

23 Trucks
Being loaded

Truck locations



Smart
lighting



Autonomous
vehicles



Roadside
units (RSUs)



Traffic management

Safety services



Gps tracking 10:08am arrival

Emergency vehicle ahead



3 Rerouting
Traffic light delays

5 Road delays
Rerouting Traffic
to side streets

Live 3D Maps



Smart transportation with C-V2X can revolutionize logistics

AI traffic management

- Vehicle location
- Last-mile delivery
- Reduced shipping time

Monitoring sensors

Freight pressure / temperature/Asset tracking

Driver monitoring cloud based management

Daily Mileage

Mon	Tue	Wed	Thur	Fri	Mon	Tue	Wed	Thur	Fri	Mon	Tue
77	65	52	76	84	86	79	83	100	88	91	

Trip completed 85%

Truck location

Smart road technology
Electronic toll booths

Traffic monitoring

Logistics cloud platform

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, reflecting the lights. In the background, a car with its headlights on is visible, slightly out of focus. The overall scene is dimly lit, with the primary light sources being the car's headlights and the ambient night light.

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

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

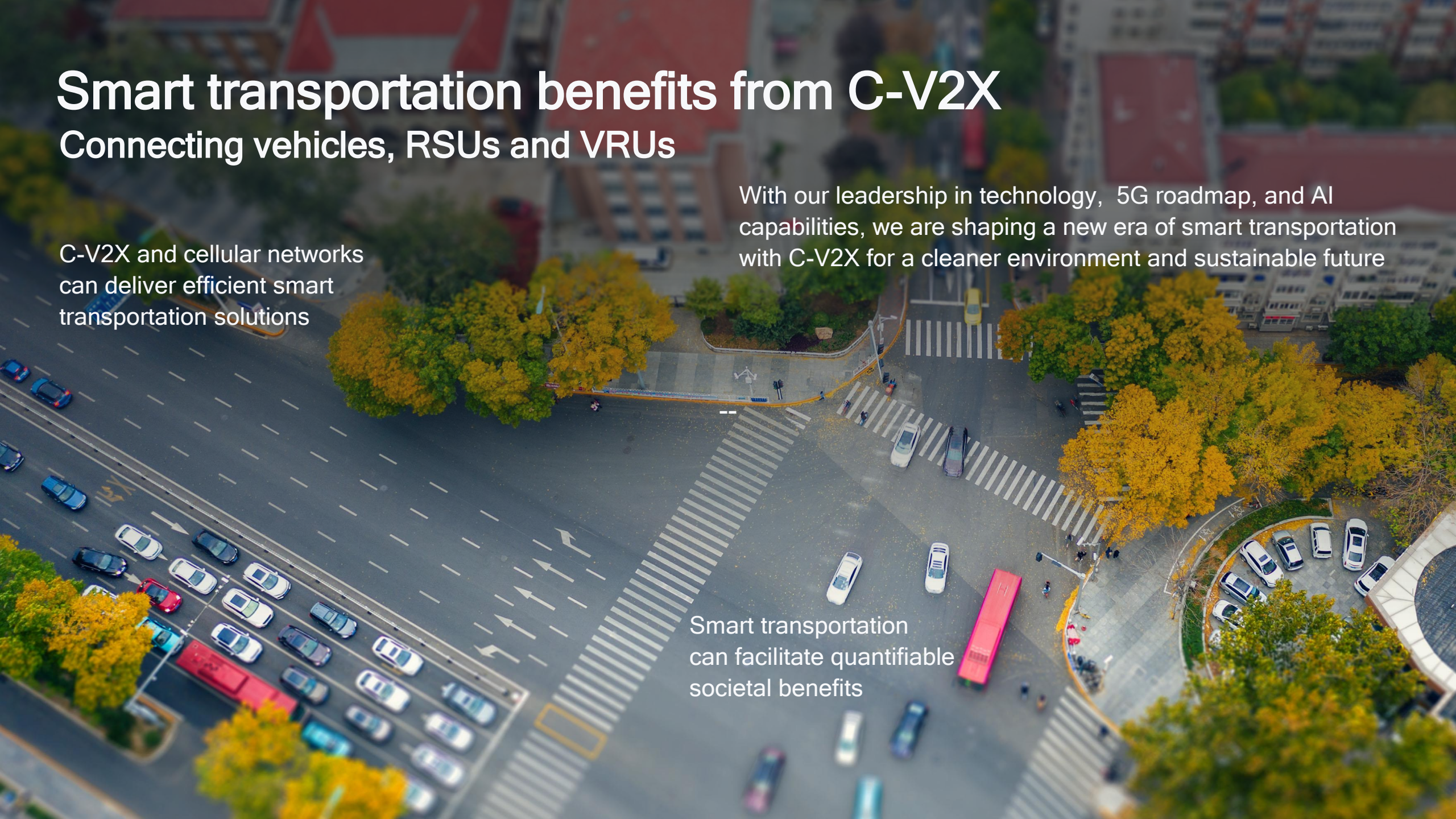
Smart transportation benefits from C-V2X

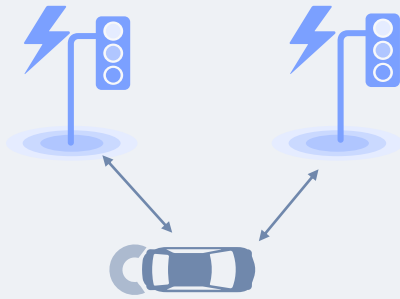
Connecting vehicles, RSUs and VRUs

C-V2X and cellular networks can deliver efficient smart transportation solutions

With our leadership in technology, 5G roadmap, and AI capabilities, we are shaping a new era of smart transportation with C-V2X for a cleaner environment and sustainable future

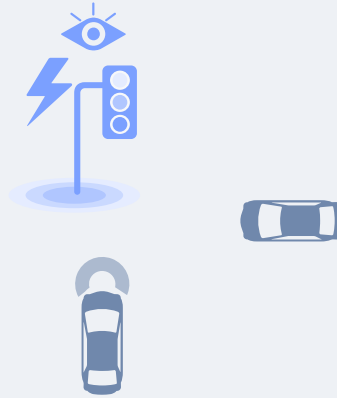
Smart transportation can facilitate quantifiable societal benefits





Sidelink positioning

Improve positioning accuracy
in GNSS challenged areas



Evolving smart RSUs

Enhanced network effect
Optionally supplement ADAS



Enhance VRU safety





Combining V2X with upper layer
software enhancement

C-V2X use cases continue to grow

From Day One safety for vehicles and VRUs to enabling new use cases for intelligent transportation



Thank you

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