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How NR-based sidelink expands 5G C-V2X to support new advanced use cases

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Cellular-Vehicle-to-Everything (C-V2X), which includes vehicle-to-vehicle (V2V), vehicle-to-pedestrian (V2P), and vehicle-to-infrastructure (V2I), builds on several decades of research and standardization work in automotive safety, improved transportation, and traffic efficiency — applying the collaborative efforts of the SAE, ETSI ITS, China-SAE/C-ITS, and other groups.

C-V2X-enabled vehicles use a short-range direct-communication mode that provides 360° non line-of-sight (NLOS) awareness, complementing onboard line-of-sight (LOS) sensors such as cameras, radar, LiDAR, and others. This combination of wireless technology and onboard sensors enables C-V2X vehicles to see, hear, and anticipate potential driving hazards, even at blind intersections or in poor weather conditions. Moreover, C-V2X vehicles can understand alerts from other C-V2X-enabled autos, road infrastructure, and future mobile devices. Integrating short-range C-V2X direct communications with the expansive mobile cellular network for longer-range communications and access to the cloud can deliver measurable safety enhancements and traffic efficiency benefits, bringing the transportation and auto industries to the cusp of a massive technology transformation.



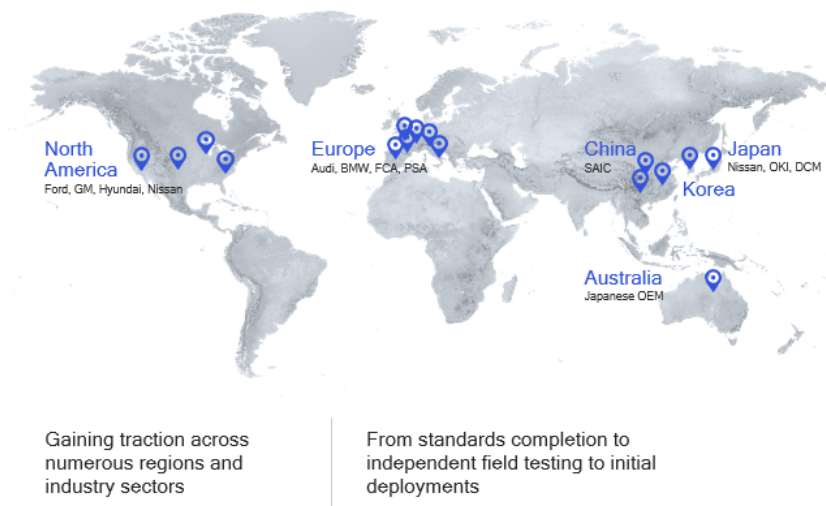
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United States, Europe, China, Japan, Korea, Australia, and other markets.

Automakers are keenly following the safety benefits brought by C-V2X, with the goal to greatly increase road safety. Our collaborative efforts have resulted in growing momentum to deploy C-V2X vehicles and infrastructure for direct communication in China along with several initial deployments in the U.S., in anticipation of formal support from the FCC to allocate 5.9 GHz ITS spectrum for C-V2X. In addition, we have continued to see C-V2X developments in Europe including a new European Standard (EN) defining the use of C-V2X as an access layer technology for a Cooperative Intelligent Transport System (C-ITS) approved through the European Telecommunication Standardization Institute (ETSI).

Driving C-V2X global presence with trials and demos



5GAA Automotive Association

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Anritsu - Applied Information - AT&T - Audi - BAIC - Baldu - Baocheng - Beijing University
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Verizon - Viat - Vodafone - Volkswagen - Volvo Cars - VT Direct - WNC - ZF - ZTE

Key participants

Driving global C-V2X activities with Qualcomm Technologies

Ford	Quectel	Kapsch	On Board Security
PSA	Lear	SWARCO	Neusoft Reach
BMW	Valeo	Commsignia	Simcom
Daimler	WNC	Genwict	Sasken
SAIC	CMCC	Nebulalink	Thundersoft
Continental	AT&T	R&S	Telit
Bosch	NTT DoCoMo	Datang	Lacrolx
LG	CMRi	Ficoa	And more...
ZTE	McCaun	Savari	

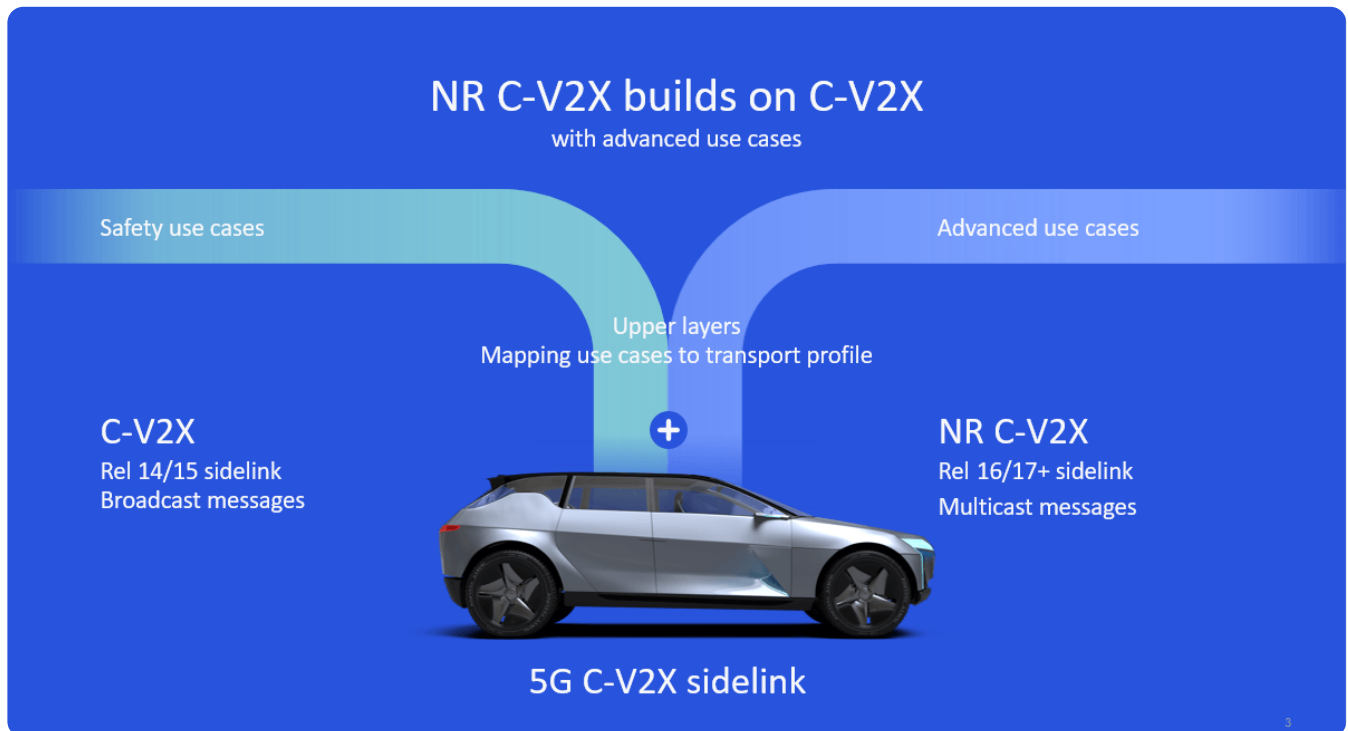
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3GPP Release 14 introduced direct communication modes that standardized how vehicles communicate with virtually everything around them — other vehicles (V2V), pedestrians (V2P), and infrastructure (V2I) — over a short range *without relying on the cellular network*. So, latency-sensitive basic safety messages aimed at improving road safety and traffic efficiency are conveyed using the direct communication mode operating on the globally¹ harmonized 5.9 GHz ITS spectrum. As C-V2X technology continues to evolve, the 3GPP Release 16 NR C-V2X direct communication mode (or sidelink) specifications² will support advanced use cases that could enhance autonomous driving, once again, *without using the cellular*



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V2V or V2I technologies that use sidelink are complemented by vehicle-to-network (V2N), which requires participation from the mobile network operators to deliver information through the cellular network. V2N has been available for roughly 20 years, supporting telematics, automatic crash notification, infotainment, cloud services such as map and other software updates, route guidance with traffic information, and more recently, remote supervisory control (teleoperation) for driving and parking.

We are seeing increased demand for cellular connectivity in new vehicles driven either by mandate, (e.g., eCall service in Europe), consumer demand, or automakers' decision to deliver software and firmware updates or services. According to Strateav



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C-V2X applications: Rel 14/15 basic safety and Rel 16 NR C-V2X advanced use cases

The auto industry has seen the advantages of basic safety messages provided by Rel 14/15 NR C-V2X sidelink.

Here are some of the most common V2V applications that served as use cases for SAE J2945/1³:

- Forward Crash Warning (FCW)
- Intersection Movement Assist (IMA)
- Blind Spot Warning/Lane Change Warning (BSW/LCW)

For V2I applications with roadside units (RSUs) there are several Signal Phase and Timing (SPaT)⁴ applications of which the most common are:

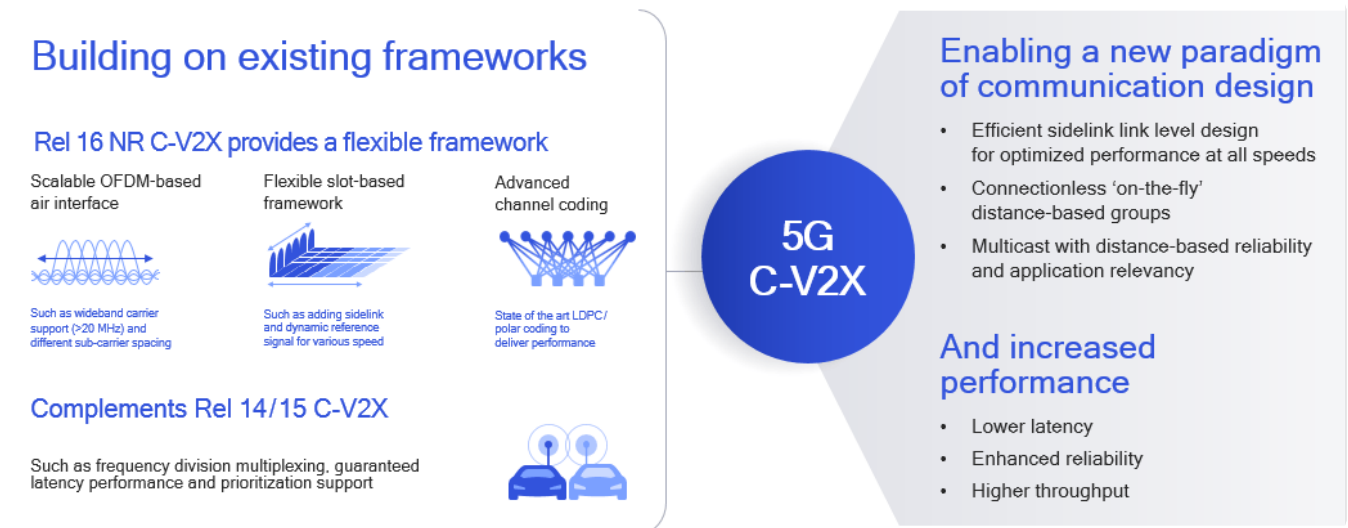
- Transit Signal Priority (TSP)
- Optimal Speed Advisory (OPA)
- Curve Speed Warning (CSW)
- Emergency Vehicle Preempt (PREEMPT)
- Pedestrian in Signalized Crosswalk Warning (PED-X)

3GPP Release 15 added transmit diversity (cyclic delay diversity) and improved performance, as advancements to the direct communication mode introduced in Release 14. These Release 15 additions are fully compatible with Release 14.

The direct communication mode in Release 16 NR C-V2X sidelink offers major enhancements in terms of new short-range features enabling advanced applications to complement these basic safety use cases. We believe the combination of Release 14/15 C-V2X and the NR-based sidelink in Release 16 will provide a comprehensive 5G C-V2X solution covering both basic safety and advanced applications; no solutions have been announced as the specifications are



achieved by leveraging functionalities of 5G NR such as OFDM-based air interface with wideband carrier support and scalable sub-carrier spacing, a flexible slot-based framework and making demodulation reference signals (DMRS) a function of speed, and advanced channel coding. Further, NR C-V2X sidelink has support for sidelink time synchronization allowing robust C-V2X operation even without GPS coverage.



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NR C-V2X sidelink also moves the default mode of operation from broadcast to reliable multicast communication which is enabled by some fundamental new innovations. NR C-V2X sidelink is probably the first wireless system to introduce distance as a dimension at the physical layer. This helps in getting a uniform communication range across widely varying radio environments — for both line-of-sight and non-line-of-sight scenarios. Introducing distance as a dimension also enables formation of “on-the-fly” multicast groups based on distance and applications. Such multicast groups require little or no overhead for group formation and dismantling.

As advanced use cases continue to evolve, seamless wireless connectivity becomes critical. With NR C-V2X sidelink, vehicles reach a more sophisticated level of coordinated driving through intent sharing. NR C-V2X is designed to facilitate



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There is improved situational awareness and collective perception delivered through high-throughput sensor sharing from onboard cameras, radars, and LiDAR imagery; real-time updates of 3D High Definition Maps; and the ability to see “through” vehicles and around blind corners, improving road awareness. NR C-V2X sidelink also enables intent sharing among vehicles even in high-density vehicle areas, thanks to low latency and higher throughput.

The road ahead...

The automotive industry is heading toward rapid adoption of cellular technology. With the integration of C-V2X direct communications and automotive cellular platforms, the transportation and automotive industries are at a breakthrough point to achieve noteworthy, quantifiable safety and traffic efficiency benefits through a high-adoption rate of the C-V2X technology. It is not surprising that in less than five years, the 5G Automotive Association (5GAA) has grown from its eight founding members to a multi-industry global organization with more than 140 companies, including some of the most recognized leaders in automotive and telecommunications industries.

The current advanced use cases provided by NR C-V2X along with subsequent improvements in future 3GPP releases for the 5.9 GHz ITS band will facilitate vehicles, roadside infrastructure, and someday even vulnerable roadside users, to exchange messages, imagery, and other sensor data, without relying on network subscriptions. Benefits such as shortening of travel time, saving energy, and reducing emissions are becoming conscious purchasing decisions for today's consumers. We can envision a truly advanced transportation system capable not only of improving road safety but providing these additional services and benefits when we pair artificial intelligence with smart RSUs that have advanced imaging sensors detecting vehicles and vulnerable road users. Such services will increase the data requirement compared to basic safety services by an order of magnitude. While some part of the increase in data demand will be absorbed by advances in spectral efficiency offered by NR C-V2X sidelink, 40 MHz of additional spectrum will be needed in the ITS band to carry such advanced services. The possibilities and



To learn more, attend our webinar and hear from our very own Qualcomm

Technologies' wireless R&D lead for 5G automotive applications, Shailesh Patil.

You'll learn about the enhancements of NR C-V2X sidelink and how some of these features can provide overall capacity gains for NR C-V2X applications.

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1. <https://news.itu.int/intelligent-transport-systems-towards-automated-vehicles/>
2. <https://www.3gpp.org/release-16>
3. [On-Board System Requirements for V2V Safety Communications J2945/1 201603](#)
4. [ARC-IT USDOT service package](#)

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