

5G ON THE HIGHWAY TO V2X

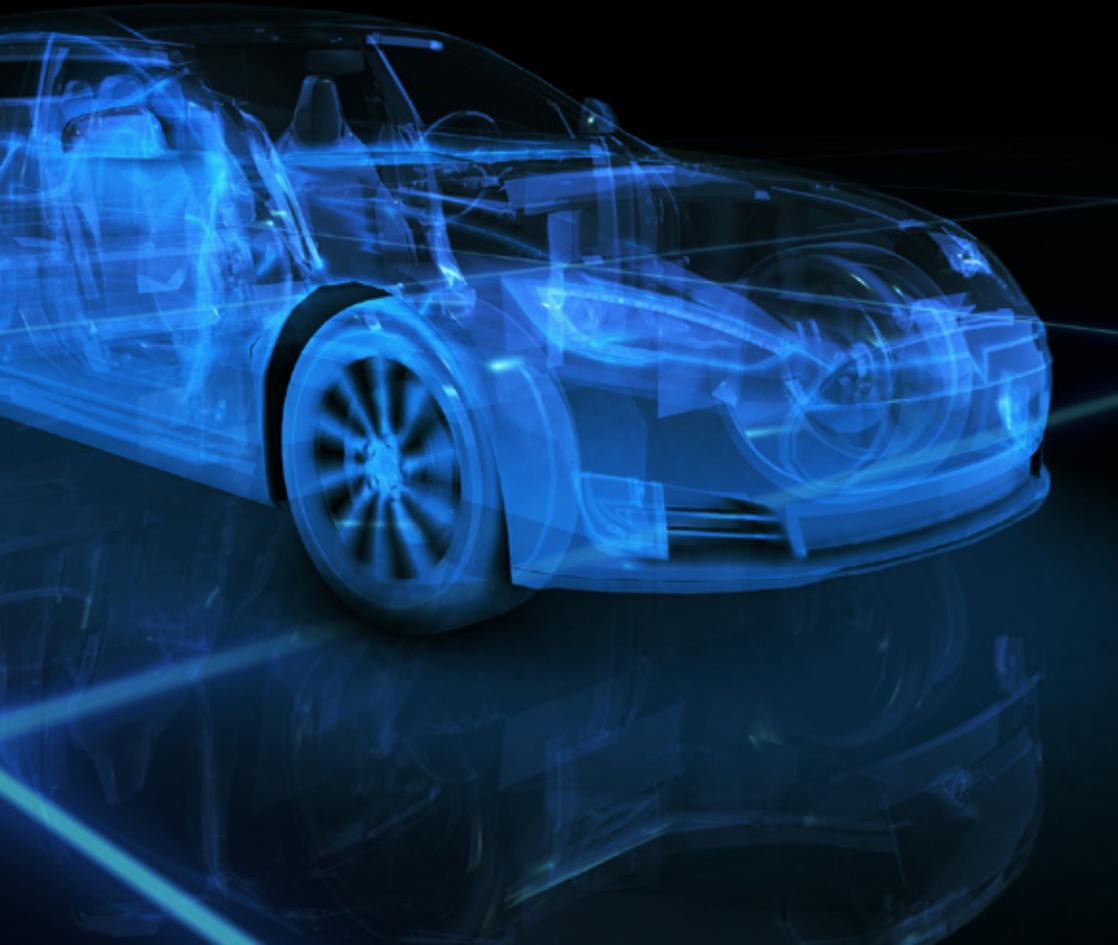


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4000 GB

Of data per day will be used by one single, autonomous car

\$220 billion

The global connected cars market was valued at \$220 billion in 2025. It is estimated to grow at a CAGR of 15% for the period: 2016 - 2025

18%

Projected CAGR OF V2X market for the period 2017 - 2025, estimated to reach a valuation of \$99.55 billion in 2025

2020

5G connectivity enabled for the market

15%

Of all new cars sold will be fully autonomous by 2030

320 million

Will be the number of connected cars in 2022

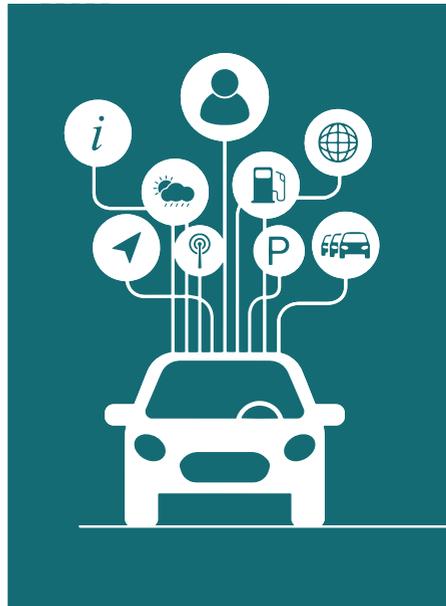
Market context and challenges

The booming automotive market, taking a step towards digitization and autonomous vehicles, is increasing the need for safe and secure connectivity.

The new generation of vehicles need to deliver different types of applications in various domains such as infotainment, telematics, driver assistance, and autonomous driving with maximum reliability, safety, and privacy.

As a result, vehicles should be able to communicate not only with other vehicles, but also with pedestrians, roadside equipment, and the internet. Automobiles are taking a more proactive role by warning drivers of potential collisions with oncoming vehicles, monitoring intersections, gathering real-time traffic information pieces, and exchanging incident alerts and emergencies with quick response and paramedic services.

These use cases are collectively called Vehicle to Everything (V2X) connectivity and communications. The global V2X market is projected to grow and reach a valuation of around \$100 billion in 2025 at a double-digit CAGR of 18% between 2018 and 2025.



What is V2X?

Vehicle-to-Everything (V2X) communication is a term that aggregates many different acronyms depending on the type of peer the vehicle communicates with:

- V2I (Vehicle-to-Infrastructure): to communicate with Road Side Units (RSU)
- V2V (Vehicle-to-Vehicle): to communicate between vehicles, without the telecom network
- V2P (Vehicle-to-Pedestrian): to proactively scan for pedestrians or bicycles. Various terminals are expected to aid V2P – such as smartphones, walking sticks, strollers, bicycle lights, and bicycle navigators
- V2D (Vehicle-to-Device): to communicate with smart devices such as smartphones, smart keys, and car trackers
- V2G (Vehicle-to-Grid): for electrical vehicles to communicate with the power grid
- V2M (Vehicle-to-Motorcycle): to communicate with motorcycles
- V2N (Vehicle-to-Network): to communicate with a mobile network and network connectivity

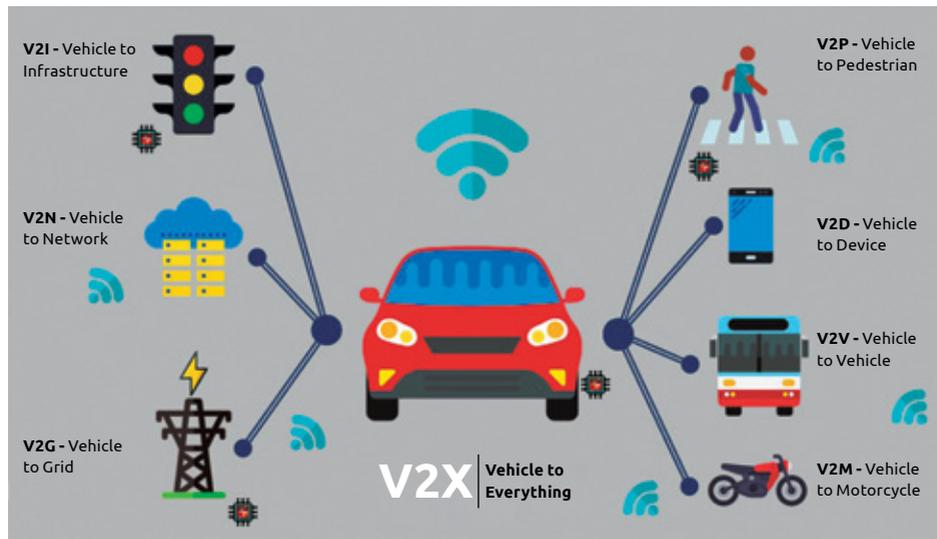
V2X can be used in many different ways to improve road safety while making efficient use of existing smart traffic infrastructure. Most of the use cases are part of the following categories:

- Platooning: the formation of a convoy in which the vehicles are much closer together than can be safely achieved with human drivers, making better use of road space, saving fuel, and making the transport of goods more efficient

- Cooperative driving: vehicles can use V2X and work together to minimize the disruption caused by lane changes, sudden braking, and exchanging real-time pieces of information with panels and traffic lights
- Queue warning: roadside infrastructure can use V2X to warn vehicles of queues or road works ahead of them so that they can slow down and avoid hard braking
- Avoiding collisions: each vehicle on the road could use V2X to broadcast its identity, position, speed, and direction. An on-board computer could combine that data with that from other vehicles to build its own real-time map of the immediate surroundings and alert the driver of any potential collisions
- Hazards ahead warning: V2X can be utilized to extend a vehicle's electronic horizon, so that it can detect hazards around a blind corner, obscured by fog or other obstructions, such as heavy vehicles or undulations in the landscape
- Increasing autonomous driving: along with other sensors and communications systems, V2X will play an important role in enabling vehicles to become increasingly autonomous.
- Driving assistance: leveraging Augmented Reality (AR) and supported by the huge bandwidth to provide driver assistance such as a real-time dashboard, heads-up navigation, and infotainment

Why current standards are not enough for new market needs?

The different types of V2X applications require extreme connectivity performance – very low latency for real-time applications requiring <1millisecond delay, high security, ultra-reliable connectivity for safety issues, and enhanced mobile broadband to support AR (>1Gb/s). Two types of V2X communication standards are available in the market, depending on the underlying technology being used – WLAN (Wi-Fi) based, and cellular-based.



V2X standard	Wi-Fi based IEEE 802.11p	Cellular based C-V2X	
		2016	2018
Launch	2012	2016	2018
Comments	Designed for V2X	V2X on top of LTE/4G	V2X on top of 5G
Supported applications	Direct communications: V2V, V2I	<ul style="list-style-type: none"> • Direct communications: V2V, V2I • Indirect communications: V2N 	
Functions	Out-of-coverage mode (direct V2V)	<ul style="list-style-type: none"> • Out-of-coverage mode (direct V2V) • In-coverage mode (connected to network) 	
Throughput or interferences	~ 6 Mbps (10 MHz bandwidth) / High level	~50 Mbps (10 MHz bandwidth) / Low level	~10 Gbps V2N and > 100 Mbps V2V / Low level
Maturity	+++	++	+
Massive connectivity	+	+++	+++++
Range	++	++++	++++
Reliability	++	+++	++++
Latency	+++	+++	+ Ultra-low (<1ms)
Standard compatibility	++ Wi-Fi family only	++++ 2G/3G family	+++++ 2G,3G,4G, and Wi-Fi
Mass market appeal	++	++++	++++

In reality, neither the Wi-Fi-based IEEE 802.11p nor the LTE/4G based C-V2X has a clear advantage over the other. Some applications are better suited to IEEE 802.11p while others perform better on LTE/4G C-V2X.

Automakers like General Motors and Toyota back the Wi-Fi-based IEEE 802.11p. The U.S. government has also invested millions of dollars in this technology that allows cars to link to smart traffic lights. This standard has been available on the market since 2012 and has demonstrated high reliability. However, no major evolutions have taken place and the performances will be limited to meet future requirements of vehicles' connectivity.

C-V2X has the support of almost all mobile operators, leading mobile equipment makers, and automakers including Audi, BMW, Daimler, Ford, PSA, SAIC, Tesla, and Toyota, along with chipset manufacturer Qualcomm.

The biggest expectation in C-V2X is the introduction of 5G to meet the different connectivity requirements for the different use cases. In the 5G era, C-V2X will be able to support:

- The formation of a convoy in which the vehicles are much closer together than can be safely achieved with human drivers, making better use of road space, saving fuel, and making the transport of goods more efficient

- Very precise positioning and ranging to support cooperative and automated driving
- High throughput and low-latency connectivity to enable the exchange of raw or processed data gathered through local sensors and live video images
- High throughput to build local, dynamic maps based on camera and sensor data. This data can be distributed at street intersections to exchange information with cars and local authorities. For example, C-V2X could be used to supply a driver or an on-board computer with a bird's eye view of an intersection or see-through capability when driving behind a truck.
- Very low latency and high reliability to support high-density platooning

Moreover, 5G will be able to support a very large number of simultaneous connections in a small geographic area, enabling each vehicle to gather more information about its immediate surroundings.

V2X market roadmap and standards evolution

Capgemini Engineering expects target deployment of C-V2X worldwide in the second part of 2020.

The C-V2X roadmap will benefit enormously from the introduction of 5G technologies in the coming years. Most of our modern cars already have LTE/4G systems and this makes it easy to upgrade to 5G, owing to the common, standard backbone.

C-V2X will continue to evolve as a part of the 5G roadmap to improve performances – with 3GPP Releases 16 and 17, 5G will add advanced V2X features with a longer range, higher density, very high throughput and reliability, submeter positioning, and ultra-low latency.



Conclusion

For the key market players – automobile manufacturers, government mobile operators, and end-users, C-V2X offers multiple technical and economic advantages over other dedicated vehicle connectivity technologies. Unlike the alternatives, C-V2X can support a very broad range of use cases spanning safety, navigation, and integrated transport systems.

The 5G-based V2X solutions that 3GPP is working towards standardizing, aim to provide advanced V2X use cases, leveraging the enhancement that 5G will bring to the radio access and network infrastructure.

Currently, the key players are already completing trials in the U.S. and Europe. There will be no doubt that C-V2X will be fully adopted worldwide and that 5G enhancements will be mandatory and integrated into the next generation of cars and infrastructures to face new market needs.



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