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5G ON THE HIGHWAY TO V2X

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4,000 GB

of data per day will be used by a single autonomous car

$220 billion

Global connected-cars market in 2025 with 15% CAGR for the period 2016–2025

18% CAGR

Growth in V2X market for the period 2018–2025 to reach $99.55 billion in 2025

2020

5G connectivity enabled for mass market

15%

of all new cars sold will be fully autonomous in 2030

360 million

connected cars in 2022

MARKET CONTEXT AND CHALLENGES

The booming interest in automotive digitization and autonomous vehicles is raising the need for safe and secure connectivity.

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

As a result, vehicles 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 alerts about incidents and emergencies with quick-response and paramedic services.

The requirements for each domain and the associated use cases can be very different and influence the telecommunication standards used to provide adequate services.

These use cases are collectively called Vehicle-to-Everything (V2X) connectivity and communications. The resulting market is projected to grow worldwide and reach 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 different acronyms depending on the type of peer the vehicle communicates with:

V2I (Vehicle-to-Infrastructure): to communicate with Road Side Units (RSU) such as traffic lights and traffic cams

V2V (Vehicle-to-Vehicle): to communicate between vehicles, without the telecom network

V2P (Vehicle-to-Pedestrian): to proactively scan for pedestrians and bicycles. Various terminal types aid V2P, such as smartphones, walking sticks, strollers, bicycle lights, and bicycle navigators

V2D (Vehicle-to-Device): to communicate with smart devices such as a smartphone, smart key, and car tracker

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 improves 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.

· **Co-operative driving:** Vehicles can use V2X to work together to minimize the disruption caused by lane changes and sudden braking, and exchange 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 they can slow down smoothly 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 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 extend a vehicle's electronic horizon to detect hazards obscured by corners, fog, heavy vehicles, or changes in the landscape.

· **Increasingly autonomous driving:** Along with other sensors and communications systems, V2X will enable vehicles to become increasingly autonomous.

• **Driving assistance:** Leveraging augmented reality, this will 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, including latency of less than one millisecond for real-time applications, ultra-reliable connectivity, and enhanced mobile broadband of more than one gigabit per second to support augmented reality

Two types of V2X communication standards are available in the market, depending on the underlying technology used: WLAN (Wi-Fi) or cellular based.

V2X standard	Wi-Fi-based IEEE 802.11p	Cellular-based C-V2X	
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	• Direct communications: V2V, V2I • Indirect communications: V2N	
FUNCTIONS	Out-of-coverage mode (direct V2V)	• Out-of-coverage mode (direct V2V) • In-coverage mode (connected to network)	
MATURITY	⊕ ⊕ ⊕	⊕ ⊕	⊕
MASSIVE CONNECTIVITY	⊕	⊕ ⊕ ⊕	⊕ ⊕ ⊕ ⊕ ⊕
RANGE	⊕ ⊕	⊕ ⊕ ⊕ ⊕	⊕ ⊕ ⊕ ⊕
RELIABILITY	⊕ ⊕	⊕ ⊕ ⊕	⊕ ⊕ ⊕ ⊕
LATENCY	⊕ ⊕ ⊕	⊕ ⊕ ⊕	⊕ Ultra low (<1ms)
STANDARD COMPATIBILITY	⊕ ⊕ Wi-Fi family only	⊕ ⊕ ⊕ ⊕ 2G/3G family	⊕ ⊕ ⊕ ⊕ ⊕ 2G/3G/4G family & 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. 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 links cars 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 connectivity requirements for the different use cases. In the 5G era, C-V2X will 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/or 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 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

C-V2X features associated with 5G came with the first evolution of the 5G standard (in Release 16), completed in 2019. Target deployment of C-V2X occurred 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 part of the 5G roadmap to improve performances.

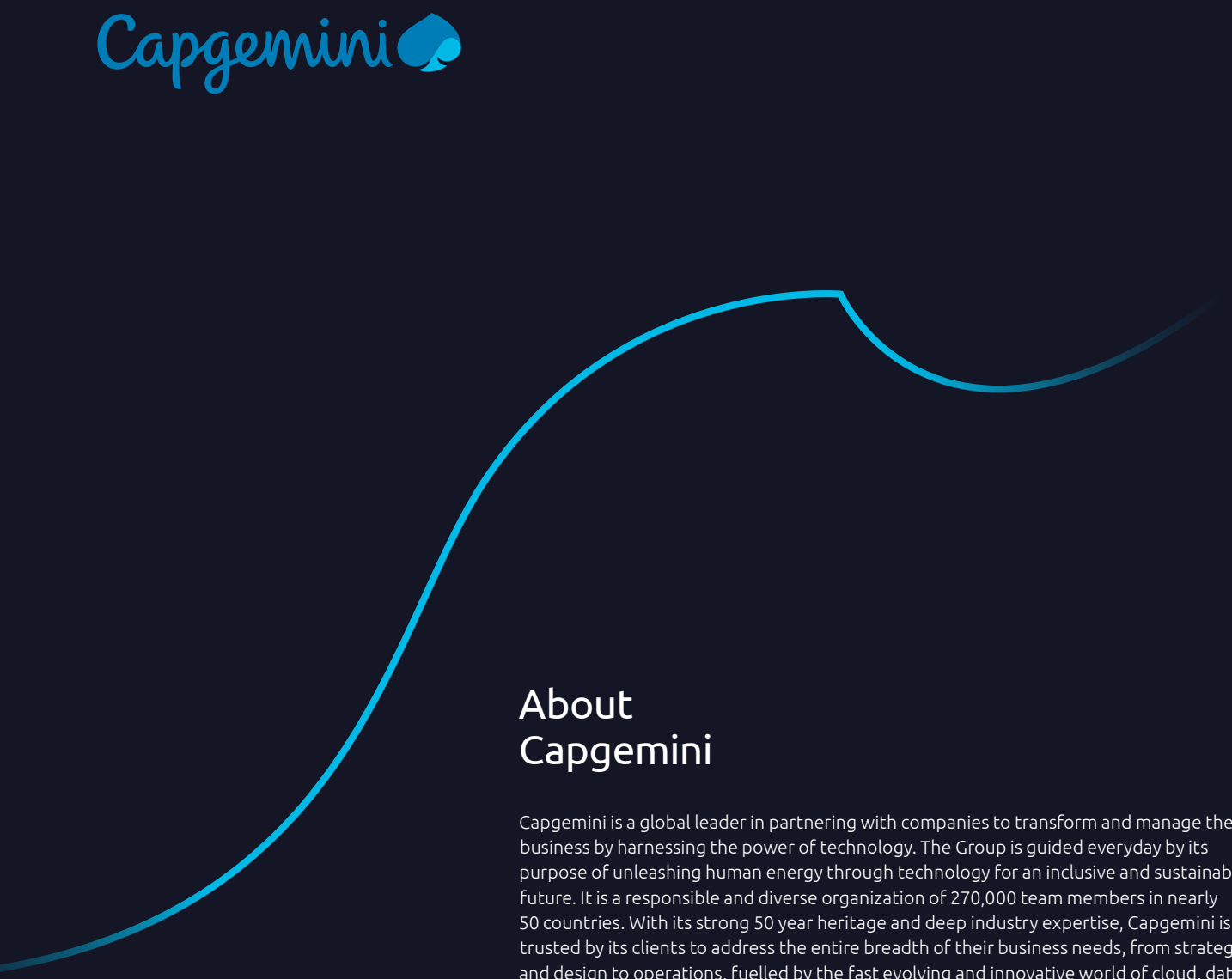
With 3GPP Releases 16 and 17, 5G will add advanced V2X features with longer range, higher density, very high throughput and reliability, sub-meter positioning, and ultra-low latency.

NEXT-GENERATION AUTOMOTIVE

For the key market players (automobile manufacturers, government mobile operators, 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. C-V2X will be fully adopted worldwide and 5G enhancements will be mandatory and integrated in the next generation of cars and infrastructures to face new market needs.



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Note: current conversion is €1 to $1.20 (2/17/21)

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