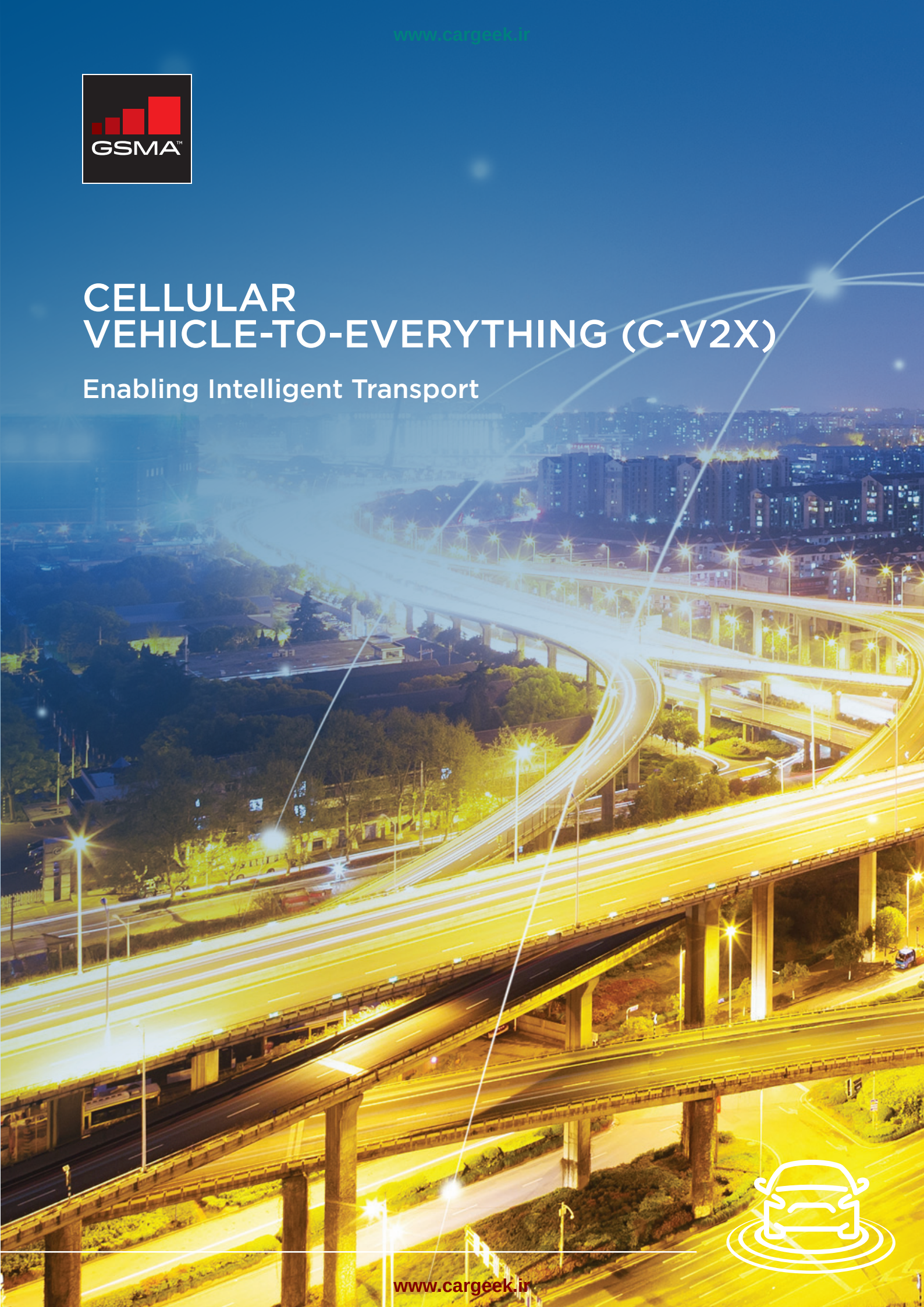
GSMA

CELLULAR VEHICLE-TO-EVERYTHING (C-V2X)

Enabling Intelligent Transport



Executive Summary

In June 2017, 3GPP completed the standardisation of Cellular Vehicle-to-Everything (C-V2X) technology. Based on LTE, this cellular technology is designed to connect vehicles to each other, to roadside infrastructure, to other road-users and to cloud-based services.

It promises to transform information and safety services on highways and within cities both by connecting individual vehicles and by enabling the development of cooperative intelligent transport systems (C-ITS) that reduce congestion and pollution and enhance travel. It will help cities to become smarter and support increasingly automated transport systems that are safer and more efficient than today's networks.

Why C-V2X?

Many automakers are adding C-V2X connectivity to their vehicles because it has several key advantages over earlier technologies designed to enable vehicle-to-vehicle communications. It can:

- Leverage the comprehensive coverage of secure and well-established LTE networks
- Enable highly reliable, real-time communication at high speeds and in high-density traffic
- Support both short-range and long-range transmissions between vehicles and roadside infrastructure
- It is part of the roadmap to 5G connectivity

Combining secure wide area and short-range connectivity in one module, C-V2X is a versatile and cost-effective solution for automakers looking to improve road safety. C-V2X will enable drivers to benefit from a wide range of compelling services, including pay-as-you drive insurance, vehicle diagnostics, eCall and connected infotainment, as well as an array of safety features. Moreover, harnessing the existing cellular infrastructure reduces the amount of roadside infrastructure that needs to be installed and maintained by municipalities and highway agencies in both urban and rural areas. Crucially, C-V2X also leverages the robust security built into cellular networks.

C-V2X employs two complementary transmission modes:

1. Direct communications between vehicles, between vehicles and infrastructure, and vehicles and other road users, such as cyclists and pedestrians. In this mode, C-V2X works independently of the cellular networks.
2. Network communications, in which C-V2X employs the conventional mobile network to enable a vehicle to receive information about road conditions and traffic in the area.

How C-V2X Could Change Driving

C-V2X can be used in many different ways to improve road safety, while making more efficient use of transport networks and infrastructure. For example, it could support:

- **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 C-V2X to work together to minimise the disruption caused by lane changes and sudden braking.
- **Queue warning:** Roadside infrastructure can use C-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 C-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 to any potential collisions.
- **Hazards ahead warning:** C-V2X can be used to extend a vehicle's electronic horizon, so it can detect hazards around a blind corner, obscured by fog or other obstructions, such as high vehicles or undulations in the landscape.
- **Increasingly autonomous driving:** Along with other sensors and communications systems, C-V2X will play an important role in enabling vehicles to become increasingly autonomous.
- **Collecting road tolls:** designed to reduce congestion and the impact of motor transport on the environment

The Roadmap For Deployment

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. Mobile operators, equipment suppliers and automakers are teaming up to run trials of C-V2X, ahead of the first commercial deployments towards the end of 2018. China is on course to be one of the first countries to deploy C-V2X, while some European countries are also likely to be in the vanguard of adoption.

Huawei, for example, has run trials with China Mobile, SAIC Motor Corporation, Deutsche Telecom, Audi and Toyota, including a live demonstration at the G20 Summit in Hangzhou in September 2016. In February 2017, Orange and PSA Group announced the completion of initial C-V2X field trials in France and are now running further tests with Qualcomm. Trials are also underway in Germany, where Audi, Ericsson, Qualcomm, SWARCO Traffic Systems and the University of Kaiserslautern, have formed the Connected Vehicle to Everything of Tomorrow (ConVeX). In October 2017, AT&T, Ford, Nokia and Qualcomm announced trials in San Diego to demonstrate the potential of C-V2X technologies to improve automotive safety, enable automated driving, and increase traffic efficiency.

C-V2X is designed to be fully compatible with forthcoming 5G mobile technologies, meaning investments in infrastructure and modules today will be future-proof. C-V2X technology will be further refined and its capabilities expanded with Release 15 of the 3GPP standards, due in June 2018, and Release 16 in June 2019.

> *"C-V2X is designed to be fully compatible with forthcoming 5G mobile technologies, meaning investments in infrastructure and modules today will be future-proof"*

In the 5G era, C-V2X will be able to support a range of advanced safety services, including very precise positioning and ranging to enable cooperative and automated driving, the delivery of local, dynamic maps based on camera and sensor data, and the very low latency connectivity necessary to enable high-density platooning. As 5G will be able to support very large numbers of connections in a small area, individual vehicles will be able to capture more data about their immediate surroundings. Ultimately, C-V2X will play a pivotal role in enabling the deployment of fully autonomous vehicles, which will transform the way people travel.

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1. Introduction

The connected vehicle market continues to grow rapidly. Advances in mobile technologies are enabling drivers and passengers to benefit from increasingly sophisticated infotainment, navigation, safety and telematics services. As demand rises around the world, the connected vehicle market is one of the fastest growing segments of the Internet of Things, potentially generating application revenue of US$273 billion by 2026, according to Machina Research's forecasts.

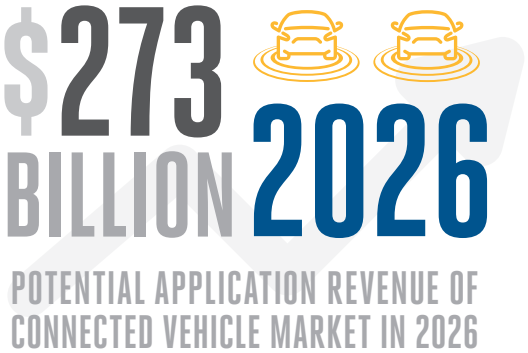
Cellular Vehicle to Everything (C-V2X) Technology

More than 800 mobile operators around the world have deployed networks that are compatible with the 3GPP standards, enabling them to benefit from global interoperability and economies of scale. In June 2017, 3GPP finalised Cellular Vehicle-to-Everything (C-V2X) technology in Release 14 of its standards. Based on LTE, this cellular technology is designed to deliver safety and information services to vehicles, paving the way for the development of cooperative intelligent transport systems (C-ITS) that reduce congestion and pollution, while making travel faster and more efficient.

This paper explains what C-V2X is, what it does, how it works, why it is important and why it is well suited to enabling communications between vehicles, roadside infrastructure and other road users. The paper is written as a guide for automakers, mobile operators, equipment vendors, policymakers and regulators.

The Role of the GSMA

The GSMA is working with mobile operators, automakers and suppliers, relevant industry associations and regulatory bodies to accelerate the growth of the connected vehicle market by agreeing a common approach to security, regulatory and infrastructure solutions. Only a standardised and collaborative approach can unlock the full potential of this market. The GSMA is consulting with global regulatory bodies to align the industry around a common approach to security and spectrum harmonisation.



Source: Machina Research

2. How Mobile Networks Can Improve Road Safety

The latest vehicles on the world's roads contain very advanced information and communications technologies, including on-board computers, a wide range of sensors and, in many cases, both short-range and wide area connectivity. Many new vehicles rely on cellular networks to deliver a broad range of infotainment and telematics services, including pay-as-you drive insurance, navigation and automated emergency calling. In particular, mobile networks are playing an increasingly important role in improving road safety and enhancing safety-critical systems on-board vehicles.

As well as making individual journeys safer, connected vehicles can deliver broader benefits for society by helping people to choose the most efficient form of transport and the quickest routes, while enabling the collection of automated road tolls designed to reduce congestion, carbon emissions and the impact of transport on the environment.

As experienced, trusted and licensed providers of connectivity, mobile operators are capable of meeting the automotive industry's need for scalable, secure and proven solutions. Mobile operators have a long track record of deploying and managing secure, reliable and comprehensive end-to-end communication services and coverage. For the connected vehicle market to scale to its full potential, drivers need to trust the security and reliability of all components and layers of connected vehicles. Mobile operators can work with automakers and other stakeholders in the connected vehicle ecosystem to implement a proven and robust approach to cyber-security.

Mobile operators bring a number of assets to this market, including:

- Broad coverage via existing cellular net works and mobile ecosystem support
- Extensive experience in deploying, managing, and maintaining complex communication systems
- Complementary services, such as navigation, pay-as-you-drive insurance and vehicle diagnostics
- Public key infrastructure (PKI) certificate management
- Data storage and data analytics

The Role of Cellular Vehicle-to-Everything (C-V2X)

In June 2017, the mobile industry body 3GPP standardised a set of technologies specifically designed to enable communications between vehicles and roadside infrastructure. Known as Cellular Vehicle-to-Everything (C-V2X), these technologies can enhance safety and ultimately support autonomous driving by:

- Leveraging the comprehensive coverage of secure and already established LTE networks
- Enabling highly reliable, real-time communication at high speeds and in high-density traffic
- Supporting short and long range transmissions between vehicles and roadside infrastructure

By providing real-time information on conditions beyond the driver's line of sight, C-V2X can work with other sensors on-board a vehicle to increase safety. The information captured by a C-V2X system can complement the data being captured by radar, lidar and ultrasonic systems that help the driver to keep the vehicle a safe distance from the vehicle in front and contend with bad weather conditions and low light situations. A vehicle's on-board computer can combine data received via C-V2X with information captured by on-board cameras to interpret road signs and objects. Moreover, GNSS systems pinpointing the vehicle's location on 3D and HD maps can be updated in real-time over a cellular network. The fusion of ever evolving and improving sensors and computational machine intelligence will ultimately emulate and then surpass the sensing and cognitive capabilities of human drivers.

How C-V2X Could Change Driving

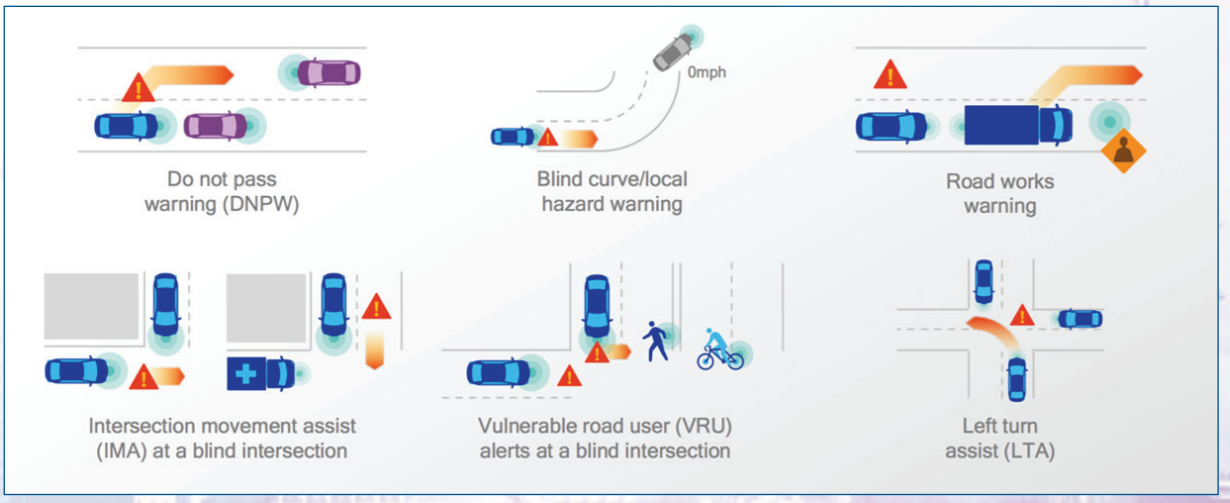
C-V2X can be used in many different ways to improve road safety, while making more efficient use of transport networks and infrastructure. This section gives examples of the many scenarios in which C-V2X can help to enhance safety.

Platooning refers to the formation of a convoy in which the vehicles are much closer together than can be safely achieved with human drivers. Such automated convoys make better use of road space, save fuel and make the transport of goods more efficient. C-V2X can be used to enable communications between up to three vehicles in the platoon, so that they all slow down or speed up simultaneously. And C-V2X could also be used to signal the presence of the platoon to other vehicles and roadside infrastructure. Platoons will be flexible in that they will typically be established on a motorway, then broken up when a vehicle leaves the motorway. For platoons of more than three vehicles, relaying information between vehicles takes too long to enable synchronous braking. Therefore, platoons of more than three vehicles will also need to make use of the low latency cellular network infrastructure that will be deployed with 5G.

Co-operative driving: Vehicles can use C-V2X to work together to make the best use of the available road space and minimise the disruption caused by lane changes and sudden braking. C-V2X can be used to convey intent to other road users. For example, once a vehicle has overtaken another vehicle, the most efficient way to re-enter a slower lane during periods of dense traffic, is for the vehicle in front of it to accelerate slightly, and for the following car to slow down slightly to make sufficient space for the merging car. The same process can also be used to smooth a vehicle's entry on to a busy motorway.

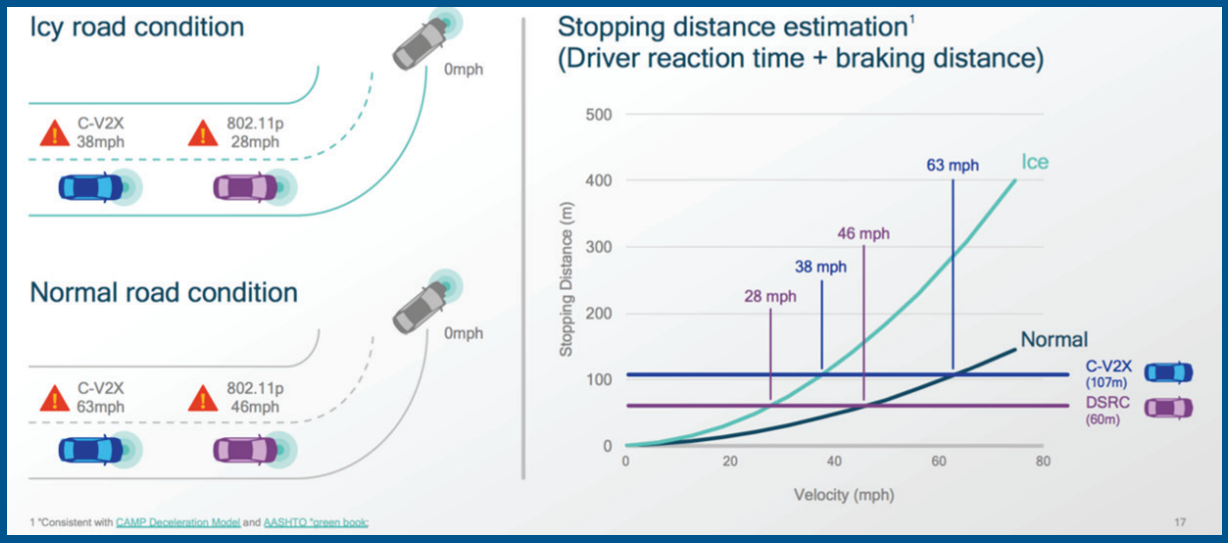
Queue warning: Roadside infrastructure can also use C-V2X to warn vehicles of queues or road works ahead of them, so they can slow down smoothly and avoid hard braking. More broadly, the roadside infrastructure can use C-V2X to help vehicles retain a consistent speed and reduce the number of so-called phantom traffic jams caused by the ripple effect caused by sudden braking and lane changes on motorways.

Avoiding collisions: Each vehicle on the road could use C-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 determine whether any other vehicle is on a potential collision trajectory. The vehicles involved could then take evasive action, such as braking or accelerating, that will enable a collision to be avoided. In cases where a human driver is about to cause an accident, the information collected by C-V2X could be used to over-ride the manual controls. For example, if a driver is about to pull out at a junction into the path of another vehicle, the on-board computer could automatically apply the brakes and prevent the car moving forward.



Source: Qualcomm

Hazards ahead warning: C-V2X can be used to extend a vehicle's electronic horizon, so it can detect hazards around a blind corner, obscured by fog or other obstructions, such as high vehicles or undulations in the landscape. Roadside signs could use C-V2X to broadcast hazard warnings to each vehicle on a particular stretch of road. Moreover, a vehicle could use C-V2X to send salient data captured by its sensors, such as ice on the road, to other vehicles travelling behind it. If a vehicle is braking hard, it could use C-V2X to transmit a warning to the vehicles behind it.



Source: Qualcomm

Increasingly autonomous driving: Along with other sensors and communications systems, C-V2X will play an important role in enabling vehicles to become increasingly autonomous. For example, C-V2X could be used to give advance warnings of changes in traffic conditions so that the on-board computer can make better decisions on when to change lanes, accelerate or slow down.

3. How C-V2X Works

An advanced technology based on 4G, C-V2X can support a wider range of capabilities than earlier dedicated vehicle connectivity solutions, which are generally based on a Wi-Fi variant, known as 802.11p. C-V2X employs two complementary transmission modes to enable a very broad range of driving safety features. These modes are:

1. Direct communications between vehicles (V2V), between vehicles and infrastructure (V2I), and vehicles and other road users, such as cyclists and pedestrians (V2P). In this mode, C-V2X operates in the 5.9 GHz frequency band – the ITS (intelligent transport system) spectrum that has been identified and harmonised internationally for safety purposes. In this mode, C-V2X works independently of the cellular networks.

2. Network communications, in which C-V2X employs the conventional mobile network to enable the vehicle to receive information about road conditions and traffic in the area. In this mode, C-V2X operates in spectrum that has been licensed to mobile operators to provide connectivity to their customers.

Direct Communications

The ITS 5.9 GHz spectrum band has been set aside by governments worldwide to enable vehicles to talk to each other using dedicated frequencies that won't be subject to interference. Using this band, C-V2X can support direct low latency connections over short distances, without the involvement of the cellular network. Like 802.11p, C-V2X employs the global navigation satellite system (GNSS) to determine the position of the vehicle and to synchronize communications between vehicles and with roadside infrastructure. In this mode, no SIM card is required, as the vehicle doesn't need to connect to the cellular network. The vehicle and its driver remain anonymous, as no cellular subscription is required for direct safety communications. C-V2X and 802.11p can co-exist in the ITS spectrum by employing different channels within the 5.9 GHz band. Just 10MHz of spectrum in the 5.9GHz band is required to support basic safety services, while 70MHz could support advanced safety services, such as sharing large amounts of data collected by on-vehicle sensors.

Network Communications

C-V2X can also support vehicle-to-network (V2N) applications delivered over commercially-licensed cellular spectrum. This mode can be used to provide network assistance for safety-related features, as well as commercial services, requiring the involvement of a mobile operator, providing access to cloud-based data or information. This mode also enables C-V2X to harness the data security and privacy of mobile networks. Time-critical services can be supported by edge computing – the deployment of computer servers and data analytics on the edge of the network.

Developed to be both deployable in the near term and future-proof, C-V2X is versatile enough to support both today's use cases, and those of tomorrow. Compatible with 4G and 5G cellular networks, it is intended to be both scalable and interoperable. In time, C-V2X will support advanced driver assistance systems (ADAS) where vehicles can cooperate, coordinate and share information collected by sensors, and ultimately, connected automated driving (CAD).

4. The Advantages of C-V2X

C-V2X has several major advantages over other vehicle connectivity solutions for each of the key stakeholders in this sector.

For automakers: Combining secure wide area and short-range connectivity in one technology, C-V2X is a versatile and cost-effective solution for automakers looking to improve road safety. For example, an automaker using C-V2X can install a single connectivity module in a vehicle to support both secure communications with the Internet and cloud-based systems, and direct communications with nearby vehicles, infrastructure and road-users. As well as leveraging the security built into cellular networks, the automaker can benefit from the massive economies of scale in the 4G mobile ecosystem, in which a large and diverse group of chipset, module and equipment makers all comply with the 3GPP standards. In essence, C-V2X has the support of a large, innovative and competitive supply chain.

For road operators: As the ITS band uses high frequency spectrum (5.9 GHz), in which radio signals have a limited range, providing extensive connectivity coverage is challenging for road operators. However, C-V2X allows for direct communications in the 5.9 GHz band to be supplemented with cellular communications using lower frequencies in which radio signals travel further. The net result is high service availability and reliability. Moreover, in future, C-V2X will enable road operators to also harness the millimetre waves that will be used by 5G mobile networks for high volume data transfer, and low latency wide area network support for assisted driving. In essence, harnessing the existing cellular infrastructure will reduce the amount of roadside infrastructure that will need to be installed and maintained by municipalities and highway agencies in both urban and rural areas. That would free up funds for other purposes, such as the training of road agency personnel and highway maintenance.

For mobile operators: To keep deployment costs down, mobile operators can harness their existing cellular infrastructure to support the rollout of C-V2X connectivity. The synergies between the roadside infrastructure and the conventional cellular infrastructure can generate significant economic benefits. Firstly, the operators' base stations can work with roadside infrastructure to provide the comprehensive coverage required to create cooperative intelligent transport systems (C-ITS). At the same time, operators' commercial cellular networks can also provide backhaul to link the roadside infrastructure to the cloud. As C-V2X is based on a variant of 4G, it is compatible with existing LTE base stations, enabling rapid deployment.

The Technical Advantages of C-V2X

C-V2X has a number of technical advantages over 802.11p-based alternatives, as summarised in the graphic below. Together, these advantages equate to a significantly higher link budget and system performance, enabling range, Doppler (speed) and reliability advantages over 802.11p. C-V2X has a higher spectral efficiency, enabling it to serve more road users within a given chunk of spectrum. Hence, C-V2X can provide higher levels of safety to more road users than alternative technologies.

More broadly, ad hoc networks relying solely on direct communications between vehicles can become inefficient if the number of hops becomes significant, due to the protocol overhead. A practical limit tends to be five hops. However, if there is an active antenna system located in the front and rear of a car, the number of hops can be doubled.

As well as offering superior direct communications, C-V2X offers a higher degree of security than 802.11p for all operating modes. Mobile operators secure all traffic travelling to and from their networks, which can be supplemented with Public Key Infrastructure (PKI) encryption services.

	C-V2X: PC5	802.11p	C-V2X: PC5 ADVANTAGE
Synchronization	Synchronous	Asynchronous	Spectral Efficiency. Synchronization enables time division multiplexing (TDM) and lowers channel access overhead.
Resource Multiplexing Across Vehicles	FDM and Time Division Multi-plexing (TDM) Possible	TDM Only	Frequency Division Multiplexing allows for larger link budget and therefore longer range - or more reliable performance at the same range
Channel Coding	Turbo	Convolutional	Coding gain from turbo codes leads to longer range - or more reliable performance at the same range.
Retransmission	Hybrid Automatic Repeat Request (HARDQ)	No HARQ	Leads to longer range - or more reliable performance at the same range.
Waveform	SC-FDM	OFDM	Allows for more transmit power with the same power amplifier. Leads to longer range - or more reliable performance at the same range.
Resource Selection	Semi-persistent transmission with relative energy-based selection.	Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA)	Optimizes resource selection with selection of close to 'best' resource with no contention overheads. By contrast 802.11p protocol selects the first "good enough" resource and requires contention overhead.

Source: 5GAA

5. The Roadmap for Deployment

C-V2X has widespread support within the telecoms and automotive industries. The 5GAA, a cross industry consortia to help define 5G V2X communications, is a strong supporter of C-V2X. Audi, BMW, Daimler, Ford, Jaguar Land Rover, Nissan, SAIC Motor and Volkswagen are among its members, along with most of the world's leading mobile operators and their equipment suppliers.

C-V2X is being tested extensively by mobile operators, equipment suppliers and automakers. These trials are likely to continue into 2018, ahead of the first commercial deployments towards the end of that year. China is on course to be one of the first countries to deploy C-V2X, while some European countries are also likely to be in the vanguard of adoption.

Huawei, for example, has run trials with China Mobile, SAIC Motor Corporation, Deutsche Telecom, Audi and Toyota, including a live demonstration at the G20 Summit in Hangzhou in September 2016, which simulated real-life driving conditions.

In February 2017, Orange and PSA Group announced the completion of initial C-V2X field trials in France. The trials explored two use cases: "see through" between two connected vehicles on a road, and "emergency vehicle approaching," aiming at notifying drivers in real-time when an emergency vehicle is nearby. Orange and PSA said they employed a new radio access network configured with edge-computing features, to achieve an average delay of just 17 milliseconds for vehicle-to-network-to-vehicle communications at a vehicle speed of 100 km/h. This is in comparison to the 30-60 millisecond results measured in conventional LTE networks. These results were achieved in the 2.6 GHz frequency band, delivering a 100 Mbps performance.

Working with Qualcomm, Orange and the PSA Group are now

- Implementing a dedicated network slice to prioritize intelligent transportation system (ITS) vehicular traffic over other traffic
- Using the direct communication features of C-V2X to test V2V, V2I and V2P capabilities
- Helping to develop new use cases to assess how C-V2X with 5G NR features will support advanced applications, including traffic flow optimization, improved safety and automated driving

Trials are also underway in Germany, where Audi, Ericsson, Qualcomm, SWARCO Traffic Systems and the University of Kaiserslautern, have formed the Connected Vehicle to Everything of Tomorrow (ConVeX). Co-funded by the participating organizations and the German Federal Ministry of Transportation and Digital Infrastructure (BMVI), ConVeX has integrated C-V2X direct communications, in the 5.9GHz ITS spectrum, into an Ericsson 5G test network covering highways, roads and cities in Germany.

> *"Digitization will redefine the properties of the car. Connectivity and autonomous driving are two megatrends to shape tomorrow's vehicles, but this transformation will go further. Data, cloud technology and new business models will be the major drivers of innovation and create an ecosystem around our core product," said Alfons Pfaller, head of infotainment development, AUDI AG. "Therefore the key to success is cross-industry collaboration – and so we are very happy to work together in the ConVeX consortium on new solutions for our customers.*[1]

Alfons Pfaller, *head of infotainment development,* ***AUDI AG***

[1] Source: https://www.qualcomm.com/news/releases/2017/01/03/consortium-leading-automotive-and-telecom-companies-host-3gpp-release-14

> *"Connected and collaborative mobility has an enormous potential to improve traffic efficiency, enhance traffic safety and to lower emissions," said Professor Schotten, head of the chair for Wireless Communications and Navigation at the University of Kaiserslautern. "ConVeX will be an important step towards realizing this vision and we are glad to be able to contribute to this process.*[2]

Professor Schotten, *head of the chair for Wireless Communications and Navigation at the* ***University of Kaiserslautern.***

C-V2X is also gaining traction in the US, where the Trump administration appears to be moving away from its predecessor's proposals to mandate the use of an 802.11p-based system in vehicles. In October 2017, AT&T, Ford, Nokia and Qualcomm announced plans for trials in San Diego to demonstrate the potential of C-V2X technologies to improve automotive safety, enable automated driving, and increase traffic efficiency. The participants are also seeking to demonstrate to automakers and road operators the cost benefits associated with embedding cellular technology in vehicles and synergies between the deployment of cellular base stations and roadside infrastructure.

The trials will test direct C-V2X communications operating in the 5.9 GHz ITS spectrum, encompassing vehicle-to-vehicle use cases, including "do not pass warnings", "intersection movement assist", and "left turn assist". The trials will also explore advanced vehicle communication capabilities, such as real-time mapping updates and event notifications, relayed using AT&T's cellular network and Nokia Cloud infrastructure.

[2]Source: https://www.qualcomm.com/news/releases/2017/01/03/consortium-leading-automotive-and-telecom-companies-host-3gpp-release-14

How Will 5G Change C-V2X?

C-V2X is designed to be fully compatible with 5G, meaning investments in infrastructure and modules today won't be made obsolete for a long time to come. C-V2X technology will be further refined and its capabilities expanded with Release 15 of the 3GPP standards, due in June 2018, and Release 16 in June 2019.

The deployment of commercial 5G networks from 2020 onwards based on the 3GPP standards will enhance C-V2X in several different ways. In the 5G era, C-V2X will be able to support:

- 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 or live video images
- High throughput to build local, dynamic maps based on camera and sensor data; which can then be distributed at street intersections. 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 very large numbers of simultaneous connections in a small geographic area, enabling each vehicle to gather more information about its immediate surroundings.

Additional Spectrum Requirements

The International Telecommunication Union (ITU) is considering allocating more spectrum to road safety applications. ITU-R Working Party 5A is further developing spectrum requirements and studies at the national, regional and global level that will support existing and future use cases envisaged for road safety and traffic efficiency applications. These applications are likely to require spectrum beyond the currently harmonized 5.875-5.905 GHz, comprising at least the 5.905-5.925 GHz band. Additionally, 5GAA advocates that sharing with unlicensed Radio Local Area Networks (RLANs) at 5.855-5.875 GHz should be considered provided ITS spectrum is adequately protected.

CONCLUSIONS

For road operators, automakers and mobile operators, 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. One of the main advantages of using a cellular system is that it can address all V2X applications in an end-to-end manner with the same technology. That makes it very scalable and future-proof. Moreover, as part of the 3GPP standards family, C-V2X has the support of a broad and global ecosystem, while providing a clear evolution path from LTE to 5G. In summary, C-V2X is a better choice than any hybrid solution that incorporates 802.11p-based technology.

Now that C-V2X technology has been standardised, it is set to be widely adopted by vehicle manufacturers and mobile operators, paving the way for deployments around the world by road operators and municipalities. From 2018, C-V2X systems will begin to go live in China, Europe and North America. As a matter of urgency, governments and public agencies need to ensure that there are no regulatory barriers preventing the widespread adoption of C-V2X. Rather than mandating the use of a specific technology in the spectrum bands dedicated to road safety, policymakers should allow stakeholders to select the most efficient and effective option to meet their needs. With a flexible and future-proof regulatory framework, C-V2X will help to transform road transport, delivering numerous socio-economic and environmental benefits along the way.

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