

Cellular V2X (C-V2X) could fulfil a market need, if the commercial timing is right

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V2X will enable communication between vehicles, and between vehicles and infrastructure. It will potentially complement on-board sensors in vehicles by providing enhanced information (such as data from other vehicles) over a longer range.

Cellular V2X (C-V2X) is a technology developed by the Third Generation Partnership Project (3GPP) to deliver V2X services, including a direct vehicle-to-vehicle (V2V) mode (called 'PC5' in 3GPP specifications) and a network communications interface for vehicle-to-network (V2N) communication. The former short-range communications mode is designed to use spectrum designated for intelligent transport systems (ITS) in the 5.9GHz band for V2V and vehicle-to-roadside infrastructure (V2I) messaging, whereas the V2N mode will utilise the spectrum assigned to mobile operators within cellular networks.

There is also an existing, short-range, wireless technology that has been standardised for V2V and V2I connectivity, based on IEEE 802.11p. These standards have been developed over the past decade, although applications based on IEEE 802.11p have not seen widespread adoption to date. Both IEEE 802.11p and C-V2X can be considered as possible solutions for the deployment of co-operative intelligent transport systems (C-ITS) such as those being proposed both in Europe and globally.

The 5G Automotive Association (5GAA) is a cross-industry association between the cellular and automotive industries, set up to develop, test and promote C-V2X communications solutions, initiate their standardisation and accelerate their commercial availability and global market penetration, with applications such as automated driving, ubiquitous access to services and integration into smart cities and intelligent transportation. The 5GAA commissioned Analysys Mason to conduct a study on the socio-economic benefits of C-V2X in Europe after recognising that the European Commission (EC) was holding a public consultation closing in December 2017 on the deployment of C-ITS. Our report was completed in December 2017 and has been published by the 5GAA.¹ In this article, we discuss the report's key findings.

Features of C-V2X include its low deployment costs and wide-area coverage potential, as well as a clear medium-term evolution path to 5G

A key reason for C-V2X developments is to meet demand within the automotive sector to enhance automated driving technologies with improved wireless connectivity. Such automated driving technologies are evolving rapidly and are widely expected to transform driving experiences, provide safer cars and improve the efficiency of car travel. C-V2X will potentially complement on-board sensors (used within automated driving solutions currently) by providing enhanced information (such as data from other vehicles) and enabling operation over a

¹ <http://5gaa.org/news/5gaa-study-the-cost-benefit-analysis-on-cellular-vehicle-to-everything-c-v2x-technology-and-its-evolution-to-5g-v2x/>

longer range. For car drivers, this will contribute to further improvements in the safety, efficiency and convenience of car travel.

Both C-V2X and IEEE 802.11p technologies have the potential to bring improved safety and efficiency to transport. We identified in our study, however, that using the currently defined long-term evolution (LTE) technology for V2V ad-hoc short-range communication, combined with LTE cellular networks for V2N, has the potential to bring additional benefits, including:

- better coverage for V2N, by exploiting existing cellular network coverage provided by lower-frequency spectrum
- reduced infrastructure deployment costs and improved service reliability, by using existing mobile infrastructure, and thus making use of cellular technology integration and economies of scale, rather than building independently operated roadside infrastructure
- the potential for V2X and other telematics services in vehicles (such as infotainment) to be provided through a common cellular interface
- increased deployment flexibility, along with the ability to provide coverage for both short-range and wide-area applications
- the opportunity for integration with smart cities and other connected-transportation initiatives that also use cellular technology
- enhanced security, through the use of mobile subscriber identity module (SIM) cards
- certainty of future evolution, which will enable C-V2X communications to progress seamlessly into the 5G era (while offering backward compatibility with earlier C-V2X solutions).

Net benefits in Europe could reach EUR43 billion by 2035

As part of the study, we defined four scenarios to help us quantify the changes in the magnitude of the overall costs and benefits associated with different timescales and volumes of V2X adoption. We also wanted to distinguish relative differences in the net benefits, depending on whether LTE/4G PC5 and the forthcoming 5G PC5 or IEEE 802.11p technology is adopted in vehicles, and the extent to which synergies with cellular networks are exploited for the provision of V2I/vehicle-to-pedestrian (V2P). When quantifying the costs and benefits of C-V2X, we considered the time period from 2018 to 2035.

A summary of the net benefits that we calculated, per scenario, is as follows:

Figure Summary of scenarios for quantitative analysis

Scenario	Summary	Net benefits by the end of the modelling period (2035)
1 - Base case	The adoption and timing of the deployment is determined by automotive original equipment manufacturers (OEMs), in the absence of any regulatory measures.	EUR39 billion
2 - 2020 EC mandate on V2V/V2I	An EC mandate requiring all new vehicle models to support EC-defined 'Day 1' and 'Day 1.5' services from 2020 results in C-ITS services using IEEE	EUR20 billion

Scenario	Summary	Net benefits by the end of the modelling period (2035)
	802.11p technology for V2V and V2I. Provision of V2I using IEEE 802.11p requires an extensive roll-out of 5.9GHz roadside units (RSUs).	
3 – 2023 EC mandate on V2V/V2I	An EC mandate requiring all new vehicle models to support ‘Day 1’ and ‘Day 1.5’ services from 2023 results in C-ITS services using LTE PC5 technology for V2V and V2I. Provision of V2I using PC5 requires an extensive roll-out of 5.9GHz RSUs.	EUR27 billion
4 – Equitable 5.9GHz use	C-V2X and IEEE 802.11p technologies co-exist in 5.9GHz spectrum, with the division of spectrum enabling the adoption of both technologies based on market demand.	EUR43 billion

Source: Analysys Mason, 2017

Rapid completion of end-to-end tests and commercialisation is now needed

Road authorities across Europe are actively considering digital infrastructure requirements and several governments are actively supporting the roadside connectivity agenda through the funding of research and development and trials.

C-V2X has the potential to meet the future digital infrastructure requirements for connected and autonomous vehicles, initially using the latest LTE-based specifications (as per Release 14 of the 3GPP specifications), and subsequently with 5G. The re-use of cellular networks to provide V2N will reduce road infrastructure costs significantly, and might also allow high infrastructure penetration from the point of C-V2X launch (resulting in benefits from V2I/V2N services being realised sooner). Our study also found a greater likelihood of C-V2X integration into smartphones, compared to IEEE 802.11p, meaning that V2P services – a further component to enable future automated driving – can be more rapidly achieved.

In conclusion, the study made several recommendations in relation to the European ITS policy. Firstly, the cost-benefit results from the study indicate strong benefits to the European market from synergies between the different modes of C-V2X, and with the wider eco-system of mobile infrastructure already deployed in Europe. Hence, it is recommended that European ITS policies encourage these synergies to be realised. Secondly, it is recommended that the European C-ITS policy should be designed to encourage migration from the current V2X technologies to 5G once forthcoming 5G PC5 technology is available.