



European
Automobile
Manufacturers
Association

ACEA Position Paper Frequency bands for V2X



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ABSTRACT

This position paper of the European Automobile Manufacturers' Association (ACEA) treats frequency bands for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, collectively known as V2X communication. It will highlight the current challenges with the allocated 5.9 GHz band and the reasoning why the automotive industry is supporting investigations on using a lower carrier frequency for new approaches to achieve V2X such as the 3.4-3.8 GHz frequency band.

INTRODUCTION

In 2008, the Electronic Communications Committee (ECC)¹ issued a recommendation (ECC/REC/(08)01) and a decision (ECC/DEC/(08)01) regarding intelligent transport systems (ITS) in the 5.9GHz band (see figure 1). The very same year the European Union designated a 30 MHz frequency band (5 875-5 905 MHz) for ITS through Commission Decision 2008/671/EC.

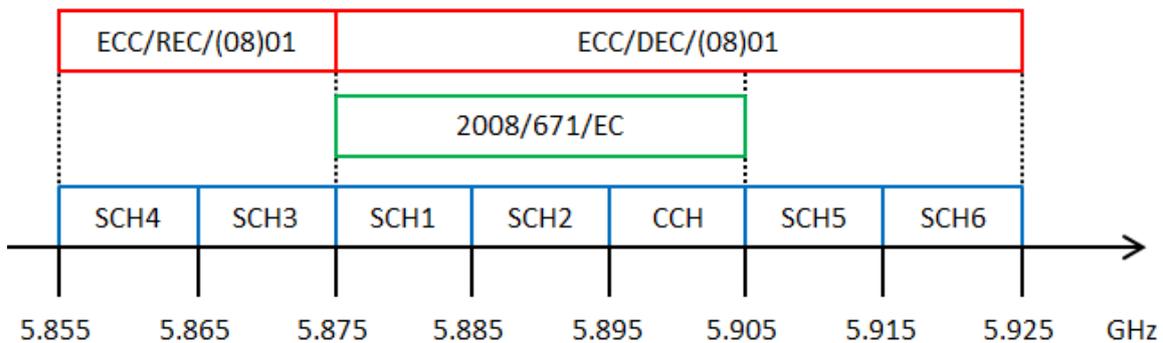


Figure 1: overview of frequency band at 5.9 GHz.

Standardisation took off in 2008 with the creation of the Technical Committee on Intelligent Transport Systems (TC ITS) within the European Telecommunications Standards Institute (ETSI)² with the goal to develop a set of protocols facilitating an interoperable V2X system between vehicles and between vehicles and smart infrastructure in support of traffic safety applications.

In 2014, standardisation was more or less finalised and the work with deployment issues started.

¹ Electronic Communications Committee (ECC) is one out of three business units of European Conference of Postal and Telecommunications Administrations (CEPT), www.cept.org/ecc

² European Telecommunications Standards Institute, www.etsi.org, officially recognised by the EU as a European standards organisation

The CAR2CAR Communication Consortium (C2C-CC)³ stated that initial deployment could begin as soon as 2019⁴ in Europe using the wireless technology ITS-G5 (also known as IEEE 802.11p) for establishing communication between vehicles from different automobile manufacturers for deployment in the 5.9 GHz frequency band. More information about V2X deployment using ITS-G5 in Europe can be found in reference [1].

Lately, also V2X initiatives have been taken by the cellular and automotive industry jointly⁵. In Release 14 of the cellular specification from 3GPP finalised in July 2017, there are two modes of V2V operation: '(i) cellular-assisted V2V (called Mode 3)' and '(ii) pure ad hoc V2V (called Mode 4)'. The V2V communication in Release 14 'in Mode 4' is not targeting operation on the frequency bands, which operators have under license, but rather uses license-exempt bands such as the 5.9 GHz.

To operate in 'Mode 3', vehicles need to be in coverage of a base station that divides the resources among vehicles (using the frequency channel under license by the operator) and then the V2V communication takes place on a license-exempt band (eg 5.9 GHz). It should be noted that vehicles under management of the same operator can enjoy this V2V communication (Mode 3). Mode 4, which is operated in a true ad-hoc manner, is a candidate for basic and advanced V2V communication. Mode 3 and Mode 4 will hereafter be collectively called LTE-V2X. 5GAA announces deployment of LTE-V2X by 2020 [2].

ITS-G5 and LTE-V2X interfere with each other if operated on the same frequency channel due to different approaches on how to access the communication channel (ie medium access control, MAC). However, recent ETSI work in 2018 [3] has shown that ITS-G5 and LTE-V2X could coexist on the same frequency channel in the 5.9 GHz frequency band. While some co-channel coexistence solutions require changes to the LTE-V2X standard, some others like for instance the solution based on energy signals only require software modification of both technologies ITS-G5 and LTE-V2X, while preserving the usage of the whole 30 MHz spectrum. ACEA is of the opinion that, if there is any technical solution to allow coexistence in the same frequency channels, it shall make use of the whole 30 MHz from day one to avoid sterilising the band for future ITS service.

³ CAR2CAR Communication Consortium, www.car-2-car.org, non-profit organisation bringing together automobile manufacturers, suppliers, research institutes and universities in Europe, working towards the deployment of ITS-G5 at 5.9 GHz

⁴ C2C-CC press information, https://www.car-2-car.org/fileadmin/press/pdf/CAR_2_CAR_Communication_Consortium_Press_Release_on_near-termed_deployment.pdf

⁵ 5G Automotive Association, <http://5gaa.org/>

THE 5.9 GHZ BAND

Much research efforts have been devoted to issues related to the high carrier frequency at 5.9 GHz and the signal propagation. The high carrier frequency is challenging because the higher carrier frequency the more optical behaviour of the signal. The wavelength at 5.9 GHz is approximately 5 cm, objects larger than the wavelength will affect the signal when it is travelling between sender and receiver. Radio waves having a wavelength smaller than 9 cm have difficulties in penetrating into buildings and through rugged terrain [4]. Best performance is achieved when there is line-of-sight between the antennas of the sender and receiver, respectively.

When the line-of-sight component is blocked, the receiving antenna needs to rely upon strong multipath components (replicas of the signal bounced off from objects in the environment) to receive packets successfully.

From the perspective of automobile manufacturers, the antenna installation to achieve maximum performance of the V2X system at 5.9 GHz is crucial. For large vehicles such as trucks, the antenna cannot be placed on the roof of the cabin because the majority of trucks have some kind of trailer or bodywork that is higher than the cabin itself. This implies that putting the antenna on the cabin is not providing good radio coverage behind the truck because the line-of-sight component will always be blocked backwards (although coverage in front of the truck will be good). Therefore, two antennas are needed in trucks and those need to be placed in the wing mirrors or on the side of the truck itself to achieve acceptable performance behind and around the truck.

For antenna installations in cars, the curved roofs of today's passenger cars induce problems. The shark fin, placed at the end of the roof, is not an ideal placement for a 5.9 GHz antenna due to the curvature of the roof.

The shark fin contains antennas for cellular connectivity and broadcast radio for example. The reception of signals in these kinds of systems is different compared to V2X since the car is receiving signals from a fixed base station above it as opposed to other moving objects where the antennas are at approximately the same height in the V2X case. An ideal placement in a passenger car would be in the middle of the roof, which is not possible from a practical point of view.

In summary, the antenna installation at 5.9 GHz is crucial and this does not depend on the selected wireless technology itself but merely the natural characteristics of wave propagation at 5.9 GHz and the small wavelength. In other words, regardless of the technology (ITS-G5 or LTE-V2X) the problems with antenna installation and performance remain due to the high carrier frequency. Furthermore, the distance between the receiver (ie radio) and the antenna within a vehicle should be kept as small as possible because signals at 5.9 GHz exhibit higher attenuation compared to lower carrier frequency signals when propagating in an antenna cable.

Due to the propagation conditions at 5.9 GHz mainly the closest neighbours are reached, which is

exactly the intention with safety-related applications (100-300 meters in urban environment). This leads to a significantly higher spatial capacity and a natural reuse of frequencies. Much lower carrier frequencies, such as the 700 MHz band designated for V2V communication in Japan, lead to signals travelling much further than needed, thereby creating unnecessary interference.

THE 3.4-3.8, 3.4-4.2 GHZ BAND

As pointed out in the section about the 5.9 GHz band, a frequency band with a lower carrier frequency for V2X would be beneficial. The sweet spot for mobile communication is between 300 MHz and 3.5 GHz [4] when one or both communicating parties are moving and the line-of-sight component might be missing (it should be noted that, for example, fixed communication links on roof tops at a high carrier frequency is of course possible). A carrier frequency that is too low results in large antennas, which is also impractical from an automotive perspective.

The 3.4-3.8 GHz band would not imply the same difficulties with antenna installation for vehicles at large. However, investigations and new research need to be carried out also for this frequency band for vehicles in order to find a suitable placement maximizing performance. Furthermore, communication at a carrier frequency between 3.4 and 3.8 GHz does not have harmonics in the 5.9 GHz band, which is an advantage.

In summary, the 3.4-3.8 GHz band is a good compromise between high and low carrier frequencies with regards to propagation characteristics and antenna size.

FUNCTIONAL SAFETY ASPECTS

Connected and automated vehicles put the functional safety analysis of cooperative applications in a new perspective. Up until now, automobile manufacturers have been performing hazard analysis of the in-vehicle electrical systems mainly based on ISO 26262. However, this standard is only addressing the internal architecture and does not include external sources of information coming from other vehicles or backend systems (eg 'the cloud'), here the more generic ISO 61508 and ISO 20078 standards come into play.

ITS-G5 and LTE-V2X (Mode 4) might have to be included in a hazard analysis because we are dealing with communication directly between vehicles although certain applications such as platooning might require a redundant communication channel to solve the hazard analysis. Operating V2X communication technology additionally on different carrier frequencies would add true redundancy and the overall system would be more robust against jamming, for example.

CONCLUSION

ITS-G5 and LTE-V2V interfere with each other if operated on the same frequency channel because there are differences between the wireless systems. To foster ITS applications using the 5.9 GHz frequency band regardless of technology, coexistence methods between available technologies should be developed (ie several technologies can be co-located the same frequency channel). This is also in line with the advocated technology-neutral principle and most spectral efficient. Lately, ETSI has made significant efforts in finding a coexistence method. Installation of 5.9 GHz equipment including antennas in vehicles is crucial regardless of wireless technology.

LTE-V2X and/or ITS-G5 in the 3.4-3.8 GHz and/or 5.9 GHz bands can introduce redundancy for serving connected and automated vehicles. V2X applications in need of redundancy can run applications on one or two technologies on well-separated frequency channels. Furthermore, using two different frequency bands will provide extra robustness to the overall V2X system (compare how line-of-sight sensors such as radar and camera provide robustness for different applications).

To conclude, Europe's automobile manufacturers support investigation and research into additional use of V2X technologies at a carrier frequency between 3.4 and 3.8 GHz given the rationales provided in this position paper.

REFERENCES

- [1] K Sjöberg, P Andres, T Buburuzan and A Brakemeier, 'C-ITS Deployment in Europe – Current Status and Outlook', in IEEE Vehicular Technology Magazine, vol 12, no 2, June 2017, pp 89-97.
- [2] 5GAA press information, <http://5gaa.org/news/timeline-for-deployment-of-lte-v2x/>.
- [3] SRDMG(18)105, Complementary LS from ETSI to WG FM and WG SE on work progress on the ITS mandate subject (ERM(18)0065b021r1).
- [4] M Lazarus, 'The Great Spectrum Famine', in IEEE Spectrum, vol 47, no 10, October 2010, pp 26-31.



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ABOUT ACEA

- ACEA represents the 15 Europe-based car, van, truck and bus manufacturers: BMW Group, DAF Trucks, Daimler, Fiat Chrysler Automobiles, Ford of Europe, Honda Motor Europe, Hyundai Motor Europe, Iveco, Jaguar Land Rover, PSA Group, Renault Group, Toyota Motor Europe, Volkswagen Group, Volvo Cars, and Volvo Group.
- More information can be found on www.acea.be or [@ACEA_eu](https://twitter.com/ACEA_eu).

ABOUT THE EU AUTOMOBILE INDUSTRY

- 13.3 million people – or 6.1% of the EU employed population – work in the sector.
- The 3.4 million jobs in automotive manufacturing represent over 11% of total EU manufacturing employment.
- Motor vehicles account for some €413 billion in tax contributions in the EU15.
- The sector is also a key driver of knowledge and innovation, representing Europe's largest private contributor to R&D, with €54 billion invested annually.
- The automobile industry generates a trade surplus of €90.3 billion for the EU.