IEEE 802.18

Radio Regulatory Technical Advisory Group

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| Reply Comments on FCC19-138 NPRM  Revisiting Use of the 5.850-5.925 GHz Band | | | | |
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Abstract

r04: 07apr, before ad-hoc: further edits based on inputs by Dick Roy and Amelia Andersdotter, started cleanup.

r03: 06apr, .18 ad-hoc: edits and further comments as suggested in the call.

r02: 06apr, before ad-hoc: further edits based on comments made during 03apr ad-hoc

r01: 03apr, .18 ad hoc – update based on edits suggested by Joseph Levy (merged by Sebastian Schiessl), additional clarifications on cellular connectivity, new section on non-periodic traffic and variable size messages. ad-hoc discussions inserted.

r00: 31mar, .18 ad hoc - initial draft based on clean copy of 18-20-0045-r4, with EC comments and ad-hoc call edits and ad-hoc discussions inserted

Yellow: Changes to 18-20-0045 that are considered acceptable

Blue: Changes that require further discussions

}} TODO: Quote filings from proponents of LTE V2X to back up our statements.

}} TODO: V2X is not only about cars and vehicles, try using more general terms

}} TODO: Find proper term for 802.11p: Is it “IEEE 802.11-2016 OCB mode” or simply “DSRC”? Be consistent with original comments!

}} TODO: try avoiding the word but

}} TODO: Try avoiding First, Second, … to start paragraphs

**Before the**

**Federal Communications Commission**

**Washington, D.C. 20554**

In the Matter of )

)

Use of the 5.850-5.925 GHz Band ) ET Docket No. 19-138

)

**Reply Comments of IEEE 802**

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Standards Committee

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26 April 2020

# Introduction

IEEE 802 LAN/MAN Standards Committee (LMSC) is pleased to provide reply comments on the above-captioned proceeding to the NPRM on the use of the 5850-5925 MHz Band dated 06 February 2020 in the United States Federal Register.

IEEE 802 LMSC is a leading- consensus-based industry standards body, producing standards for wireless networking devices, including wireless local area networks (“WLANs”), wireless specialty networks (“WSNs”), wireless metropolitan area networks (“Wireless MANs”), and wireless regional area networks (“WRANs”). We appreciate the opportunity to provide these reply comments to the Commission.

IEEE 802 is a committee of the IEEE Standards Association and Technical Activities, two of the Major Organizational Units of the Institute of Electrical and Electronics Engineers (IEEE). IEEE has about 420,000 members in about 190 countries and supports the needs and interests of engineers and scientists broadly. In submitting this document, IEEE 802 acknowledges and respects that other components of IEEE Organizational Units may have perspectives that differ from, or compete with, those of IEEE 802. Therefore, this submission should not be construed as representing the views of IEEE as a whole.[[1]](#footnote-1)

# Executive Summary

With the release of FCC NPRM 19-129 (E.T. Docket 19-138), the United States Federal Communications Commission has requested comments and reply comments regarding assessing the 5.9 GHz band rules and proposing appropriate changes to ensure the spectrum supports its highest and best use. The Commission proposes to: “… continue to dedicate spectrum — the upper 30 megahertz portion of the band — for transportation and vehicle safety purposes, while repurposing the remaining lower 45 megahertz part of the band for unlicensed operations to support high-throughput broadband applications.”

In the following pages IEEE 802 will address several key points made by commenters as they relate to the Dedicated Short-Range Communication (DSRC) technology for V2X (Vehicle-to-everything) communications, ~~its evolution,~~ and make recommendations for Commission’s consideration.

First, DSRC incorporates the same state-of-the-art 802.11 technology that is used in many products on the market today. Furthermore, the IEEE 802.11 WG is in the process of developing next generation V2X technology, IEEE P802.11bd, as an amendment to the IEEE 802.11 standard that ensures backward compatibility and coexistence with current DSRC deployments.

Second, DSRC has been and continues to be deployed in over a hundred sites around the US. Thousands of vehicles are outfitted with DSRC onboard units, all successfully executing ITS safety and efficiency services.

Third, IEEE 802 believes C-V2X has several shortcomings that make DSRC better-suited for deployment of ITS safety and efficiency services. For example, IEEE 802 believes that the IEEE 802.11 Working Group practice of ensuring same channel backwards compatibility and coexistence for evolving IEEE 802.11 technologies provides a significant advantage over the proposed C-V2X evolution plan for Release 14 LTE V2X to 5G NR V2X that specifies neither same-channel backward compatibility nor same-channel coexistence.

Finally, IEEE 802 recommends that the V2X technology of choice for the ITS band 1) must be the subject of a mature set of standards, 2) must be proven through real-world testing to work effectively in ITS environments, and 3) must be future-proof by having a well-defined evolutionary path that maintains backward compatibility and coexistence with previous generations, including coexistence with DSRC which already occupies the ITS band. IEEE 802 notes that DSRC meets these criteria.

The IEEE Std 802.11p-2010 amendment, now incorporated into IEEE Std 802.11-2016, provides core technology for DSRC. ~~The term "OCB" (outside the context of a BSS (Basic Service Set)) was introduced in IEEE Std 802.11p, which specified "Wireless Access in Vehicular Environments". The OCB specifications within IEEE Std 802.11 continues to support DSRC-compatible operation~~. The IEEE 802.11 Working Group (WG) is now specifying an IEEE Next Generation V2X (NGV) amendment within the IEEE P802.11bd project. The IEEE P802.11bd amendment is intended to provide a seamless evolution path from DSRC in the 5.9 GHz ITS band. Any consideration of the rules governing use of the 5.9 GHz band must recognize the societal value of allowing DSRC and IEEE P802.11bd to interoperate in the ITS band. It should be noted that one of the advanced features being specified for the IEEE P802.11bd project is 20 MHz bandwidth operation that co-exists with 10 MHz DSRC ~~specified in IEEE Std 802.11-2016.~~

# Advantages of DSRC

## Evolution of Standards, Same-Channel Co-Existence

In its comments, 5G Americas stated that 3GPP Release 16 5G NR V2X has considered “support of … mechanisms for coexistence between LTE and NR.” [6, page 11]. IEEE 802 finds this statement from 5G Americas misleading. It is important to understand that “5G NR V2X is not being designed to be backwards compatible to LTE V2X” as commented by Toyota [23, p. 25], and noted also by the Car-2-Car Communication Consortium [22, p. 6]. Furthermore, the 3GPP considerations on coexistence methods between 5G NR V2X and LTE V2X only concern operations in different, adjacent channels [23, p. 22] and do not address same-channel operations. The proponents of C-V2X have only considered the use of different channels when mentioning compatibility and coexistence between these technologies, for example [1, p. 7]: “To be clear, the basic safety messages will continue to be carried over 4G LTE in a 20 MHz channel. New vehicles supporting 5G-based advanced C-V2X will use a separate wider 40 MHz (or 55 MHz) channel […]”. However, same-channel coexistence and compatibility modes are not being specified.

~~LTE V2X (Release 14) and 5G NR V2X (Release 16) only refers to operations in adjacent channels, but not to same-channel operations. Therefore, 3GPP’s “consideration of support for coexistence mechanisms” does not address simultaneous same channel operation and only considers coexistence in adjacent channels [16].~~

}} Car-to-Car comments [22, p.6] “5G-NR V2X is not interoperable or backward compatible with LTE-V2X.”

}} Toyota comments [23, p. 25]. “5G NR V2X is not being designed to be backwards compatible to LTE V2X”, “5G NR V2X is also not capable of same-channel coexistence with LTE V2X”

The Commission should take into account what the lack of same-channel evolution and backward-compatibility of LTE-V2X (Release 14) will mean in the future, for example in the year 2030 or 2040. While mobile phones might already support the 6-th and 7-th generation of cellular communication standards, ITS devices could end up communicating via a 4-th generation standard. At that point, redistributing this spectrum to a newer technology would become nearly impossible, as it would require modifying millions of ITS devices, while ensuring that this modification is carried out simultaneously on virtually all devices, because even a small fraction of devices transmitting the old waveforms could create harmful interference and substantially reduce traffic safety. The lack of evolution and backward-compatibility may prevent automakers from deploying V2X today.

}} TODO: Make a point that average cars are being kept for 10, 15, 20 years. Average 11 years. Need reference

}} Note: Next Paragraph was moved from Sec. 8. Does it fit here?

In this regard, safety-critical systems are very different from commercial communication systems, where there is no need for a single air interface standard. For example, 3GPP 3G (UMTS), 4G (LTE), and 5G (NR) standards can all exist in the same handset, operating on different sub-bands and requiring different radios since each standard has unique over-the-air protocols and waveforms. This 3GPP definition of coexistence differs greatly from the IEEE 802.11 WG definition of coexistence, as IEEE Std 802.11 assumes coexistence is the ability of all generations ~~of technologies~~ ~~deployed per IEEE Std 802.11 being able~~ to share the same frequency and time resources. IEEE Std 802.11 assures through backwards compatibility that communication is possible even when older radios do not have all the advanced capabilities of newer radios. ~~It is important to allow older radios to continue to operate, while allowing newer radios to use both old and new capabilities.~~

}} TODO: must reconnect this paragraph with the rest of the section

}} Might be better placed in the introduction.

Following this philosophy, the next generation V2X (NGV) standard is being developed in IEEE P802.11bd to ensure backwards-compatibility and coexistence with current IEEE 802.11p devices, allowing seamless evolution in the same frequency channel. Specifically, when there are still some ITS devices in the vicinity supporting only current DSRC communication modes, all messages will be sent such that they can be received also by those devices. As soon as all ITS devices in the vicinity will support IEEE 802.11bd, they will communicate using the modern communication modes, enabling true evolution and thus providing certainty that current investments will still be operable in the future.

IEEE 802 recommends that the Commission continues to allocate ITS spectrum for current and backward compatible future generations of DSRC in order to enable improved efficiency and future innovation in the ITS band.

## Performance of DSRC

IEEE 802 disagrees with comments that~~dismissedaan technology or~~ imply that LTE V2X (Rel. 14) offers better performance solely based on the fact that LTE V2X was standardized at a later date than DSRC, e.g., [1, pages 2, 7], [2, page 2], and [3, pages 2, 3]. ~~To summarize the main arguments, LTE V2X Rel. 14 – despite a later standardization date – does not incorporate any of the key technologies that have improved physical-layer data rates in the recent years. Thus, in theory, the physical layer performance of LTE V2X is not better compared to DSRC, and in a number of practical tests, it was observed to be worse than DSRC [20, page 11], [21, minute 12]. Furthermore, the medium access mechanisms of DSRC still provide several key advantages over the medium access used in LTE V2X [19].~~

Regarding the physical layer performance, there is no reason to assume that LTE V2X is superior to DSRC. Both standards share common technologies such as OFDM waveforms and are subject to the same restrictions imposed by physical laws and high Doppler spreads in vehicular environments. In their default configurations, they use different parameter settings which may favor transmission range or spectral efficiency. However, when similar configuration parameters are chosen, the achievable physical layer performance of these technologies is inherently similar, at least in theory. In practice, a number of real-world field tests have shown that DSRC devices significantly outperformed LTE V2X devices. For example, u-blox found that a competitive DSRC device offers “significantly better performance under field trial conditions” than LTE V2X [20, p. 11]. Other sources also indicate that DSRC may offer superior physical layer performance compared to LTE V2X. For example, Cohda Wireless offers a DSRC on-board unit [18] that has almost 6 dB better receive sensitivity than their LTE V2X device [17]. Experiments conducted by NXP showed that DSRC covers an approximately 65% longer range than LTE V2X in a non-line-of-sight setting [21, at 12 minutes]. This performance advantage of DSRC on the physical layer – which exists despite the use of similar waveforms – is evidence of the maturity and market-readiness of DSRC. DSRC devices have been extensively deployed and tested in the field, which has allowed optimization of all relevant system parameters. More importantly, DSRC devices are available from multiple manufacturers, who have steadily improved their designs over the past years in a competitive free market environment.

Second, the physical layer of LTE V2X (Rel. 14) might soon be considered outdated. ~~Neither IEEE Std 802.11p nor~~ LTE V2X (Rel. 14) does not support advanced features such as higher-order modulation schemes (256-QAM) and multi-antenna operations for increased throughput (MIMO) that were the main driving factors for the massive increase in data rates in all wireless systems over the past years. Only the respective newer standards (IEEE P802.11bd and 5G NR V2X) will support these features. However, LTE V2X (Rel. 14) will not be able to evolve towards 5G NR V2X (Rel. 16) in the same frequency channels [add ref or refer to previous section] If the Commission were to allocate any spectrum to LTE V2X (Rel. 14), all devices operating in that spectrum would need to continue transmitting 4G-based signals, which might be considered outdated in the near future. On the other hand, IEEE P802.11bd is developing the next-generation V2X standard that will allow seamless evolution in the same frequency channel and will thus soon offer the benefits of new features for improved physical layer performance.

Regarding the performance of the medium access layer, IEEE 802 notes that while the strictly time-slotted medium access scheme of LTE V2X Release 14 might be efficient when all the messages are strictly periodic and of a particular size, many traffic-related messages are generated at non-periodic intervals (for example, due to congestion control, vehicle dynamics, or the asynchronous occurrence of critical events like hard-braking) and are of variable size. Due to the semi-persistent scheduling scheme of LTE V2X, such messages generated at random times can experience delays up to 100 milliseconds, which is significantly higher than the 2 milliseconds that can be observed for the vast majority of DSRC messages [19]. Furthermore, the resource allocation algorithm of LTE V2X is designed for packets of a particular size and is therefore not efficient for variable-size data. While Basic Safety Messages (BSMs) will contain basic fixed-size data like position and speed, there exists a large amount of variable-size data, for example the number of path history points and the size of the security overhead. For LTE V2X, a slight increase in message size can result in the need for an additional time slot having to be allocated which significantly decreases user efficiency and increases latency, both of which substantially degrade ITS safety and efficiency. Such a design could easily discourage the adoption of innovative new features that require the use of additional message data fields. In contrast, in extensive field trials and more recently in deployments of large numbers of DSRC devices, efficient channel access has been achieved under high load and with non-periodic and variable-size messages. Therefore, DSRC provides better latency performance and provides flexibility to support future innovations that require additional data fields.

}} .18 ad hoc 2020-04-03: Insert comment to reply to, e.g., any comment on future evolution and innovation, or any comment that claims LTE V2X is superior, or simply reply to IEEE 802 comments.

}} .18 ad hoc 2020-04-03: Might be difficult to get approved. Any factual statements on LTE V2X should be backed up by references.

## Deployments of DSRC

Some commenters have downplayed the extent of existing deployments of DSRC [1, pages 2], [3, pages 2, 3]. IEEE 802 notes that a significant number of DSRC deployments has been reached. Thighlight DSRC deployments and This includes that .

}} Exact comments: BMW [3], page 2: “Due to inherent technical limitations of DSRC technology, it has not achieved significant market deployment.” page 3: “Due to the lack of large-scale DSRC technology rollout over the past decade,”

}} Qualcomm [1], page 2: ”ever since the rules were adopted so long ago, only a few thousand cars with DSRC were ever sold”

## Obstacles to Market Adoption

Some commenters have also implied that the slow market adoption of DSRC technology was due to performance issues or that LTE V2X would achieve faster market adoption [1, pages 5], [3, pages 2]. IEEE 802 believes that the market adoption was delayed for a variety of other reasons, most importantly the lack of a mandate to deploy the technology. This “voluntary deployment scheme” suffers from the fact that individual customers experience little benefit until a high market penetration has been achieved. The US TAG TC204 [14] notes that "had the original NHTSA NPRM mandating V2V deployments in vehicles starting in 2019 been adopted, these deployments would have been much farther along". Furthermore, as noted by General Motors [15]: "Regrettably, the significant uncertainty of the rules created by ongoing FCC statements [...] have threatened any further deployments". These obstacles to market adoption apply to LTE V2X as well. There is no reason to assume that using a voluntary deployment scheme, LTE V2X would experience significantly improved deployment rates compared to DSRC technology. On the contrary, LTE V2X is not yet deployed, providing less incentive to customers, while DSRC is now reaching a significant number of deployments that provide a direct benefit to market adoption. In addition, any decision made by the Commission that allocates spectrum to LTE V2X in some parts of the ITS band will further contribute to the market uncertainty. As long as there is spectrum allocated to both technologies, automakers and truck manufacturers, along with providers of public infrastructure, as well as pedestrians and bicyclists, will remain uncertain about the future of ITS technology and might refrain from investments.

}} Exact comments: BMW [3], page 2: “Due to inherent technical limitations of DSRC technology, it has not achieved significant market deployment.”

}} Qualcomm [1]. Page 5: “C-V2X is on an accelerated timeline for deployment based on its cost-efficiency and a well-established upgrade path to 5G and future cellular technology generations.”

## Layer-2 Unicast Support

IEEE 802 disagrees with 5G Americas’s [6, page 5] assertion that 3GPP Release 14 LTE V2X supports a “richer range of services than is possible using DSRC”. DSRC supports every ITS service supported by Release 14 C-V2X sidelink. Moreover [7], DSRC supports a wide range of “advanced V2X” [8] services that 3GPP concedes Release 14 LTE V2X was never intended to support such as vehicle platooning and sensor data sharing. Furthermore, Release 14 LTE V2X uses only broadcast [24, p. 6], a native unicast capability on the medium access layer (layer 2). Even though LTE V2X Release 14 could implement unicast transmissions using protocols above layer 2, such an approach is not efficient, especially when it comes to acknowledgment messages, which would have significant delay and large packet size overhead due to higher-layer protocols. In contrast, the IEEE Std 802.11p medium access allows DSRC devices to respond to unicast message by sending an acknowledgment message within 32 microseconds with minimal packet sizes. Many ITS safety and efficiency services require direct unicast transmissions, for example, infrastructure-to-vehicle warnings (e.g. Wrong-Way Driving Alert [9]), communication to a V2X security credential management system (SCMS), and collection of probe vehicle data. These services will not be natively supported by the lower layers of LTE V2X, however, such services are natively supported by DSRC.

}} Need to fix references [7] and [8], or drop the sentence and mention vehicle platooning in the second-to-last sentence.

## Additional Services Enabled by Commercial Cellular Networks

Several commenters [1, pages 5-7] [2, page 3] [3, page 2]] suggest that an LTE V2X modem can provide cellular connectivity without the need for additional hardware resources, or even go further and imply that the benefits of providing cellular connectivity to vehicles can only accrue by allocating ITS spectrum specifically to LTE V2X. Both implications are inaccurate. First, any LTE V2X module used for ITS safety and efficiency services in ITS spectrum must be available for ITS services most of the time and would then not be available to provide connectivity to commercial cellular networks in a different band. Cellular connectivity will therefore require separate communication resources (i.e. different radios operating on different channels). Hence, the use of LTE V2X in the ITS band provides no advantages to cellular connectivity. Second, connectivity to a commercial cellular network is just as easily coupled with a DSRC communication module. In fact, all on board units deployed today have cellular interfaces in addition to DSRC modules operating in ITS spectrum and as such, are already utilizing the benefits of cellular connectivity for additional services that can tolerate the lower reliability and increased latency of commercial cellular networks. IEEE 802 acknowledges that these additional services can be highly valuable, and notes that cellular connectivity is unrelated to the technology choice for direct V2X communication in the ITS band to achieve traffic safety.

}} TODO: Insert Quote: In every implementation of LTE V2X, there is a cellular modem

}} .18 ad hoc 2020-04-03: Two different false claims are addressed: False claim 1: There is hardware synergy between cellular connectivity and LTE V2X (you only need to buy an LTE modem, you get LTE V2X for free). False claim 2: In order to allow additional services through cellular connectivity, there needs to be spectrum for LTE V2X in the 5.9 GHz band.

}} Qualcomm [1, page 5] states that “C-V2X technology will make roadway travel safer and more efficient because it provides vehicles, roadway users, and roadway operators a real-time picture of the traffic environment and path ahead due to the technology’s superior radio performance and ability to leverage commercial mobile network connectivity.”. Clearly, they are comparing (“superior”), so they are implicitly comparing LTE V2X to DSRC. No other way for me to read this statement as an implication that C-V2X can make use of cellular networks, whereas DSRC cannot. Furthermore, T-Mobile: “As T-Mobile explained, C-V2X technologies can leverage 5G wireless networks to increase road safety and facilitate America’s global leadership in connected cars.” Our text is already cautious enough, we state that this message is “implied”, and I think we can and should correct their false implications.

others wrote

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# Technology Choice

IEEE 802 believes that the criteria for permitting a given V2X technology to use the ITS band, whatever its eventual bandwidth, should be that the technology is:

* Fully standardized
* Proven through testing to work effectively
* Future-proof by maintaining backward compatibility, including compatibility with DSRC which already occupies the ITS band.

IEEE 802 disagrees with the 5GAA [10, page 45] that the Commission should exclusively designate the major share of the ITS spectrum to “5G-based” technology which is not ready for deployment, and which has not even seen significant field testing[[2]](#footnote-2). ~~that has not even completed the standardization phase, let alone any necessary steps for testing.~~ IEEE 802 also disagrees with 5GAA that the Commission should permit all 3GPP sidelink technologies and exclude all non-3GPP technologies [10, page 46]. 3GPP has standardized one V2X technology and is standardizing another (LTE V2X and 5G NR V2X, respectively). They do not coexist in the same channel as AT&T also has stated [11, pages 13 and 14], they are not backward compatible, and they lack interoperability. 5GAA’s request that these incompatible technologies be permitted to occupy the same channel is evidence of a lack of commitment to deploy LTE V2X. IEEE 802 believes the criteria for permission to use the band should not be based on the standards organization from which they emerge, but on the objective criteria listed above.

}} TODO: insert citation 5GAA roadmap for standardization of 5G NR V2X

# Implications of “Technology-Neutral” Approaches

IEEE 802 agrees with the following US DoT comments [12] regarding a so-called “technology-neutral” approach:

1. “… being technology-neutral is not the same as being outcome-neutral in determining the appropriate technology to be used for V2X communications, especially those related to critical safety-of-life applications. That is, the Department is supportive of any and all communication technologies that could be used for V2X, but these technologies must be proven to meet safety performance requirements before they can be deployed.”
2. “… the work done to develop DSRC under the existing allocation makes clear that moving from an idea to a band plan and technology suitable for safety-of-life communications is a complex process that takes considerable effort. These complications arise from both the unique aspects of V2X communications and the importance of having confidence that V2X technologies can perform critical safety-of-life applications without challenges from harmful interference, and with the assurance that priority is given to safety communications and that testing results show that all the technologies can actually co-exist within the band. These all underscore that V2X is complicated and that all of these factors must be addressed in any effective band plan.”
3. “… to achieve the reliable connectivity needed to enable safety-of-life communications, V2X must grapple with factors that are, in some respects, more complex than consumer electronic communications.”

IEEE 802 supports the concept of the technology selection process being based on fair scientific principles and extensive testing. IEEE 802 also believes that the Commission should keep existing rules that allow field testing of LTE V2X and in the future, also the more capable 5G NR V2X technologies, in order to allow a fair, scientific and objective performance evaluation. Nevertheless, IEEE 802 supports the concept that V2X is a safety of life system and not a commercial communications system. Hence all deployed devices in a V2X system must be able to communicate over the air using a single standardized protocol. If the Commission adopts a “technology-neutral” approach and allows vehicle manufacturers to choose between different technologies that are not interoperable, then the involved ITS devices will not be able to communicate with each other and ITS systems will fail to prevent collisions between them. Therefore, while IEEE 802 largely supports many of the comments made by AT&T [11], it disagrees with the suggestion to let the technologies “succeed or fail in the marketplace on the basis of their merits and other market factors”. IEEE 802 opposes the idea of allowing the use of different non-interoperable technologies in the ITS band, as it would take several more years until the markets decide on a preferred technology, with many preventable traffic collisions still occurring in all of those years. It may even take longer than that: when given the choice between two incompatible technologies, automakers also have the option to choose neither of those technologies and instead refrain from investments into a highly uncertain market altogether.

# Conclusion:

IEEE 802 believes that the Commission should not allocate ITS spectrum to LTE V2X / 3GPP technologies as they are neither future-proof nor the best technical choice for delivering ITS safety and efficiency services.

IEEE 802 thanks the Commission for providing an opportunity to comment on the NPRM ET Docket 19-138 and respectfully requests these reply comments be considered by the Commission during the final rule making process.

Regards,

By: /ss/ .

Paul Nikolich

IEEE 802 LAN/MAN Standards Committee Chairman

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**References:**

[1] Comments of Qualcomm, Inc., FCC ET Docket 19-138, March 9, 2020; <https://ecfsapi.fcc.gov/file/10309941330157/Qualcomm%20Comments%20on%205.9%20GHz%20NPRM.pdf>

[2] Comments of T-Mobile USA, Inc., FCC ET Docket 19-138, March 9, 2020; <https://ecfsapi.fcc.gov/file/1030957937118/T-Mobile%205.9%20GHz%20Comments%20(As-Filed)%203.9.20.pdf>

[3] Comments of The BMW Group, FCC ET Docket 19-138, March 9, 2020; <https://ecfsapi.fcc.gov/file/1031040719061/BMW%20Submission%20ET%20Docket%20No.%2019-138%20(003).pdf>

[4] Comments of the NTIA and DOT, FCC ET Docket 19-138, March 9, 2020;

[https://ecfsapi.fcc.gov/file/10313251510165/5.850-5.925 GHz Band C ET Dkt No. 19-138.pdf](https://ecfsapi.fcc.gov/file/10313251510165/5.850-5.925%20GHz%20Band%20C%20ET%20Dkt%20No.%2019-138.pdf)

[5] CV Pilot Deployments:

<https://www.its.dot.gov/pilots/index.htm>

<https://www.tampacvpilot.com/learn/resources/>

<https://www.its.dot.gov/pilots/pilots_nycdot.htm>

<https://wydotcvp.wyoroad.info/>

<https://smart.columbus.gov/uploadedFiles/Projects/Smart%20Columbus%20Concept%20of%20Operations-%20Connected%20Vehicle%20Environment.pdf>

[6] Comments of 5G Americas, FCC ET Docket 19-138, March 9, 2020; <https://ecfsapi.fcc.gov/file/1030957873656/5G%20Americas%205.9%20GHz%20Comments%203.9.20%20FINAL.pdf>

[7] 3GPP, “Overall description for RAN aspects for V2X based on LTE and NR (Release 16)”, 3GPP TR 37.985, v1.1.0, February 2020, Section 4; <https://www.3gpp.org/ftp/Specs/archive/37_series/37.985/37985-110.zip>

[8] 3GPP, “Overall description of Radio Access Network (RAN) aspects for Vehicle-to-everything (V2X) based on LTE and NR (Release 16)”, 3GPP TR 37.985 v1.1.0, February 2020; <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3601>

[9] SAE, “Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for SAE J2945/X Documents and Common Design Concepts”, SAE J2945\_201712, December 2017; <https://www.sae.org/standards/content/j2945_201712/>

[10] Comments of 5G Automotive Association, FCC Docket 19-138, March 9, 2020; <https://ecfsapi.fcc.gov/file/10309096401111/5GAA%20Comments%20(3-9-2020).pdf>

[11] Comments of AT&T, FCC ET Docket No. 19-138, March 9, 2020; <https://ecfsapi.fcc.gov/file/1030982287529/ATT%20Comments%20(final%2003.09.20).pdf>

[12] the March 9, 2020 letter to The Honorable Ajit Pai Re: Use of the 5.850-5.925 GHz Band ET Docket No. 19-138; FCC 19-129; FRS 16447 85 Fed. Reg. 6841 (Feb. 6, 2020); ([https://ecfsapi.fcc.gov/file/10313251510165/5.850-5.925 GHz Band C ET Dkt No. 19-138.pdf](https://ecfsapi.fcc.gov/file/10313251510165/5.850-5.925%20GHz%20Band%2C%20ET%20Dkt%20No.%2019-138.pdf))

[13] Momar D. Seck and David D. Evans, “Major U.S. Cities Using National Standard Fire Hydrants, One Century After the Great Baltimore Fire” NISTIR 7158, NIST, <https://www.govinfo.gov/content/pkg/GOVPUB-C13-c33f9384233e5a13eca491ede462acdf/pdf/GOVPUB-C13-c33f9384233e5a13eca491ede462acdf.pdf>

[14] Comments of US Technical Advisory Group to ISO/TC 204 Intelligent Transport Systems, March 9, 2020 <https://ecfsapi.fcc.gov/file/10310066302855/USTAG%20TC204%20Comments%20on%20FCC%20NPRM%2019-138%202020-03-09.pdf>

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<https://ecfsapi.fcc.gov/file/103102450728782/3-09-20%20GM%20FINAL.pdf>

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1. This document solely represents the views of the IEEE 802 LAN/MAN Standards Committee and does not necessarily represent a position of either the IEEE, the IEEE Standards Association or IEEE Technical Activities. [↑](#footnote-ref-1)
2. While there are initial deployments of 5G-based cellular technology, the 5G-based NR V2X technology is not yet market-ready. [↑](#footnote-ref-2)