**Before the
US Department of Transportation**

**Washington, D.C. 20554**

In the Matter of

V2X Communications -” Notice of Request for Comments (RFC)”;

Docket No. DOT-OST-2018-0210

To:

Mr. Finch Fulton

Deputy Assistant Secretary for Transportation Policy Office of the Secretary (OST)

U.S. Department of Transportation (DOT)

1200 New Jersey Avenue S.E.

Washington, DC 20590

**COMMENTS OF IEEE 802**

Paul Nikolich

Chair, IEEE 802 LAN/MAN Standards Committee

em: IEEE802radioreg@ieee.org

[Month, Day, Year filed]

1. Introduction

IEEE 802 LAN/MAN Standards Committee (LMSC) is pleased to provide comments in the above-captioned proceeding.

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 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)

1. Answers to questions asked in the Request for Comments
2. Please provide information on what existing or future technologies could be used for V2X communications, including, but not limited to, DSRC, LTE C-V2X and 5G New Radio. What are the advantages and disadvantages of each technology? What is the timeframe for deployment of technologies not yet in production? Please provide data supporting your position.

Response:

* proposed outline:
* 4 known technologies: DSRC, LTE V2X, NR V2X, IEEE NGV
* Summarize status (mature/deployed, in testing, in standardization, etc.)
* \*\*Most important point\*\*  DSRC is the incumbent and is in deployment, so consideration of any non-DSRC technology is by definition a question of evolution from DSRC.  For that reason, when answering USDOT questions about the technologies it is critical to consider the relationship between DSRC and the three non-DSRC technologies (not just head-to-head comparisons)
* Use agreed TGbd definitions of interoperability, coexistence, and ~~backward~~ compatibility.
* Summarize relationships as: LTE V2X and NR V2X have none of those three qualities with respect to DSRC, while IEEE NGV has all three
* There could also be comments about head-to-head comparison of technologies. Example: DSRC meets requirements of all known 5.9 GHz use cases.
Example: Counter some claims of C-V2X superior performance (e.g. borrow from NXP, Autotalks, U-blox comments on 5GAA waiver)
Example: cite ABI Research study that concluded DSRC has cost advantage over LTE V2X
* A central point for me is that DSRC/NGV represents an interoperable family that can be deployed throughout the band with no fragmentation (avoiding costs and inefficiencies). Thus, the development of NGV protects and enhances investments today, which is what we most need. By comparison the lack of interop/coex/back compatibility represented by C-V2X means we won't all be able to communicate, which is disruptive of current deployments, costly (if need multiple radios), spectrally inefficient (due to duplication of services), and reduces the incentive to deploy anything. However, this point may be better made as part of Michael's answer to Q2 - though some overlap between Q1 and Q2 answers is not too bad
	+ Look at 18-18-0159r6; pull section 3 and update for this. (includes PAR info)
1. Of the V2X communications technologies previously discussed, at present only DSRC is permitted to be used in the 5.9 GHz spectrum band for transportation applications. If that allocation were to be changed to allow any communication technology for transportation applications, could DSRC and other technologies (*e.g.*, C-V2X, 5G or any future technology) operate in the same spectrum band or even the same channel without interference? Why or why not? If there are any technical challenges to achieving this goal, what are they and how can they be overcome?

Draft Response:

It is only feasible for technologies other than DSRC to operate the 5.9 GHz spectrum without destructive interference and impairment of the safety functions if the other technologies are required to provide interoperability, coexistence, compatibility, and fairness with DSRC. Because the medium access control and physical layers of DSRC are defined in the IEEE 802.11p standard, the functional definitions of these terms are as follows: Interoperability means the ability of the DSRC (IEEE 802.11p) devices to decode at least one mode of transmission by the other technology devices and of the other technology devices to decode IEEE 802.11p transmissions. Coexistence means the ability of the other technology devices to detect and defer to transmissions by DSRC (IEEE 802.11p) devices to avoid collisions, and vice versa. Compatibility means the ability of the other technology devices to operate in a mode that can exchange messages with DSRC devices. Fairness means that DSRC devices and other technology devices have the same opportunities to access the assigned channel of the wireless medium for safety comunications. The other technologies which have been proposed for use in the 5.9GHz spectrum, including C-V2X and 5G, meet **none** of these requirements, hence are unable to operate without exclusion of, or serious impairment to, DSRC communication. However, the IEEE 802.11 Working Group is currently developing its NGV (Next-Generation V2X) amendment (IEEE P802.11bd) that will fulfil **all** of these criteria for usage in conjunction with DSRC. Indeed, the scope statement for the P802.11bd amendment includes these specific requirements:

“This amendment shall provide interoperability, coexistence, backward compatibility, and fairness with deployed OCB (Outside the Context of a BSS) devices.” [Project Authorization Request P802.11bd (“Enhancements for Next Generation V2X”), approved 5 December 2018, which can be found at <https://development.standards.ieee.org/get-file/P802.11bd.pdf?t=99204200003>.]

The term “OCB” was introduced in the IEEE 802.11p amendment which specified “Wireless Access in Vehicular Environments” and is used within the IEEE 802.11 standard to refer to the medium access control and physical layer facilities used for DSRC.

In January 2019 the IEEE P802.11 Working Group affirmed these definitions by a unanimous (44-0) vote:

* **Interoperability** – IEEE 802.11p devices to be able to decode at least one mode of transmission of IEEE 802.11bd devices, and IEEE 802.11bd devices to be able to decode IEEE 802.11p transmissions
* **Co-existence** – IEEE 802.11p devices to be able to detect IEEE 802.11bd transmissions (and hence defer from transmissions during IEEE 802.11bd transmissions causing collisions) and vice versa
* **Backward compatibility** – Ability of IEEE 802.11bd devices to operate in a mode in which they can interoperate with IEEE 802.11p devices
* **Fairness** – Ability of IEEE 802.11p devices to have the same opportunities as IEEE 802.11bd devices to access the channel
[”TGbd agreed terminology and requirements”, January 17, 2019, IEEE 802.11 document 11-19-0202r1, which can be found at <https://mentor.ieee.org/802.11/dcn/19/11-19-0202-01-00bd-tgbd-definitions-and-requirements.pptx>.]

Because 802.11bd devices will provide interoperability, coexistence, compatibility, and fairness with 802.11p (DSRC) devices, not only in the same frequency band but also in the same channel, 802.11bd can be introduced with no band fragmentation and no loss of DSRC services. The Society of Automotive Engineers (SAE) DSRC Technical Committee recently communicated to the IEEE 802.11 NGV Task Group to state that the combination of a capability for interoperability and fair, same-channel coexistence “form the basis for a seamless evolution strategy from IEEE 802.11p [DSRC] to IEEE 802.11 NGV and beyond.”
[SAE DSRC Technical Committee, “Response to IEEE 802.11 Next Generation V2X Study Group (NGV SG) Liaison Request”, November 28, 2018, IEEE 802.11 document 11-18-2097r0, which can be found at <https://mentor.ieee.org/802.11/dcn/18/11-18-2097-00-0000-2018-12-liaison-from-sae-dsrc-tc-re-ngv-use-cases-and-requirements.docx>.]

* + Look at 18-18-0159r6; pull section 2 or 3 and update for this
	+ Safety msgs available to all..
	+ 11-18/1323r2, page 5; see what we can pull into here.
	+ 11-19/0202r1 is the **updated 1323r2** and approved by the WG 44/0; refer to this one.
1. To what extent is it technically feasible for multiple V2X communications technologies and protocols to be interoperable with one another? Why or why not? Can this be done in a way that meets the performance requirements for safety of life applications, as they were discussed in the V2V NPRM? What additional equipment would be needed to achieve interoperability or changes in standards and specifications? What is the projected cost of any necessary changes? How soon can these changes and equipment prototypes be available for testing?

Draft Response:

Interoperability between multiple V2X communications protocols are only feasible if the newer ones of the protocols are specifically architected to provide such interoperability, which requires the newer/secondary protocol(s) to include a mandatory operating mode to transmit and receive messages that can be decoded by the older/primary protocol(s) as well as a mechanism by which the protocol capabilities of the various devices within communication range can be determined. Without this degree of protocol interoperability, multiple V2X technologies can, at best, only achieve coexistence (where transmissions by the two protocols do not collide which each other). Achieving said coexistence requires equipping each vehicle with two (or more) radios, which increases cost, and may reduce reliability. Furthermore, a requirement for multiple radios would impair the safety of life applications by reducing the adoption of V2X technologies by the transportation industry.

Because the medium access control and physical layers of DSRC are defined in the IEEE 802.11p standard, any other V2X technology needs to be interoperable with IEEE 802.11p. The IEEE 802.11 Working Group is currently developing its NGV (Next-Generation V2X) amendment (IEEE P802.11bd) that is specifically designed to provide the required interoperability with IEEE 802.11p, along with coexistence, backward compatibility, and fairness. Accordingly, IEEE 802.11bd is the one V2X technology that can be deployed as an enhancement to DSRC.

* + NGV has started, that is all we can say for now. cost of going to next evolution 11p and NGV will be lower with the backward compatibility .
		- We want to stress the interoperable with all and backward compatibility is needed.
		- get definitions of these from NGV
	+ no formal reply comments, so could do an ex parte, to respond to other companies/orgs comments.
	+ there is still the rule process that will be another round of comments.
	+ cross technologies focus
1. To what extent is it technically feasible for different generations of the same V2X communications technologies and protocols to be interoperable with one another? Why or why not? Can this be done in a way that meets the performance requirements for safety of life applications? What additional equipment or changes in standards and specifications would be needed to achieve interoperability? What is the projected cost of any necessary changes?

Draft Response:

As is typical for 802.11 generations, 802.11bd data rates will be a superset of the existing 802.11p data rates. As such, in all scenarios the previous generation can communicate with later generation of devices. For the case of the later generation communicating with the previous generation, this is a decision made by the device on a packet by packet basis. The expectation is that the application will take this architecture in consideration when it is designed. Applications can be designed to fully interoperate at all times, they can be designed to only interoperate with a later generation, or they can be designed to selectively choose the rate based on various input. One such input has already been designed by the 802.11bd task group and allows any later generation device to be informed about the generational capabilities of the nearby vehicle population.

IEEE 802.11bd will have these intergenerational interoperability capabilities available for use by upper layer applications including safety of life applications. At a minimum, the 802.11p rates which continue to form a subset of 802.11bd, and have proven to meet the requirements of current safety of life applications, will continue to be available. The addition of later generation 802.11bd rates will only improve performance. Performance improvement is already being studied in two different dimensions. First is longer range to increase the distance at which data can be sent, and second is increased robustness to things like higher vehicle speed and non-line-of-sight reflections.

There should be no incremental cost to add interoperability to the later generation 802.11bd because by definition the later generation is a superset of the data-rates and technology in the 802.11p standard. There may be small adjustments to the application layer standards to take advantage of both new rates, and interoperability features. This could be as simple as specifying a certain data transmission rate for a certain application (which is already done by SAE J2945/1 for example), or it could involve more complicated designs that take advantage of the wider range of data-rates and MCS (modulation and coding schemes) available in 802.11bd.

* + compared to above, adjust answers.
	+ ~~are there any other generations out their, maybe not?~~
1. Even if they are interoperable across different technologies and generations of the same technology, would there be advantages if a single communications protocol were to be used for V2V safety communications? What about other V2X safety applications, such as those involving V2I and V2P communications?

Response:

* + yes.
	+ it seems is it too late for V2V, but open to V2I/V2P?
	+ how do they define V2I and V2P? These are much more complex.
		- V2I has many applications, how to differentiate
		- PHY and MAC maybe the same, the application layer is where they digress.
			* though depending on functionality could a different PHY provide an enhanced service. more discussion/ may be early on this yet. e.g. data needed and latency differences
		- V2P – when will mobile devices have 11p/NGV
	+ could they be looking at a single tech. for safety and then maybe multiple tech. for non-safety?
	+ so can it be interoperable and still advance the functionality and safety… it is a goal of NGV.
		- 11-18/1323r2, page 5; see what we can pull into here.
	+ privacy and security has to be considered, over time. this is an eternal process over time
1. How would the development of alternative communication technologies affect other V2I and V2P communications, such as those supporting mobility or environmental applications? Do these applications have the same or different interoperability issues as V2V safety communications? Do different V2X applications (e.g., platooning) have different communication needs, particularly latency?

Response:

* + - should keep all 3 we should have in the same systems/network.
		- should not expect latency differences between these.
		- do we pull in other transportation, e.g. rail?
		- BW, latency(DSRC s better than other technologies) and reliability all translate into what can be done for platooning.
1. Do different communication technologies present different issues concerning physical security (i.e., how to integrate alternative communication technologies into vehicle systems), message security (i.e., SCMS design or other approaches), or other issues such as cybersecurity or privacy? Would these concerns be affected if multiple but still interoperable communication technologies are used rather than one?

Draft Response:

Systems that involve infrastructureless direct communication such as 802.11p and 802.11bd as well as the 3GPP LTE PC5 mode 4 operating in the 5.9GHz band are typically designed with the same SCMS system which provides message authenticity. One could refer to the work projects going on in IEEE 1609.2c on the device interfaces to the SCMS and IEEE 1609.2.1 on the SCMS design. The security model of infrastructure-based systems, whether they use IEEE 802.11 (Wi-FiTM) based on association with an AP in license-exempt spectrum, or whether they use a 3GPP cellular subscription with an operator in licensed spectrum, is completely different. In an infrastructure system subscriber identity is tracked not just at the point of authentication, but throughout the communication session. In the infrastructureless design, the SCMS provides pseudonym certificates, identities are short lived and not tied to a person or vehicle. In the infrastructureless SCMS design, security is provided at the application layer, for example the Basic Safety Message (BSM) uses a different type of certificate than V2I messages. One could expect that new and different applications would introduce new and different security models possibly requiring new and different certificate types. This is tied more to the application than the underlying radio, be in different generations of the same technology, or orthogonal technologies. The main difference is whether the system is infrastructureless or using infrastructure.

* + yes, ……….
	+ if different vehicles have different tech can ID them, so not as private.
	+ borders need to considered also.
1. How could communications technologies (DSRC, C-V2X, 5G or some other technology) be leveraged to support current and emerging automated vehicle applications? Will different communication technologies be used in different ways? How?

Response:

* + there are automated applications being standardized to operate over DSRC and NGV. SAE and ETSI. there is growth path with DSRC/NGV to enhance existing and future applications. >> this is more than just for automated applications. be sure it is covered in the other questions where appropriate.
	+ no comment on 2nd question
1. How could deployments, both existing and planned, assess communications needs and determine which technologies are most appropriate and whether and how interoperability could be achieved?

Draft Response:

There are two requirements for deployment of an interoperable technology with enhanced capabilities, relative to 802.11p/DSRC. The first is the ability of the enhanced technology stations to transmit and receive 802.11p frames so that they can communicate directly with the stations which only support 802.11p/DSRC. The second is for the enhanced communication protocol to include a means by which the enhanced stations can detect and distinguish the capabilities of the other stations in their vicinity. If these requirements are met, as they will be for IEEE 802.11bd, there is full interoperability, and the decisions regarding the most appropriate technologies can be made dynamically by each transmitting station, based on the capabilities of the intended recipient station(s) and the population of other nearby stations.

* + assess communications needs 🡪 needs in 2025?
	+ automous vehicles will tremendous amount of data in the future, how will that be handles along with safety message.
	+ capability indications on who is in the neighborhood and how to communicate with them. this works best if on same channels and protocol, etc., e.g. NGV has.
1. Conclusion

IEEE 802 LMSC would like to thank the US Department of Transportation for the opportunity to respond to their consultation on V2X.

Regards,

By: \_\_\_\_

Paul Nikolich

IEEE 802 LAN/MAN Standards Committee Chairman

em: IEEE802radioreg@ieee.org

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)