February 25, 2019

Mr. Finch Fulton
Deputy Assistant Secretary for Transportation Policy
U.S. Department of Transportation
1200 New Jersey Avenue SE
Washington, DC 20590-0001

RE: Docket No. DOT-OST-2018-0210 – V2X Communications

Dear Deputy Assistant Secretary Fulton:

Thank you for this opportunity to comment on developments in V2X communications and the Department of Transportation's role in encouraging the integration of V2X. NXP Semiconductors is the world's largest semiconductor supplier to the automotive industry and is the global leader in automotive chipsets that enable Intelligent Traffic Systems ("ITS") through Dedicated Short Range Communications ("DSRC") technology.[1] Because of our long history supplying technology to the automotive market, we believe our perspective regarding the specific requirements and constraints of technology utilized in automotive applications can be useful to the Department.

Executive summary

DSRC is the only proven and mature technology available today for ITS applications. Alternative technologies, such as LTE-V2X, are immature and still require much testing while offering no significant incremental benefits. Adopting an immature and untested technology will be a step back in the ongoing deployment of V2X in the market.

Interoperability is crucial for the realization of the first wave of ITS applications. Permitting multiple competing technologies for the same application inhibits interoperability, frustrating the most fundamental purpose of ITS—for vehicles to be able to communicate with each other with the goal of saving lives and preventing property damage by avoiding accidents. There are

[1] NXP Semiconductors, a combination of the former semiconductor divisions of Philips and Motorola, is a semiconductor company with significant operations in the United States, Europe and Asia, built on more than 60 years of combined experience and expertise. NXP has design, research and development, manufacturing and sales operations in the United States, where we employ approximately 5,000 people. NXP owns and operates three semiconductor wafer fabrication facilities in the US, two of which are in Austin, Texas, with a third facility in Chandler, Arizona. The representative products of these fabs include microcontrollers (MCUs) and microprocessors (MPUs), power management devices, RF transceivers and amplifiers, and sensors. NXP, working with partners, is a proud industry technology sponsor supporting the US Department of Transportation Smart City Challenge.

currently no realistic options to enable interoperability between competing ITS communication technologies.

NXP suggests that the use of DSRC in 5.9GHz, complemented by regular 4G (and in the future 5G) cellular long-range communication in commercial bands for less time- and availability-critical use cases, offers the best strategy to support various ITS applications for the foreseeable future. Longer term, this will be further extended for high-bandwidth, low-latency use cases by standards currently being defined for use in the 60 GHz ITS spectrum.

The industry interests to develop ITS as a complete system including all required complementary services are dispersed over various weakly-connected stake holders (for example automotive manufacturers, road infrastructure manufacturers, governments). There may be benefit in support for an active program to investigate and remove any remaining obstacles to launching ITS in the market, as for example in the design of the PKI/certificate management system.

At present, there is no collaborative path forward on the part of all industry stakeholders aimed at launching a holistic ITS system. As such, NXP believes there may be a benefit to establishing an overarching ITS enablement initiative, aimed at overcoming inertia to ultimately stand up a fully-fledged ITS ecosystem.

General Comments

We believe that a continued focus on DSRC as the primary means of V2V communications is still the appropriate strategy. As noted in the Department's Notice of Request for Comment, significant commitments to DSRC-based V2X deployment have been announced by major automotive OEMs, and we perceive the current development of DSRC as reasonable given the relatively long lead times in introducing new technology in the automotive industry (see Annex 2, section IV.E). NXP also believes that allowing multiple competing technologies for short-range V2X communication addressing the same applications is inappropriate and should be reconsidered. We offer the following information to support this:

1. Short range V2X communication requires an interoperable technology to achieve the required informational exchange on which all ITS applications are built. We refer to the attached Annex 2, Section II.
2. Alternative technologies, as LTE-V2X, are immature and still require much testing (Annex 2, section IV.A) while offering no significant incremental benefits. Adopting an immature and untested technology will be a step back in the ongoing deployment of V2X in the market.
3. 5G technology in general holds significant potential. Nevertheless, 5G-V2X is undefined as to date and will not be compatible with LTE-V2X that is promoted today.

NXP respectfully suggests that long range (5G) Uu cellphone technology can offer complementary long-range communication functions, which can augment short-range V2X communication based on DSRC.

Specific Comments

1. ***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.***

In the view of NXP, the best candidate for V2X (and especially V2V) communications remains DSRC, based on IEEE802.11p. DSRC is a currently existing and exhaustively tested technology, with ample implementations available, and proven to fulfill the requirements especially for safety-critical V2V applications.

IEEE802.11 has a continuous V2X roadmap, whereby the current IEEE802.11p standard will be extended for future use in a backwards interoperable way (IEEE802.11bd task group in progress, sometimes referred to as NGV). Backwards compatibility is essential, to ensure that legacy DSRC devices based on IEEE802.11p will be able to exchange information with newer devices based on IEEE802.11bd). IEEE802.11bd will most likely re-use some advanced modulation techniques that have already been implemented, tested and validated in recent IEEE802.11 variants like IEEE802.11n or ac.

Another group of communication protocols was developed recently by 3GPP and mainly targets cellular applications, with standards such as 4G LTE or 5G NR (New Radio). From 4G LTE, a V2X access layer was derived, called LTE-V2X and a similar re-use of 5G for V2X application is under discussion.

It should be noted that the term 'C-V2X' is a technically incorrect term. Rather, C-V2X is a marketing term that gathers 4G LTE-V2X (sidelink mode 3 or mode 4 or LTE Uu) under 3GPP Release-14 (Rel-14) or Release-15 (Rel-15), and upcoming (but not yet standardized) 5G-V2X, although these are often used interchangeably. We therefore recommend to avoid the usage of the broader term "C-V2X", and instead employ the term "LTE-V2X" as referring to 3GPP Rel-14 and 3GPP Rel-15. 5G-V2X is currently still undefined, and will very likely be incompatible with LTE-V2X.

The technical advantage of LTE-V2X Rel-14 is unclear as the standard is immature, and the technology does not offer benefits over DSRC in terms of performance and cost-efficiency. Deployment and field testing of LTE-V2X is in a premature state, and would take several years to get to the current deployment availability level as DSRC.

5G V2X standardization effort has started but, importantly, 5G V2X is not a continuation of LTE-V2X, with no backwards compatibility path due to different waveform encoding structures. 5G V2X will be a completely new standard.

Permitting both DSRC and LTE-V2X to compete on the market will create two non-interoperable sets of cars in a domain where interoperability is key for achieving the traffic safety goals for the system. This consideration of interoperability was a fundamental consideration in the original assignment of the DSRC standard for ITS applications in the 5.9GHz band by the FCC and this very straightforward argument remains equally valid today.

LTE (4G) and 5G cellular communication (not V2X) are best adapted to long-distance communication traffic management tasks tolerating higher latency, such as traffic flow control and fleet/platoon management. We believe the ideal ITS system would be a hybrid approach where DSRC manages the communications it handles more effectively than other solutions (short-range, low latency tasks such as emergency braking and other safety functions) complemented by LTE (and ultimately 5G) for long-distance communications. Such a hybrid system would offer redundancy without requiring competition for the same frequency resources.

Further ahead, the need for new use cases with high bandwidth low-latency V2V is also expected (real-time sensor sharing/cooperative perception, video see-through etc.). For this, significant bandwidth is required, and is not easily available with either of the current systems. Short range communication in the 60 GHz ITS band reservation would serve best for these applications.

2. 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?

Same-band, different-channel coexistence is technically possible as long at the inter-channel interferences are well regulated. Power leakage of one channel technology to an adjacent channel could severely degrade the victim channel, especially if the victim is based on a gentle listen-before-talk CSMA type of channel access, interpreting leakage as real messages in the band.

However, splitting the band in channels per technology will reduce the spectral efficiency, while bringing in no additional benefits. In the worst case there could be two distinct groups of stations, incapable of exchanging messages to the other group, which goes against the cooperativeness concept of ITS ('blue cars vs red cars'). Also, such a fragmentation could only accommodate a finite number of technologies, and thus block access to potential future new technology.

As a reference point, this topic of same-band, different-channel coexistence has been studied by European ETSI ERM/ITS for the European 5.9 GHz ITS band. ETSI TC-ERM has a report describing multiple ways to achieve coexistence[2]. However, there is no consensus method, and discussions on feasibility are still ongoing.

Same-channel coexistence is in principle technically possible and has some advantages over simple "band split approaches", however a defined approach to access the common channel must be

[2] ERMTG37(18)000072r1, https://docbox.etsi.org/ERM/ERMTG37/05-CONTRIBUTIONS/2018/ERMTG37(18)000072r1_Road_ITS_coexistence_study.docx

agreed and a number of fairness rules have to be clearly established from the start which normally requires novel technologies to integrate the incumbent technology access-layer. For example, in order to have LTE-V2X deployed in the same channel as DSRC, one would need to add the DSRC CSMA channel sensing methods, metrics, and access scheme to LTE-V2X. The previously mentioned report of ETSI TC-ERM[2] also describes possible methods for this, such as section 4.2.2.4 "Coexistence between Road-ITS Systems using header insertion". This type of solution has been implemented by 3GPP for LAA (License Assisted Access) coexistence with WiFi in the 5GHz band, showing cellular standards are technically able to comply with this. However, 3GPP seems reluctant to make similar changes in the LTE-V2X communication standard.

Fairness in channel access between the different technology should be guaranteed. This should ensure the partitioning of the channel between the technologies remains fair and dynamic, reflecting the real usage of the channel. The mentioned report of ETSI TC-ERM[2] describes possible methods for this, see ETSI report Annex B.4 "Fair dynamic temporal partitioning".

3. 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?

At access layer (radio), interoperability is not feasible between different technologies, as waveform data encoding is incompatible. C-V2X systems will not be able to receive DSCR messages and vice versa.

At upper protocol level (i.e. above the access layer) interoperability is possible. For example, the definition and formatting of the BSM messages can be kept identical for various access layer technologies.

However, for full system interoperability this would then require every car to be equipped with multiple access layer technologies (for reception, transmission, or both) where the data would be combined at the higher layers. This will increase cost and increase development/testing time and defeats the original interoperability purpose since both technologies would have to be supported by all cars. Alternatively, it has been suggested in ETSI studies that transcoding could be done by infrastructure, but would require an unrealistic investment for the foreseeable future as this would require nation-wide network/infrastructure coverage for both standards.

Furthermore, both dual transmission formats in stations as well as infrastructure-based transcoding require twice the amount of spectrum since all messages need to be transmitted in both formats.

In Europe, ETSI has a draft technical report defining multiple ways to achieve interoperability (ETSI TR 103 576-2[3]) as mentioned above. The outcome of this draft report is that there is no clear conclusion. The problem remains essentially unresolved.

4. 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?

Interoperability for different generation is possible, if taken into account in the design right from the start. For example, see the backwards compatibility requirements expressed at IEEE802.11bd standardization group, where 802.11bd messages aim to be backwards compatible and decodable by legacy IEEE802.11p stations: see Annex 1.

However, 3GPP has a history of non-interoperable generations of wireless standards. 3G was not interoperable with 4G, and 4G V2X will not be interoperable with 5G V2X. Moreover, the multiple-users access scheme and synchronous nature of the 3GPP networks, organized based on fixed time slots makes it hard to mix different generations that may have different subframes times. This incompatibility choice is completely justified in the cellphone world where the cellphone infrastructure can adapt to the protocol option in the mobile station and the radio connection is always mobile to base-station, but it is not suitable for a peer to peer network where all stations have to be able to directly communicate, especially in a market where station life (cars) is very long.

Instead, WiFi (IEEE 802.11) defines a more futureproof framework, based on an asynchronous network topology and a simpler scheme where only message user occupies the channel at a time, make interoperability between successive generations of standards a much simpler challenge.

5. 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?

[3] ETSI technical report TR 103 576-2, Pre-standardization study on ITS architecture; Part 2: Interoperability among heterogeneous ITS systems and backward compatibility

Usage of a single technology, or family of technologies that provides interoperability between different standards generation (IEEE802.11) would provide significant benefits. Such benefits were also recognized in the original FCC rulemaking for ITS[4]:

- Ensures interoperability allows the exchange of messages between all traffic participants and infrastructure, which is essential to achieving V2V and V2I safety applications. Any additional technology should be complementary, not an alternative to this single short-range technology.
- Having one technology in place eliminates the need to transmit the same message in multiple formats (for example at least DSRC and LTE-V2X), and is therefore significantly more efficient in terms of spectrum usage (as compared to two competing systems), which is especially important in light of the limited 5.9 GHz ITS band.
- Lower the amount of investment and test time for all industry participants and accelerate the technology penetration.
- Creates a unified market message to all participants; something which is vital for ITS to be able to succeed.

We do not see a specific reason for a separate technology for vulnerable road users such as pedestrians. For pedestrian V2P type of applications, DSRC IEEE802.11p is also well-suited, as was previously demonstrated by Qualcomm and Honda[5].

For those V2I type of applications where latency is less of an issue, a more classical cellular pipe ("Uu" link), for example in the licensed 2-4 GHz bands is an option. This could be used in a hybrid setup using DSRC for short-range short-latency link, and 5G (initially LTE) for the long-distance link, as explained in question 8. Having such a hybrid system would also potentially offer redundancy, instead of competing for the same frequency resources. Note however that this does require a subscription to a cellphone service for the vehicle or station involved as well as an additional subscription to a ITS-cloud service; both of which would be commercial services. This is less desirable for safety type applications.

6. 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?

Different applications have significant different latency requirements (even depending on the various data types per application). For example, vehicle platooning has relaxed latency

[4] *See Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band (5.9 GHz Band)*, et al., Report and Order, 19 FCC Rcd 2458 (2003) ("Report and Order"), paras. 11-22.

[5] https://www.qualcomm.com/news/onq/2015/06/16/how-snapdragon-and-honda-are-working-save-lives-smartphones; http://cvt-project.ir/Admin/Files/eventAttachments/QCom-Honda-paper-2014-Cars%20Talk%20to%20Phones_625.pdf; http://news.honda.com/newsandviews/article.aspx?id=7352-en

requirements for platoon forming (order of seconds or larger), making classical or 5G cellular cloud communication systems a possible candidate. However, once platooning is active, in order to maintain platoon stability and safety the latency requirements become much stricter (below 100 ms), and operation in the 5.9 GHz direct V2V communication with a low-latency technology such as DSRC would likely be a requirement. For some applications latency requirement can be more relaxed, and range and infrastructure coverage requirements can be extended. This permits the *complementary* use of long range (4G or 5G) communication as a (paid-for) option.

7. 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?

Wireless communication technologies as such do not directly imply security methodologies, instead this is mainly determined by the application requirements. For V2X application stacks such as DSRC, security is not handled inside the access layer(s), but in the layers above. The requirements for an SCMS design should not essentially differ for different short-range peer-to-peer communication technologies. Message security requirements can be different between short range peer-to-peer and long-range point-to-point communication technologies.

Having said this, specific system implementations do have specific risks. For example, a cellular system (being centralized) has the potential of higher privacy risks than localized distributed systems because data is distributed over a larger geographical area and more attack surfaces are available such as back-end offices and Mobile Edge Computing nodes. Increased attack surfaces (and commensurate greater security risk) may also occur if multiple, interoperable communication technologies are used, depending on the interoperability methodologies employed.

8. 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?

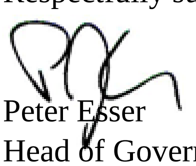
V2X is an integral part of the autonomous driving ecosystem. V2X complements the other sensors of autonomous cars (radar, lidar, camera etc.) especially by its non-line-of-sight capabilities, and provides additional and different information. V2X typically provides information (GPS coordinates, speed, headings, etc.) of the other vehicles in the surrounding environment, which is extremely relevant information that other sensors may not be capable of delivering, for example allowing to “see around corners” or past trucks, not possible from camera/lidar/radar. Also, V2X can be used to further relay information (for example a road incident). Additionally, new emerging functionalities of V2X such as Collective Perception would allow using V2X not only as a sensor, but also as a pipe for exchanging the other sensors’ info. For example, a car equipped with sophisticated camera detection can identify a pedestrian crossing the road and transmit this information via V2X to the surrounding cars.

We believe that it is helpful to distinguish between short- and long-distance communication needs as well as low data rate and high data rate needs. Such a ‘hybrid approach’ is also proposed in the European legislative ‘Delegated Act on ITS’ currently handled in the European parliament.[6] For long distance communication, 5G is the expected technology to address these applications over the long term, with cellular 4G LTE Uu operation filling the gap for the time being, at least for use cases accepting higher latency and/or lack of coverage. Long-distance communication is applicable for traffic management tasks tolerating higher latency, such as traffic flow control and fleet/platoon management. Short-distance communication is required for direct, low-latency interaction between neighboring cars, (e.g. safety use cases such as Electronic Emergency Brake) and for cooperative actions as required for automated vehicle applications such as platooning, cooperative driving, etc. DSRC is the proven technology for short-distance communication (especially for safety applications) due to the low latency and lack of need for infrastructure. For localized use cases with high data rates (e.g. sensor sharing, high resolution video see-through), the bandwidth in the 5.9 GHz ITS band might be too limited (7 channels of 10 MHz). The 60 GHz ITS band is a more likely candidate, for example with usage of the IEEE802.11bd standard.

9. 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?

Similar to the field testing that has been completed for DSRC technology, we advise setting up large-scale realistic field tests, where performance (throughput, latency, application stability) is assessed in a variety of scenarios, including heavily congested situations, with hardware coming from multiple vendors for each technology to evaluate interoperability. The combination of DSRC and long-range communication (including applications running in the back office and traffic control centers) remains largely untested up to date, resulting in limited data on scalability, latency and similar metrics. Also, real-life coexistence and interoperability between DSRC and LTE-V2X has not been tested.

Respectfully submitted,



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[6] Delegated Act on ITS section 3.3 defines the ‘hybrid communication’ approach, covering the differences between short-range and long-range use cases. https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-2592333_en

Annex I: IEEE 802.11bd

Created	Year	DCN	Group	Title	Author	Actions
16-Jan-2019 ET	2019	82	TGbd	Interoperable Approach for NGV New Modulations	Michael Fischer (NXP)	Download
12-Jan-2019 ET	2019	83	TGbd	Indicating NGV Capabilities in MAC Header	Michael Fischer (NXP)	Download
12-Jan-2019 ET	2019	82	TGbd	Interoperable Approach for NGV New Modulations	Michael Fischer (NXP)	Download
12-Jan-2019 ET	2019	79	TGbd	Considerations for Backward Compatibility	Michael Fischer (NXP)	Download
Ow 13-Sep-2018 ET	2018	1660	TGm	Proposed Resolution to CID 1548	Michael Fischer (NXP)	Download
13-Sep-2018 ET	2018	1660	TGm	Proposed Resolution to CID 1548	Michael Fischer (NXP)	Download
13-Sep-2018 ET	2018	1660	TGm	Proposed Resolution to CID 1548	Michael Fischer (NXP)	Download
10-Sep-2018 ET	2018	1457	NGV SG	Items for Completing the PAR	Michael Fischer (NXP)	Download
10-Sep-2018 ET	2018	1457	NGV SG	Items for Completing the PAR	Michael Fischer (NXP)	Download
09-Sep-2018 ET	2018	1577	NGV SG	Additional Details About Interoperable NGV PHY Improvements	Michael Fischer (NXP)	Download
30-Aug-2018 ET	2018	1457	NGV SG	Items for Completing the PAR	Michael Fischer (NXP)	Download
06-Jul-2018 ET	2018	1186	NGV SG	Interoperable NGV PHY Improvements	Michael Fischer (NXP)	Download
18-Feb-2016 ET	2015	1446	LRLP TIG	LRLP Output Report Draft	Michael Fischer (NXP)	Download

Selected slides from "*Additional Details About Interoperable NGV PHY Improvements*", Michael Fischer (NXP) 06-Jul-2018 ET, as proposed at the IEEE 802.11 Next Generation V2X meeting. As can be seen, great emphasis is put on maintaining backwards compatibility and interoperability in defining the enhanced version of the V2X communication standard.

Technical detail slides are omitted, but can be found in the full version of the document obtainable at https://mentor.ieee.org/802.11/dcn/18/11-18-1577-00-0ngv-additional-details-about-interoperable-ngv-phy-improvements.pptx

September 2018 **doc.: IEEE 802.11-18/1577r0**

Additional Details About Interoperable NGV PHY Improvements

Date: 2018-09-10

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Submission **Slide 1** **Fischer-Filippi-Martinez, NXP**

Abstract

This submission provides additional technical details and new simulation results for the adaptive message retransmission technique for interoperable NGV PHY improvements initially described in submission 11-18/1186, which was presented in July 2018.

Background

- Thousands of cars equipped with IEEE 802.11p are already on the road, and several major auto manufacturers have announced massive 802.11p roll-outs [including Toyota, VW, and GM]
- Improvements to IEEE 802.11p by NGV need to take into account the large number of 802.11p systems that will be in service by the time NGV is adopted and deployed
- **In the 5.9GHz band, NGV needs to be fully interoperable with "legacy 802.11p"**
  - We cannot segment the safety critical V2X applications between "legacy" and "NGV users" – Millions of lives are at stake
  - ➢ **Therefore, it is highly desirable to identify and adopt techniques which improve PHY performance while retaining full interoperability with the IEEE 802.11p PHY**

Introduction

- In July, NXP presented document 11-18/1186, which proposed a series of fully-interoperable PHY improvements, addressing topics such as spectrum emission mask, receiver sensitivity, channel model, Doppler, and, most importantly, better link reliability and/or range through reduction of packet error rate.

- The proposals are fully interoperable, and the technique for link reliability improvement ***provides benefits to 802.11p stations as well as NGV stations***

- These improvements can be classified into the following categories:
  1. Transmitter RF improvements
  2. Receiver performance improvements
  3. Waveform design improvements

Benefits

- **These techniques improve performance while maintaining interoperability, coexistence, backward compatibility, and fairness with 802.11p equipment**

- **These techniques provide substantial improvements for communication between NGV stations, while also providing some improvement for communication to and from 802.11p stations that do not implement NGV**

- **These techniques do not increase channel load in congested environments**

- **These techniques do not require changing higher layers of the ITS protocol stack**

Annex II: NXP Response to FCC on 5GAA Petition for Waiver to Allow C-V2X in the 5.9 GHz Band

Selected chapters (as referenced in the main body of this reply) from the NXP reply to the request of FCC on the issue of "5GAA Petition for Waiver to Allow Deployment of Cellular Vehicle-To-Everything (C-V2X) Technology in the 5.9 GHz Band" (GN Docket No.: 18-357)

The full text (including references to relevant work and proof points) of the NXP reply can be found on the FCC web site, link https://ecfsapi.fcc.gov/file/10129081209560/NXP%20C-V2X%20Technology%20Comments%20(Final%20-%201.29.2019).pdf

Section II. The Commission Should Not Waive its Requirement for a Single ITS Standard

(Excerpt from NXP answer to FCC on 5GAA Petition for Waiver to Allow C-V2X in the 5.9 GHz Band)

Grant of the requested waiver would conflict with the Commission's finding that a single standard for ITS systems is appropriate.

As the Commission noted in the Report and Order adopting licensing and service rules for DSRC, the overall effectiveness of the national ITS would be drastically reduced without an interoperability standard that enables vehicles and infrastructure to communicate reliably regardless of location, equipment used or the licensee. The C-V2X technology that is the subject of 5GAA's waiver request is not interoperable with the existing DSRC standard adopted by the Commission because the radio interfaces are simply incompatible. Vehicles equipped with the C-V2X technology will not be able to communicate with vehicles equipped with DSRC technology and vice versa. As a result, safety applications such as crash avoidance and intersection collision avoidance would not be available. Allowing two separate technologies to operate in the dedicated ITS 5.9 GHz band that are unable to communicate frustrates the most fundamental purpose of the ITS: for vehicles to be able to communicate with each other with the goal of saving lives and preventing property damage by avoiding accidents.

By creating a second competing system for V2X communications, grant of the requested waiver would create a split market which will detract from the business case for V2X communications and actually inhibit nationwide ITS deployment. 5GAA's assertion that LTE-V2X would resolve current market inhibitions to V2X deployment is unrealistic: cost, functionality and car industry support would all be negatively affected by competition between C-V2X and DSRC.6 With one exception, all commenters to the Commission's Notice of Proposed Rulemaking regarding the service rules for the DSRC in the 5.9 GHz band urged the Commission to adopt a single standard as a means to ensure that DSRC units would be interoperable nationwide. Grant of the waiver request would be inconsistent with the Commission's decision to require interoperability through the use of a single standard and would be inconsistent with Congress's intent when it adopted legislation concerning DSRC.

Section IV.A DSRC Is Mature Technology and C-V2X Is Not

(Excerpt from NXP answer to FCC on 5GAA Petition for Waiver to Allow C-V2X in the 5.9 GHz Band)

While DSRC technology is fully tested and is beginning to be deployed, C-V2X technology is still in its initial stage of development and has not been proven in any significant field test. It is expected to take at least several more years until the technology is mature enough to be proven and be interoperable within the C-V2X set of manufacturers. As a result, real volume deployment is unlikely to happen before 2023.

In Annex A *[of the NXP reply to the FCC request for comment],* NXP highlights a number of shortcomings which have been identified in the first implementation version of C-V2X, LTE-V2X Rel-14.17 While some of these deficiencies already have been published and corrected in the next version, Rel-15, those corrections are not backwards compatible with Rel-14. In other words, the corrections are only applicable for future applications. Consequently, Rel-14 applications – including safety applications – cannot make use of the corrections. Moreover, some of the other known shortcomings are still in the process of being published and corrected, and thus will not be part of either Rel-14 or Rel-15. Still other issues may not yet be known, due to lack of large-scale testing. A whitepaper by NXP and Autotalks provides additional analysis regarding the immaturity of C-V2X.

Another illustration of the immaturity of C-V2X is the recent change from a 10 MHz channel configuration (as used in the test report in the waiver petition) to a 20 MHz channel configuration (as included in the actual waiver request). The consequences of such a change are far from trivial. For example, the change requires a renewed consideration for the choice of actual LTE-V2X transmission parameter selection like the set of modulation and coding schemes, subchannel size and number of subcarriers. In addition, C-V2X in a 20 MHz channel configuration will suffer from amplified performance degradation due to the "near-far problem" and the "half duplex problem."

In contrast, DSRC technology already has undergone years of field, interoperability and conformance testing. U.S. plug tests by OmniAir and the European 'Plugtest™' by ETSI/Ertico (roughly yearly since 2011) have verified performance, interoperability between vendors and functionality. Projects with hundreds of cars using DSRC have been completed (e.g., large scale simTD already completed in 2013). Deployment has started at locations worldwide. Cars are now available in the U.S. with DSRC systems pre-installed (e.g., select GM Cadillac models) and Volkswagen and Toyota have begun to offer cars with pre-installed DSRC systems in Europe and Asia.

With tens of thousands of cars already equipped with DSRC systems, jurisdictions are investing in DSRC-equipped fleets and infrastructure. For example, in New York City, the city's department of transportation is deploying 8,000 vehicles (mainly buses) and hundreds of DSRC-enabled intersections. Most states also have announced commitments to invest in and deploy DSRC fleet vehicles and infrastructure. Further, the U.S. DOT reports that by the end of 2018, there will have been more than 18,000 vehicles deployed with aftermarket DSRC-based V2X communications devices and more than 1,000 infrastructure V2X devices installed at intersections and along roadways in 25 states.

Section IV.C LTE-V2X Is a Temporary Solution that Should Not Be Permitted to Interfere with DSRC

(Excerpt from NXP answer to FCC on 5GAA Petition for Waiver to Allow C-V2X in the 5.9 GHz Band)

The presently proposed version of C-V2X is LTE-V2X, which is based on legacy 4G LTE technology. As such, it is not 5G and it is not part of a roadmap to 5G using new radio technology. The move to 5G will need to be standardized and tested in dedicated spectrum. Moreover, cellular 5G V2X is not expected to be backwards compatible with 4G LTE, making any investment in or commitment to LTE C-V2X questionable. In contrast, DSRC IEEE 802.11p has a continuous roadmap, whereby the standard is extended for future use in a backwards interoperable way in the form of the IEEE 802.11bd standard definition (work in progress).

The 5GAA petition for waiver points to future developments of LTE-V2X into the 5G New Radio architecture as an argument in favor of the technical superiority of C-V2X. 5GAA also speculates that massive MIMO and beamforming would be part of the 5G New Radio architecture thereby improving characteristics. However, 5GAA does explain how such a transition will happen and it does not address the impracticality of massive MIMO technology in V2V and many V2I applications, the expense of such technology in infrastructure roadside units (RSUs), or the undesirability of beamforming in any application requiring multicasting, as is typical for many V2V and I2V applications. 5GAA's suggestions of future enhancements are at this point purely speculative and should therefore not be relied upon by the Commission.

Section IV.E. DSRC Market Development Is Happening at a Reasonable Pace

(Excerpt from NXP answer to FCC on 5GAA Petition for Waiver to Allow C-V2X in the 5.9 GHz Band)

DSRC deployment is happening at a reasonable pace that reflects the automotive industry's 6-year design cycle for safety-critical systems. This design cycle is made up of contributions from the integrated circuit component manufacturer and from the car OEM as shown in Figure 1 below. In effect, there is typically a 6-year lead time in introducing new technology to a new production model. This can be even longer if the technology has an impact on a car's styling or its outward appearance, as may be the case with V2X when the technology requires roof or side mirror antennas.

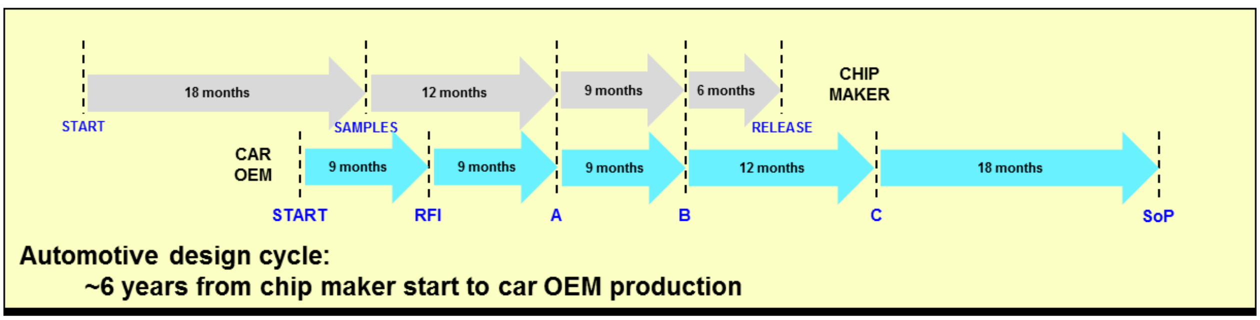

Figure 1

Although this 6-year lead time is often perceived as dead time, where the automotive industry is not moving forward, this is not the case. For example, NXP started development of the 1st-generation DSRC chipset in 2011, and GM subsequently committed to the technology and began pre-installing DSRC systems in its first Cadillac model in 2016.

It also is important to note that some U.S. car OEMs have been waiting for the completion of the NHSTA DSRC research trials which have lasted 10 years, and which will ensure the maturity of the technology and of the standards for safety applications. The trials will conclude with the successful operation of more than 32 smart city DSRC projects in 23 states across the U.S., with more than 10,000 vehicles and 5,000 RSUs deployed. The final pieces of the puzzle are now being finalized for a comprehensive roll-out in the U.S. in 2021, with the SCMS security architecture concluded and a test and certification body in place (OmniAir Consortium). The 2021 roll-out will be jeopardized if a new, untried and untested standard is introduced in 2019, which might have the potential to interfere with the already deployed DSRC systems. Any change required by the chipset supplier and car OEM would push out more wide scale introduction of any life-saving ITS systems likely until 2025 or later.

Staying the course will be essential to the ability of the U.S. not only to lead but to keep pace with the rest of the word in ITS deployment and advances. In Europe, for example, Volkswagen is pushing ahead with deployment of DSRC technology across all models from 2019, safe with the knowledge that EU regulators have put in place legally-binding guiding principles for the introduction of any new technology after 2019:

- It should demonstrate technical maturity
- It should be interoperable
- It should maintain backward compatibility

Based on this stable regulatory landscape, European truck manufacturers will start deployment of DSRC technology to support truck platooning applications from 2021, providing additional fuel-saving opportunities for haulage companies on top of the existing safety applications. And like many U.S. states and smart cities, many European jurisdictions are moving forward with the deployment of DSRC-based roadside infrastructure. Austria, for example, has decided to deploy DSRC-based roadside infrastructure on a nationwide basis.