Texas Department of Transportation

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January 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

Dear Deputy Assistant Secretary Fulton:

The Texas Department of Transportation (TxDOT) appreciates the opportunity to provide you with comments on the U.S. Department of Transportation's Notice of Request for Comments on V2X Communications. TxDOT has been engaged in various activities related to advancing connected vehicles (CVs), including vehicle-to-vehicle (V2V), vehicle-to infrastructure (V2I), and vehicle-to pedestrian (V2P) communications, collectively referred to as "V2X" communications. While the focus of this docket is on V2X communications, we see and anticipate realizing the safety, mobility, and other benefits associated with V2X applications as part of a robust Connected Vehicle Environment throughout the State of Texas.

As surface transportation infrastructure owners and operators (IOOs), state and local transportation agencies are at the core of the CV infrastructure. While automakers and device manufacturers will dictate availability of vehicular on-board equipment, transportation agencies will control the deployment and operation of roadside infrastructure and the incorporation of CV technologies into infrastructure applications. With this background, the Connected Vehicle Pooled Fund Study (CV PFS) was created in 2008 by a group of nine states and the Federal Highway Administration (FHWA) to provide a means to conduct the work necessary for IOOs to play a leading role in advancing CV technologies. As of January 2019, the CV PFS had 25 transportation agencies involved as paid members. TxDOT has been a member since its inception in 2008.

Collectively, this CV PFS has developed a wealth of experience and credibility through its robust research program, which has spanned over the past ten years. More than $8 million has been invested in CV PFS deployment-focused research projects. We understand that a CV environment holds the potential to support a fundamental advance in surface transportation. While the vehicle component and infrastructure component of the transportation system have traditionally been only loosely coupled (through static signing and markings, dynamic message signs, traffic sensors, etc.), CV technology will allow the components to "work" actively together – creating a fully cooperative transportation environment. This provides the potential for safety improvements, reduction in congestion, reduced fuel consumption, lowered emissions, and improved traveler experience. In order to realize this potential, a CV environment will require unprecedented collaboration between the private and public sectors, on a scale not required in the current loosely coupled system. We understand that Dedicated Short Range Communications (DSRC) is here now, and could begin saving lives almost immediately. We also have seen firsthand how the uncertainty caused by the

lack of a federal mandate on communications to support CV applications has caused unnecessary delays in this deployment.

We believe that V2X communications will act as a catalyst that enables us to connect vehicles with our infrastructure to support our mission – delivering a safe, reliable, and integrated transportation system that enables the movement of people and goods. Additionally, the V2X communications mandate will allow us to explore new ways to reduce infrastructure costs; for example, TxDOT is interested in understanding how drivers of vehicles with V2X communications are able to obtain information they need directly into the vehicle to operate safely and efficiently, instead of passively through signs and markings as we know them today.

TxDOT has invested significant staff time and financial resources in CV research and deployments, and it is imperative that TxDOT's investments remain relevant. TxDOT strongly believes in the importance of this national initiative to ensure interoperability between systems, vehicles, and users. National standards for V2X communications are essential, and TxDOT believes individual states should not establish separate systems or regulations.

Below are our responses to the nine questions posed in this docket.

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.***

   Existing V2X technologies:
   - DSRC -- ideal for localized V2I information exchange or V2V with small packets and low latency; limited deployment currently.
   - 4G Long-Term Evolution (LTE) -- widely deployed and available in most new vehicles and smart phones; requires infrastructure for communications and good for applications that do not require localized communication directly between two vehicles or a vehicle and infrastructure.
   - Satellite -- widespread coverage, but limited ability to provide localized alerts for a large region.
   - Wi-Fi (IEEE 802.11) -- widespread coverage but limited distance; is good for applications where vehicles are at low speed or stopped (e.g. fleet vehicles in a garage).

   Future V2X technologies:
   - LTE C-V2X -- similar to DSRC, but is based on 3GPP standards instead of IEEE 802.11, leading to fundamentally different non-interoperable access layer with DSRC.
   - 5G New Radio (NR) -- 3GPP Release 16+ based communications which will support much higher bandwidths and can support applications such as sensor sharing.
   - Optical Camera Communications (OCC) -- a form of Visible Light Communication (VLC) that modulates LEDs at a frequency higher than visible to the human eye to transmit data from one source to another. Could be very useful for redundant communications or communications between two line-of-sight units.
   - Next Generation Vehicular (NGV) communications -- based on IEEE 802.11; supports much higher data rates and packet reliability than DSRC.

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?

DSRC could potentially coexist with other technologies using the two schemes that have been proposed to date: 1) Detect-and-Vacate, and 2) Re-channelization. These proposed schemes have various advantages and disadvantages that have been rehashed in the transportation and communications industry over the last few years and have now been tested by the FCC in a controlled laboratory setting. Neither scheme promotes interoperability but would support coexistence. DSRC would be interoperable with IEEE 802.11 NGV.

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?***

Multiple V2X communications technologies can potentially be interoperable if their lower networking layers are identical. This is due to signal processing, RF modulation schemes, and data frame processing of the physical and data link layers. This still does not guarantee interoperability as applications will not be able to interact if their upper layers are different. They may be able to co-exist better but will unlikely be interoperable unless all seven layers of the Open Systems Interconnection (OSI) model developed by the International Organization for Standardization (ISO) are compatible.

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?***

It is technically feasible for different generations of the same V2X communications technologies and protocols to be interoperable with one another, if they utilize compatible lower networking layers as mentioned previously. It is not feasible if they are not compatible at the lower layers. IEEE 802.11 NGV would be interoperable with DSRC just like LTE C-V2X would be interoperable with 4G LTE. It is unlikely that interoperability between these two families of communications technologies can be made interoperable. It may be possible for them to co-exist if on separate channels, but it will not be possible for a DSRC vehicle to receive and process a message from a C-V2X based vehicle unless both vehicles have both types of radios. This in turn could be cost-prohibitive, by adding costs to both consumers and to states.

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?***

Advantages:

- Every vehicle could hear and understand every other vehicle. This would realize the full potential of V2X communications and result in more lives saved and increased mobility.
- Lower cost deployment in vehicles as well as infrastructure. Reduced hardware, software, and testing costs.
- Potentially better security.
- For IOOs, it would reduce deployment costs and complexity, if there are not multiple protocols.

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?***

In general, yes, they have the same interoperability issues, but it will depend on the type of application. Some mobility and environmental applications will have the same interoperability issues as safety applications. For example, consider a vehicle that optimizes its powertrain based on information from vehicles and infrastructure around it. This application shares the same interoperability issues whereas some applications, that do not require low-latency, localized communications may not.

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?***

Each communication technology will offer a new attack vector and another way in which privacy can be compromised. These will have to be carefully considered during system design and deployment.

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?***

Different communications technologies will be used in different ways based on their characteristics (e.g., range, reliability, bandwidth, performance) and the business model. There must be value for OEMs to include each technology in each vehicle in the absence of a mandate and there also must be value for the IOOs to deploy and maintain the technology. This value can come in many ways:

- Safety -- lives saved, crashes prevented, or severity of a crash lessened
- Mobility -- moving people and goods more efficiently
- Environmental -- improved air quality and reduced emissions
- Economic -- Reduced cost for the traveler or economic benefit for a region or public agency

The current applications and supporting technologies are just the tip of the iceberg. There will continually be an expanding need for communications technology and emerging technologies to meet those needs. To realize the full potential of V2X technologies, we must

be willing to adopt a technology when it has been proven to meet the requirements of the applications which we want to deploy and then we must also be able to adapt to new technologies as they emerge. If we continually wait for the next technology that is in development to finally arrive, we will be waiting forever and there will continue to be tremendous loss of life that may have been preventable.

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?***

For the U.S. to be on a level playing field with other countries, this needs to be coordinated at the national level with input from USDOT, states, cities, OEMs, and other industry stakeholders. To realize the full potential of V2X communications, our national deployment of the technology needs to be interoperable and not just something that only works for vehicles and infrastructure in a particular region.

USDOT could serve as a leader in this area and determine how interoperability could be achieved (or if it can't) and which communication mechanisms are appropriate for each application. Then IOOs, like TxDOT, could follow this guidance in deployment based on the applications being deployed in their region.

Thank you for allowing TxDOT the opportunity to provide comments on the importance of advancing V2X communications. If you have any questions regarding these comments, please contact me directly at (512) 305-9508 or at Darran.Anderson@txdot.gov.

Sincerely,

Darran Anderson
Director, Strategy and Innovation

cc: James Bass, Executive Director
Marc D. Williams, P.E., Deputy Executive Director
Jerry Haddican, Director, Government Affairs