Mr. Finch Fulton
Department Assistant Secretary for Transportation Policy
U.S. Department of Transportation
1200 New Jersey Avenue SE
Washington, DC 20590-00001

February 7, 2019

RE: Docket No. DOT-OST-2018-0210 (Notice of Request for Comments on V2X Communications)

The Colorado Department of Transportation (CDOT) appreciates the opportunity to respond and comment on the U.S. Department of Transportation's (U.S. DOT) Request for Comments on V2X Communications. CDOT is committed to fostering an environment in which technology can thrive to improve the safety and efficiency of our roadways. CDOT is building one of the largest and most robust digital infrastructure ecosystems in the country. Completion of our V2X communication data ecosystem will feature over 500 miles of connected roadways on CDOT's interstates and highways, enabling delivery of safety critical messages between roadway operators and roadway users. Leveraging these technologies offers great potential to improve the safety and mobility of our roadways.

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.*

   - CDOT is currently developing and deploying a world class, full scale connected vehicle architecture system that is flexible to existing technology solutions (such as DSRC and LTE C-V2X), but also has room to grow and expand as new, innovative solutions are introduced.
   - The technology infrastructure deployed by CDOT serves the purpose to provide data intelligence to the department that can help inform operators and owners of safety-critical information, which, in turn aids in the department's mission to improve safety and mobility on the roadways. CDOT's large scale, real-world I-70 Mountain Corridor deployment serves as an ideal location to evaluate the usefulness and application of the data collected, how it is collected, and

identify barriers and opportunities that may exist to improve data information and flow.

- CDOT recognizes that market innovation will continue to occur, and as such, CDOT remains committed to keeping a pulse on new technologies, assessing their practicality, operation and existence in CDOT's automotive grade V2X information system, and flexible to respond as more efficient and improved solutions enter the market.

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?*

- CDOT supports preservation and dedication of the 5.9 GHz spectrum for safety critical applications, regardless of any particular communication technolog(y/ies). The spectrum is critical for DOTs across the country to have a dedicated space for transportation-related communication between vehicles, infrastructure and road users that can help improve the safety of our roadways, and can foster partnership and collaboration for relevant stakeholders and the industry to identify innovative solutions.
- CDOT remains committed to continually assessing how safety critical applications cooperate and exist in the overall 5.9 GHz spectrum, including assessing and identifying possible technical challenges brought forth by interference or other operations. CDOT's connected vehicle ecosystem along I-70 offers a real-world living laboratory to test, validate, and verify how various devices and users of the spectrum will work among one another and coexist including identification of challenges or opportunities. CDOT is currently in discussions with the USDOT ITS Joint Program Office (JPO) on how to leverage this virtual ecosystem for real-work testing including, but not limited to, assessments pertaining to potential interference within a real-world transportation environment.

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?*

- CDOT continues to assess how varying devices and systems work in interoperability capacity. These assessments are built into existing project scopes of work for 2019 and beyond at CDOT and include dedicated collaboration between CDOT and several major OEMs and technology providers. CDOT remains committed to building a system that can receive safety-critical

messages from multiple devices, multiple owners and in turn send that information to any vehicle, technology, or information system equipped with V2X capability. Exploration, assessment and evaluation of how varying technology and hardware can communicate within the software remains vital to ensure interoperability.

- Partnership and collaboration among early deployers can provide key information, real-world data and insight on how technology of today may (or may not) be able to send messages between and to vehicles and infrastructure and vice versa to identify opportunities for innovation.
- CDOT is currently assessing available roadside units that provide flexible capabilities for both DSRC and CV2X applications within Colorado's full-scale V2X network. While industry may drive the type communication technology within the vehicle (DSRC or CV2X), CDOT digital infrastructure can effectively and efficiently communicate (send and receive safety-critical messages) with vehicles with DSRC or CV2X. A future consideration by the industry may be how DSRC and CV2X vehicles can directly communicate between one another as today, V2V is inhibited between a vehicle with DSRC and a vehicle with CV2X.

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?*

- As one of the few deployers of dual RSUs, CDOT offers a unique test environment to identify how dual units such as DSRC and CV2X radios coexist in one area. CDOT's real-world environment offers a unique stage to identify, evaluate, and inform best practices, data standards, and specifications that can help aid in operability. Likewise, CDOT's current scopes of work seek to incorporate both legacy and new technologies into the same interoperable V2X environment. This is a key strategy within Colorado's approach and is currently being tested and proven out between both the City and County of Denver's V2X system and Wyoming's V2X system that was developed through USDOT's connected vehicle pilot program.

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?*

- Interoperable communications between all modes of transportation and each other (V2V, V2P, etc.) and the infrastructure (I2V, I2P, etc.) is critical to realizing the full benefits of V2X, however, full potential of vehicle to everything applications may require more than one communication protocol. Understanding the use cases of a specific roadway and operational environment is critical to identifying the needs of that particular transportation system.

Once again, CDOT is actively exploring the potential for such a system through current projects.

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?*

   - Communication needs are dependent on the specific use cases involved and the tolerance for latency and other factors. However, ability to have interoperable communications between all modes of transportation and each other and the infrastructure is critical to realizing the fully benefits of V2X.
   - Continual assessment and evaluation of how various communication technologies can support mobility or environmental application is crucial to producing the best technological outcome.

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?*

   - Different communication technologies may present different challenges to security, network architecture and integration. Like any infrastructure information device, CDOT thoroughly gates the security and network needs presented by varying technology solutions and incorporates current and evolving industry best practices for systems security.

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?*

   - CDOT recognizes the power for decision and tremendous potential for safety presented by timely transportation and roadway data. CDOT currently utilizes roadway data to improve the safety, efficiency and mobility of real-time operations. Data collected by humans today will have utility to emerging technologies and automated vehicles of the future by providing information (for decision-making) to the vehicle. Data and information can be used by the vehicle when the vehicle based solutions (such as sensors and cameras) do not have adequate visibility or may be otherwise compromised and also to provide data to an automated vehicle that is of a proximity where sensors and cameras cannot capture it or "see it" (for example, an emergency breaking event that is 100 vehicles ahead of an automated vehicle).
   - CDOT is currently in discussions with several automated vehicle manufacturers on how to best share data between infrastructure owners and operators and automated driving systems. These discussions include both the delivery

mechanism(s) and establishing trusted data quality standards for safe, seamless and effective communications.

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?*

- Existing deployments, such as CDOT's I-70 Mountain Corridor offer a thoroughly designed, meticulous approach to understanding the needs of a real-world, scalable, test environment to assess connected and automated technologies. Colorado's infrastructure features the installation of fiber to support the overall system connectivity and the deployment of roadside and on-board connected vehicle units that can send messages between the vehicle and the roadside unit. CDOT's test environment offers a unique space to test and evaluate technologies in a real-world application.
- As an early deployer of a large-scale connected vehicle environment, CDOT supports efforts to continue bring national leaders, deployers, and relevant stakeholders together to evaluate and share best practices regarding the V2X communications to promote interoperability from one deployment to the next, several jurisdictions, and promote development of a cohesive network. Collaborations, partnerships, and sharing forums will continue to propel the nation forward to identify technology solutions, standards, and best practices that can impact the safety of our roadways.
- CDOT adamantly welcomes meaningful collaboration with the USDOT ITS JPO and other relevant USDOT offices to advance understanding and deployment in this area.

Thank you for allowing CDOT the opportunity to provide comments on the technology and application of V2X communications. If you have any questions regarding these comments, please contact me directly at (303) 757-9593 or ryan.rice@state.co.us.

Sincerely,

Ryan D. Rice

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