MEMORANDUM

To: Task Force on Autonomous Vehicles, Subcommittee on Road and Infrastructure Design
From: ODOT Staff
Date: March 28, 2019
Re: State Efforts on Infrastructure for Connected and Automated Vehicles

Background Information

The Intersection of Connected and Automated Vehicle Technology
Manufacturers are separately developing automated vehicle (AV) and connected vehicle (CV) technologies, and a few have indicated their intention of producing AVs that can operate without any communication links to other vehicles or infrastructure. However, many researchers and industry experts anticipate that in the future vehicles will be both automated and connected, and that combining these technologies will maximize the potential safety and mobility benefits.

Road operators and AV manufacturers are beginning to discuss potential changes to road infrastructure and design that could enable or improve AV operation, such as higher-contrast pavement markings. Infrastructure changes necessary for CVs are better understood, but have also encountered barriers to deployment.

Competing Connected Vehicle Communications Technologies
Connected vehicles use wireless communications systems to exchange messages with other vehicles and the driving environment. Vehicle-to-vehicle (V2V) communications refer to messages sent between vehicles, while vehicle-to-infrastructure (V2I) refers to messages exchanged with roadside equipment; the term vehicle-to-anything (V2X) refers broadly to any type of connected vehicle communication, including communications with vehicles, infrastructure, or even cell phones.

Connected vehicles could rely on one of two communications technologies: dedicated short range communications (DSRC) or cellular technology. DSRC is an open-source protocol for wireless communication that can send messages with low latency and limited interference from radio or adverse weather conditions.

Connected vehicles could also rely on 5G cellular technology, which is still under development. 5G cellular technology also has the potential to transmit with low latency and could allow for more features and flexibility. 5G cellular technology has gained currency among a number of automakers and telecom providers in recent years.

In 2016, the National Highway Traffic Safety Administration (NHTSA) and U.S. DOT initiated the federal rulemaking process to mandate use of DSRC radios in all new light vehicles by 2023, but the current administration has delayed this process and taken a technology-neutral approach to regulation. Some auto manufacturers have committed to DSRC, while others are focused on 5G. The ongoing lack of certainty around vehicle equipment and communications protocol has made it difficult for transportation agencies to spend limited funds on roadside CV infrastructure.
State Efforts on Infrastructure for Connected and Automated Vehicles

This memo highlights a few efforts by states and local jurisdictions to prepare for or pilot infrastructure innovations related to connected and automated vehicles. The list below is intended to provide an overview of the variety of infrastructure projects underway and is not comprehensive.

**FIBER**

**Colorado’s Smart Mobility Plan and Statewide Strategic Fiber Plan (20+ years)**

Over the past 20 years, Colorado DOT has installed or acquired approximately 1,400 miles of fiber optic cable. In some cases, Colorado DOT installed the fiber themselves, but in many cases they partnered with public and private entities, requiring that they install fiber in exchange for access to and use of the right-of-way. Colorado’s Statewide Strategic Fiber Plan is intended to create a “carrier grade network” and improve critical communications facilities.

Colorado DOT recently established a 5-10 year Smart Mobility Plan to prepare the agency’s “assets, data management, communications systems, and infrastructure to maximize the benefits of connected and autonomous vehicles.” One element of the plan is to install fiber optic cable along “Smart Mobility Corridors.” For example, in January Colorado DOT began installing 17 miles of fiber optic cable along US 24. The fiber will enable real-time access to traffic monitoring cameras, variable message signs, and traffic signals. In the future, it may also be accessible to automated vehicles and enable communication with connected vehicles.

Link: [https://www.codot.gov/programs/operations/intelligent-transportation-systems/infrastructure/planning](https://www.codot.gov/programs/operations/intelligent-transportation-systems/infrastructure/planning)

**Utah’s Fiber-Optic Broadband Expansion Agreements (20+ years)**

In 2008, Utah passed a law defining 30-year shared-use agreements with telecom services to coordinate fiber-optic broadband network development in the public right of way along state roads. UDOT policy allows telecom providers to get easy access to the right of way for continuous build-outs, which prevents any one company from having exclusive access to the right of way. UDOT installs fiber during all roadway projects in anticipation of future needs, including providing high-speed internet access to local jurisdictions and enabling operation of CVs and AVs. Utah’s goal is to connect every traffic signal and equip all roadways with communications infrastructure to provide information on roadway and weather conditions.

Link: [https://www.fhwa.dot.gov/policy/otps/successprac.cfm](https://www.fhwa.dot.gov/policy/otps/successprac.cfm)

**INFRASTRUCTURE TO ENABLE AV NAVIGATION**

**California’s 6-inch Striping on I-5 (2018)**

Last year, California’s Department of Transportation (Caltrans) replaced striping along I-5 to increase visibility for both human drivers and automated driving systems. Caltrans widened the stripes from four inches to six inches and used thermoplastic or tape-like material rather than paint. The thermoplastic and tape contain tiny glass beads that are highly reflective and improve visibility at night and during inclement weather.

According to Donald Anderson, deputy director for maintenance and operations at Caltrans, automated vehicle manufacturers have indicated that wider stripes could help automated vehicles more accurately
and reliably identify and respond to pavement markings. Preliminary results of NCHRP 20-102(06): Road Markings for Machine Vision indicated that high contrast is vital for automated vehicles’ camera and sensor systems. The International Society of Automotive Engineers (SAE) has also convened a committee to research potential changes to infrastructure, and one of the topics under consideration is pavement markings.

Link: https://www.ttnews.com/articles/stripes-california-highway-pave-way-self-driving-vehicles

**Las Vegas’ Digitized Roadways (2018-2019)**
The Regional Transportation Commission of Southern Nevada (RTC) has partnered with INRIX to “digitize” key roads in Las Vegas. This process involves using INRIX AV Road Rules software to convert local map data and traffic rules into data usable by automated vehicles. This data can be used by automated vehicles to improve their functionality and make sure they can comply with local rules, such as school zones. The system also allows data from automated vehicles to be used to identify needs such as missing signage or striping.

RTC is the leading road authority in using this technology, but INRIX is working with other jurisdictions such as Boston, MA and Austin, TX.


**TRAFFIC MANAGEMENT**

**New York City Connected Vehicle Pilot (2018-2020)**
Part of USDOT’s Connected Vehicle Pilot Deployment Program, The New York City Connected Vehicle Project has been evaluating the safety benefits of CV technology and challenges to the deployment of the technology, especially those specific to dense urban areas. The pilot has equipped approximately 8000 vehicles with CV devices. Most of these vehicles are taxis, city buses or and other fleet vehicles. There are approximately 350 intersections equipped with RSUs. New York City Department of Transportation is using V2I and V2V communication to test safety alerts, such as alerts about sudden braking areas, and compliance messages about speed and red light violations.

The project is evaluating techniques to combat difficulties with location data that arise from NYC’s “urban canyons.” These methods involve dead reckoning, CAN bus integration, triangulation and others. Early testing of these efforts is said to be encouraging. The pilot has also tested an over the air update process using the DSRC technology that is deployed on the pilot vehicles and infrastructure. The NYC pilot began in August of 2018 and will continue until February 2020.

Link: https://cvp.nyc/

**Tampa-Hillsborough Expressway Authority Pilot (2018-2020)**
Also part of USDOT’s Connected Vehicle Pilot Deployment Program, The Tampa-Hillsborough Expressway Authority will pilot V2V and V2I technology to improve traffic congestion and safety, especially by reducing the risk of rear-end and wrong-way collisions, in downtown Tampa, FL.

Rear-end crashes are a significant problem on Tampa’s Lee Roy Selmon Expressway. This pilot will use V2V among participating vehicles to warn drivers of upcoming slowdowns in traffic to combat this problem. The Expressway also features a reversible lane. This has contributed to wrong-way collisions. V2I communications will be deployed to issue warnings to potential wrong-way drivers. The V2I and V2V
infrastructure will also be used for pedestrian safety, signal timing, traffic monitoring and other applications. The pilot will include 1600 private cars, 10 buses, 10 streetcars, 500 pedestrians and 40 RSUs. The pilot began operation in 2018 and will conclude in January 2020.

Link: [https://www.tampacvpilot.com/](https://www.tampacvpilot.com/)

**Michigan’s Connected Vehicle Test Beds (2012-Present)**
The University of Michigan researches and tests CV technology at Mcity, a 32-acre mock city constructed as a proving ground for AV and CV technology. The University has also established several on-road, real-world test beds in southeast Michigan: in Ann Arbor, Detroit, Farmington Hill, and Southfield. The Ann Arbor Connected Vehicle Test Environment is intended to be the largest operational CV deployment in the world. It began in 2012 with a three year pilot involving 73 lane miles, 25 roadside units, and approximately 2,800 vehicles, but has now been expanded with the goal of connecting 45 street locations, 12 freeway sites, 27 square miles around the City of Ann Arbor, and up to 5,000 equipped vehicles. Using DSRC technology, the vehicles and roadside infrastructure exchange information about vehicle position, speed, direction of travel, crash warnings, ice warnings, intersection movement assit, curve speed warning, red light violation, and pedestrian detection.

Link: [https://mcity.umich.edu/our-work/on-the-road/](https://mcity.umich.edu/our-work/on-the-road/)

**FREIGHT**

**Wyoming DOT Connected Vehicle Pilot (2014-Present)**
Wyoming’s I-80 is a major freight corridor, but dangerous winter driving conditions lead to many truck blowovers and crashes every year. Through U.S. DOT’s Connected Vehicle Pilot Deployment Program, Wyoming DOT is developing a system that uses V2I and V2V communications technology to improve safety and reliability for trucks traveling along I-80.

When the pilot is complete, Wyoming DOT will have installed approximately 75 roadside units (RSUs) and 400 on-board units (OBUs), including 100 on Wyoming DOT fleet vehicles and at least 150 on commercial trucks. The RSUs and OBUs communicate via DSRC technology. This technology will enable forward collision warnings, distress notifications, and alerts about speed restrictions, vehicle restrictions, weather conditions, road conditions, road closures, work zones, and crashes further down the road.

Link: [https://wydotcvp.wyoroad.info/](https://wydotcvp.wyoroad.info/)

**I-80 INFRA Grant Proposal (2019)**
The Infrastructure for Rebuilding America discretionary grant program creates opportunities for all levels of government and the private sector to fund infrastructure, using innovative approaches to improve the necessary processes for building significant projects. The states that contain sections of I-80 have submitted a proposal through the INFA grant program for a project that will upgrade I-80 from coast-to-coast to support freight automation. The proposal was submitted to this year’s INFRA grant program. Project selection results will be announced later this year.

Link: [https://www.transportation.gov/buildamerica/infragrants](https://www.transportation.gov/buildamerica/infragrants)

**CONNECTED VEHICLE ECOSYSTEM**

**Colorado DOT’s Partnership with Panasonic (2016-Present)**
Colorado DOT contracted with Panasonic to build a connected vehicle ecosystem, in which connected vehicles and infrastructure will be able to share data in real time. The ecosystem will also provide information to roadway operators, who can then provide road users with up-to-date alerts and better manage the transportation system. The goal is to improve safety, mobility, and reliability of Colorado’s transportation system, especially once more connected and automated vehicles are on the roads.

Colorado DOT and Panasonic are outfitting fleet vehicles with communications equipment and installing roadside infrastructure along a 90-mile stretch of I-70, with 400 more miles of coverage planned for the near future. Panasonic is also developing a data processing platform capable of handling the large volume of messages that will be generated by connected vehicles and infrastructure when they are widely deployed.