

FINAL



Freight Task Force, Year 2

Task 5 – Truck Platooning Exploration

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Prepared by:

CPCS Transcom Inc.

MnDOT North/West Passage – Project 10.4: Freight Task Force, Year 2

The objective of Year 2 activities of the North/West Passage (NWP) Freight Task Force is to continue the momentum of the Year 1 work. Specifically, to 1) support the active engagement of NWP Members, 2) conduct best practice (and practical) research on project funding opportunities, 3) to help refine the truck parking concept so that it best fits NWP needs, and 4) to explore the potential for a truck platooning demonstration in the corridor. Each of these activities is aimed at getting the coalition closer to project implementation.

Working Paper

This Working Paper represents the Task 5 deliverable. The aim of Task 5 is to conduct exploratory research on truck platooning technologies and initiatives to provide a basis for the NWP in assessing their own next steps.

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Opinions

Unless otherwise indicated, the opinions herein are those of the authors and do not necessarily reflect the views of the NWP Freight Task Force.

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Acronyms / Abbreviations

AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ATRI	American Trucking Research Institute
AV	Autonomous Vehicle
BSM	Basic Safety Message
CACC	Cooperative Adaptive Cruise Control
CEO	Chief Executive Officer
CV	Connected Vehicle
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communications
FCC	Federal Communications Commission
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
GPS	Global Positioning System
ITS	Intelligent Transportation Systems
ITS JPO	Intelligent Transportation Systems Joint Program Office
ND	North Dakota
NWP	North/West Passage
RFI	Request for Information
SAE	Society of Automotive Engineers International
TARDEC	Tank Automotive Research, Development, and Engineering Center
TBD	To Be Determined
TTI	Texas A&M Transportation Institute
TX	Texas
U.S.	United States
U.S. DOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Anything

Executive Summary

Advances in Autonomous Vehicle (AV) and Connected Vehicle (CV) technology make the national discussion of the application of technology to the movement of goods and people more relevant today than at any time in recent history. Private sector-led initiatives are the driving force behind AV/CV research and development, and the AV/CV marketplace is comprised of multiple industries from mapping and sensors to heavy manufacturing.

Throughout the U.S. and in Europe, truck platooning demonstrations are being considered and legislation is being advanced to enable “real world” trials. Two demonstrations are particularly relevant to NWP discussions on advancing a truck platooning demonstration: 1.) The Dutch-led European Truck Platooning Challenge had the goal of facilitating a multi-national harmonized approach to developing truck platooning regulations and infrastructure in Europe (an effort that would be required across multiple states in the NWP) and 2.) the Texas Transportation Institute’s efforts in Texas, while to-date have been held on a closed course, will seek to demonstrate the technology in corridors similar to those of the NWP beginning in April 2019.

During NWP Freight Task Force Year 1 (2014) both autonomous and connected vehicles were identified as areas for potential future research. During the course of conducting Freight Task Force Year 2 (2017) activities – which, in part, aimed to confirm research and implementation priorities for the corridor – AV/CV generally, and as applied to commercial vehicles specifically, received wide interest from most NWP states.

The NWP presents a unique opportunity to further advance truck platooning research in a multistate corridor setting.

To further explore logical next steps for the NWP, on July 12, 2017, a roundtable discussion of NWP member states was convened to gauge interest for truck platooning on the I-90/94 corridor. Staff from the states of Idaho, Minnesota, Montana, North Dakota, South Dakota, and Washington joined the discussion.

At the onset of the roundtable each state was provided an opportunity to note if their state is pursuing truck platooning or related legislative initiatives. North Dakota indicated they are considering what studies may be needed to advance the truck platooning concept, South Dakota is considering legislation that should be fed into the next state legislative cycle, and Washington recently passed an executive order that enables the testing of autonomous vehicles in the state and their Department of Licensing established a licensing/permitting process for these applications.

Each of the states participating in the roundtable noted that they were either interested in a truck platooning project along the corridor, or were not openly opposed to one. North Dakota

noted their interest and the interest by the legislature, as evidenced by the questions to the DOT. South Dakota noted that they are most interested in developing model legislation to enable truck platooning, and also indicated that if a truck platooning project were advanced, objectives would need to be established for the demonstration so that the effort wouldn't be redundant of others work.

The NWP states recommend taking an incremental approach, and one that is able to capture low hanging fruit.

Each of Minnesota, South Dakota and Montana suggested a likely first step would be to work on legislative barriers. In terms of a demonstration, Idaho noted that there are parts of the corridor that likely would not be suitable for a demonstration (e.g., narrow and mountainous passes), and that a demonstration that touched at least two states to work on legislative issues, as well as aimed at any new technical objectives, would be ideal.

When queried, the group expressed minimal concern about private sector involvement or lead in a demonstration. The group did note that the private sector would have to have liability insurance at a level adequate/acceptable for states. Note that it will be important for the states where the demonstration is held to work with the private sector during scoping and mobilization so that the environment it is conducted in is safe. And, that licensing and permitting of platooned vehicles is addressed where operating.

Next Steps

Based on research presented in this Working Paper and interest expressed during the roundtable discussion next steps were identified to flow over the course of 18-months. These were developed keeping in mind the interest of NWP members to take small steps first.

North/West Passage Role

First, it is recommend that the NWP continues to serve in a lead role related to truck platooning. This is particularly important as the NWP member states have interest in exploring a number of legislative and demonstration next steps that cross borders and could benefit from the NWP serving as a clearing house of information and a neutral forum for discussion.

A Project Champion should be established to lead and follow through with recommended actions. As the NWP Freight Task Force already has a formal structure that designates state and staff leads for various topics, it is recommended that this structure be followed and a lead for future truck platooning activities is named (Project Champion). Depending on the speed NWP states would like to advance activities, multiple state task leads that support the Project Champion should be designated to work on behalf of the members on specific activities.

Model Legislation for Autonomous and/or Connected Vehicle Operations

This project developing model legislation has been funded as part of the NWP Freight Task Force Year 3 activities. Considering the operating and legislative environment (and barriers) within and among NWP states is a step that is in line with feedback provided during the roundtable discussion. This initial step start with legislation and provides a basis to build upon gradually.

Identify Research Gaps and North/West Passage Objective

While the concept of a truck platooning demonstration has been discussed by the NWP for a number of years, to date no formalized concept or research objective has been developed. Based on the information provided in this Working Paper, as well as the roundtable discussion, some features the NWP may consider in developing a demonstration that advances truck platooning research includes a multistate demonstration, a 2+ truck platoon demonstration, and evaluation of platoon operations in various conditions/situations such as inclement weather, seasonal restrictions, and changes in elevation or terrain.

There are likely numerous other features that could be considered to ensure a NWP demonstration is unique and adds upon existing and ongoing studies. As these are further explored, a vision for the corridor/research objective should be formed to focus all future truck platooning related activities.

Seek University or Other Research Partner

Many of the truck platooning demonstrations, in particular the Texas demonstration that is working toward advancing to Level 2 automation, have a university or research partner on the team. The NWP itself has a number of research institutions (e.g., the Upper Great Plains Institute at North Dakota State University, Western Transportation Institute at Montana State University, Pacific Northwest Transportation Consortium at the University of Washington, or other) that should be leveraged. In seeking a university or other research partner there could be benefit in understanding the university's ongoing research and research strengths, and building on those as appropriate as a research objective is formed.

Identify Potential Demonstration Location(s)

The NWP members have provided some initial thoughts on what locations could work better than others (e.g., border between North Dakota and Montana could be better than the borders between North Dakota and Minnesota or Washington and Idaho). Bi-state corridor segments should be identified, and discussions convened with state DOTs and other potentially affected agencies, as appropriate. This step does not select "the" corridor(s) for demonstration, but rather identifies a slate of possibilities that best aligns with research objectives.

Leverage Private Sector Innovations

Building on the previous recommended activities, a refined demonstration concept will be beginning to form. At this point, in an effort to leverage private sector resources, a Request for Information (RFI) should be published to collect ideas and insights from a variety of

industry players and potential partners based on the concepts and research objectives conceived by the NWP. During the RFI process vendors can respond to and augment the concept based on their perspective and the technology they offer. After evaluation of the RFI responses, the NWP can better gauge if it is in their best interests to proceed with a demonstration and the potential vendors that may be able to assist.

1 Introduction

1.1 Background

The North/West Passage (NWP) is a multi-state operations-focused partnership between the states of Idaho, Minnesota, Montana, North Dakota, South Dakota, Washington, and Wyoming initiated with the leadership of Minnesota DOT in 2002. These states share similar challenges with Interstates 90 and 94 serving as major passenger and commercial vehicle highway corridors, and both subject to operational challenges due in part to extreme weather conditions. Many of the operational issues are exacerbated for commercial vehicles and are related to truck parking management, traveler information, truck permitting and other operational issues.

The Freight Task Force (Task Force) was established in 2014 to help realize the NWP Corridor's vision of...

...developing effective methods for sharing, coordinating, and integrating traveler information and operational activities across state and provincial borders.

1.2 Objectives

Year 2 activities of the Task Force are being pursued to continue the momentum of the Year 1 work. Specifically the activities are designed to:

- Support the active engagement of Task Force members,
- Conduct best practice (and practical) research on project funding opportunities,
- Help refine the truck parking concept so that it best fits NWP needs, and
- Conduct exploratory research on truck platooning for the NWP corridor.

Each of these activities is aimed at getting the coalition closer to implementation of those projects that are most important to the seven NWP member states.

1.3 Project Structure

The project was conducted in five phases, as set out in Figure 1-1. The present working paper is the output of Task 5.

Figure 1-1: Project Management Task Organization



1.4 Purpose of this Working Paper

The aim of Task 5 is to conduct exploratory research on truck platooning technologies and initiatives to provide a basis for the NWP in assessing their own next steps. Specifically, Task 5:

- Educates the NWP members on truck platooning activities underway nationally and internationally.
- Provides information to facilitate discussions with NWP members so that interest in advancing a truck platooning project can be assessed.
- Identifies an action plan for next steps to advance a platoon demonstration, or other related activities.

1.5 Methodology

This Working Paper was prepared by 1) conducting a desk scan of national and international truck platooning technology and initiatives; 2) coordinating a NWP member to attend a truck platooning demonstration and conducting a follow-up interview on his perspectives on applicability to the NWP and next steps; 3) conducting two web meetings focused on providing NWP members information on truck platooning; and 4) conducting a roundtable discussion with NWP members on their thoughts on next steps for the corridor related to truck platooning.

1.6 Limitations

Some of the findings in this report are based on the analysis of third party data. While CPCS makes efforts to validate data, CPCS cannot warrant the accuracy of third party data.

2 Truck Platooning Initiatives

Key Chapter Takeaway

Advances in Connected Vehicle (CV) and Autonomous Vehicle (AV) technology makes the national discussion of the application of technology to the movement of goods and people more relevant today than at any time in recent history. Private sector-led initiatives are the driving force behind AV/CV research and development, and the AV/CV marketplace is comprised of multiple industries from mapping and sensors to heavy manufacturing.

Throughout the U.S. and in Europe, truck platooning demonstrations are being considered and legislation advanced to enable their use in the “real world.” Two demonstrations are particularly relevant to NWP discussions on advancing a truck platooning demonstration: 1.) The Dutch-led European Truck Platooning Challenge had the goal of facilitating a multi-national harmonized approach to developing truck platooning regulations and infrastructure in Europe (an effort that would be required across multiple states in the NWP) and 2.) the Texas Transportation Institute (TTI) efforts in Texas, while to-date have been held on a closed course, will seek to demonstrate the technology in corridors similar to those of the NWP beginning in April 2019.

2.1 Transportation Technology

Advances in Connected Vehicle (CV) and Autonomous Vehicle (AV) technology makes the national discussion of the application of technology to the movement of goods and people more relevant today than at any time in recent history. While the focus of this Working Paper is truck platooning (one type of CV technology), it is critical to understand both CV and AV terminology and technologies, and how they relate to each other and to other technologies.

2.1.1 Connected Vehicles

CV technology, often framed as Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) or Vehicle-to-Anything (V2X), is the wireless transmission of information to/from vehicles. The different applications to CV technology has different approaches and goals. The following provides an example of each application:¹

- **V2V** – Connection between vehicles which provides information which can be used by the vehicle to change performance or alert the driver. For example, the connection between a lead and follow vehicle allows the lead vehicle to inform the following

¹ Fitzpatrick, D, G. Cordahi, L. O'Rourke, C. Ross, A. Kumar, and D. Bevy. “Challenges to CV and AV Applications in Truck Freight Operations.” Transportation Research Board. December 2016.

vehicle when braking occurs. The following vehicle could then slow or notify the operator of the action of the lead vehicle. **Truck platooning is classified as V2V.**

- **V2I** – Connection between the vehicle and infrastructure to provide information to the operator and/or allow information to be collected from the vehicle. For example, notification sent to a vehicle regarding a slowdown ahead or the collection of operating characteristics (speed, braking activity, windshield wiper activation, etc.) to notify the infrastructure operator or manager of the performance of the roadway.
- **V2X** – Connection between the vehicle and other devices such as mobile phones. For example, a mobile phone could communicate with the vehicle to notify the operator when a pedestrian is in a crosswalk.

V2V, V2I, and V2X are not mutually exclusive technologies, in fact the benefits of one approach could be amplified rather than replaced by another approach. For example, a vehicle could be connected to surrounding vehicles to monitor changes in speed, infrastructure to receive and provide information on the performance of the roadway, and to other devices such as mobile phones as the vehicle encounters pedestrians. Additionally, the means for communicating with vehicles can take many forms including Dedicated Short-Range Communications (DSRC), cellular, and Wi-Fi. The Federal Communications Commission (FCC) has allocated spectrum to enable V2V and V2I technology.

2.1.2 Autonomous Vehicles

AVs use technology to control some or all aspects of a vehicles movement. AVs use sensors in conjunction with background information and decision making algorithms to make decisions affecting movement of a vehicle independent of the operator.

The United States Department of Transportation (U.S. DOT) acknowledged the need to define the levels of automation in order to properly formulate policy. Ultimately U.S. DOT adopted SAE International's (SAE) definitions of levels of automation shown in Figure 2-1. AVs range from no automation (level 0), where the operator is responsible for all aspects of driving to full automation (level 5), where the vehicle performs all driving functions. Low levels of automation such as adaptive cruise control have been in use for many years, but companies have only recently begun to push capabilities into automation levels three through five.²

AVs do not rely on infrastructure, vehicles, or other roadway users (pedestrians, cyclists, etc.) to communicate with the vehicle, rather the vehicle senses the world around it to manage its actions. AVs stand in contrast to CVs that rely on communication with infrastructure (V2I) and/or other users (V2V/V2X). The requirement of connection with infrastructure and/or other users makes the overall benefits of implementing CV technology heavily contingent on widespread investment, whereas the benefits from the use of AVs are more independent of whether other users adopt the technology.

² National Highway Traffic Safety Administration. "Federal Automated Vehicles Policy." September 2016. <https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf>.

Figure 2-1: Levels of Automation

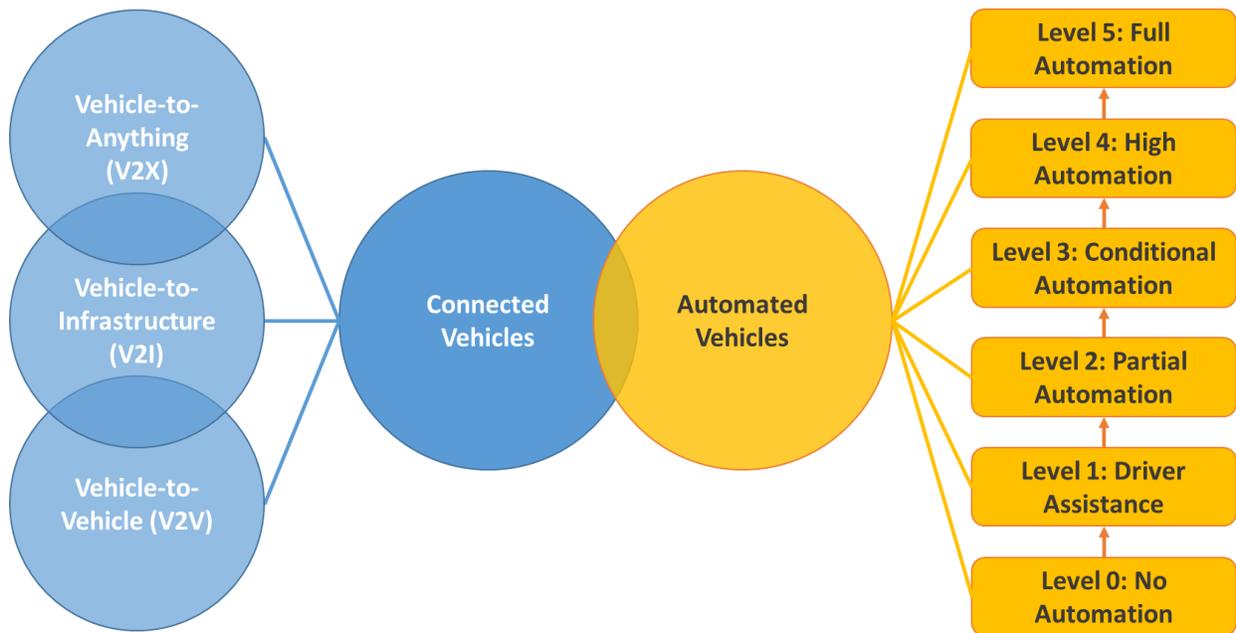
SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the <i>human driver</i> of all aspects of the <i>dynamic driving task</i> , even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the <i>driving mode</i> -specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the <i>driving mode</i> -specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	System	Human driver	Human driver	Some driving modes
Automated driving system (“system”) monitors the driving environment						
3	Conditional Automation	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the dynamic driving task with the expectation that the <i>human driver</i> will respond appropriately to a <i>request to intervene</i>	System	System	Human driver	Some driving modes
4	High Automation	the <i>driving mode</i> -specific performance by an automated driving system of all aspects of the <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond appropriately to a <i>request to intervene</i>	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i>	System	System	System	All driving modes

Source: SAE International and J3016

2.1.3 Relationship between Connected and Autonomous Systems

CV and AV technology is often presented as distinct classifications, but they are not mutually exclusive. While autonomous vehicles do not need to be connected to other vehicles, roadway users, or the infrastructure, the benefits of widespread use of AVs could be magnified via connection. For example, dynamic routing or signal timing could be optimized through the information collected and implemented via CV technology, such as V2I. Figure 2-2 displays the approaches to CVs and the levels of AVs and that there is overlap between the technologies.

Figure 2-2: Transportation Technology Landscape



Source: CPCS

The specific focus of this Working Paper, truck platooning, benefits truck drivers by improving safety and efficiency. Truck platooning creates a link between vehicles equipped to platoon, allowing the rear truck to decrease following distance. This decreased following distance can reduce air resistance for both trucks, in turn increasing fuel economy. In addition to fuel economy, the trucks are in communication, which allows the lead truck to inform the following truck of changes in operation such as the application of brakes. This communication reduces reaction times, impacting safety. Existing research found fuel savings from the implementation of truck platooning were affected by truck speed, following distance, gross vehicle weight, the number of trucks in the platoon, truck geometry, and the offset of platooning trucks.³ The study found fuel savings ranged from 2.7 to 5.3 percent for the lead vehicle and 2.8 to 9.7 percent in the following vehicle. Interestingly, when the following

³ Fitzpatrick, D, G.Cordahi, L. O'Rourke, C. Ross, A. Kumar, and D. Bevly. "Challenges to CV and AV Applications in Truck Freight Operations." Transportation Research Board. December 2016.

vehicle got too close to the lead, the engine cooling fan engaged, which reduced fuel efficiency. Therefore when the following vehicle did not have the cooling fan engaged achieved savings of 8.4 to 9.7 percent.⁴

There is significant uncertainty about the rate of development, acceptance, and implementation for CVs and AVs. There is similar uncertainty about whether the majority of vehicles in the future will be CVs, AVs, or some combination of CV and AV technology.

2.1.4 Impact of Connected and Autonomous Vehicle Technology on the Public Sector

The Federal Highway Administration (FHWA) identified many impacts of AVs/CVs, many of which will require State DOT engagement. Some of these impacts include:⁵

- AVs/CVs will necessitate the incorporation of AV/CV supporting infrastructure into investment plans and data architectures. The need to consider this new technology requires investment priorities to change and projects to be added or removed from long-range plans.
- Public sector agencies need to understand the costs and benefits of AVs/CVs to assess and make a case for public sector investments.
- AVs/CVs also allow for new performance measures to be assessed as data are collected or made available.
- AVs/CVs are developing quickly and the regulatory frameworks are being debated and developed in response. The public sector needs to devote time and resources providing input and assessing the impacts of these technologies to their specific geographies.
- The impact of widespread use of AVs/CVs may make previously used frameworks and models for understanding and forecasting obsolete, requiring the development of new frameworks and models.

CV and AV technology has the potential to disrupt the core activities of State DOTs, but not in the same way. While truck platooning (V2V) will require State DOT action, it does not require the same level of investment required by V2I. A primary role for State DOTs is to assess whether the state's rules on following distances prohibit or allow for truck platooning. Additionally, State DOTs will have a primary role in ensuring the application of platooning technology is correctly applied in their jurisdiction, in order to ensure the safety of all roadway

⁴ Lammert, M., Duran, A., Diez, J., Burton, K. et al., "Effect of Platooning on Fuel Consumption of Class 8 Vehicles Over a Range of Speeds, Following Distances, and Mass," SAE Int. J. Commer. Veh. 7(2):2014, doi:10.4271/2014-01-2438

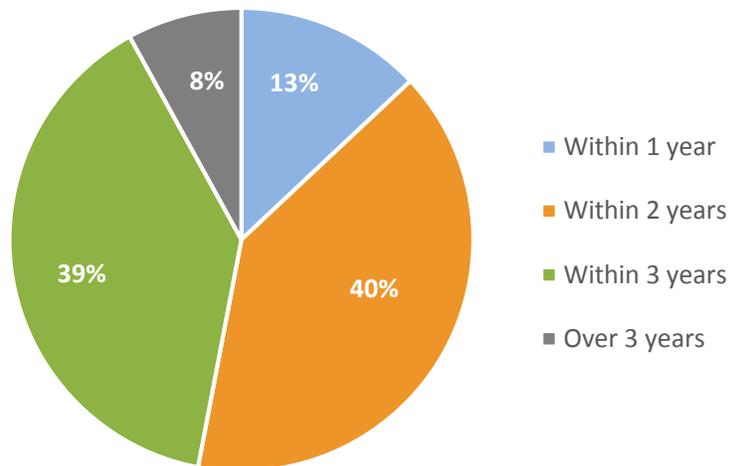
⁵ Krechmer, D., J Osborne, J. Bittner, M. Jensen, and E. Flanigan. "Technical Memorandum #2: Connected Vehicle Planning Processes and Products and Stakeholder Roles and Responsibilities." U.S. Department of Transportation. January 2015. <https://ntl.bts.gov/lib/55000/55700/55711/FHWA-JPO-16-246.pdf>.

users. The application of truck platooning has the promise of increasing efficiency and safety, making the technology of interest to State DOTs.

2.2 Private Sector Innovations

Much of the specifics of the technology used, and status of these AV/CV demonstrations are proprietary and are subject to rapid change. Private sector developers of truck platooning technology highlight safety and fuel savings as the primary benefits of their technology. As shown in Figure 2-3, a 2015 survey of large carriers found that over half of respondents wanted to see a return on their investment within two years. Another 39 percent were willing to wait up to three years before seeing a return.⁶ While this study was not platooning specific, it shows that the desired timeline for technologies to “pay off” is relatively short.

Figure 2-3: Expected Carrier Return on Investment Period



Source: ITS America

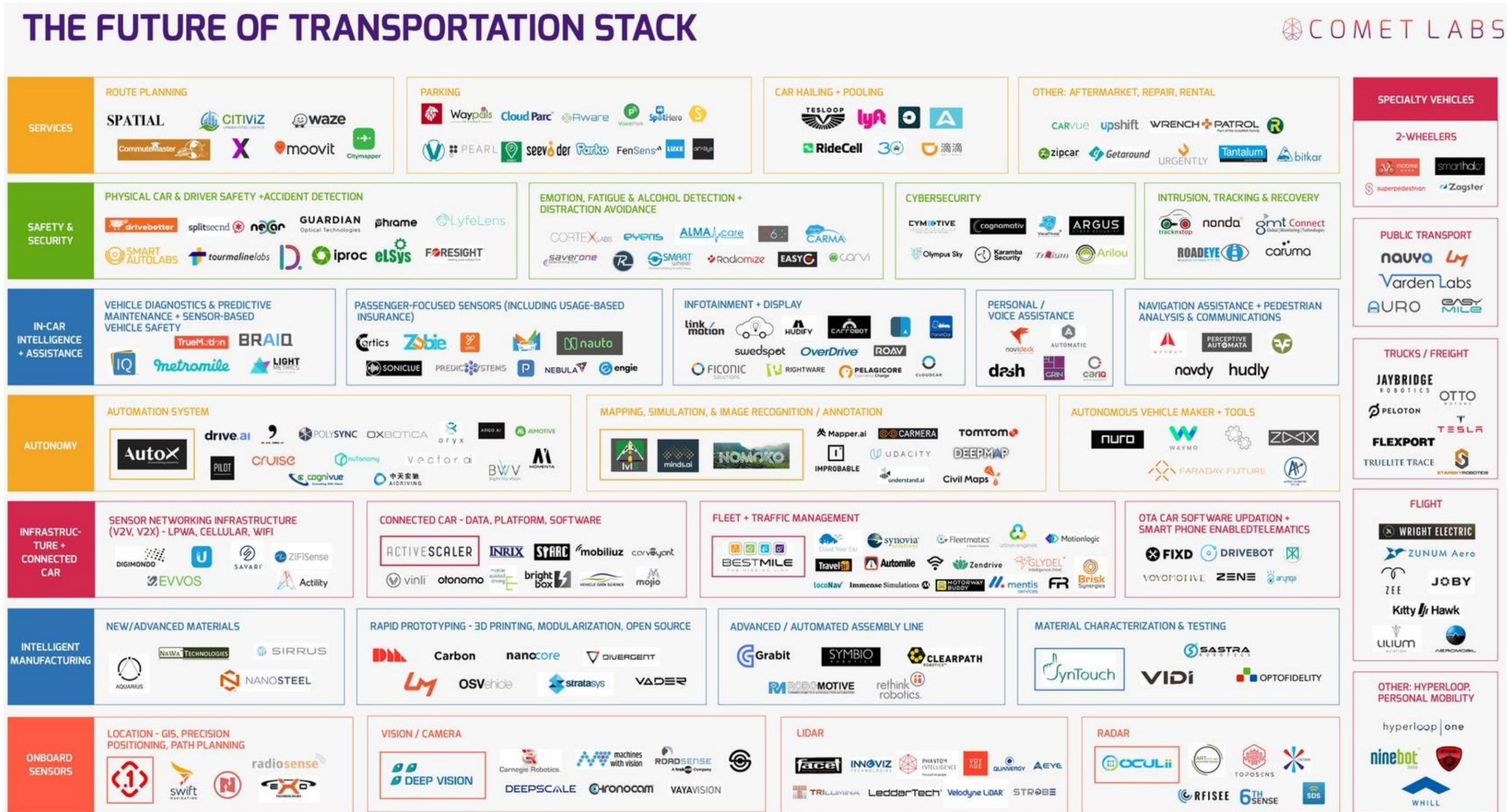
Another study of owner-operators conducted by the American Trucking Research Institute (ATRI) found only 30 percent of respondents were willing to pay for a platooning system. The median response of owner operators suggested they expected to break-even within six months of investing in a platooning system. Fleet managers had a higher threshold of 18 months.⁷

Private sector-led initiatives are the driving force behind AV/CV research and development, and the AV/CV marketplace is comprised of multiple industries, from mapping and sensors to heavy manufacturing. Figure 2-4 displays a snapshot of some of the industries and companies that are engaged in the development of AVs. Some of the same systems and companies are also working on CV technology. The remainder of this section outlines select companies engaged in truck platooning.

⁶ ITS America. 2015. “Deploying Safety Technologies in Commercial Vehicles: Market Data Study.”

⁷ Fitzpatrick, D, G. Cordahi, L. O'Rourke, C. Ross, A. Kumar, and D. Bevely. “Challenges to CV and AV Applications in Truck Freight Operations.” Transportation Research Board. December 2016.

Figure 24: Companies Involved in Autonomous Vehicles



Source: Comet Labs

Peloton

Peloton is one of the most visible private firms currently engaged in platooning work, thanks to its multiple public demonstrations across the western U.S. Peloton's platoon system uses a cloud-based computer network, GPS trackers, and cellular modems in trucks to track the locations of participating trucks and identify trucks that can platoon together. Once in platoon, speeds and distances are measured using radar and cameras, the two trucks communicate via DSRC, and throttle and braking are automatically controlled. However, steering functions are not automated, and both drivers must steer at all times. When trucks are not platooned, the radar and camera systems can still be used for adaptive cruise control, collision avoidance, and emergency braking.⁸ The Peloton system designates which truck will lead and which will follow based on braking ability, with the truck better able to brake placed in the rear.

In order to form a platoon, trucking companies must use Peloton's technology and subscribe to their service. Since the Peloton system includes cellular internet equipment, Peloton is marketing information services that can notify trucks of hazards and changing conditions well in advance. The system can also be used to track the condition and maintenance of trucks, and the behavior of drivers. According to a 2017 interview with Peloton's founder and CEO, Josh Switkes, Peloton will sell the platooning hardware to fleets roughly at the cost of production and then generate revenue based on a percentage fee assessed on the fuel savings the truck receives when the truck is platooning. The fee on fuel savings is not assessed until the user has recouped the initial cost of the hardware. This business model incentivizes platooning for Peloton and fleets, and charges the rear truck a greater fee because the fuel savings of that vehicle is higher than the lead vehicle. Peloton claims that fuel savings are 4.5 percent for the lead and 10 percent for the following vehicle and anticipates that it will begin filling orders in late 2017.⁹

In February 2017 the NWP Freight Task Force received a web briefing by Peloton describing their technology, its benefits and status of U.S. demonstrations. Peloton's presentation is in **Appendix A – Peloton Web Briefing**

Volvo

Volvo's Road Train platoon system uses cameras and radar to monitor speeds and distances and control a truck's throttle and brakes. An additional automated steering function is under development.¹⁰ These systems have been demonstrated on Volvo's European model trucks. In the U.S., however, Volvo's trucks have been outfitted with a three-truck "Cooperative Adaptive Cruise Control" (CACC) system developed by the University of California-Berkeley.

⁸ "How it Works." Peloton. 2017. <https://peloton-tech.com/how-it-works/>

⁹ Switkes, Josh. "Josh Switkes on Truck Platooning Rollout, Future Plans." Transportation Topics.

¹⁰ "Volvo Self-driving Truck Platoon in the European Truck Platooning Challenge." Volvo Group Videos. March 18, 2016. <https://www.youtube.com/watch?v=lx9EFJ6ggZc>

CACC uses radar to monitor speed and distance and DSRC to communicate with other platooned vehicles.¹¹

Daimler/Freightliner

Daimler, a German company that owns truck manufacturer Freightliner, has been working on platooning technology in various forms since 1999. Their current system is called Highway Pilot Connect, and components of this system are used in Freightliner's "Inspiration" model of truck. The Inspiration was the first autonomous commercial vehicle to operate on public roads in the U.S., and is equipped with radar and cameras that give the vehicle adaptive cruise control and automatic steering functionality, with future options for platooning. However, the Inspiration's platooning ability has not been publicly demonstrated.¹²

Navistar/International

Navistar (also known as International trucks), in conjunction with other transportation companies has developed a platooning system that can link two trucks as close as 40 feet. For Navistar's system, each truck is equipped with radar, cameras, V2V communications equipment, and a driver interface. The system allows the rear truck to operate autonomously: the rear driver does not need to control speed, or steer, while the front driver controls both speed and steering. This system was publicly demonstrated in Texas in 2016.¹³

Other Manufacturers

European truck manufacturers have developed AV/CV truck systems, but do not have a presence in the U.S. These companies include:

- DAF: A Dutch truck manufacturer using radar and WiFi to monitor distance and communicate with platooned trucks.¹⁴
- IVECO: An Italian company is developing a platooning system using cameras, radar, GPS, and Wi-Fi.
- MAN: a German company is developing a camera-based platooning system.¹⁵

¹¹ "Cooperative Adaptive Cruise Control (CACC) Definitions and Operating Concepts." Shladover, et al. University of California, Berkeley. 2014. <http://docs.trb.org/prp/15-3265.pdf>

¹² "Freightliner Inspiration." Freightliner. 2017. <http://www.freightlinerinspiration.com/inspiration/>

¹³ "Follow the Leader: Two-Truck Automated Platoon Test Is a Winner." Texas A&M Transportation Institute. 2016.

<https://tti.tamu.edu/2016/08/04/follow-the-leader-two-truck-automated-platoon-test-is-a-winner/>

¹⁴ <https://globenewswire.com/news-release/2016/04/05/825910/0/en/Autonomous-Trucks-NXP-Demonstrates-the-Future-of-Smart-Highways-and-Freight-Transport-Using-Vehicle-to-Vehicle-Communications.html>

¹⁵ http://www.truck.man.eu/de/en/man-world/man-in-germany/press-and-media/Networked-trucks_-DB-Schenker-and-MAN-intensify-their-partnership-for-autonomous-driving-287232.html

2.3 Government Truck Platooning Initiatives/Pilots/Demonstrations

2.3.1 International

European Commission CHAUFFEUR Project (1999 – 2002)

The CHAUFFEUR project was sponsored by the European Commission and ran from 1999 to 2002. CHAUFFEUR's goal was the development of basic technology necessary to support the safe operation of closely-spaced trucks in a platoon, and a public demonstration of platooned trucks on a closed track occurred in 2002. For the CHAUFFEUR project, following distances and steering control were maintained using an "electronic towbar:" cameras on following trucks would monitor special markings on the trailer in front. Onboard computers would examine the position of these markings in the camera image feed, use this spatial information to infer changes in speed and position, and adjust steering and throttle or brakes as necessary. This project was coordinated by Daimler.¹⁶

German National KONVOI Project (2005 – 2009)

While CHAUFFEUR demonstrated that platooning was technologically feasible, it did not investigate the potential benefits (such as fuel savings) of platooning. The German government, in cooperation with Aachen University developed the KONVOI project to study the social, environmental, and safety impacts of truck platoons. KONVOI used laser scanners to measure distance to the next truck and to monitor lane markings for automatic steering purposes. KONVOI was the first public test of truck platooning, and its four-truck platoons drove over 1,900 miles on German highways for nine days. The project demonstrated that fuel savings and safety improvements could be derived from platoon operations, and set the stage for future public tests.¹⁷

European Commission SARTRE Project (2009 – 2012)

The Safe Road Trains for the Environment (SARTRE) project was created by the European Commission to further develop technologies and policies that could enable vehicle platooning on European highways. Between 2009 and 2012, a group of automotive and technology companies developed a platoon system that was intended to accommodate multiple cars behind a professionally-driven lead vehicle. The first demonstration of technology developed by SARTRE occurred in 2011, with a single car autonomously following a lead truck on a closed

¹⁶ "CHAUFFEUR II." European Commission. 2002. http://cordis.europa.eu/project/rcn/56873_en.html

¹⁷ "KONVOI." Aachen University. 2012. <https://www.ika.rwth-aachen.de/en/research/projects/driver-assistance-vehicle-guidance/1636-konvoi.html>

track.¹⁸ A second demonstration took place in 2012 in Spain. This on-road demonstration using vehicles from Volvo had three cars follow a truck for 120 miles.¹⁹

Japanese ITS Projects (2010 – 2013)

The Japanese Ministry of Economy, Trade, and Industry sponsored research and development of truck platooning technology, which was demonstrated on closed tracks between 2010 and 2013. Three- and four-truck platoons were demonstrated, and researchers were able to reduce following distances to about 13 feet. In the Japanese system, following trucks were intended to be autonomous, with the exception of manual driver control for lane changes.²⁰

Daimler Autonomous Platoon Demonstration (2016)

In March 2016, Daimler demonstrated the company's Highway Pilot Connect system on a public section of the German highway system. The three-truck demonstration platoon was fully autonomous: drivers did not have to steer, or control speed. However, drivers did need to remain attentive, as the system required the lead driver to take control in certain situations, such as lane changes.²¹ A variant of the Highway Pilot Connect system is available for the Freightliner brand "Inspiration" truck in the U.S.

European Truck Platooning Challenge (2015 – 2016)

In 2015, the Dutch government created the European Truck Platooning Challenge with the goal of facilitating a multi-national harmonized approach to developing truck platooning regulations and infrastructure in Europe. **This project is especially relevant to the NWP because a major part of the demonstration's work involved negotiating problems created by different regulatory environments of multiple nations.**

In April 2016, six truck manufacturers (Scania, Volvo, Daimler (Benz), MAN, IVECO, and DAF) and five nations (Sweden, Denmark, Germany, Belgium, and the Netherlands) participated in a region-wide demonstration of truck platooning. A truck platoon from each manufacturer drove to the Port of Rotterdam in the Netherlands. Figure 2-5 shows the routes used in the demonstration.

To accommodate the decreased following distance necessary for platooning, national and regional governments along the routes issued temporary permits for platoon vehicles, which

¹⁸ "Road Train Technology Trials Get Rolling." Ward, Mark. BBC News. January 18, 2011.

<http://www.bbc.com/news/technology-12215915>

¹⁹ Project SARTRE: Volvo Road Train Travels 120 Miles Autonomously in Spain. Illiafar, Amir. Digital Trends. April 20, 2015. <https://www.digitaltrends.com/cars/project-sartre-volvo-road-train-travels-120-miles-autonomously-in-spain/>

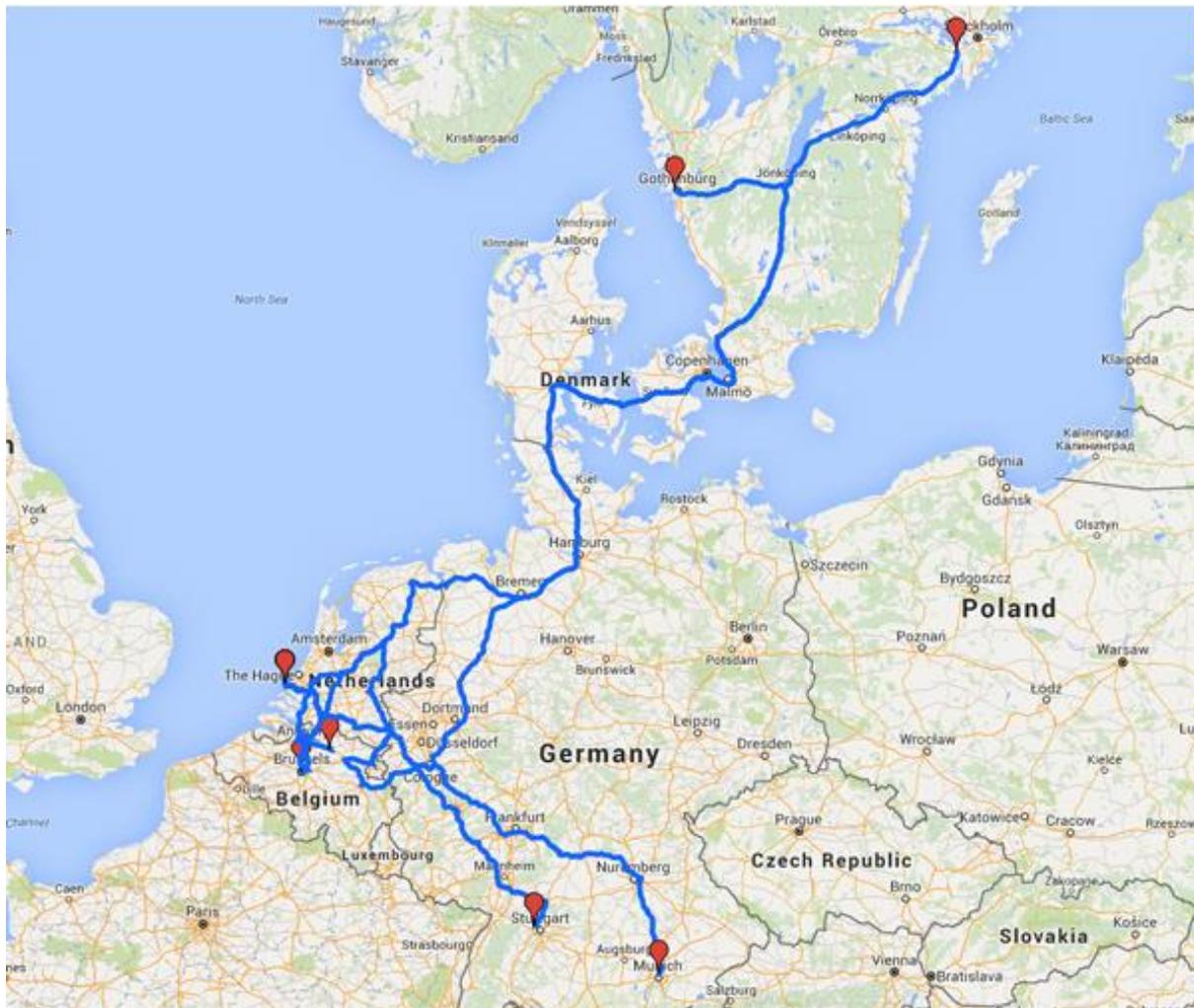
²⁰ "Current Asian Activities in Cooperative Vehicle-Highway Automation." Federal Highway Administration. 2013. <https://www.fhwa.dot.gov/advancedresearch/pubs/12033/005.cfm>

²¹ "Daimler Demonstrates Three-Truck Platoon in Germany. Transport Topics. March 22, 2016.

<http://www.ttnews.com/articles/basetemplate.aspx?storyid=41323>

allowed for a minimum following time between trucks of 0.5 to 1.3 seconds. A total of 19 transportation regulation exemptions were issued by European nations for the Challenge.

Figure 2-5: European Truck Platooning Challenge Routes



Source: European Truck Platooning Challenge. 2016

Interviews with the eighteen drivers in the platoons revealed some common responses:

- Participating truckers believed that truck platoons were more troublesome for other road users than for truckers themselves: the public often did not immediately recognize the platoon's size, and were hesitant to pass a long line of trucks.
- Re-forming platoons after traffic cut in between platooned trucks was time consuming.
- In complex situations, drivers "decoupled" from the platoon on their own, even if it was not required.

Four areas for future harmonization efforts were identified by the project:

1. **Drivers:** for the demonstration, truck drivers had to be employed by the manufacturer of the truck they drove (Volvo, Daimler, etc.), and following trucks in the platoon had to have a co-driver. These requirements were considered barriers to participation for future field tests, and barriers to adoption of platooning technology, as the requirement for co-drivers would increase labor costs.
2. **Vehicle characteristics:** identification requirements for platooned vehicles varied between countries. For example, some nations required different combinations of platoon notification placards and flashing lights.
3. **Load:** truck weight restrictions varied between nations. Some of the 19 exemptions issued for the demonstration imposed a weight limit of 20 metric tons per truck, and some exemptions required platoons to either increase following distance, or decouple before crossing weight-sensitive bridges. Project leaders concluded that platoons' wear and tear on pavements and bridges warrants further research.
4. **Settings of the platooning system:** a greater understanding of whether or not platooning system settings (ex: following distance) are easily changed when crossing borders. If some settings are not flexible, those topics must be harmonized across nations.²²

²² "Lessons Learnt." European Truck Platooning Challenge. 2016.

2.3.2 United States

In the U.S., truck platoon-specific legislation and demonstrations have been underway since 2013. Figure 2-6 provides a timeline of these demonstrations and legislation.

Figure 2-6: Truck Platoon Legislation and Demonstration Timeline

Date	State	Accomplishment
2013		
November	Utah	Platoon demonstration with CR England trucking
2014		
May	Nevada	Platoon demonstration on I-80
2015		
May	Utah	Reduced following distance regulation for platooning
August	California	Exempted platoon demos from minimum following distance regulation
November	Utah	Platoon demonstration on I-80
November	California	Peloton platoon demonstration near Sacramento
2016		
July	Florida	Legislation instructing FDOT to study truck platooning technology, and authorizing a pilot project to test vehicles
July	Texas	Technology demonstrations on closed tracks
July	Michigan	U.S. Army truck platoon demonstration on I-69
December	Michigan	Exempted platoon demos from minimum following distance regulation
2017		
January	Multiple	Pennsylvania, Michigan, and Ohio created 'Smart Belt Coalition' to promote development of AV and CV technologies, including truck platooning
March	California	Platoon demonstration near Port of Los Angeles
April	Arkansas	Reduced following distance regulation for platooning
May	South Carolina	Exempted platooned trucks from following distance regulations
Upcoming Events		
TBD	Iowa	Platoon enabling legislation under consideration
TBD	Ohio	Planned platoon demonstrations on Ohio Turnpike
TBD	North Carolina	Platoon enabling legislation under consideration

Utah

In November 2013, Utah hosted the U.S.’s first public truck platoon demonstration, which was organized by Peloton and the C.R. England trucking company.²³ Two years later, in May 2015,

²³ “Nevada state agencies to observe truck technology demonstration - DOT, DPS, DMV to see two-truck platooning demonstration.” Nevada Department of Motor Vehicles. May 2014. <http://www.dmvnv.com/news/14005-truck-tech-demo.htm>

Utah House Bill 373 lowered the following distance requirements for platooned vehicles to 30 feet. This enabling legislation was followed by another Peloton platoon demonstration on I-80.²⁴

Nevada

Peloton's second public platooning demonstration was performed in May 2014 on I-80 in Nevada.²⁵

California

In August 2015, California Senate Bill 719 authorized CalTrans to test platoon technologies, and required CalTrans to prepare a report on the findings of these tests by July 2017.²⁶ Three months later, Peloton performed a platoon demonstration for state officials near Sacramento.²⁷ In March 2017, CalTrans and its partners hosted a platooning demonstration featuring technology from UC Berkeley. For this demonstration, a three-truck platoon operated repeatedly on a 12-mile portion I-110 near the Port of Los Angeles.²⁸

Texas

The Texas A&M Transportation Institute (TTI), FHWA, and Texas DOT collaborated to host a platoon demonstration in July 2016. This two-truck demonstration was hosted on a closed track, and featured technology developed by multiple private-sector partners. Unlike the Peloton demonstrations, which only controlled acceleration and braking, the TTI demonstration allowed for the following trucks to operate autonomously, both steering, and speed were controlled with no driver intervention. As part of the demonstration, an autonomous truck followed a human-controlled truck through lane changes, speed changes, and figure-eight maneuvers.²⁹ This demonstration was the first U.S. demonstration where following trucks followed the steering actions of a human-controlled lead truck.

The TTI project has just entered Phase 2 of a three Phase project. While demonstrations to date have been on a closed course, Phase 3 seeks to conduct a "real world" demonstration in corridors that have the following requirements. Corridor stretches in the NWP could very well satisfy these requirements:

²⁴ "Peloton Demonstrates Truck Platooning for Top Utah Transportation Officials." Peloton. 2015. <https://peloton-tech.com/20151120/>

²⁵ "Truck Platooning System Tested in Nevada. Transport Topics. June 6, 2014. <http://www.ttnews.com/articles/basetemplate.aspx?storyid=35167>

²⁶ "Senate Bill No. 719." California Legislative Information. 2015. http://leginfo.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB719

²⁷ "Peloton Demonstrates Truck Platooning in California." Peloton. November 5, 2015. <https://peloton-tech.com/20151105/>

²⁸ "California Demonstrates Truck Platoon in Los Angeles." Transport Topics. March 9, 2017. <http://www.ttnews.com/articles/basetemplate.aspx?storyid=45202>

²⁹ "Follow the Leader: Two-Truck Automated Platoon Test is a Winner." Texas Transportation Researcher. 2016. <https://tti.tamu.edu/2016/12/01/follow-the-leader-two-truck-automated-platoon-test-is-a-winner-2/>

- 4-lane, rural interstate highways
- Low AADT
- High truck percentage, at least 15% of AADT
- Relatively long stretches of highway between urban centers
- Posted speed limit \geq 65 mph

The TTI Phase 3 activities are expected to begin after Phase 2 is complete in April 2019.

TTI has hosted demonstrations to continue to educate state decision makers on platooning technology and its' benefits. One such demonstration was hosted on May 5, 2017 in conjunction with the Texas A&M Transportation Technology Conference in College Station, TX. One NWP member state attended the demonstration and provided his perspectives during the NWP Steering Committee's Annual Meeting on May 16, 2017. TTI also presented information on their efforts during the Annual Meeting. These presentations are provided in **Appendix B – TTI/Texas DOT Truck Platooning Initiatives**

Florida

The 2016 Florida DOT funding package required the DOT to study the use and operation of truck platooning technology, and authorized a pilot project to test platooning technology-equipped trucks.³⁰

Michigan

Michigan has been the site of multiple truck platoon demonstrations by the U.S. Army Tank Automotive Research, Development, and Engineering Center (TARDEC), which is located in Michigan. In July 2016, TARDEC demonstrated platooning technology on I-69.³¹ In December 2016, the Michigan Legislature passed legislation that exempted platooned vehicles from minimum following distance requirements. The law also allows for individuals to operate platoons, but they must file a plan detailing their platoon operations (such as route) with the state police and the Michigan DOT.³² The next month, Michigan DOT, in partnership with the University of Michigan, and organizations in Ohio and Pennsylvania, created the "Smart Belt

³⁰ HB 7207 – Department of Transportation. The Florida Senate. 2016.

<https://www.flsenate.gov/Committees/billsummaries/2016/html/1356>

³¹ "The Army's Self-Driving Trucks Hit the Highway to Prepare for Battle." Wired. July 8, 2016.

<https://www.wired.com/2016/07/armys-self-driving-trucks-hit-highway-prepare-battle/>

³² "Senate Bill 0995." Michigan Legislature. 2016.

[http://www.legislature.mi.gov/\(S\(cng3vfvqvcouaxfa3q0pgaqhl\)\)/mileg.aspx?page=getobject&objectName=2016-SB-0995](http://www.legislature.mi.gov/(S(cng3vfvqvcouaxfa3q0pgaqhl))/mileg.aspx?page=getobject&objectName=2016-SB-0995)

Coalition.” The Coalition will focus on automated and connected vehicle initiatives, including research on truck platooning.³³

Other Non-North/West Passage States

- Arkansas exempted platooned vehicles from its following distance requirements in April 2017.³⁴
- South Carolina exempted platooned vehicles from its following distance requirements in May 2017.³⁵
- Iowa and North Carolina are considering legislation that would enable platoon operations by reducing following distances.^{36, 37}
- Ohio is expected to host a Peloton platoon demonstration on the Ohio Turnpike in 2017.³⁸

³³ “Transportation Agencies in Pennsylvania, Ohio, and Michigan Form ‘Smart Belt Coalition’ to Collaborate on Automated, Connected Vehicles. Pennsylvania DOT. January 17, 2017. <http://www.penndot.gov/Pages/all-news-details.aspx?newsid=287>

³⁴ “Truck Platooning’ Soon to be Seen on Arkansas Interstates. Della Rosa, Jeff. Talk Business & Politics. 2017. <http://talkbusiness.net/2017/04/truck-platooning-soon-to-be-seen-on-arkansas-interstates/>

³⁵ Assembly Bill 66. South Carolina General Assembly. May 19, 2017. http://www.scstatehouse.gov/sess122_2017-2018/bills/3289.htm

³⁶ “Truck Platoons Could Hit US 20 in Iowa this Year.” Lynch, James Q. Quad City Times. February 22, 2017. http://qctimes.com/news/state-and-regional/iowa/truck-platoons-could-hit-u-s-in-iowa-this-year/article_2b093c7a-b4ca-5068-b98e-5ccb7c84bc76.html

³⁷ “Senate Leaders Tap Brakes on ‘Platooning’ Trucks.” WRAL-TV. May 14, 2017. <http://www.wral.com/senate-leaders-tap-brakes-on-platooning-trucks/16707520/>

³⁸ “Turnpike Travelers Will See Semi-Autonomous Trucks on the Road this Year.” Christ, Ginger. Cleveland.com. April 1, 2017. <http://www.cleveland.com/metro/index.ssf/2017/04/turnpike-travelers-will-see-se.html>

3 Truck Platooning in the North/West Passage

Key Chapter Takeaway

During NWP Freight Task Force Year 1 (2014) both autonomous and connected vehicles were identified as areas for potential future research. During the course of conducting Freight Task Force Year 2 activities which, in part, aimed to confirm research and implementation priorities for the corridor, autonomous and connected vehicles generally, and as applied to commercial vehicles specifically, received wide interest from most states.

Four research initiatives have been identified for further study by the NWP and are in various stages of advancement:

- Day One Activities to Prepare for Connected and Automated Vehicles (on-going)
- Model Legislation for Autonomous and/or Connected Vehicle Operations (expected, 2017/18)
- Multistate Commercial Vehicle Platoon Demonstration (awaiting research results)
- Expanded I-80 Connected Vehicle Pilot (not funded)

And, in the states of North Dakota and Washington, legislation is being considered/put in place to ensure that autonomous vehicles – their operations and impacts – are considered in the future.

The NWP could serve as a unique demonstration location for both autonomous and connected vehicles in that – the corridor states have a history of partnership on operations, the multi-state nature of the corridor could serve as a testbed that has not yet been explored in a U.S. demonstration, the corridor presents weather and terrain challenges, and states are actively taking steps on their own that could be enhanced through partnership with others.

3.1 Project Concepts and Current Status

3.1.1 Current North/West Passage Research

NWP Project 11.4, *Day One Activities to Prepare for Connected and Automated Vehicles* was initiated in 2016, with the goal of identifying strategies, plans, or policies to prepare for the potential adoption of AV/CV technologies. The findings of this project could inform future NWP work on commercial AV/CV demonstrations and policies. Project 11.4 includes the following tasks:

- Work with NWP member agencies to confirm (and define details of) the need for better guidance on what they need to do to prepare for AV/CV deployments.

- Provide NWP members with direction to better use the vast amount of resources that have been (and are still) being developed regarding AV/CV technologies and preparation guidance.
- Develop a mechanism for NWP members to share knowledge of AV/CV resources in an organized way to maximize efficient use of such material.
- Identify gaps and/or needs for additional training or skills needed to make AV/CV deployments a success.
- Develop a plan to help achieve the additional training and knowledge identified as missing from current sources

As the findings of Project 11.4 become available, NWP states should identify the next steps to prepare for AV/CV deployments, with an explicit focus on the role of the NWP as a regional group. A focus on the role of the NWP will ensure that projects provide value to the passage as a whole.

3.1.2 Proposed North/West Passage Research

Model Legislation for Autonomous and/or Connected Vehicle Operations

In 2014, the NWP Freight Task Force identified commercial AV/CV operations as a potential topic for future research. While AV/CV commercial vehicles have the potential to revolutionize trucking in the NWP, the legislation required for AV/CV operations is not in place in most NWP states.³⁹ For example, many states require trucks to maintain a minimum following distance that is too far apart for platooning operations to yield any fuel savings.

One of the proposed Freight Task Force projects seeks to develop model legislation to allow AV/CV operations in NWP states. Tasks include collecting examples of successful legislation, and interviews with representatives in states where AV/CV legislation failed, and in states where it was successfully adopted. AV/CV legislation best practices would be identified, and model legislation would be developed for potential adoption by NWP states.⁴⁰

When this project was first proposed in 2013, the estimated time was six to nine months, and estimated cost was about \$25,000. In spring 2017, states were asked to re-evaluate their desired research projects, and Figure 3-1 shows which states are currently interested in developing model legislation for AV/CV operations.

³⁹ Technical Memorandum 1: Freight Task Force Work Plan, North/West Passage, October 2014

⁴⁰ Ibid.

Figure 3-1: State Interest in Model Autonomous Vehicle Legislation, 2017

State	Status
Idaho	Interest in the topic, but not currently funded
Minnesota	Interest in the topic
Montana	Interest in the topic, but not currently funded
North Dakota	Active
South Dakota	Interest in the topic
Washington	Interest in the topic
Wyoming	Interest in the topic, but not currently funded

Source: CPCS Survey of NWP States. Updated July 2017, during truck platooning roundtable discussion.

In early 2017, North Dakota’s legislature signed a bill directing the North Dakota DOT to begin: studying how autonomous vehicles could be used in the state, gathering information on what data could be collected by autonomous vehicles, and studying how current laws and requirements would apply to autonomous vehicles. The long-term goal of the bill is to support the state’s role as an early leader in autonomous vehicle development.⁴¹ In Washington State a bill has been introduced in the legislature aimed at getting government agencies ready to deal with driverless cars.⁴²

Due to the strong NWP state interest in commercial AV/CV operations, and the natural cross-border movements of autonomous vehicles, it makes sense for the NWP to lead research so that AV/CV standards established at the national level consider state DOT perspectives.

This project has been funded and is expected to be included in NWP Freight Task Force Year 3 activities.

Multistate Commercial Vehicle Platoon Demonstration

Another proposed Freight Task Force research project is a commercial vehicle platoon demonstration, similar to demonstrations that have been performed in Europe, Utah, Nevada, and California. However, differing CV and safety regulations between NWP states could be a potential barrier to a demonstration. Should NWP states successfully pass legislation enabling CV operations, platooning will become a potential research topic.⁴³

The purpose of this project is to demonstrate the potential safety and environmental benefits of platooning in the NWP corridor. Possible tasks include applying for grants to explore and

⁴¹ “Lawmakers Encouraging Self Driving Vehicle Research,” The Bismarck Tribune, January 19, 2017

⁴² “Washington state considers autonomous vehicle regulations — but is it too early?,” GeekWire, March 17, 2017

⁴³ Technical Memorandum 1: Freight Task Force Work Plan, North/West Passage, October 2014

demonstrate multi-state, multi-vehicle platoons.⁴⁴ The current NWP work plan includes multistate commercial vehicle platoon discussions and next steps identification.

The advancement of this research project will be partially informed by the output of Project 11.5: Exploring Options for Truck Platooning along the North/West. Project 11.5 (the subject of this Working Paper – Truck Platooning Exploration).⁴⁵ Information and recommendations from this project will inform the options and opportunities for the NWP Freight Task Force to pursue a Multistate Commercial Vehicle Platoon Demonstration Project.

When proposed, the CV demonstration project was expected to take two years,⁴⁶ with an estimated cost of \$250,000. Again, in spring 2017, states were asked to re-evaluate their desired research projects and Figure 3-2 shows states’ current level of interest in a platoon demonstrations. Future projects should take the findings of this current platooning work, and states’ level of interest into account.

Figure 3-2: State Interest in Commercial Motor Vehicle Platoon Demonstration

State	Status
Idaho	Interest in the topic, but not currently funded
Minnesota	Interest in the topic
Montana	Interest in the topic, but not currently funded
North Dakota	Interest in the topic, but not currently funded
South Dakota	Interest in the topic
Washington	Interest in the topic
Wyoming	Interest in the topic, but not currently funded

Source: CPCS Survey of NWP States. Updated July 2017, during truck platooning roundtable discussion.

As a group of states with a shared highway corridor and varied terrain, the NWP is in unique position to host a long-distance demonstration of platooning technology. This regional approach makes this project a good candidate for future cooperation.

Expanded I-80 Connected Vehicle Pilot

Sponsored by the U.S. DOT Intelligent Transportation Systems Joint Program Office (ITS JPO), the Connected Vehicle Pilot Deployment Program is a national effort to deploy, test, and operationalize mobile and roadside technologies and enable multiple connected vehicle

⁴⁴ Ibid.

⁴⁵ Transportation Pooled Fund Study TPF-5(190) – FINAL Work Plan 11, North/West Passage, August 16, 2016. Note: this Working Paper will form the content of this Pooled Fund Study.

⁴⁶ Note: research shows that the European demonstration was coordinated in one year.

applications. In September 2015, the U.S. DOT awarded the I-80 corridor in Wyoming a grant to explore a freight-focused connected vehicle application.

I-80 in Wyoming is a major corridor for east/west freight movement and conveys more than 32 million tons of freight per year. At 6,000 feet in elevation, during winter, wind speeds and gusts exceed 30 mph and 65 mph respectively and crash rates are 3 to 5 times as high compared to the summer. The Wyoming DOT pilot is developing applications that use V2I and V2V connectivity to support a range of services from advisories including roadside alerts, parking notifications and dynamic travel guidance to help reduce the number of blow over and adverse weather related incidents in the corridor in order to improve safety and reduce incident-related delays.⁴⁷

In November 2016, the NWP Freight Task Force received a web briefing on Wyoming's I-80 connected vehicle pilot providing an overview of the project, its expected benefits, and the technology that will be deployed. The presentation is in **Appendix C – I-80 Connected Vehicle Demonstration**

In 2016, AASHTO announced the SPaT Challenge (Signal Phase and Timing Challenge) as an initiative to encourage state and local DOTs to take a first step in deploying connected vehicle technologies at signalized intersections. As a result, many DOTs will deploy DSRC broadcasts of signal phase and timing from signalized intersections, learning about the procurement, deployment, operations, and maintenance of connected vehicle equipment in the process.

NWP members have expressed interested in the SPaT Challenge, as it would enable NWP members to take another step toward rural freeway connected vehicle deployment, and build on the I-80 Connected Vehicle Pilot. In the Wyoming pilot, approximately 400 vehicles will be equipped to broadcast and receive the Basic Safety Message (BSM). Of the 400 vehicles equipped, 150 will be commercial vehicles (heavy trucks), and most likely some of these commercial vehicles will travel outside Wyoming. As these vehicles will continuously be broadcasting the BSM, NWP members could deploy one or more BSM receivers on the roadside to capture the DSRC BSM messages broadcasts from these vehicles.⁴⁸

The SPaT Challenge component of the I-80 connected vehicle pilot has not been funded by the NWP.

3.1.3 Future Funding Considerations for AV/CV Research Projects

The increased national and international interest in AV/CV technology presents a significant opportunity for NWP member states to actively pursue funding, and NWP states could position themselves to pursue grant opportunities on a multistate basis when available. Opportunities vary between connected and autonomous technologies.

⁴⁷ U.S. DOT ITS Joint Program Office, Connected Vehicle Pilot Deployment Program
https://www.its.dot.gov/pilots/pilots_wydot.htm

⁴⁸ North/West Passage, SPaT Challenge Project Description

In regard to connected technologies, there are a significant number of programs that allow for investment in V2I equipment that can interact with CVs. These programs include the National Highway Performance Program, Surface Transportation Block Grant, Congestion Mitigation and Air Quality Program, and the National Highway Freight Program. Additionally, research and demonstrations could be eligible for research and implementation projects, as shown by Wyoming DOT's receipt of a grant under the CV Pilot Deployment Program. Other funding programs may also be applicable, the Intelligent Transportation Systems Program and the Advanced Transportation and Congestion Management Technologies Deployment Program both note CVs as an area of focus.

AVs do not have the same infrastructure needs as CVs. Therefore, it is likely that subsequent projects will be research focused, making NWP Pooled Funds and state research funds relevant funding sources. Additionally, the Federal Government is dedicating significant funds to conduct AV/CV research. Active Federal research should be considered when defining the next steps for AV/CV research in the NWP.

3.2 Following Distance Laws in the North/West Passage

As indicated in Section 2.2, in February 2017 the NWP Freight Task Force received a web briefing by Peloton describing their technology, its benefits, and status of U.S. demonstrations. Peloton's presentation is in **Appendix A**. As part of the Peloton presentation, they provided an overview of the following distance laws in the NWP.

As shown in Figure 3-3, there are two main types of requirements in state vehicle codes:

- A variable distance standard (which is often referred to as a "reasonable and prudent" requirement), and
- A fixed distance standard (which specifies the required minimum distance between motorized vehicles).

States have either one or the other of these requirements, not both. In terms of platooning, generally (and the Peloton product specifically), states that have a reasonable and prudent standard often have the flexibility to introduce a demonstration with minimal or no legislative changes. For example Ohio officials have interpreted their reasonable and prudent standard to mean that platooning is allowed on Ohio's roadways.

In the NWP, the states of Idaho, Montana, North Dakota, South Dakota, Washington, and Wyoming have reasonable and prudent standards, and Minnesota has a fixed distance standard.

Figure 3-3: “Following too Closely” Laws

“Following too closely” laws – typical legal elements

- Two common elements to prevent rear-end collisions involving combination vehicles
 - Variable distance standard
 - typically phrased as a “reasonable and prudent” requirement
 - discretionary – accounts for speed, traffic, etc.
 - 28 states – including ID, MT, ND, SD, WA, WY
 - Fixed distance standard
 - varies by state between 100 and 500 ft
 - 22 states – including MN
- All states have additional element(s) such as requiring “sufficient space” for another vehicle to “enter and occupy”



Source: Peloton

3.3 Roundtable Discussion on Truck Platooning in the North/West Passage

On July 12, 2017, a small roundtable discussion of NWP member states was convened to gauge interest in three general areas related to truck platooning:

1. If the NWP state has an interest in a truck platooning project along the I-90/94 corridor,
2. If the NWP state has any concerns about a private led truck platooning demonstration along the I-90/94 corridor, and
3. If the NWP state has a preference in advancing a truck platooning project as a corridor, or as individual states.

Staff from the states of Idaho, Minnesota, Montana, North Dakota, South Dakota, and Washington joined the discussion. Wyoming was unable to attend. The attendees were each provided content from this Working Paper (Sections 1 through 3.1) as background in advance of the discussion, and a short presentation was provided during the roundtable to ensure all attendees had the same base level of understanding with respect to AV/CV technology, truck platooning demonstrations conducted elsewhere, and the status of CV-related activities by the NWP Coalition. The roundtable presentation is in **Appendix D – Truck Platooning Roundtable**

At the onset of the roundtable each state was provided an opportunity to note if their state is pursuing truck platooning or related legislative initiatives. Of the states in attendance North

Dakota indicated they are considering what studies may be needed to advance the truck platooning concept, South Dakota is considering legislation that should be fed into the next state legislative cycle, and Washington recently passed an executive order that enables the testing of AVs in the state and their Department of Licensing established a licensing/permitting process for these applications.

The following subsections highlight the discussion among NWP states during the roundtable.

Interest in a Truck Platooning Project Along the I-90/94 Corridor

Each of the states participating in the roundtable noted that they were either interested in a truck platooning project along the corridor, or were not openly opposed to one. North Dakota noted their interest and the interest by the legislature, as evidenced by the questions to the DOT. South Dakota noted that they are most interested in developing model legislation to enable truck platooning, and also indicated that if a truck platooning project were advanced, objectives would need to be established for the demonstration so that the effort wouldn't be redundant of others work. Minnesota, South Dakota and Montana all suggested an approach that first worked on capturing "low hanging fruit" – and indicated that likely this first step would be to work on legislative barriers. In terms of a demonstration, Idaho noted that there are parts of the I-90/94 corridor that likely wouldn't be suitable for a demonstration (e.g., narrow and mountainous passes), and that a demonstration that touched at least two states to work on legislative issues, as well as aimed at any new technical objectives, would be ideal.

Concerns about a Private Led Truck Platooning Demonstration Along the I-90/94 Corridor

As shown, most demonstrations have a large private sector component. When queried, the group expressed minimal concern about private sector involvement or lead in a demonstration. The group did note that the private sector would have to have liability insurance at a level adequate/acceptable for states. Also, that it will be important for the states where the demonstration is held to work with the private sector during scoping and mobilization so that the demonstration is conducted safely. This could mean that the demonstration is not held in areas where terrain poses challenges, or where adverse weather is a concern. Minnesota specified that the state would need to have an oversight role during field work/demonstration. Washington noted that licensing and registration will need to be addressed before mobilization.

Preference in Advancing a Truck Platooning Project as a Corridor, or as Individual States

There was general consensus from the group that the NWP corridor provides a unique opportunity to conduct a demonstration jointly, and focusing on a portion of the corridor that covers at least two states. As noted in Section 3.2, following distance requirements of states may preclude participation absent legislative changes. The only state in the NWP that does not have a "reasonable and prudent" standard is Minnesota; potentially posing additional challenges if Minnesota were part of a platooning demonstration. North Dakota indicated that it may be a good candidate because terrain is straight and flat; they are also actively investigating legislative changes to allow for AVs to operate in the state. Both South Dakota

and Washington had words of caution. For South Dakota, approaching the demonstration as a corridor would benefit understanding of border issues, but it would also make logistics harder. Washington noted it may be difficult for the state to participate in the demonstration; due to I-90 having a large population center at the border (Spokane) that could make a cross border deployment there difficult.

Other Thoughts on a North/West Passage Truck Platooning Demonstration

Additional discussion during the roundtable centered on what features or considerations are most important to the states if the NWP did pursue a demonstration. Some of these points are reiterated from the earlier discussion.

- Need to distinguish the NWP from other efforts (as shown in Section 2.3).
- Need to set project and research objectives to focus the effort.
- Further consider some of the unique features of the NWP and how they could be used to set research objectives (e.g. weather conditions (wind and snow), seasons (which translates to intense construction activity/work zone during milder months), terrain/elevation change, and multistate partnership).
- Consider both the legislative/regulatory issues with a demonstration, as well as an appropriate site to conduct the demonstration in the field.
- Ensure there is not a cost burden to host states.
- Reach out to the NWP academic community to see if there is interest in participation, which could help advance research objectives, understand their available resources, and potentially their ability to aid in cost sharing.

Again, while the group was willing to discuss conducting a field demonstration in the NWP, they reiterated that the next steps should be scaled appropriately and ease the NWP gradually into a demonstration. This could mean that the first steps would be to work together on legislative barriers. North Dakota also indicated that the Central North American Trade Corridor Association is advancing US 83 as an autonomous corridor for both land and air based vehicles between Canada and Mexico.⁴⁹ Specifically, a platooning demonstration is being discussed along the corridor between Minot, ND and Bismarck, ND. This could be something the NWP could build upon.

⁴⁹ "Autonomous Friendly Corridor," Central North American Trade Corridor Association, <http://www.cnatca.com/Autonomous-Friendly-Corridor>

4 Next Steps

Key Chapter Takeaway

Based on research presented in this Working Paper and interest expressed during the roundtable discussion, next steps were identified to flow over the course of 18-months. Next steps were developed keeping in mind that NWP members expressed interest in taking small steps first, and not directly jumping into a truck platooning demonstration absent a better understanding the corridor potential.

4.1 Lessons Learned

The background research in Section 2 related to AV/CV technology generally, and truck platooning technology specifically, as well as the demonstrations previously conducted provide a number of lessons learned for the NWP, including:

- The development and advancement of technology and applications is moving at a very fast pace. Additionally, there are many private sector companies in the space aiming to carve out their own unique niche.
- Industry is ahead of DOTs in terms of implementation. In fact, industry is finding ways to conduct demonstrations and deploy technology absent interfacing with public sector agencies and regulations.
- Most truck platooning demonstrations are led by the private sector, sometimes with a university partner providing expertise for the DOT to leverage.
- Truck platooning demonstrations have been successfully conducted in several settings:
 - Multi-jurisdiction (Europe)
 - 2- (U.S.), 3- (Europe) and 4-(Japan) truck platoon configurations
 - Closed track, open road
- Following distance legislation is key barrier for on-the-road demonstrations.

As the NWP states endeavor to advance truck platooning in the corridor, these points should be considered along with feedback received during the roundtable discussion described in Section 3.3.

4.2 Action Plan

4.2.1 Next Steps

The following presents a suggest list of next steps. Next steps were developed keeping in mind that NWP members expressed interest in taking small steps first, and not directly jumping into a truck platooning demonstration absent a better understanding the corridors potential.

North/West Passage Role

First, it is recommend that the NWP continues to serve in a lead role related to truck platooning. This is particularly important as the NWP member states have interest in exploring a number of legislative and demonstration next steps that cross borders and could benefit from the NWP serving as a clearing house of information and a neutral forum for discussion.

A Project Champion should be established to lead and follow through with recommended actions. As the NWP Freight Task Force already has a formal structure that designates state and staff leads for various topics, it is recommended that this structure be followed and a lead for future truck platooning activities is named (Project Champion). As mentioned in the following section on timeline of activities, depending on the speed NWP states would like to advance activities, multiple state task leads that support the Project Champion should be designated to work on behalf of the members on specific activities.

Model Legislation for Autonomous and/or Connected Vehicle Operations

As noted in Section 3.1.2, as part of NWP Freight Task Force Year 3 activities this project to develop model legislation has been funded. Considering the operating and legislative environment (and barriers) within and among NWP states is a step that is in line with feedback provided during the roundtable discussion. This initial step start with legislation and provides a basis to build upon gradually.

Identify Research Gaps and North/West Passage Objective

While the concept of a truck platooning demonstration has been discussed by the NWP for a number of years, to date no formalized concept or research objective has been developed. Based on the information provided in this Working Paper, as well as the roundtable discussion, some features the NWP may consider in constructing a demonstration that advances truck platooning research include:

- Multistate demonstration
- 2+ truck platoon demonstration
- Evaluation of platoon operations in various conditions/situations:
 - Weather conditions (wind and snow)
 - Seasons (which translates to intense construction activity/work zone during milder months)

- Terrain/elevation change

There are likely numerous other features that could be considered to ensure a NWP demonstration unique in the U.S. As these are further explored, a vision for the corridor/research objective should be formed to focus all future truck platooning related activities.

Seek University or Other Research Partner

Many of the truck platooning demonstrations, in particular the Texas demonstration that is working toward advancing to Level 2 automation, have a university or research partner on the team. The NWP itself has a number of research institutions (e.g., the Upper Great Plains Institute at North Dakota State University, Western Transportation Institute at Montana State University, Pacific Northwest Transportation Consortium at the University of Washington, or other) that should be leveraged. In seeking a university or other research partner there could be beneficial in understanding the university's ongoing research and research strengths, and building on those as appropriate as a research objective is formed.

Identify Potential Demonstration Location(s)

The NWP members have provided some initial thoughts on what locations could work better than others (e.g., border between North Dakota and Montana could be better than the borders between North Dakota and Minnesota or Washington and Idaho). Bi-state corridor segments should be identified, and discussions convened with state DOTs and other potentially affected agencies, as appropriate. This step does not select "the" corridor(s) for demonstration, but rather identifies a slate of possibilities that best aligns with research objectives.

Leverage Private Sector Innovations

Building on the previous recommended activities, a refined demonstration concept will be beginning to form. At this point, in an effort to leverage private sector resources, a Request for Information (RFI) should be published to collect ideas and insights from a variety of industry players and potential partners based on the concepts and research objectives conceived by the NWP. During the RFI process vendors can respond to and augment the concept based on their perspective and the technology they offer. After evaluation of the RFI responses, the NWP can better gauge if it is in their best interests to proceed with a demonstration and the potential vendors that may be able to assist.

4.2.2 Timeline of Activities

A conceptual timeline of activities, leading up to mobilizing toward a demonstration is shown in Figure 4-1. The key items presented in the previous section are aligned against a monthly timescale.

Figure 4-1: Potential Timeline of North/West Passage Next Steps

Activity	Month																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Model Legislation for Autonomous and/or Connected Vehicle Operations	█	█	█	█	█	█	█	█	█									
2. Identify Research Gaps and North/West Passage Objective							█	█	█									
3. Seek University or Other Research Partner							█	█	█	█	█	█						
4. Identify Potential Demonstration Location(s)												█	█	█				
5. Leverage Private Sector Innovations														█	█	█	█	
6. Evaluate Next Steps																		█

As shown, the first activity beginning in **Month 1** is reflective of one the NWP Freight Task Force has already identified as a next step - Model Legislation. When originally scoped this task was anticipated to have a six to nine month duration. In the interest of providing a conservative schedule, the nine month duration was used.

The next two activities, Identify Gaps and Research and Seek University or Other Research Partner, should be conducted in coordination with each other. These activities are slated to begin in **Month 7**, but could also begin earlier. The intent of scheduling this activity during Month 7, is to ensure that state resources (namely personnel) tasked with overseeing these activities is not overly taxed. Traditionally, the NWP Freight Task Force has had a single lead/champion, but if the desire is to initiate Activities 2 and 3 earlier, it is recommended that a second NWP Freight Task Force member is assigned to champion these steps. Conversations and establishing a formal partnership with the selected research partner is expected to extend beyond simply discussion of research topics (Activity 2).

The fourth activity relates to identifying a demonstration location(s) and begins in **Month 12**. And, again, this step could be accelerated provided level of comfort by NWP members, as well as available staffing resources.

The fifth activity, beginning in **Month 14**, reflects solicitation additional information on technology and applications through a Request for Information (RFI). The idea here is that the activities in Months 7 through 14 will have help the NWP refine research objectives, potential research or evaluation partner and possible location(s) for a demonstration that vendors can

respond to and augment based on their perspective. The process of developing an RFI and soliciting responses is expected to take four months.

Lastly, in **Month 18** after information is received related to vendor interest and technology proposals, the NWP has a few options:

- Advance discussions with one of the vendors,
- Selectively solicit vendors from the RFI results to respond to a competitive RFP,
- Continue to refine the concept of a truck platooning demonstration in the NWP internally, among NWP members, or
- Decide that an alternate approach is in the better interest of NWP members (e.g., postponing or canceling discussions on a NWP truck platooning demonstration).

As noted in several places in this timeline description, each of these steps could potentially be advanced at a quicker pace, but they have been intentionally spaced to provide NWP members an increased level of comfort with the process.

Appendix A – Peloton Web Briefing

Preventing Crashes Saving Fuel Connecting Trucks



Safety must be our highest priority



- From NTSB: In 2012, over 1.7 million rear-end crashes
 - almost half of all 2-vehicle crashes
 - 1,705 fatalities and over half a million injuries
- Highway end-of-queue crashes involving commercial vehicles (often with fatigued or distracted drivers) are particularly deadly

FCAM Systems can avoid or mitigate many crashes

- Commercially available radar-based **Forward Collision Avoidance and Mitigation (FCAM)** Systems can reduce the frequency and severity of these commercial vehicle rear-end crash types.
- Conway study:
 - 30 months w/ 12,600 tractors
 - **71% reduction in rear-end collisions; 63% reduction in unsafe following behavior**
- Volvo/USDOT study:
 - 3 years w/ 100 trucks
 - **80% of drivers preferred to drive w/ collision avoidance systems**
 - 37% reduction in “conflicts” (i.e. hard braking, situations that could result in collision)



MERITOR WABCO

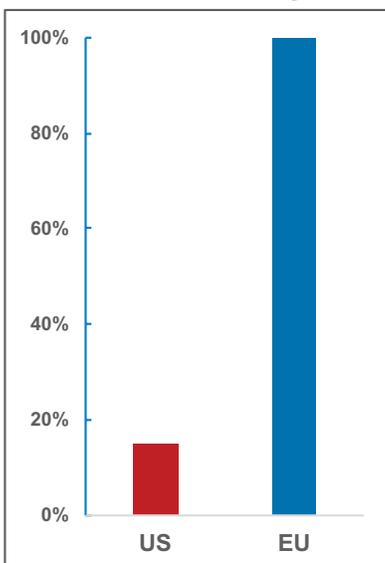
OnGuard™

Collision Mitigation System



But FCAM uptake in the industry is slow

New Class-8 Trucks Sold w/ FCAM System



- EU regulations mandated FCAM systems on all heavy trucks since 2015, estimated to save 5,000 lives per year
- In US, Passenger car OEMs voluntarily pledge to make FCAM standard on all vehicles by 2022.
- No similar agreement on commercial vehicles in US, and years away from possible mandate.
- Systems can cost \$2-3k upfront and have hard-to-measure payback for fleets



Similarly, Air Disc Brakes can improve safety but are rare

ADB provide improved braking performance and reduced fade...

...BUT, are on only about 13% of Class 8 Trucks because of increased cost

Summary of Air Disc Brake Benefits

Superior Performance	Shorter Stops	Stops 42 feet shorter than today's drum brakes** from 60 MPH Stops 100 feet shorter than today's drum brakes** from 70 MPH
	Better Braking Feel	Passenger car like feel Improved side to side brake consistency
	Safety	Greater braking power can result in fewer accidents
Lower Maintenance	Longer Lining Life	Typically twice the lining life of drum brake applications
	Sealed Design	Sealed design, no periodic lube required Sealed reliable, integrated automatic brake adjustment
	Quick Pad Changes	Quick change pads – 15 minutes per brake (with wheels off)
Light Weight	Design Optimization	Weight comparable to high performance larger (16.5") front drum brakes Patented splined rotor design with Aluminum Hubs for optimized weight Lightest dual piston air disc brake available

**Standard drum brakes compared to all wheel disc brakes on a 6x4 Tractor, 59,470 pounds GVW, un-braked trailer

Table Courtesy Bendix

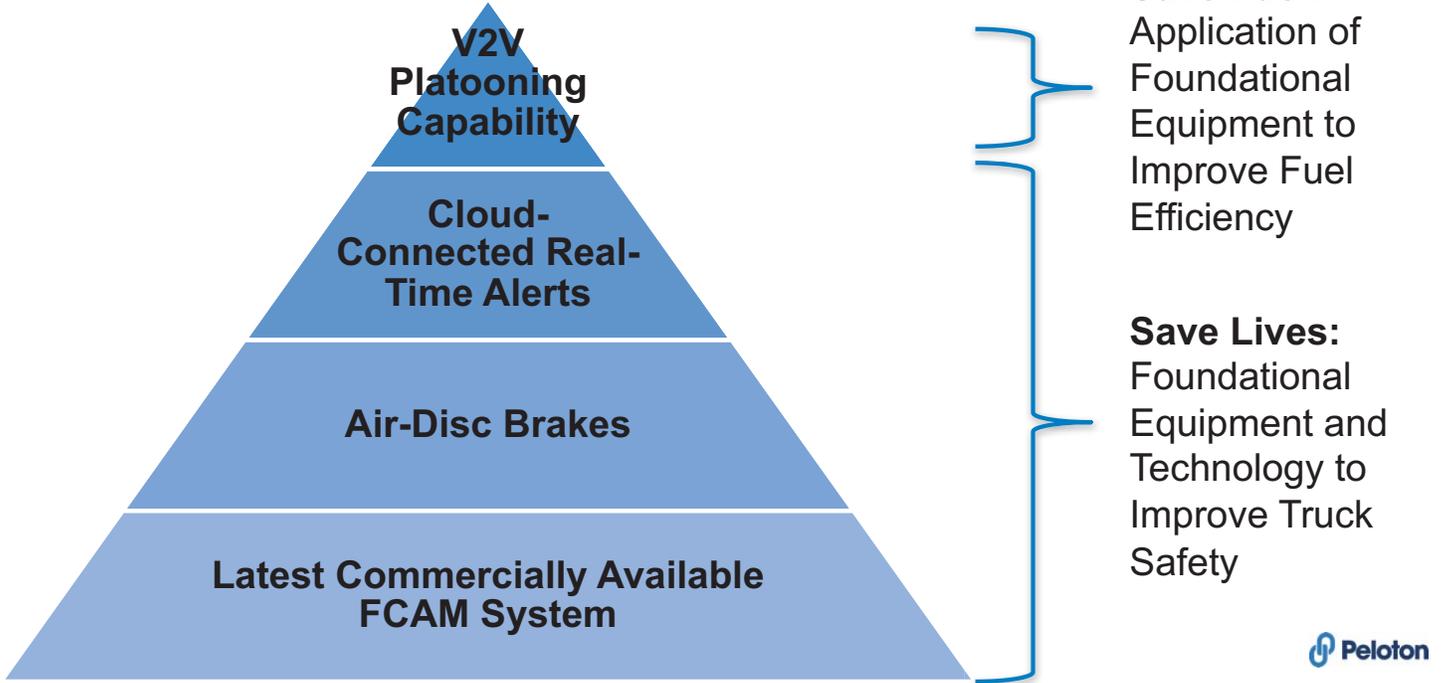


Peloton's Driver-Assistive Truck Platooning (DATP) System Requires and Incentivizes FCAM & ADB Adoption

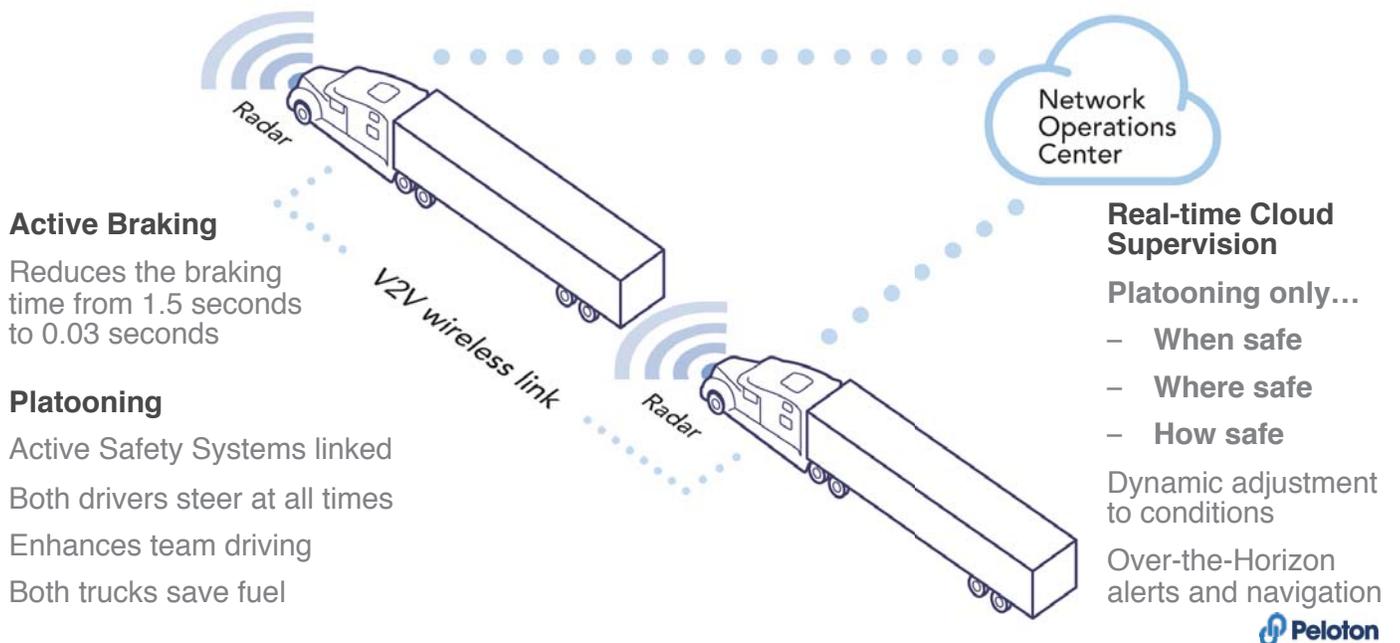
- Trucks must have the latest FCAM systems and air disc brakes, along with Peloton's proprietary DATP hardware, in order to platoon.
- In return for spec'ing trucks with FCAM, ADB, and the Peloton System, fleets are able to platoon and save fuel, creating a tangible economic benefit for adopting the latest safety equipment.



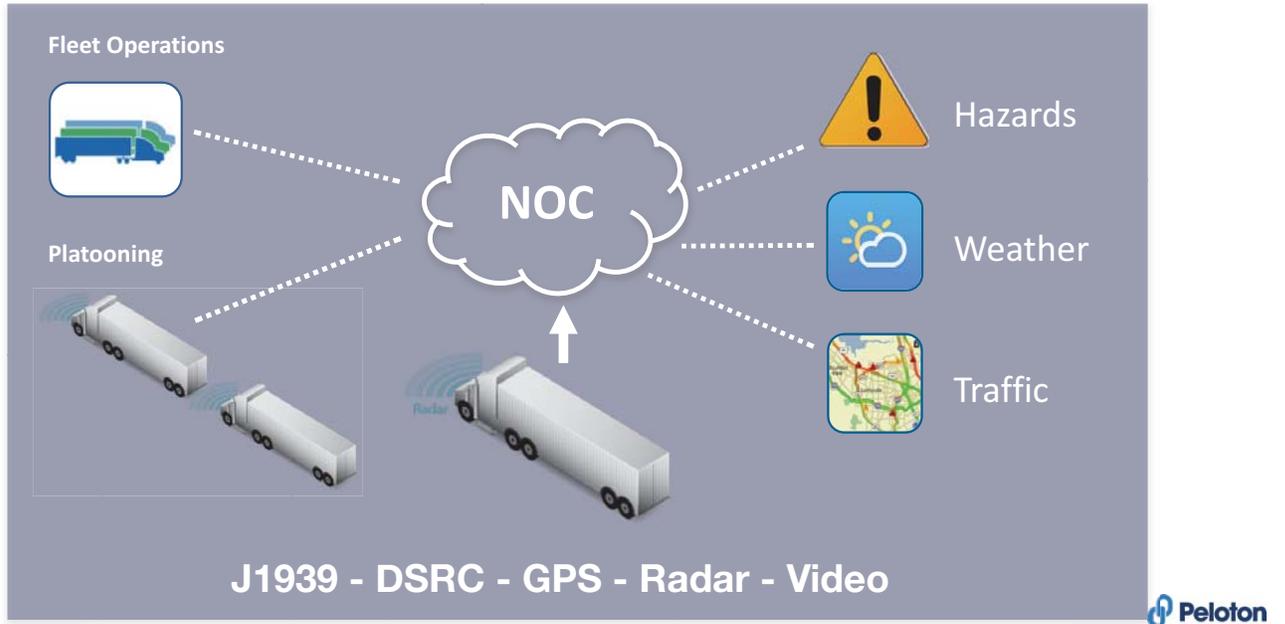
Peloton-Equipped Trucks are Safer Trucks



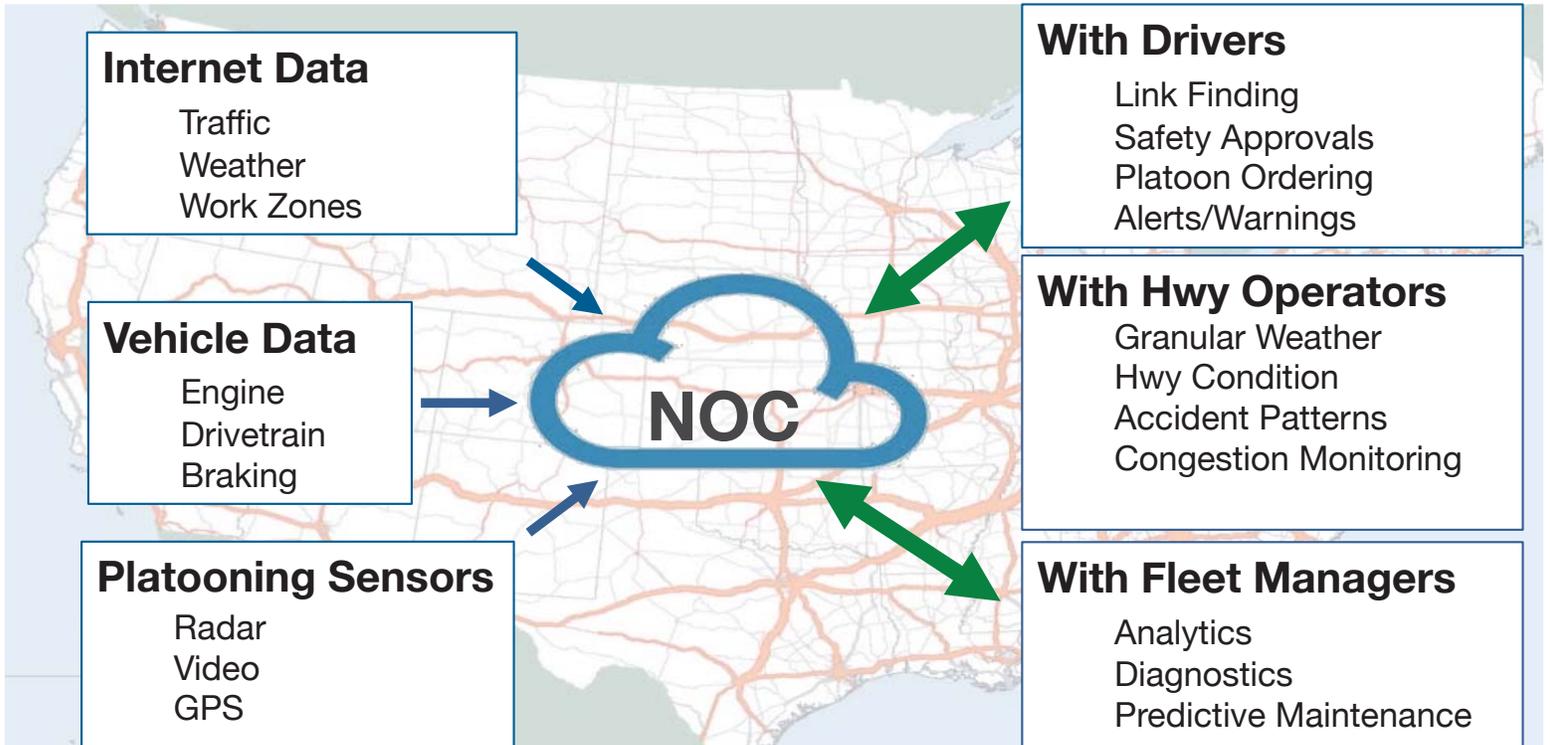
Connecting Pairs of Trucks: Better Safety and Efficiency



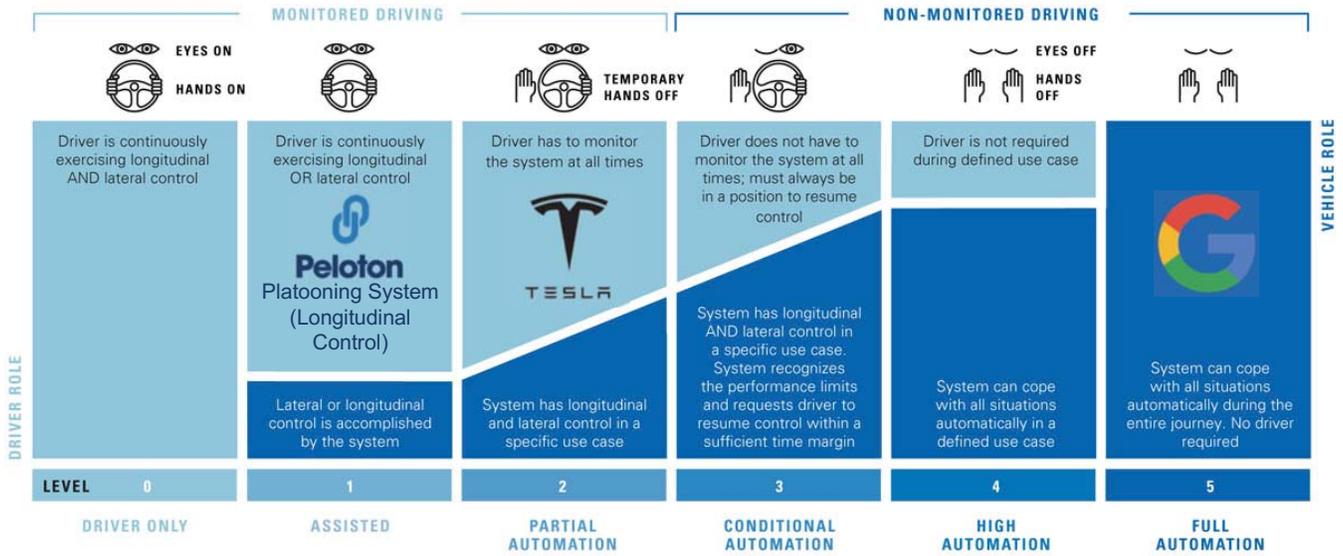
Peloton DATP: Safety and the Network Operations Center



Peloton DATP: Safety and the Network Operations Center



Peloton DATP: Minimal Automation



Graphic courtesy:



Peloton DATP: Drivers Fully Engaged At All Times



Lead Driver:
 -Hands on
-Feet on
 -Eyes/Brain on



Follow Driver:
 -Hands on
-Feet off
 -Eyes/Brain on
 -Similar to Adaptive Cruise control



Peloton DATP: Drivers Fully Engaged At All Times

Live video from other driver's view

- Look Ahead view of road ahead of lead truck for follow driver
- Both drivers in communication to share critical information



Peloton DATP: Fuel Efficiency



Fuel savings of 10% on rear truck and 4.5% on front truck

Verified savings at 40 foot gap at 64mph (NACFE)

Further independently testing by US DOE and US DOT

NREL & FHWA tests confirming savings at varying speeds, gaps of 75ft +

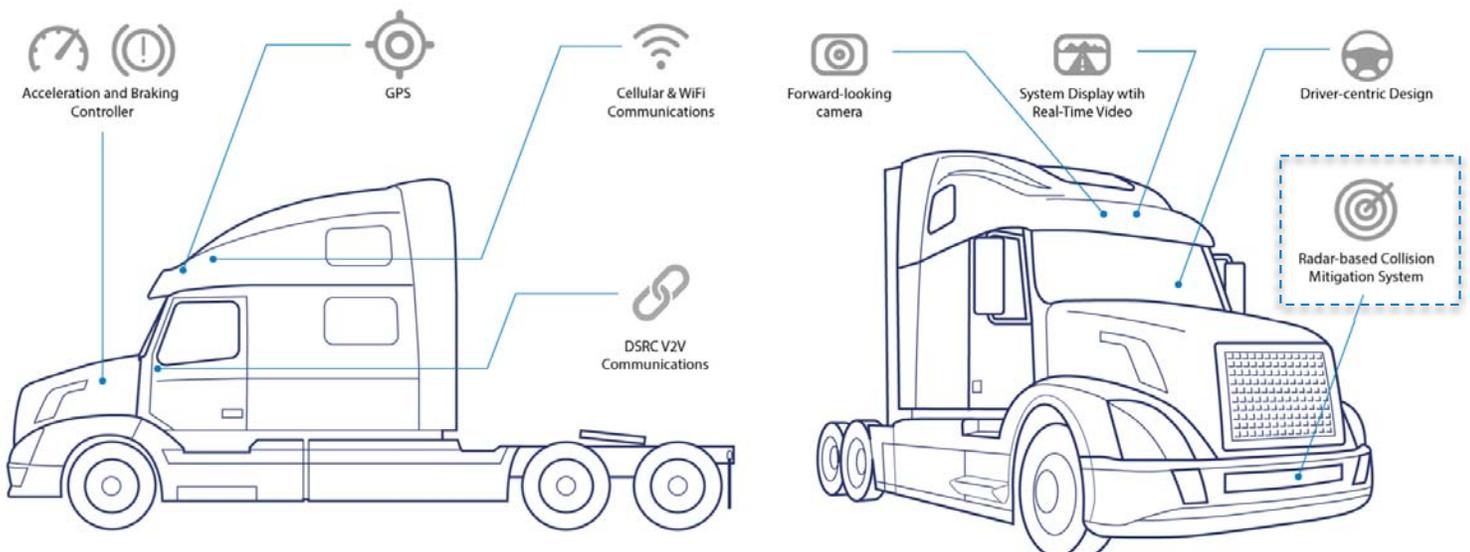


Peloton DATP: Wider Benefits

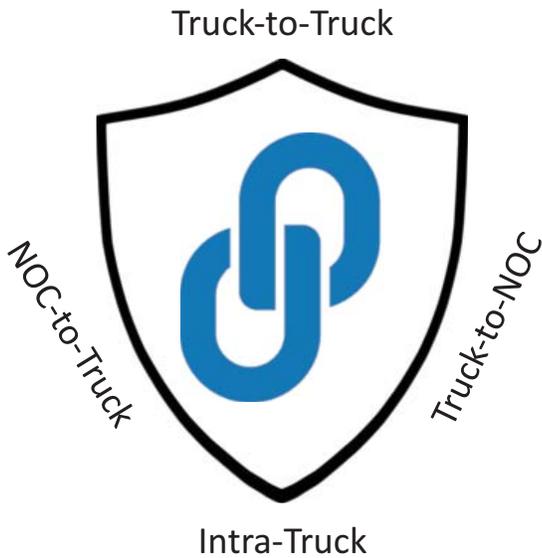
- Improves fleet economics for adopting FCAM systems and ADB
- Crash reduction and crash congestion-related fuel savings
 - NTSB: Collision Avoidance Systems could reduce ~80% of rear-end crashes. NHTSA: \$3.1B annual savings from full deployment of just current FCAM technology (and system capability is improving)
- Corresponding reduction in GHG & Criteria Pollutant emissions
- High quality data generation for fleets & governments
- Increased infrastructure efficiency
- Economically viable with <1 year platoon system payback period for fleets



Peloton Platooning System: Tractor Components



Cybersecurity



Our philosophy and practices:

1. We use the **strongest available, independently audited systems.**
2. We **encrypt all communication** between trucks and with the Network Operations Center.
3. All communications are **mutually authenticated.**
4. We actively monitor for and **defend against malicious attacks.**
5. Our systems are continually improved through **automatic over-the-air updates.**



Platooning is real and widely supported

Companies Developing Near Commercial Systems and/or Research/Future Systems:



Market Development: Global Activity in Platooning



EU - Platooning Challenge 2016



Japan - ENERGY ITS 2009-12



EU (Sweden) - SARTRE 2009-Present



Canada - PIT 2009



Germany – KONVOI 2005-09



US – PATH, NREL, etc. '90s and ongoing



Peloton Technology: Wide-Ranging Investor Base

Trucking Industry

Technology and Energy

Financial Investors



Market Development: Government Engagement & Partnerships

Demonstrating platooning with fleets, establishing best practices & creating deployment pathway

Federal	States
<ul style="list-style-type: none"> • Two USDOT (FHWA) platooning projects <ul style="list-style-type: none"> • CalTrans/PATH/Volvo • Auburn/Peterbilt • DOE Volvo Supertruck 2 • USDOT Smart City: Smart Columbus • USDOE ARPA-E (Purdue-Cummins+) • State projects include: TX Transportation Institute-TxDOT; CEC Port of San Diego 	<ul style="list-style-type: none"> • Deployment Approval Laws in 7 states [edited 6/14]: AR, GA, NC, SC, TN, TX, NV • Demo activity held in 7 states (MI, UT, NV, FL, CA, TX, OH, more ahead) • Trials/testing approved in other states incl. AL, AZ, CA, FL, VA, UT • 28 states with “reasonable and prudent” following distance standard conceptually permissive of platooning (for example, OH officials have taken this position)

Funded Projects with:



Legal Slides – North/West Passage Coalition

“Following too closely” laws – typical legal elements

- Two common elements to prevent rear-end collisions involving combination vehicles
 - Variable distance standard
 - typically phrased as a “reasonable and prudent” requirement
 - discretionary – accounts for speed, traffic, etc.
 - 28 states – including ID, MT, ND, SD, WA, WY
 - Fixed distance standard
 - varies by state between 100 and 500 ft
 - 22 states – including MN
- All states have additional element(s) such as requiring “sufficient space” for another vehicle to “enter and occupy”



Typical variable, “reasonable and prudent”-type law

North Dakota Century Code. 39-10-18. Following too closely.

1. The driver of a motor vehicle **may not follow another vehicle more closely than is reasonable and prudent**, having due regard for the speed of such vehicles and the traffic upon and the condition of the highway.
2. The driver of **any truck or motor vehicle drawing another vehicle** when traveling upon a roadway outside of a business or residence district and which is following another truck or motor vehicle drawing another vehicle shall, whenever conditions permit, **leave sufficient space so that an overtaking vehicle may enter and occupy such space without danger....**
3. Motor vehicles being driven upon any roadway outside of a business or residence district in **a caravan or motorcade** whether or not towing other vehicles must be so operated as to **allow sufficient space between each such vehicle or combination of vehicles so as to enable any other vehicle to enter and occupy such space without danger....**



How the Peloton System enables compliance with a “reasonable and prudent” following distance element

1. The driver of a motor vehicle **may not follow another vehicle more closely than is reasonable and prudent**, having due regard for the speed of such vehicles and the traffic upon and the condition of the highway.

*Peloton’s Platooning System is engineered and safety-validated with Tier 1 HD collision avoidance system manufacturers to ensure that the Follow Truck will **automatically and safely** stop without colliding into the lead truck, even during a full-brake event. The System orders the two trucks in a platoon so that **the truck with shorter stopping distance capability is always the Follow Truck**. The System applies commercial radar-based collision avoidance systems (e.g. Bendix, WABCO) and DSRC vehicle-to-vehicle (V2V) communications to **bypass delays in human perception and response time**, reducing braking latency between the Trucks to less than 0.1s.*



Connected Braking for following distance compliance

An operator can safely stop without colliding with the preceding vehicle under manual driving conditions only by allowing **enough distance for human perception and reaction**.



Radar can reduce the assured clear distance needed to safely stop without colliding by automatically reacting to the preceding vehicle slowing.



Via a low-latency truck-to-truck wireless link, the follow truck reacts automatically to the brake activation of the lead truck’s brakes within 0.03-0.1s, **before the lead truck actually begins to slow**. The truck with the longer stopping distance – based on integrated active braking system data – is ordered as the lead truck in the platoon.



How the Peloton System enables compliance with “sufficient space” to “enter and occupy” elements

2. ... leave sufficient space so that an overtaking vehicle may enter and occupy such space without danger ...

3. ... allow sufficient space between each such vehicle or combination of vehicles so as to enable any other vehicle to enter and occupy such space without danger ...

*All drivers of trucks equipped with the Peloton System are **trained to monitor the driving environment** for vehicles that may move between the trucks in a platoon, and to **increase the gap between trucks** to a distance typical of safe manual following in order to allow other vehicles to safely enter and occupy the space.*

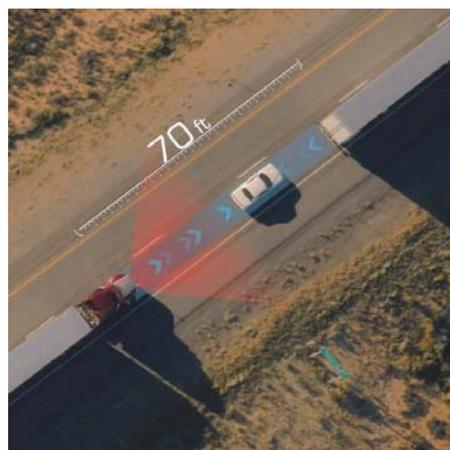
*In addition, Peloton’s platooning system **detects vehicle cut-ins via commercial radar-based CAS**, resulting in automatic platoon dissolution which involves deceleration by the follow truck in order to increase the gap between trucks.*



Responsive Gap Increase for following distance compliance



Driver sees car cutting in and backs off
OR



If driver does not respond, system radar detects cut-in vehicle and automatically begins to back off follow truck



Follow truck will continue to back off to safe manual following distance and then give full manual control back to follow driver







Texas A&M Transportation Technology Conference



Jeff Marker

Freight Program Manager

Transportation Technology Conference

❖ Focus

- Connected and Automated Vehicles (CV / AV)

❖ Transportation Revolution?

- Uber, Lyft, Google
- System Thinking – Car, Road, Driver



❖ Policy / Legislation

- Michigan, Texas, Florida, Illinois
- Liability...who's responsible with AV
- Decision Making Programming / Ethical Issues



Transportation Technology Conference

❖ Infrastructure

- Level of Dependence on Infrastructure
- Signs, Traffic Signals, Lines
- Gap – Maintenance vs. Development
- Modeling



❖ Recommendation:

- Address Policies
- I-90



Transportation Technology Conference

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Our Mission:
Your Safety. Your Mobility.
Your Economic Opportunity.



TTI Commercial Truck Platooning

TxDOT Project 0-6836

North/West Passage Steering
Committee

16 May 2017

Beverly Kuhn, Ph.D., P.E., PMP
Division Head, System Reliability
Texas A&M Transportation Institute



What is Truck Platooning?

- Extension of cooperative adaptive cruise control
- *Automated lateral and longitudinal vehicle control.*
- Tight formation with short following distances
- Lead truck: manually driven
- Following truck(s): driver disengaged

Levels of Automation: Simplified

- Level 0: hands, feet, eyes and eyes/brain ON
- Level 1: hands or feet OFF and eyes/brain ON
- Level 2: hands and feet OFF, eyes/brain ON
- Level 3: hands, feet, eyes OFF, brain ON
- Level 4: hands, feet, eyes, brain OFF
 - constrained environments
- Level 5: hands, feet, eyes, brain OFF
 - unconstrained



Lives, Time and
Lives, Time and Resources
Lives, Time and

Why Truck Platooning?

- Fuels savings
- Emission reductions
- Vehicle safety benefit
- Increased highway throughput
- Other benefits



The Project Goal

Position TxDOT as a leader in this research area and the overall TSM&O and CV/AV initiatives.

- Comprehensive truck platooning demonstration in Texas.
- Proactive effort in assessing innovative operational strategies.

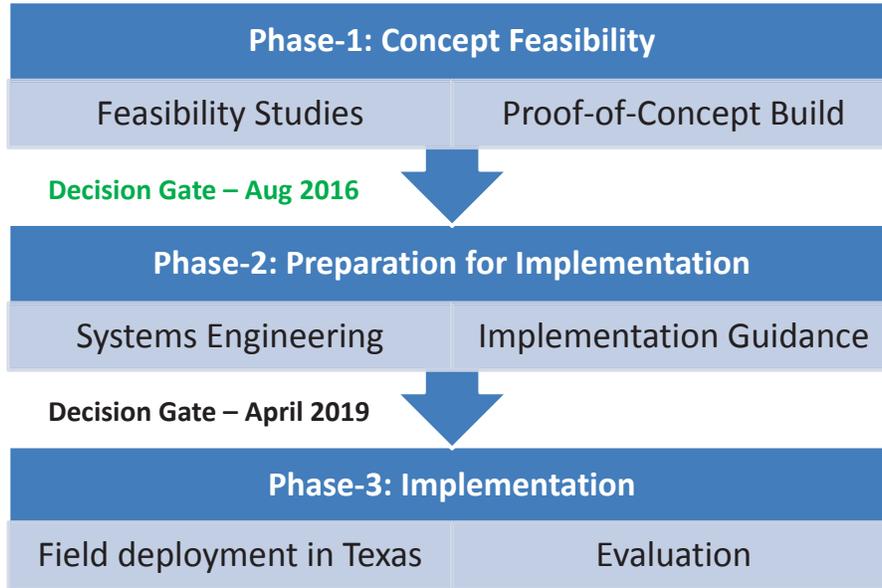


Project Focus

- Assess the feasibility of deploying 2-vehicle truck platoons on specific corridors in Texas in 5 to 10 years
- Bring together major public and private sector partners who have committed in-kind resources
 - Equipment
 - Engineering services, and
 - Intellectual property.



Project Structure



Phase I

	Foundational Studies	<ul style="list-style-type: none"> Literature Review Legislative Impacts Liability Issues
	Platooning	<ul style="list-style-type: none"> Develop alternative scenarios and corridors Validate scenarios
	System Development	<ul style="list-style-type: none"> Operational requirements Safety analyses Specifications
	Demonstration	<ul style="list-style-type: none"> Design and Implementation Integration Demonstration



Vehicle Build



Project Partners

Project Partners	Contribution
Ricardo	Software Engineering + Integration
Navistar	2x Sleeper cab trucks + Maintenance + Engineering + Graphic Design
TRW	2x ColumnDrive + Engineering
Denso	2x DSRC Radios/Antennas + Engineering
Bendix	2x Wingman Fusion + Engineering
GreatDane Trailer	2x 48ft Trailers + Maintenance + Engineering
Lytx	2x DriveCam Solutions + Engineering
Argonne National Lab	2x Fuel & Engine Temp Data Acquisition, Testing Support and Analysis
US Army TARDEC	Engineering consulting to the project

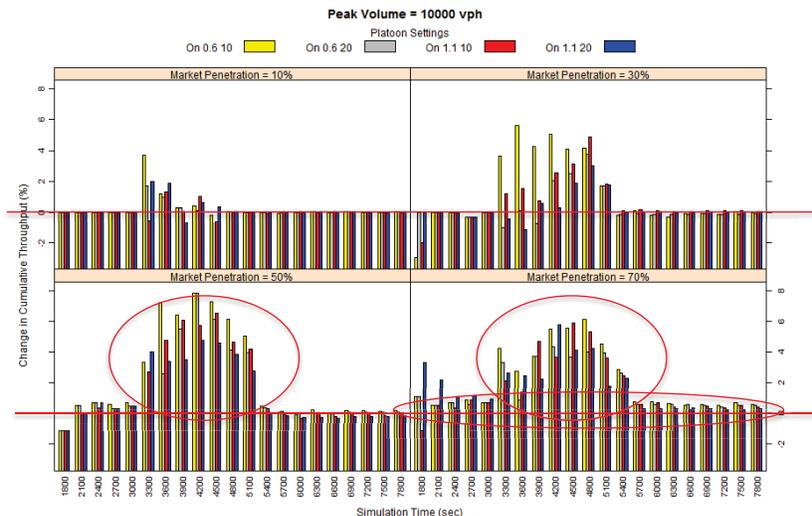


Simulation: Fuel Consumption Results

- *Average fuel savings* in the range *to 12%*
 - High volume and high MPR produce more savings, but only in non-congested traffic condition.
 - In congested traffic condition, platoons are governed by stop-and-go condition leading to reduced effectiveness in fuel consumption performance.



Simulation: % Change in Vehicle Throughput



With platooning, there is a noticeable increase in throughput observed in high volume condition at MPR > 30%. *The maximum increase in throughput is in the range of 6-8% at 50% MPR*, tight following gap, and quick formation time.





Final Questions



Contact Information

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Alternative Platooning Concepts

- Phase 1: Defined five alternative truck platooning concepts that could be deployed in TX in 5 -10 yrs.
 1. Ad Hoc “On-the-Fly” Platooning
 2. Guided Hoc “On-the-Fly” Platooning
 3. Scheduled Platooning
 4. Trip Platooning
 5. Platoon Service Provider



Deployment Site Characteristics

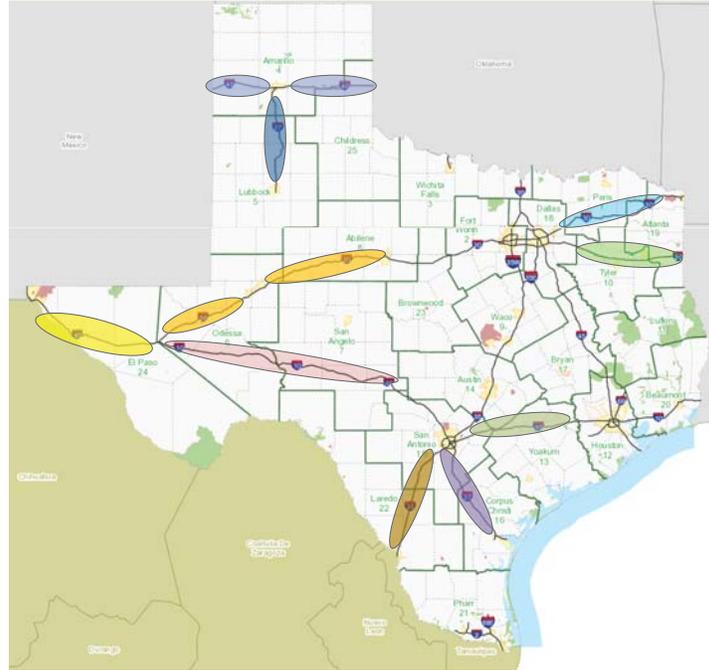
Phase 3 Requirements

- ≥ 4 -lane, rural interstate highways
- Low AADT
- High truck percentage \rightarrow least 15% of AADT.
- Relatively long stretches of highway between urban centers
- Posted speed limit ≥ 65 mph





Potential Corridors



Appendix B – TTI/Texas DOT Truck Platooning Initiatives

Appendix C – I-80 Connected Vehicle Demonstration



North/West Passage Freight Task Force, Year 2

Web Meeting #5 – Connected Trucks

November 1, 2016



About This Web Meeting

- ~30 Minutes for presentation
- 30 Minutes for questions and discussion
 - Type comments in the chat box
 - Share your perspectives at prompted discussion points throughout the meeting
- *Please mute your phone when not speaking*

The benefits of the meeting increase with your active participation

- Name
- Organization
- Is your organization active in any connected truck initiatives?

Idaho	Montana	Washington
Minnesota	North Dakota	Wyoming
	South Dakota	

Vince Garcia, Wyoming DOT
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Tony English, TriHydro
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Wyoming DOT Connected Vehicle Pilot Deployment Program Phase 2

NWP FREIGHT TASK FORCE
NOVEMBER 1, 2016



Project Background

Pilot Project



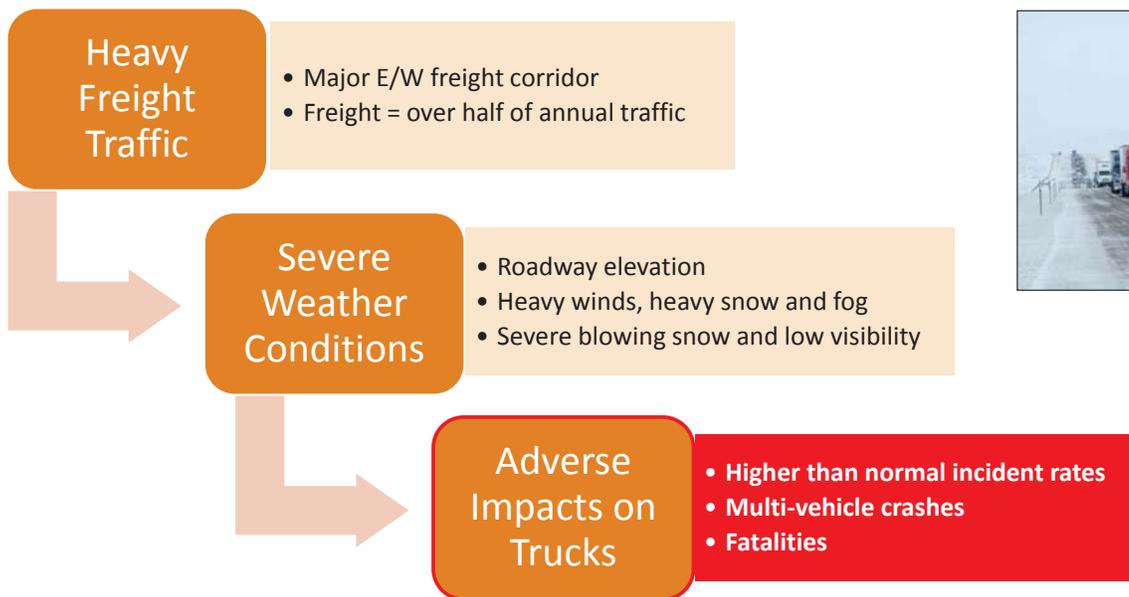
- Using Connected Vehicle (CV) Technology to enable equipped vehicles to transmit and receive data to other equipped vehicles and roadside infrastructure.
- Reduce the impact of adverse weather on truck travel along the corridor through CV-based advisories, roadside alerts, parking notifications, and dynamic traveler information

Connected Vehicle Overview



- Connected Vehicles
 - Vehicles that are equipped with onboard devices that can send messages to and receive messages from nearby vehicles and roadside infrastructure
- Vehicle to Vehicle (V2V)
 - Vehicles send out basic messages that are received by nearby vehicles.
 - This information can be used for a number of reasons, including speed harmonization and crash avoidance.
- Vehicle to Infrastructure (V2I)
 - Vehicles send out basic messages or data that are received roadside infrastructure.
 - This can include basic vehicle metrics, like whether windshield wipers are on, antilock brakes are engaged or airbag deployment.
 - Data comes from vehicle sensors, including weather data.

Wyoming's I-80 Corridor



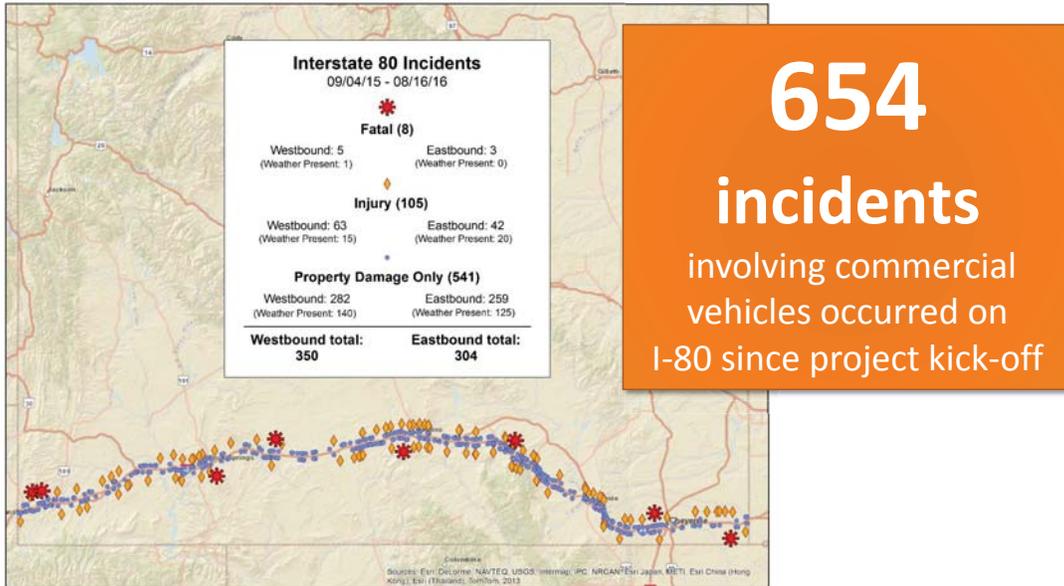
Source: WYDOT (Dec 17, 2015)

5 Focus Areas



- Manage following speed and distance between vehicles**
 - By alerting trucks to slowing traffic ahead to prevent multiple-vehicle crashes
- Provide custom alerts and advisories**
 - For vehicles that are at risk due to their weight, profile, or traveling speeds due to high-winds or near work zones, including alerting drivers if vehicles are too tall for bridges
- Provide location-based parking information**
 - With a focus on directing drivers to safe parking areas in the event of a road closure
- Allow first responders to be notified of a crash automatically**
 - Based on vehicle metrics, such as airbag deployment
- Use data collected from vehicle's weather sensors**
 - Such as the status of windshield wipers and if anti-lock brake systems are activated.
 - This information will be used to develop advisories and forecasts for travel to fleet management centers and the general public.

Why this project is important



654
incidents
involving commercial
vehicles occurred on
I-80 since project kick-off

Why this project is important



1,498 crashes
1,923 vehicles
\$773.5M
Societal Impact

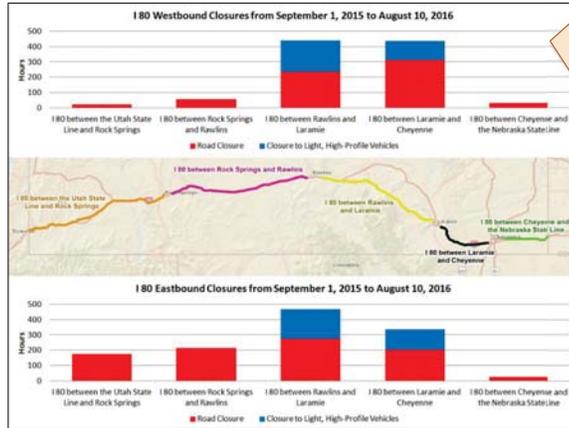


Response to an incident on I-80

Type	No.	Societal Impact
Fatality	13	\$120,891,446
Injury	253	\$110,578,475
Property Damage	1,232	\$542,080,000

Economic impacts based on figures provided by WYDOT Public Safety.
Assumes one moderate injury or one fatality per crash.

Why this project is important



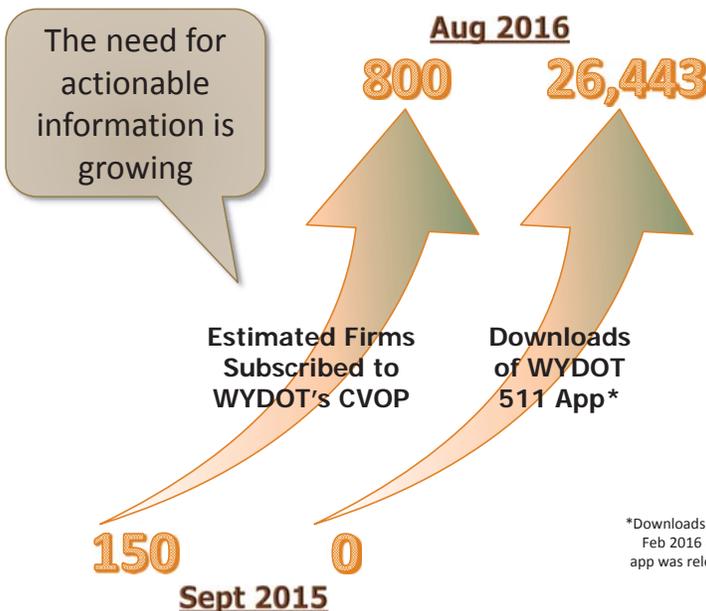
Over the past year...

250 Hours
Full Lane Closures

~180 Hours
High Profile Vehicle
Restriction

37 Days
Inclement Weather

Need for Actionable Road Weather Info



WYDOT's Commercial Vehicle Operator Portal (CVOP)

Created for trucking community and designed with their input. Includes:

- o Road weather forecasts (surface conditions, visibility, wind)
- o Pre-event forecast information through FHWA's RWMP's Pathfinder initiative

Performance Improvements



Road Weather Condition Input

1. Improve road weather condition reports received into the TMC



TMC Information Dissemination

1. Improve ability of the TMC to generate wide area alerts and advisories
2. Efficiently manage closures, restrictions and speed limits
3. Effectively disseminate and receive messages from TMC to en-route vehicles
4. Improve information to commercial vehicle fleet managers



Vehicle/Roadside Alerts & Advisories

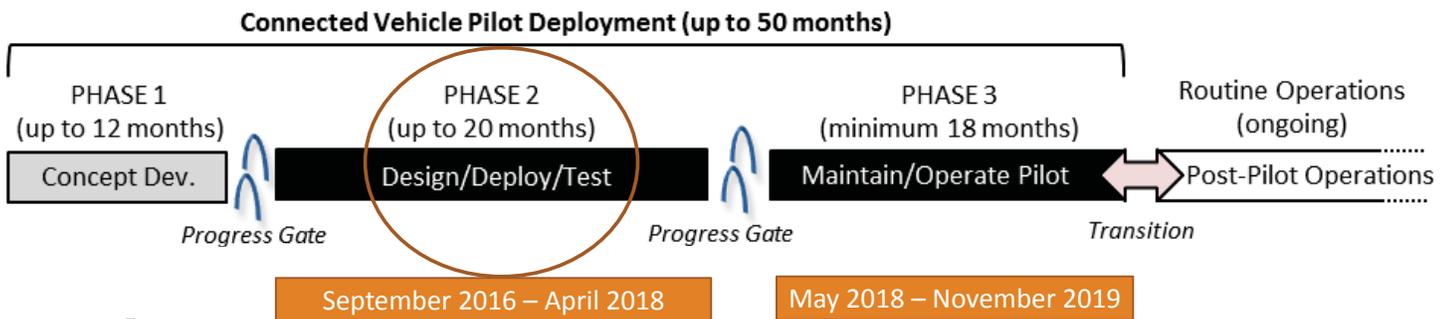
1. Effectively transmit and receive V2V messages to reduce incidents and their severity
2. Enhance emergency notifications of a crash



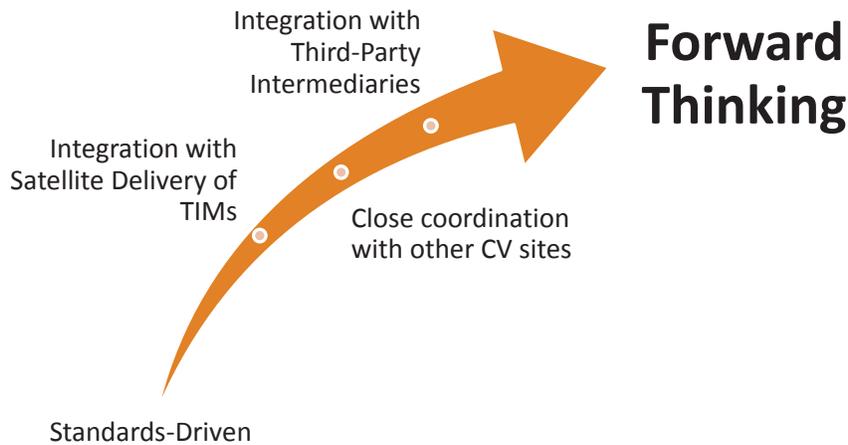
Outcomes

1. Improve speed adherence and reduce speed variation
2. Reduce vehicle crashes

Project Phases



Forward Thinking



Wyoming Connected Vehicle Pilot



Project Stakeholders



- WYDOT
- Freight Partners
 - CVOP Subscribers
 - Third Party Services
 - Trucking Fleets
 - Freight Distribution Centers
- Other Stakeholders
 - Independent Evaluator
 - IRB
 - Trucking Association
 - Other CV Pilot Sites
- Vendors
 - CV equipment installation and support
 - Other hardware and software vendors



Questions?

Idaho
Minnesota

Montana
North Dakota
South Dakota

Washington
Wyoming



The System

Freight-focused



Freight-Focused

- ~150-200 are large trucks
- ~ 100 are small/medium trucks

CV Trucks



- Trucking Companies of various sizes
 - UPS
 - Dooley Oil
 - Transpro Burgener
 - Others...

Fleet Partners



- CVOP Users (800 firms)
- Wyoming Trucking Association
- Third Party Intermediaries

Freight Partners



Integrated with the TMC



Supports I-80 Traveler Information



Supports VSL and other traffic mgmt. strategies



Integrated with TMC Management Systems



WYDOT's VSL, 511 and other services will rely on CV data

Integrated with WYDOT Fleets



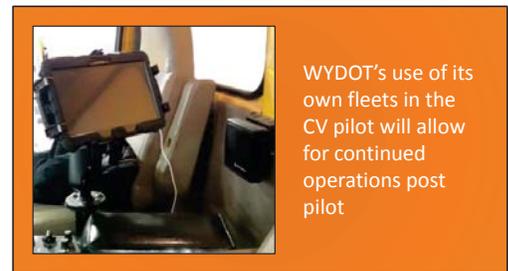
Environmental Probe Data Collection



Leverage existing technology



~100 DSRC-enabled snow plows and highway patrol vehicles

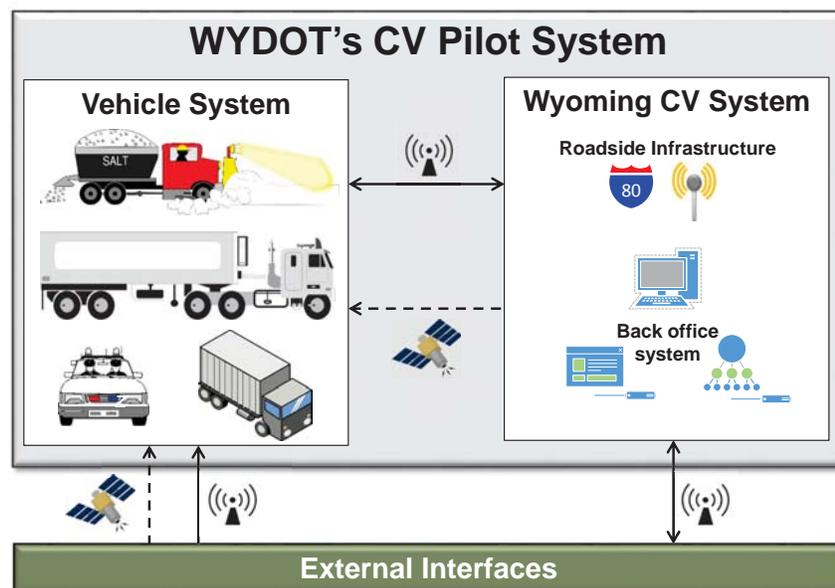


WYDOT's use of its own fleets in the CV pilot will allow for continued operations post pilot



System Overview

System Overview



System Overview – Vehicle System



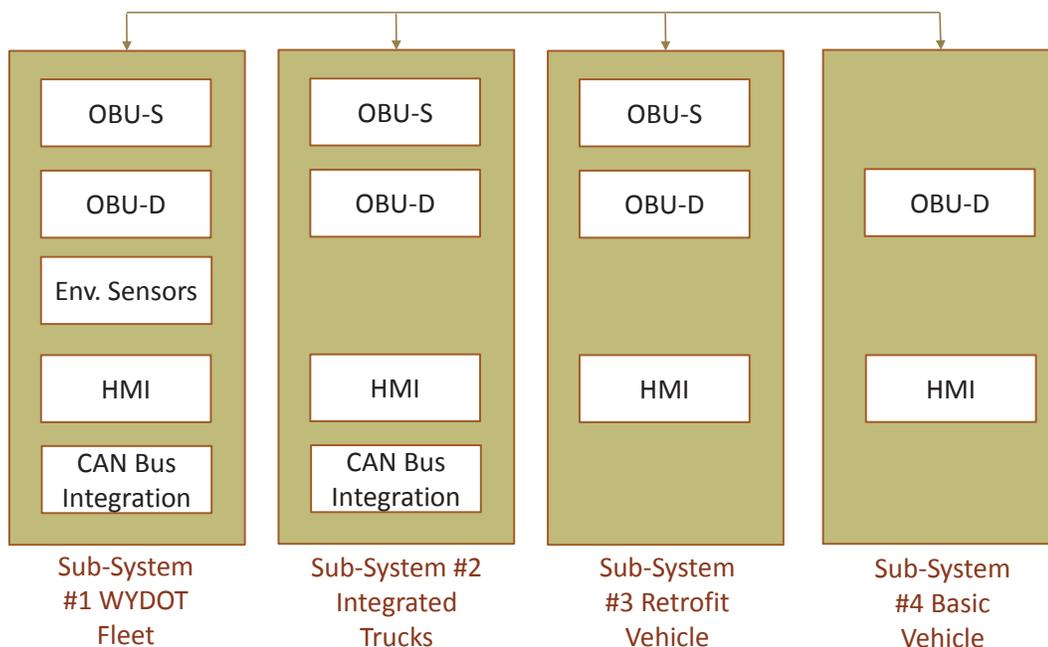
Vehicle Sub-Systems

1. WYDOT Fleets
2. Integrated Trucks
3. Retrofit Vehicles
4. Basic Vehicles

On-board Vehicle Technologies

- OBU with DSRC only
- OBU with DSRC and Satellite Receiver
- Human Machine Interface
- CAN Bus Integration
- Environmental Sensors

System Overview – Vehicle System



LEGEND:

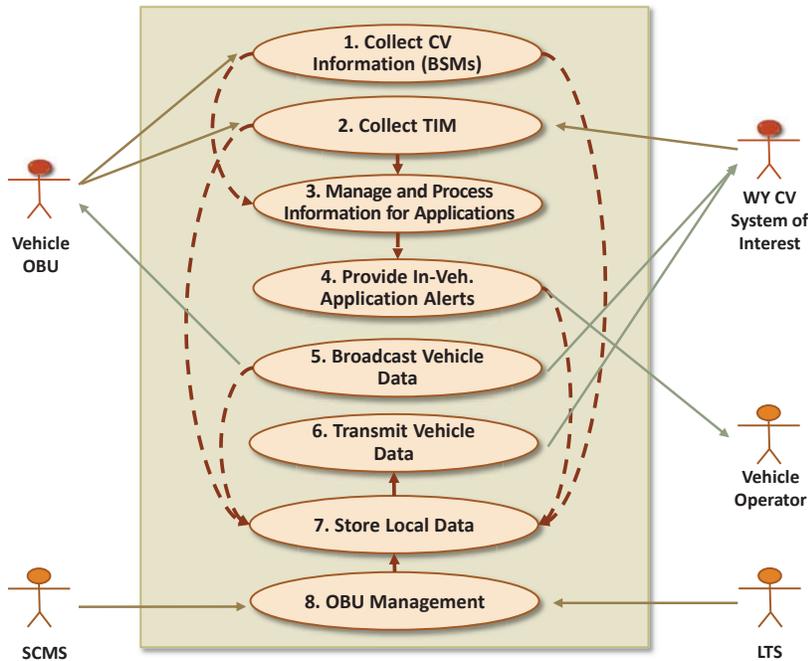
OBU-D: On-Board Unit with DSRC

OBU-S: On-Board Unit with Satellite

HMI: Human-Machine Interface



System Overview – Vehicle System

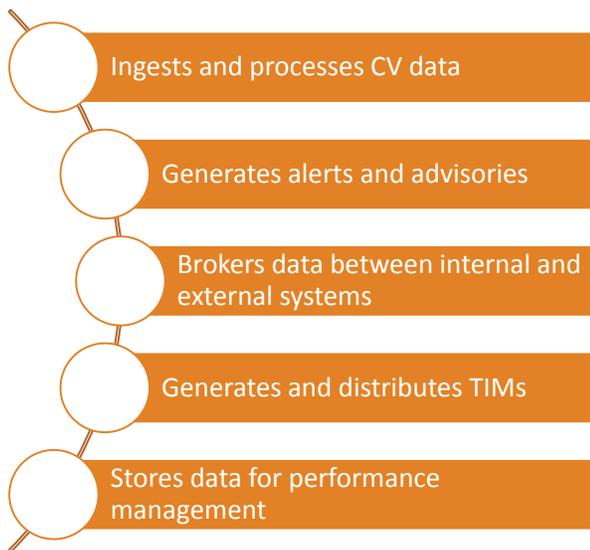


All vehicles that are part of the *Vehicle System* will have

- Ability to share and receive information via DSRC from other connected devices (vehicles and RSUs)
- Ability to broadcast Basic Safety Message Part I
- Ability to receive Traveler Information Messages (TIM)
- A human-machine interface that allows alerts and advisories to be communicated with the driver.



System Overview – Wyoming CV System



Wyoming CV Pilot System

External Interfaces

- US DOT Interfaces (e.g. SCMS)
- WYDOT Interfaces (e.g. ATMS and ATIS Systems at the TMC)
- Weather

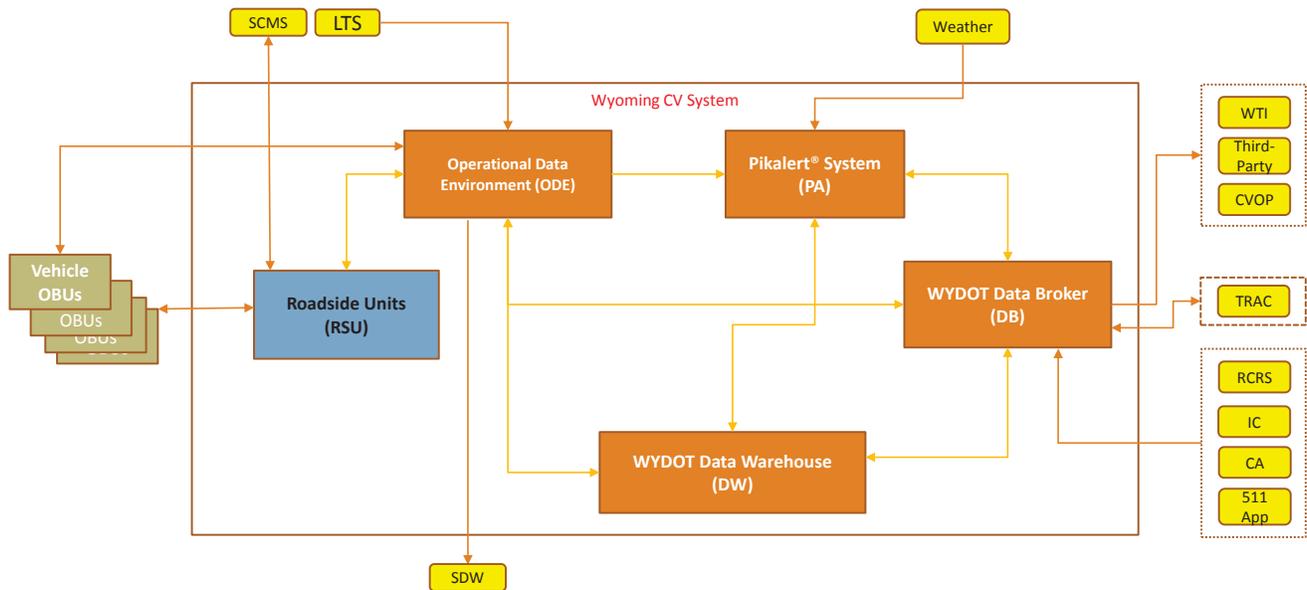
CV Subsystems

- Roadside Units
- Operational Data Environment
- Pikalert® System
- WYDOT Data Broker
- WYDOT Data Warehouse

System Overview – Wyoming CV System



Back-office functions located at the Wyoming Transportation Management Center



CV Applications



On-Board Applications

- Applications available to equipped vehicles



TMC Operations Applications

- Support for WYDOT Traveler Information and Traffic Management

On-Board Applications



The pilot will develop five on-board applications that will provide key information to the drivers of equipped vehicles.

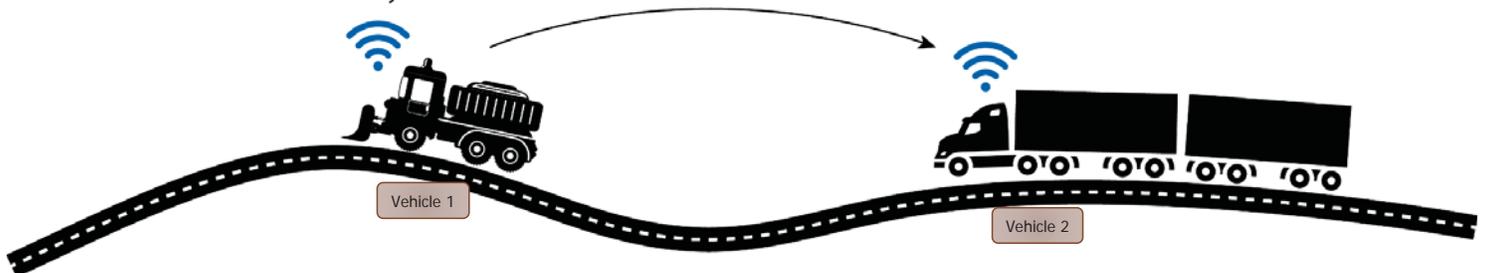
- 1 **Forward Collision Warning (FCW)**
- 2 **Infrastructure-to-Vehicle (I2V) Situational Awareness (SA)**
- 3 **Work Zone Warning (WZW)**
- 4 **Spot Weather Impact Warning (SWIW)**
- 5 **Distress Notification (DN)**

On-Board Applications Forward Collision Warning



Slow moving vehicles like Snow Plows or Heavy equipped trucks, or in low visibility conditions

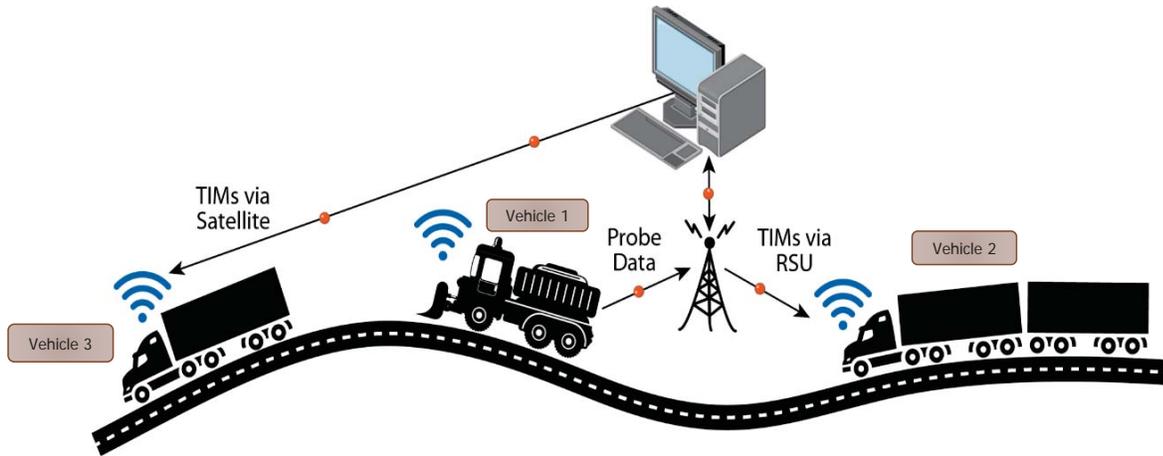
Host vehicle receives BSM information from remote vehicles.



- Impending front-end collision warning
- Data sent to approaching vehicles (from vehicle 1 to vehicle 2)
- Same direction of travel
- All roadway geometries

Relevant Standards: J2945/1 March 2016 Section 4.2.4

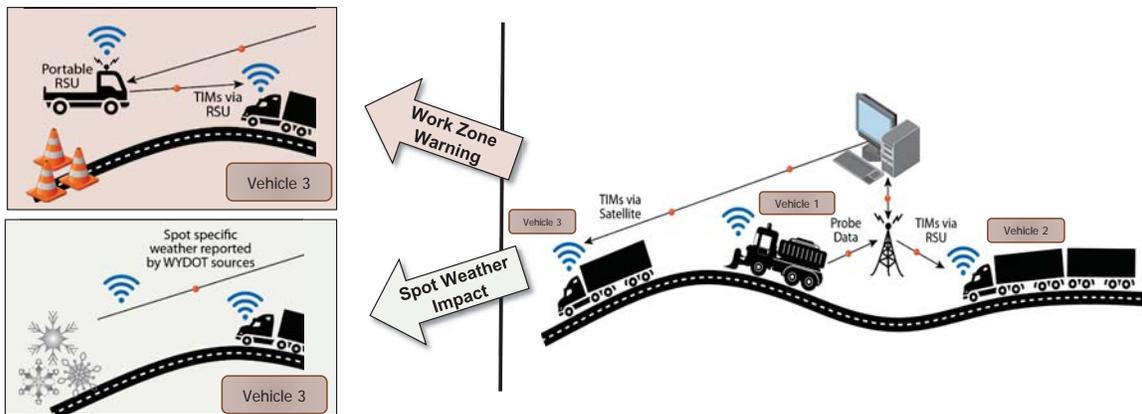
On-Board Applications I2V / V2I Situational Awareness (TIM)



- Probe data collected from WYDOT fleet to supplement existing observations
- Downstream road conditions (speed and vehicle restrictions, incidents, parking, road closures etc.) sent

Relevant Standards: J3067 August 2014 Section 2.9.3.6.

On-Board Applications I2V / V2I Situational Awareness (WZW, SWIS)

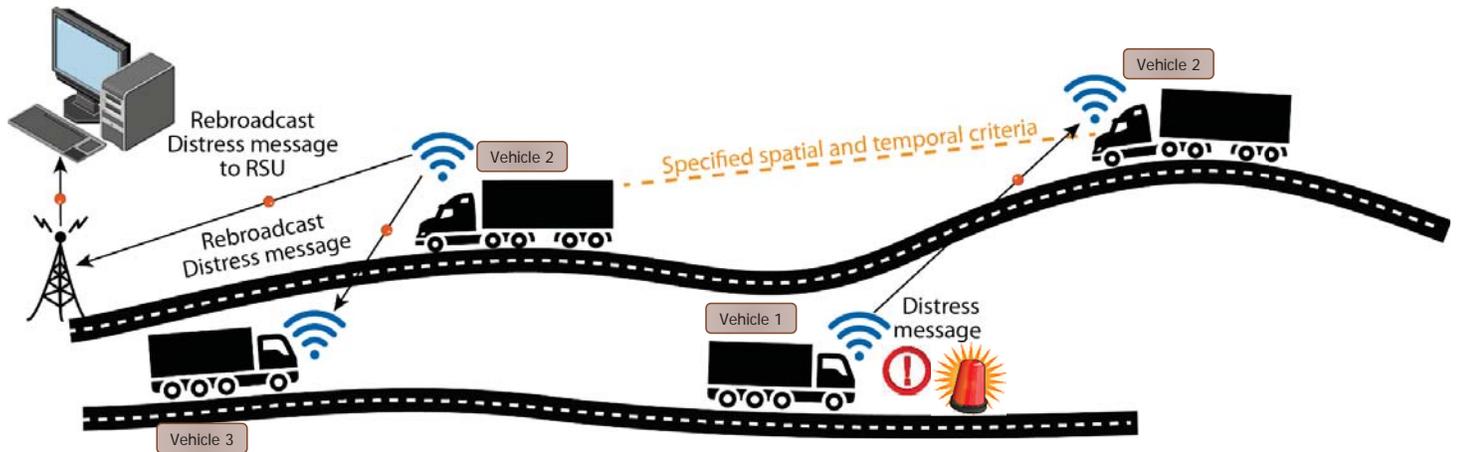


- Similar applications included in the pilot:
 - **Work Zone Warning:** Unsafe work zone conditions (obstructions, closures, shifts, etc.)
 - **Spot Weather Impact Warning:** Localized road weather information (fog, ice, etc.)

WZW Relevant Standards: This application will follow the TIM advisory content from part 3 defined in J2735 Section 6.142 for ITIS data elements 6.54 for weather conditions and 6.55 for winds defined in J2540_2.

SWIS Relevant Standards: TIM work zone warning described in J2735 part 3 in Section 6.142.

On-Board Applications Distress Notification



- Generation and broadcast of distress message (e.g., Mayday)
- CV and RSU within vicinity receive and forward message

Relevant Standards: Application is loosely based on the Mayday application description from J3067 Section 3.5.9.2.1; it is built on a higher priority TIM communication using J2735 March 2016, Section 5.16, Part 3, Integrated Transport Information System (ITIS) advisory elements.

TMC Operations Applications



CV Data will support several TMC functions for traffic management and traveler information on I-80. All these applications will be enabled by external interfaces to the existing TMC Systems from the Wyoming CV System

- **Support Variable Speed Limit, Closures, Restriction Management**
- **Support Wyoming Traveler Information (WTI) Updates**
- **Support Commercial Vehicle Operators Portal Updates**
- **Support Third-Party Interface**



Questions?

Idaho
Minnesota

Montana
North Dakota
South Dakota

Washington
Wyoming



Thank You

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Appendix D – Truck Platooning Roundtable



North/West Passage – Freight Task Force, Year 2

Truck Platooning Exploration Roundtable

Solutions for
growing economies

July 12, 2017

About This Roundtable

- ~ 45 Minutes for presentation
- ~ 45 Minutes for questions and discussion
 - Type comments in the chat box
 - Share your perspectives at prompted discussion points throughout the meeting
- *Please mute your phone when not speaking*

The benefits of the roundtable increase with your active participation

Introductions

- Name
- Organization
- Is your state advancing truck platooning or related enabling legislation?

Idaho	Montana	Washington
Minnesota	North Dakota	Wyoming
	South Dakota	



North/West Passage Freight Task Force

Established in 2014 to enhance North/West Passage activities and help realize the North/West Passage Corridor's vision of...

...developing effective methods for sharing, coordinating, and integrating traveler information and operational activities across state and provincial borders



Work Plan



Task 5 – Truck Platooning Exploration

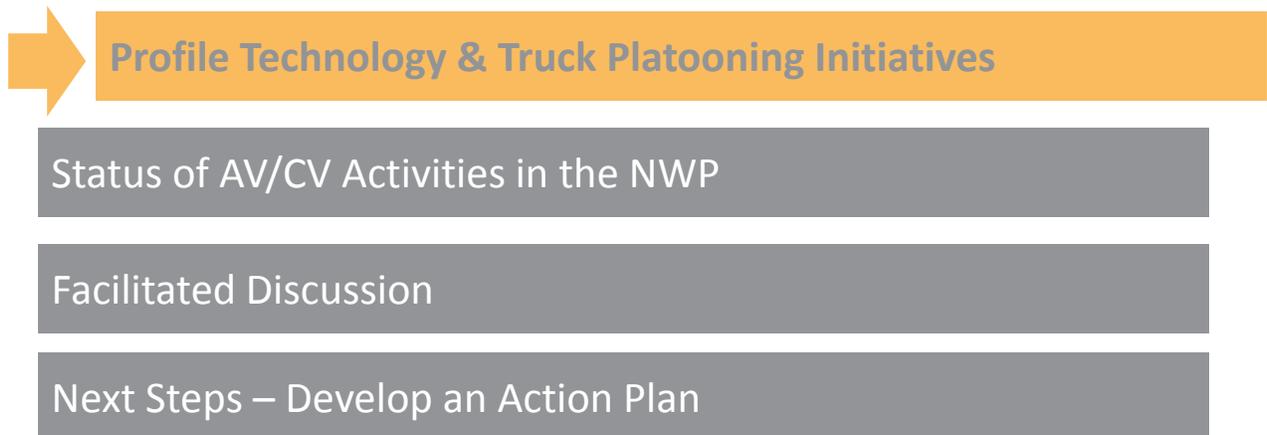
To help North/West Passage Members remain informed about truck platoon demonstrations on other corridors and determine the interest level in truck platooning demonstrations corridor-wide along the I-90/I-94 corridor

- Profile Truck Platooning Initiatives
- Facilitate Discussions
- Identify an Action Plan

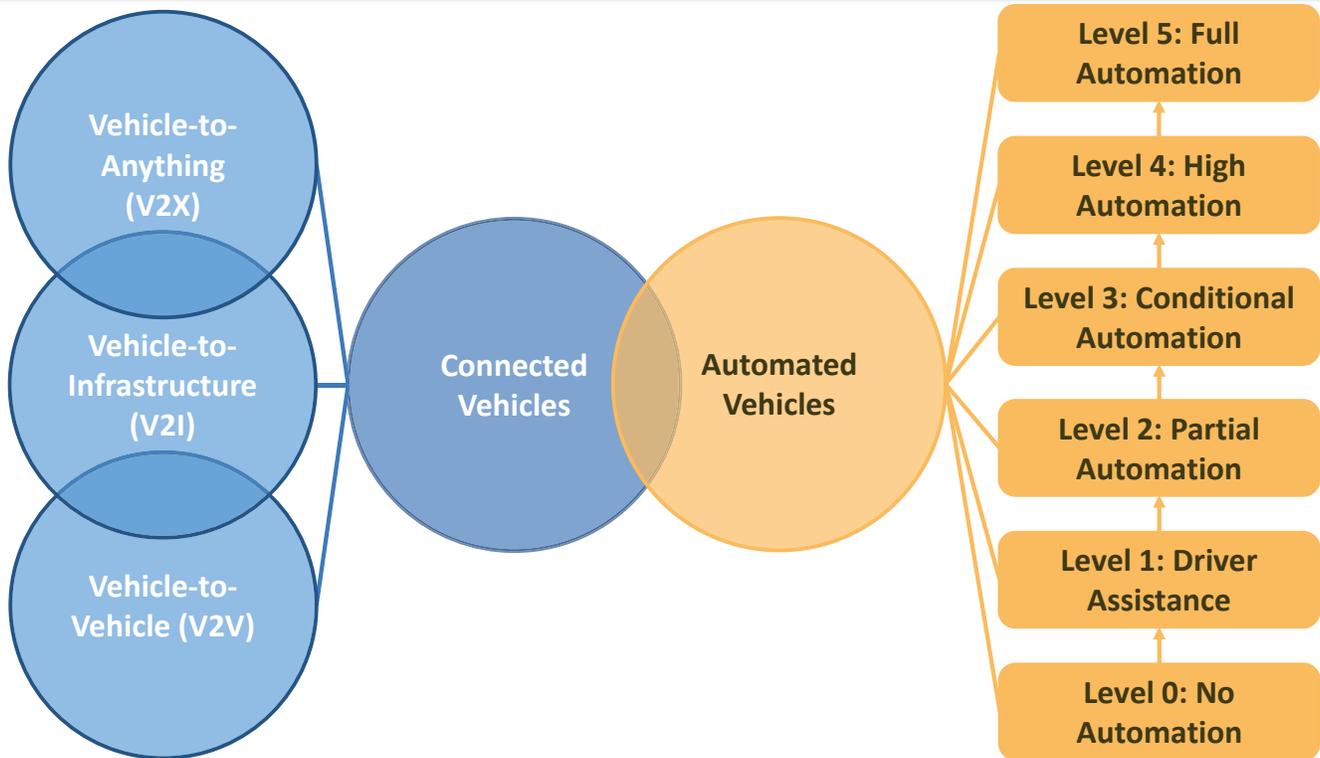
Today's Discussion

- Do you (your state) have an interest in a truck platooning project along the I-90/94 corridor?
- Do you (your state) have any concerns about a private led truck platooning demonstration (similar to Phase 3 of the demonstration in Texas)?
- Do you (your state) have a preference in advancing a truck platooning project as a corridor, or as individual states?

Presentation Map



Relationship between AVs and CVs



Levels of Automation

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the <i>human driver</i> of all aspects of the <i>dynamic driving task</i> , even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the <i>driving mode</i> -specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the <i>driving mode</i> -specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	System	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the dynamic driving task with the expectation that the <i>human driver</i> will respond appropriately to a <i>request to intervene</i>	System	System	Human driver	Some driving modes
4	High Automation	the <i>driving mode</i> -specific performance by an automated driving system of all aspects of the <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond appropriately to a <i>request to intervene</i>	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i>	System	System	System	All driving modes

The image is a detailed grid of technology categories for the future of transportation. The categories include:

- SERVICES:** ROUTE PLANNING (SPATIAL, CITIVIZ, waze, moovit), PARKING (Woparc, Cloud Parc, Piware, Spillix, S), CAR HAIRING + POOLING (LEASOP, Lyft, A, RideCell), OTHER: AFTERMARKET, REPAIR, RENTAL (CARVUE, upshift, WRENCH, PATROL, zipcar, Getaround, URGENTLY, Tantalum, bikar).
- SAFETY & SECURITY:** PHYSICAL CAR & DRIVER SAFETY + ACCIDENT DETECTION (Drivebatter, splitsecond, neqr, GUARDIAN, phrame, LyfeLens), EMOTION, FATIGUE & ALCOHOL DETECTION + DISTRACTION AVOIDANCE (CORTEX Labs, EVERS, ALMA, eGate, CARMA), CYBERSECURITY (CYMOTIVE, cognomotion, ARGUS), INTRUSION, TRACKING & RECOVERY (nonda, gmt Connect, ROADEye, caruma).
- IN-CAR INTELLIGENCE + ASSISTANCE:** VEHICLE DIAGNOSTICS & PREDICTIVE MAINTENANCE + SENSOR-BASED VEHICLE SAFETY (Metromile, BRAID, LIGHT), PASSENGER-FOCUSED SENSORS (INCLUDING USAGE-BASED INSURANCE) (Cortics, Zobie, nauto), INFOTAINMENT + DISPLAY (link motion, HUDDY, suvedspot, OverDrive, ROMY), PERSONAL / VOICE ASSISTANCE (dash, novusis, AUTOMATIC, CARMA), NAVIGATION ASSISTANCE + PEDESTRIAN ANALYSIS & COMMUNICATIONS (novdy, hudly).
- AUTONOMY:** AUTOMATION SYSTEM (AutoX, drive ai, POLYSINC, OXBOTICA, OFYX, ANSYS), MAPPING, SIMULATION, & IMAGE RECOGNITION / ANNOTATION (Mapbox, CARTERA, TomTom, IPROBABLE, UDACITY, DEBRAMP, Civil Maps), AUTONOMOUS VEHICLE MAKER + TOOLS (nuro, W, ZEX).
- INFRASTRUCTURE + CONNECTED CAR:** SENSOR NETWORKING INFRASTRUCTURE (V2V, V2X) - LPWA, CELLULAR, WIFI (DIGIMONDO, U, SAVARI, ZIFSense, EVVOS, Activity), CONNECTED CAR - DATA, PLATFORM, SOFTWARE (ACTIVESCALER, INRIX, SYRAC, mobiliz, connect, vinli, otonomo, bright box, mojo), FLEET + TRAFFIC MANAGEMENT (BESTMILE, Travel, Automile, Zendrive, GLYDEL, memtis, FR), OTA CAR SOFTWARE UPDATE + SMART PHONE ENABLED TELEMATICS (FIXD, DRIVEBOT, VOYOTIVE, ZENE, STUP).
- INTELLIGENT MANUFACTURING:** NEW/ADVANCED MATERIALS (SIRIUS, NANOSTEEL), RAPID PROTOTYPING - 3D PRINTING, MODULARIZATION, OPEN SOURCE (Carbon, nanocore, DIVERGENT, OSV, stratus, VADER), ADVANCED / AUTOMATED ASSEMBLY LINE (Grabit, SYMBIO, CLEARPATH, rethink robotics), MATERIAL CHARACTERIZATION & TESTING (SynTouch, VIDI, OPTOFIDELITY).
- ONBOARD SENSORS:** LOCATION - GIS, PRECISION POSITIONING, PATH PLANNING (swift, radiosense), VISION / CAMERA (DEEP VISION, DEEPSCALE, VISION, VAYAVISION), LIDAR (FACETS, INOVIZ, PRIMER, QUANERGY, EVEL, TRILLIUM, LeaderTech, Velodyne LIDAR, STRAË), RADAR (oculii, RFISSE, 6TH SENSE, SOA).
- SPECIALTY VEHICLES:** 2-WHEELERS (Supermotion, Zogster), PUBLIC TRANSPORT (NOVO, Varden Labs, AURO, RACE), TRUCKS / FREIGHT (JAYBRIDGE, PELOTON, OTTO, TEBLA, FLEPORT, TRILITE TRACE), FLIGHT (WRIGHT ELECTRIC, ZUNUM Aero, JOBY, Kitty Hawk, ULIUM).
- OTHER: HYPERLOOP, PERSONAL MOBILITY:** hyperloop | one, ninebot, WILL.

Source: Comet Labs



About Truck Platooning

A communications link between vehicles equipped to platoon, allowing the rear truck(s) to decrease following distance.

Benefits of platooning systems:

- Improved safety
- Reduced fuel consumption



Source: Long Beach Press-Telegram



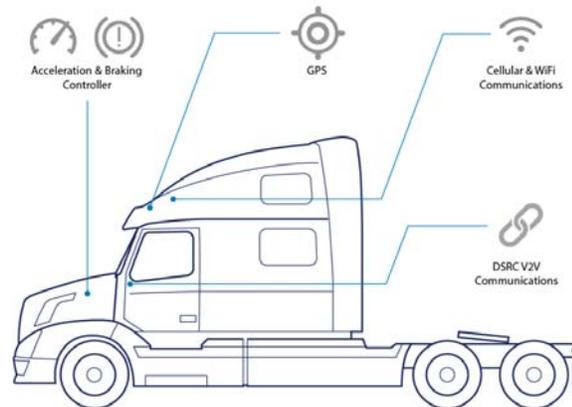
Source: San Francisco Chronicle



Private Sector Innovations

53% of large carriers want ROI in two years or less.

- Technology
 - Detection
 - Communications
- Services
 - Data collection
 - Advanced notification of road conditions



Source: Peloton

Truck Platooning Demonstrations – Europe

- European Truck Platooning Challenge (2016)
 - 5 nations, 6 companies
 - Focus on overcoming regulatory differences
 - Applicable to NWP



Source: Scania



Source: European Truck Platooning Challenge, 2016

Truck Platooning Demonstrations (and legislation) – US

Date	State	Accomplishment
2013		
November	Utah	Platoon demonstration with CR England trucking
2014		
May	Nevada	Platoon demonstration on I-80
2015		
May	Utah	Reduced following distance regulation for platooning
August	California	Exempted platoon demos from minimum following distance regulation
November	Utah	Platoon demonstration on I-80
November	California	Peloton platoon demonstration near Sacramento
2016		
July	Florida	Legislation instructing FDOT to study truck platooning technology, and authorizing a pilot project to test vehicles
July	Texas	Technology demonstrations on closed tracks
July	Michigan	U.S. Army truck platoon demonstration on I-69
December	Michigan	Exempted platoon demos from minimum following distance regulation
2017		
January	Multiple	Pennsylvania, Michigan, and Ohio created 'Smart Belt Coalition' to promote development of AV and CV technologies, including truck platooning
March	California	Platoon demonstration near Port of Los Angeles
April	Arkansas	Reduced following distance regulation for platooning
May	South Carolina	Exempted platooned trucks from following distance regulations
Upcoming Events		
TBD	Iowa	Platoon enabling legislation under consideration
TBD	Ohio	Planned platoon demonstrations on Ohio Turnpike
TBD	North Carolina	Platoon enabling legislation under consideration



Saves, Time and
Lives, Time and Resources
Saves, Time and

The Project Goal

Position TxDOT as a leader in this research area and the overall TSM&O and CV/AV initiatives.

- Comprehensive truck platooning demonstration in Texas.
- Proactive effort in assessing innovative operational strategies.

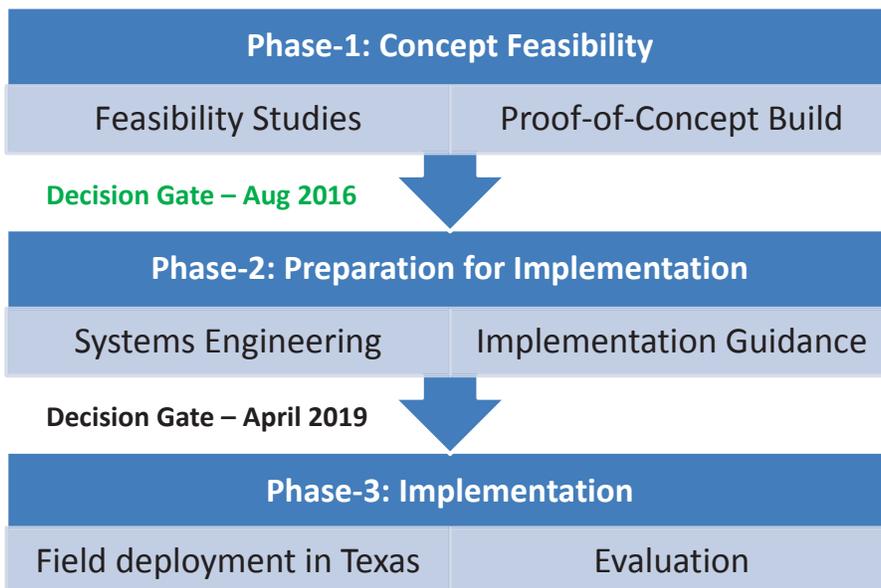


Project Focus

- Assess the feasibility of deploying 2-vehicle truck platoons on specific corridors in Texas in 5 to 10 years
- Bring together major public and private sector partners who have committed in-kind resources
 - Equipment
 - Engineering services, and
 - Intellectual property.



Project Structure



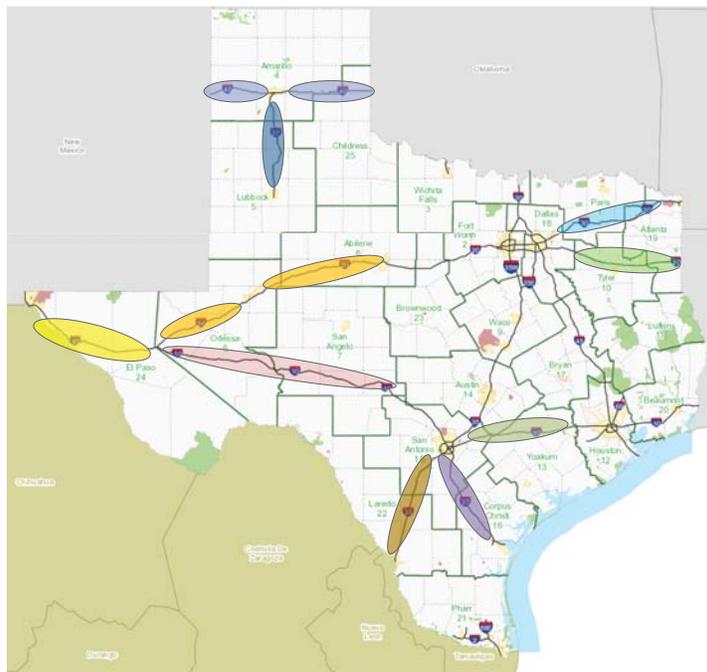
Deployment Site Characteristics

Phase 3 Requirements

- ≥ 4 -lane, rural interstate highways
- Low AADT
- High truck percentage \rightarrow least 15% of AADT.
- Relatively long stretches of highway between urban centers
- Posted speed limit ≥ 65 mph



Potential Corridors



“Following too closely” laws – typical legal elements

- Two common elements to prevent rear-end collisions involving combination vehicles
 - Variable distance standard
 - typically phrased as a “reasonable and prudent” requirement
 - discretionary – accounts for speed, traffic, etc.
 - 28 states – including ID, MT, ND, SD, WA, WY
 - Fixed distance standard
 - varies by state between 100 and 500 ft
 - 22 states – including MN
- All states have additional element(s) such as requiring “sufficient space” for another vehicle to “enter and occupy”



Lessons Learned

- Technology is moving at a very fast pace
- Industry is ahead of DOTs
- Most demos are led by the private sector, sometimes with a university partner
- Platooning has been successfully demonstrated in several settings:
 - Multi-jurisdiction (Europe)
 - 2-, 3- and 4-truck platoons
 - Closed track, open road
- Following distance legislation is key for on-the-road demonstration

Discussion

- What other background information would you like to see on truck platooning?
- What “lessons learned” are you familiar with?

Idaho
Minnesota

Montana
North Dakota
South Dakota

Washington
Wyoming

Presentation Map

Profile Technology & Truck Platooning Initiatives



Status of AV/CV Activities in the NWP

Facilitated Discussion

Next Steps – Develop an Action Plan

Status of Truck Platooning Implementation in the NWP

- Four research initiatives have been identified for further study:
 - Day One Activities to Prepare for Connected and Automated Vehicles (*on-going*)
 - Model Legislation for Autonomous and/or Connected Vehicle Operations (*expected, 2017/18*)*
 - Multistate Commercial Vehicle Platoon Demonstration (*awaiting research results*)*
 - Expanded I-80 Connected Vehicle Pilot (*not funded*)

* NWP members were surveyed on their level of interest in these projects in early 2017



Model Legislation for Autonomous and/or Connected Vehicle Operations

- Purpose: develop model legislation to allow AV/CV operations in NWP states.
- Possible tasks include collecting examples of successful legislation, interviews with states where AV/CV legislation failed, as well as where it was successfully adopted. Identify best practices and develop model legislation for potential adoption by NWP states.
- Project has been funded for 2017/18.

State	Status
Idaho	Interest in the topic, but not currently funded
Minnesota	Not interested, not planned
Montana	Interest in the topic, but not currently funded
North Dakota	Active
South Dakota	Not Answered
Washington	Not interested, not planned
Wyoming	Interest in the topic, but not currently funded

Source: CPCS Survey of NWP States. To be updated as new information is received.



Multistate Commercial Vehicle Platoon Demonstration

- Purpose: demonstrate the potential safety and environmental benefits of platooning in the NWP corridor.
- Possible tasks include applying for grants to explore and demonstrate multi-state, multi-vehicle platoons.
- Originally scoped: 2-years, \$250,000

State	Status
Idaho	Interest in the topic, but not currently funded
Minnesota	Not interested, not planned
Montana	Interest in the topic, but not currently funded
North Dakota	Interest in the topic, but not currently funded
South Dakota	Not Answered
Washington	Not interested, not planned
Wyoming	Interest in the topic, but not currently funded

Source: CPCS Survey of NWP States. To be updated as new information is received.

Discussion

- Do we have your (State) position accurately reflected in preceding tables?
- Are you aware of other activities to advance truck platooning in the NWP states (led by you or others)?

Idaho Montana Washington
Minnesota North Dakota
South Dakota

Presentation Map

Profile Technology & Truck Platooning Initiatives

Status of AV/CV Activities in the NWP



Facilitated Discussion

Next Steps – Develop an Action Plan

Question 1

- Do you (your state) have an interest in a truck platooning project along the I-90/94 corridor?

Idaho Montana Washington
Minnesota North Dakota Wyoming
South Dakota

Question 2

- Do you (your state) have any concerns about a private led truck platooning demonstration (similar to Phase 3 of the demonstration in Texas)?

Idaho	Montana	Washington
Minnesota	North Dakota	Wyoming
	South Dakota	

Question 3

- Do you (your state) have a preference in advancing a truck platooning project as a corridor, or as individual states?

Idaho	Montana	Washington
Minnesota	North Dakota	Wyoming
	South Dakota	

Presentation Map

Profile Technology & Truck Platooning Initiatives

Status of AV/CV Activities in the NWP

Facilitated Discussion



Next Steps – Develop an Action Plan

The NWP Truck Platooning Demo Concept?

- Policy?
 - Multistate coordination
 - Legislation
 - Determine best fit roles for public and private sectors
- Field Demonstration?
 - Real-world corridor
 - Rural, distance, truck AADT
 - Terrain, elevation change
 - Weather/seasons
 - Construction activity
- Partnership with university located in the NWP?

Discussion

- What is your “concept” for a NWP truck platooning demonstration?
- What other information do you need to make an informed decision on truck platooning?

Idaho	Montana	Washington
Minnesota	North Dakota	Wyoming
	South Dakota	

Our Next Steps

- Process feedback from NWP member states
- Make recommendations for future Freight Task Force activities
- Formalize recommendations in a Working Paper

Questions?

Thank You



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