North/West Passage Freight Task Force - Year 3

Working Paper 1: Truck Platooning Research and Implementation

Prepared for:
North/West Passage Pooled Fund

Prepared by:
CPCS Transcom Inc.
North/West Passage Freight Task Force

The North/West Passage Freight Task Force (Task Force) was established in 2014 to enhance 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.

Year 3 activities of the Task Force are being pursued to continue the momentum of work conducted during Years 1 and 2. Specifically the activities are designed to 1) support the active engagement of Task Force members on emerging freight operations issues in the corridor and nationally, 2) conduct research on and recommend criteria for regulations in the corridor to support truck platooning, and 3) recommend guidance for selecting virtual weigh station deployments in the North/West Passage states.

Working Paper

This Working Paper represents the Task 3 deliverable. The aim of Task 3 is to provide insight into where a truck platooning demonstration should be conducted in the NWP, and provide a vehicle to initiate private sector partnership on that demonstration.

Acknowledgments

The CPCS Team acknowledges, and is thankful for, the input of those consulted in the development of this Working Paper, as well as the guidance and input of representatives from state trucking associations, state DOTs, the Upper Great Plains Transportation Institute, and Western Transportation Institute.

Opinions

Unless otherwise indicated, the opinions herein are those of the authors and do not necessarily reflect the views of North/West Passage.

Contact

Questions and comments on this Working Paper can be directed to:

Erika Witzke, PE
Project Manager
T: 614-537-5814
ewitzke@cpcstrans.com

Cover image source: Federal Highway Administration
# Table of Contents

**Executive Summary** ........................................................................................................... v

1 **Introduction** .................................................................................................................... 1
  1.1 Background .................................................................................................................... 1
  1.2 Objectives ..................................................................................................................... 1
  1.3 Project Structure .......................................................................................................... 1
  1.4 Purpose of this Working Paper .................................................................................... 2
  1.5 Methodology ................................................................................................................. 2
  1.6 Limitations .................................................................................................................... 2

2 **Truck Platooning Basics** .................................................................................................. 3
  2.1 Platooning Operations ................................................................................................. 3
  2.2 Anticipated Benefits of Platooning ........................................................................... 4
    2.2.1 Improved Fuel Economy ....................................................................................... 4
    2.2.2 Improved Safety ................................................................................................... 5
  2.3 Platooning Technology .................................................................................................. 5
    2.3.1 Sensor and Control Systems ................................................................................ 6
    2.3.2 Communications .................................................................................................. 6
    2.3.3 Driver Interface ..................................................................................................... 6
  2.4 Current North/West Passage Efforts .......................................................................... 6
  2.5 Previous Platoon Demonstrations ............................................................................. 9
    2.5.1 International Demonstrations .............................................................................. 9
    2.5.2 United States Platooning Demonstrations ............................................................ 9

3 **Platoon-Relevant Laws and Regulations** ....................................................................... 11
  3.1 Introduction ................................................................................................................... 11
  3.2 Following Distance Laws ............................................................................................ 12
  3.3 Merging Space Laws ................................................................................................... 13
  3.4 Other Barriers Investigated ....................................................................................... 14
  3.5 Removing Barriers to Platooning Demonstrations .................................................... 15
    3.5.1 Gaining Clarity ....................................................................................................... 15
    3.5.2 Communicating with Stakeholders ....................................................................... 17
  3.6 Future Policy Considerations ..................................................................................... 17

4 **Candidate Corridors for Platoon Demonstrations** ....................................................... 18
  4.1 Introduction ................................................................................................................... 18
4.2 Criteria for Selection .................................................................................................................. 18
4.3 Conclusion: Platoon Demonstration Candidate Corridors ......................................................................................................................... 25

5 Potential Partnerships .................................................................................................................. 27

5.1 Introduction ..................................................................................................................................... 27
5.2 Potential Academic Partners ........................................................................................................ 27
5.3 Potential Private Partners .............................................................................................................. 29

6 Conclusions and Next Steps ........................................................................................................ 30

6.1 Conclusions ................................................................................................................................... 30

Appendix A: Request for Information .............................................................................................. 31

Request for Information: Multistate Truck Platooning Demonstration ........................................ 31
General Background ......................................................................................................................... 31
Project Background .......................................................................................................................... 31
Information Requested ........................................................................................................................ 32
Submission Requirements (to be determined) .................................................................................. 33
# Table of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>Project Approach</td>
<td>2</td>
</tr>
<tr>
<td>2-1</td>
<td>Platoon Demonstration</td>
<td>3</td>
</tr>
<tr>
<td>2-2</td>
<td>Reduced Drag from Platoon Operations</td>
<td>4</td>
</tr>
<tr>
<td>2-3</td>
<td>Platooning Technology Examples</td>
<td>5</td>
</tr>
<tr>
<td>2-4</td>
<td>Platoon-Relevant Projects, Laws, and Study Groups</td>
<td>7</td>
</tr>
<tr>
<td>2-5</td>
<td>International Platoon Demonstration</td>
<td>9</td>
</tr>
<tr>
<td>2-6</td>
<td>Truck Platoon Legislation and Demonstration Timeline</td>
<td>10</td>
</tr>
<tr>
<td>4-1</td>
<td>Total Traffic Volumes</td>
<td>20</td>
</tr>
<tr>
<td>4-2</td>
<td>Truck Traffic Volumes</td>
<td>21</td>
</tr>
<tr>
<td>4-3</td>
<td>Ramp Density (Areas where ramps are less than 3 miles apart)</td>
<td>22</td>
</tr>
<tr>
<td>4-4</td>
<td>Interchange Spacing Suggestions</td>
<td>23</td>
</tr>
<tr>
<td>4-5</td>
<td>Maximum Grades and Speed Limits</td>
<td>23</td>
</tr>
<tr>
<td>4-6</td>
<td>Steep Slopes on NWP Interstates</td>
<td>24</td>
</tr>
</tbody>
</table>
## Acronyms / Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>ATCMTD</td>
<td>Advanced Transportation and Congestion Management Technologies Deployment</td>
</tr>
<tr>
<td>AV/CV</td>
<td>Autonomous and/or Connected Vehicles</td>
</tr>
<tr>
<td>CHAPTA</td>
<td>Collaborative Human-Automated Platooned Trucks Alliance</td>
</tr>
<tr>
<td>DOT</td>
<td>Department of Transportation</td>
</tr>
<tr>
<td>DSRC</td>
<td>Digital Short-Range Communications</td>
</tr>
<tr>
<td>FDOT</td>
<td>Florida Department of Transportation</td>
</tr>
<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
</tr>
<tr>
<td>NDDOT</td>
<td>North Dakota Department of Transportation</td>
</tr>
<tr>
<td>NWP</td>
<td>North/West Passage</td>
</tr>
<tr>
<td>RFI</td>
<td>Request for Information</td>
</tr>
<tr>
<td>TBD</td>
<td>To be Determined</td>
</tr>
<tr>
<td>TRAC</td>
<td>Washington State Transportation Center</td>
</tr>
<tr>
<td>V2V</td>
<td>Vehicle-to-Vehicle</td>
</tr>
<tr>
<td>UGPTI</td>
<td>Upper Great Plains Transportation Institute</td>
</tr>
<tr>
<td>USGS</td>
<td>United State Geological Survey</td>
</tr>
<tr>
<td>WSDOT</td>
<td>Washington State Department of Transportation</td>
</tr>
<tr>
<td>WTI</td>
<td>Western Transportation Institute</td>
</tr>
</tbody>
</table>
Executive Summary

Truck platooning technology consists of sensors, communication, and control equipment that enable trucks to safely and closely follow one another. This practice can improve fuel economy by reducing air drag for following trucks, and improve highway safety as platooning systems are equipped with collision avoidance and emergency braking technologies. The cost savings from these efficiency and safety improvements are expected to be greater than the cost of additional sensors and computing equipment needed to facilitate platooning, making adoption of platooning an attractive option for truck operators. State DOTs are also interested in the potential safety and emissions benefits of platooning, and the potential operational impacts from widespread adoption of the technology.

Currently, most North/West Passage (NWP) states are engaged in studying the potential value of connected and autonomous vehicle operations, a concept that includes truck platooning. In particular, Washington and North Dakota are pursuing the development of platooning demonstrations along I-90 and I-94 respectively. The platoon-specific work in these states, and ongoing connected and autonomous vehicle studies in other NWP states, set the stage for a potential multi-state truck platoon demonstration. Given this ongoing work, NWP states have expressed interest in learning more about a multi-state platoon demonstration, the potential barriers to a demonstration, possible highway corridors that could host a demonstration, and possible partners. The geography of the NWP from Billings, Montana eastward is well-suited to platoon operations, with large, relatively empty expanses, and low grades. At the same time, operators must deal with inclement weather such as snowstorms. These unique geographic and climatic considerations, combined with a demonstration across multiple states could advance understanding of platooning’s capabilities, its cost savings on long-haul routes, its limitations, and the potential challenges associated with harmonizing platoon regulations across multiple states.

Barriers to Platoon Demonstrations

Platooning’s benefits are only possible if trucks can operate close together. However, these close-following operations, and other elements of platooning such as vehicle length and weight, could be in conflict with state rules and regulations. This study found two potential barriers to a demonstration: 1) minimum following distance laws, and 2) laws that require vehicles to maintain a distance great enough to allow vehicles to safely merge between them. These two types of rules may be barriers to a potential demonstration because they are vaguely worded, and leave room for various interpretations between stakeholders. Overcoming this vagueness can be accomplished through methods such as executive orders and legislative changes to specifically allow platooning. In general, NWP state Departments of Transportation (DOTs) believed that the issue of vague laws could be overcome, and there are no long-term or insurmountable barriers to a platoon demonstration in NWP states.

Candidate Corridors for Platoon Demonstrations

Most of the interstates in NWP region east of Billings, Montana are well-suited for platooning operations, with moderate to low traffic volumes, few steep grades, and relatively few densely-
populated areas. A spatial analysis of potential candidate corridors found that best candidates for a multi-state platooning demonstration and include the following corridors shown in Figure ES-1:

- I-90 from Winona, MN to Billings, MT
- I-94 from St. Cloud, MN to Billings, MT
- I-29 from Pembina, ND to Sioux City, IA
- I-25 from Cheyenne, WY to Billings, MT

**Platoon Demonstration Partnership**

State DOTs are increasingly regarding the adoption of autonomous and connected vehicle (AV/CV) technologies as inevitable, and they are seeking to understand how adoption of AV/CV technologies will affect operations. However, DOTs do not necessarily have in-house expertise with AV/CV technologies to conduct their own demonstrations, nor to evaluate the impacts observed during the demonstrations. Partnership with the private sector and academia can provide state DOTs with both the technology and knowledge necessary to create a demonstration.

First, the NWP will need to partner with one or more producers of platooning technology, who can provide hardware and technical expertise to install platoon systems on trucks. Potential partners in the private technology sector include Peloton, Daimler, and Volvo. Additionally, once a technology partner is secured, platoon demonstration organizers may wish to engage with private trucking companies who can utilize platooning in every-day operations, and determine the potential business benefits of platoon systems. Two potential academic partners with platoon-specific experience are the Upper Great Plains Transportation Institute and the Western Transportation Institute. During development of this Working Paper both of these institutions presented their research to the NWP. In addition to these, many other universities in the NWP region have experience with AV/CV technology and freight research and could be viable academic partners, supporting the evaluation of the demonstration.

**Next Steps**

To assist the NWP states in soliciting further interest in a platoon demonstration, the report Appendix includes a Request for Information that states can modify and distribute to academia, platoon technology vendors, and trucking companies.
Figure ES-1: Ideal Interstates for a Multi-State Platoon Demonstration

Source: CPCS analysis of National Transportation Atlas and FHWA data.
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 3 activities of the Task Force are being pursued to continue the momentum of work conducted during Years 1 and 2. Specifically the activities are designed to:

1. Support the active engagement of Task Force members on emerging freight operations issues in the corridor and nationally.

2. Conduct research on and recommend criteria for regulations in the corridor to support truck platooning.

3. Recommend guidance for selecting virtual weigh station deployments in the North/West Passage states.

Each of these activities is aimed at getting the coalition closer to implementation of projects that will improve freight operations in the NWP corridor.

1.3 Project Structure

The project is to be developed through four broad tasks, as set out in Figure 1-1. The present Working Paper is the output of Task 3 – Truck Platooning Regulations.
1.4 Purpose of this Working Paper

The aim of this Working Paper is to provide insight into where a bi-or multi-state truck platooning demonstration should be conducted in the NWP, and provide a vehicle to initiate private sector partnership on that demonstration. Specifically this paper addresses the following questions:

- What codes/regulations affect the legality of allowing truck platooning in each of the NWP states?
- What are the gaps/inconsistencies in codes/regulations that could hinder truck platooning in the NWP?
- What criteria should be used to select a location for an ideal truck platooning demonstration in NWP states?
- What locations (on all interstates) in the NWP states should be considered as candidate demonstration locations?
- Who may be interested in collaborating with the NWP to conduct a truck platooning demonstration at candidate locations?

1.5 Methodology

This Working Paper was prepared by 1) conducting a desk scan of rules and regulations relevant to platoon operations; 2) conducting outreach and interviews with trucking associations, state DOTs, and academic stakeholders; 3) conducting a web meeting focused on providing NWP members information on truck platooning; and 4) conducting GIS analysis to identify candidate corridors for a platoon demonstration.

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 Basics

Key Chapter Takeaway

Truck platooning technology enables trucks to closely follow one another, a practice which can improve fuel economy and highway safety. The cost savings from these improvements are expected to exceed the cost of additional sensors and computing equipment needed to facilitate platooning, making platooning an attractive option for truck operators.

Currently, most NWP states are engaged in some work studying the potential value of connected and autonomous vehicle operations, a concept that includes truck platooning. In particular, Washington and North Dakota are pursuing the development of platooning demonstrations on I-90 and I-94. The platoon-specific work in these states, and ongoing connected and autonomous vehicle studies in other NWP states sets the stage for a potential multi-state truck platoon demonstration.

2.1 Platooning Operations

Truck platooning refers to the operation of two or more trucks in a line with reduced following distance between them. Platoon operations are intended to reduce operating costs, as a reduction in following distance between trucks reduces wind resistance. In turn, this reduced wind resistance reduces fuel consumption for both leading and following vehicles. Figure 2-1 provides an example of a platoon demonstration, with three trucks driving close together.

![Figure 2-1: Platoon Demonstration](source: Transport Canada. 2018).

Usually, operating trucks at highway speeds with minimal following distance would create a safety hazard, as following drivers could not see the road ahead and react quickly enough to prevent collisions with leading trucks. This safety concern has been overcome through the creation and application of technologies that allow a lead truck to automatically transmit braking and acceleration commands to following platooned trucks, eliminating the need for following platoon...
drivers to directly brake or accelerate. Some platooning systems also enable following drivers to relinquish control of their steering functions while platooned with a lead truck, however these systems are less common.

2.2 Anticipated Benefits of Platooning

Truck platooning promises two main benefits that can reduce costs: reduced fuel consumption and improved highway safety. If the cost savings associated with these benefits are great enough to cover the cost of advanced technologies required for platooning, then platooning may be commercially viable. Additionally, public agencies like state DOTs and the Federal Highway Administration (FHWA) are interested in the potential safety improvements and emissions reductions that may be possible with platoon operations. However, the magnitude of these savings is not known, and longer-term testing of platoon technology with commercial trucking companies is needed to determine the real-world financial implications. This section provides further information on the potential benefits associated with improved fuel economy and improved safety.

2.2.1 Improved Fuel Economy

Operating two or more trucks with minimal following distance reduces wind resistance, as following vehicles can drive in the air “pocket” formed behind the lead truck. At the same time, the following vehicle reduces the inefficient “vacuum” that forms behind the lead truck and creates drag, thereby applying pressure to the lead vehicle. Figure 2-2 provides an illustration of the aerodynamic improvements associated with platooning.

![Figure 2-2: Reduced Drag from Platoon Operations](source)

Estimated fuel savings for individual trucks engaged in platooning range widely, depending on the position of the truck in the platoon, distance between trucks, and the number of trucks platooned. However, estimates for overall combined fuel savings for platoon operations usually range between 6% and 7%.\(^1\)\(^2\) As of 2016, fuel costs made up about 21% of per-mile trucking costs, and have made up as much of 40% of operating costs in the past (such as in 2011), so even modest

\(^1\) 2014 Study by NREL
\(^2\) Peloton Study
improvements in fuel efficiency may reduce fuel bills enough to entice large trucking companies to adopt platooning technology.3

2.2.2 Improved Safety

The advanced sensors required for platoon operations can also be used for other applications, such as collision avoidance, lane departure warnings, and lane keeping assistance. Automatic safety systems like these could improve the overall safety record of a company’s fleet, reducing the frequency and cost associated with accidents and possibly reducing insurance premiums. Some commercial vendors of platooning technology have used these safety cost savings to make a business case for adoption of platooning systems.

2.3 Platooning Technology

Generally, truck platooning technologies are classified as vehicle-to-vehicle (V2V) technologies, wherein a wireless data connection between vehicles provides information which can be used by the vehicle to change its operation or alert the driver. Within this broad category of V2V, there are a number of common enabling technologies, such as sensors, control systems, and communication systems. Figure 2-3 provides an example of some of the types of technology needed to facilitate platoon operations.

![Figure 2-3: Platooning Technology Examples](Source: Federal Highway Administration. 2017.)

---

2.3.1 Sensor and Control Systems

Since the benefits of platooning depend on reducing following distance between trucks, a consistent distance between vehicles is important for both fuel savings and safety. In order to maintain a safe, but relatively small distance, platoon systems must be capable of accurately and frequently measuring the bumper-to-bumper gap between trucks. This measurement is accomplished in varying ways, based on the specific platoon system, but the most common technologies for measuring vehicle-to-vehicle distance are radar, LiDAR (light-based radar), and multi-camera systems. Ranged detection systems like radar and LiDAR calculate distance by measuring the time it takes for radio or light waves to travel between two trucks. Stereoscopic camera systems calculate distance by using computers to analyze images from each camera, and compare differences in the placement of objects in these images against information about the position of the cameras.

Once the distance between two trucks is calculated, the platoon control system can make decisions based on this information, such as commanding a following platooned truck to release its accelerator or apply brakes to increase following distance. These detection and measurement systems are also used for automated driving functions such as automatic collision avoidance, or lane-keeping assistance. For example, platoon systems are programmed to automatically detect “cut-ins,” or non-platoon vehicles merging between two platooned trucks. When a “cut-in” is detected, the platoon system will automatically slow the following truck, to create a safe amount of following distance behind the merging vehicle.

2.3.2 Communications

Once a platooning command is generated by a lead truck, it must be communicated to other vehicles. V2V communication is most often facilitated by Dedicated Short Range Communications (DSRC), a medium to short-range radio communication protocol. In platooning applications, DSRC systems may communicate information about braking, acceleration, steering, collision warnings, vehicle condition, and video feeds of the road ahead from the lead truck. Some systems may also utilize WiFi communication protocols to communicate between vehicles.

In addition to V2V communications, some platoon systems include cellular communication equipment, allowing trucks to communicate their platoon status to centralized control centers.

2.3.3 Driver Interface

Generally, drivers control the acts of initiating or terminating platoons, and these actions are controlled through a touchscreen or physical button/switch hardware packages in each truck. Some platoon systems also have video screens, which allow following drivers to see the road ahead from the view of the lead truck.

2.4 Current North/West Passage Efforts

Almost all NWP states are engaged in some form of research or review that is relevant to truck platooning. This includes active work to establish platoon demonstrations as well as working groups related to connected and autonomous vehicles in general. Figure 2-4 provides a visual summary of the level of engagement among NWP states. The states in yellow are actively pursuing
platooning demonstrations and researching autonomous and connected vehicle (AV/CV) technologies, while the states in blue are only researching AV/CV technologies.

Figure 2-4: Platoon-Relevant Projects, Laws, and Study Groups

DOTs in NWP states and the US as a whole are becoming more involved in research and testing of AV/CV technologies because DOTs need to understand and prepare for how these technologies may impact their operations. In general, the prevailing attitude among DOTs is that adoption of AV/CV technologies is inevitable, and DOTs need to start trying to anticipate the operational impacts of AV/CV technology. Since many of these technologies are being developed by the private sector, partnership and engagement in demonstrations with the private sector can help DOTs guide some of the development of AV/CV technology. In the context of truck platooning, state DOTs are particularly interested in the potential safety improvements and emission reductions associated with platoon operations.

Current platooning-relevant legislation and work in each NWP state is listed below:

**Idaho**

In January 2018, Idaho Governor CL “Butch” Otter signed Executive Order 2018-01, which created an Autonomous and Connected Vehicle Testing and Deployment Committee. The Committee’s responsibilities include:

- Identifying agencies relevant to the testing and deployment of AV/CV.
- Coordinating with identified agencies and discussing how to regulate testing and operation of AV/CV.
• Reviewing existing state statutes and rules to identify potential impediments to testing and deployment.
• Identifying partnerships to leverage the benefits of AV/CV.

Minnesota
In March 2018, Minnesota governor Mark Dayton signed executive order 18-04, which established the Governor’s Advisory Council on Connected and Automated Vehicles. This committee has been tasked with preparing a report to recommend changes to statutes, rules, and policies related to AV/CV. The executive order also directs the DOT to establish programs and guidelines for AV/CV testing and deployment.

Montana
In 2017, Montana State University’s Western Transportation Institute (WTI) launched a program called the Collaborative Human-Automated Platooned Trucks Alliance (CHAPTA). This program was intended to study how platooning technologies could be safely integrated into the trucking industry. However, a change in presidential administrations meant that expected funding for the Institute was not available. As of this report, Montana has not established a committee or workgroup to review the potential implications of AV/CV.

North Dakota
In April 2017, the North Dakota State Legislature passed a bill directing the North Dakota DOT (NDDOT) to study the use of AV/CV in North Dakota, including a review of current laws, and how they should apply to AV/CV. Currently, NDDOT is working in cooperation with the Upper Great Plains Transportation Institute (UGPTI) and the technology vendor Peloton to apply for an Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant to fund platoon demonstrations. Some of these demonstrations are intended to be multi-state, opening up the opportunity for a NWP multi-state demonstration. UGPTI staff have indicated that platoon demonstrations are likely to occur regardless of whether or not the grant is secured.

Washington
In 2017, Washington Governor Jay Inslee signed Executive Order 17-02, which allowed for certain types of AV/CV pilot programs and directed the DOT and other transportation-relevant agencies to support the safe testing and operation of AV/CV. The order also created an AV/CV work group tasked with evaluating the state government’s role in the development of AV/CV, evaluating AV/CV in other modes, and proposing changes to state laws, rules, and policies.

Starting in early 2018, the AV/CV workgroup, in partnership with Washington State DOT and Peloton, began exploring the possibility of conducting platoon demonstrations and operations on eastern segments of I-90.

Wyoming
In 2015, USDOT selected I-80 in Wyoming as a corridor to test DSRC applications. The Wyoming DSRC pilot uses DSRC to communicate information about road conditions between vehicles and infrastructure. Information collected and transmitted includes data about work zones, inclement
weather, speed restrictions, vehicle distress, and collision warnings. This ongoing research could serve as the starting point for a platoon demonstration in Wyoming.

### 2.5 Previous Platoon Demonstrations

This section provides a brief background on previously-completed platoon demonstrations in both the US and world as a whole.

#### 2.5.1 International Demonstrations

Platoon tests and demonstrations have been going on since the late 1990s, mostly in Europe. Of particular note are the European Truck Platooning Challenge and ENSEMBLE, which are especially relevant to the NWP because a major part of the demonstrations’ work involves resolving problems created by different regulatory environments of multiple nations. The European Truck Platooning Challenge project included six truck manufacturers and five nations, and could serve as a model for future demonstrations in the NWP.

**Figure 2-5: International Platoon Demonstration**

<table>
<thead>
<tr>
<th>Project</th>
<th>Sponsor</th>
<th>Year</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAUFFEUR</td>
<td>European Commission</td>
<td>1999-2002</td>
<td>Test of camera technology to measure and maintain following distance, and automated braking, acceleration, and steering.</td>
</tr>
<tr>
<td>KONVOI</td>
<td>Germany</td>
<td>2005-2009</td>
<td>First public test of highway platooning, and first attempt to measure fuel savings and safety improvements.</td>
</tr>
<tr>
<td>SARTRE</td>
<td>European Commission</td>
<td>2009-2012</td>
<td>Test of “road train” concept, with multiple vehicles behind a professionally-driven lead vehicle.</td>
</tr>
<tr>
<td>Misc</td>
<td>Japan</td>
<td>2010-2013</td>
<td>Test of near-autonomous trucking, with divers only controlling lane changes.</td>
</tr>
<tr>
<td>Daimler Demonstrations</td>
<td>Germany</td>
<td>2016</td>
<td>Demonstration of a fully-autonomous platoon.</td>
</tr>
<tr>
<td>European Truck Platooning Challenge</td>
<td>Netherlands</td>
<td>2015-2016</td>
<td>First multi-national demonstration of platooning technology. Trucks drove through Sweden, Denmark, Germany, Netherlands, and Belgium.</td>
</tr>
<tr>
<td>Sweden 4 Platooning</td>
<td>Sweden</td>
<td>2017-2019</td>
<td>Three-year multi-agency research project to test platooning and gather data in real traffic.</td>
</tr>
<tr>
<td>UD Trucks</td>
<td>Japan</td>
<td>2018</td>
<td>Multi-manufacturer platoon technology demonstration on public roads.</td>
</tr>
<tr>
<td>ENSEMBLE</td>
<td>European Commission</td>
<td>2018-2021</td>
<td>Project to harmonize and ensure safe platooning among different brands of trucks. Testing will be multi-national and gather information on harmonization of platoon regulations.</td>
</tr>
</tbody>
</table>

Source: CPCS

#### 2.5.2 United States Platooning Demonstrations

Figure 2-6 provides a brief list of notable demonstrations and platoon-related laws in the US. 2017 represented a major year for truck platooning demonstrations with major events in multiple states, with multiple sponsors and technology vendors.
<table>
<thead>
<tr>
<th>Date</th>
<th>State</th>
<th>Accomplishment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Utah</td>
<td>Platoon demonstration with CR England trucking</td>
</tr>
<tr>
<td>2014</td>
<td>Nevada</td>
<td>Platoon demonstration on I-80</td>
</tr>
<tr>
<td>2015</td>
<td>Utah</td>
<td>Reduced following distance regulation for platooning</td>
</tr>
<tr>
<td>August</td>
<td>California</td>
<td>Exempted platoon demos from minimum following distance regulation</td>
</tr>
<tr>
<td>November</td>
<td>Utah</td>
<td>Platoon demonstration on I-80</td>
</tr>
<tr>
<td>November</td>
<td>California</td>
<td>Peloton platoon demonstration near Sacramento</td>
</tr>
<tr>
<td>2016</td>
<td>Florida</td>
<td>Legislation instructing FDOT to study truck platooning technology, and authorizing a pilot project to test vehicles</td>
</tr>
<tr>
<td>July</td>
<td>Texas</td>
<td>Technology demonstrations on closed tracks</td>
</tr>
<tr>
<td>July</td>
<td>Michigan</td>
<td>U.S. Army truck platoon demonstration on I-69</td>
</tr>
<tr>
<td>December</td>
<td>Michigan</td>
<td>Exempted platoon demos from minimum following distance regulation</td>
</tr>
<tr>
<td>2017</td>
<td>Multiple</td>
<td>Pennsylvania, Michigan, and Ohio created ‘Smart Belt Coalition’ to promote the development of AV and CV technologies, including truck platooning</td>
</tr>
<tr>
<td>March</td>
<td>California</td>
<td>Platoon demonstration near Port of Los Angeles</td>
</tr>
<tr>
<td>April</td>
<td>Arkansas</td>
<td>Reduced following distance regulation for platooning</td>
</tr>
<tr>
<td>May</td>
<td>South Carolina</td>
<td>Exempted platooned trucks from following distance regulations</td>
</tr>
<tr>
<td>September</td>
<td>Virginia</td>
<td>FHWA platoon demonstration</td>
</tr>
<tr>
<td>September</td>
<td>Oregon</td>
<td>Daimler Trucks (Freightliner) platoon demonstrations</td>
</tr>
<tr>
<td>December</td>
<td>Florida</td>
<td>1,000-mile demonstration with Peloton</td>
</tr>
<tr>
<td>December</td>
<td>Michigan</td>
<td>Peloton demonstration on I-96</td>
</tr>
<tr>
<td>2018</td>
<td>North Carolina</td>
<td>Volvo and FedEx demonstration on NC-540</td>
</tr>
<tr>
<td>TBD</td>
<td>National</td>
<td>Peloton expects to launch commercial platooning in 2018</td>
</tr>
<tr>
<td>TBD</td>
<td>Washington</td>
<td>Platoon demonstration on I-90</td>
</tr>
<tr>
<td>TBD</td>
<td>North Dakota</td>
<td>Platoon demonstration and commercial operations on I-94</td>
</tr>
</tbody>
</table>

Source: CPCS
3 Platoon-Relevant Laws and Regulations

Key Chapter Takeaway

Truck platooning’s benefits are only possible if trucks can operate close together. However, these close-following operations, and other aspects of platooning such as vehicle length and weight, could be in conflict with state rules and regulations. This chapter summarizes findings from consultations with state DOTs on the potential legal barriers to a platoon demonstration.

The two potential barriers to a demonstration are 1) minimum following distance laws, and 2) laws that require vehicles to maintain a distance large enough to allow vehicles to safely merge between them. These two types of rules are barriers because they are vaguely worded, and leave room for various interpretations. Overcoming this vagueness can be accomplished through methods like executive orders and legislative changes to specifically permit platooning.

3.1 Introduction

This chapter provides answers to two key questions about the feasibility of platooning in the NWP:

- What state codes/regulations affect the legality of allowing truck platooning in each of the NWP states?
- What are the gaps/inconsistencies in codes/regulations that could hinder truck platooning in the NWP?

To answer these questions, nine (9) consultations were conducted with fifteen (15) state DOT staff including legal counsel, commercial vehicle office staff, law enforcement officers, and freight planning staff. The regulatory issues that were discussed included:

- Following distance requirements between platooned trucks
- Space for vehicles to merge in between platooned trucks
- Truck weight limits
- Vehicle length limits
- Distracted driving laws

After consultations with DOT staff, it was determined that following distance and merging space requirements created almost all of the potential regulatory barriers to a platoon demonstration.
These barriers are a product of vague language in following distance and merging space laws, and it is feasible to resolve them prior to a platooning demonstration.

### 3.2 Following Distance Laws

Truck platooning is only beneficial if trucks can drive close together. However, the close following distance required for platooning may be in direct conflict with states’ following distance laws, which set standards for following distances to ensure highway safety. Six of the seven NWP states have “reasonable and prudent” following distance laws. These types of laws do not specify a fixed minimum following distance, but instead require that drivers maintain a “reasonable and prudent” following distance that reflects their speed, environmental conditions, and other factors such as vehicle weight. Minnesota is the exception, it has a fixed minimum following distance of 500 feet for vehicles pulling trailers.

Under Minnesota’s fixed-distance law, any truck platooning operations are prohibited. However, the rest of the NWP states’ “reasonable and prudent” laws leave room for interpretation and enforcement, and how “reasonable and prudent” is measured varies from state-to-state. Often this interpretation is left to a law enforcement officer. For example:

- **Idaho law enforcement** bases their determination of “following too close” on speed versus distance. An officer would pull people over for following at platoon distances (50-100 feet) at 60 mph, therefore it is possible that an officer would consider a platoon demonstration illegal.

- **In South Dakota,** determination of “following too close” is based on the speed of vehicles, traffic volumes, and highway conditions. These criteria do not include onboard technology of trucks, which make closer following distances feasible and safe. Therefore, DOT legal staff believe that platooned trucks may need distinguishing features so that law enforcement can determine they are not following too closely.

- **In Minnesota,** a DOT official noted that enforcement was not an insurmountable barrier to beginning platooning demonstrations immediately, as a platoon operator “if they wanted...could just take the [following distance] ticket and do a demonstration.”

- **Other states,** such as Washington, Montana, and North Dakota, said they did not see following distance laws as a barrier, provided law enforcement officers were made aware of the demonstration and brief on how platoons operate.

The vague legal definition and varying interpretation of “reasonable and prudent” requirements could be a barrier to platooning, as truckers, trucking companies, and platoon providers would want to be sure that their operations are fully and unambiguously legal. However, the state DOT staff who were consulted for this project believed that following distance laws themselves would not be a barrier to platooning demonstrations. Instead, DOT staff noted that the uncertainty of these distance could be resolved by a variety of approaches, from lobbying the legislature to pass enabling legislation or asking the governor to sign executive orders specifically approving platooning, to educating law enforcement officers about the existing legality and safety of platooning operations under current regulations. Discussion about these potential resolution methods is provided in section 3.5.
Following distance laws by themselves are not barriers to platoon operations, but the uncertainty created by varied interpretation and enforcement practices across states must be resolved.

### 3.3 Merging Space Laws

In addition to following distance requirements, all NWP states have requirements related to safe gaps to accommodate merging vehicles. The text of these laws generally require that drivers:

...allow for sufficient space between each vehicle or combination of vehicles to enable any other vehicle to enter and occupy the space without danger.

Like following distance laws, merging space laws are vague in their definition, providing little specific guidance on what constitutes “sufficient space.” However, unlike following distance, many DOT staff believed that merging space requirements could be a firmer barrier to platooning demonstrations. For example, one state noted that they interpreted the law to require space for multiple cars to merge between trucks. Another state interpreted their law to require space to fit an equal-sized truck between two platooned trucks. In both cases, these space requirement interpretations would require platooned trucks to maintain a following distance that would yield less-than-optimal fuel savings. Not all states mentioned this merging space requirement as a barrier to a demonstration.

Laws requiring adequate space for vehicles to merge between two vehicles could make platoon operations inefficient, and should be clarified or altered in order to legally accommodate platooning.

The optimal space between platooned vehicles to reduce drag and improve fuel efficiency is small enough that platoon operations will likely be in conflict with states’ merging space requirements. However, some states provided some suggestions on how this barrier could be overcome:

- **Exempting or expressly approving vehicles equipped with platooning technology.** Platooning systems have been engineered to accommodate merging or “cut-ins,” between platooned trucks: when a vehicle attempts to cut between two platooned trucks, the system automatically decreases the speed of the following truck to create a larger gap, and increase following distance. This technology may provide states with a justification to exempt platoons from merging space requirements without jeopardizing highway safety. A waiver could come from the legislature, the governor, law enforcement, or DOT executives.
• **Classifying a platoon as one combination vehicle, caravan, or motorcade.** Under this approach, platoons could be classified by the DOT or legislature as a single vehicle, which would mean that individual trucks would not have to maintain as large of a gap.

• **Notifying law enforcement in advance.** Not all NWP states noted merging space as a concern or barrier to a demonstration, but did mention that simply notifying law enforcement in advance would be sufficient to enable platoon demonstrations.

The discussion of both merging space and following distance revealed a common theme: the need to educate law enforcement and the general public about platooning operations, and the need for platooning operations to carry clear identifying markings for both law enforcement and the general public. These two items are needed because law enforcement needs to properly identify platooned vehicles for enforcement purposes, and the public needs to be able to identify platoons in order to understand how to drive around them.

### 3.4 Other Barriers Investigated

At the start of consultations, other potential barriers to platooning demonstrations were identified, including weight limits, and vehicle length limits. A discussion of these and other issues identified during consultations is provided below.

#### Weight Limits

Since platoon demonstrations are likely to be restricted to interstate highways, the weight effects of two trucks driving in close proximity, particularly on bridges was a potential concern. However, states said that this would not be a concern for vehicles below 80,000 pounds, but higher weights may present problems. Previous research in other states suggests weight on interstates should not be a concern: a 2018 study in Florida found that less than 1% of the state’s bridges on interstates and mainline routes could not accommodate the weight of platooned trucks, so long as their following distance exceeded 30 feet.⁴ These preliminary findings and a relative lack of concern from consultations suggest that weight will not be a barrier for platoon demonstrations on NWP interstates. State DOTs engaged in platooning demonstrations should still do due diligence with their engineering departments to ensure that any structurally-deficient bridges are excluded from a demonstration, particularly if weights higher than 80,000 pounds will be platooned.

Weight limits are not expected to be a barrier to platoon demonstrations or operations.

#### Vehicle Length and Multiple Trailers

This topic was initially considered a potential barrier. No states noted problems with vehicle length for two-truck platoons, although some states like Idaho said they would not allow platoons with

---

double or triple trailers. Other states, such as North Dakota, expressed interest in conducting a platoon demonstration with double trailers.

Other Potential Barriers
Other issues that could affect platoon demonstrations include:

- **Distracted Driving Laws.** In platooning systems, drivers are often given a small touchscreen which provides a video feed from the lead truck, allowing drivers to link or delink from the platoon. Washington State DOT (WSDOT) noted that viewing screens is generally forbidden while driving. However, states often make exceptions for screens that assist in the safe operation of a vehicle. For example, Florida’s legislature made a specific exemption for platooning screens in its distracted driving laws, and other states have determined that platooning screens are exempt from existing regulations, as they aid in safe operation of a vehicle.  

- **Moving over for emergency vehicles.** Montana DOT staff noted that they would like a clarification on how platoons will move to opposite lanes to accommodate passing or stopped emergency vehicles. This merging action into the left lane could create conflict with passing traffic.

### 3.5 Removing Barriers to Platooning Demonstrations

Currently, there are two primary regulatory barriers to a platooning demonstration in NWP states: 1) following distance requirements, and 2) merging space requirements. Both types of regulations are barriers because their language is vague, and could be interpreted to prohibit the close following distances required to make platooning efficient. This vague definition, and the accompanying potential for uneven enforcement, must be resolved if platoon demonstrations are to be feasible. Resolving this issue will require a two-step process: first, regulations must be clarified or altered, and second, these new rules and regulations must be communicated to law enforcement, truck operators, and the general public. This section provides insight on how different states may be able to clarify their platooning-relevant regulations, what types of information may need to be communicated, and what additional policies may be needed in the future as platooning moves from demonstrations to everyday practice.

#### 3.5.1 Gaining Clarity

There are three approaches advocates for a platooning demonstration could use to gain clarity and definitions on existing regulations:

- **Soft touch:** where formal approval for platooning is not needed, and a demonstration can proceed so long as all stakeholders are “on the same page.”

- **Executive leadership:** executive orders from the governor or guidance from DOT chief provides clarification on problematic regulation.

---

5 Conference call with WSDOT and Peloton staff, March 2018.
• **Legislative approval:** formal alteration or clarification of state law by the state legislature.

The type of approach necessary will vary based on each NWP state’s political climate and government leaders’ tolerance for risk associated with experimental technologies operating on public roads. However, a common and important thread among these approaches is the need for a project champion who can shepherd a platoon demonstration through these processes. Without a clear champion to drive a project forward and advocate for it politically, it is less likely to succeed.

Regardless of the method of removing regulatory barriers, a platooning demonstration will require a project champion to shepherd it through uncertainty.

**Soft-Touch Approach**

The “soft touch” approach involves little formal approval for platooning demonstrations. Instead, it emphasizes informal communication between the DOT, platooning partners, and law enforcement to communicate about what platooning is, and how a demonstration will work. Under this approach, platooning operations may technically be in violation of state regulations, but law enforcement will not cite or stop a demonstration. This approach may be appropriate for states that wish to advance a demonstration quickly, and where there is little concern or confusion over the meaning of state regulations.

**Executive Leadership Approach**

The “soft touch” approach may be unsuitable for states where there is greater disagreement over the interpretation of following distance and passing space regulations, or where DOT leaders or state governors want more control over a potential demonstration. In cases like this, uncertainty and barriers can be eliminated through executive orders waiving or clarifying regulations for platoons.

Using executive orders to clear the way for a demonstration appears to be a more favorable approach for many NWP states, and staff from Minnesota, North Dakota, Wyoming, and Idaho specifically mentioned executive orders as a necessary enabling element for a platoon demonstration. The foundation for this approach has already been laid in most NWP states, as five states have AV/CV projects or committees that were created with input from the state governor. Executive orders could be a better approach for a multi-state demonstration, because such a project will require cooperation across state lines, and having the governor’s support may make forging cross-border working relationships easier. However, this approach will not be suitable for states where a governor may be unwilling to assume some of the risks for enabling platooning, in the event an accident occurs.

**Legislative Approval**

The slowest, but politically “strongest” approach from a risk standpoint is lobbying state legislators to alter state code to allow for platooning operations. This approach is slowest because it requires platoon proponents to lobby legislators, requires legislators to negotiate on proposed changes, and can only be accomplished at times of year when the legislature is in session. It may also be difficult
if legislators perceive AV/CV technologies as untested or dangerous. However, barring a veto from the governor, legislative approval is the true “final word” on platooning feasibility in a state, and can set the stage for long-term adoption of everyday platooning. Staff from South Dakota and Idaho noted that this type of approval may be necessary for their states.

3.5.2 Communicating with Stakeholders
Once the vagueness of state regulations has been eliminated, new policies must be communicated to platooning stakeholders, particularly to law enforcement, platoon operators, and the general public. Communication with law enforcement is important so that:

- Officers do not cite platoon operators for legal activity, such as close following.
- Platoon operators understand the bounds and restrictions on platooning in the state, including vehicle inspections, vehicle markings, and areas where platooning is not allowed.
- The general public can identify platoons, and understand how to drive around platooned trucks.

3.6 Future Policy Considerations
After consulting with each state DOT, it appears that the anticipated barriers to a platooning demonstration in the NWP may be overcome in a fairly straightforward manner. However, making platooning an everyday, long-term occurrence in NWP states will require the examination and creation of additional policies that are beyond the scope of this report. Some of the potential topics that will need to be resolved are listed below:

- Specific placards and signage standards to identify platooned vehicles, particularly when they are actively engaged in a platoon.
- Equipment requirements for trucks engaged in platooning operations. However, many platoon system manufacturers already have their own set of requirements (brake types, tire quality, truck age, etc.) beyond the level of safety and quality of average trucks.
- Inspection and maintenance regimens for trucks participating in platooning operations.
- Permitting and fee practices for truck operators that wish to engage in platooning.
- Establishing “no-go” zones for statewide, routine platooning operations.
- Educating other drivers about platooning and proper driving behavior.

While these future policy issues are outside the scope of this project, it likely that the work of organizing a demonstration will likely further illuminate potential policy issues, as well as solutions. Should the NWP successfully launch a multi-state demonstration, NWP states will be well-positioned to advocate and advise on national-level standards for platooning in the future.
4 Candidate Corridors for Platoon Demonstrations

Key Chapter Takeaway
Most of the interstates in the NWP region east of Billings, Montana are well-suited for platooning operations, with moderate to low traffic volumes, few steep grades, and relatively few densely-populated areas. Potential candidate corridors for a demonstration are:

- I-90 from Winona, MN to Billings, MT
- I-94 from St. Cloud, MN to Billings, MT
- I-29 from Pembina, ND to Sioux City, IA
- I-25 from Cheyenne, WY to Billings, MT

4.1 Introduction
This chapter answers two key questions related to the suitability of specific routes within the NWP for platoon demonstration:

- What criteria should be used to select a location for an ideal truck platooning demonstration in NWP states?
- What locations (on all interstates) in the NWP states should be considered as candidate demonstration locations?

To answer these questions, the research team developed criteria based on existing best practices for highway design as well as limitations on platooning established by current platoon technology vendors. These criteria were then applied to interstate highway segments in the NWP using GIS, and maps were created to illustrate the suitability of the NWP interstate system as a whole.

4.2 Criteria for Selection
Safety was the key principle guiding the evaluation of road segments within the NWP for platooning. The approach taken was exclusionary: the team sought to identify and exclude areas where platoon operations would not be allowed, or would be potentially less-safe. To start, candidate roads were restricted to those that met the all of the following criteria:

- **Divided highways** – to reduce the risk of median cross-over collisions.
- **A minimum of four lanes** – to give traffic ample safe space to pass platoons.
• **Controlled access** – to eliminate the potential for collisions with cross traffic.

• **Corridor includes at least two NWP states** – to reflect the desire for a multistate demonstration including at least two NWP states.

Using these criteria, the team isolated eligible roads to interstate highways. US and state highways were excluded from this analysis. Once interstates had been isolated, additional criteria were used to identify potentially hazardous interstate segments that would be unsuitable for platooning operations. These criteria are discussed below.

---

**Where are Washington and Idaho?**

Washington and Idaho were excluded from further analysis because they are separated from NWP states and each other by steep mountain passes that are unsuitable for truck platoon operations. Since the goal of this research was to identify candidate corridors for multiple state platoons, Washington and Idaho were excluded as the mountainous terrain on I-90 and I-15 would prevent continuous platoon trips into those states from other NWP states.

---

**No Congested or Urban Areas**

Congested and urban areas may have higher volumes of traffic, and a higher density of access ramps and interchanges. Both of these characteristics increase the likelihood that a platoon will come in conflict with other road users. Furthermore, some platoon technology vendors prohibit use of their systems on urban highways, citing similar safety concerns.

Congested and urban areas were identified in two ways. First, overall and truck-specific traffic volumes were mapped for the interstate system to determine where traffic concentrations were highest. Figure 4-1 shows the results of this analysis for total traffic volume, and Figure 4-2 shows truck traffic volume only. No specific traffic volume threshold was set as a “cut-off” for suitability, instead, annual daily average traffic volumes are colored from green to red, with green showing low volumes, and yellow and red showing higher volumes.

In terms of total traffic volumes, most of the interstates in the five-state study area have relatively low to moderate volumes, with the exception of I-94 and I-35 around the Twin Cities, and localized higher volumes around smaller cities such as Fargo, Billings, Cheyenne, and Sioux Falls. A similar pattern emerged for truck volumes, which were more evenly spread across the region, with the exception of the Twin Cities and I-80 in Wyoming.

**Traffic volume is not a concern for platooning demonstrations outside of the Twin Cities.**
Figure 4-1: Total Traffic Volumes

Source: CPCS analysis of the National Performance Measurement Research Data Set.
Figure 4-2: Truck Traffic Volumes

Source: CPCS analysis of the National Performance Measurement Research Data Set.
Figure 4-3: Ramp Density (Areas where ramps are less than 3 miles apart)

Source: CPCS analysis of the Federal Highway Administration data.
After analysis of traffic volume was complete, the density of ramps per mile of interstate was examined using design criteria provided by the American Association of State Highway and Transportation Officials (AASHTO). AASHTO’s criteria are shown in Figure 4-4, and note that in rural areas, interstate highway interchanges should be at least three miles apart. Figure 4-3 provides an illustration of all areas where there are less than three miles between interchanges.

<table>
<thead>
<tr>
<th>Figure 4-4: Interchange Spacing Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interchange Spacing Suggestions</td>
</tr>
<tr>
<td>Urban</td>
</tr>
<tr>
<td>1 mile</td>
</tr>
<tr>
<td>Rural</td>
</tr>
<tr>
<td>3 miles</td>
</tr>
</tbody>
</table>


Using this three-mile criteria for rural interstate interchanges, it appears that more sections of the study area’s interstate system would be unsuitable for platooning. However, when taken in context with previously-mapped traffic volumes, it is clear that many of these sections with less than three miles between interchanges have relatively low traffic volumes. Therefore, interchange spacing should not be used by itself to exclude areas from platoon operations. Instead, ramp information should be used in combination with traffic volume and qualitative knowledge of the road system to exclude road segments from platoon operations. For example, many rural areas with a higher density of ramps had relatively low traffic volumes, which means that the potential for conflict between merging traffic and platoons is relatively low, and such areas should not be excluded from platooning operations.

Interchange spacing should be considered within the broader context of traffic volumes.

**Slope and Terrain**

Areas that were particularly steep were also excluded, as maintaining safe control of a truck in these areas would be more difficult, and some platoon system manufacturers prohibit the use of their systems in steep areas. For the purpose of this analysis, interstate segments with grades steeper than 4% were highlighted. This criteria was based on AASHTO’s interstate design standards, shown in Figure 4-5 below. Areas with 4% grade are generally considered rolling, while 5% and above are considered mountainous. Figure 4-6 shows areas where 4% and 5% or higher grades were identified.

<table>
<thead>
<tr>
<th>Figure 4-5: Maximum Grades and Speed Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Speed (Miles per Hour)</td>
</tr>
<tr>
<td>55</td>
</tr>
<tr>
<td>Level</td>
</tr>
<tr>
<td>4%</td>
</tr>
<tr>
<td>Rolling</td>
</tr>
<tr>
<td>5%</td>
</tr>
<tr>
<td>Mountainous</td>
</tr>
<tr>
<td>6%</td>
</tr>
</tbody>
</table>

Figure 4-6: Steep Slopes on NWP Interstates

Source: CPCS analysis of USGS National Elevation Dataset, National Highway Planning Network.
Almost all of the steep interstate segments in the study area were found in western Montana and Wyoming. Steep segments in South Dakota were located at I-90’s crossing of the Missouri River at Chamberlain, while steep areas in Minnesota were associated with descents to the Mississippi River in Winona and St. Paul, and descent to Lake Superior at Duluth. From this evaluation of grades, Billings, Montana emerges as a potential western terminus for platoon operations on I-90, I-94, and I-25. Platoons will not be able to travel much further west from Billings without having to break up at Bozeman Pass, and again near Butte.

Based on road grade, Billings, Montana is a logical western terminus for a platoon demonstration.

4.3 Conclusion: Platoon Demonstration Candidate Corridors

On the whole, most of the interstates sections in the study area are well-suited for platoon operations. Notable exceptions are steep grades in western Montana, and high traffic volumes in the Twin Cities. Between these two areas, low population density and gentle terrain mean that barriers to platooning are nearly nonexistent. Potential corridors for a demonstration are described below.

• **I-90 from Winona, MN to Billings, MT.** Once I-90 rises from the Mississippi River, it encounters almost no heavy traffic or steep terrain until Billings. Areas where platoons may have to briefly disband are Sioux Falls and Rapid City (higher traffic volumes), Chamberlain, SD (steeper grade), and northeast Wyoming (steeper grade).

• **I-94 from St. Cloud, MN to Billings, MT.** Once I-94 is clear of congestion and heavy development of the Twin Cities, it follows a flat and relatively less-populated route to Billings. Platoons may have to disband near Fargo, due to higher traffic volumes near the city, and the junction of I-25 and I-94. Steeper grades near Custer, MT may also necessitate disbanding.

• **I-29 from Pembina, ND to Sioux City, IA.** This route is free of geographic restrictions, and platoons may only have to disband near cities such as Fargo, Sioux Falls, and Sioux City.

• **I-25 from Cheyenne, WY to Billings, MT.** This route includes some steep grades in northeast Wyoming and south-central Montana, but is also very sparsely populated.

**Potential Platoon Expansion**

States south and east of the NWP study region have similar terrain that is well-suited for platoon operations, and could be included in a multi-state demonstration. Additionally, some of these neighboring states have ongoing AV/CV research and development of their own, including platoon demonstrations in Oregon. Of particular note, the MAASTO (Mid America Association of State Transportation Officials) states, which include Minnesota, recently completed their own review of potential options for multi-state platoon demonstrations.* Potential extensions of a NWP demonstration corridor could include I-25 into Colorado, I-29 into Iowa, and I-90 into Wisconsin.

*Ernest Perry et al. 2018. Developing a Regional Regulatory Approach to Truck Platooning in the MAASTO Region.
Areas that are *not* recommended for platoon operations include:

- **I-80 in Wyoming.** This route does not connect to other NWP states in the study area except via I-25. This route is not recommended due to this lack of connections.

- **I-15 in Montana.** This route includes numerous steep grades, making it unsuitable for a demonstration.

- **I-90 west of Billings or Butte.** I-90’s steeper grades in the western half of Montana make it less ideal for a platoon demonstration.

- **I-39 in Minnesota.** This route does not directly connect to other NWP states, and is excluded from platoon operations around a large portion of the Twin Cities metro area due to higher traffic volumes.

Ultimately, most of the study area is well-suited for platoon operations, with few areas that are notably unsafe for platooning. Given this favorable physical and social geography, partnership between specific NWP states will likely be the deciding factor for selection specific corridors for a demonstration.
5 Potential Partnerships

Key Chapter Takeaway

In order to host a successful multi-state truck platooning demonstration, NWP states will have to partner with platooning technology vendors, and may also wish to partner with academic specialists and local businesses. Potential academic partners are the Upper Great Plains Transportation Institute and Western Transportation Institute. Potential technology vendor partners include Peloton, Freightliner, and Volvo. Additionally, there may be the opportunity for trucking companies to participate, but this identification should be done once partnership with a technology vendor has been secured.

5.1 Introduction

This chapter answers the key question “Who may be interested in collaborating with the NWP to conduct a truck platooning demonstration at candidate locations?”

NWP state DOTs are primarily system operators and maintainers, and policymakers, they do not usually have first-hand experience with the research, technology, and implementation methods of platooning. Therefore, partnership with additional stakeholders will be necessary to facilitate a platooning demonstration. Partners for a platoon demonstration could include three types of partners, each with different roles:

- **Academic institutions** can serve as research partners, and evaluate various aspects of demonstrations, such as fuel savings, safety improvements, and impacts on other road users.

- **Technology vendors** provide the technological equipment and expertise needed to enable platooning.

- **Commercial trucking companies** can provide a long-term assessment of the overall cost benefits of platoon operations.

This chapter explores potential partners in each of these three groups.

5.2 Potential Academic Partners

Academic partners can provide highly-skilled evaluation expertise, and help guide a platoon demonstration to answer specific questions, such as measuring safety and emission improvements. During this research project, two potential academic partners gave presentations on their work to Freight Task Force members. The work of these two institutions is profiled, along with a brief list of additional potential partners. This list is not exhaustive, and the RFI has been written to solicit responses from additional academic partners.
Upper Great Plains Transportation Institute
The Upper Great Plains Transportation Institute (UGPTI) is a research, education, and outreach center at North Dakota State University. The Institute provides research, education and outreach work related to transportation. As part of this work, UGPTI is working with NDDOT and the platooning technology vendor Peloton to develop grant proposals for platoon demonstrations in North Dakota. As part of their recent proposal for the Advanced Transportation and Congestion Management Technologies (ATCMTD) grant program, UGPTI proposed a multi-year demonstration, which included plans a multi-state platoon demonstration with a neighboring NWP state. The executive director of UGPTI indicated that platoon demonstrations would move forward, regardless of whether or not the grant application was successful. Given UGPTI’s and NDDOT’s ongoing work on platooning, and their strong interest in a multi-state demonstration, UGPTI could serve as a technical and organizational partner for a NWP multi-state platoon demonstration.

Western Transportation Institute
The Western Transportation Institute (WTI) is associated with Montana State University and is focused on rural transportation issues. In 2017, WTI launched the Collaborative Human-Automated Platooned Trucks Alliance (CHAPTA). CHAPTA was intended to study the human factors of platooning, for example: how truck drivers would respond to driving closely for long periods of time, and how other drivers might react to platoon operations. This would involve studies of drivers using driving simulators, as well as real-world multi-weather trials on WTI’s test tracks. Ultimately, CHAPTA failed to secure enough funding from either the federal government or private partners. However, the groundwork laid to establish CHAPTA, and in-house expertise housed at WTI make it a potentially-valuable partner, especially if NWP states would like to conduct research on human factors of platooning.

Other Academic Institutions and Partnerships in the NWP
- The University of Minnesota’s Center for Transportation Studies serves as the school’s hub for transportation research and education. This research includes previous studies of AV/CV tech, including a study of platoon-like technology to provide snow plow drivers lane-keeping and collision avoidance assistance is low-visibility conditions.

- The Pacific Northwest Transportation Consortium (PacTrans) is a regional University Transportation Center that includes staff from the NWP-state institutions of University of Washington, Washington State University, Gonzaga University, and Boise State University. PacTrans’ work includes research on AV/CV technology and applications.

- The Washington State Transportation Center (TRAC) includes the University of Washington, Washington State University, and WSDOT. TRAC has completed previous research in both AV/CV technology and freight movement.

- The Mountain-Plains Consortium is another regional University Transportation center, and includes North Dakota State University, South Dakota State University, and the University of Wyoming. The consortium’s focus is “supporting sustainable energy development and the safe movement of people and goods.”
### 5.3 Potential Private Partners

There are two types of potential partners for a platoon demonstration: vendors of platoon technology, and trucking companies.

**Platoon Technology Vendors**

Platoon technology vendors are critical partners because they possess the physical hardware and technical knowledge necessary to facilitate platoon operations. In the US, three main companies have provided the trucks and/or technology for platooning demonstrations. These are not the only companies working on platooning, but they may be best-qualified to respond to an RFI given previous experience conducting demonstrations and partnering with the public sector. It is important to note that states considering a platoon demonstration should not feel obligated to partner with only one technology vendor, as previous multinational platoon demonstrations in Europe have included up to six technology vendors.

- Peloton Technology is based in California and has led more platooning demonstrations in the US than other manufacturers. Peloton only provides platoon technology such as sensors, communication, and control equipment, it does not provide base trucks themselves.

- Daimler has worked extensively on platoon demonstrations in Europe and entered the US platooning market through its subsidiary company, Freightliner. Currently, Freightliner is conducting platoon demonstrations and evaluations on public roads in Oregon. Unlike Peloton, freightliner’s platoon system is incorporated into a truck as a whole, it is not an aftermarket add-on system.

- Volvo, another manufacturer with European roots has also participated extensively in platoon technology development in Europe. Volvo has participated in US platoon demonstrations as well, including a recent partnership with FedEx to demonstrate platoon operations in North Carolina, and partnerships on demonstrations conducted by the FHWA.

In addition to these major manufacturers, there are likely other companies interested in partnering to demonstrate their platoon technology. Therefore, states should try and publicize their requests for information as widely as possible, so as to solicit the greatest number of responses.

**Trucking Companies**

The financial benefits of platooning are not yet understood, and partnering with a trucking company who can incorporate platooning into their everyday operations can provide insight into the true benefits of platooning. Identification of potential trucking partners could be accomplished through the state’s trucking association or freight advisory committee, or through the request for information as well. However, it may be helpful to determine technology partners first, as trucking companies may want to have an estimate of the cost of participation before agreeing to partner for a demonstration. Furthermore, the geographic scope of a demonstration will determine which companies may be interested in participating.
6 Conclusions and Next Steps

6.1 Conclusions

The potential cost benefits of truck platooning have driven the technology’s development, and these benefits also mean that the technology could be widely adopted in the future, as highly-competitive trucking companies look to cut costs. The lucrative commercial promises of platooning and other AV/CV technologies means that many DOTs now regard some kind of technological shift toward adoption of advanced technology as increasingly inevitable. Since platooning and other AV/CV technologies will affect how the transportation system is used, DOTs should consider partnering with technology vendors and others on platooning demonstrations. Partnership with technology vendors can help DOTs determine what potential impacts to the transportation system may be, and gives DOTs an opportunity to guide the development of private technology.

The NWP states have a unique potential for platoon demonstrations. Their long stretches of level interstate highways are well-suited to platoon operations, and their inclement weather could present new opportunities to test the capabilities of platoon systems. A successful multi-state platoon demonstration in the NWP could be the first multi-state demonstration in the US. Such a demonstration would help identify challenges and approaches to harmonizing truck platoon regulations across state lines, and establish NWP states as thought leaders in platoon adoption.

Many states in the NWP have already laid the groundwork for a platoon demonstration, with governor-created AV/CV task forces that have been created to identify impacts and partnership opportunities related to AV/CV option. Additionally, Washington and North Dakota are actively pursuing platoon-specific demonstrations. Furthermore, state DOT staff do not believe that there are any insurmountable barriers to platoon demonstrations, and most of the region’s interstates west of Billings, Montana are well-suited to platoon operations.

Building from this base of suitable geography, previous AV/CV engagement, and a favorable outlook on regulatory barriers, NWP states interested in a platoon demonstration will need to partner with technology vendors who can provide hardware and technical expertise to equip trucks with platooning equipment. States may also want to partner with academic institutions who can use their technical expertise to evaluate demonstrations and answer specific questions, and with trucking companies, who can quantify the actual cost savings associated with platoon operations. In order to identify stakeholders and gather further information about potential opportunities for a platoon demonstration, a request for information is provided below.
Appendix A: Request for Information

The Draft Request for Information was provided to the North/West Passage Steering Committee for discussion during their November 8, 2018 meeting. Based on Steering Committee preferences, this RFI will be revised prior to the formal request.

Request for Information: Multistate Truck Platooning Demonstration

The purpose of this Request for Information (RFI) is to solicit information to identify firms who may be interested in collaborating with the North/West Passage Corridor Coalition (NWP) to conduct a truck platooning demonstration.

General Background

The 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.

Project Background

The NWP’s 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.

The Task Force has expressed an interest in truck platooning (platooning), and has conducted discreet research to learn more about the topic and explore its relevance to the NWP. These studies include

- *Day One Activities to Prepare for Connected and Autonomous Vehicles*, which provided the Task force with information on CV/AV resources, and how NWP states could use them to prepare for CV/AV implementation.

- *Freight Task Force Year 2, Task 5 – Truck Platooning Exploration*, which provided an overview of previous truck platooning initiatives in the United States and internationally, and evaluated the Task Force’s interest in further platooning research.

- *Freight Task Force Year 3, Truck Platooning Research and Implementation*. This on-going Task Force research includes a review of each NWP member state’s current legislation relevant to platooning, identification of regulatory barriers to platoon demonstrations, and identification of optimal corridors.
for a multi-state platoon demonstration. As part of this project, the Task Force is soliciting information on firms’ interest and ability to conduct a multi-state platooning demonstration in two or more NWP states.

Candidate corridors that were identified for a platoon demonstration are shown highlighted in the figure below. Safety was the driving consideration for corridor evaluation, and these particular interstate corridors were identified as candidates for the following safety-related reasons: they have a relatively low volume of traffic, they do not have steep grades, and have a relatively low density of on- and off-ramps. Interstate corridors in Idaho and Washington were not evaluated because the mountainous terrain in Idaho and western Montana was considered unsafe for platoon operations, and platoons could not continuously travel into Washington or Idaho through these mountainous areas.

**Figure A-1: Candidate Multistate Platoon Demonstration Corridors**

Source: CPCS for the North/West Passage

**Information Requested**

The NWP states encourage vendors to consider testing the limits and capabilities of their technology during a proposed demonstration, and are interested in demonstrating or evaluating the following aspects of truck platooning:

- Field testing of platoon technology in adverse conditions, including wind, rain, snow, and fog.
- Platoon operations for three-truck combinations, or truck configurations with double-trailers.

In its most basic form, a platooning demonstration in the NWP would be ground-breaking because it would be the first multi-state platooning demonstration in the United States, and could give
platooning firms and trucking companies the opportunity to evaluate the business case for platooning over a larger area and longer periods of time. However, a multi-state demonstration may also be more challenging given that coordination between at least two states is required.

The Task Force has sought to improve its understanding of platoon operations and challenges to platoon demonstrations. Responders should explicitly describe their vision for, and their approach to conducting, a multi-state demonstration in their submission, and should specifically address the following topics in their responses.

- **Technical Capabilities.** Responders with technical experience related to platooning should provide information on the enabling sensing, communication, and control technologies that make up their platooning technology “suite.”

- **Safety Considerations.** Responders with technical experience should describe how their systems are intended to keep both truckers and other roadway users safe during platoon operations. Respondents should also describe how they intend to manage or assign liability associated with platoon operations.

- **Previous Partnerships.** If applicable, responders should list and briefly describe previous platoon demonstrations conducted in collaboration with public agencies, academia, or other stakeholders. Respondents should also highlight any experience resolving questions or barriers related to regulatory impediments to platooning, such as following distance laws.

- **Outreach and Communication.** If applicable, responders should explain how they would intend to communicate platoon-relevant information to the general public and other truckers.

- **Duration of Demonstration.** Respondents should indicate whether their interest is in conducting a “one-off” demonstration, or a longer-term (1 to 6 month) demonstration.

- **Benefits from Demonstration.** Respondents should describe what potential public and private benefits they would anticipate to realize through a demonstration.

**Submission Requirements (to be determined)**

- Format
- Size/length
- Due date
- Minimum submitter requirements in terms of proven capabilities
- NWP University partnerships encouraged/required
- Submit your information to - Who will be the NWP lead?
- Based on the lead, what other submission requirements and legalese should be considered?