

Truck Platooning Policy Barriers Study



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Truck Platooning Policy Barriers Study

Final Report

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Abstract

Heavy truck platooning has the potential to reduce fuel consumption by up to 10% while improving safety. Platooning has been successfully demonstrated on test vehicles by several developers in the U.S. This project investigated heavy truck platooning technology readiness; projected commercialization timeframe; fleet knowledge of, interest in, and estimated timeframe for deploying the technology; and the potential policy solutions to address barriers that will enable safe truck platooning in New York State (NYS). Data were collected via literature review and interviews with industry experts, including platooning technology developers, heavy truck manufacturers, third-party technology analysts, fleet end users, and NYS roadway operators. Most platooning system providers agree that the technology will be ready in the near future with initial productions in the 2017–2018 timeframe, but regulatory development will delay widespread deployment.

There are no specific federal policies or regulations that prohibit the use, operation, or deployment of platooning technologies for light- or heavy-duty vehicles. The U.S. Congress introduced separate bills related to automated vehicles. Under both bills, states retained the authority to set rules on registration, licensing, liability, insurance, and safety inspections, but not performance standards. Neither bill included provisions for the heavy-duty truck classes covered by this study. State-level rule changes may be required to allow initial testing and, eventually, platooning on specific roadways. Two existing NYS laws were identified that negatively impact near-term heavy-duty truck platooning use in NYS: 1) the requirement for at least one hand on the steering wheel at all times, and 2) the minimum following distance regulations. Potential policy solutions to these issues, and others identified in the project, are described along with legislative wording and references to how other states have addressed these topics.

Keywords

Platoon, platooning, truck automation, automated truck, cooperative adaptive cruise control, driver-assistive truck platooning

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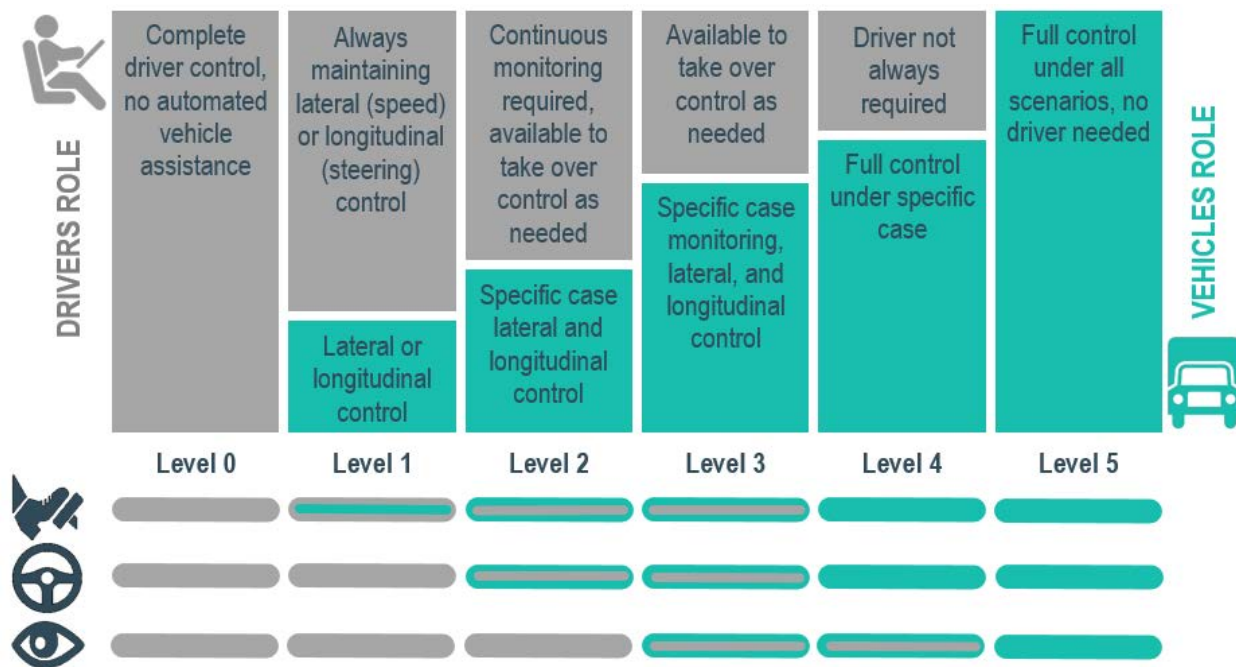
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Summary

“Platooning” is defined as two or more vehicles following each other in close proximity for the purpose of reduced aerodynamic drag and increased roadway throughput. Platooning is adaptable to all vehicle classes and types and is currently being developed for heavy-duty (HD) trucks. This report summarizes an investigation into HD truck platooning technology readiness; projected commercialization timeframe; fleet knowledge of, interest in, and estimated timeframe for deploying the technology; and the potential policy solutions to address barriers that will enable safe truck platooning in New York State (NYS).

Platooning Technology. Connected and automated vehicles includes a range of vehicle types, technologies, applications, functionality, and levels of automation/driver involvement. SAE International (SAE) defined five levels of connected and automated vehicles, as shown in Figure S-1.

Figure S-1. Vehicle Automation Levels



Currently deployed driver-assist technologies, such as adaptive cruise control (ACC), can allow for automated following, but at relatively large distances because of safety concerns during emergency maneuvers. Communication between vehicles creates a Cooperative Adaptive Cruise Control (CACC) logic that allows following vehicles to react almost instantaneously to the lead truck’s actions to form a platoon. This allows following distances to be reduced enough to realize meaningful benefits. The

minimum technology requirements to allow platooning include longitudinal vehicle control (throttle and brake) and vehicle-to-vehicle (V2V) communication. In addition, some manufacturers suggest that lateral control (steering) is also required to realize the technology's full potential.

Truck platooning is a narrow subset of connected and automated vehicles. The term "driver-assistive truck platooning" is used to describe lower automation level (e.g., Levels 1 and 2) platooning. The CACC system integrates a sensor array (e.g., millimeter-wave, infrared laser radars [LiDAR], and cameras) onboard each platooning vehicle and inter-vehicle wireless communication (e.g., dedicated short range communications radios) between all vehicles in the platoon. Platooning does not require the lead vehicle to be automated (although it could be) and in the near-term, it will be driven by a human. Platooning trucks react almost instantaneously to the lead truck's actions and safely maintain the close following distances needed to reduce aerodynamic drag and fuel consumption.

Platooning can be used by vehicles of any type, but it is most commonly used by heavy-duty tractor-trailer combination vehicles trucks (specifically U.S. Department of Transportation Class 8). These vehicles travel the longest distances, primarily at highway speeds and on the roadways best suited to platooning, so they have the highest fuel and operating cost savings potential from platooning.

Technology Availability. Platooning technology is in the final stages of commercialization and will be readily available for market in the 2017–2018 timeframe. Customer adoption will depend on a positive business case, which will require performance, reliability, and safety data to be collected and analyzed.

Some issues still exist for inter-fleet platooning operations (e.g., communications, standards, and inter-fleet agreements) that, when solved, will bolster the viability of this technology throughout various fleet types. Following that, widespread deployment is estimated to take several years due to regulatory barriers. Deployment will also likely be geographically dependent with more use in good weather (not heavy rain, snow, or strong winds) and areas with limited access highways and light traffic.

NYS trucking fleets provided insight into the potential market for platooning in NYS and identified potential deployment barriers. The fleets interviewed expressed significant interest in platooning. The most mentioned barrier to near-term deployment was scheduling multiple trucks to go to nearby destinations at the same time. Thus, inter-fleet platooning capabilities will be needed for any large-scale deployment. Comments from fleets are detailed in the section titled Potential Fleet Perspective on Platooning Technology.

Fuel Consumption Benefit: Platooning’s primary benefit for fleets is reduced fuel consumption. The associated greenhouse gas (GHG) emission reduction and positive economic impact are drivers for governments to enable the technology’s use. The fuel consumption benefit varies by vehicle weight, driving speed, and following distance. A Peloton Technology (Peloton) system test using Peterbilt trucks (consisting of a two-truck platoon) resulted in an average fuel consumption saving of 4.5% for the lead truck and 10% for the following truck (overall “team” savings were an estimated 7.25%). To provide an example, a two-truck platoon traveling between Buffalo and Albany would save 7.1 gallons of fuel, equating to a cost savings of \$18.55 (assuming a base of 6.0 mpg and a fuel cost of \$2.62 per gallon of diesel fuel). Assuming a regular five day a week route yields an estimated savings \$4,800 per year, \$14,500 savings over the typical first owner’s three-year ownership period, and a 10-year lifetime savings of \$48,500.

Safety Benefit: The trucking industry views increased safety as a primary reason to adopt platooning technology. Fewer crashes lead to fewer injuries, fewer deaths, lower crash costs (vehicle repair and “lost” productivity), and lower insurance costs. These reductions further improve the economic case for fleets to adopt platooning. Platooning may reduce stress on the following trucks’ drivers and enhance alertness over extended durations.

Roadway Types Best-Suited for Platooning: Limited access, divided highways with multiple lanes in each direction are preferred for platooning operations because of the more limited mixed traffic interference, longer distances between vehicles entering/exiting the roadway via on/off ramps, and absence of oncoming traffic crossing in front of the vehicle. The higher speeds (and aerodynamic losses that result from high-speed travel) and long-distance travel on these roads maximizes platooning’s benefits. Initial platooning will likely focus on areas with flatter roads and less traffic. The NYS Thruway (Thruway) (I-90 and I-87) from the New York City area, north to Albany, and west to Buffalo is a good initial candidate for platooning. The Thruway has at least two lanes in each direction, with some sections having three or more, and does not go directly through congested urban areas where platooning may not be well-suited. Platooning could likely also be used on other NYS interstate highways (e.g., I-81, I-86, and I-88), because these roads meet many of the roadway criteria. The NYS interstate highway system includes approximately 1,800 miles of highways (1,375 miles of main routes and 427 miles of auxiliary routes). Many of these are likely good candidates for platooning operation. However, not all will be ideal platooning candidates in the near-term because of road congestion, topography, and other factors.

Dedicated Short-Range Communications Rule: The National Highway Traffic Safety Administration (NHTSA) issued a proposed Dedicated Short-Range Communications (DSRC) rule for light-duty vehicles in December 2016.¹ If approved, the communications defined in the rulemaking would be mandatory for light-duty vehicles. Several project stakeholders suggested that a medium-duty/heavy-duty version or extension of the DSRC rulemaking could follow if the light-duty rule is approved. The SAE On-Road Automated Vehicle Committee is developing concepts for the internal architecture of the automation systems that system developers can use for guidance.² If approved, the communications defined in the rulemaking would be mandatory for HD vehicles.

Testing in the U.S.: Several states have permitted platooning tests as an involved way of receiving real-world information on platooning and an up-close perspective on the technology's potential opportunities and barriers. Platooning testing has been completed in Texas, Ohio, Michigan, California, and Nevada. Higher-level automated HD truck platooning technology (Level 3 and higher) has been tested in limited amounts in the U.S.

Feedback from Trucking Fleets: Trucking fleets housed in, or operating in, NYS that are interested in truck platooning were interviewed. Specifically, Mr. Bult's Inc. (bulk refuse and waste hauler), Terpening Trucking (bulk petroleum shipments), Clinton's Ditch Cooperative Companies (beverage bottling and transportation company), Walmart, and Leonard's Express (full service freight transport company). All were interested in testing or adopting for use in their fleets. Each fleet's operation, however, is very different, which highlighted platooning's benefits and how widespread application may be slowed by operational differences. A summary of each fleet and the potential fit for integrating platooning operation is provided in the following section.

¹ National Highway Traffic Safety Administration. 2016. "U.S. DOT Advances Deployment of Connected Vehicle Technology to Prevent Hundreds of Thousands of Crashes." Accessed December 16, 2017. <https://www.nhtsa.gov/press-releases/us-dot-advances-deployment-connected-vehicle-technology-prevent-hundreds-thousands>

² SAE International. "V2V Cooperative Automation Task Force." Accessed September 8, 2016. <https://www.sae.org/works/committeeHome.do?comtID=TEVDSRCS9>

Mr. Bult's Inc. is interested in platooning for operating cost reduction and increased safety benefits. Its NYS operation is primarily long-distance trips on limited access highways (ideal for platooning), but the trucks operate under permit to carry 117,000 lbs. Near-term platooning operation will focus on standard truck weights (80,000 lbs.) and configurations (tractor and dry/refrigerated van trailer). So platooning applications for Mr. Bult's operation will come later.

Petroleum product distributor Terpening Trucking is interested in platooning, but their cargo is classified as hazardous materials. Fleets and third-party platooning system operators need field-proven system reliability and driver attention and training for conventional trucks/loads are needed before platooning's use is extended to this application.

Clinton's Ditch Cooperative Companies', beverage deliveries throughout NYS and throughout the Northeast frequently operate on limited access highways, which is an ideal fit for platooning. Over 90% of Clinton's Ditch's hauls use tandem (48') trailers. However, depending on where deliveries are required, tandem trailers are not always a viable/allowable option. The fleet sees platooning (using standard 53' trailers) as a potential option to using tandem 48' trailers to provide logistical flexibility.

Leonard's Express is interested in platooning, but it is a smaller fleet, so the company relies on test results and experience from larger fleets (e.g., Walmart and UPS) that evaluate new technologies. Deliveries that primarily use smaller roads limit platooning application across the fleet's operation, but it has potential application on some routes and as a logistical option to tandem 48' trailers.

Walmart's truck scheduling uses an on demand model, which is different than the typical "hub and spoke" delivery concepts. The results are irregular routes and lower probability of multiple company trucks travelling the same route. Because of this, platooning near-term potential that requires intra-fleet operation is limited. Additionally, inter-fleet platooning capabilities will likely be required before Walmart will see significant deployment of this technology.

Policies/Regulations. There are no specific federal policies or regulations that prohibit the use, operation, or deployment of platooning technology. Both chambers of the U.S. Congress introduced bills to accelerate automated vehicle testing and deployment. The House bill does not specifically address trucks and other heavy-duty vehicles. The Senate bill applies to vehicles weighing 10,000 lbs. or less, so the U.S. Department of Transportation would maintain authority over long- and regional-haul. Under both bills, states could still set rules on registration, licensing, liability, insurance, and safety inspections, but not performance standards. Several states have permitted platooning tests as an involved way of receiving real-world information on platooning and an up-close perspective on the technology’s potential opportunities and barriers. Platooning testing has been conducted in Texas, Ohio, Michigan, and Nevada. Higher-level automated HD truck platooning technology (Level 3 and higher) has been tested in limited amounts in the U.S. Key regulatory topics related to platooning technology are mentioned here with more details included in the *Near-Term Platooning Policy Considerations* section. The National Conference of State Legislatures, Autonomous Vehicles searchable legislative database is a convenient single-source to locate and view the bill text for these types of bills from around the country, including additions and deletions.³

Hand on the Wheel. NYS Vehicle and Traffic Law Article 33 § 1226 stipulates a human operator must have at least one hand on the steering wheel at all times while a vehicle is operated. NYS is the only state with such legacy legislation still in place. This is not a barrier for Level 1 platooning, but it is a barrier for Level 2 or higher platooning that includes lateral control. The issue is known to NYS legislators and several NYS bills have been introduced to address the issue. One approach proposed to eliminate the wording entirely while another maintained the rule “at all times when the motor vehicle is in motion, unless driving technology is engaged to perform the steering function.” None of the bills has been passed, so the hand on the wheel rule remains.

Following Distance. All vehicles in NYS are required to “...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.” This rule is subjective and requires law enforcement officers to use their judgment. The phrase “reasonable and prudent” is typically included with more specific language to provide law enforcement with some flexibility. HD vehicles in NYS are required to leave sufficient space for other vehicles to enter the space between them. This results in following distances of hundreds

³ National Conference of State Legislatures, Autonomous Vehicles | Self-Driving Vehicles Enacted Legislation, <http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx>

of feet and hinders the potential for coordinated platooning. It has been recommended that this law be amended to allow for closer following distances in cases when inter-vehicle communication and control software is used to ensure synchronized acceleration, braking, and potentially steering between two or more trucks (i.e., platooning). This approach has been successfully enacted by Nevada, Georgia, Arkansas, Michigan, Texas, and South Carolina and is pending in Illinois and North Carolina (see Table A-2). An alternative approach could be to allow platooning (i.e., exempt its use from the close following distance law) for testing purposes and amend the law once the technology's functionality and safety are established by NYS.

Platooning Definition. Several states have found it valuable to develop policy language that defines what the term “platooning” specifically means and in what capacity it relates to commercial vehicle operations. These definitions differentiate between platooning-specific operation and the much broader topic of automated vehicle operation to create a simpler and more focused policy. Near-term platooning is expected to solely involve commercial on-highway vehicles with drivers in each truck. Georgia, Arkansas, Michigan, Nevada, Tennessee, and North Carolina have passed relevant bills. Illinois and Pennsylvania have similar pending bills (see Table A-3 in Appendix A).

Permission to Operate Platooning Vehicles. Truck platooning technology's use on public roads with mixed traffic has not been extensively documented. To address this, Arkansas, Michigan, and Tennessee require truck fleets to secure special pre-deployment permission, via an approved platooning plan to operate platooning trucks on public roads. Similar bills were pending in Illinois and Pennsylvania (see Table A-4 in Appendix A). The typical policy for operating platooned vehicles involves submitting an operations plan to the governing agency (typically the DOT or state police) with an application review period of 30-45 days. If the plan is either approved or not rejected after the review period expires, the plan is deemed to be approved and the applicant can deploy platooning vehicles on public roadways within that state. Other states, however, have approved commercial platooning operation without requiring a plan review.

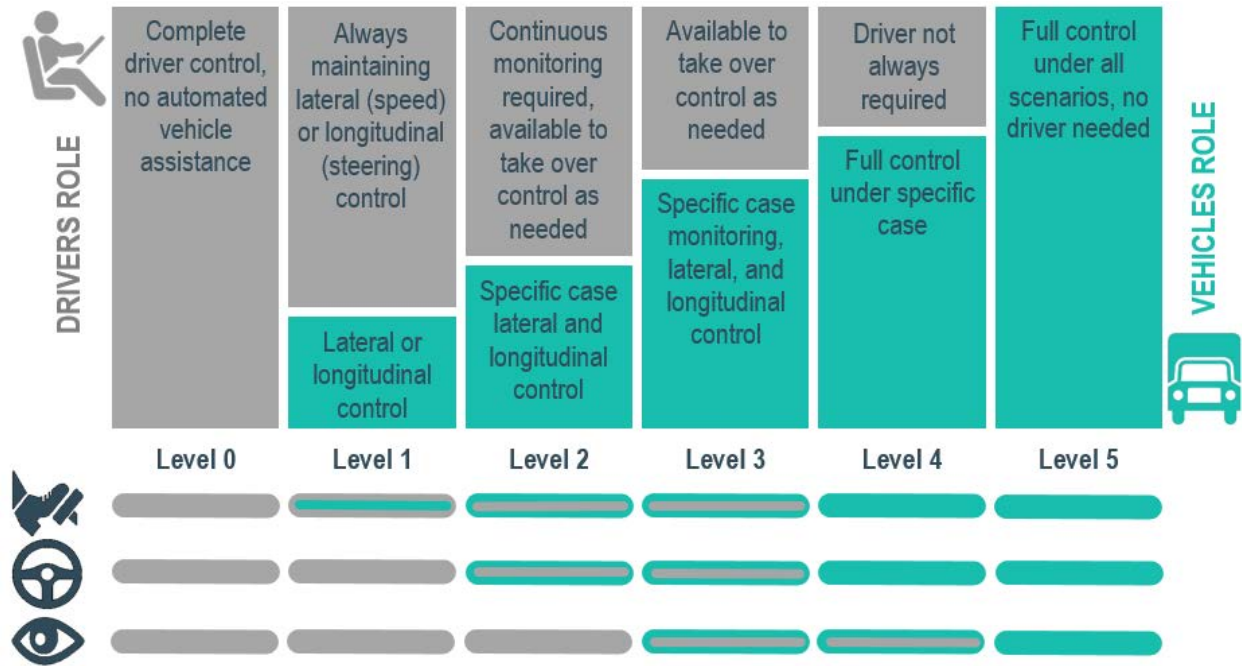
Longer-Term Policy Needs. More highly automated vehicle technology will likely be integrated into future HD truck applications. As technology advances, additional vehicle automation, not necessarily platooning-specific, policies may be needed to support testing and widespread deployment, so its benefits can be realized.

1 Heavy-Duty Vehicle Platooning System Analysis

Platooning is defined as two or more trucks following each other in close proximity to reduce aerodynamic drag and increase roadway throughput. Currently deployed driver-assist technologies, such as adaptive cruise control (ACC), can allow for automated following but at relatively large distances because of safety concerns during emergency maneuvers. Communication between vehicles creates a Cooperative Adaptive Cruise Control (CACC) logic that allows following vehicles to react almost instantaneously to the lead truck's actions. This allows following distances to be reduced enough to realize meaningful benefits. The minimum technology requirements to allow platooning include longitudinal vehicle control (throttle and brake) and vehicle-to-vehicle (V2V) communication. In addition, some manufacturers suggest that lateral control (steering) is also required to realize the technology's full potential.

SAE categorized vehicle automation into five levels to define the amount of driver aid, or replacement, that a specific system provides. These levels are discussed in detail later in this report, but a high-level summary is shown in Figure 1. Near-term heavy truck platooning efforts focus on Level 1 automated technology, with some manufacturers developing Level 2 systems (particularly in Europe). Long-term future platooning efforts may include higher levels of automation, but higher levels of automation are not likely within the coming years.

Figure 1. Vehicle Automation Levels



This section describes the current state of the vehicle systems and subsystems that are required to platoon heavy-duty trucks. Input from the Technical Advisory Committee (TAC) and literature review findings were used to develop an estimate of when platooning systems will be ready to be offered as a commercial product for the North American market. Several heavy truck manufacturers (such as Volvo Trucks North America [Volvo], which includes both Volvo and Mack truck brands in the U.S., and Daimler Trucks, which includes Freightliner in the U.S.) are developing platooning systems for the European market. However, there are significant differences between European and North American trucks (platform, architecture, engines, components, accessories, vendors, business case, etc.). These European systems cannot be directly ported to North American trucks.

1.1 Heavy-Duty Vehicle Platooning Technology

Platooned trucks, regardless of automation level, require a base hardware set and computational requirements. The enabling hardware currently used may include the following: (1) millimeter-wave radar and/or infrared laser radars to detect obstacles in front of them, (2) infrared laser radars and cameras to recognize the lane markings, (3) Dedicated Short Range Communications (DSRC) radios

to communicate with other vehicles, (4) a controller (i.e., computer) to run the system control software, (5) a drive by wire system (braking and throttle), and/or (6) electronic steering control. Level 1 platooning requires drive by wire (brake and throttle), and Level 2 adds electronic steering control capabilities as well.

Some of these technologies are commercially available for heavy-duty trucks for performing other non-platooning functions. For example, ACC systems use front-facing radars. Lane keeping systems use cameras to monitor lane position. Current systems notify the driver with visual and/or audio cues but do not use steer by wire functions to correct the vehicle's path. (No heavy-duty truck manufacturer has commercialized a steer by wire system.) DSRC radios are in production and are used for other applications, and they are being used for connected vehicle pilot programs. Starting in 2017, all new heavy-duty trucks will be mandated to have stability control functionality. This mandate will require the use of drive by wire control for several important platooning-enabling systems, including throttle and braking.⁴ Electronic control of throttle and braking are critical enablers for platooning systems and provide the foundation for intelligent vehicle control and increased automation. Currently 20-30% of new trucks are equipped with some form of applicable technology.⁵ Figure 2 is an example of how these sensors are integrated into the vehicle.⁶

⁴ FleetOwner. 2015. "NHTSA Announces Electronic Stability Control Mandate for Class 7-8 Tractors." Accessed September 14, 2016. <http://fleetowner.com/regulations/nhtsa-announces-electronic-stability-control-mandate-class-7-8-tractors>

⁵ Roeth, M. *Key Freight Issues*. Presentation at I-95 Corridor Coalition Connected and Automated Vehicles Conference.

⁶ Used with permission from Peloton. Accessed November 7, 2016. <http://peloton-tech.com/how-it-works/>

Figure 2. Truck Platooning System Components Summary

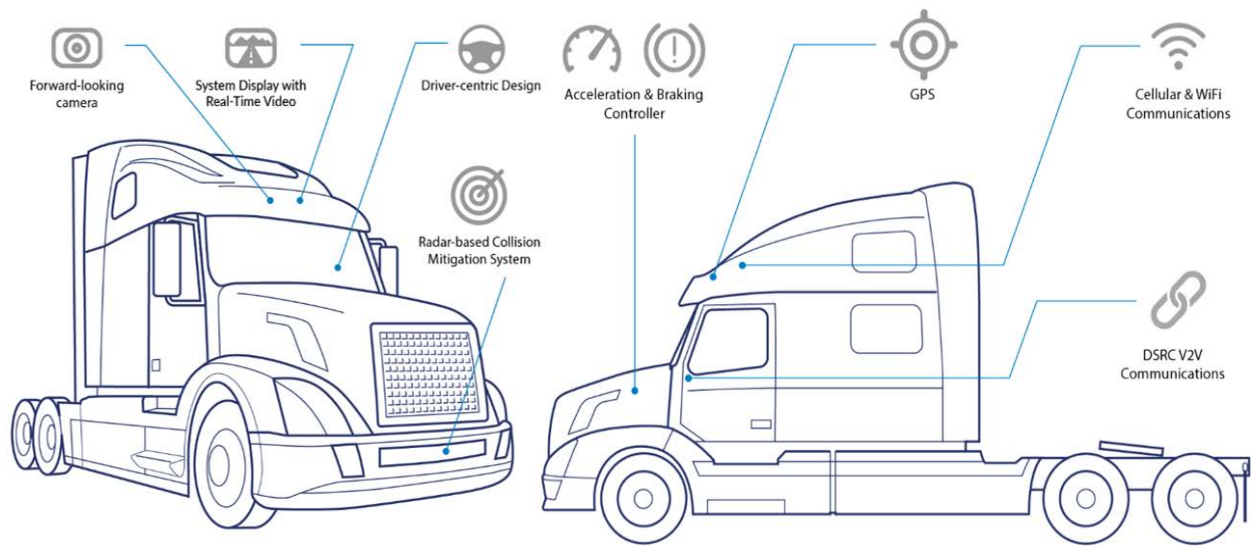
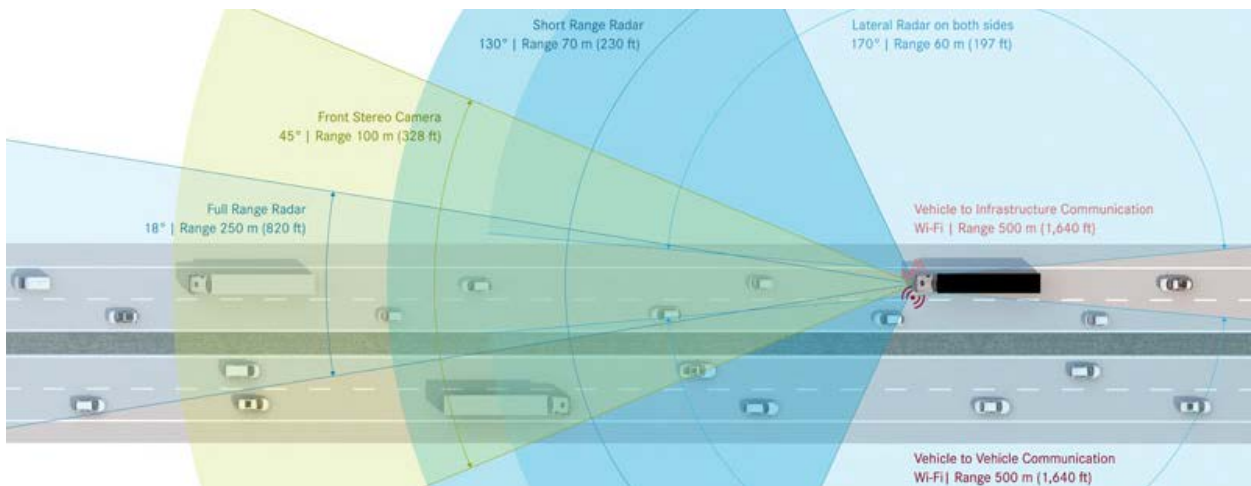


Figure 3 depicts the sensor range and coverage around the truck.⁷ The levels of on-board hardware and software required vary depending on the automation level.

Figure 3. Summary of Coverage of Sensor Package



⁷ Automotive World. 2014. "Mercedes-Benz Future Truck 2025: Autonomous Driving in Long-Distance Truck Operations with the 'Highway Pilot.'" Accessed September 26, 2016. <http://www.automotiveworld.com/news-releases/mercedes-benz-future-truck-2025-autonomous-driving-long-distance-truck-operations-highway-pilot/>

Near-term platooning demonstration and deployments are expected to primarily fall under Level 1 automation levels. Some more advanced systems may fall under the Level 2 automation category if they include both lateral and longitudinal control. Some systems may extend the automation to Level 3 and higher, which require very little driver input from following trucks. Otto demonstrated a Level 4 heavy-duty truck automation system in use on a commercial delivery in Colorado in October 2016.⁸ (Otto was formed by former Google self-driving car project employees. It was acquired by Uber in late 2016 and the truck system development is now included in the Uber Advanced Technologies Group.⁹) These higher automation levels are currently not part of near-term technology for most organizations working to deploy truck platooning. Otto is also testing a Level 2 automation system in California. Both are vehicle automation systems that may accommodate platooning functionality.

One current Level 1 platooning system example consists of V2V communication between platooning vehicles, a radar system, a central electrical control unit to control the system, an interface to the vehicle's throttle and brake systems, a camera to monitor the road ahead of the lead truck, and a monitor to display the roadway image to follower trucks. Platooning operations in the near future would likely be required to include only trucks from the same fleet and manufacturer because of initial interoperability limitations. However, planned efforts are incorporating the potential for platoons to include various fleets and manufacturers and interaction between technologies, and standards development will augment these efforts.

Platooning trucks in the U.S. typically use a DSRC radio for V2V communication and information sharing. The shared information allows the following truck to react almost instantaneously to conditions encountered by the lead truck, thereby avoiding collisions. The reaction time for this DSRC-enabled system is mere milliseconds compared to an average of 2.3 seconds for a human driver.¹⁰ The radar systems measure distance between vehicles and their relative speed and act as a redundancy to the V2V communication by providing automatic braking capabilities. The vehicle controls interface allows the required actions calculated by the system controller to have a mechanical effect on the vehicle's

⁸ Byrne, B. 2016, May 17. "Ex-Google Employees Are Developing Self-Driving Trucks." <http://www.valuewalk.com/2016/05/otto-self-driving-trucks/>

⁹ 2017, May 26, "Uber Retires Otto Brand Name", <http://www.truckinginfo.com/channel/fleet-management/news/story/2017/05/uber-retires-otto-brand-name.aspx>

¹⁰ NHTSA. "Driver Reaction Time in Crash Avoidance Research." Accessed September 26, 2016. http://copradar.com/redlight/factors/IEA2000_ABS51.pdf

throttle and braking (and potentially steering for advanced technology) systems and alter longitudinal placement. Some developers are implementing a camera in the lead truck and a display in the following truck to improve driver comfort and acceptance, but this feature is not required for platooning.

Advanced systems incorporating higher automated driving levels can also include a steering actuator for lateral control of the vehicle and some way to monitor the lateral position of the lead vehicle (such as a smart camera). However, systems envisioned for the near future of platooning would rely on the driver to steer the vehicle, and the interior of these vehicles are typical for large trucks (shown in Figure 4), with the only discernable difference (for some systems) being a large display screen that shows the view in front of the lead truck to follower trucks. Longitudinal control would be automated for following vehicles while in a platoon. (Level 2 and 3 systems require constant human monitoring.) Maintaining a safe platooning following distance of 40 to 50 feet is possible using radar/camera fusion systems available today.¹¹

Figure 4. Example Interior Cabin View of Operator in a Following Platooning Heavy-Duty



1.2 Non-Platooning Systems/Components

Several systems and components not directly related to platooning capabilities could increase its performance and benefits. These concepts include enhanced vehicle lateral control, aerodynamic devices, and optimized engine cooling. Additional truck aerodynamic devices may be beneficial to augment the favorable aerodynamic aspects of platooning trucks. For example, devices added to the front of the truck

¹¹ Auto Motors. 2016. "Daimler Leads Connectivity Trucks." Accessed September 26, 2016. <http://www.automotores-rev.com/lidera-daimler-conectividad-en-camiones/>

may be designed to help move air up and over the hood, windshield, and roof fairing, but they may be less effective than in an open airstream.¹² Much of these aerodynamic concepts are also beneficial to trucks outside of a platoon formation and are increasingly installed to assist with overall fuel efficiency.

1.3 Technology Development Needs to Enable or Enhance Platooning

While the technologies and systems required for automated longitudinal control are quite well established, some areas could benefit from additional development to enhance optimal platoon performance. Improvements in on-board technologies such as Light Detection and Ranging (LiDAR) and on-board human-machine systems will enhance platooning. Development of higher performance and lower cost LiDARs will enhance the evolution of platooning to higher levels. While platooning technologies can help reduce driver stress and fatigue, the task of following a lead vehicle closely

could be stressful for drivers. To reduce this, system developers are studying the driving experience of the following truck drivers to understand the impact and develop a suitable solution. Some developers provide a graphic display screen that shows the road in front of the lead vehicle in following trucks to improve the driver's comfort and acceptance. Level 1 automation requires either longitudinal control (i.e., acceleration/braking) or lateral control (i.e., steering). All current Level 1 truck platooning systems being developed for the U.S. (e.g., Peloton Technology [Peloton] and Volvo) control longitudinal movement. Freightliner is testing platooning with higher levels of automation, but it has released little public information. Level 2 and higher systems use longitudinal and lateral control. Lateral control provides tightly controlled alignment of trucks in the platoon to maximize the platoon's aerodynamics and the fuel efficiency benefits. Future platooning systems will likely include lateral control, but it is not expected to be included in near-term deployments.

Other platooning technology developments suggested by the TAC include developing a method to dynamically optimize the platoon's operations. This concept would determine the optimum ordering for each platoon position based on the shapes, sizes, types, and other factors of the trucks in the platoon.

¹² Kahn, B. – Peterbilt Motors Company. 2016, July 28. Phone interview.

The system would then reorder the trucks into this optimum order. Some form of closed-loop testing would be used to ensure that the platoon efficiency is within a predetermined threshold and make adjustments as needed to meet these criteria.¹³ Safety and braking distances must take priority above all else and would override potential efficiency improvements.

1.4 Platooning Technology Providers and Market Factors

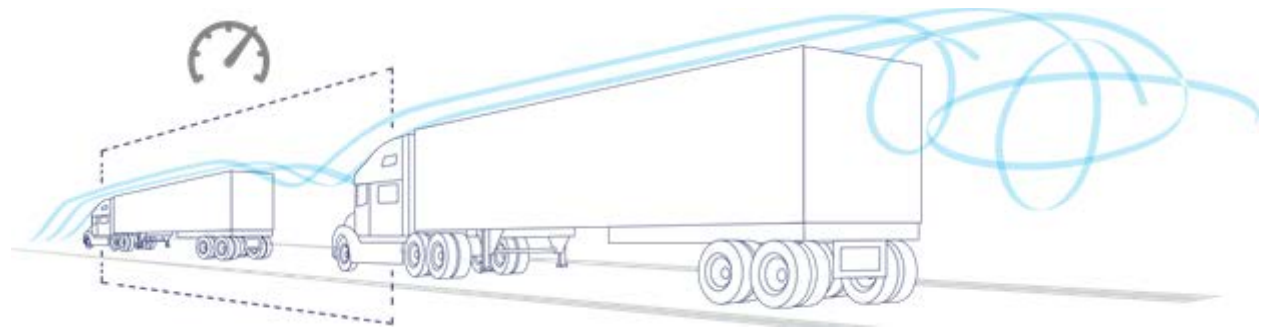
As with any transportation change in the trucking market, platooning technology requires the interaction and cooperation of a wide range of potential stakeholders including system manufactures to design, develop, and manufacture the technology, and fleet operators, owners, and managers that will operate the vehicles equipped with these systems. Most heavy-duty truck manufacturers have been involved in platooning efforts and startup company Peloton is also a major player. Large trucking fleets are carefully monitoring the progress of platooning technology and how it could be incorporated into their operation, but none have fully committed to platooning technology's use because it has not yet been fully validated.

Most major heavy truck manufacturers are involved in connected and automated vehicle technology development at some level. However, some organizations have been more active in the development and promotion of platooning technologies for heavy-duty trucks. Information on these platooning advocates is included below.

Peloton Technology has been involved in most platooning demonstration efforts in the U.S. and provides the necessary hardware, software, and cloud-based communication for Level 1 truck platooning. Adaptive cruise control coupled with V2V communication and cloud control, which makes vehicles “always aware” of changing weather, traffic, and other conditions, allows for safe Level 1 platooning without the addition of any infrastructure requirements. Peloton has demonstrated their system (shown in Figure 5) with several truck manufacturers including Peterbilt Motors, Volvo, and others.

¹³ Brown, M., Southwest Research Institute (2016, July 15). Phone interview.

Figure 5. Peloton Platooning Truck Configuration



Much of the automated medium-duty and heavy-duty work that Volvo has been involved in is focused on truck platooning on highways. In Europe they have extensive experience with two and three truck platoons using Level 1 and Level 2 automated technology to allow trucks to safely follow each other at close distances to reduce aerodynamic drag and to decrease driver stress. Volvo has also been involved in several Level 1 platooning efforts in the U.S. while partnered with Peloton.¹⁴

Peterbilt Motors has been involved in platooning efforts in Europe for some time and participated in several demonstrations in the U.S. with Peloton as well. While they are involved with the development of this technology at an early stage, they feel the business case potential of platooning abilities must be fully proven to fleet operators before it will be available on the market. Because of this, initial systems are likely to be a retrofit system on existing trucks. However, if market demand is there, the sensors and hardware could easily be integrated into new trucks. Peterbilt Motors mentioned they would like to see more specific regulation language before committing to developing this technology. As it stands, many states do not specifically prohibit low level automation, but vague laws often leave it up to law enforcement officers, which can vary significantly. Specific allocations for platooning, preferably with parallel regulations in each state, are considered a prerequisite to full market availability. Some fleets using Peterbilt Motors equipment are interested in platooning, particularly ones with multiple trucks going between similar locations (UPS and FedEx were mentioned as examples). However, other fleets require more results on the potential benefits and see potential operational limitations (Walmart was mentioned).¹⁵

¹⁴ Lockwood, R., Truckinginfo. Truck Platooning, Past, Present, and Future. (April 2016). <http://www.truckinginfo.com/article/story/2016/04/platooning-is-on-the-way.aspx>

¹⁵ Kahn, B., Hankins, B. - Peterbilt Motors Company (2016, December 14). Phone interview.

Freightliner's Highway Pilot highly automated driving system for its semi-trucks was developed by parent company Daimler Trucks. The technology was revealed in 2014 and has been demonstrated on concept Freightliner Cascadia trucks (Figure 6). The trucks are approved for operation in the state of Nevada.¹⁶ Drivers are still required for non-highway operation. The Highway Pilot system operates the trucks on limited access highways.¹⁷ A driver must still be in the vehicle on other road types and in the event the Highway Pilot must relinquish vehicle control.

Figure 6. Freightliner Cascadia Truck Equipped with Highway Pilot



Daimler (Freightliner's parent company) stated that fleet user acceptance is key to the deployment of platooning technology. The technology to enable low level platooning is currently available but significant market penetration is not viable until the savings potential is proven and the demand from fleets justifies deployment. A standard 18- to 36-month payback requirement is expected to achieve marketable status and interest fleets in adopting the new technology. Initial product offerings will likely be lower level automated control (Level 1 and Level 2) and possibly progressing if market demand is there. They stated that some additional standards will likely be required for widespread deployment, such as for inter-fleet communication, vehicle markings, and potential payment standards to equalize and incentivize inter-fleet platooning. Daimler envisions product introductions in the 2020–2023 timeframe as driver acceptance, standards development, and regulatory changes are made.

¹⁶ Daimler Trucks North America, Freightliner Inspiration Truck Unveiled at Hoover Dam. (May 5, 2015). <http://www.freightlinerinspiration.com/newsroom/press/inspiration-truck-unveiled/>

¹⁷ Daimler Trucks North America. Driving Autonomously Through Nevada. Accessed (December 12, 2016). <https://www.daimler.com/innovation/autonomous-driving/freightliner-inspiration-truck.html>

Navistar also expressed interest in automated technologies, but they provided limited information on ongoing work and future technologies. They stated that a new line of trucks will include predictive cruise control that will evaluate the terrain of the road in front of the trucks and automatically optimize vehicle speed and gear selection to increase fuel efficiency.¹⁸ This system will also reportedly allow for two-truck platooning operations and is currently undergoing road tests as shown in Figure 7.¹⁹

Figure 7. Navistar Platooning Trucks



TAC members and literature sources provided varying estimates of when platooning technology could be commercially available to the heavy-duty truck market. Most technology providers agree that the technology itself will be ready in the near future with initial productions in the 2017–2018 timeframe. Customer adoption will depend on a positive business case for the technology. Fleets require sufficient performance, reliability, and safety data to make the decision whether to adopt platooning. Acquiring and analyzing this data will slow the adoption and deployment timing will likely be geographically dependent. For example, the technology is expected to be deployable within several years for use in non-harsh environmental conditions and areas with limited access highways and minimal traffic. Platooning's use on a given roadway could be time-of-day dependent, i.e., used at off-peak times. This type of operation is similar to current operation on the NYS Thruway. Platooning's use on highways in challenging areas

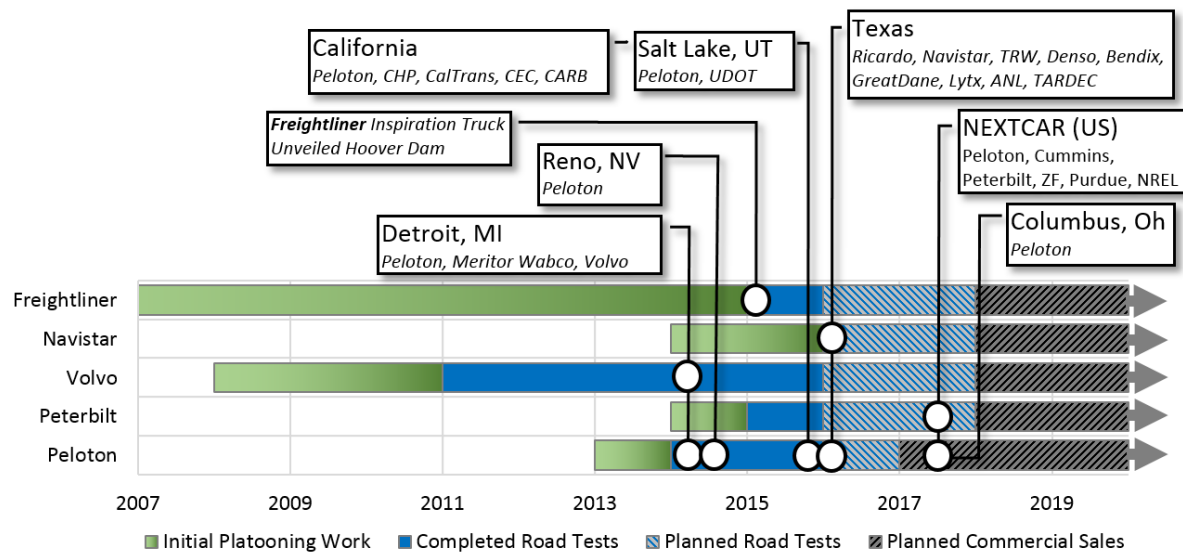
¹⁸ Hawes, C., Trucks.com. Navistar Exec Bets Big on Autonomous Trucks and Platooning. (October 3, 2016). <https://www.trucks.com/2016/10/03/navistar-autonomous-trucks-platooning/>

¹⁹ Menzies, J., Truck News. Navistar Demonstrates SuperTruck, Platooning. (October 14, 2016). <http://www.trucknews.com/equipment/navistar-demonstrates-supertruck-platooning/1003074563/>

could be further out because of several complicating factors: heavy traffic, more mixed roadways, and urban environments (e.g., I-95). However, it is notable that solutions commercially available for light-duty vehicles, such as traffic jam assist combined with Collision Mitigation Systems, are being demonstrated on Class 8 trucks. These integrated systems are expected to be introduced into the heavy-duty truck market in the next few years.

An approximate timeline for the U.S. platooning market major players is shown in Figure 8. This data only includes specific projects that occurred in the U.S., but it does show broad platooning activities worldwide (such as Volvo that has been active in European platooning efforts for years). Many truck manufacturers are testing retrofit systems and are not planning on offering integrated systems until the market proves the viability of the technology.

Figure 8. U.S. Heavy-Duty Truck Platooning Testing and Expected Commercialization Timeline



2 Heavy-Duty Platooning Testing and Estimate of NYS Benefits

NYS is ideal for heavy-duty truck platooning because the roadways are a key freight transport route to and from the northeastern U.S., there are long stretches of rural limited access highways, and it has favorable population/traffic density profiles in many areas. However, NYS presents several challenges to near-term platooning because of its varied weather and topography. Platooning technology's use has the potential to positively affect many key factors to improve freight transportation safety in NYS while reducing fuel consumption, greenhouse gas (GHG), criteria emissions, and congestion.

2.1 Petroleum and Emission Reduction Potential

Platooning large trucks significantly decreases the aerodynamic drag of each vehicle in the platoon. The following vehicles take advantage of the low pressure point just behind a lead vehicle traveling at highway speeds.

Figure 9 shows computational fluid dynamics simulation results of the airflow around a two-truck platoon.²⁰ Highlighting this point, at 70 mph, over 65% of a U.S. Department of Transportation (U.S. DOT) Class 8/National Highway Traffic Safety Administration (NHTSA) Class 9 tractor trailer's fuel consumption is used to overcome aerodynamic drag.²¹

²⁰ Lawrence Livermore National Laboratory. 2016. DOE's Effort to Improve Heavy Vehicle Fuel Efficiency through Improved Aerodynamics. Accessed August 29, 2016. http://energy.gov/sites/prod/files/2016/06/f33/vs006_salari_2016_o_web.pdf

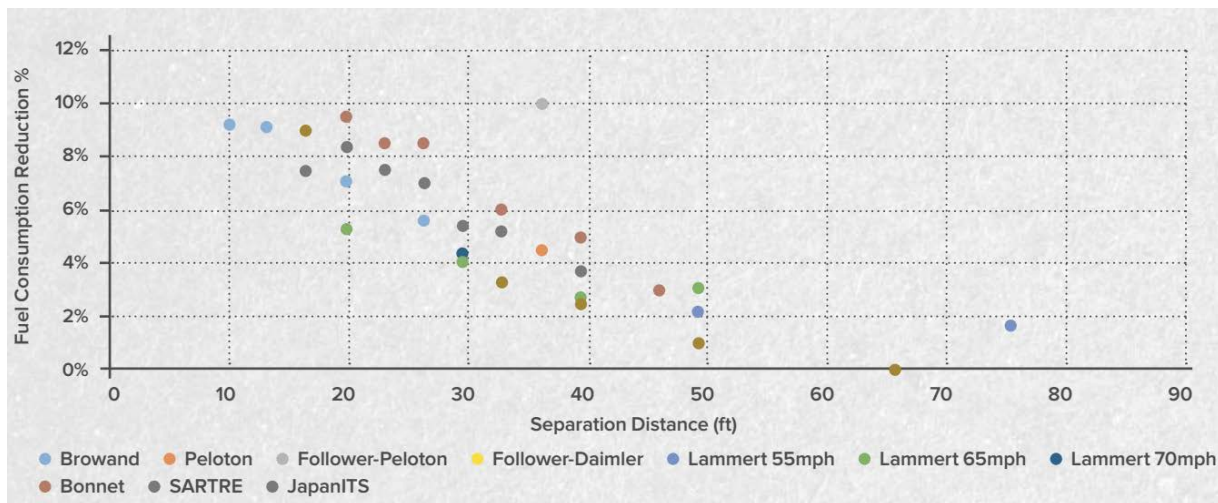
²¹ McCallen, R., R. Couch, J. Hsu, F. Browand, M. Hammache, A. Leonard, M. Brady, et al. 1999. "Progress in Reducing Aerodynamic Drag for Higher Efficiency of Heavy Duty Trucks (Class 7-8)." Accessed August 29, 2016. <http://www.osti.gov/scitech/servlets/purl/771211>

Figure 9. Platooning Truck Aerodynamics



Fuel savings, and the associated GHG emissions reduction, is a leading motivation for fleets to implement platooning efforts and one of the highest priorities to deploy this technology throughout NYS. The benefits of platooning have been well documented but are subject to several influences, including vehicle specifics, ambient conditions, roadway geography, and cargo types. A number of studies have been completed to estimate the potential savings of platooning technology (results shown for two-truck platoons in Figure 10²²) with slight variation due to ambient conditions, truck types, and other factors.

Figure 10. Potential Platooning Fuel Savings



²² North American Council for Freight Efficiency. 2016. Two-Truck Platooning. Accessed November 1, 2016. www.truckingefficiency.org/sites/truckingefficiency.org/files/reports/TE%20Platooning%20CR%20FINAL%20_0.pdf

Many studies have been completed to fully establish platooning benefit potentials in real-world use. One notable test was completed in 2013 outside of Salt Lake City, Utah, by the North American Council for Freight Efficiency and fleet partner C.R. England, using the Peloton platooning system. This test, shown in Figure 11, platooned two identical Peterbilt trucks. These vehicles, outfitted with test fuel tanks to accurately measure fuel use, were operated at a constant 64 mph at a following distance of 36 feet. This configuration resulted in an average fuel consumption savings of 4.5% for the lead truck and 10% for the following truck (overall “team” savings were an estimated 7.25%).

Figure 11. Peloton Platooning Testing



The full potential extent for platooning technology would be most logically deployed first in NYS on the Thruway system. The Thruway has multiple divided lanes, limited access, and a 65-mph speed limit. The Thruway is the primary freight artery running from New York City, north to Albany (I-87), and west to Buffalo (I-90) (the Thruway Mainline section). The Thruway’s 570 total miles include other sections, but this project’s focus is on the 426-mile mainline section of I-90 and I-87 as previously stated.

The Thruway Authority publishes vehicle travel data between each exit for each vehicle class. For tolling purposes, the Thruway has its own vehicle classification system (Table 1).²³ Using these classifications, a Class 5H is equivalent to a USDOT Class 8/Federal Highway Administration Class 9 truck. Classes 6H and 7H are likely tandem tractor-trailers, which could be viable options for platooning, but are not included here because they fall outside the project’s target vehicle classes.

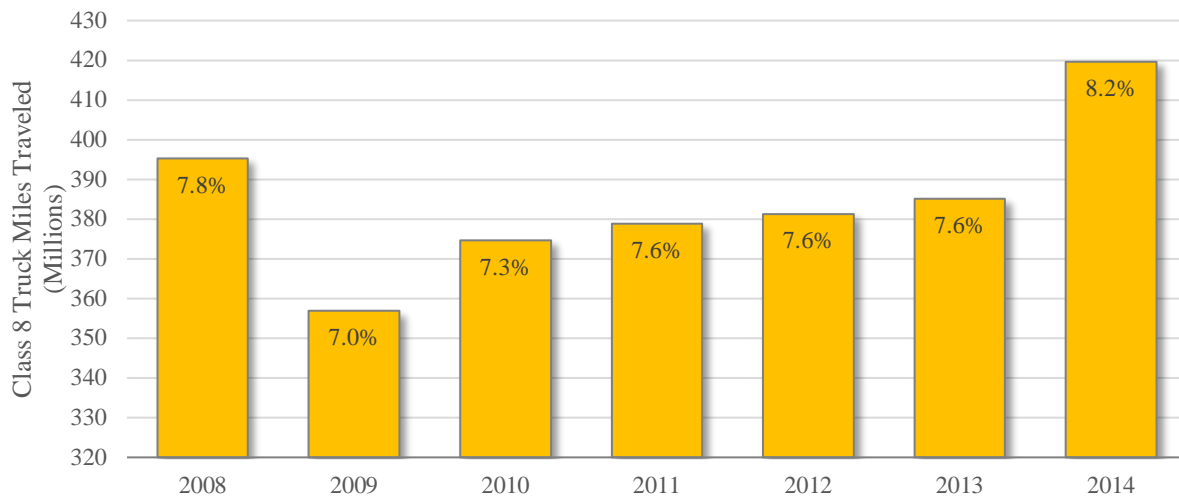
²³ New York State Thruway Authority. *Vehicle Reference Codes*. Accessed August 30, 2016. <http://www.thruway.ny.gov/commercial/ezpass/forms/ta-w68162.pdf>

Table 1. Thruway Vehicle Classification

Class	Height	Axles
2L	UNDER 7 feet 6 inches	2
3L	UNDER 7 feet 6 inches	3
4L	UNDER 7 feet 6 inches	4+
2H	7 feet 6 inches or greater	2
3H	7 feet 6 inches or greater	3
4H	7 feet 6 inches or greater	4
5H	7 feet 6 inches or greater	5
6H	7 feet 6 inches or greater	6
7H	7 feet 6 inches or greater	7+

Thruway vehicle travel and mileage data were downloaded from <https://data.ny.gov/>. These data were analyzed to estimate the potential fuel and GHG savings impact that platooning could have on the Thruway. The resulting total miles traveled by the U.S. DOT Class 8/Federal Highway Administration Class 9 tractor trailers and the percentage of total vehicle miles traveled on the Thruway are shown in Figure 12 for 2008 through 2014. However, because the nation was under a severe recession in earlier years, data from 2014 was used in the following calculations.

Figure 12. Truck Miles Traveled on the NYS Thruway



Assuming an average of 5.9 miles per gallon fuel efficiency²⁴ of the average tractor-trailer, over 65 million gallons of diesel fuel are consumed each year by trucks traveling on the Thruway. Technical Advisory Committee and fleet input to the project indicated that platooning operation would not apply to all fleets or all truck routes (e.g., hub and spoke versus on-demand). Therefore, to provide an example of platooning technology's longer-term potential, and assuming platooning deployment on 10% of Class 8 truck miles traveling on the Thruway, an estimated 400,000 gallons of diesel fuel could be saved and nearly 4,500 tons of carbon dioxide could be eliminated annually.²⁵ This roughly equates to removing 1,010 passenger cars from the road.²⁶

To provide another example, the estimated fuel savings in a two-truck platoon traveling between Buffalo and Albany would be 7.1 gallons of fuel, equating to a cost savings of \$18.55 (assuming a base of 6.0 mpg and a fuel cost of \$2.62 per gallon of diesel fuel). Assuming a regular five day a week route yields an estimated savings \$4,800 per year, \$14,500 savings over the typical first owner's three-year ownership period, and a 10-year lifetime savings of \$48,500. These statistics demonstrate the significant, long-term potential of heavy-duty truck platooning technology.

2.2 Safety Impact

The trucking industry views increased safety as a primary reason to adopt connected and automated vehicle technology (including platooning technology). In addition to fewer injuries and deaths reduced crashes are also expected to decrease incident costs (vehicle repair and "lost" productivity) and lower insurance costs. These reductions will further improve the economic case for fleets to adopt platooning. Enabling platooning, specifically automated longitudinal truck control and inter-vehicle communication, in NYS is projected to result in significant safety benefits. Platooning technology may reduce the stress on the driver of following trucks and enhance alertness over extended durations. In the event of an emergency when a driver is not fully focused, the automated control can perform automatic emergency braking to avoid a collision.

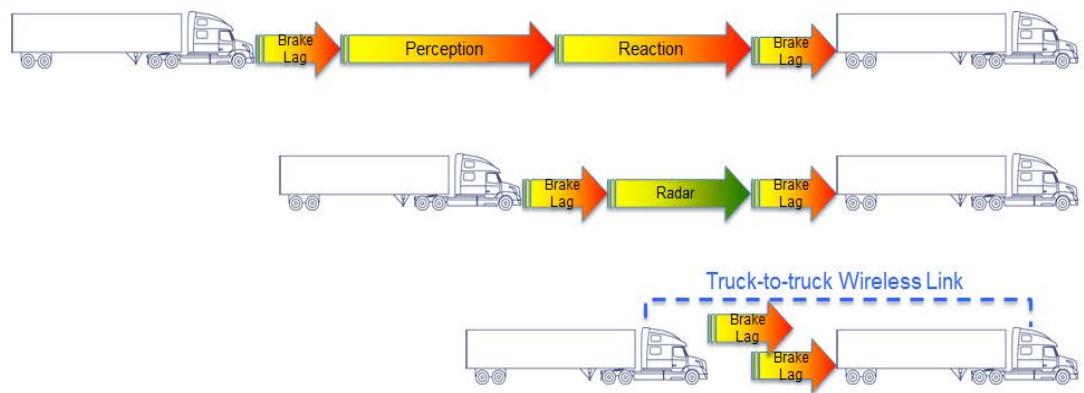
²⁴ Tuft, T. 2013. "How to Improve Fuel Efficiency on the Road." Trucking Info. Accessed August 30, 2016. <http://www.truckinginfo.com/article/story/2013/06/how-to-improve-fuel-efficiency-on-the-road.aspx>

²⁵ Calculated based on data from: U.S. Energy Information Administration. 2016. "Frequently Asked Questions." Accessed August 30, 2016. <http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11>

²⁶ Calculated based on data from: U.S. Environmental Protection Agency. 2014. "Greenhouse Gas Emissions from a Typical Passenger Vehicle." Accessed August 24, 2017. EPA-420-F-14-040a, <https://www.epa.gov/sites/production/files/2016-02/documents/420f14040a.pdf>

In addition, V2V communication allows the lead vehicle to share information with the following vehicles immediately without driver perception or reaction delays. The effect of this inter-vehicle communication results in the simultaneous application of all vehicles in the platoon, which reduces potential rear-end collisions as well as overall stopping distance of the platoon. The addition of these automation technologies can also increase safety when not in a platoon and provide a return on investment that justifies adding driving aids to the fleet. As shown in Figure 13, cooperative braking of platooning trucks (bottom) reduces braking distance of the following trucks compared to trucks not in a platoon, both with (middle) and without (top) active braking systems. Not all collisions are avoidable; extreme conditions and unforeseen events (e.g., another vehicle swerving into the lane) could result in contact between vehicles. However, active braking as soon as possible would at least reduce the kinetic energy at the moment of impact.

Figure 13. Truck Braking Performance Comparison



Overall, Level 1 platooning with longitudinal control provides drivers of the following trucks with some relief from the stress of long distance driving. However, following too closely may negatively affect the following driver. TAC input based on experience suggests that following distances of 40 feet or greater are acceptable to most drivers. Ultimately, the vehicle following distance will likely be fleet-selectable based on driver fatigue, driver acceptance, and other factors. The stress of having no view of the road ahead can be reduced by using a display that offers the driver a view of the road in front of the lead vehicle. Driver stress is reduced at longer following distances and higher automation levels. At Level 4 automation, the driver could be in the driver’s seat, but be largely disengaged from driving duties.²⁷

²⁷ 2017, May 26, “Uber Retires Otto Brand Name”, <http://www.truckinginfo.com/channel/fleet-management/news/story/2017/05/uber-retires-otto-brand-name.aspx>

2.3 Potential Infrastructure Impacts

The potential for detrimental effects to existing roadways and infrastructure is likely minimal. It is also hypothesized, but not proven, that platooned trucks with lateral control (Level 2 or higher) could create “tracks” or ruts in the roadway by traveling repeatedly over the same part of the road.^{28,29} Near-term platooning trucks would not control lateral vehicle positioning (steering), which mitigates the risk that automated trucks will travel repeatedly over the same “tracks.” Hence, the lateral placement of platooned trucks will be identical to non-platooned vehicles. Increased routing of trucks to platooning-friendly lanes (e.g., limited access, divided highways) could increase wear and tear on those lanes. Fleets will only change routing (potentially for longer distances and travel times) if the platooning benefits outweigh the costs.

Theoretically, long “truck trains” could potentially exceed bridge load capacities. Foreseeable truck platoon formations, however, are expected to use two-truck platoons, which will pose less risk. Furthermore, inter-truck following distance could be increased to accommodate specific bridges based on their load capacities where necessary.

2.4 Roadway Throughput Impact

Three-truck platoons are estimated to double the potential throughput of trucks in dense traffic conditions. These savings are possible because of the real-time speed control due to traffic conditions and cooperative adaptive speed control.³⁰ As the number of vehicles in a platoon increases and the following distances decrease, the overall throughput of a roadway will increase. Platooning also eliminates the accordion effect between trucks to smooth the flow of traffic and is projected to reduce the number of crashes, which would further improve roadway congestion.

²⁸ Dutch Ministry of Infrastructure and the Environment. European Truck Platooning Challenge 2016: Lessons Learnt, <https://www.eutruckplatooning.com/Support/Booklet+Lessons+Learnt/handlerdownloadfiles.ashx?idnv=529927>

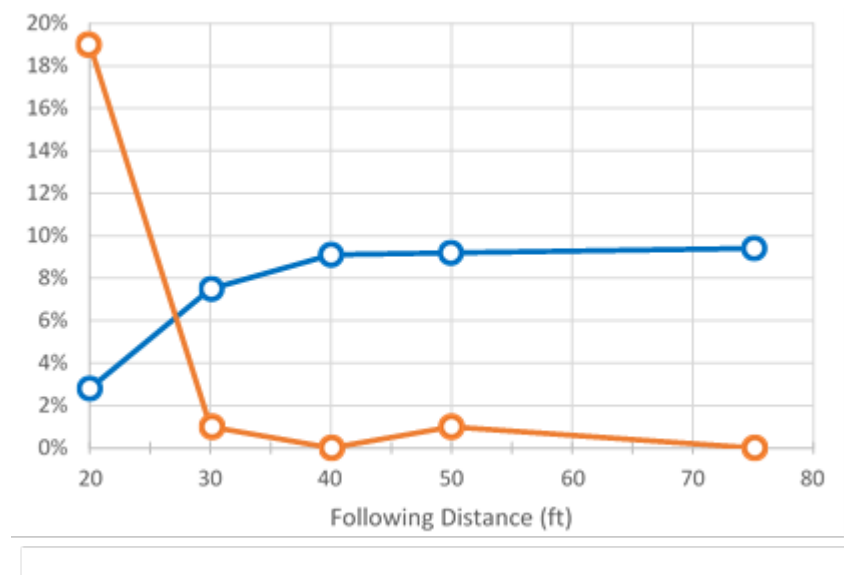
²⁹ Innamaa, S., Wilmik, I., and Reed, N., Road Automation 4, Impact Assessment: Use Case: Platooning, June 2017.

³⁰ U.S. Department of Transportation. Federal Highway Administration. Increasing Highway Throughput. Accessed August 29, 2016. <https://www.fhwa.dot.gov/advancedresearch/pubs/highway.pdf>

2.5 Engine Cooling

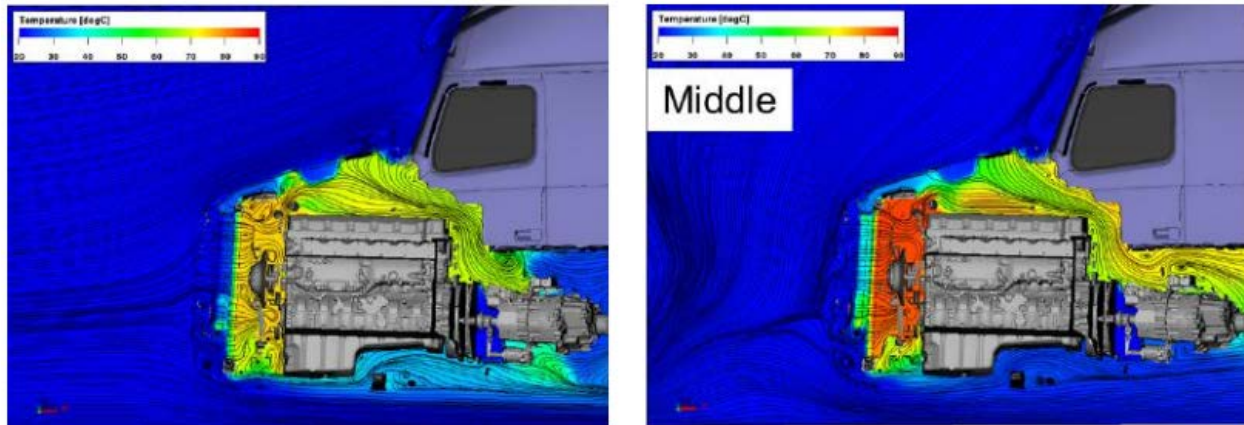
Engine cooling has been noted as a potential issue for platooning trucks. However, discussions with the TAC revealed this is not a significant concern. This situation only arises at extremely close following distances when airflow is drastically reduced. Additionally, no damage to the vehicle occurs. Instead, the cooling fan operates more frequently to maintain engine temperatures, which increases fuel consumption. Results from a prototype platooning system showed that the cooling fan run time increases at shorter following distances because of reduced frontal airflow and increased coolant temperatures (Figure 14). Warmer ambient temperatures and heavy loads increase the cooling load requirement, while operation in colder temperatures reduce the strain on the cooling system. Trailing vehicles experience a decreased airflow and pressure at following distances of less than 40 feet, most notably at the extreme front of the vehicle where the radiator is located. The temperature profiles near the radiator on a typical heavy-duty truck following at 16 feet are shown in Figure 15. This difference essentially disappears as following distances exceed 40 feet.³¹

Figure 14. Fuel Savings and Cooling Fan Operation



³¹ Menzies, J., Truck News. Navistar Demonstrates SuperTruck, Platooning. (October 14, 2016). <http://www.trucknews.com/equipment/navistar-demonstrates-supertruck-platooning/1003074563/>

Figure 15. Thermal Effects Comparison of Lead Trucks (left) vs. Following Trucks (right)



2.6 Potential Fleet Perspective on Platooning Technology

The overall perspective of fleet owners, truck operators, and fleet managers is that platooning technology has the potential to positively affect the trucking industry. Many are cautiously evaluating the technology performance and experience in other fleets before being willing to implement into their own vehicles. Fleets are also skeptical of the actual benefits, but they feel the market will sort out the issues eventually. The North American Council for Freight Efficiency performed a study on two-truck platooning that interviewed potential platooning technology users. Information gathered through these interviews are summarized in the following sections.³²

Platooning Timeframe. Most truck operators and fleet managers feel that platooning technology is highly developed, but it will still take time to implement into real-world operation. Some indicated that initial deployments could start as soon as 2017. Large fleet managers do not predict widespread adoption before 2028–2030. Overall most of the interviewees felt potential savings and the overall safety must be fully proven before widespread commercialization will occur.

Platooning Costs and Potential. Technology developers estimate a platooning system commercialization cost of approximately \$2,000 for long-haul tractor-trailer trucks in addition to the cost of a CMS system with the required enabling Collision Mitigation System equipment. Potential platooning users are concerned, however, that hardware and service fee prices may significantly increase when the technology

³² Roberts, J., Mihelic, Roeth, M., 2016, The North American Council for Freight Efficiency. Confidence Report: Two-Truck Platooning. Accessed January 17, 2017 from http://truckingefficiency.org/sites/truckingefficiency.org/files/reports/TE%20Platooning%20CR%20FINAL%20_0.pdf

is commercially available based on experience with previous technologies' commercial introduction. Fleets are also cautiously optimistic for the potential fuel savings. Respondents felt that the real-world savings will likely be approximately half of the testing results.

Platooning's Effect on Drivers. Drivers who tested platooning equipped trucks reported that while there is a period of apprehension, the driving experience feels normal after an acclimation period. However, fleet managers are not confident that drivers will buy into platooning and feel they may choose to not participate unless it is required. Additionally, fleet managers feel drivers will require a pay incentive to platoon, particularly in the following truck. Drivers see their jobs transforming into a team effort more than the individual job it is now. They are unsure how all these changes will unfold.

Operational Impacts of Platooning. Inter-fleet platooning operations are viewed as a potential issue by all operators interviewed due to conflicts of interest and the challenges of working with the competition. They agree that, at least initially, platooning operations will only occur between trucks of the same fleet and will not be a random process on the highway. Litigation concerns are also a serious consideration that will be carefully evaluated before this technology can be deployed. While operators want the fuel savings, they are cautious of accidents that would eliminate cost savings.

2.6.1 Feedback from Trucking Fleets

Trucking fleets housed or operate in NYS interested in truck platooning were identified and interviewed.

Walmart operates approximately 600 trucks throughout the U.S. The company is monitoring the progression of platooning and automated truck technology because of its potential to help optimize its fleet. The fleet will test two-truck platooning systems and will potentially deploy the technology on public roads in Florida in 2018. Walmart fleet managers do not feel platooning is a primarily viable technology in the near-term due to the operational/logistical characteristics of Walmart's fleet. The fleet's truck scheduling uses an "on demand" model, which is different than the typical "hub and spoke" delivery concepts. This results in irregular routes and lower probability of multiple company trucks traveling the same route. This means there are limited times when multiple trucks are going to the same location at the same time (less than 1% of their travel is done with tandem trailers), so platooning's near-term potential that requires intra-fleet operation is limited. Because of this, inter-fleet platooning capabilities will likely be required before Walmart will see significant deployment of this technology.

Clinton's Ditch Cooperative Companies (Clinton's Ditch) is a beverage bottling and transportation company that is headquartered in Cicero. The company operates a fleet of 39 trucks (with an average age of eight years) transporting beverages daily to destinations throughout NYS and the Northeast. Clinton's Ditch's loads typically are weight limited (i.e., not volume limited). Because of this, the fleet uses tandem 48' trailer extensively whenever possible because the trailer capacity meets the need. In recent years, over 90% of Clinton's Ditch's hauls used tandem trailers. However, depending on where deliveries are required, tandem trailers are not always a viable/allowable option. For example, a daily group of 4-6 trucks travel south on I-81, where tandems are not allowed. Platooning trucks could be beneficial in this application.

Clinton's Ditch's tractor fleet is made up primarily of Kenworth tractors, with some older International and Freightliner tractors. (All new tractor purchases will be Kenworth tractors.) Many of its trailers are equipped with an underside splitter, which was chosen over skirts and tail modifications after testing various configurations. Clinton's Ditch as a company is very willing to try new technologies and has flexibility to allow successful implementation. The company does not have a fixed acceptable technology payback period but does look for technologies that will provide operational cost savings. Overall, it is interested in what platooning technology has to offer and is interested in discussing participation in demonstration opportunities.

Terpening Trucking is a transportation company specializing in petroleum shipments. The company has six locations in NYS and operates a fleet of 10, 2017 Western Star tractors and 68 Kenworth tractors. Due to tanker trucks aerodynamics, hazardous cargo, scheduling dynamics, and routes traveled, platooning is not a viable near-term option. The fleet also had concerns regarding how driver alertness could be ensured when platooning is engaged on public roads. The fleet also felt that driver training should be part of the technology deployment. The company is interested in platooning and wants to stay informed on the technology development and deployment status.

The fleet's currently used vehicle technologies are slightly different than those used in typical truck-trailer operations due to tanker restrictions. The 10 Western Star trucks have the option to use adaptive cruise control (~\$5,000 option), but that has not been activated. A driver coaching program resulted in more than 0.5 mpg improvement throughout the fleet and is ongoing, combined with driver incentives to increase efficiency. No tandem operations are used due to the tanker trailers and limited trucks going similar directions.

Mr. Bult's Inc. (MBI) is a nationwide trucking company providing primarily refuse and waste hauling services using over 4,000 pieces of equipment out of 225 locations. The company operates 220 Kenworth trucks in NYS with an average truck age of seven years. The current average age is because it pre-bought before the 2010 emission regulations went into effect and had a refurbishment program to upgrade/repair older trucks to avoid purchasing new trucks. The company's refurbishment program is ending and it is starting to buy new trucks. The company evaluated other truck manufacturers' vehicles many times before, but it remained with Kenworth. The fleet is averaging three new trucks being delivered each week. This results in a constantly decreasing average fleet truck age. All MBI's NYS fleet is rated for 120,000 lbs., but they are limited to 117,000 lbs. due to State law. All trips are fully loaded and at the maximum allowable weight. Throughout much of the nation, MBI trucks travel relatively short distances (~80 miles between destinations). However, State operations are unique because they are typically much longer (>300 miles). This results in a better application for platooning operations. The longer routes reduce the potential time loss impact from one waiting several minutes for another truck to unload to join it in a platoon for the return trip. Additionally, most of the miles transported are on limited access highways resulting in a higher percent of the trip that has the potential for platooning to be used.

MBI's interest in platooning technology is due to the cost reduction and increased safety benefits the technology could provide to its NYS operations. MBI has an ideal payback period of less than two years, but solutions with estimated paybacks of three to four years may be considered under the circumstances. The benefits platooning provides could be used to justify purchasing trucks with advanced technologies (e.g., collision mitigation and lane keeping) as the return on investment of these technologies is not currently quantifiable. However, its current truck acquisitions are not available with this technology due to a need for a central tow hook at the front of the truck occupying the same space that is required for radar systems. MBI noted that as long as platooning systems and savings proved viable, it would not have to see widespread use before considering the technology for its own fleet.

Leonard's Express operates 275 trucks out of its facility in Farmington. Most of its current fleet is Kenworth trucks, with several Freightliner and International models as well. Ten of the newest trucks are outfitted with Advanced Driver Assistance Systems including adaptive cruise control, collision avoidance, and lane keeping. Much of its fleet is also outfitted with aero aids (side skirts, tails, wheel covers, etc.).

Cost is the primary driver/barrier to platooning deployment. Current truck turnover rate is typically four to five years, just below the 500,000-mile major warranty expires, resulting in an ideal payback of under 18 months. Additionally, Leonard's Express is a smaller fleet, so the company typically lets larger fleets (e.g., Walmart and UPS) evaluate new technologies to learn about their performance and issues before deciding on whether to implement in its own fleet. Driver buy-in is a significant enabler for any technology, particularly fuel savings technologies, so it encourages driver feedback. Even the use of aerodynamic aids require acceptance by drivers for technology success.

The usefulness of platooning technology for Leonard's Express could be somewhat limited due to several deliveries that follow small, rural routes. However, three to five tandem trailers are operated daily on the Thruway and the additional flexibility provided by platooning (and the ability to use 53' trailers instead of 48' trailers) may provide a viable application for future platooning efforts.

3 Platooning Related Critical Highway Design Criteria

TAC member feedback and literature review findings indicated limited access divided highways with multiple lanes in each direction are preferred for platooning operations because of the more limited mixed traffic interference, longer distances between vehicles entering/exiting the roadway via on/off ramps, and absence of oncoming traffic crossing in front of the vehicle. The higher speeds (and aerodynamic losses that result from high-speed travel) and long-distance travel on these roads maximizes platooning's benefits. The ability for non-platooned light-duty and heavy-duty vehicle traffic to pass the platoon is also preferred, because heavy-duty platoons will likely travel somewhat slower than adjacent light-duty traffic.

According to TAC member feedback and literature review results, heavy-duty truck platooning can be used on major roadways without any roadway infrastructure modifications in NYS and across the country. Because near-term platooning deployments would utilize Level 1 automation technology and retain a human driver, modifications to the highway infrastructure (additional lanes, lines, structure, communication infrastructure, etc.) are not needed to deploy and use this technology. Higher automation levels of the lead and follower trucks may require periodic repainting to ensure the sensor packages can "see" the road lanes. This is more accurately included in the broader connected and automated vehicles topic, not specifically a platooning topic.

TAC member input also indicated that initial heavy-duty truck platooning in NYS could be implemented on any limited access highway. Roads in less congested environments such as the Thruway (I-90 and I-87) from the New York City area, north to Albany, and west to Buffalo are good initial candidates for platooning. The entire length of the Thruway meets the desired platooning criteria. It has at least two lanes in each direction, with some sections having three or more. Furthermore, the Thruway also does not go through congested near-urban areas where platooning may not be well-suited. Therefore, the Thruway appears to be a logical first step to demonstrate heavy-duty truck platooning.

Platooning could likely also be used on other NYS interstate highways (e.g., I-81, I-86, and I-88), because these roads meet many of the criteria previously described. The NYS interstate highway system includes approximately 1,800 miles of highways (1,375 miles of main routes and 427 miles of auxiliary routes).³³ Many of these are likely good candidates for platooning operation. However, sections of these roadways in or near cities and towns that are more congested and have higher concentrations of entry/exit points may not be suitable for platooning. The American Trucking Associations (ATA) Task Force on Automated Driving and Platooning addresses this concern, noting the importance of “managed platooning” in which inter-vehicle gaps change with conditions (e.g., traffic density and interchange density) to adapt to the road situation in real time. For example, platooning systems could use vehicle-to-cloud (V2C) communications to perform geo-fencing to prevent platooning in highly congested areas or when other unsuitable conditions are present.

Although not necessary, some infrastructure development may make platooning simpler to implement by providing a more controlled space and reducing the workload of the truck automation system. Such infrastructure development could enhance the overall use of platooning and the potential benefits. However, it is understood that heavy-duty truck platoons will operate on existing roads this is the goal of technology providers according to TAC member input.

Heavy-duty truck platooning does not require dedicated lanes, but TAC members indicated dedicated truck lanes are considered the most beneficial infrastructure technology to enable or improve platooning because they would completely segregate light-duty and heavy-duty vehicle traffic. This separation could eliminate many of the potential issues with multiple traffic types operating on the same roadway and interfering with commercial vehicle platoons. Dedicated lanes would eliminate issues with light-duty vehicle dynamics, how quickly they change speed and direction, and the potential for drivers to interrupt a platoon by cutting in-between trucks. However, few truck-only lanes exist in the U.S. (none in NYS). The implementation cost would be significant, and there may not be sufficient land access available.^{34,35} Because of this, platooning technology must be designed to operate in mixed traffic.³⁶

³³ Wikipedia page “List of Interstate Highways in New York”, accessed November 27, 2017, https://en.wikipedia.org/wiki/List_of_Interstate_Highways_in_New_York

³⁴ Brown, M. – Southwest Research Institute. 2016, July 15. Phone interview.

³⁵ Johnson, G. and S. Boyd – Peloton Technology. 2016, July 8. Phone interview.

³⁶ Dutch Ministry of Infrastructure and the Environment. European Truck Platooning Challenge 2016: Lessons Learnt, <https://www.eutruckplatooning.com/Support/Booklet+Lessons+Learnt/handlerdownloadfiles.ashx?idnv=529927>

Roadway condition may come into play for platooning technology using Level 2 or higher technology. It would be simpler to implement platooning on roadways that are newly paved (smoother for easier truck control) and newly painted (more definition for roadway markings). Level 1 truck platooning with longitudinal control does not require these infrastructure upgrades. Roadway upgrades may be necessary for higher-level automated platooning (Level 2 and higher). Smoother roadways and well-defined lane markings make vehicle control simpler and automated control via cameras more effective.³⁷ As the automated platooning systems become more advanced, they could benefit from vehicle-to-infrastructure (V2I) communication. V2I communication could inform autonomous platoons of unsafe areas, including intersections, work zones, and dangerous curves.³⁸

It is important to note that platooning system developers are including the capability to dynamically adjust and limit platooning to appropriate portions of highways under suitable conditions. This capability would account for the type of highway (e.g., multi-lane, divided, and limited access), road grades, curvatures, speed limit ranges, variable weather and traffic conditions, and changing construction zones. As a result, the TAC indicated that detailed state regulations that limit truck platooning operation, rather than requiring a basic set of requirements be met, would be overly prescriptive.

³⁷ Calculated based on data from: U.S. Environmental Protection Agency. 2014. "Greenhouse Gas Emissions from a Typical Passenger Vehicle." Accessed August 24, 2017. EPA-420-F-14-040a, <https://www.epa.gov/sites/production/files/2016-02/documents/420f14040a.pdf>

³⁸ Murthy, G. 2016, June 21. *AASHTO Updates on Connected and Automated Vehicle Programs*. Presentation at I-95 Corridor Coalition Connected and Automated Vehicles Conference: What States Need to Know. http://i95coalition.org/wp-content/uploads/2016/03/I-95-CC_AASHTO-updates-on-CV-AV-GM-slide-show-v4_final-_SHORT.pdf

4 Federal and State Approval Approaches to Allow Platooning

A government/industry partnership is important in the rollout of new vehicle technologies to ensure their effectiveness and safety while on the roadways. Stakeholder partnerships are often quite complex and should address high-level system functionality, safety standard compliance, manufacturer compliance, end users' needs, and enforcement needs. Government regulation of this technology is divided between state and federal responsibilities. Typically, federal regulations oversee vehicle design and safety while state regulations are limited to licensing.³⁹

Representatives of many stakeholder organizations, including vehicle manufacturers, Tier 1 suppliers, and state DOTs, feel that no additional regulations are needed to allow heavy-duty truck platooning. While national regulatory consistency would be helpful, truck platooning deployment can begin now in states without federal regulations. Across many medium and large states, significant volumes of truck platooning could occur on regional haul routes in which the involved trucks stay in the same state. Furthermore, platooning systems being deployed in 2017–2018 are expected to use managed geo-fencing to adjust the truck platooning parameters to comply with state rules when crossing state borders. TAC member Peloton stated that its V2C Network Operations Center can provide this geo-fencing functionality. For trucks that consistently operate on dedicated routes, it could be viable for onboard systems to perform these parameter adjustments. A patchwork of regulations by state would complicate platooning's use by interstate carriers and could prevent platoons from crossing state lines. As a result, separate state regulations would likely reduce the overall use of platooning and therefore limit the safety and other benefits it provides. More details on specific barriers and policy factors related to near-term platooning efforts are included in a platooning policy framework report located in Appendix A.

³⁹ Anderson, B. 2016. Safety Perspectives of Connected and Automated Vehicles. Presentation at the I-95 Corridor Coalition Connected and Automated Vehicles Conference: What States Need to Know.

4.1 Federal

The federal level of involvement in vehicle systems includes specific performance for new technology. The federal agencies with oversight responsibility for platooning-related factors on the nation's highways include NHTSA, the Federal Highway Administration, and the Federal Motor Carrier Safety Administration. NHTSA has the broad responsibility of reducing deaths, injuries, and financial losses due to vehicle accidents. The Federal Highway Administration "coordinates highway transportation programs in cooperation with states and other partners to enhance the country's safety, economic vitality, quality of life, and the environment." The mission includes providing funding to states, "for general improvements and development of safe highways and roads."⁴⁰ The Federal Motor Carrier Safety Administration has a similar purpose for large trucks and buses. These organizations' primary strategies to improve commercial vehicle safety include developing and enforcing regulations; using information systems to target safety regulations; educating carriers (i.e., vehicle owners), drivers, and the public; and partnering with stakeholders to reduce truck and bus accidents.

There are no specific federal policies or regulations in place that prohibit the use, operation, or deployment of platooning technologies for light-duty or heavy-duty vehicles. However, both chambers of the U.S. Congress developed bills in late 2017 related to accelerating automated vehicle testing and deployment. The House SELF DRIVE Act (H.R.3388) was passed, but it does not specifically address trucks and other HD vehicles.⁴¹ On October 4, 2017, the Senate Commerce Committee unanimously passed Senate Bill 1885 "The American Vision for Safer Transportation Through Advancement of Revolutionary Technologies (AV START) Act", indicating potential success to a Senate passed bill. The bill has many features, however it applies to vehicles weighing 10,000 lbs. or less. U.S. DOT would maintain authority over long- and regional-haul trucks.⁴²⁻⁴³ Under both bills, states could still set rules on registration, licensing, liability, insurance, and safety inspections, but not performance standards. NHTSA acknowledges that many vehicle technologies are deployed without regulations being in place that specify

⁴⁰ Federal Highway Administration. 2017. U.S. Department of Transportation; Our Administrations. Accessed June 1, 2017. <https://www.transportation.gov/administrations#FHWA>

⁴¹ Shephardson, D., 2017. U.S. House unanimously approves sweeping self-driving car measure, <https://www.reuters.com/article/us-autos-selfdriving/u-s-house-unanimously-approves-sweeping-self-driving-car-measure-idUSKCN1BH2B2>

⁴² 2017. Peters, Thune Introduce Bipartisan Legislation to Advance Development of Self-Driving Vehicles, <https://www.peters.senate.gov/newsroom/press-releases/peters-thune-introduce-bipartisan-legislation-to-advance-development-of-self-driving-vehicles>

⁴³ Shephardson, D., 2017. U.S. Senate panel puts self-driving cars in fast lane. <http://www.reuters.com/article/us-autos-selfdriving/u-s-senate-panel-puts-self-driving-cars-in-fast-lane-idUSKBN1C923N?il=0>

their use. However, NHTSA made it clear that technologies cannot pose an “unreasonable risk to safety.” Because of the lack of regulation, many technologies see significant market penetration before standards are developed. One factor leading to this situation is due to a typical five- to eight-year timeframe for regulation development and activation.⁴⁴

In the summer of 2016, NHTSA released a best practices policy guidance on fully-autonomous vehicles that may encourage consistency on automated vehicle policy among the states without setting pre-emptive federal policy. This document recognizes the inevitable development of this technology, looks to establish early guidance to enhance safety aspects, and maintains flexibility—because NHTSA is fully aware that the technology and applications for autonomous vehicles will evolve over time. The initial document was released on September 20, 2016, but the language left it open for alterations based on input from industry leaders and the public. The purpose of this policy is to accelerate the use of automated technology and acts as a guidance document rather than strict rulemaking. This approach was used to guide industry stakeholders to safe and effective design, development, testing, and deployment of this technology.⁴⁵

4.2 State

Statutory changes at the state level may be required to allow initial testing, and, eventually, platooning on specific roadways. Laws vary by state, so various levels of changes will be required for platooning to be allowed. To accelerate the testing and deployment of low-level (Levels 1 and 2) automated vehicle functions including platooning, some states are encouraging low-level platooning without additional regulations because drivers are still in control of the vehicles.

The minimum vehicle following distance allowed is a potential major issue for current regulations that could affect platooning’s use and effectiveness. Minimum following distances are defined in several ways (varying by state), including by (1) reasonable and prudent distance, (2) a defined distance, (3) sufficient space to enter and occupy without danger, and (4) time behind the vehicle ahead.⁴⁶ Regulations dictating the minimal time between vehicles typically specify a minimum time between commercial vehicles. Minimum distances are typically stated as a specific number of feet per 10 mph

⁴⁴ Innamaa, S., Wilmik, I., and Reed, N., Road Automation 4, Impact Assessment: Use Case: Platooning, June 2017.

⁴⁵ National Highway Traffic Safety Administration. 2016. Federal Automated Vehicles Policy. Accessed September 26, 2016. <https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf>

⁴⁶ Scribner, M. 2017. Authorizing Automated Vehicle Platooning – A Guide for State Legislators, 2017 Edition, 2. Accessed August 24, 2017. <https://cei.org/sites/default/files/Marc%20Scribner%20-%20Authorizing%20Automated%20Vehicle%20Platooning%202017.pdf>

and is one of the most common following distance requirements for heavy-duty trucks. The purpose of “sufficient space to enter and occupy without danger” is to allow vehicles to move into the space between heavy-duty trucks to enter or leave a highway. The most common following distance regulation, and what exists in NYS, is a “reasonable and prudent” distance between vehicles. This rule is subjective and requires law enforcement officers to use their judgment. The phrase “reasonable and prudent” is typically included with more specific language to provide law enforcement with some flexibility.⁴⁷ Several state DOTs have participated in truck platooning demonstration activities, including Utah, Nevada, Michigan, Florida, California, and Texas. More states are expected to participate in the future.

NYS Senate Bill S2005C/Assembly Bill A3005C (2017-2018 Legislative Session) that included “approval of demonstrations and tests for motor vehicles equipped with autonomous vehicle technology” was signed into law by Governor Andrew M. Cuomo on May 20, 2017.^{48,49} The resulting “autonomous vehicle technology demonstration/testing” program was open for application submissions on the same day. The bill defines that “...the term ‘autonomous vehicle technology’ shall mean the hardware and software that are collectively capable of performing part or all of the dynamic driving task on a sustained basis, and the term ‘dynamic driving task’ shall mean all of the real-time operational and tactical functions required to operate a vehicle in on-road traffic...” As such, the wording appears to apply to the use of any automated driving technology, not solely fully-autonomous vehicles. The demonstration/testing program expires on April 1, 2018.

Twenty states have ongoing discussions as to how to incorporate heavy-duty truck platooning legislation into their future efforts. Approximately 30 states do not stipulate precise minimum following distances. Automated vehicle technology testing (including platooning) could theoretically be approved through administration action. However, states with more specific following distance regulations will require legislative action to permit platooning.

Several states have permitted platooning tests as an involved way of receiving real-world information on platooning and an up-close perspective on the technology’s potential opportunities and barriers.

⁴⁷ Scribner, M. 2017. *Authorizing Automated Vehicle Platooning – A Guide for State Legislators*, 2017 Edition. Accessed August 14, 2017. <https://cei.org/sites/default/files/Marc%20Scribner%20-%20Authorizing%20Automated%20Vehicle%20Platooning%202017.pdf>

⁴⁸ New York State Assembly, Senate Bill S02005C, http://nyassembly.gov/leg/?default_fld=&leg_video=&bn=S02005&term=2017&Summary=Y&Actions=Y&Text=Y

⁴⁹ *Governor Cuomo Announces Autonomous Vehicle Testing to Begin in New York State*. 2017, May 10. <https://www.governor.ny.gov/news/governor-cuomo-announces-autonomous-vehicle-testing-begin-new-york-state>

Platooning testing has been conducted in Texas, Ohio, Michigan, and Nevada. Higher-level automated heavy-duty truck platooning technology (Levels 3 and higher) has been tested in limited amounts in the U. S. Currently, only California, Nevada, Michigan, Florida, New York, and the District of Columbia allow automated vehicle testing on public roadways. Florida enacted a law in 2016 that allows for the operational use of automated vehicles (i.e., beyond just testing). The law does not specify the automation level(s) or type(s) of vehicle. To facilitate the adoption and implementation of connected and automated freight vehicles, the regulatory, planning, policy, operational, technical, and commercial implications of these technologies need to be evaluated, so enabling testing is critical.⁵⁰

Tests and demonstrations held to date show the potential of this technology. For example, the Texas Department of Transportation—along with the Federal Highway Administration, Texas Transportation Institute, and private sector partners—successfully demonstrated Level 2 heavy-duty truck platooning at the Texas A&M University System RELLIS campus in 2016. This demonstration platooned two tractor-trailers in several tests, including following each other in a figure-eight pattern at about 40 mph, conducting an increased gap distance test, and executing lane changes in both directions.⁵¹

Peloton also conducted tests and demonstrations in several different states. In December 2015, Peloton conducted on-road testing and demonstration in Texas and is planning further on-road demonstrations and trials with major fleets in Texas expected in the near future.⁵² In 2014, Peloton, Meritor WABCO, and Denso demonstrated a truck platooning system in Detroit, Michigan, using two driver-operated and wirelessly-linked tractor trailers. The trucks were platooned using longitudinal control only (Level 1), with a sensor package and V2V that maintained following distances. The drivers provided lateral control via the conventional steering system. The vehicles traveled at approximately

⁵⁰ Scribner, M. 2016. *Authorizing Automated Vehicle Platooning – A Guide for State Legislators*. Accessed August 17, 2016. <https://cei.org/sites/default/files/Marc%20Scribner%20-%20Authorizing%20Automated%20Vehicle%20Platooning.pdf>

⁵¹ Texas A&M Transportation Institute. 2016. "Follow the Leader: Two-Truck Automated Platoon Test Is a Winner." Accessed September 14, 2016. <https://tti.tamu.edu/2016/08/04/follow-the-leader-two-truck-automated-platoon-test-is-a-winner/>

⁵² Transport Topics. 2015. "Peloton On-Highway Platooning Test to Take Place in Texas." Accessed September 14, 2016. <http://www.ttnews.com/articles/basetemplate.aspx?storyid=39503>

55 mph at a 40-foot following distance. Peloton also demonstrated its technology on I-80 west of Salt Lake City, Utah, with fleet partner C.R. England. The primary motivation for this test was to demonstrate the technology's fuel efficiency. The testing produced fuel savings of 4.5–10% (savings varied by position in the platoon). In addition, Peloton held a demonstration in partnership with Nevada state government officials in May 2014. Nevada Department of Motor Vehicles Director Troy Dillard was supportive of the project, stating that, "technology that makes our roadways safer is worth exploring," and that he believed "industry and government should work closely together" to enhance safety.⁵³ In November 2015, Peloton held demonstrations in Utah and California, in coordination with officials in those states. Peloton is planning on-road demonstrations in additional states in 2017 and 2018 to showcase its technology.

4.3 New York Specific Information

NYS does not have many significant legislative barriers that would limit the testing and deployment of heavy-duty truck platooning technology. The most significant legislative limitation is the minimum following distance regulations. The specific legislation language is as follows:

New York Vehicle & Traffic Law § 1129 – Following Too Closely

- (a) The driver of a motor vehicle shall 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.
- (b) The driver of any motor truck or motor vehicle drawing another vehicle when traveling upon a roadway outside of a business or residence district and which is following another motor 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, except that this shall not prevent a motor truck or motor vehicle drawing another vehicle from overtaking and passing any like vehicle or other vehicle.
- (c) 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 shall 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. This provision shall not apply to funeral processions.⁵⁴

⁵³ Jim, Beach. 2014. "Truck Platooning System Offers Fuel Savings Potential." *Trucking Info*. Accessed September 13, 2016. <http://www.truckinginfo.com/news/story/2014/05/truck-platooning-system-offers-fuel-savings-potential.aspx>

⁵⁴ Governor's Traffic Safety Committee. *NYS Vehicle & Traffic Law Excerpts*. Accessed August 18, 2016. <http://www.safeny.ny.gov/drrt-vt.htm#1129>

All vehicles are required to maintain a following distance that is “reasonable and prudent.” This language provides flexibility for law enforcement to interpret whether the requirement has been met. Heavy-duty vehicles have the additional requirement to leave sufficient space for vehicles to enter the space between them. This results in following distances of hundreds of feet, which hinders the potential for coordinated platooning at close following distances.

TAC member feedback recommended altering these regulations to allow closer following distances in cases when inter-vehicle communication ensures coordinated acceleration and deceleration with the lead vehicle (i.e., platooning). If the State feels this is too aggressive, an alternative could be to allow platooning for testing purposes only. In this case, the legislation could be amended once the technology’s functionality and safety are established.⁵⁵

Article 33 S 1226

Another problematic regulation (for Level 2 and above automation) is Article 33 S 1226, which stipulates that a human operator must have at least one hand on the steering wheel at all times while the vehicle is in operation. The legislation’s wording is shown here:

No person shall operate a motor vehicle without having at least one hand or, in the case of a physically handicapped person, at least one prosthetic device or aid on the steering mechanism at all times when the motor vehicle is in motion.⁵⁶

This regulation is not a concern for near-future platooning efforts for Level 1 platooning since drivers must remain at the wheel to control lateral vehicle operation. However, higher automation level systems that control lateral control (steering) that are being developed/tested will be affected by this limitation.

NYS Assembly Bill 7445 (and Senate Bill 5280) from the 2015–16 legislative session was proposed to eliminate this rule under all conditions.⁵⁷ The bill was not passed. A related bill, NYS Senate Bill 7879, was introduced later in the 2015–16 legislative session proposed to maintain this rule “at all times when the motor vehicle is in motion, unless driving technology is engaged to perform the steering function.” This more specific approach likely targeted a path to allow automated vehicles on NYS roads. The

⁵⁵ Scribner, M. 2016. Authorizing Automated Vehicle Platooning – A Guide for State Legislators. Competitive Enterprise Institute. <https://cei.org/sites/default/files/Marc%20Scribner%20-%20Authorizing%20Automated%20Vehicle%20Platooning.pdf>

⁵⁶ New York State Vehicle and Traffic Law. Accessed August 18, 2016. <http://ypdcrime.com/vt/article33.htm#t1226>

⁵⁷ New York State Assembly, Assembly Bill 7445, 2015-20126 Legislative Session, http://nyassembly.gov/leg/?default_fld=&leg_video=&bn=A07445&term=2015&Summary=Y

bill was passed in the Senate, but it was not approved by the Assembly.⁵⁸ A similar bill, Senate Bill 4807, (identical to Assembly Bill 1064) was introduced in the 2016–17 legislative session that “repeals a provision of law relating to the control of a steering mechanism.”⁵⁹ The bill was referred to the Transportation Committee in early March 2016, but was not enacted, so the hand on the wheel rule remains. This is less of a concern for near-term platooning for lower automation levels (SAE Level 1 and Level 2) since they require the driver to remain at the wheel to control lateral vehicle operation.

⁵⁸ Blain, G. 2016. “EXCLUSIVE: N.Y. Pols Want to Fix 1971 Steering Wheel Law to Allow for Self-Driving Car,” New York Daily News. Accessed September 23, 2016. <http://www.nydailynews.com/news/politics/n-y-self-driving-cars-fix-1971-law-article-1.2654122>

⁵⁹ New York State Assembly, Senate Bill 048070, http://nyassembly.gov/leg/?default_fld=&leg_video=&bn=S04807&term=2017&Summary=Y

5 Current State of Heavy-Duty Truck Platooning Codes and Standards

Compliance with codes and standards is not mandatory but can be a beneficial tool. Codes and standards can provide a common link between various stakeholders and improve interoperability of systems. However, as with many new technologies, the creation of codes and standards takes a “wait and see” approach as the technology is developed, tested, and matured by industry and academia to determine its direction and functionality.

The development, testing, and deployment of platooning technology is progressing prior to specific platooning codes and standards. Ongoing work will help guide the creation of these standards and ensure their applicability to efforts in this field. However, many aspects of platooning technology may not be included in standardization work because of proprietary technology. Several technical, professional, and governmental organizations, including the SAE, IEEE, and the USDOT are developing these codes, standards, and guidelines. Each organization has a different focus and purpose and develops codes and standards to satisfy its purpose and stakeholders. There are few fully-established codes and standards that guide the use and development of platooning for both light-duty and heavy-duty vehicle applications in the United States. Some standards were developed for other technologies but now apply to platooning technology and operations. Several existing and fundamental standards provide building blocks for codes and standards development. This section presents the applicable existing and developing standards, arranged according to the developer organization.

5.1 SAE International

SAE is a worldwide professional association with more than 138,000 members, including engineers and technical experts in the aerospace, automotive, and commercial vehicle industries. SAE’s primary purpose is technology standards development and information sharing between their members and divisions. SAE Recommended Practices and standards address several topics, including safe testing, public data, performance requirements, evaluation and simulation, and security.⁶⁰

⁶⁰ SAE International of Automotive Engineers. 2016. “On-Road Automated Vehicle (ORAV) Standards Committee.” Automated Vehicles Symposium. Accessed September 8, 2016. <http://www.automatedvehiclessymposium.org/program/presentations/on-road-automated-vehicle>

SAE's On-Road Automated Vehicle Standards Committee is active in many vehicle automation related topics.⁶¹ Although the committee does not currently have any platooning-specific activities, it is responsible for developing and maintaining SAE's standards, Recommended Practices, and information reports related to motor vehicle driving automation systems that perform the dynamic driving task across the full range of levels of automation. The committee does not focus on specific short-range communication systems and active safety systems (e.g., electronic stability control and automated emergency braking) or other driver assistance systems (e.g., lane keeping). The automated vehicle subsystem standards developed by other SAE committees are integrated into on-road automated vehicle standards that address relevant portions of the automated driving system. This committee provides a communication network to enable personnel from manufacturers, suppliers, government organizations, universities, and consultants to stay up to date in this rapidly changing field.

SAE's Cooperative Vehicle Task Force is responsible for developing and maintaining SAE Technical Reports applicable to short- to medium-range wireless communication protocols specifically designed to support CACC and higher levels of cooperative automation (such as platooning) functionalities. This task force, which reports to the SAE DSRC Technical Committee, develops recommendations for the messages exchanged with external entities (e.g., other vehicles and infrastructure) by the cooperative automation systems. Use of these messages is currently voluntary. NHTSA issued a proposed DSRC rule for light-duty vehicles in December 2016.⁶² If approved, the communications defined in the rulemaking would be mandatory for light-duty vehicles. Several project stakeholders suggested that a medium-duty/heavy-duty version/extension of the DSRC rulemaking could follow if the light-duty rule is approved. The SAE On-Road Automated Vehicle Committee is developing concepts for the internal architecture of the automation systems that system developers can use for guidance.⁶³

⁶¹ SAE International. "On-Road Automated Vehicle Standards Committee." Accessed September 19, 2016. <https://www.sae.org/works/committeeHome.do?comtID=TEVAVS>

⁶² National Highway Traffic Safety Administration. 2016. "U.S. DOT Advances Deployment of Connected Vehicle Technology to Prevent Hundreds of Thousands of Crashes." Accessed December 16, 2017. <https://www.nhtsa.gov/press-releases/us-dot-advances-deployment-connected-vehicle-technology-prevent-hundreds-thousands>

⁶³ SAE International. "V2V Cooperative Automation Task Force." Accessed September 8, 2016. <https://www.sae.org/works/committeeHome.do?comtID=TEVDSRCS9>

A number of standards have been created to help guide the development and deployment of connected and automated vehicle technology. Some standards were also developed for other applications but provide some degree of overlap for platooning and automated vehicle systems. The most relevant SAE standards are described in the following sections.

SAE J3016 – Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles: This On-Road Automated Vehicle Standards Committee Recommended Practice provides the taxonomy and definitions for levels of automated driving. It classifies the level of automation, ranging from no automation (Level 0) through full automation (Level 5). Figure 17 defines the levels of driver involvement required for driving, monitoring, and backup control.⁶⁴ Truck platooning functionality is relevant to Levels 1–5.

Figure 16. SAE J3016 Automation Level Summary Table

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

⁶⁴ SAE International. Automated Driving. Accessed August 10, 2016. http://www.sae.org/misc/pdfs/automated_driving.pdf

SAE J3018 – Guidelines for Safe On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems (ADS): This standard, currently under development, falls under SAE’s On-Road Automated Vehicle Standards Committee and defines the guidelines for on-road testing of Level 3, 4, and 5 automated vehicles. The standard will not cover Levels 1 or 2 systems, because they require an active human driver. The standard assumes the prototype vehicle has successfully completed closed course and component-level testing prior to attempting on-road operations. The guidelines outlined by the standard only pertain to on-road tests and address safety aspects of the tests and technology. The guidelines do not cover tests conducted on closed courses or performance-oriented criteria.

SAE J3061 – Cybersecurity Guidebook for Cyber-Physical Vehicle Systems: This standard is a best practice guide on vehicle cybersecurity based on existing practices and information from industry and government sources. The guide was designed to be a high-level handbook to provide a list of best practices as opposed to a set of strict standards. It applies to a wide variety of vehicle applications.⁶⁵

SAE J2735 – Dedicated Short Range Communications (DSRC) Message Set Dictionary: This standard specifies a communication message set, the data frames, and data elements specifically for use by applications that utilize the 5.9 GHz DSRCs for Wireless Access in Vehicular Environments (WAVE) communications systems. The application of this standard is typically used between platooning vehicles in V2V communication and data transfer.⁶⁶

SAE J2945/x – Dedicated Short Range Communication (DSRC) Family of Standards: The J2945/x is a family of standards that define the information exchange that is necessary to perform V2V and V2I communication. These communications are needed to conduct coordinated maneuvers (acceleration, braking, steering, lane keeping, lane changes, etc.). The standard applies to all vehicle classes. The SAE J2945/6 standard (“The Performance Requirements for Cooperative Adaptive Cruise Control and Platooning”) specifically addresses truck platooning.⁶⁷

⁶⁵ SAE International. “Cybersecurity Guidebook for Cyber-Physical Vehicle Systems.” Accessed August 10, 2016. <http://standards.sae.org/wip/j3061/>

⁶⁶ SAE International. “Dedicated Short-Range Communications (DSRC) Message Set Dictionary.” Accessed August 10, 2016. http://standards.sae.org/j2735_201603/

⁶⁷ SAE International. “Performance Requirements for Cooperative Adaptive Cruise Control and Platooning.” Accessed August 10, 2016. <http://standards.sae.org/wip/j2945/6/>

SAE J1321 – Fuel Consumption Test Procedure – Type II: This standard defines the accepted fuel consumption test procedures to quantify fuel savings for trucks and buses with gross vehicle weights of more than 10,000 pounds. The standard applies to conventional and automated driving. The standard is designed for testing on a closed course test track or on public roads. The standard, however, cautions against using public testing because of reduced accuracy compared to closed-course testing.

5.2 IEEE

IEEE develops many of the international standards that form the foundation for modern telecommunications, information technology, and power generation products and services. The IEEE 1609 family of standards focuses on Wireless Access in Vehicular Environments. They standardize system interfaces to enable V2V and V2I communications and increase security. This group of standards is designed to aid in a broad range of communication systems for the transportation sector, including safety, navigation, data acquisition, automated payments, and vehicle coordination. The standards, described below, are not platooning-specific, but rather are more broadly related to V2V communication.

IEEE 1609.0-2013 – Active Standard – IEEE Guide for Wireless Access in Vehicular Environments (WAVE) – Architecture: This standard describes the WAVE architecture and services necessary for multi-channel DSRC/WAVE devices to communicate in a mobile vehicular environment.

IEEE 1609.2-2016 – Active Standard for Wireless Access in Vehicular Environments (WAVE) – Security Services for Applications and Management Messages: This standard defines secure message formats and processing. It also defines the circumstances for using secure message exchanges and how those messages should be processed based upon the purpose of the exchange.

IEEE 1609.3-2016 – Active Standard for Wireless Access in Vehicular Environments (WAVE) – Networking Services: This standard defines network and transport layer services, including addressing and routing that support secure WAVE data exchange. It also defines WAVE Short Messages, providing an efficient WAVE-specific alternative to Internet Protocol version 6 directly supported by applications. Further, this standard defines the Management Information Base for the WAVE protocol stack.

IEEE 1609.4-2016 – Active Standard for Wireless Access in Vehicular Environments (WAVE) – Multi-Channel Operations: This standard provides enhancements to the IEEE 802.11 Media Access Control to support WAVE operations.

5.3 U.S. Department of Transportation

The U.S. DOT is involved in platooning operations through its connected vehicle program, which works to integrate and develop advanced transportation technologies. The Connected Vehicle Reference Implementation Architecture is the structure through which stakeholders can be engaged and standard strategies and action plans enacted.⁶⁸ The architecture has three primary focus areas:⁶⁹

- *A Connected Vehicle Reference Implementation Architecture* as a basis for identifying standards. The architecture will identify the key interfaces of a connected vehicle environment, which will support further analysis to identify standards.
- *A standards development plan* that will allow identification and prioritization of the standards needed in support of connected vehicle implementation. The plan will consider the adoption of existing industry standards from other areas, the adaption of existing standards, and the need for the development new standards. The plan also includes an architecture definition affording alignment with the National Intelligent Transportation System (ITS) Architecture and supporting consideration of connected vehicle implementations within the context of the National ITS Architecture.
- *Policy* considerations for certification, standards, core system, and potentially other elements of the connected vehicle environment.

The U.S. DOT established NHTSA to help increase the safety of highway systems on a nationwide level and safe vehicle operation overall. Its guiding policy is to “facilitate and encourage wherever possible the development and deployment of technologies with the potential to save lives.” In this endeavor, NHTSA is committed to determine the safety and potential of new technologies, overcome barriers to the deployment of these technologies, and work with stakeholders to accelerate their adoption where possible.

As part of this effort, NHTSA is interested in automated vehicle technologies and closely monitored the progress of this technology. Current safety standards assume the presence of a human driver, so future concepts, including automated vehicles where a driver is not present, may require changes. However, most current truck platooning implementations, which are Level 1 or 2, have a human driver onboard, so the current standards for human drivers apply.

⁶⁸ U.S. Department of Transportation. “About.” Connected Vehicle Reference Implementation Architecture. Accessed September 30, 2016. <http://www.iteris.com/cvria/html/about/about.html>

⁶⁹ U.S. Department of Transportation. “Development Activities.” Intelligent Transportation Systems Joint Program Office. Accessed August 11, 2016. <https://www.standards.its.dot.gov/DevelopmentActivities/CVReference>

The U.S. DOT report *Review of Federal Motor Vehicle Safety Standards (FMVSS) for Automated Vehicles* provides a comprehensive list and detailed description of the potential standards that will be applicable to automated vehicles, including platooning.⁷⁰ The report identified existing regulations that could hinder technology development, or that may require changes to ensure safe vehicle operations. The only issue for truck platooning technology identified by this report pertains to the vehicle brake systems (§571.135), which states, “The service brakes shall be activated by means of a foot control.” This standard thus requires a human driver to be onboard and activate the breaks.

In September 2016, NHTSA modified its policy to adopt the SAE’s five automation levels description, stating, “There are multiple definitions for various levels of automation and for some time there has been need for standardization to aid clarity and consistency.”⁷¹ The policy also stated that NHTSA is committed to supporting the rapidly growing automated vehicle field, and that “a highly automated vehicle (HAV) represents SAE Levels 3–5 vehicles with automated systems that are responsible for monitoring the driving environment.”⁷² Thus, the relevance to and impact on Level 1, and potentially Level 2, automated systems is not yet known.

5.4 Estimated Timing

The timing for obtaining a complete set of platooning-related codes is uncertain. The codes and standards may be useful to facilitate the ongoing investigation and innovation. However, TAC member input and the literature review findings indicate that having platooning-related codes and standards are not necessary to develop the technology. Thus, the current availability of these codes and standards will not hamper the development and use the technology.

⁷⁰ Volpe, John A. 2016. Review of Federal Motor Vehicle Safety Standards (FMVSS) for Automated Vehicles. U.S. Department of Transportation, National Transportation Systems Center, Technology Innovation and Policy Division. Accessed August 11, 2016. http://ntl.bts.gov/lib/57000/57000/57076/Review_FMVSS_AV_Scan.pdf

⁷¹ U.S. Department of Transportation. 2016. Federal Automated Vehicles Policy – Accelerating the Next Revolution in Roadway Safety. Accessed October 28, 2016. <https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016>

⁷² Ibid.

Appendix A: Heavy-Duty Vehicle Platooning Policy Requirements for New York State

Truck platooning is two or more trucks following each other in close proximity for the purpose of reducing aerodynamic drag to decrease fuel use. This technology has shown positive testing results and has promise to benefit New York State (NYS) fleets through fuel cost savings and the State's economy by reducing reliance and investment in imported petroleum. These benefits are described in more detail in the main "Truck Platooning Policy Barriers Study" project report. To enable long-term heavy-duty truck platooning's testing and use in the State, there are current and potential NYS policy issues to address.

Currently deployed driver-assist Adaptive Cruise Control systems for heavy-duty trucks enable a form of automated following, but at relatively large following distances (≥ 300 feet). This large separation between trucks does not provide any aerodynamic or fuel consumption reduction benefit. Cooperative Adaptive Cruise Control technology, also referred to as truck platooning, is needed to realize these benefits. Cooperative Adaptive Cruise Control integrates a sensor array and inter-vehicle wireless communication between all vehicles in the platoon. Platooning systems use specialized system control software to interface with the vehicle to automate and synchronize the longitudinal control (i.e., braking and acceleration) for SAE Level 1 automation and lateral control (i.e., steering) for higher automation levels (SAE Level 2 and higher). In the near-term, the lead truck will be manually controlled by a human operator. These systems enable the follower truck(s) to react almost instantaneously to the lead truck's actions. Heavy-duty truck platooning systems, some of which are SAE Level 2, are being developed by several companies including Peloton Technology, Daimler Trucks North America (includes Freightliner and Western Star truck brands), and Volvo Trucks North America (includes Volvo and Mack truck brands). The term "driver-assistive truck platooning" is frequently used to describe lower automation level (e.g., Levels 1 and 2) truck platooning.

The category “connected and automated vehicles” includes a broad spectrum of vehicle technologies, applications, and functionality. Platooning describes a narrow subset of these. Platooning does not require the lead vehicle to be automated (although it could be). Platooning can be used by vehicles of any type, but it is most commonly used by heavy-duty tractor-trailer combination vehicles trucks (specifically U.S. DOT Class 8/National Highway Traffic Safety Administration Class 9). These vehicles travel the longest distances, primarily at highway speeds and on the roadways best suited to platooning (i.e., limited access dual carriage way highways), so they will have the highest fuel and operating cost savings potential from platooning.

NYS recently demonstrated support for automated vehicles on its roadways through NYS Senate Bill S2005C/Assembly Bill A3005C (2017-2018 Legislative Session) that was passed and signed into law by Governor Andrew M. Cuomo on May 20, 2017. This included “approval of demonstrations and tests for motor vehicles equipped with autonomous vehicle technology.”^{73,74} The bill defined “...the term ‘autonomous vehicle technology’ shall mean the hardware and software collectively capable of performing part or all of the dynamic driving task on a sustained basis, and the term ‘dynamic driving task’ shall mean all of the real-time operational and tactical functions required to operate a vehicle in on-road traffic...” The wording can be interpreted to apply to any automated driving technology, not solely fully-autonomous vehicles, so truck platooning would be included. The demonstration/testing program allows approved autonomous vehicle tests and demonstrations on NYS public roadways through April 1, 2018, but continuous State police supervision is mandatory along with other requirements. The program’s results are expected to provide proof and experiences with automated vehicles’ performance and benefits. It is suggested that the program’s limited timeframe should not take focus away from developing a permanent solution for deploying platooning and other automated driving technologies.

This policy analysis document focuses solely on heavy-duty truck platooning-related policy issues that need to be addressed to allow for the long-term use of truck platooning in NYS. Therefore, policy barriers associated with the broader topic of connected and automated vehicles are not discussed in this document.

⁷³ New York State Assembly, Senate Bill S02005C, http://nyassembly.gov/leg/?default_fld=&leg_video=&bn=S02005&term=2017&Summary=Y&Actions=Y&Text=Y

⁷⁴ *Governor Cuomo Announces Autonomous Vehicle Testing to Begin in New York State*. 2017, May 10. <https://www.governor.ny.gov/news/governor-cuomo-announces-autonomous-vehicle-testing-begin-new-york-states>

A.1 Near-Term Platooning Policy Considerations

Platooning functionality can be integrated into automated driving from SAE-defined Level 1 (driver assist of acceleration/braking or steering only) to Level 5 (fully-autonomous under any operational domain).

The platooning-specific state policy legislation identified include only a few unique requirements.

Heavy-duty truck platooning is expected to be commercially available starting in 2017. Near-term truck platooning is expected to focus on SAE Level 1 and Level 2 automated systems. These systems require the operator (i.e., driver) to remain in the driver's seat at all times to monitor the vehicle operation and assume vehicle control when needed. The lead vehicle for near-term truck platooning will be manually-controlled by a driver. Due to the limited policy challenges of lower automation levels incorporating platooning (i.e., compared to SAE Level 3 and higher which involves more automation) and expected near-term commercialization, it is suggested that initial platooning policy solutions focus on SAE Levels 1 and 2 platooning to enable the potential near-term deployment. Attempting to address platooning policy along with the wide range of anticipated automated driving operations will likely delay the ability for near-term, low level, platooning testing and deployment.

Two existing NYS laws were identified that negatively impact near-term platooning use in NYS:

1. The requirement for at least one hand on the steering wheel at all times (for Level 2 and higher)
2. The minimum following distance regulations

These topics as well as other supporting topics that have been addressed by other states are discussed further. Two helpful online resources dedicated to tracking and posting legislative and regulatory activity related to automated driving, automatic driving, autonomous driving, self-driving vehicles, and driverless cars are: (1) Stanford University Center for Internet and Society,⁷⁵ and (2) the National Conference of State Legislatures.^{76,77}

⁷⁵ Gabriel Weiner and Bryant Walker Smith, Automated Driving: Legislative and Regulatory Action, http://cyberlaw.stanford.edu/wiki/index.php/Automated_Driving:_Legislative_and_Regulatory_Action

⁷⁶ National Conference of State Legislatures, Autonomous Vehicles | Self-Driving Vehicles Enacted Legislation, <http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx>

⁷⁷ National Conference of State Legislatures, Autonomous Vehicles | Legislative Database, <http://www.ncsl.org/research/transportation/autonomous-vehicles-legislative-database.aspx>

A.2 Hand on the Steering Wheel

Another problematic regulation (for SAE Level 2 and higher platooning/automation) is NYS Vehicle and Traffic Law Article 33 § 1226⁷⁸ that stipulates a human operator must have at least one hand on the steering wheel at all times while the vehicle is being operated. NYS is the only state with this type of legacy legislation still in place.⁷⁹ The legislation's wording is as follows:

Article 33 § 1226 – No person shall operate a motor vehicle without having at least one hand or, in the case of a physically handicapped person, at least one prosthetic device or aid on the steering mechanism at all times when the motor vehicle is in motion.

This presents an obstacle for a person to “operate” an automated vehicle, including SAE Level 2 and higher platooning trucks in NYS. However, if a person is not considered to be “operating” the vehicle when it is a follower vehicle in a platoon, it is possible that defining platooning and the driver's role appropriately could exempt it from this law. The purpose of this law could remain in place if it is stated or understood as being not applicable to follower vehicles in a platoon.

NYS Assembly Bill 7445 (and Senate Bill 5280) from the 2015–16 legislative session was proposed to eliminate this rule under all conditions.⁸⁰ A related bill, NYS Senate Bill 7879, introduced later in that legislative session proposed to maintain this rule “at all times when the motor vehicle is in motion, unless driving technology is engaged to perform the steering function.” This more specific approach likely targeted a path to allow automated vehicles on NYS roads, but unfortunately neither bill was passed.⁸¹ A similar Senate Bill 4807 (and Assembly Bill 1064) for the 2016-17 legislative session was introduced

⁷⁸ New York State Vehicle and Traffic Law. Accessed August 18, 2016 from <http://ypdcrime.com/vt/article33.htm#1226>

⁷⁹ Blain, G., EXCLUSIVE: N.Y. pols want to fix 1971 steering wheel law to allow for self-driving cars, New York Daily Times, May 30, 2016, <http://www.nydailynews.com/news/politics/n-y-self-driving-cars-fix-1971-law-article-1.2654122>

⁸⁰ New York State Assembly, Assembly Bill 7445, 2015-20126 Legislative Session, http://nyassembly.gov/leg/?default_fld=&leg_video=&bn=A07445&term=2015&Summary=Y

⁸¹ Blain, G. 2016. “EXCLUSIVE: N.Y. Pols Want to Fix 1971 Steering Wheel Law to Allow for Self-Driving Car,” New York Daily News. Accessed September 23, 2016. <http://www.nydailynews.com/news/politics/n-y-self-driving-cars-fix-1971-law-article-1.2654122>

to “repeals a provision of law relating to the control of a steering mechanism.”⁸² The bill was referred to the Transportation Committee in early March 2016, but was not enacted, so the hand on the wheel rule remains. This is less of a concern for near-term platooning for lower automation levels (SAE Level 1 and Level 2) since they require the driver to remain at the wheel to control lateral vehicle operation.

A.3 Following Distance

A significant legislative barrier to allow near-term platooning operations in NYS is the following distance law. The specific NYS legislation language is as follows:

N.Y. Vehicle & Traffic Law § 1129 – Following too closely

1. The driver of a motor vehicle shall 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 motor truck or motor vehicle drawing another vehicle when traveling upon a roadway outside of a business or residence district and which is following another motor 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, except that this shall not prevent a motor truck or motor vehicle drawing another vehicle from overtaking and passing any like vehicle or other vehicle.
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 shall 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. This provision shall not apply to funeral processions.⁸³

All vehicles are required to maintain a following distance that is “reasonable and prudent.” This language provides flexibility for law enforcement to interpret whether the requirement has been met. Heavy-duty vehicles have the additional requirement to leave sufficient space for other vehicles to enter the space between them. This results in following distances of hundreds of feet and hinders the potential for coordinated platooning at close following distances. Examples of how other states have addressed the following distance issue for platooning vehicles are provided.

⁸² New York State Assembly, Senate Bill 4807, 2015-20126 Legislative Session, http://nyassembly.gov/leg/?default_fld=&leg_video=&bn=S04807&term=2017&Summary=Y

⁸³ Governor’s Traffic Safety Committee. NYS Vehicle & Traffic Law Excerpts. Accessed August 18, 2016 from <http://www.safeny.ny.gov/drrt-vt.htm#1129>

Industry expert Technical Advisory Committee⁸⁴ member feedback recommended this law be amended to allow for closer following distances in cases when inter-vehicle communication and control software is used to ensure linked acceleration, braking, and potentially steering between two or more trucks (i.e., platooning). If there is too much concern this would broadly allow platooning trucks in all cases before the technology is fully proven, an alternative could be to allow platooning (i.e., exempt its use from the close following distance law) only for testing purposes. In this case, the law could be amended once the technology's functionality and safety are established by NYS.⁸⁵

States that have issued bills related to truck platooning policies typically include language that exempts platooning vehicles from the minimum following distance regulations (when the platooning systems are engaged). Example state legislation language is shown in Table A-1. The National Conference of State Legislatures, Autonomous Vehicles searchable legislative database⁸⁶ is a convenient single-source to locate and view the bill text for these bills, and future bills, including additions and deletions.

⁸⁴ The project Technical Advisory Committee was comprised of technical experts from platooning system technology developers, heavy truck manufacturers, technology analysts, and truck fleet operator advocacy groups.

⁸⁵ Scribner, M., "Authorizing Automated Vehicle Platooning: A Guide for State Legislators", Competitive Enterprise Institute, July 2016, <https://cei.org/sites/default/files/Marc%20Scribner%20-%20Authorizing%20Automated%20Vehicle%20Platooning.pdf>

⁸⁶ FleetOwner. 2015. "NHTSA Announces Electronic Stability Control Mandate for Class 7-8 Tractors." Accessed September 14, 2016. <http://fleetowner.com/regulations/nhtsa-announces-electronic-stability-control-mandate-class-7-8-tractors>

Table A-1. Example State Policy for Minimum Following Distance Exemptions

State	Status	Bill #	Language
Nevada	Enacted	2017 A 69	This section [Sec. 11.7 which describes allowable following distances] does not apply to a vehicle which is using driver-assistive platooning technology.
Georgia	Enacted	2017 H 472	This Code section [40-6-49] shall not apply to the operator of any non-leading vehicle traveling in a coordinated platoon... All laws and parts of laws in conflict with this Act are repealed.
Illinois	Pending	2017 H 4050	This Section shall not apply to a driver of a motor vehicle operating in a platoon or a driver of a motor vehicle operating with a connected automated braking system.
Arkansas	Enacted	2017 H 1754	Vehicles equipped with driver-assistive truck platooning systems, may follow other vehicles closer than allowed under (existing regulations).
Michigan	Enacted	2016 SB 995	(3) Except as provided in subsection (4), a distance of not less than 500 feet shall be maintained between two or more driven vehicles being delivered from one place to another. (4) Subsections (2) and (3) do not apply to a vehicle in a platoon.
Texas	Enacted	2017 HB 1791	An operator of a vehicle equipped with a connected braking system that is following another vehicle equipped with that system may be assisted by the system to maintain an assured clear distance or sufficient space as required by this section. In this subsection, "connected braking system" means a system by which the braking of one vehicle is electronically coordinated with the braking system of a following vehicle.
South Carolina	Enacted	2017 H 3289	This section does not apply to the operator of any nonleading commercial motor vehicle subject to Federal Motor Carrier Safety Regulations and traveling in a series of commercial vehicles using cooperative adaptive cruise control or any other automated driving technology.
North Carolina	Pending	2017 H 716	(c) Subsections (a) and (b) of this section shall not apply to the driver of any non-leading commercial motor vehicle traveling in a platoon on any roadway where the Department of Transportation has by traffic ordinance authorized travel by platoon. For purposes of this subsection, the term "platoon" means a group of individual commercial motor vehicles traveling at close following distances in a unified manner through the use of an electronically interconnected braking system.

A “Model State Automated Driving Law” was developed as a guide for consistent state law and policy development.⁸⁷ The model addresses following distance with this language: “Any provision of this Title requiring a minimum following distance other than a reasonable and prudent distance shall not apply to operation of any non-leading vehicle traveling in a procession of vehicles if the speed of each vehicle is automatically coordinated.”

⁸⁷ Bryant Walker Smith, Model State Automated Driving Law (2017), newlypossible.org/modellaws

Platooning-capable trucks will not be actively platooning all the time. So, the condition that the following distance requirement is waived when the platooning systems are engaged leaves a gap for indicating to road users (i.e., law enforcement and the public) when trucks are actively platooning, likely requiring some form of signage, lights, or other means. This has been identified as a need by the Technical Advisory Committee and other heavy-duty vehicle manufacturers, but an approach for addressing this has not yet been done. One example was demonstrated by Freightliner on an advanced automated driving technology demonstrator truck where “the license plate, indicators, and radiator grille shine blue when the vehicle is in automated mode, and white and yellow while in standard operation.”⁸⁸ This truck was a highly-automated truck, not necessarily operating in a platoon, but the same or similar approach could be used for platooning trucks. This system could be considered a vehicle safety system, so the U.S. Department of Transportation will likely be the responsible entity for establishing a standard approach.

A.4 Platooning Definition

Defining what the term “platooning” specifically means, and in what capacity it relates to commercial vehicle operations, is valuable to address with policy. This differentiates between platooning-specific operation and general automated vehicle operation. Near-term platooning operations are expected to solely involve commercial vehicles in on-highway operations with drivers in the driver’s seat. This limited scope requires a simpler, focused policy than other emerging automated vehicle operations.

Platooning operation, often termed a “coordinated platoon,” is typically defined as multiple vehicles being involved, use some form of inter-vehicle communication and automation systems to coordinate follower vehicle control, and the vehicles are in the same lane. Table A-2 summarizes how platooning has been defined in states that have issued related bills. Some states use specific language to specify onboard systems and operations. Others are more general, perhaps to provide flexibility in future efforts and to ensure the policy applies as technology evolves.

⁸⁸ American Trucking Associations, Technology and Maintenance Council, Future Truck Program, Automated Driving and Platooning Task Force, White Paper: Automated Driving and Platooning Issues and Opportunities, September 21, 2015.

Table A-2. Example State Policy for Platooning Definition

State	Status	Bill #	Language
Georgia	Enacted	2017 H 472	... the term "coordinated platoon" means a group of motor vehicles traveling in the same lane utilizing vehicle-to-vehicle communication technology to automatically coordinate the movement of such vehicles.
Illinois	Pending	2017 H 4050	Platoon. A group of individual motor vehicles that travel in a unified manner at electronically coordinated speeds.
Arkansas	Enacted	2017 H 1754	"driver-assistive truck platooning system" means technology that integrates sensor array, wireless communication, vehicle controls, and specialized software to synchronize acceleration and braking between two (2) or more vehicles while leaving each vehicle's steering control and systems monitoring and intervention in the control of its human operator.
North Carolina	Enacted	2017 H 716	The term "platoon" means a group of individual commercial motor vehicles traveling at close following distances in a unified manner through the use of an electronically interconnected braking system."
Pennsylvania	Pending	2017 S 427	"Platooning." A series of motor vehicles that are (1) equipped with at least one highly automated vehicle system (2) traveling in a unified manner (3) connected by wireless communication or other technology allowing for coordinated movement on the trafficway
Michigan	Enacted	2016 SB 995	Sec. 40c. "Platoon" means a group of individual motor vehicles that are traveling in a unified manner at electronically coordinated speeds.
Nevada	Enacted	2017 AB 69	"Driver-assistive platooning technology" means technology that enables two or more trucks or other motor vehicles to travel on a highway at electronically coordinated speeds in a unified manner at a following distance that is closer than would be reasonable and prudent without the use of the technology. The term does not include an automated driving system.
Tennessee	Enacted	2017 S 676	"Platoon" means a group of individual motor vehicles traveling in a unified manner at electronically coordinated speeds.

A.5 Permission to Operate Platooning Vehicles

Truck platooning technology's use on public roads with mixed traffic has not been extensively documented. To address this, some states use an approach to require truck fleets to secure special pre-deployment permission, via an approved platooning plan to operate platooning trucks on public roads. As automated technology becomes more widespread, the permission process for allowing platooning operations is expected to become more streamlined, or not required at all.

Example legislation language for platooning plan processes in states that have enacted platooning vehicle use policies (or are in the process of proposing them) are shown in Table A-3. The typical plan process involves submitting a platooning request and operations plan to the governing agency (typically the state Department of Transportation or state police). An application review period of 30-45 days follows. If the plan is either approved, or not rejected after the review period expires, the plan is deemed approved and the applicant can deploy platooning vehicles on public roadways within that state.

Table A-3. Example State Policy for Platooning Plan

State	Status	Bill #	Language
Illinois	Pending	2017 H 4050	Before the operation of a platoon upon the streets or highways of this State, a person shall file a plan for general platoon operations with the Department of State Police. If the Department of State Police do not reject the plan within a 30-day time period after receipt of the plan, the person may operate the platoon. The Department shall adopt rules to implement this Section.
Arkansas	Enacted	2017 H 1754	A person may operate a driver-assistive truck platooning system on a street or highway of this state if the person files a plan for general platoon operations with the State Highway Commission. (b) A person may operate a driver-assistive truck platooning system on a street or highway of this state. (1) Upon approval of the plan required under subsection (a) of this section by the commission. (2) Forty-five (45) days after the submission of the plan required under subsection (a) of this section, if the plan has not been rejected by the commission.
Pennsylvania	Pending	2017 S 427	An automated vehicle tester shall submit an application to the department for authorization to test highly automated vehicles or platooning on trafficways. The department may charge a reasonable application fee not to exceed \$200. (b) Application requirements...
Michigan	Enacted	2016 SB 995	(9) A person may operate a platoon on a street or highway of this state if the person files a plan for general platoon operations with the department of state police and the state transportation department before starting platoon operations. If the plan is not rejected by either the department of state police or the state transportation department within 30 days after receipt of the plan, the person shall be allowed to operate the platoon. (c) If the platoon includes a commercial motor vehicle, an appropriately endorsed driver who holds a valid commercial driver license shall be present behind the wheel of each commercial motor vehicle in the platoon.
Tennessee	Enacted	2017 S 676	A person may operate a platoon... after the person provides notification to the department of transportation and the department of safety. The notification provided... must include a plan for general platoon operations... If the notification and the plan submitted... are not rejected by either the department of transportation or the department of safety within thirty (30) days after receipt of the notification and the plan, the person may operate a platoon.

A.6 Longer-Term Platooning Policy Considerations

More highly automated vehicle technology will likely be integrated into future heavy-duty truck applications. The U.S. Department of Energy identified advanced truck platooning as one of the top connected and automated vehicle concepts to evaluate.⁸⁹ The concept uses an SAE Level 3 or Level 4 automated follower trucks. Other advanced platooning concepts will likely be developed. As technology advances, additional platooning-specific policies may be needed to support testing and widespread deployment, so its benefits can be realized.

⁸⁹ Shladover, S., “Definition of Connected and Automated Vehicle (CAV) Concepts for Evaluation”, 2017 DOE Vehicle Technologies Office and Hydrogen and Fuel Cells Program Annual Merit Review and Peer Evaluation Meeting, https://energy.gov/sites/prod/files/2017/06/f35/eems010_shladover_2017_o.pdf

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