Commercial Vehicle Safety Alliance—Automated Commercial Motor Vehicle Working Group

In partnership with

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

Final Report

Submitted by MaineWay Services, with the support of
Cambridge Systematics, Inc.

October 2019
(Updated September 2020)

Table of Contents

List of Figures

List of Tables

Acronym List

AAMVA	America Association of Motor Vehicle Administrators
ABS	Anti-lock brake system
ADS	Automated driving systems
ATG	Advanced Technologies Group
CMV	Commercial motor vehicle
CES	Consumer Electronics Show
CVSA	Commercial Vehicle Safety Alliance
EIM	Enforcement and Industry Modernization
ELD	Electronic logging device
eRODS	Electronic Record of Duty Status
EU	European Union
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulation
FMVSS	Federal Motor Vehicle Safety Standard
HOS	Hours of service
ODD	Operational design domain
NAS	North American Standard
NHTSA	National Highway Transportation Safety Administration
SAE	Society of Automotive Engineers
U.S. DOT	United States Department of Transportation

Executive Summary

Introduction

The development within the last decade of automated driving systems (ADS) or vehicle automation is both an enormous opportunity and a challenge to those tasked with creating policy and inspection processes to ensure the safety of both commercial motor vehicles (CMV) and the traveling public. As an area of growth and constant change, understanding the technology involved, the potential uses of that technology, and the best ways to ensure that the technology is applied safely is a direct concern for the Commercial Vehicle Safety Alliance (CVSA). CVSA is a nonprofit association of local, State, provincial, territorial, and Federal CMV official and industry representatives with a mission to improve CMV safety and uniformity throughout North America by providing guidance and education to enforcement, industry, and policy-makers.

CMV safety also is a primary concern of the Federal Motor Carrier Safety Administration (FMCSA). FMCSA has actively participated and provided support in this initiative to address CVSA's concerns and explore opportunities in using technology to improve CMV safety. However, any recommendations offered herein are solely those of the Automated CMV Working Group.

The Automated CMV Working Group was formed as part of CVSA's Enforcement and Industry Modernization (EIM) Committee in September 2018. This Working Group was charged with assessing the latest advances in CMV automation and developing recommended approaches to inspecting these vehicles.

This report completes the first phase of that charge, recommending two approaches for inspecting ADS-equipped CMV. Additional work will be necessary across a number of realms (training, technology development, standardization, and potentially regulatory rulemaking) to implement these recommendations and to address multiple associated issues that, although beyond the scope of this initial study, must be tackled in order to fully prepare CVSA's members for a future with more and higher levels of automated CMV.

Research and Outreach

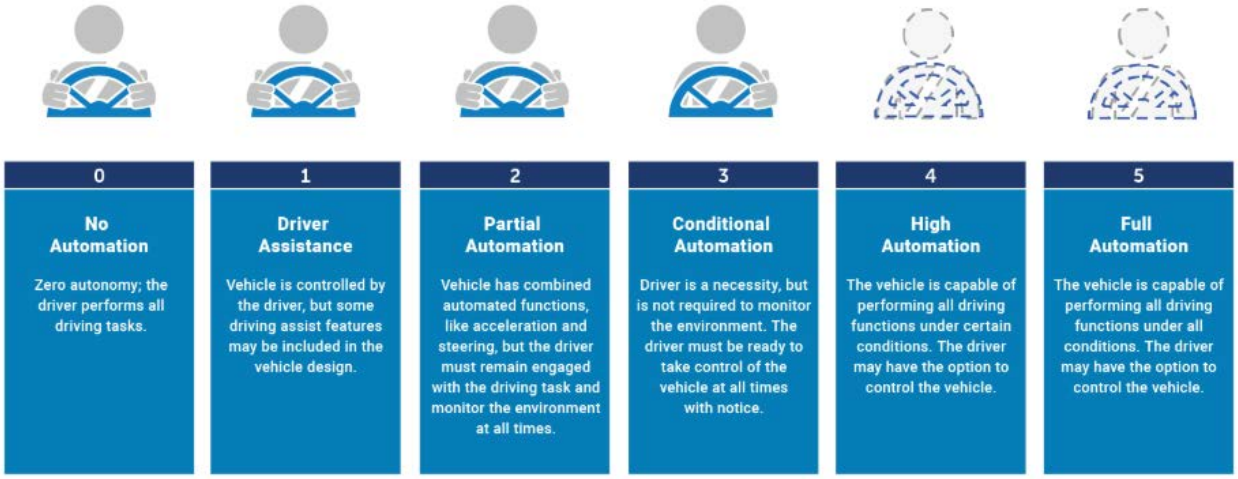
The Society of Automotive Engineers (SAE) "Levels of Driving Automation" (SAE J3016) is the standard classification schema for automated vehicles.[1] It spans six levels ranging from no automation to full automation. U.S. Department of Transportation (USDOT) uses this classification in its Federal Automated Vehicles Policy, and has become the standard reference, as shown in Figure ES.1.

Essentially, SAE Level 0 vehicles have no autonomous functions, while SAE Level 1 and Level 2 vehicles have features that can *assist* a human driver in certain functions (such as staying in the center of the lane, maintaining a consistent following distance, etc.), but *do not replace* the human driver. SAE Level 3

[1] This report will refer to levels of autonomy as SAE Levels 0 to 5. https://www.sae.org/standards/content/j3016_201401/.

vehicles can operate without driver intervention; however, a human must be behind the steering wheel and ready to take control of the vehicle at all times with notice.

Figure ES.1 Society of Automotive Engineers Levels of Vehicle Autonomy



Source: https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety.

SAE Level 4 and Level 5 vehicles do not require any human presence in the vehicle. Level 4 vehicles can operate without a human driver in a specified operational design domain (ODD). The ODD may include prescribed weather conditions, road conditions, and preselected and mapped routes. If outside these parameters, the vehicle either requires a human driver or will not function. SAE Level 5 vehicles can operate in all circumstances without a human driver.

Stakeholder outreach to a number of ADS-equipped CMV operators and manufacturers revealed that companies are developing SAE Level 1, Level 2, and Level 4 vehicles at this time, with Level 1 and Level 2 vehicles already operating in the United States. SAE Level 4 vehicles are still in development and testing phases, but some are carrying commercial loads with a safety driver onboard and ready to take control of the vehicle. More recently, stakeholders have indicated some exploration of SAE Level 3 deployment as an interim step towards SAE Level 4. Within these broadly defined SAE categories, there are different use-scenarios, including platooning, highway exit-to-exit automation, highway automation with remote (drone) access, and facility-to-facility automation (when facilities are located close to a highway interchange).

All industry interviewees were interested in continued collaboration with enforcement and regulatory officials to help develop safety standards and ensure that their vehicles were as safe as possible. Industry generally recommended the following in terms of interaction with inspection needs:

- **Focus on Functionality**. Regulatory agencies and enforcement should focus on specifying desired functional requirements and let industry develop the specific approach and supporting systems. For example, enforcement could require that a vehicle display its ODD so that enforcement can verify the vehicle is operating in a location and under conditions that it should. Industry should be responsible for deciding the best way to meet this requirement (light, door placards, 24/7 contact information, etc.).

- **Strive for Uniformity**. Once the functionality for safety assurances are specified, apply them uniformly throughout the country.

Recommendations and Next Steps

Based on this information, the Working Group developed eight inspection options that could be applied to ADS-equipped CMVs during a CVSA North American Standard (NAS) Level I inspection, including:

- **Option 1**—Continue inspections as done now with no changes. All ADS-equipped CMV would be treated similarly to SAE Level 0 CMV and be designed in such a way as the inspector could complete all steps of the existing inspection.

- **Option 2**—Add a new Step to the NAS Level I to inspect the overall ADS using a malfunction lamp, indicator, electronic readout, or some other method to be determined. This approach could work similarly to the antilock brake system (ABS) malfunction lamp check (Step 21) in the existing NAS Level I. This option would apply to SAE Levels 1 to 3 CMV.

- **Option 3**—Add a new Step to the NAS Level I to inspect individual components of an ADS using a malfunction lamp, indicator, electronic readout, or similar method to be determined. This option would apply to SAE Levels 4 to 5 CMV.

- **Option 4**—Add a new Step to the NAS Level I to conduct a physical inspection of ADS component systems. Examples would include checking cameras to ensure the lens is not covered by debris or cracked. This option would apply to all SAE Levels CMV.

- **Option 5**—This option is a combination of Options 2 and 4 and would apply to all ADS-equipped CMVs.

- **Option 6**—This option is a combination of Options 3 and 4 and would apply to all ADS-equipped CMVs.

- **Option 7**—This option would apply to SAE Levels 4 to 5 CMVs. It would limit roadside inspection of these vehicles to situations where an imminent hazard is observed or during a post-crash investigation, and instead focus on an origin/destination (terminal) inspection model. The vehicle would be required to communicate to enforcement while in-motion that it had passed the origin/ destination inspection, that its ADS systems (as a whole) were functioning, and that it is operating within its ODD.

- **Option 8**—This option is similar to Option 7 above, except that the in-motion verification would include that each ADS component system was functioning instead of an overall system check.

Option 2 for SAE Levels 1 to 3 CMV and Option 7 for SAE Levels 4 to 5 CMV were identified as the initial recommendations and were subsequently approved by a majority vote of the Automated CMV Working Group. They were presented to the EIM Committee during the CVSA Annual Conference and Exhibition in Biloxi, Mississippi in September 2019 and approved by the Committee. These recommendations, along with a recommendation to continue to the efforts of the Automated CMV Working Group for another year

were then sent to and approved by the CVSA Board of Directors. While FMCSA and other industry partners have provided input to the Working Group, the recommendations are those of CVSA only.

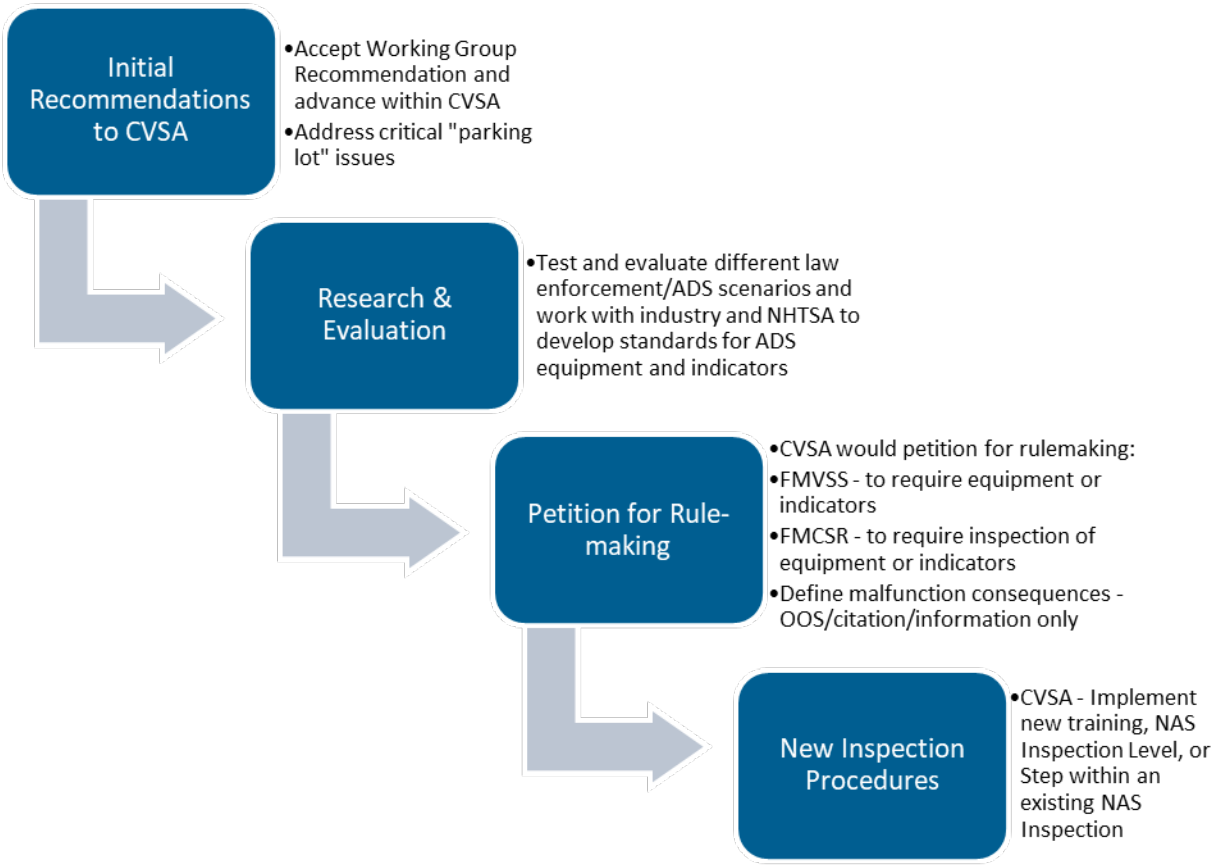
This study provides a groundwork for future ADS-equipped CMV policy and should be considered as Phase I of developing a comprehensive approach to enforcing ADS-equipped CMV. These recommendations will require additional work to resolve a number of critical issues including the following:

- **Should the ADS malfunction indicator system be defined, or should a functional requirement be created that the vehicle must be able to communicate to enforcement (either roadside for SAE Levels 1 to 3 or in-motion for SAE Levels 4 to 5) that it has passed its check, and allow industry to determine how this communication is done?**
- What are the implications of the malfunction indicator? Should a vehicle with an ADS malfunction be able to:
  - Continue to operate using ADS?
  - Operate using ADS to reach a safe location, repair facility, or some other designated location?
  - Operate as an SAE Level 0 CMV, or not be able to operate at all?
- Should the ADS malfunction indicator include any systems on a trailer, or should it be for tractor-only components? If tractor systems are to be included, which ones? Does this change for SAE Levels 1 to 3 vehicles versus SAE Levels 4 and 5 vehicles?
- **For the Option 7 recommendation (origin/destination inspections for SAE Levels 4 and 5), what elements should be included in the terminal inspection? This applies to both ADS components (e.g., what systems are in the overall system check) and to non-ADS components (e.g., load securement). The Working Group identified the Canadian "Daily Vehicle Trip Inspection" as a possible template for this inspection. The American Association of Motor Vehicle Administrators (AAMVA) is also revising its commercial driver license test to focus on a subset of critical systems for the Vehicle Inspection portion of the test, based on common crash causation, CVSA inspection process and citation data.[2]**
- **For the Option 7 recommendation, who is authorized to conduct the origin/destination (terminal) inspection? What training or certification should they have, and how is that training obtained?**

The concerns in **bold** above are recommended as the next topics for CVSA to address. Resolving these issues will require research and coordination within CVSA; between CVSA and partner agencies including FMCSA, National Highway Traffic Safety Administration (NHTSA), and AAMVA; and with industry stakeholders to develop new technology and standards, new training and policies, and possibly new Federal regulations. Potential next steps are outlined in Figure ES.2.

[2] https://www.ugpti.org/resources/proceedings/downloads/2018-11-28-kevin-lewis.pdf

Figure ES.2 Commercial Motor Vehicle Automated Driving Systems – Suggested CVSA Next Steps



1.0 Introduction

The Commercial Vehicle Safety Alliance (CVSA) is a nonprofit association of local, State, provincial, territorial, and Federal commercial motor vehicle (CMV) officials and industry representatives with a mission to improve CMV safety and uniformity throughout North America by providing guidance and education to enforcement, industry, and policy-makers.

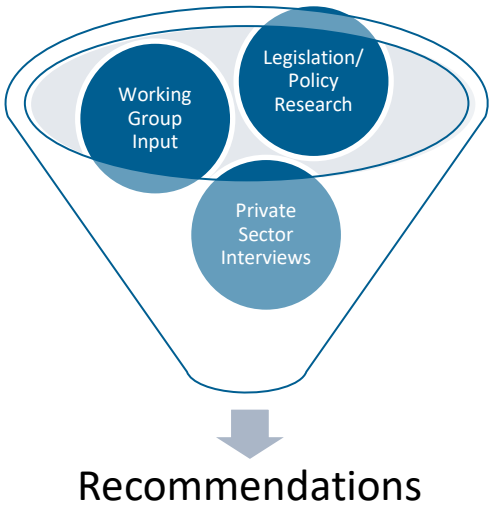
The development within the last decade of automated driving systems (ADS) or vehicle automation is both an enormous opportunity and a challenge to those tasked with creating policy and inspection processes to ensure the safety of both CMVs and the traveling public. As an area of growth and constant change, understanding the technology involved, the potential uses of that technology, and the best ways to ensure that the technology is applied safely is a direct concern for CVSA, as well as the Federal Motor Carrier Safety Administration (FMCSA). FMCSA has collaborated with CVSA in this initiative to address these concerns and opportunities to improve CMV safety, though recommendations offered are solely those of the Automated CMV Working Group, part of the Enforcement and Industry Modernization (EIM) Committee within CVSA.

This report represents an initial step to understand the ADS-equipped CMV universe, identify use-scenarios that enforcement officials are likely to face in the next three to five years, and recommend changes to policy and procedures to ensure that enforcement officials are able to identify safety issues while not unduly burdening industry.

1.1 Automated Commercial Motor Vehicle Working Group Task and Goal

The EIM Committee was created by the CVSA Board of Directors in 2016 in response to the growing need to follow and understand advances in technologies, both in vehicles and inspection systems and equipment. Shortly after the committee's inaugural meeting, Otto, a self-driving truck technology start-up company, announced it had completed the first highway freight delivery demonstration with a self-driving tractor trailer. While Otto's demo used a self-driving prototype technology using a lidar-based sensor and neural network-based machine learning perception approach, it became clear that advances in automation are already changing CMV safety inspections. In September 2018, the EIM Committee appointed a new Automated CMV Working Group, with representation from CVSA's Class I (State/provincial/territorial enforcement), Class II (local enforcement), Class III

Figure 1. CVSA Working Group Recommendation Process

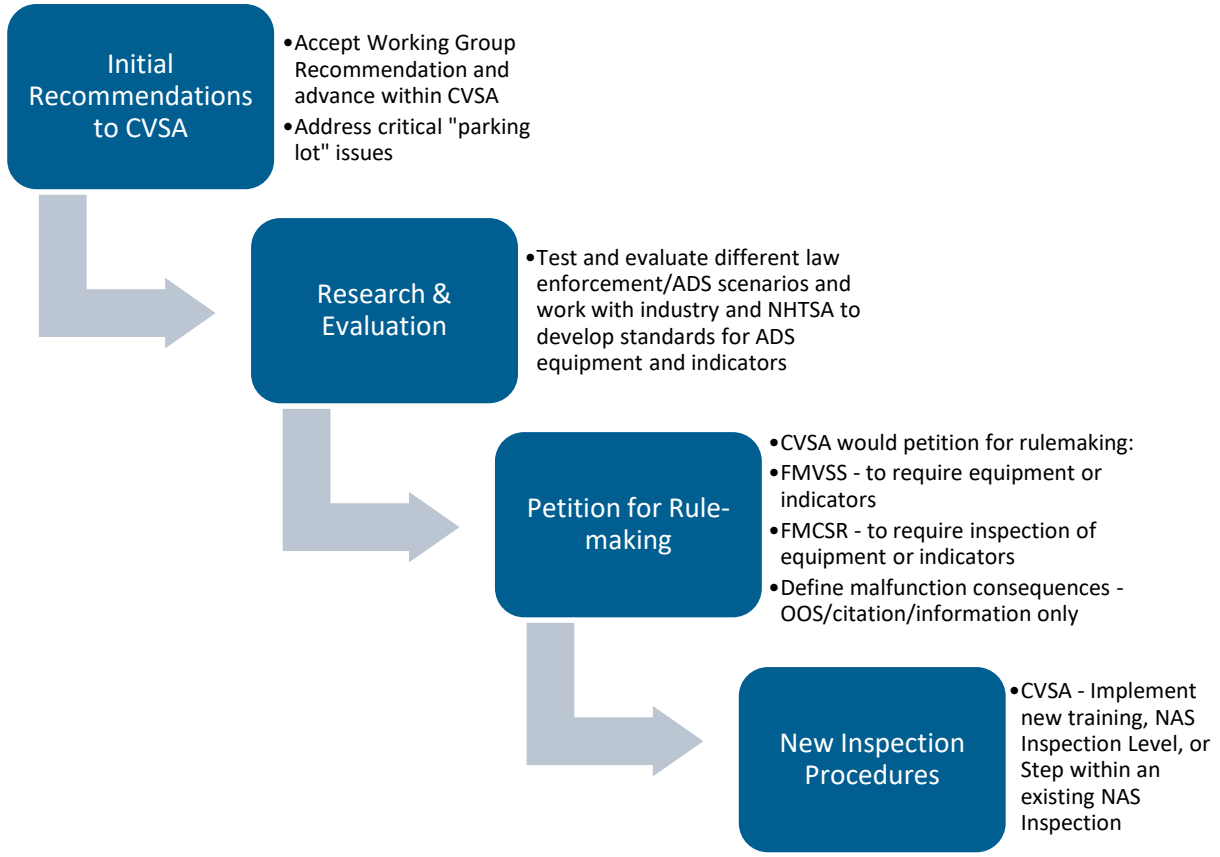


(associate), and Class IV (Federal) membership. Members of this Working Group are listed in the following section.

This Working Group was charged with assessing the latest advances in CMV automation; and developing recommended approaches to inspecting these vehicles through the use of stakeholder interviews, research into best practices and current deployment and testing trends, and input from CVSA members.

This report completes the first phase of that charge by offering recommendations for inspection requirements and procedures for ADS-equipped CMVs. Following this report, additional steps will be necessary to implement the Working Group's recommendations. These steps include additional research within CVSA to address critical "parking lot" issues, new policy and training within CVSA, a request to the National Highway Transportation Safety Administration (NHTSA) for research and testing, and ultimately the development of new Federal Motor Vehicle Safety Standards (FMVSS) and Federal Motor Carrier Safety Regulations (FMCSR). These potential next steps are shown in Figure 2.

Figure 2. Commercial Motor Vehicle Automated Driving Systems – Suggested CVSA Next Steps



This study also identifies a number of "parking lot" issues that were considered outside the initial scope of this study, which will need to be addressed in coming years to fully address enforcement needs for interacting with ADS-equipped CMV.

1.2 Automated CMV Working Group

Table 1 lists the members of the Automated CMV ADS Working Group.

Table 1. Automated Commercial Motor Vehicle Working Group Membership

Working Group Executive Committee	State, Province, and Local Representatives	Federal Representatives	Industry Representatives
• Derek Barrs (FL)—EIM Committee Chair • Tony Coronado (CA)—Chair until 05/19 • Clint Kneip (CA)—Chair after 05/19 • John Sova (ND)—Vice Chair • Tom Kelly (FMCSA)—Secretary • Will Schaefer (CVSA)	• William Alarcon (NJ) • Robert Anderson (UT) • Chris Childs (CA) • Krista Cull (Newfoundland-Labrador) • Jacquie Daumont (Alberta) • Joe Greene (KS) • Jeff Mills (ME) • William Moore (NC) • Chris Nordloh (TX) • Daniel Plumer (Dallas, TX Sheriff) • Kyle Roach (Houston, TX Police Dept) • Jay Thompson (AR)	• Catherine Bordzal (FMCSA) • Luke Loy (FMCSA) • Jon Mueller (FMCSA) • Dominick Washington (FMCSA) • Vacant (NHTSA) (Invited)	• Tom Cuthbertson (Omnitracs) • Scott Dewey (FedEx Freight) • Ross Froat (American Trucking Associations) • Jack Legler (American Trucking Associations/The Maintenance Council) • Craig Lundgren (Saia Inc.) • Andrea Sequin (Schneider) • Dave Taylor (Penske)

Capt. Tony Coronado from California served as the Chair of the Working Group from its formation through April 2019 when he left the Working Group. Lt. Clint Kneip from California was added to the Working Group in April and served as Chair through the end of this study. John Sova from North Dakota served as the Vice-Chair, and Thomas Kelly from FMCSA served as the Secretary for the Working Group. Will Schaefer from CVSA served as the Working Group liaison and support. These members, joined by consultant support provided by MaineWay Services and Cambridge Systematics, Inc. and funded by FMCSA, formed the executive committee for the Working Group.

1.3 Report Organization

The remainder of this report contains the following sections:

- **Section 2.0** provides an overview of automated vehicle technology, CVSA inspection processes, known ADS-equipped CMV deployments, and policy and legislative action taken in the U.S. and around the world.

- **Section 3.0** contains an overview of outreach conducted with industry stakeholders as part of this study.
- **Section 4.0** presents an interim "Decision Tree" tool that was used to help enforcement officials identify the types and combinations of ADS-equipped CMVs that they may encounter roadside.
- **Section 5.0** examines the inspection options considered by the Working Group and provides recommendations and potential next steps for CVSA.
- **Section 6.0** lists "parking lot" issues identified during this study. Some of these issues are immediately relevant to the recommendations made in Section 5.0; others are broader concerns for ADS-equipped CMV enforcement that will need to be addressed in future efforts.
- **Appendix A** contains a matrix showing the analysis of the NAS Level I inspection steps and various ADS-equipped CMV use-scenarios that drove the creation of the "Decision Tree" tool shown in Section 4.0.
- **Appendix B** provides details on the development of the Automated CMV Working Group's Inspection Option Recommendations.

2.0 Background

This section provides an overview of the levels of vehicle automation; the different CVSA inspection processes; and a review of Federal, State, and international policy and legislations regarding the testing, deployment, and inspection of CMV.

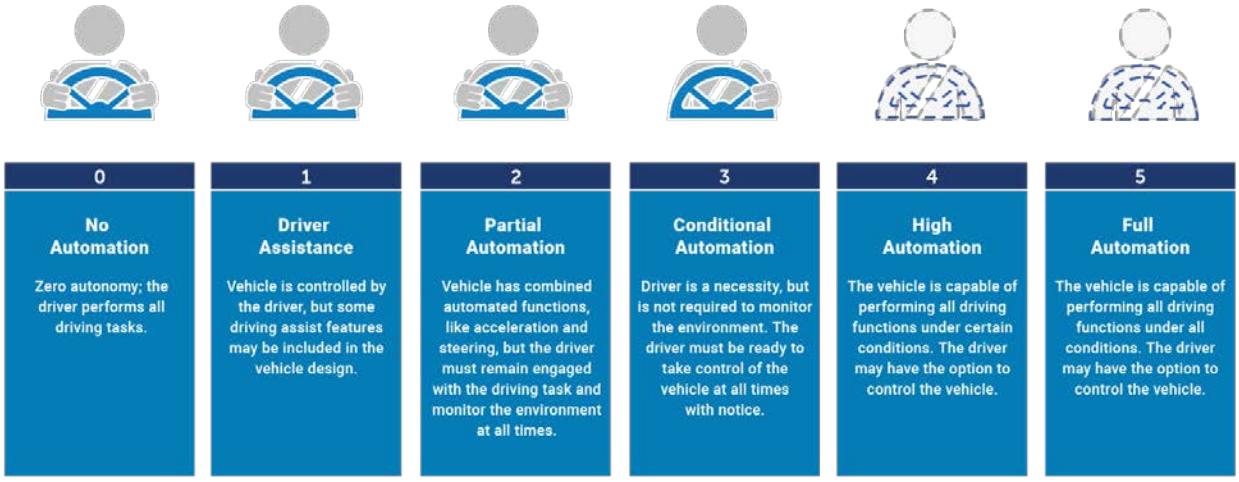
2.1 Levels of Automated Vehicles

Discussions with industry stakeholders indicate that multiple configurations, levels of autonomy, and use-scenarios are envisioned in the future for the deployment of ADS-equipped CMVs. This section provides an overview of the various levels of autonomy and use-scenarios deployed or under development within the CMV realm.

Society of Automotive Engineers Levels 0 to 5 of Autonomy

The Society of Automotive Engineers (SAE) "Levels of Driving Automation" (SAE J3016) is the standard classification schema for automated vehicles.[3] It spans six levels ranging from no automation to full automation, as shown in Figure 3. U.S. Department of Transportation (DOT) uses this classification in its Federal Automated Vehicles Policy, and it has become the standard industry reference.

Figure 3. Society of Automotive Engineers Levels of Vehicle Autonomy



Source: https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety.

Essentially, SAE Level 0 vehicles have no autonomous functions, while SAE Level 1 and Level 2 vehicles have features that can *assist* a human driver in certain functions (such as staying in the center of the lane, maintaining a consistent following distance, etc.), but *do not replace* the human driver. SAE Level 3 vehicles can operate without driver intervention; however, a human must be behind the steering wheel and ready to take control of the vehicle at all times with notice. This blending of responsibility is a key

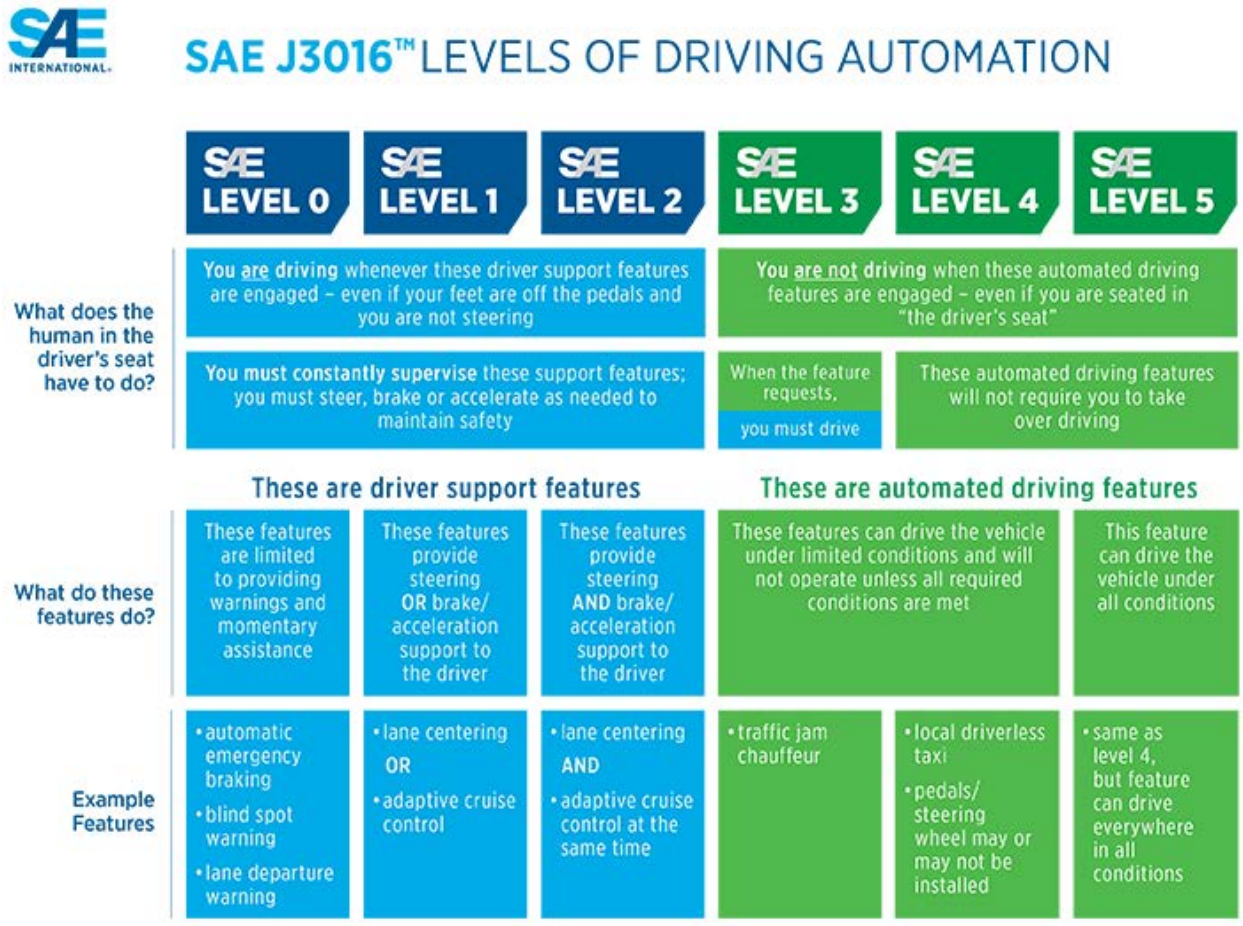
[3] This report will refer to levels of autonomy as SAE Levels 0 to 5. https://www.sae.org/standards/content/j3016_201401/.

challenge for developing SAE Level 3 vehicles. In an SAE Level 1 or Level 2 vehicle, the human driver must always be responsible for the vehicle's performance. In an SAE Level 4 or Level 5 vehicle, a human has no responsibility for operating the vehicle.

SAE Level 4 and Level 5 vehicles do not require any human presence in the vehicle. Level 4 vehicles can operate without a human driver in specified operational design domain (ODD). The ODD may include prescribed weather conditions, road conditions, and preselected and mapped routes. If outside these parameters, the vehicle requires a human driver; and if a human driver is not available the vehicle will not function. In contrast, SAE Level 5 vehicles can operate in all circumstances without a human driver.

Figure 4 provides additional clarification of what actions a human driver is responsible for at each level of autonomy.

Figure 4. Society of Automotive Engineers Levels of Driving Autonomy—Updated Infographic



Source: https://www.sae.org/news/2019/01/sae-updates-j3016-automated-driving-graphic.

Truck platooning is an example of an SAE Level 1 system. While operating in the current two-vehicle configuration, the lead vehicle is fully controlled by a human driver while in the second vehicle, steering is

under the control of the human driver, but vehicle speed (following distance) is controlled by a computer system. As of the end of February 2019, 23 States allow CMV platooning on public highways.[4]

Beyond platooning, discussions with industry stakeholders indicate that the emerging market is split in two groups. One group is focusing on deploying a robust SAE Level 2 system, which will provide driver assistance across all weather and traffic conditions. While these systems will be able to control both steering (lane centering) and speed, the human driver must be alert and ready to take control of the vehicle. The second group is focusing on deploying SAE Level 4 vehicles operating under specific ODD.

Discussions at the CVSA Annual Meeting and Exhibition indicated that some companies are beginning to explore deploying SAE Level 3 vehicles as an interim step towards Level 4. However, publicly available information is currently limited as to the scope and timing of such developments.

Vehicle Size Considered by the Working Group

The Working Group focused its research and recommendations on a CMV most typically found at fixed site inspection stations. Small vans and other smaller trucks may be automated faster, for example, in short-distance drayage situations. Understanding and adjusting for variations between these other types of vehicles and the vehicles considered by the Working Group are identified as a "parking lot" issue.

An Alternative View: Operational Use-Scenarios

Although the SAE Levels are a standard way to discuss ADS, they do not capture the full range of options or use-scenarios that industry are pursuing. Some of these use-scenarios do not neatly fit into the SAE schema, and each use-scenario can change the way in which law enforcement would interact with the vehicle to conduct an inspection.

A 2018 research study identified six general deployment scenarios for ADS-equipped CMVs.[5] They include the following:

1. **Human-human platoon.** Platoon with human driver in each vehicle in the platoon.

2. **Human-drone platoon.** Human drives the first vehicle, remaining vehicles in platoon operate autonomously. Local human drivers would drive loads to/from an origin/destination to a transfer hub near the highway and swap the trailer with the platooning trucks.

3. **Highway automation + drone operation.** Vehicle operates autonomously on the highway, and a drone operator drives the vehicle for the first/last mile off the highway (remote teleoperation). See Figure 5 below.

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4 https://peloton-tech.com/majority-of-us-freight-ton-miles-now-occur-in-platooning-approved-states/.

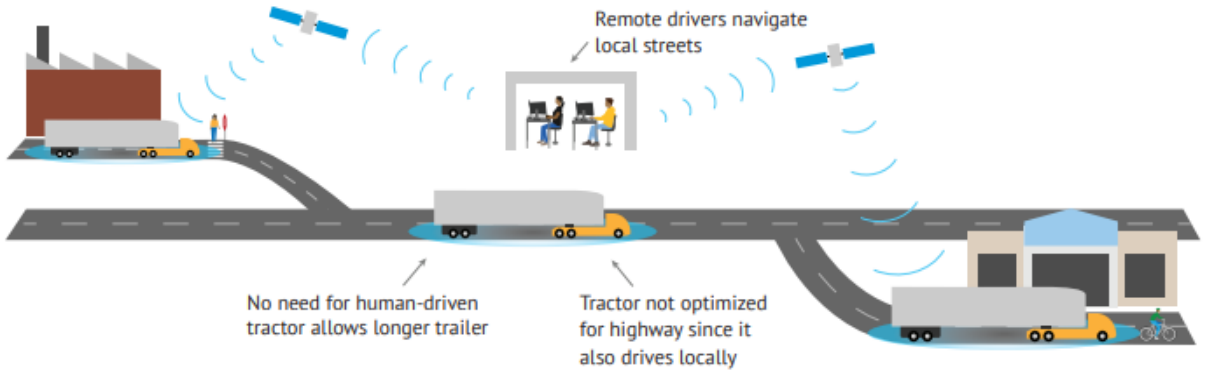
5 Viscelli, S., "Driverless? Autonomous Trucks and the Future of the American Trucker," University of California (UC), Berkeley Center for Labor Research and Education and Working Partnerships USA, September 2018. Online at: http://laborcenter.berkeley.edu/pdf/2018/Driverless.pdf (accessed April 12, 2019).

4. **Autopilot.** Human operates the vehicle for first/last mile, and then sleeps in the truck during autonomous operation on the highway.

5. **Highway exit-to-exit automation.** Human operates vehicle on first/last mile off the highway, and handles nondriving tasks (paperwork, pretrip inspection, etc.). Driver brings trailer to a transfer hub next to the highway and switches trailer to automated vehicle for highway portion. See Figure 6 below.

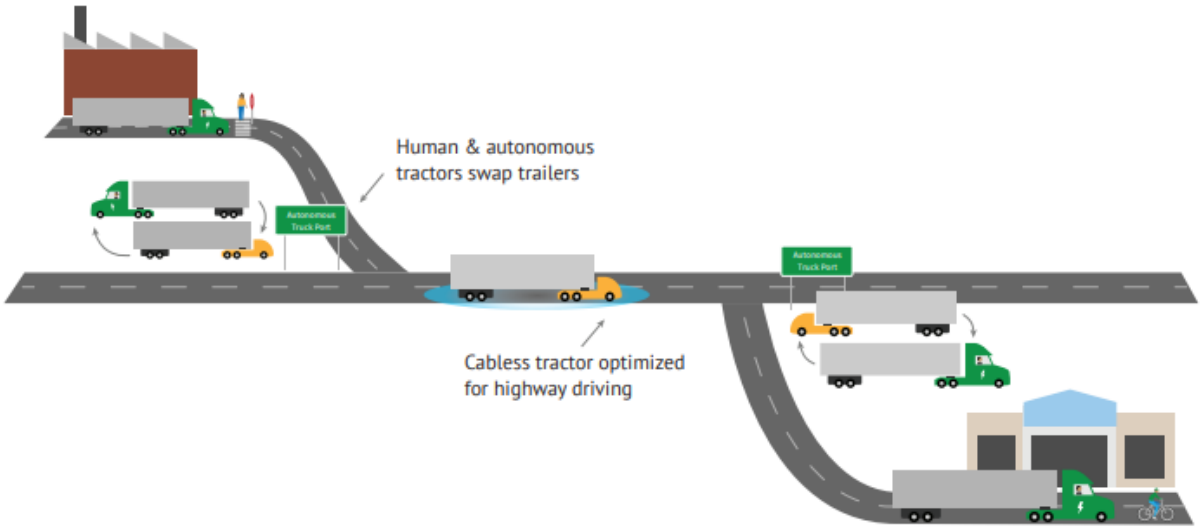
6. **Facility-to-facility automation.** Vehicle operates autonomously for the entire trip, with origins/ destinations located close to the highway and in areas with few complicated traffic patterns (e.g., industrial roads with few pedestrians and simple intersections).

Figure 5. Highway Automation + Drone Operation (Teleoperation) Use-Scenario



Source: http://laborcenter.berkeley.edu/pdf/2018/Driverless.pdf.

Figure 6. Highway Exit-to-Exit Automation Use-Scenario



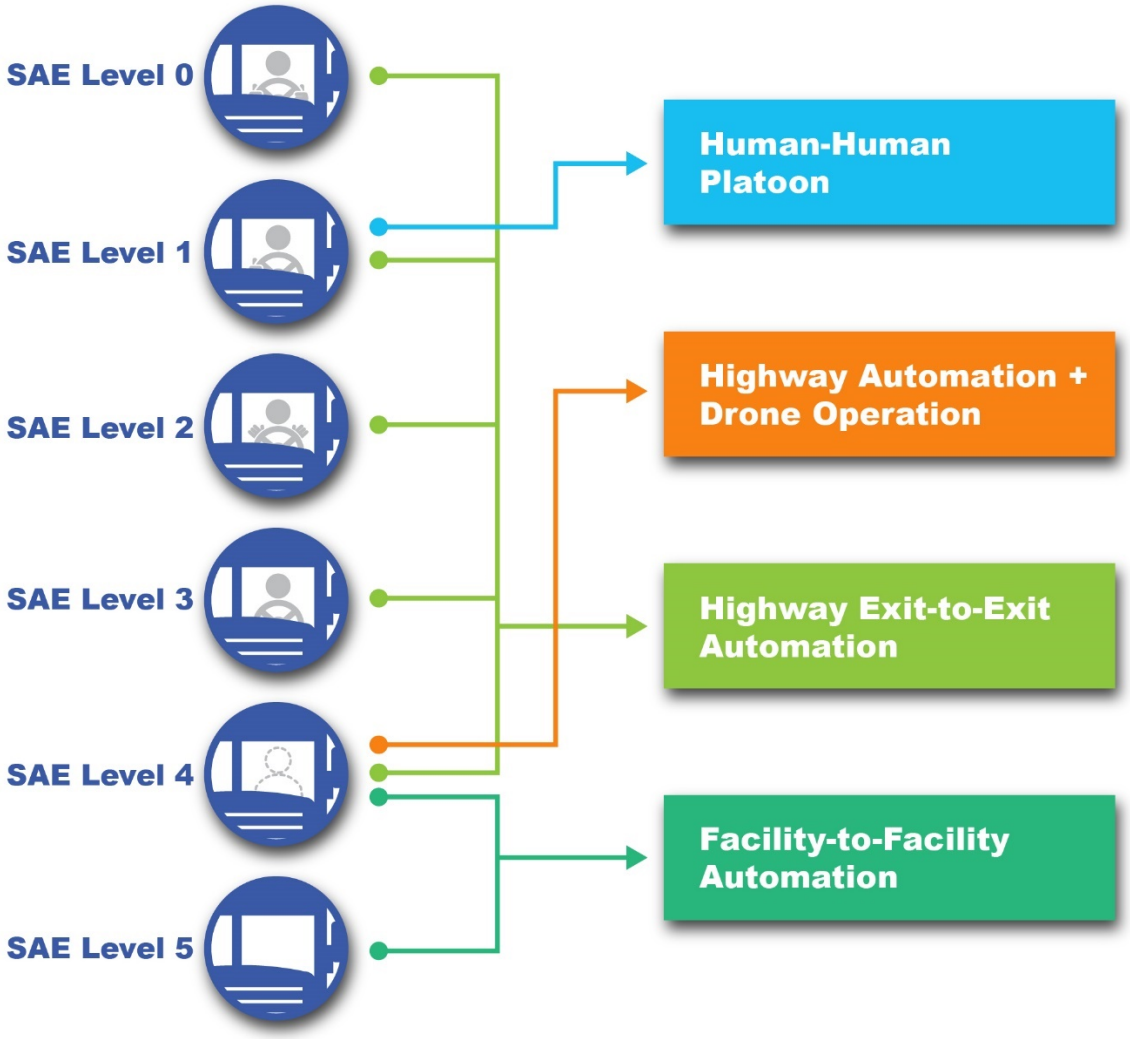
Source: http://laborcenter.berkeley.edu/pdf/2018/Driverless.pdf.

All of these potential use-scenarios, with the exception of the human-human platooning, would fall under SAE Level 4 CMV operating over specified routes and only under certain weather conditions, as defined by each company's ODD. Interviews with industry stakeholders confirmed companies are actively pursuing the following use-scenarios:

- Human-human platoon.
- Highway automation + drone (remote) operation.
- Highway exit-to-exit automation.
- Facility-to-facility automation.

Figure 7 shows how each of these use-scenarios fits within the SAE Level schema. Human-human platooning currently is in operation in the U.S. using SAE Level 1 CMVs. Highway automation and drone operation is in testing as an SAE Level 4 CMV, although control of a CMV by a remote teleoperator does not neatly fit in any of the existing SAE levels. Highway exit-to-exit automation includes an SAE Level 4 vehicle on the highway, but the portions of the trip off the highway could occur with SAE Levels 0 to 4 vehicles. Facility-to-facility automation could occur with either SAE Level 4 CMV (if using a predefined route) or SAE Level 5 CMV.

Figure 7. Interaction of SAE Level and Current/Anticipated Use-Scenarios



Each use-scenario presents different challenges for a potential roadside inspection. For example, under the highway automation + drone operation scenario, a remote operator may be able to operate the vehicle if it were stopped for an inspection in much the same way as an onboard driver would. However, under the facility-to-facility automation scenario, there would be no driver for an inspector to interact with which could make many portions of the current North American Standard (NAS) Level I inspection process difficult (or impossible) to conduct.

2.2 CVSA Inspection Levels

CVSA defines the components of an inspection by Level, ranging from a Level I to a Level VIII. These include the following:[6]

- **Level I—NAS Inspection.** This is a "full" inspection, which includes all physical elements of the vehicle (including hazardous material/dangerous goods, if applicable) and driver, including hours of service (HOS) and medical fitness.
- **Level II—Walk-Around Driver/Vehicle Inspection.** This inspection is similar to a Level I, except that it excludes examination of any vehicle elements that would require an inspector physically getting under the vehicle.
- **Level III—Driver/Credential/Administrative Inspection.** This inspection examines the status of the carrier (including vehicle inspection reports and carrier identification and status) and driver (including medical certificates, duty status, HOS compliance, and seat belt usage).
- **Level IV—Special Inspections.** This inspection typically is a one-time examination of a particular item made in support of a study, or to verify or refute a suspected trend.
- **Level V—Vehicle-Only Inspection.** This inspection includes all aspects of a Level I inspection related to the vehicle. The driver of the vehicle does not need to be present.
- **Level VI—NAS Inspection for Transuranic Waste and Highway Route Controlled Quantities of Radioactive Material.** This inspection is for select radiological shipments with special procedures and enhancements to the Level I Inspection.
- **Level VII—Jurisdictional-Mandated Commercial Vehicle Inspection.** This inspection is to meet a specific jurisdictional-mandated inspection that does not meet the requirements of any other level of inspection. Inspections of school buses, limousines, taxis, and other intrastate/intra-provincial vehicles would apply.
- **Level VIII—NAS Electronic Inspection.** This inspection is conducted electronically or wirelessly while the vehicle is in motion without direct interaction with an enforcement officer; confirms the driver's record of duty status, HOS compliance, and medical certificates; and the vehicle's identity, operating authority, registration, and Unified Carrier Registration (UCR) compliance; and checks for a Federal out-of-service (OOS) order.

2.3 Known Deployments of Automated Commercial Motor Vehicles

This section provides a high-level review of ADS-equipped CMV deployments in the United States and the rest of the world, including private organizations and public agencies, as of May 2019. Note that while this review strives to be as up-to-date and comprehensive as possible, due to the nature of this fast

[6] This report will refer to CVSA inspection levels as NAS Levels I to VIII.

paced, competitive, and evolving industry, information may have changed since publication; and some deployment information is not publicly available due to confidentiality concerns.

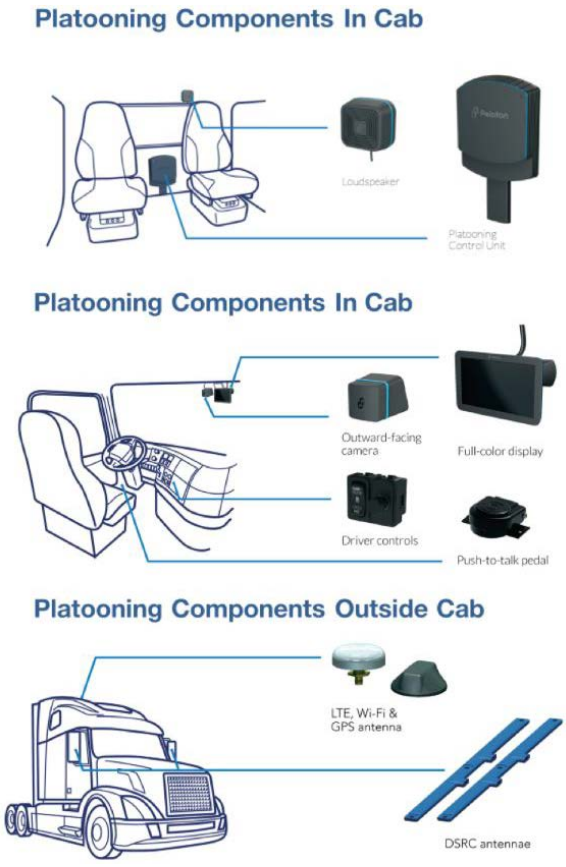
Information in the following sections is presented by geographic region (United States, then rest of the world) and by SAE automation Levels within each geography.

United States

Peloton Technology (Current SAE Level 1 with Goal of SAE Level 4)

On December 1, 2017 Peloton Technology demonstrated their driver-assistive truck platooning system. The demonstration occurred on I-96 in Michigan, near Novi and west of Lansing. Peloton's two-truck system provides a robust wireless communications link between the active safety systems of Class 8 trucks, enabling pairs of trucks to coordinate their speeds and maintain a safe, aerodynamic-following distance, typically between 40 and 80 feet. The Peloton system includes a Network Operations Center (NOC) that intelligently orders pairs of trucks and determines their optimal following distance. The system also limits platooning to appropriate multilane, divided, limited access highways, as well as specific weather and traffic conditions. Drivers are kept fully engaged with driving at all times (control of steering).[7] As of June 2019, 23 States have amended or clarified their traffic laws to allow commercial platooning on roadways.[8] Platooning components are shown in Figure 8.

Figure 8. Platooning Components in Cab



Source: https://peloton-tech.com/peloton-platooning-solution-headed-to-cooper-hewitt-smithsonian-design-museum/.

In July 2019, Peloton publicly announced that they would pursue the development of an SAE Level 4 system that would allow the following vehicle(s) in a platoon to operate without a driver:[9]

Daimler (SAE Level 2)

At the 2019 Consumer Electronics Show (CES), Daimler announced that its new Freightliner Cascadia will include SAE Level 2 autonomous features and will start production in July 2019. During CES 2019, a

[7] https://www.ccjdigital.com/peloton-shows-truck-platooning-in-michigan-commercial-release-set-for-2018/.

[8] https://peloton-tech.com/majority-of-us-freight-ton-miles-now-occur-in-platooning-approved-states/.

[9] https://www.fleetowner.com/autonomous-vehicles/peloton-outlines-plan-platoons-driverless-following-truck.

test vehicle was driven on a public road in Las Vegas to show how their Level 2 features operate in a real-life situation.[10]

Pronto AI (SAE Level 2)

In December 2018, The Guardian newspaper published an article outlining the Pronto.ai's (Pronto) autonomous car journey across the United States from San Francisco to New York City. The article notes that the technology being tested is not meant for cars however, "instead, it will form the basis of an advanced driver assistance system (ADAS) called Copilot, offering lane keeping, cruise control and collision avoidance for commercial semitrucks."[11] Pronto is focusing on delivering a "Copilot" technology suite that will provide emergency braking, continuous lane centering, and adaptive cruise control to assist CMV operators. Pronto's driving technology relies on video cameras pointing to the front, side, and rear of the vehicle to feed information into an onboard computer system. Pronto will begin selling the Copilot in the first half of 2019, initially as a $5,000 aftermarket installation for newer trucks."

Embark (Current Focus on SAE Level 2 with Goal of SAE Level 4)

In November 2017, Embark announced a partnership with Frigidaire and Ryder Systems to pilot SAE Level 2 ADS technology. The pilot focused on transporting Frigidaire refrigerators 650 miles through four States (Texas, New Mexico, Arizona, and California), using Embark automated tractors on the highway segments and Ryder tractors and drivers on surface streets. The pilot used a professional driver in the driver's seat actively monitoring the road and autonomous driving system. Operationally, the current scenario works as follows;

> "During the pilot, a Ryder Dedicated Transportation Solutions driver picks up a trailer filled with Frigidaire refrigerators at a yard in El Paso, TX, and drives it through the City to a transition point along I-10. At the transition point, the driver unhooks and connects the trailer to Embark's automated truck, which then hauls the cargo 650 miles along I-10 and hands it off to a Ryder driver at a transition point in Palm Springs, CA. The local Ryder driver in Palm Springs will then pick up the trailer to complete the final mile delivery to an Electrolux distribution center in Ontario, CA."[12]

In 2018, Embark completed a coast-to-coast trip from Los Angeles to Jacksonville, FL (2,400 miles) on I-10.[13]

Tesla (Current Focus on SAE Level 2 with Goal of SAE Level 4)

On November 16, 2017, Tesla announced their autonomous truck—Semi—which comes standard with what Tesla calls its Enhanced Autopilot, the second generation of Tesla's semiautonomous technology, equipped with automatic braking, lane keeping, and lane departure warnings. In April 2019, Tesla released videos of Tesla Semis delivering Tesla cars to customers and has shown prototypes to select

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10 https://mashable.com/article/daimler-semi-autonomous-truck-cascadia-ces-2019/.

11 https://www.theguardian.com/technology/2018/dec/18/controversial-engineer-i-traveled-over-3000-miles-in-a-self-driving-car.

12 https://www.businesswire.com/news/home/20171112005077/en/Embark-Frigidaire%C2%AE-Ryder-Partner-Pilot-Automated-Driving.

13 https://techcrunch.com/2018/02/06/embarks-self-driving-truck-drove-2400-miles-across-the-u-s/.

customers (UPS and Albertsons), but there has been no reported news about testing the Enhanced Autopilot features on the Tesla Semi as of this report's publishing date.

Ike Robotics (SAE Level 4)

The Ike Robotics team was formed after Uber's self-driving CMV project ended.[14] According to Wired, Ike's CTO Jur van den Berg says, "he envisions Ike's trucks pulling into roadside transfer hubs, where humans drivers will climb in and pilot the rigs to their final destinations." This model would mean SAE Level 4 automation on highways with human drivers handling the first- and last-mile trips. Ike Robotics currently is testing one vehicle in the San Francisco Bay Area and expects to start testing a second truck in California and beyond during 2019.

Kodiak (SAE Level 4)

Kodiak is a relatively new entrant in the ADS-equipped CMV field. Based in California, but operating out of a Dallas, Texas hub, Kodiak currently is operating an SAE Level 4 CMV with a safety driver onboard during commercial freight operations. The company had eight ADS-equipped CMVs in its fleet as of August 2019, with plans to grow quickly.[15]

Paccar (SAE Level 4)

Paccar is the parent company of Kenworth Truck Company, Peterbilt Motors Company, and international brand DAF Trucks. Peterbilt is working in collaboration with Embark, and Peterbilt will be manufacturing Embark's custom fleet at their Denton, Texas factory.[16] At the 2018 Consumer Electronic Show (CES), Peterbilt displayed their SAE Level 4 Autonomous truck built on a Peterbilt Model 579.[17] In January 2019, Paccar's CEO stated that "the truck maker also is investigating autonomous driving technologies, such as auto docking, which could automatically maneuver a tractor trailer into a loading dock. Beyond that, Armstrong said Paccar is developing trucks with driver-assist technology that would offer SAE Level 4 automated driving capabilities, in which the driver can completely disengage and let the system take control under certain conditions."[18]

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14 https://www.wired.com/story/ike-self-driving-truck-startup-nuro-software-deal/.

15 https://www.dcvelocity.com/articles/20190806-self-driving-truck-startup-runs-freight-routes-in-texas/.

16 https://www.paccarusedtrucks.com/content/tech-startup-embark-partners-peterbilt-change-trucking-industry-self-driving-trucks.

17 https://www.fleetowner.com/technology/autonomous-trucks-tusimple-peterbilt-attract-attention-ces-show.

18 https://www.ttnews.com/articles/paccar-ceo-outlines-path-toward-zero-emission-trucks-automated-driving.

Phantom Auto (SAE Level 4)

Founded in 2017, "Phantom Auto's teleoperation platform allows a remote driver, sometimes located thousands of miles away, to take control of an autonomous vehicle, if needed." The system is designed to act as a safety backup to take control of a vehicle during difficult scenarios. Within the CMV world, Phantom Auto is expanding remote operation to include "yard truck" tractors that move trailers around warehouses and shipping centers (see Figure 9. This deployment scenario does not yet envision operation on public highways."[19]

Figure 9. Phantom Auto Remote Driving

Source: https://techcrunch.com/2019/04/18/phantom-auto-raises-13-5m-to-expand-remote-driving-business-to-delivery-bots-and-forklifts//.

Starsky Robotics (SAE Level 4)

In 2018, Starsky Robotics tested an autonomous truck (with no driver in the vehicle) along a 7-mile journey in Florida. Starsky uses a teleoperation model, where a driver sits behind a screen in a call center-like office, reviewing in real-time the truck and the autonomous system performance. The company is testing and collecting data on Florida highways, and envisions one joystick-equipped driver manually guiding trucks through the trickier bits of operations through construction zones and the last few miles between an interstate and distribution center, while the computer handles the bulk of the simpler highway driving tasks. In its full build-out, one driver might be able to handle up to 30 trucks per 8-hour shift. "These would be remote drivers who get to go home at the end of the day," says founder Stefan Steltz-Axmacher.[20]

TuSimple (SAE Level 4)

TuSimple was founded in 2015 with headquarters in San Diego, California. TuSimple tests its robotic Peterbilt trucks in Tucson, equipped with laser lidar sensors, cameras, radar, computers, and software, where it is focused on perfecting long-range perception and the ability to drive in heavy rain. As of February 2019, TuSimple makes three to five revenue-generating trucking deliveries a day in Arizona (from depot-to-depot, which requires both highway and local street driving); and aims to have more than 50 trucks by June 2019 to expand its commercial routes to Texas. Each TuSimple truck has a systems engineer and a driver in them at all times when they are running, but are planning to deploy SAE Level 4 vehicles within the next few years.[21][22] In May 2019, it was announced that TuSimple was partnering with the U.S. Post Office on a pilot project "testing its first long-haul self-driving delivery truck in a two-week pilot program that will use an autonomous tractor-trailer to deliver mail between distribution centers in

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19 https://techcrunch.com/2019/04/18/phantom-auto-raises-13-5m-to-expand-remote-driving-business-to-delivery-bots-and-forklifts/.

20 https://www.wired.com/story/starsky-robotics-truck-self-driving-florida-test/.

21 https://www.businessinsider.com/autonomous-trucker-tusimple-announces-95-million-funding-2019-2.

22 https://www.autonomousvehicletech.com/articles/1463-autonomous-truck-company-expands.

Phoenix and Dallas." The vehicle will be provided by TuSimple and have a safety engineer and driver in the cab.[23]

Uber Advanced Technologies Group (SAE Level 4)

Otto/Budweiser

On October 20, 2016, Otto partnered with Anheuser-Busch to haul 51,744 cans of Budweiser 120 miles down I-25 from Fort Collins, Colorado through downtown Denver to Colorado Springs, Colorado, in Otto's self-driving truck system. The automated driving occurred only on the interstate segment of the trip; and during that segment, there was no driver in the driver's seat. During the interstate segment, the driver of the truck was monitoring the self-driving system from the sleeper berth in the rear of the truck.[24] In August of 2016, Otto was acquired by Uber and renamed Uber (Advanced Technologies Group). Otto worked on developing kits to retrofit commercial trucks to steer themselves on highways with radars, cameras, and laser sensors. Prior to this test in Colorado, Otto was testing its self-driving technology in trucks on highways in San Francisco.[25]

Uber ATG/Arizona

From November 2017 to March 2018, Uber contracted with commercial trucking companies to haul freight using its autonomous Volvo commercial trucks. During the hauls, a driver sat in the driver's seat to monitor the self-driving systems but did not drive. The hauls were only on interstate routes, not end-to-end runs, due to issues navigating urban environments.[26]

On July 30, 2018, Uber announced that Uber ATG will stop the development of self-driving trucks and focus on self-driving cars.[27]

Waymo (Google) (SAE Level 4)

In June 2017, Waymo began limited testing of their autonomous truck in California and Arizona.[28] On March 9, 2018, Waymo announced that its autonomous trucks would begin delivering freight for Google's data centers in Atlanta. Waymo's trucks use the same suite of custom-built sensors that power the company's self-driving minivans and the same self-driving software that has enabled Waymo's passenger cars to go fully driverless in Arizona.[29] In May 2019, Waymo announced that they will be conducting a

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23 https://www.cnbc.com/2019/05/20/post-office-to-test-autonomous-semi-trucks-for-hauling-mail-across-state-lines.html?__source=iosappshare%7Ccom.apple.UIKit.activity.Mail.

24 https://blog.ot.to/proudly-brewed-self-driven-95268c520ba4.

25 https://www.vox.com/2016/8/18/12540068/uber-paid-680-million-for-self-driving-truck-company-otto-for-the-tech-not-the-trucks.

26 https://www.usatoday.com/story/tech/2018/03/06/uber-trucks-start-shuttling-goods-arizona-no-drivers/397123002/.

27 https://techcrunch.com/2018/07/30/ubers-self-driving-trucks-division-is-dead-long-live-uber-self-driving-cars/.

28 https://www.theverge.com/2017/6/2/15728012/waymo-alphabet-test-self-driving-trucks.

29 https://www.theverge.com/2018/3/9/17100518/waymo-self-driving-truck-google-atlanta.

more advanced stage of their truck testing in Arizona, focusing on freeways around the metro Phoenix area. The test version of the trucks will have two safety drivers in them who can take control of them if needed.[30]

Rest of the World

ENSEMBLE (SAE Level 1)—Europe

The European Union-funded ENSEMBLE consortium will demonstrate truck platooning on European roads starting in 2018 with six different brands of trucks: Volvo Group, DAF, Daimler, Iveco, MAN, and Scania. The testing will confirm technological viability for vehicles across the different manufacturers and across national borders within the EU.[31] Daimler (Mercedes-Benz Trucks) has since announced that it will focus future research on developing an SAE Level 4 vehicle, although it will remain as part of the ENSEMBLE consortium.[32]

Paccar (DAF Trucks) (SAE Level 2)—United Kingdom

DAF Trucks is a division of Paccar. In August of 2017, it was announced that DAF Trucks will participate in a two-year truck platooning trial in the United Kingdom (UK), led by the UK's Transport Research Laboratory. The following truck in a platoon can automatically accelerate, brake, and steer using a wireless connection with the lead vehicle.[33] Together with its partners, TNO, Ricardo, and logistics company DHL, DAF Trucks has been selected by the UK Government's Department for Transport, in conjunction with Highways England, to gain experience with truck platooning on selected routes on England's strategic road network. The first platooning DAF test trucks are scheduled to begin trials in the UK in the spring of 2019.[34]

Daimler (SAE Level 4)—Japan

In January 2018, Daimler announced they would be "testing their vehicle-to-vehicle (V2V) communications technology in a joint operation with other manufacturers' trucks on public roads around greater Tokyo," after successful testing of truck platooning in Europe and the U.S. Truck platooning in Japan will be under the brand name Fuso. Initial test drives are taking place in January and February 2019 on two highways near Tokyo.[35]

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30 https://techcrunch.com/2019/05/29/waymo-is-bringing-its-self-driving-trucks-back-to-arizona/.

31 https://www.volvogroup.com/en-en/news/2018/feb/truck-platooning-on-european-roads.html.

32 https://www.commercialfleet.org/news/truck-news/2019/02/04/mercedes-switches-focus-away-from-platooning-trials.

33 https://www.daf.com/en/news-and-media/news-articles/global/2017/q3/30-08-2017-daf-trucks-participates-in-uk-truck-platooning-trial.

34 https://www.commercialfleet.org/news/truck-news/2019/02/04/mercedes-switches-focus-away-from-platooning-trials.

35 https://www.truckinginfo.com/278416/fuso-begins-truck-platooning-tests-in-japan.

Fabu Technology (SAE Level 4)—China

In March 2019, it was announced that, "China Post and Deppon Express, two of China's leading delivery and logistics companies, will begin autonomous package delivery services this April with the first self-driving vehicles to be put into daily commercial use in the country."

The delivery trucks will operate using ADS technologies developed by Fabu Technology, an artificial intelligence (AI) company focused on intelligent driving systems. The deployment follows evaluation testing that was completed in November 2018, which tested SAE Level 4 trucks in China's heavily populated Zhejiang Province. During the testing, the trucks averaged 40-mile daily round trips along three different routes, with one delivery route passing through 50 intersections, 26 of which were controlled by traffic lights. The trucks drove both in daylight and at night; during winter weather conditions; and on highways, through tunnels, and along residential streets.[36]

Volkswagen Truck and Bus (Scania/MAN) (SAE Level 4)—Germany and Singapore

Volkswagen owns/controls Scania and MAN Truck & Bus AG. In October 2017, Volkswagen stated that Level 5 trucks were already running on nonpublic roads and were being vigorously developed. They also noted that autonomous mining trucks from Scania currently are in use and available with no driver in the vehicle. For the first time in Germany, a driverless MAN truck is driving autonomously as a safety vehicle for mobile road maintenance works. Scania also is developing a platooning solution for Singapore, which comprises four vehicles transporting containers between different terminals at the Port of Singapore using public roads. Only the first truck in the platoon will have a driver, while the three trucks running behind this lead truck will be autonomous.[37]

2.4 Policy and Legislation in the United States

Legislation and policy addressing ADS in the United States is still in its infancy, especially at the national level. However, recent Federal spending legislation and a number of policy documents are beginning to provide more guidance.

This section provides a high-level review of Federal legislation and policy, focusing on topics specific to ADS-equipped CMVs whenever possible. The following section will examine available State-, provincial-, and municipal-level policy and training that provide guidance to enforcement personnel on how to interact with ADS.

36 https://www.truckinginfo.com/326433/china-post-to-begin-autonomous-truck-operations-in-april.

37 https://uploads.volkswagen-newsroom.com/system/production/uploaded_files/12257/file/0dc5ca2adc4696e2597a4da0e84e6223792d50c0/Tradepress_autonom.pdf?1530379397.

Recent Federal Legislation

Consolidated Appropriations Act, 2018

On March 23, 2018, President Trump signed into law the Consolidated Appropriations Act, 2018[38]. This legislation, among other things, directs the U.S. DOT to conduct research on the development of automated vehicles and provides necessary funding. The Joint Explanatory Statement (JES) accompanying the act states that the legislation reallocates $100 million in the Fixing America's Surface Transportation (FAST) Act "to remain available until expended for a Highly Automated Vehicle (HAV) research and development program to fund planning, direct research, and demonstration grants" for HAV technologies and Advanced Driver-Assistance Systems (ADAS).[39]

Pending Federal Legislation

Between 2017 and 2018, two bills were developed that would have provided specific recommendations and guidance for ADS. Neither bill became law, but both provide insight into congressional thinking on the topic.

AV START Act

The American Vision for Safer Transportation Through Advancement of Revolutionary Technologies Act[40] (S.1885) passed the Senate Commerce Committee but was not brought forward to a full Senate vote in 2018. The Bill would have:

1. Established a framework for a Federal role in ensuring the safety of HAVs.
2. Preempted States from adopting, maintaining, or enforcing any law, rule, or standard regulating an HAV or ADS regarding certain safety evaluation report subject areas.
3. Set forth conditions under which HAVs may be introduced into interstate commerce for testing, evaluation, or demonstration.
4. Applied certain safety exemptions to HAVs.

SELF DRIVE Act

The Safely Ensuring Lives Future Deployment and Research in Vehicle Evolution Act[41] passed by the U.S. House of Representatives on September 6, 2017, but a companion Bill was not passed by the Senate. The Bill would have the following:

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38 https://www.congress.gov/bill/115th-congress/house-bill/1625/text.

39 https://www.congress.gov/bill/115th-congress/house-bill/1625/text.

40 https://www.congress.gov/bill/115th-congress/senate-bill/1885.

41 https://www.congress.gov/bill/115th-congress/house-bill/3388.

1. Established the Federal role in ensuring the safety of highly automated vehicles by encouraging the testing and deployment of such vehicles.

2. Preempted States from enacting laws regarding the design, construction, or performance of HAVs or automated driving systems, unless such laws enact standards identical to Federal standards.

3. Instructed the U.S. DOT to require safety assessment certifications for the development of an HAV or an automated driving system.

4. Instructed manufacturers of HAVs to develop written cybersecurity and privacy plans for such vehicles prior to offering them for sale.

5. Applied certain safety exemptions and testing standards to HAVs.

6. Instructed U.S. DOT to:

    a. Inform prospective buyers of HAVs of the capabilities and limitations of such vehicles.

    b. Establish the HAV Advisory Council to, among other things, develop guidance regarding mobility access for the disabled, elderly, and underserved populations.

    c. Require all new passenger motor vehicles less than 10,000 pounds to be equipped with a rear seat occupant alert system.

    d. Research updated safety standards for motor vehicle headlamps.

Policy and Guidance Documents

U.S. DOT

Numerous agencies under the umbrella of the U.S. DOT have developed guidance or policy documents can inform how law enforcement interacts with ADS-equipped CMVs. In March 2019, Secretary Chao laid out six preliminary principles that will guide the agency's approach to policy development. These include the following:

1. "DOT's commitment to safety directs every action and decision.

2. Be flexible, technology neutral, and let the market determine effective solutions.

3. When regulations are needed, make them as nonprescriptive and performance based as possible. In all regulatory actions and policy decisions going forward, do not assume that a vehicle's driver is a human.

4. Work with States and other authorities to avoid a regulatory and legal patchwork that could inhibit innovation and make it difficult for autonomous vehicles (AV) to cross State lines.

5. Provide stakeholders with guidance, best practices, pilot programs, and other assistance to facilitate the safe integration of AVs into our transportation system—and prepare for complementary

technologies that enhance the benefits of AVs, such as V2V and vehicle-to-infrastructure (V2I) communications.

6. Recognize that AVs will need to operate side-by-side with traditional vehicles, in both rural and urban areas. Do not assume universal implementation."[42]

Brief summaries of the key documents are discussed below.

Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0)

In October of 2019, U.S. DOT released their Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0),[43] which builds upon their Automated Driving Systems 2.0: A Vision for Safety (ADS 2.0). U.S. DOT views AV 3.0 as the starting point for a national discussion around the future of the on-road surface transportation system. AV 3.0 is structured around three key areas:

1. Advancing multimodal safety.
2. Reducing policy uncertainty.
3. Outlining a process for working with U.S. DOT.

For commercial vehicles, the Policy specifically states that AV 3.0:

- Informs stakeholders of the FMCSA's intent to initiate an Advance Notice of Proposed Rulemaking to better understand areas of responsibility between the State and Federal Governments in the context of ADS-equipped commercial motor vehicles and commercial carriers.
- States that FMCSA also will consider changes to its motor carrier safety regulations to accommodate the integration of ADS-equipped commercial motor vehicles.
- Recognizes the term "driver" and "operator" do not refer exclusively to a human but may include an automated system. In addition, for vehicles that do not require a human operator, human-specific FMCSRs, such as drug testing, HOS, commercial driver's licenses, and physical qualification requirements do not apply.

Under the section titled, Operating ADS-Equipped CMVs under Existing Regulations, AV 3.0 states that:

- FMCSA retains its authority to take enforcement action if an automated system inhibits safe operation. It will do this by asking if the ADS-equipped CMV complies with the requirements for parts and accessories for which there are no FMVSS. FMCSA will then consider whether the motor carrier has complied with the operational requirements of the current FMCSRs, but if the motor carrier

[42] https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/317351/usdot-comprehensive-management-plan-automated-vehicle-initiatives.pdf.

[43] https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf.

cannot fully comply with the FMCSRs through use of its ADS-equipped CMV, then the carrier may seek an exemption.

- If FMCSA determines that State or local legal requirements may interfere with the application of FMCSRs, the Department has preemptive authority. FMCSA also has authority, in coordination with the States, to set the Federal qualifications required for CDLs. FMCSA will consider whether there is a reasonable basis to adapt its CDL regulations for an environment in which the qualified commercial driver may be an ADS.

- In adapting its regulations to accommodate automated vehicle technologies, FMCSA will seek to make targeted rule changes and interpretations and will supplement its rules as needed to account for significant differences between human operators and computer operators.

- U.S. DOT is working with the Department of Labor to assess the impact of ADS on the workforce, including the ability of ADS to mitigate the current driver shortage in the motor carrier industry.

Under the section titled, Considerations for State Commercial Vehicle Enforcement Agencies, AV 3.0 recommends that State agencies responsible for enforcing commercial vehicle operating rules and regulations consider the following:

- Ensure that intrastate and interstate commercial motor vehicles regulations remain compatible. As regulatory guidance is developed by FMCSA for interstate vehicles, intrastate motor carrier safety regulations may need to be amended. This is an important consideration for States seeking grant funding under the Motor Carrier Safety Assistance Program (MCSAP).

- Continue existing inspection selection procedures. States should continue utilizing their existing selection process and refrain from selecting ADS-equipped CMVs for inspection solely because of the technology. States also should partner with FMCSA as it develops inspection procedures and criteria specific to ADS-equipped CMVs.

Commercial Vehicle Safety Alliance Comments on Preparing for the Future of Transportation: Automated Vehicles 3.0

In November 2018, CVSA released their comments on the U.S. DOT's Preparing for the Future of Transportation: Automated Vehicles (3.0), and noted that they were pleased to see that commercial vehicles were incorporated in AV 3.0's guiding principles, and that there was consideration given to the enforcement challenges of AVs.[44] Overall, CVSA strongly supports policies that encourage development of ADS-related technology that can prevent or mitigate the severity of crashes.

CVSA provided specific areas that U.S. DOT should consider when developing policy, including the following:

- Roadside Inspections.

- Driver/Operator Participation in the Inspection Process.

[44] https://Cvsa.informz.net/CVSA/data/images/Leg%20Reg%20Files/CVSA%20Comments%20to%20AV%203.0%20With%20Attachments.pdf.

- Connectivity Barriers.
- Inclement Weather.
- Vehicle Breakdown.
- Out-of-Service Condition.

The second question is particularly important to this Working Group's mission. CVSA noted that a number of inspection steps within the existing NAS Level 1 inspection (NAS Level 1) require a driver to perform some task (operate turn signals, press the brake, etc.). Understanding how (and if) these steps will be completed in an ADS environment is the initial goal of this Working Group.

CVSA also noted that "requiring all commercial motor vehicles to be equipped with technology that allows them to be identified electronically by enforcement would revolutionize the way commercial motor vehicle roadside monitoring, inspection, and enforcement are conducted…" Allowing electronic inspections of moving vehicles would massively grow the number of inspected vehicles, while reducing costs and improving safety. However, more work needs to be done to understand what information can be checked and broadcast electronically.

AV Research Roadmap (AVS Strategic Plan)—FMCSA

FMCSA is developing a roadmap/plan that outlines research priorities for automated vehicles. This document is still in draft format, but a presentation by Jeff Loftus of FMCSA at the 2019 Transportation Research Board (TRB) meeting[45] outlined highlights of the plan. The presentation noted a number of primary AV research areas for FMCSA, including one specific to this Working Group (in *italics*):

- **Providing voluntary Best Practices to States and Industry Automated Vehicle (AV) Implementers.**
  - Support Regulatory Updates:
    - Complete research to support updated Federal Motor Carrier Safety Regulations, ensuring flexibility for entities working to test and deploy truck platoons and automated CMVs.
  - Support Pilot Tests, Safe Deployments:
    - Aid in development, execution, and oversight of pilot programs/tests.
    - Help States develop consistent platooning and automated CMV regulations and standards for technology deployments.

45 https://cms.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/safety/research-and-analysis/technology/445436/jeff-loftus-fmcsa-av-research-program-art-sessions-january-2019.pdf.

- Support Safe Enforcement of Automated CMVs, Platoons:
  - *Develop new inspection procedures, tools for enforcement.*
  - Provide basis for updated inspection standards, out-of-service criteria.

- **Researching CMV Driver Factors and Vehicle Safety Components.**
  - Platooning and Automated CMV Test Track Evaluations:
    - Conduct truck platooning and ADS-equipped CMV safety, human factors, and cybersecurity testing on a closed test track.
  - Evaluate In-Service Truck Platoons:
    - Measure the safety and operational impacts of truck platooning on truck drivers, surrounding traffic, and infrastructure on select public roadways.

- **Developing Cybersecurity Guidance for CMVs.**
  - Develop Recommended Best Practices, Guidelines for Aftermarket Electronic Systems:
    - Develop a set of best practices and guidelines focused on minimizing cyber risks for aftermarket electronic systems intended for use in the CMV industry.
    - Develop a set of cybersecurity best practices and guidelines for original equipment manufacturers (OEM), telematics providers.

- **Establishing Data Elements and Data Sharing Guidance to Support Testing.**
  - Determine data parameters that should be included in future automated CMV naturalistic driving studies and pilot tests.
  - Establish data exchange standards for secure data sharing to support relevant third-party research, evaluation, and application development.

- **Engaging and Communicating with State and Industry Stakeholders.**
  - Accelerate Industry Adoption of Advanced Driver Assistance Systems (ADAS), ADS;
    - Partner with industry associations, original equipment manufacturers to accelerate the adoption of proven ADAS and ADS technologies on CMVs.
    - Encourage Open Communication and Collaboration with Stakeholders.
    - Host public listening sessions, organize and attend conferences and working groups, solicit comments, and conduct webinars and briefings.

- Publish information on the FMCSA website about ongoing and completed research activities and related findings.
- Partner with States and industry to support truck platoon and highly automated CMV demonstrations and field operational tests.

Commercial Vehicle Safety Alliance Comments to FMCSA

In May 2018, CVSA provided comments on "FMCSRs Which May Be a Barrier to the Safe Testing and Development of Automated Driving System-Equipped Commercial Motor Vehicles on Public Roads" (Docket Number FMCSA-2018-0037), which is related to implementation of ADS in CMVs.

CVSA noted that their comments focused on SAE Levels 3 to 5, and identified a major challenge in providing comments on this topic because there are few Federal rules that a technology or vehicle manufacturing company must follow to establish whether their ADS is a Levels 1 to 2 technology or a Levels 3 to 5 technology. CVSA then noted that their comments assume providers of ADS are achieving their claimed automation level. In their comments, CVSA:

- Urged FMCSA and NHTSA to not remove or relax necessary safety regulations to enable testing unproven automated driving systems on public roads.
- Encouraged FMCSA to work with NHTSA and establish requirements for commercial motor vehicles to communicate upon request information essential to enforcing traffic laws and conducting inspections, at least including the following:
  - Electronic vehicle identification.
  - Time stamp.
  - Automation operational status (verifiable level of automation and whether a human operator is in the vehicle, operating or monitoring it remotely, or if it is in a fully autonomous mode).

This final point is critical to enforcement officers during inspection, since identifying the level of vehicle autonomy (or potentially the exact operating scenario) will help determine how the inspection will occur and what ADS systems may need to be examined.

CVSA also provided specific questions and comments for FMCSA to consider and respond to. Specific to roadside enforcement, CVSA asked, "How could an enforcement official identify CMVs capable of various levels of automated operation? For example, should CMVs with ADS be visibly marked to indicate the level of automated operation they are designed to achieve, or would making these vehicles so easily identifiable cause other road users to interact unfavorably with CMVs with ADS?"

The document also includes a number of questions for consideration across other topic areas, including distracted driving, HOS, and commercial driver's license endorsements. These topics are outside the scope of this Working Group but are important to consider in the overall context of ADS-equipped CMVs.

Safe Integration of Automated Driving Systems-Equipped Commercial Motor Vehicles—FMCSA Advance Notice of Proposed Rulemaking

In May 2019, FMCSA, in partnership with NHTSA, released an advance notice of proposed rulemaking (ANPRM) to obtain comments on identifying and addressing regulatory barriers to deployment of ADS vehicles and better understand how changes to Federal rules can account for differences between human-operated and computer-operated CMV.[46]

Of direct relevance to this study, the ANPRM includes a number of questions around roadside inspections, including:

- Should (and how) could a vehicle indicate that they are operating in an SAE Level 4 or Level 5 mode?
- How would roadside enforcement know that a vehicle can no longer operate safely?
- What qualifications should be required for people performing pretrip inspections of ADS-equipped CMVs?
- How, when, and by whom should mechanical systems not related to ADS (such as load securement) be verified as operating correctly? How does enforcement confirm that information?

Review of Federal Motor Carrier Safety Regulations (FMCSR) for Automated Commercial Vehicles—Volpe National Transportation Systems Center (Volpe)

In March 2018, Volpe released their Review of FMCSR for Automated Commercial Vehicles,[47] which was a preliminary assessment of interpretation and enforcement challenges, questions, and gaps for commercial vehicles equipped with ADS.[48] CMVs must operate under the purview of FMCSR, propagated at the Federal level by FMCSA. FMCSRs apply to vehicle equipment, driver training and licensing, and vehicle operations.[49] However, FMCSRs were drafted before the invention of ADS and assume a human driver is solely responsible for operation of the CMV. Volpe's research focused on identifying the following challenges:

- How ADS-equipped CMVs will operate under existing FMCSRs.
- How States will enforce existing FMCSRs.
- How existing requirements should be interpreted in the context of automated CMVs.

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46 Docket No. FMCSA-2018-0037. Online at: https://www.federalregister.gov/documents/2019/05/28/2019-11038/safe-integration-of-automated-driving-systems-equipped-commercial-motor-vehicles.

47 https://rosap.ntl.bts.gov/view/dot/35426.

48 https://rosap.ntl.bts.gov/view/dot/35426.

49 Passenger vehicles are subject to Federal regulations for motor vehicle equipment only. Driver training and licensing and operations are regulated at the state level.

The Review developed Automated Commercial Vehicle Concepts that relate to the SAE levels, and identified existing regulatory issues for each of the concepts. The report goes into detail describing each of the issues identified for each of the concepts. An overview of the issues is shown in Figure 10.

Figure 10. Volpe Review of FMCSR—General Issues Identified

Concept Group	Automated CMV Concepts – SAE Level
Automated CMVs with active driver involvement	A. Partially Automated CMV – 2/3 B. Conventional CMV, Limited Use Full Automation – 4 (limited use) C. Highly Automated CMV – 4
Automated CMVs with onboard technicians	D. Highly Automated CMV with Licensed Onboard Technician – 4/5 E. Highly Automated CMV with Onboard Technician – 4/5
Automated CMVs with remote supervision	F. Highly Automated CMV with Licensed Remote Supervisor – 5 G. Highly Automated CMV with Minimal Direct Supervision – 5

General Issues Identified	A	B	C	D	E	F	G
Requirement for driver to be secured by seatbelt at driver's seat	Y*	Y	Y	Y	Y	Y	Y
General requirements regarding unsafe driving and operation and installation of additional equipment that may decrease safety	Y	Y	Y	Y	Y	Y	Y
Skills, knowledge, and licensing of drivers	N†	N	N	D‡	D	D	D
Clarification of "safety-sensitive function"	N	N	D	D	D	D	D
Hours of service requirements	N	Y	N	D	D	D	D
Alcohol and controlled substance restrictions	N	Y	N	N	N	D	D
Physical qualifications for drivers	N	N	N	D	D	D	D
Inspection and cargo securement procedures	N	N	N	N	N	Y	Y
Definition of "disabling damage"	N	N	N	N	N	Y	Y

*Y: potential challenge present

†N: challenge not present

‡D: extent of challenge depends on interpretation of definition(s) and/or applicability statement(s)

Source: https://rosap.ntl.bts.gov/view/dot/35426.

After reviewing relevant FMCSRs in detail, the Volpe report provided an overview of gaps in current regulations. These gaps include the following:

- **Driver Requirement**
  - Volpe found that the driver requirement language in existing FMCSRs can be interpreted to mean that they do not explicitly require a human driver. However, they note that "other requirements for activities that must be performed in the course of operating a CMV (e.g., periodically inspecting the load and equipment) may implicitly require a human driver to be present on a commercial vehicle while it is underway."

- **Safe Driving Qualifications for an Automated Driving System**
  - Volpe found that "FMCSRs contain no specific requirements for the safe performance of an automated driving system," and "establishment of any safe driving performance requirements would likely need to be coordinated with NHTSA."
- **Ensuring the Safe Performance of Physical Systems on AVs**
  - Volpe found that automated driving systems may require the ability to identify degraded vehicle performance (such as brakes and tires) to ensure the vehicle remains within an acceptable performance window.
- **Inspections of AV Equipment**
  - Volpe found that for automated commercial vehicles "identifying damage or malfunctions during roadside inspections could be critical to ensuring their safe operation," and notes that NHTSA's Automated Vehicle Performance Guidance specifies that "HAVs operating on the road should be capable of detecting that their HAV systems have malfunctioned, are operating in a degraded state, or are operating outside of their ODD; and of informing the human driver in a way that enables the driver to regain proper control of the vehicle, or allows the HAV system to return to a minimal risk condition independently."
- **Qualifications for New or Shifting Roles in CMV Operations**
  - Volpe found that FMCSA may need to develop separate qualifications for new roles, such as onboard technicians and remote supervisor, and introduce additional qualifications for licensed drivers who plan to operate a vehicle equipped with automation.
- **Vehicles Subject to FMCSRs**
  - Volpe found that "automation may enable new types of vehicles to serve operational needs currently met by CMVs that fall under the purview of the FMCSRs. These dynamics could potentially push some freight and passenger movement beyond the authority of FMCSA."

Pipeline and Hazardous Materials Safety Administration (PHMSA)

The Pipeline and Hazardous Materials Safety Administration (PHMSA) develops and enforces regulations for the safe, reliable, and environmentally sound transportation of hazardous material, including goods moved by CMV. In this capacity, PHMSA has some oversight authority over CMV policy and operations. Part of PHMSA's regulatory process is a large self-certification system for classification, containment, and commercial transportation of hazardous materials. In addition to PHMSA's self-certification process, it also operates a premarket approval process in which PHMSA (or contract experts from outside the agency) reviews and approves certain types of transportation of hazardous materials. In addition, to address innovative ideas and technological advances, PHMSA's approval program provides authorizations on a case-by-case basis through an application process.

As of February 2019, PHMSA has not released any policies that specifically mention autonomous or connected vehicles. However, PHMSA did release a Request for Information on *Regulatory Challenges to*

Safely Transporting Hazardous Materials by Surface Modes in an Automated Vehicle Environment in March 2019.

Commercial Vehicle Safety Alliance Comments to PHMSA

In November 2018, the Commercial Vehicle Safety Alliance sent comments to PHMSA on Regulatory Challenges to Safely Transporting Hazardous Materials by Surface Modes in an Automated Vehicle Environment (Docket Number PHMSA-2018-0001).[50]

CVSA raised questions around specific areas for further examination by PHMSA. Most of the comments for PHMSA are similar to those raised in CVSA's response to U.S. DOT's AV 3.0 document. Questions directly related to the goal of this Working Group include the following:

- **Roadside Inspections.** How will an ADS commercial motor vehicle respond to law enforcement and pull over to a designated area for inspection? If a roadside inspection is not possible, how will ADS commercial motor follow law enforcement to a safe location?

- **Participation in the Inspection Process.** If an ADS commercial motor vehicle does not have a driver, how will these inspection components that require driver interaction (operating the turning wheel for instance) be carried out?

- **Authorized Inspectors and Emergency Responders.** Given the security concerns associated with the transportation of hazardous materials, how will an ADS commercial motor vehicle identify if a person attempting to interact with it is authorized or not?

- **Shipping Papers and Emergency Response Information.** Since shipping papers and emergency response information play a critical role in inspections of commercial motor vehicles carrying hazardous materials, how will required documentation be presented to an inspector if there is not a driver in an ADS commercial motor vehicle?

Federal Automated Vehicles Policy—NHTSA

In September 2016, NHTSA developed their Federal Automated Vehicles Policy,[51] rather than rulemaking, "in order to speed the delivery of an initial regulatory framework and best practices to guide manufacturers and other entities in the safe design, development, testing, and deployment of HAVs." This policy does not specifically mention commercial vehicles or inspection issues, but the policy does apply to commercial vehicles. The Policy states that the "guidance should be considered by all individuals and companies manufacturing, designing, testing, and/or planning to sell automated vehicle systems in the United States." The policy outlines four sections for how to develop and deploy HAVs:

1. Vehicle Performance Guidance for Automated Vehicles.

2. Modal State Policy.

[50] https://Cvsa.informz.net/CVSA/data/images/Leg%20Reg%20Files/CVSA%20Comments%20on%20PHMSA%20ADS%20RFI.pdf.

[51] https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/av_policy_guidance_pdf.pdf.

3. NHTSA's Current Regulatory Tools.

4. New Tools and Authorities.

Of specific note to law enforcement agencies, under "Section 2, Model State Policy, Chapter C," there is Section 7, Law Enforcement Considerations. This section highlights the impact HAVs will have on their duties, including potential new training and education that will be required to understand how to interact with the drivers/operators of HAVs in both the testing and development stages. It goes on to state that for vehicles that are not fully automated, there is a risk of dangerous activities, such as distracted driving; and recommends that there should be consistent regulations and methodologies across jurisdictions (States, counties, cities) that limit and discourage these dangerous activities. The Policy also recommends that regulations and methodologies will need to continue to be revised to respond to the changing technology. Finally, it notes that HAVs will be involved in crashes, especially during the testing phases, and that first responders will need to have specialized training for interaction with HAVs.

American Association of Motor Vehicle Administrators (AAMVA)

In May 2018, AAMVA published their Jurisdictional Guidelines for Safe Testing and Deployment of Highly Autonomous Vehicles,[52] which provided voluntary recommended guidelines for motor vehicle administration and law enforcement for the safe testing and deployment of automated driving systems. The recommendations of the report apply to Levels 3, 4, and 5 noncommercial motor vehicles and determined that commercial motor vehicles, as defined by the Federal Motor Carrier Safety Regulations (FMCSR) (390.5), were out of scope for this report. However, the report does offer information applicable to commercial vehicles, such as the following:

- Application and Permit for Manufacturers or Other Entities to Test Vehicles on Public Roadways.
- Federal Motor Vehicle Safety Standards (FMVSS) and Canadian Motor Vehicle Safety Standards (CMVSS).
- Establishing Operational Responsibility and Law Enforcement Implications.
- First Responder Safety.
- Law Enforcement and First Responder Training.
- Vehicle Response to Emergency Vehicles, Manual Traffic Controls, and Atypical Road Conditions.
- Identification of a Motor Vehicle as a HAV.

The final bullet in particular has resonance for enforcement of CMVs. As the vehicle's level of autonomy changes, the potential systems to be inspected and the inspection process itself are likely to change. AAAMVA notes that SAE, the International Organization for Standardization (ISO), and NHTSA have all developed guidelines or proposed rules for labeling of alternative fuel vehicles and may provide guidance for a similar approach to automated vehicles.

[52] https://www.aamva.org/GuidelinesTestingDeploymentHAVs-May2018/.

State-Level Policy and Legislation

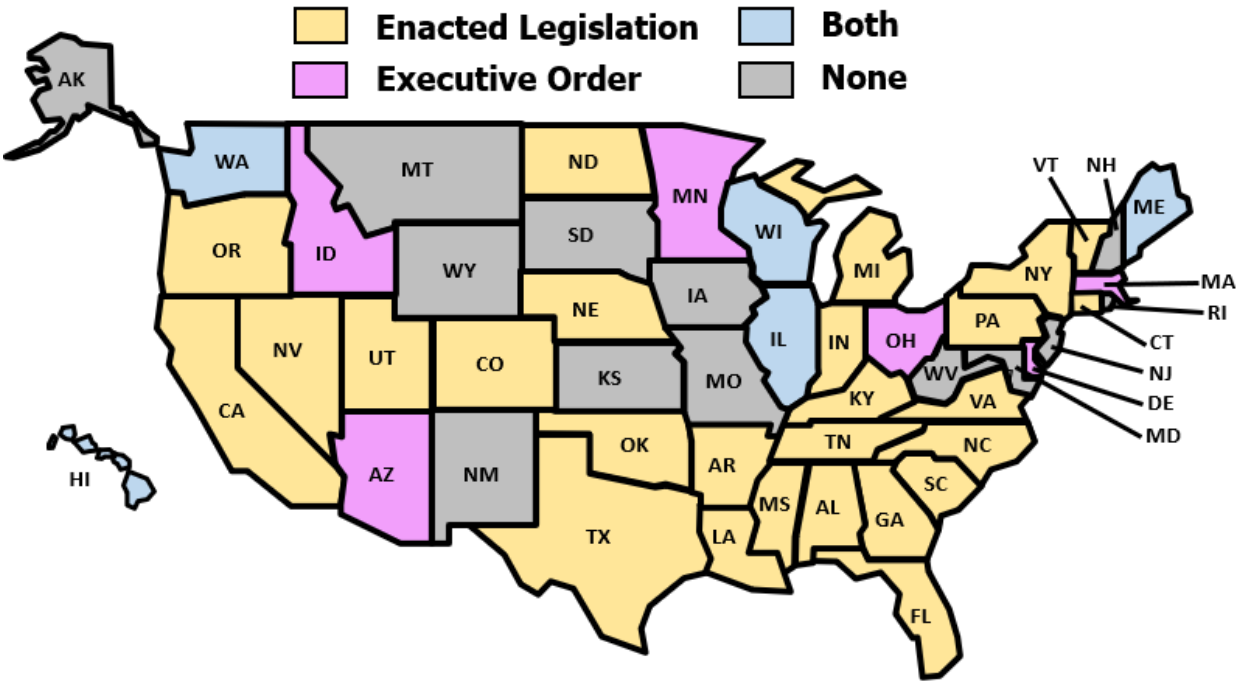
This section briefly reviews U.S. State policy and legislation relevant to all autonomous vehicles, and then looks at autonomous CMV policy and legislation in more detail.[53] Documents from other CVSA members (Canada and Mexico) are discussed in Section 2.6.

All Automated Vehicles

The laws that govern self-driving/autonomous vehicles (AV) can be complex. Like the entire industry, these regulations can change rapidly, and there are few Federal guidelines. States and localities control a large portion of the policy framework. Responsibilities cross jurisdictional agencies with authority for driver licensing, registration, permitting, road types (public), enforcement activity, and more.

In the past decade, States have begun to more clearly define requirements and regulations, aimed at facilitating the safe testing of AVs on public roads through the use of both executive orders and legislative action. Figure 11 shows the extent of this activity as of June 2019.

Figure 11. States With Automated Vehicle Executive Order or Legislation



Source: National Conference of State Legislatures, Eno Center for Transportation.

The level of testing or deployment allowed in each State varies; and many States have additional permitting, cost, routing, and reporting requirements. About seven States currently allow testing on public roads without the presence of a safety driver: Arizona, California, Florida, Georgia, Michigan,

[53] Except where noted, data for this section is based on a scan of the National Conference of State Legislatures' Autonomous Vehicles State Bill Tracking Database. See: http://www.ncsl.org/research/transportation/autonomous-vehicles-legislative-database.aspx.

North Carolina, and Ohio. Louisiana will allow vehicles to transport property or passengers without a driver present starting in August 2019, if the vehicle can follow State vehicle and traffic laws, meet Federal vehicle safety standards, and obtain "a minimal risk condition if an (operational) failure occurs."[54] The remaining States that have passed legislation or executive orders allow testing with a safety driver present.

Commercial Motor Vehicles

State-level policy and legislation focused specifically at CMVs is relatively new. In general, CMV policy is covered under the existing State regulations governing AV in the United States. While there is notable activity and movement toward advancement, States are careful in considering legislation that properly addresses safety and operational purpose, while not creating undue restrictions or burdens to enforcement personnel, judicial process, vehicle operators, or private-sector partners.

The most common type of legislation specific to CMVs are rules governing following-distances. Changes to this rule exempt or narrow the following distance for CMVs behind the lead vehicle in a platoon. Figure 12 below shows 20 States as of June 2019 that allow for trucking platooning on public roads. Three additional States allow testing with legislation pending in two additional States.

Figure 12. States which Allow Truck Platooning

Source: Minnesota Governor's Advisory Council. http://www.dot.state.mn.us/automated/docs/Governor's%20Advisory%20Council%20Connected%20and%20Automated%20Vehicles%20Executive%20R....pdf,

54 https://www.mcall.com/sns-bc-la—self-driving-trucks-louisiana-20190706-story.html.

As mentioned above, in addition to the seven States, which already allow testing without a safety driver, Louisiana will specifically allow testing and deployment of ADS-equipped CMVs starting in August 2019. During the April 2019 CVSA meeting in St. Louis, participants were asked to provide any knowledge or guidance in their jurisdiction/region pertaining to law enforcement policies, or training on interactions with ADS-equipped CMV. Members were also asked to provide any lessons learned in the areas of roadway safety procedures and validation of vehicle system performance gained during interactions with ADS-equipped CMVs. Key lessons learned include:

- Permit conditions are being used to dictate the testing requirements for each test.
- Determining if the testing is being done on public highways or private locations has required a legal opinion for each request.
- Policies are not yet in place to guide decision-making for license plates and registration requirements.
- Reporting of disengagements (ADS asking human driver to takeover) are seen to be negative in nature when in fact they should be an expected part of testing.

Additionally:

- Virginia noted that a study is in progress to determine how to inspect passenger carriers (buses) with ADS.
- Region V jurisdiction in Saskatchewan and Yukon confirmed new testing of autonomous farm equipment.
- Jurisdictions in Manitoba and Quebec mentioned that they have tested autonomous vehicles.

Jurisdictions also noted that guidelines or training material related to ADS-equipped CMV inspections does not yet exist. An online search for additional enacted or adopted legislation regarding inspection of ADS-equipped CMVs also was conducted for U.S. jurisdictions spanning 2018 and 2019 (through May) with no results discovered for vehicle inspection requirements.

2.5 Private-Sector-Developed Guidelines

Private-sector industry partners are critical in the development of commercial motor vehicle technologies, which seek to improve safety, operating efficiency, and streamline productivity. Working in concert with Federal agencies, private-sector partners are able to develop and test technologies in testbed areas and share results with agencies, other industry partners, and the public.

Some private-sector industry leaders are involved in testing technologies, which showcase safety and efficiencies in real-world conditions. This framework also creates an environment for industry to complete these optional Vehicle Safety Self Assessments (VSSA). As of June 2019, the following 12 industry partners have completed these assessments:

1. Apple
2. AutoX
3. Ford
4. GM
5. Mercedes-Benz/Bosch
6. Navya
7. Nuro
8. Nvidia
9. Starsky Robotics
10. Uber
11. Waymo
12. Zoox

The VSSAs include information on:

- System Safety.
- Operational Design Domain.
- Object and Event Detection and Responses.
- Fallback (Minimal Risk Condition).
- Validation Methods.
- Human Machine Interface.
- Vehicle Cybersecurity.
- Crashworthiness.
- Post-crash ADS Behavior.
- Data Recording.
- Consumer Education and Training.
- Federal, State, and Local Laws.

Similarly, a coalition of 11 companies published a document titled, "Safety First for Automated Driving," in July 2019.[55] This document is intended to provide an overview of and guidance on the steps necessary for developing and validating safe automated driving systems, with a focus on SAE Levels 3 and 4 vehicles. While not specific to CMV or inspection procedures, this document shows the industry perspective on the development of automated vehicles. The following are 12 principles of automated driving:

1. **Safe Operation.** If safety-related functions or system components become hazardous, the ADS will be capable of compensating and transferring the system to a safe condition (with acceptable risk), and ensure a sufficient timeframe for safe transition of control to the vehicle operator.
2. **Operational Design Domain**. If the vehicle recognizes it is beyond its ODD, the system shall react to compensate or issue a driver takeover request.

Safety First for Automated Driving Participants include:

- Aptiv
- Audi
- Baidu
- BMW
- Continental
- Daimler
- Fiat Chrysler Automobiles
- Here
- Infineon
- Intel
- Volkswagen

[55] https://newsroom.intel.com/wp-content/uploads/sites/11/2019/07/Intel-Safety-First-for-Automated-Driving.pdf.

3. **Vehicle Operator-Initiated Handover**. Engaging and disengaging the ADS shall require explicit interaction from the vehicle operator, indicating a high confidence of intent.

4. **Security**. Steps should be taken to protect the ADS from security threats.

5. **User Responsibility**. The user's state of alertness must be suitable for a responsible takeover of the vehicle, and the vehicle must recognize the user's state and keep them informed about their responsibilities.

6. **Vehicle-Initiated Handover.** Vehicle must be able to attain a minimal risk condition if the vehicle operator does not comply with a takeover request. Vehicle-initiated handovers must be clearly understandable and manageable for the vehicle operator.

7. **Interdependency Between the Vehicle Operator and the ADS.** Evaluation of system safety must take account of effects on the driver due to automation.

8. **Safety Assessment.** Verify and validate data to ensure safety goals are met and reach a consistent improvement of overall safety.

9. **Data Recording.** Vehicle shall record relevant data pertaining to status of ADS when an event or incident is recognized while complying with applicable data privacy laws.

10. **Passive Safety.** Vehicle layout should accommodate crash modification to crash scenarios resulting from vehicle automation.

11. **Behavior in Traffic.** Behavior of the vehicle must be easy to understand for surrounding road users and predictable.

12. **Safe Layer.** The ADS will recognize system limits, especially those that do not allow safe transition of control of the vehicle to the operator, and react to minimize risk.

Figure 13 shows the connection between these principles and basic system properties (defined here as capabilities).

Figure 13. Matrix—Automated Driving Systems Capabilities and the 12 Principles of Automated Driving

Traceability of the Capabilities												
ID	Safe Operation	Safety Layer	Operational Design Domain	Behavior in Traffic	User Responsibility	Vehicle-Initiated Handover	Veh.-Op.-Initiated Handover	Interdep. Veh. Op. & ADS	Data Recording	Security	Passive Safety	Safety Assessment
FS_1 Determine location			X	X						X		X
FS_2 Perceive relevant objects				X						X		X
FS_3 Predict the future behavior of relevant objects				X						X		X
FS_4 Create a collision-free and lawful driving plan				X						X		X
FS_5 Correctly execute the driving plan				X						X		X
FS_6 Communicate and interact with other (vulnerable) road users				X						X		X
FS_7 Determine if specified nominal performance is not achieved		X	X							X		X
FD_1 Ensure controllability for the vehicle operator	X				X	X	X	X		X		X
FD_2 Detect when degraded performance is not available	X									X		X
FD_3 Ensure safe mode transitions and awareness	X	X			X	X	X	X		X		X
FD_4 React to insufficient nominal performance and other failures	X	X								X		X
FD_5 Reduce system performance in the presence of failures	X	X								X		X
FD_6 Perform degraded mode within reduced system constraints	X	X	X			X				X		X

Source: https://newsroom.intel.com/wp-content/uploads/sites/11/2019/07/Intel-Safety-First-for-Automated-Driving.pdf.

2.6 Policy and Legislation Outside the United States

Automated vehicle technology is being developed around the world. This section gives a brief overview of ADS-equipped CMV legislation and policy documents developed in Canada, Mexico, the European Union, and China.

North America

Canada Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles

In June 2018, the Canadian Council of Motor Transport Administrator's (CCMTA) Automated Working Group published the "Canada Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles," which provides a series of considerations and recommendations that support Canadian jurisdictions in their planning and roll-out of ADS vehicles.[56] This includes providing guidance for:

- Vehicle registration and permitting programs.
- Driver training, testing, and licensing programs.
- Enforcement of traffic laws.
- First response to traffic-related incidents.

The purpose of this guidance is to provide a point-in-time set of voluntary recommendations for Canadian jurisdictions to use in developing testing programs, and preparing for the deployment of the technology.

Of note, AAMVA supported and participated in the development of this guidance. Also of note, this guidance was used in the development of the Testing Highly Automated Vehicles in Canada: Guidelines for Trial Organizations by adopting a number of definitions to ensure common, clear, and consistent language for the discussion of automated vehicle issues in Canada.

Testing Highly Automated Vehicles in Canada: Guidelines for Trial Organizations

In 2018, Transport Canada published the "Testing Highly Automated Vehicles in Canada: Guidelines for Trial Organizations," which informs the safe conduct of automated vehicle trials in Canada; and clarifies, for trial organizations, the various roles and responsibilities of Federal, provincial, and territorial levels of Government involved in facilitating trials.[57] The guidance notes that provinces and territories are encouraged to consult the Canadian Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles (referenced above), in conjunction with this document, to inform the development of their testing and deployment policies and regulations.

The guidance lays out the Federal, provincial/territorial, and municipal areas of responsibility. In Canada, provinces and territories are responsible for approving and overseeing trials of automated vehicles that take place within their jurisdiction. Municipal Governments, to varying degrees, are responsible for the enactment and enforcement of by-laws concerning vehicle movement; the use of local infrastructure; and the provision of public transportation in their respective jurisdictions.

56 https://ccmta.ca/images/publications/pdf/CCMTA-AVGuidelines-sm.pdf.

57 https://www.tc.gc.ca/en/services/road/safety-standards-vehicles-tires-child-car-seats/testing-highly-automated-vehicles-canada.html.

The guidance also outlines trial guidelines for pretest, test, and post-test considerations, which include the following:

- Compliance with Federal and Provincial/Territorial Requirement.
- General Safety Requirements.
- Automated Driving System Requirements.
- Insurance.
- Cross-Border Trials.
- Self-Declaration of Vehicle Safety.
- Driver Training and Responsibilities.
- Reporting and Responding to Serious Incidents Involving Trial Vehicles.
- Encouraging Information Sharing and Collaboration on Emerging Technologies.
- Sharing Best Practices and Information on Trial Outcomes.

Mexico

As of publication of this document, Mexico's la Secretaría de Comunicaciones y Transportes (SCT) has not developed any Federal automated vehicle guidance documents. Increasing investment in automated vehicles in the U.S. and Canada will provide Mexico with both a challenge and an opportunity through the new U.S.-Mexico-Canada trade agreement to integrate and enhance its transportation infrastructure around this emerging technology.

Beyond North America

European Union

Of the top 10 nations in the KPMG "2019 Autonomous Vehicles Readiness Index,"[58] 5 are members of the European Union (EU) and a sixth (Norway) is a neighbor.

On the Road to Automated Mobility: An EU Strategy for Mobility of the Future

On May 17, 2018, the European Commission published the Communication "On the Road to Automated Mobility: An EU Strategy for Mobility of the Future," which was part of the European Commission's "Europe on the Move III" report.[59] The Communication the Commission proposed outlined a

[58] https://assets.kpmg/content/dam/kpmg/xx/pdf/2019/02/2019-autonomous-vehicles-readiness-index.pdf.

[59] https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf; https://ec.europa.eu/transport/modes/road/news/2018-05-17-europe-on-the-move-3_en.

comprehensive EU approach towards connected and automated mobility by providing a common vision that identifies supporting actions for developing and deploying key technologies, services, and infrastructure. It ensures that EU legal and policy frameworks are ready to support the deployment of safe connected and automated mobility, while simultaneously addressing societal and environmental concerns, which will be decisive for public acceptance.

However, the document noted that regulatory changes will have to follow in order to build a harmonized, complete, and future-proof framework for automation. EU vehicle approval framework legislation, which was modernized in 2018, ensures an internal market for vehicles. Member States cannot adopt national rules that contradict EU vehicle legislation, and a special procedure to adopt new technologies from outside the EU is needed.[60]

The Communication also noted that the European Commission made available up to EUR 450 million under the Connecting Europe Facility to support digitization in transportation in support of automation and:

- Encourages Member States and regions to make use of the opportunities offered by EU regional policy and the European Structural and Investment Funds for co-financing investments in research, innovation, and deployment.
- Will work with Member States in 2018 to draw up a priority list of transport use cases for large-scale testing and take advantage of possible synergies between connectivity and automation use cases.
- Will put in place in 2018 one single EU-wide platform grouping all relevant public and private stakeholders to coordinate open-road testing and making the link with pre-deployment activities.
- Will build on work already carried out by establishing a partnership under the next European multiannual financial framework to give a clear long-term framework to the strategic planning of research and pre-deployment programs on driverless mobility at EU and national levels.
- By 2019, will offer Galileo's initial high-accuracy services for free, being the first to be able to offer such a navigation service on a worldwide basis.
- By 2019, will prepare guidelines for the optimized use of advanced services (i.e., high accuracy, robustness, authentication of positions) offered by the EU satellite navigation systems, EGNOS/ Galileo, and their inclusion in vehicle navigation systems to address liability and safety issues.

China

In 2018, the Ministry of Industry and Information Technology released the “Guidelines for the Construction of the National Internet of Vehicle Industry Standard System (Intelligent and Connected Vehicles).”[61] This document is meant to promote and strengthen the top-level design of ADS vehicles, and promote industry

60 http://www.europarl.europa.eu/doceo/document/TA-8-2018-0179_EN.pdf?redirect.

61 http://www.catarc.org.cn/upload/201802/13/201802131152200937.pdf.

research and development. The People's Republic of China also intends to develop new ADS-related regulations that adapt to China's national conditions and international practices.[62]

[62] "Safety First for Automated Driving," https://newsroom.intel.com/wp-content/uploads/sites/11/2019/07/Intel-Safety-First-for-Automated-Driving.pdf.

3.0 Stakeholder Outreach and Input

As part of the consideration of how a CMV equipped with automated driving systems ADS might be inspected at the roadside, the Workgroup identified and interviewed six firms that have been engaged in developing and testing ADS-equipped CMVs. The purpose of these interviews was to identify the technologies that industry intends to deploy, and the likely vehicle operating scenarios that an inspector might encounter. Each interview was framed around a similar set of questions sent to the interviewees before the discussion:

- What ADS technologies are commonly deployed on existing CMV?
- How can roadside officers verify that the technology is working correctly and safely?
- What new ADS-equipped CMV technologies might be deployed within three to five years?
- What use-cases or operating scenarios currently are deployed or planned?
- How can operators of ADS-equipped CMVs interact with law enforcement, and how this might change with varying levels of vehicle autonomy?

Industry stakeholders were generally appreciative of the opportunity to speak with CVSA and FMCSA; and were interested in working with relevant local, State, and Federal officials in a collaborative manner going forward.

3.1 Operating Scenarios and Use-Cases

The specific deployment of ADS-equipped CMV technology varies widely within the six firms interviewed and spans several SAE Levels of Autonomy. Most of the firms currently are operating in test or limited deployment environments and were limited to routes where the weather and traffic conditions were amenable to operations. These use-scenarios are generally defined as follows:

- **Platooning**. Two or more vehicles have the capability for V2V communication. This technology allows for trail vehicles in the platoon to achieve and maintain a following distance behind the lead vehicle that would otherwise be unsafe. All vehicles in the platoon have human drivers who are responsible for initiating and terminating the platoon and *maintain steering control over the vehicle at all times*. This is an example of SAE Level 1 automation with the speed/distance between vehicles automated when the technology is turned on. In the future, consideration might be given to the second vehicle becoming driverless (SAE Level 4 for second vehicle).
- **Integrated Level 2**. The current focus of this use-scenario is on complete integration of systems now relatively common, such as lane departure warnings, adaptive cruise control, collision warning, automated emergency braking, and advanced visibility. A driver is present but can rely on technology for operation until intervention might be required, or when the driver chooses to have the vehicle leave the highway.

- **Level 4 Driverless**. ADS-equipped CMVs in this scenario operate independent of human interaction for their entire trip. These trips occur under defined ODD on pre-selected and mapped routes and in specific conditions. The following are three variations to this approach identified by industry:
  - In the first variation, vehicles operate door-to-door with the entire route automated, including off-highway segments.
  - In the second variation, ADS vehicles operate on the highway between transfer points located near highway interchanges (weigh stations, rest areas, or custom facilities in the future). Human drivers in separate trucks then drive between the origin/destination and the highway transfer point.
  - In the third variation, ADS vehicles operate on the highway between exits. Once the vehicle exits the highway, remote operators (teleoperators) take over control of the vehicle to navigate the "last-mile" between the highway and the origin/destination. It is important to note that in this variation, the teleoperator may be available to act as the "driver" during an inspection.
- **Level 4 with Driver Present**. In the short term, some companies indicate that a safety driver will remain in the vehicle during SAE Level 4 vehicle testing and initial deployments. In the long term, all companies that are developing Level 4 vehicles will operate without a human driver in the vehicle.

3.2 ADS Technologies

The interviews focused on two points relating to ADS technologies:

1. **Physical and Mechanical—the Truck Systems.** The concerns here relate to how the foundational systems—brakes, steering, tires, weight profiles, hydraulics, lighting, and others—are connected to or related to the ADS technology itself, and how these would be inspected.
2. **Technological—the ADS Systems.** The concerns here are the core technologies, including software, that enable ADS operation, and where and how these technologies can be observed and diagnosed to ensure safety.

With respect to the Physical and Mechanical Systems, several interviewees suggested that they would rely on onboard diagnostics transmitted to control centers or potentially to others. This would be integrated in the ADS system. These diagnostics would be available in real time and would be checked at departure and during the drive itself.

With respect to Technological Systems, vendors are using the following in combinations unique to their integrated systems:

- **Communications and Positioning**. Global Positioning System (GPS) and inertial measurement, 3D high-definition maps, reliance on 4G LTE, and Cloud connections. Key factors are latency, bandwidth, and video quality.
- **Hardware**. Radar and Camera Systems positioned on Tractor (and in some cases, trailers) appear to be near universal amongst the companies contacted. Lidar and driver monitoring systems are present in some approaches.

- **Software**. Unique to each vendor. Various logic approaches for operations with means for recognition of other vehicles and road environments. Companies see their software approaches as distinguishing and competitive advantages. Integration with vehicle systems and diagnostics is common. Capability to monitor all systems in real time.

3.3 Potential Interactions with Roadside Inspectors

In regard to inspection, the interviews focused on the following two key elements:

1. **The Vehicle.** When at roadside, could the existing inspection process still apply? The interviewees generally felt that:

    a. Pre-trip inspections conducted by the company will be thorough and critical prior to departure. Records of these inspections could be made available for query in real time, or at the roadside to appropriate enforcement personnel.

    b. Real-time monitoring of key systems will be available, so that electronic diagnostics could be available. Suggestions that tests could be done with applications similar to electronic logging devices (ELD) or ABS approaches. Point made that electronic brakes will be necessary for ADS vehicles.

2. **ADS Systems.** Suggestions by vendors included the following points:

    a. The ADS systems require all elements to be operating and functional, or the trip cannot start or will be interrupted if any component is not operating effectively.

    b. A “green light” or other indicator could be utilized to validate all systems are functioning correctly.

    c. For operations with drivers, an indicator could be placed to show that the truck is operating with ADS.

    d. Desire to avoid requiring inspectors to also be “computer scientists.”

All interviewees were interested in collaboration with enforcement and generally recommended the following:

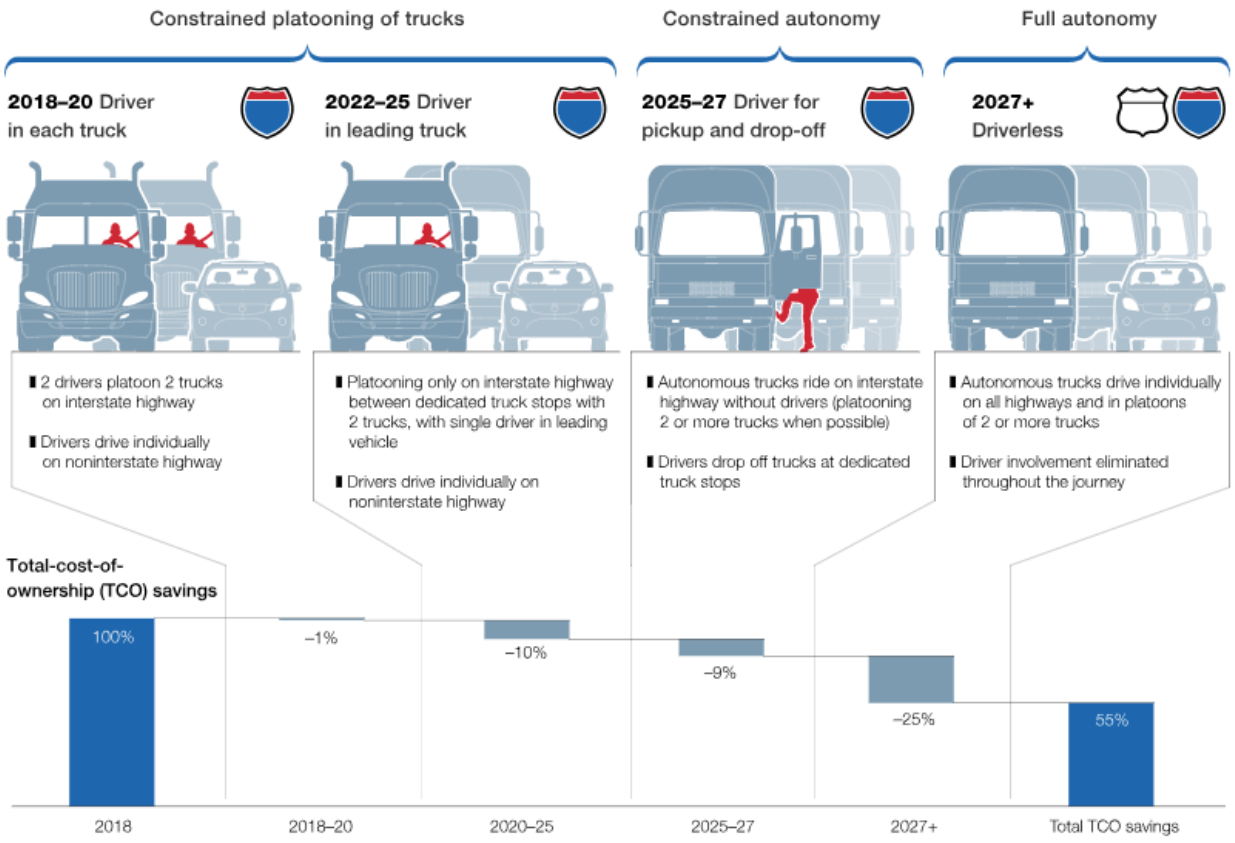
- **Focus on Functionality**. Regulatory agencies and enforcement should focus on specifying desired functional requirements, and let industry develop the specific approach and supporting systems. For example, enforcement could require that a vehicle is able to display its ODD so that enforcement can verify the vehicle is operating in a location and under conditions that it should. Industry should be responsible for deciding the best way to meet this requirement (light, door placards, 24/7 contact information, etc.). This should be the case for all levels of autonomous vehicle operations (both with drivers and driverless).

- **Strive for Uniformity**. Once the functionality for safety assurances is specified, apply them uniformly throughout the country.

Anticipated Timeline for Deployment

Although fluid and subject to change, Figure 14 below identifies a general timeline for anticipated deployment of ADS-equipped CMVs. Some interviewees felt that the "constrained autonomy" approach could occur sooner than shown below, and that many of the remaining challenges were policy or public relations in nature rather than technological.

Figure 14. Commercial Motor Vehicle Automated Driving Systems—Deployment Timeline



Source: https://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/distraction-or-disruption-autonomous-trucks-gain-ground-in-us-logistics.

4.0 Creating a Decision Tree for ADS-Equipped CMV Identification

One challenge with the introduction of ADS is determining what SAE Level of vehicle is being examined. In addition, since vehicles are not yet required to display what level of technology is onboard and ADS components are not required equipment under FMVSS, it can be difficult for enforcement personnel to understand how they should inspect an ADS-equipped CMV under current procedures.

4.1 CVSA NAS Level 1 Inspection—Gap Analysis by SAE Level

One of the first analysis tasks produced by this Working Group was an examination of gaps or concerns that exist when examining a CMV using the existing NAS Level I inspection process. As a simple example, Step 5 of the NAS Level I is to collect a driver's documents. In an SAE Level 4 environment, there is no driver, and there may be no human in the vehicle at all. How would an inspector complete this task?

A more complicated example involves Step 36, which is the check for fifth wheel movement. This step currently requires the assistance of the driver to apply spring brakes on the trailer. Without a driver, can this step still be accomplished? Without the ability to control the vehicle remotely (which is not required under current Federal legislation), would a driver have to report to the inspection location to operate vehicle in order to complete an inspection? Would this step be skipped?

This gap analysis was a valuable first step in understanding the existing gaps in both regulation and CVSA policy, and how the existing NAS Level I inspection steps apply to a CMV in the various use-scenarios under development by industry. A full matrix showing the NAS Level I steps and the potential issues for each step based on the various SAE Levels is included in Appendix A.

4.2 SAE Level Decision Tree for Roadside Officer

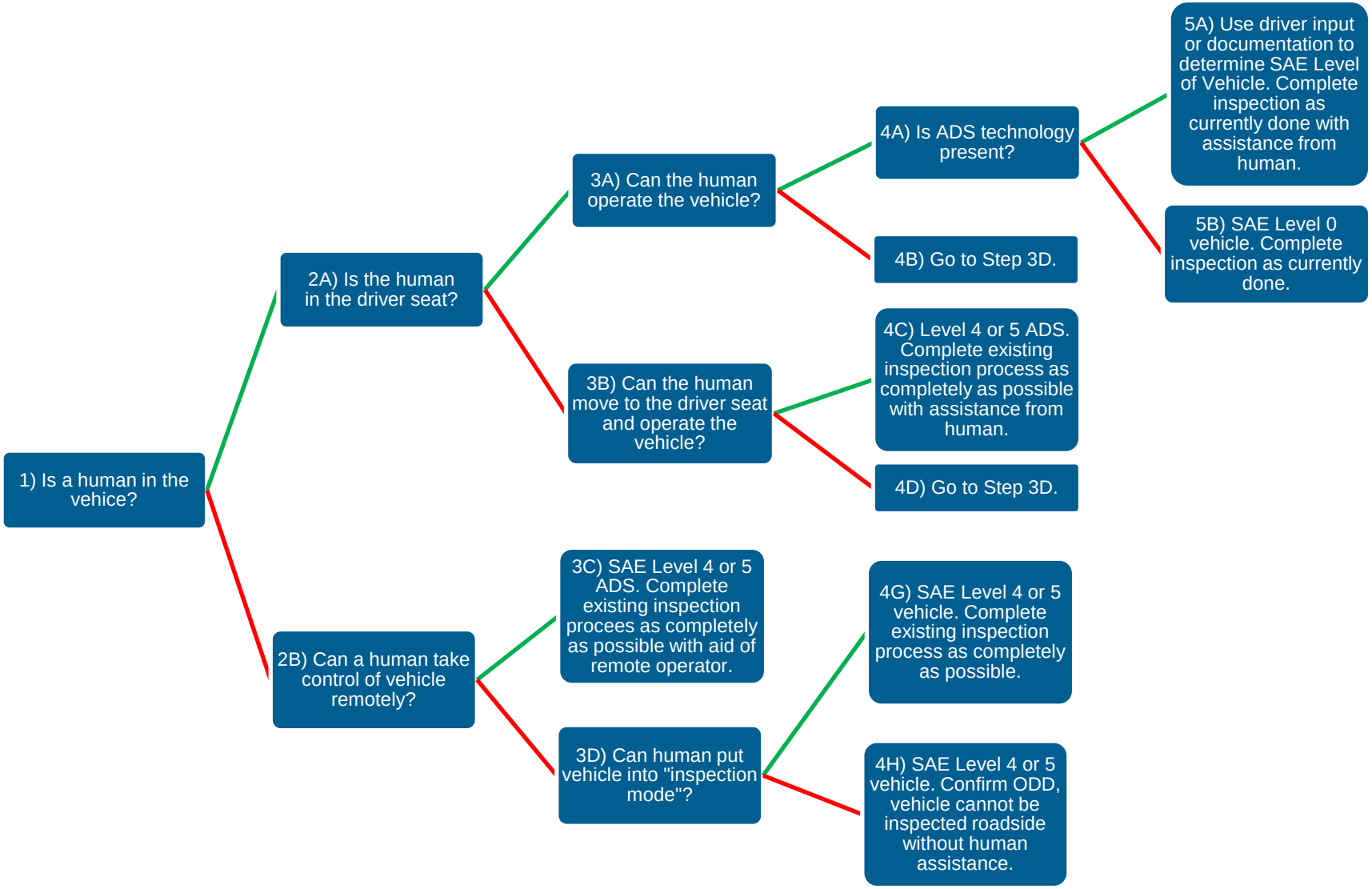
As an interim product, the Working Group developed a decision tree to help enforcement personnel identify the SAE Level of an ADS-equipped CMV that may be encountered roadside, and how the vehicle can be inspected *considering existing procedures*.

This decision tree is intended as an interim product until the following:

- Changes are made to the inspection process to add new requirements or steps for inspection of ADS components or systems.
- Vehicles are required to display, broadcast, or otherwise provide enforcement personnel with their SAE Level and related information (Carrier information, Pre-trip inspection, ODD, etc.).

Figure 15 on the following page shows the steps for the decision tree. Each box (except for those at the end) are framed as a question. A "yes" answer to the question follows the green line (up), and a "no" answer to the question follows the red line (down).

Figure 15. SAE Level Identification—Decision Tree



5.0 Recommendations and Next Steps

This section describes the work completed to identify inspection options for various types of ADS-equipped CMVs, the process used to vet those options within the Working Group, and the consequences and potential next steps that these recommendations entail.

5.1 Analysis and Selection of Inspection Recommendations

Based on conversations with stakeholders and Working Group members, eight Inspection Options were identified. A matrix was developed to consider the potential application, impacts, and challenges each Inspection Option would have for different SAE Level vehicles and use-scenarios envisioned by industry; and what changes would be required within the CVSA NAS Inspection process. This matrix is shown in Table 2.

Three key points informed the following discussion:

1. A simpler approach is likely better. With rapidly changing technology and market conditions, trying to recommend complex solutions would likely be problematic and difficult to implement.

2. Any recommendations made by this Working Group would require approval by the CVSA Board of Directors. This means that recommendations will ultimately require buy-in from the wider enforcement community.

3. Recommendations that require inspection of any equipment not currently required by regulations will require NHTSA and/or FMCSA to initiate rulemaking.

The following ADS-equipped CMV operating use-scenarios were considered during development of the matrix:

- **SAE Level 1 ADS.** Speed/distance control automated (platooning)—human driver in vehicle actively monitoring.

- **SAE Level 2 ADS.** Speed/distance control and lane centering automated while on highway—human driver in vehicle actively monitoring.

- **SAE Level 4a ADS.** Operates on highway between transfer points autonomously under specific ODD—no human driver, no ability to control vehicle remotely.

- **SAE Level 4b ADS.** Operates on highway and first-/last-mile roads autonomously under specific ODD—no human driver, no ability to control vehicle remotely.

- **SAE Level 4c ADS.** Operates on all roads autonomously under specific ODD—no human driver, limited ability to control vehicle (make vehicle stationary and speak with enforcement) remotely.

- **SAE Level 4d ADS.** Operate on highway autonomously under specific ODD, first/last mile via remote human driver (teleoperator)—remote human driver able to control vehicle.

Table 2. Inspection Option Matrix

Inspection Option	This means…	To do this would require…	What changes to the existing NAS Level I would occur?	This option could apply to which SAE Level CMV?	Recommendation
1. Continue inspection as done now—**no changes**.	• All ADS vehicles are treated similarly to non-ADS vehicles.	• Communication within CVSA that ADS vehicles should be treated no differently than non-ADS vehicles. • All ADS-equipped CMVs would need to be able to follow the instructions of an inspector to complete the existing inspection process. • Functional Requirement that CMV must have human present with vehicle who can facilitate an inspection at all times.	• None	• All	• This option is **not recommended** because it would be prohibitive on industry and severely limit the potential deployment options (especially for SAE Levels 4 and 5 CMV).
2. Add new Step—**electronic/visual inspection of ADS overall system** (by light, readout, electronic message to new inspection device, etc.).	• A full NAS Level I is still completed. • In addition, the NAS Level I is modified to include a new step for an inspector to check a malfunction indicator on an ADS vehicle. • If indicator is "on," the ADS piece of the inspection has failed. • This approach is intended to operate very similarly to how ABS currently is checked.	• Functional Requirement is that the vehicle must provide an ADS full system malfunction indicator (what that indicator is—light, digital readout, electronic message, etc.—would be left up to industry). • Research and rulemaking to decide the logic determining if the malfunction indicator is on or not. • All ADS-equipped CMVs would need to be able to follow the instructions of an inspector to complete the existing NAS Level I inspection process. • Communication needed within CVSA that ADS vehicles should be treated no	• Wording in NAS Level I must change to allow "driver" to not be present with vehicle ("someone" instead of "driver") if applies to SAE Levels 4 and 5 vehicles. • Addition of new ADS system malfunction indicator step.	• All	• **Recommend this option for SAE Levels 1, 2, and 3 vehicles**, as these will have a human driver in them to help facilitate the existing NAS Level I inspection. An overall system malfunction indicator is simple to check and does not require extensive additional training for enforcement staff.

Inspection Option	This means…	To do this would require…	What changes to the existing NAS Level I would occur?	This option could apply to which SAE Level CMV?	Recommendation
		differently than non-ADS vehicles, except for the added malfunction indicator inspection step.			
3. Add new Step—**electronic/visual inspection of ADS individual component systems** (by light, readout, electronic message to new inspection device, etc.).	• A full NAS Level I is still completed. • In addition, the NAS Level I is modified to add an additional step for an inspector to check multiple malfunction indicators for any component systems critical to ADS vehicle operation. • If any indicator is "on," the ADS piece of the inspection has failed. • This is a challenge because we do not know what all the components are, and this will change rapidly with innovation.	• Functional Requirement is that the vehicle must provide ADS component systems malfunction indicators (what that indicator is—light, digital readout, electronic message, etc.—would be left up to industry). • Research and rulemaking to decide the logic determining if the malfunction indicators are on or not. • All ADS-equipped CMVs would need to be able to follow the instructions of an inspector to complete the existing NAS Level I inspection process. • Communication within CVSA that ADS vehicles should be treated no differently than non-ADS vehicles, except for the added malfunction indicators inspection step.	• Wording in NAS Level I must change to allow "driver" to not be present with vehicle ("someone" instead of "driver") if applies to SAE Levels 4 and 5 vehicles. • Addition of multiple new ADS system malfunction indicators step.	• All	• This option is **not recommended** due to the wide range of potential component systems—rulemaking to continuously define what systems would require a malfunction indicator could be prohibitive.
4. Add new Step—**physical inspection of ADS component systems** (check cameras are not cracked or covered in debris, look at cables, etc.).	• Inspectors would need to act as "mechanics" for all systems deployed by each vehicle and ADS manufacturer. • This is a challenge because we do not know what all the components are, and this will	• Must define level of physical issue before the component "fails" and a list of all potential components and physical locations on vehicle specific to each vehicle/system/company.	• Addition of new ADS inspection step that is a physical inspection of ADS components.	• All	• This option is **not recommended** because of the potential complexity, variety, and evolving set of technology that would need to be checked. This would require an excessive amount of training in order for enforcement to properly

Inspection Option	This means…	To do this would require…	What changes to the existing NAS Level I would occur?	This option could apply to which SAE Level CMV?	Recommendation
	change rapidly with innovation. Note that FMCSR 392.9(a) is a "catch-all" that all equipment must be properly secured. • FMCSR 396.3(a)1 also requires that "parts and accessories shall be in safe and proper operating condition at all times" and includes "…any additional parts and accessories which may affect safety of operation…."	• Would need criteria for actuators (steering, brake, accelerator) and weight. • Functional requirement that inspectors have physical access to component systems.			identify and physically inspect ADS components.
5. Add new Step—**Combine #2 and #4**.	• Same as above in Options 2 and 4.	• Same as above in Options 2 and 4.	• Same as above in Options 2 and 4.	• All	• This option is **not recommended** (see comments in Option 4 above).
6. Add new Step—**Combine #3 and #4**.	• Same as above in Options 3 and 4.	• Same as above in Options 3 and 4.	• Same as above in Options 3 and 4.	• All	• This option is **not recommended** (see comments in Options 3 and 4 above).
7. **Limit inspection of ADS vehicles roadside**. Adopt an approach based on origin/ destination (terminal) inspection model and have a functional requirement for **in-motion inspection of**	• Unless there was an event/ incident prompting an inspection (crash or observed OOS defect), NAS Level I inspections roadside would not occur. • Vehicle would be required to communicate (while in motion) that it has passed a "real-time" pass/fail check of electronically checked systems that are required in an "expanded NAS	• Define terminal inspection elements/parameters. • Define communication options for vehicle in-motion to "inspector/system." • Define what "real-time" diagnostics entails. • Functional Requirement—vehicle can broadcast "real-time" electronic system overall (including ADS) pass/ fail while in-motion.	• None. The NAS Level I inspections would not be applied in this scenario. If an event/incident required an NAS Level I, a human would be required to perform the "driver" functions as necessary to complete the NAS Level I.	• SAE L4-L5	• **Recommend this option for SAE Levels 4 and 5 vehicles.**

Inspection Option	This means…	To do this would require…	What changes to the existing NAS Level I would occur?	This option could apply to which SAE Level CMV?	Recommendation
ADS system as a whole.	Level VIII." This would be presented as a single malfunction indicator/ message. • Vehicle must be able to confirm it is operating within ODD while in motion. • This approach is contingent on the development of a terminal inspection procedure (expanded NAS Level VIII or a new NAS Level IX).	• Functional Requirement—vehicle can broadcast "real-time" that it is operating within its ODD (need to define what ODD information is critical—route and weather conditions?).			
8. **Limit inspection of ADS vehicles roadside**. Adopt an approach based on origin/ destination (terminal) inspection model, and have a functional requirement for **in-motion inspection of ADS system components**.	• Unless there was an event/ incident prompting an inspection (crash or observed OOS defect), NAS Level I inspections roadside would not occur. • Vehicle would be required to communicate (while in motion) that it has passed a "real-time" pass/fail check of electronically checked systems that are required in an "expanded NAS Level VIII." This would be presented as multiple malfunction indicators/ messages. • Vehicles will be required to communicate that they have passed their terminal inspection (see below) while in motion. • Vehicle must be able to confirm it is operating within ODD while in motion.	• Define terminal inspection elements/parameters. • Define communication options for vehicle in-motion. • Define specific elements that need to be broadcast/ transmitted to "inspector/ system." • Functional Requirement—vehicle can broadcast "real-time" electronic system components (including ADS) pass/fail while in-motion. • Functional Requirement—vehicle can broadcast "real-time" that it is operating within its ODD (need to define what ODD information is critical—route and weather conditions?).	• None. The NAS Level I inspections would not be applied in this scenario. If an event/incident required an NAS Level I, a human would be required to perform the "driver" functions, as necessary, to complete the NAS Level I.	• SAE L4-L5	• This option is **not recommended** due to the wide range of potential component systems—rulemaking to continuously define what systems would be required as part of the terminal inspection, and be broadcast during a NAS Level VIII while in motion could be prohibitive.

5.2 Initial Recommendations

Following a working session, the executive committee made an initial recommendation to the Working Group to advance Option 2 for SAE Levels 1 to 3 CMV and Option 7 for SAE Level 4 and 5 CMV to the full EIM Committee for consideration.

In summary, Option 2 adds a new inspection step to the Level I inspection procedure (and other inspection levels, if applicable), instructing the inspector to conduct an electronic inspection of the ADS overall system (by indicator light, data readout or electronic message sent to an inspection tool or device, etc.).

Option 7 would limit the inspection of SAE Levels 4 and 5 CMV at the roadside, and instead emphasize origin/destination (or terminal) inspections, including a holistic functional requirement check of the ADS system. These origin/destination checks would include components that cannot be verified electronically, such as load securement.[63] Information that the vehicle had passed this check and was operating within its ODD would be available to enforcement in the field via an electronic message, and/or through a searchable database based on a vehicle-specific identification. Standard vehicle inspections would be limited to furtherance of an investigation, as the result of an incident, or some other special circumstance. Regular roadside inspections would not be conducted on these vehicles.

Additional discussions identified a potential modification to the above recommendations. This modification would make no changes to the current inspection procedure for SAE Levels 1 and 2 vehicles and move the inspection of SAE Level 3 vehicles to Option 7. This modification was considered since SAE Levels 1 and 2 CMVs are already on the road, and a human driver must be immediately available to take over control of the vehicle. In the same way that regular vehicles can have cruise control, but it is not part of a normal vehicle inspection, nor is it required to be operating to drive the vehicle, the technology necessary to operate as an SAE Levels 1 or 2 CMV is not necessary (unless in a Platooning scenario where vehicles are trailing in close proximity) and, therefore, would not be subject to inspection. SAE Level 3 automation could be accommodated in Option #7, provided the human driver's HOS compliance and enforcement can be accounted for in some manner.

5.3 Final Recommendations and Comments

The Working Group approved recommending Option #2 for SAE Levels 1 to 3 CMV and Option #7 for SAE Levels 4 and 5 vehicles to the EIM Committee during an online vote in July and August 2019. The modification discussed above was not recommended, although it was included for discussion at the EIM Committee meeting in September 2019. The survey, results, and comments received are presented in Appendix B.

It should be noted that the Option #7 recommendation is consistent with initial language from FMCSA released as part of the Advanced Notice of Proposed Rulemaking—"Safe Integration of Automated Driving Systems-Equipped CMV." That document states,

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63 Identifying specific components of an origin/destination inspection is one of many "parking lot" issues that will need to be considered in the future. Initial discussion within the Working Group identified the Canadian National Safety Code Standard 13, "Daily Vehicle Trip Inspection" (specifically Park 2, Schedule 1) as a potential foundation.

"FMCSA believes it is appropriate to consider amending Part 396 to provide clear guidance to motor carriers dispatching Level 4 and Level 5 ADS-equipped CMVs that would operate on a public road. At a minimum, the Agency believes consideration should be given to require:

- Pre-trip inspections before dispatching ADS-equipped CMVs.
- A means for en-route inspection for cargo securement devices to ensure proper tension—currently, the driver is required to check the devices, but there may be alternative solutions based on improved technology.
- Post-trip inspection requirements, which may vary, depending on the sensors and detectors, to identify mechanical/electrical problems that may or may not be related to the ADS technology.
- Periodic or annual inspection of ADS technology."

The EIM Committee approved the Working Group's recommendations and advanced them to the CVSA Board of Directors. The Board approved Option #2 and Option #7 as CVSA policy positions and also approved a motion to continue the Working Group's efforts for another year.

5.4 Next Steps

This document represents the Final Report for the Automated CMV Working Group.

However, this work is only a starting point for determining how enforcement will interact with ADS-equipped CMVs. Adoption of these recommendations raises several questions that are directly related to inspection of these vehicles, including the following:

- **Should the type of malfunction indicator required to show that the ADS is functioning correctly be defined by the enforcement community and NHTSA (e.g., single ABS malfunction lamp), or should a functional requirement be set that the vehicle must be able to communicate to enforcement that it has passed its check and allow industry to determine how this communication is done (e.g., ELD systems)?**
- OOS implications of a malfunction indicator. The enforcement community must decide if a vehicle with an ADS malfunction should be able to continue to operate using ADS, should only be able to operate using ADS to reach a safe location, repair facility, or some other designated location, be able to operate as an SAE Level 0 CMV, or not be able to operate at all. This answer may be different for vehicles designed to operate as SAE Levels 1 to 3 versus those designed to operate as SAE Levels 4 and 5. Based on the answer to this question, there are essentially four implications from the malfunction indicator:
  - Vehicle is able to operate ADS—malfunction indicator is advisory only. However, this information could be valuable for research purposes.
  - Vehicle is able to operate ADS but is issued a citation.

  - Vehicle is able to operate but only in SAE Level 0 (conditional vehicle OOS).
  - Vehicle is not able to operate at all until the malfunction issue is resolved (vehicle OOS).

- Should the ADS malfunction indicator include any systems on a trailer or should it be for tractor-only components? If tractor systems are to be included, which ones? Does this change for SAE Levels 1 to 3 vehicles versus SAE Levels 4 and 5 vehicles?

- **For the Option 7 recommendation (origin/destination inspections for SAE Levels 4 and 5), what elements should be included in the terminal inspection? This applies to both ADS components (e.g., what systems are in the overall system check) and to non-ADS components (e.g., load securement). This Working Group identified the Canadian "Daily Vehicle Trip Inspection" as a possible template for this inspection. AAMVA is also revising its commercial driver license test to focus on a subset of critical systems for the Vehicle Inspection portion of the test, based on common crash causation, CVSA inspection process and citation data.**[64]

- **For the Option 7 recommendation, who is authorized to conduct the origin/destination (terminal) inspection? What training or certification should they have and how is that training obtained?**

The concerns in **bold** above are recommended as the next topics to address in collaboration with other Committees within CVSA, industry partners, and FMCSA. Answers to these questions must be identified prior to or in concert with additional steps potentially including testing of law enforcement scenarios involving ADS-equipped CMV, the development of new equipment standards by NHTSA, the inclusion of new safety or indication systems in the FMVSS, regulatory action by FMCSA to include inspection of the new component(s) as part of the FMCSR, and finally development of new inspection procedures and training by CVSA to inspect the new equipment.

Finally, there were many additional questions raised during the course of this work that are relevant to ADS-equipped CMV operations but are not part of the inspection process. These, along with additional information on the above "parking lot" issues, are detailed in the next section.

[64] https://www.ugpti.org/resources/proceedings/downloads/2018-11-28-kevin-lewis.pdf

6.0 Items for Future Consideration

6.1 "Parking Lot" Issues

Stakeholders raised critical questions during this study that were beyond the initial scope of this Working Group. Some are directly related to the recommendations presented in Section 5.0 and will need to be addressed as part of the ongoing work to advance those recommendations. Others are relevant to the wider operation of ADS-equipped CMVs but are not directly tied to inspection procedures. Table 3 below lists these "parking lot" issues and categorizes the issues by SAE Level of vehicle impacted by this issue, urgency, type of solution/action, and other CVSA Committees that may need to be engaged to develop resolutions to the issue.

To address relative urgency, issues are broken into the following:

- **Tier 1.** Issue is of immediate concern and should be considered critical to resolve to advance the recommendations from this study.
- **Tier 2.** Issue is of intermediate concern and should be considered in relation to the inspection of ADS-equipped CMV.
- **Tier 3.** Issue is of concern in the long term but is not immediately related to ADS-equipped CMV inspections.

To resolve the "parking lot" issues, one or more of the following types of actions or solutions will need to be pursued:

- CVSA Policy.
- Regulatory (Rulemaking).
- Officer Training.
- Technology.

The last set of columns identifies other CVSA Committees that may need to be involved in resolving the "parking lot" issues. The EIM Committee also approved a motion that the existing Working Group serve as the clearinghouse for ADS-equipped CMV inspection topics that arise in other CVSA Committees. This will limit the chance that important information is missed and ensure that, as appropriate, topics in this arena are considered by the entirety of CVSA.

Table 3. Items for Future Consideration – "Parking Lot" Issues

Issue Description	SAE Level					Urgency			Type of Solution/Action				Other CVSA Committee Involvement							
	1	2	3	4	5	Tier 1	Tier 2	Tier 3	CVSA Policy	Regulatory (Rulemaking)	Officer Training	Technology	Crash Data	Driver-Traffic Enforcement	Hazardous Material	InfoSys	Policy and Regulatory Affairs	Size and Weight	Training	Vehicle
ADS System Malfunction—OOS Implications																				
What are the consequences of having an ADS system malfunction indicator on? Does the entire vehicle become OOS, or can it still operate with a human driver and no ADS active? If vehicle can be driven, how would enforcement confirm ADS is not being used?	●	●	●			●			●	●	●						●		●	●
ADS System Malfunction Indicator—Standardization?																				
What are the functional requirements for the indicator light/malfunction indicator? Should there be a standard communication method (e.g., ABS malfunction lamp), or should industry be able to develop any approach that meets the requirement? How might this be different for Levels 1 to 3 versus Levels 4 to 5 CMVs?	●	●	●	●	●	●			●	●	●	●							●	●
ADS-Equipped CMV Identification Markings																				
Should ADS-equipped CMVs have a marking/light or some other way for emergency personnel to identify the vehicle while in motion?				●	●		●		●	●		●					●			●

Issue Description	SAE Level					Urgency			Type of Solution/Action				Other CVSA Committee Involvement							
	1	2	3	4	5	Tier 1	Tier 2	Tier 3	CVSA Policy	Regulatory (Rulemaking)	Officer Training	Technology	Crash Data	Driver-Traffic Enforcement	Hazardous Material	InfoSys	Policy and Regulatory Affairs	Size and Weight	Training	Vehicle
Pulling over an ADS-Equipped CMV																				
If Option 7 Recommendation for SAE Levels 4 and 5 vehicles is adopted, roadside inspections should be limited. However, if enforcement identifies a safety-critical issue, ADS-equipped CMVs must be able to recognize and safely pull-over. Define next steps/ requirements once stopped roadside.				●	●		●		●		●	●		●			●		●	●
ADS-Equipped CMV Trailer Condition																				
Should the trailer attached to an ADS-equipped CMV be part of the ADS system check? If so, define truck trailer elements that are checked and included in the ADS-equipped CMV malfunction indicator. If not, define elements that must be checked by certified personnel as part of the terminal inspections	●	●	●	●	●	●			●	●		●							●	●
Terminal Inspection—Certification Requirements																				
What are the certification criteria for personnel conducting an origin/destination (terminal) inspection on an SAE Levels 4 and 5 vehicles? How are they certified?				●	●	●			●	●	●						●		●	●

Issue Description	SAE Level					Urgency			Type of Solution/Action				Other CVSA Committee Involvement							
	1	2	3	4	5	Tier 1	Tier 2	Tier 3	CVSA Policy	Regulatory (Rulemaking)	Officer Training	Technology	Crash Data	Driver-Traffic Enforcement	Hazardous Material	InfoSys	Policy and Regulatory Affairs	Size and Weight	Training	Vehicle
Terminal Inspection—Inspection Elements																				
Define elements of a terminal inspection. What ADS and non-ADS systems or components of the vehicle need to be inspected.				●	●	●			●	●	●	●					●		●	●
In-Motion Electronic Inspection Elements																				
Define elements of in-motion electronic inspection. What information needs to be relayed or available to enforcement (overall system check, ODD, etc.) and how? How does the national information technology (IT) infrastructure need to change to accommodate this type of inspection?				●	●	●			●	●	●	●		●		●				●
ADS-Equipped CMV and HOS																				
What impact (if any) does operation of a Levels 1 to 3 ADS-equipped CMVs have on the driver's HOS? What if a Level 4 system is operating, but a human is in the vehicle?	●	●	●	●				●	●	●	●			●			●			●
Remote Operator Certification																				
What additional training/ certification beyond existing CDL requirements should remote operators have if they operate an ADS-equipped CMV?				●			●		●	●	●			●			●		●	●

Issue Description	SAE Level					Urgency			Type of Solution/Action				Other CVSA Committee Involvement							
	1	2	3	4	5	Tier 1	Tier 2	Tier 3	CVSA Policy	Regulatory (Rulemaking)	Officer Training	Technology	Crash Data	Driver-Traffic Enforcement	Hazardous Material	InfoSys	Policy and Regulatory Affairs	Size and Weight	Training	Vehicle
ADS-Equipped CMV Operator Certification																				
What additional training/ certification beyond existing CDL requirements should a human driver have if they are operating an ADS-equipped CMV?	●	●	●				●		●	●	●			●						
ADS-Equipped CMV and Distracted Driving																				
What modifications to distracted driving laws should apply to a human driving an ADS-equipped CMV?	●	●	●	●				●	●	●				●			●			
ADS-Equipped CMV and Hazardous Material Movement																				
Should vehicles carrying hazardous material be able to operate with ADS? Should the types of systems or SAE Level be limited? Should drivers be required to obtain additional certifications?	●	●	●	●	●			●	●	●				●	●		●		●	●

Appendix A. CVSA NAS Level I Inspection—Gap Analysis Matrix

The following table was developed as an interim work product by the Working Group and includes the following information:

- Each row is one of the existing 37 Steps (and components within each step) in the NAS Level I inspection.
- Columns describe potential ADS-equipped CMV use-scenarios. The final column indicates if this inspection step or component of the step could be conducted electronically.
- Each cell contains comments about the ability to complete the inspection step based on the use-scenario.

This information helped inform the development of the eight Inspection Options, and ultimately the selection of inspection recommendations for ADS-equipped CMV.

Table A.1. NAS Level I Inspection Concerns by SAE Level

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Step 1—Choose Inspection Site								
Select a safe location, paved, level, away from traffic, visible to traffic, and able to support the weight of the vehicle	Valid—driver present	Valid—type of location for safety does not change	Valid—type of location for safety does not change	Valid—type of location for safety does not change	Valid—type of location for safety does not change	Valid—type of location for safety does not change	Valid—type of location for safety does not change	No, electronic inspection may need to be converted to regular inspection in event of OOS or random checks
Avoid hills, curves, soft shoulders and construction sites	Valid—driver present	Valid—type of location for safety does not change	Valid—type of location for safety does not change	Valid—type of location for safety does not change	Valid—type of location for safety does not change	Valid—type of location for safety does not change	Valid—type of location for safety does not change	No, electronic inspection may need to be converted to regular inspection in event of OOS or random checks
Step 2—Approach the Vehicle								
Observe the driver	Valid—driver present	Valid—driver take controls if needed	Invalid—no driver	Invalid—no human	Valid	Invalid—no driver	Invalid—no driver	No, no need to
Adhere to inspector safety policies	Valid—driver present	Valid—driver take controls if needed	Valid—human takes controls if needed	Valid	Valid	Valid	Valid	Safety policies need to be developed for ADS vehicles
Be alert for leaks and unsecured cargo	Valid	Valid	Valid	Valid	Valid	Valid	Valid	No
Step 3—Great and Prepare Driver								
Identify yourself	Valid—driver present	Valid—driver present	Valid—human present	Invalid—no human	Valid	Valid	Invalid	Could probably be done, is it needed?
Ensure that the driver is capable of communicating sufficiently to understand and respond to official inquiries and directions	Valid—driver present	Valid—driver present	Invalid—Need way to communicate with vehicle (remote, V2V,	Invalid—Need way to communicate with vehicle (remote, V2V,	Valid	Invalid—Need way to communicate with vehicle (remote, V2V,	Invalid—Need way to communicate with vehicle (remote, V2V,	Yes, communication with system could be electronic since no driver

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
			V2E, standard system check??)	V2E, standard system check??)		V2E, standard system check??)	V2E, standard system check??)	
Place chock blocks on the driver's side	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Explain this inspection procedure	Valid—driver present	Valid—driver present	Invalid—step not needed	Invalid—step not needed	Valid	Invalid—no driver	Invalid—no driver	Yes, but communication of intent not needed
Ensure engine is off	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Yes, electronically turn it off
Check the driver's seat, the seat belt use and condition	Valid—driver present	Valid—driver present	Valid, but not based on driver. All seats checked for reg compliance	Invalid—no human	Valid	Valid, but not based on driver. All seats checked for reg compliance	Invalid—no human	No when needed, sensor can communicate if in use, but is it used properly?
Observe the driver's overall condition for illness, fatigue, or other signs of impairment	Valid—driver present	Valid—driver present	Invalid—condition of human does not matter	Invalid—no human	Valid	Invalid—no driver	Invalid—no driver	No
Check for illegal presence of alcohol, drugs, weapons or other contraband	Valid—driver present	Valid—driver present	Valid—all humans subject to check for illegal contraband	Valid	Valid	Valid	Valid	No
Step 4—Interview Driver								
Ask the driver for starting location, final destination, load description, time traveled, most recent stop and fueling location(s)	Valid—driver present	Valid—driver present	Invalid—no driver	Invalid—no human	Valid	Invalid—no driver	Invalid—no human	No

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Ask the driver what other jobs he/she has worked in the past week	Valid—driver present	Valid—driver present	Invalid—no driver	Invalid—no human	Valid	Invalid—no driver	Invalid—no human	No
Step 5—Collect the Driver's Documents								
Collect medical Examiner Certificate and Skill Performance Evaluation (SPE) Certificate (if applicable)	Valid—driver present	Valid—driver present	Invalid—no driver	Invalid—no human	Valid	Invalid—no driver	Invalid—no human	Yes
Collect driver's license, CDL, record of duty status	Valid—driver present	Valid—driver present	Invalid—no driver	Invalid—no human	Valid	Invalid—no driver	Invalid—no human	Yes
Collect shipping papers	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Yes
Collect periodic inspection certificates, CVIP	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Yes
Collect bills of lading, receipts, other documents used to verify record of duty status and trip envelope	Valid—driver present	Valid—driver present	Invalid—no driver	Invalid—no human	Valid	Invalid—no driver	Invalid—no human	Yes
Step 6—Check for Presence of Hazardous Material/Transportation of Dangerous Goods								
Check shipping papers, markings, labels, and placards	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Yes, for shipping papers, no for visual requirements
Check for any leaking material or unsecured cargo	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Step 7—Identify the Carrier								
Identify the carrier by using vehicle identification, vehicle registration, insurance, operating authority and driver interview	Valid—driver present	Valid—possible electronic communication	Valid—possible electronic communication	Valid—possible electronic communication	Valid	Valid—possible electronic communication	Valid—possible electronic communication	Yes
Step 8—Examine the Driver's License								
Check the driver's license or CDL expiration date, class, endorsements, restrictions and status	Valid—driver present	Valid—driver present	Invalid—no driver	Invalid—no human	Valid	Invalid—no driver	Invalid—no human	Yes
Step 9—Check Medical Examiner's Certificate and Skill Performance Evaluation (SPE) Certificate (if applicable)								
Note: Medical qualifications may be contained in the driver's license. Proper class indicates adequate medical requirements								Yes
Check certificate(s) date (may be valid for up to 24 months)	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	Yes
Check corrective lens requirement	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	No
Check hearing aid requirement	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	No
Check physical limitations	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	No
Step 10—Check Record of Duty Status								
Check hours of service verification	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	Yes, if ELD and no exemption claimed

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
If driver claims to be exempt, check that they meet all criteria for said exemption(s)	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	No
Check accuracy of record	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	Yes, Electronic Record of Duty Status (eRODS)
Step 11—Review Driver's Daily Vehicle Inspection Report (if applicable)								
Review the required vehicle inspection report to verify that listed safety defects have been repaired	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Yes
Step 12—Review Periodic Inspection Report(s)								
Ensure vehicle has passed the required inspection and has the required documents and decals	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Yes
Step 13—Prepare Driver for Vehicle Inspection								
Explain the inspection procedure	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	No
Advise the driver in use of hand signals	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	No
Check chock blocks, have the driver put the vehicle transmission in neutral, release all the brakes, ensure the air pressure is at maximum, turn engine off and ensure the key is in the "on" position	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Instruct driver to remain at controls	Valid—driver present	Valid—driver present	Invalid	Invalid	Valid	Invalid	Invalid	No
Step 14—Inspect Front of Tractor								
Check headlamps, turn signals (do not use four-way flashers to check turn signals) and all other required lamps for improper color, operation, mounting, and visibility	Valid—driver present	Valid—driver present	Valid—possibly electronic, but must include visual	Valid—possibly electronic, but must include visual	Valid	Valid—possibly electronic but must include visual	Valid—possibly electronic but must include visual	Partially
Check windshield wipers and washers for proper operation	Valid—driver present	Valid—driver present	Invalid—no driver	Invalid—no human	Valid	Invalid—no driver	Invalid—no human	Partially
Check the function of the horn	Valid—driver present	Valid—driver present	Invalid—no driver	Invalid—no human	Valid	Invalid—no driver	Invalid—no human	Partially
Step 15—Inspect Left Front Side of Tractor								
Check front wheel, rim, hub, and tire	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Step 16—Inspect Left Saddle Tank Area								
Check fuel tank area	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check exhaust system	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Step 17—Inspect Trailer Front								
Check air and electrical lines	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check driveline/driveshaft	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Step 18—Check Left Rear Tractor Area								
Caution: Never place yourself between tires of tandem axles								
Check wheels, rims, hubs, and tires	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check the lower, upper and slider components of the fifth wheel assembly	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check all required lamps	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Partially
Step 19—Inspect Left Side of Trailer								
Check frame and body	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check condition of hoses	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check van and open-top trailer bodies	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check cargo securement	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Step 20—Inspect Left Rear Trailer Wheels								
Check wheels, rims, hubs, and tires	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check sliding tandem	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Step 21—Inspect Rear of Trailer								
Check tail, stop, turn signals, all other required lights and lamps/flags on projecting loads	Valid—driver present	Valid—driver present	Valid, would need way to cycle lights	Valid, would need way to cycle lights	Valid, would need way to cycle lights	Valid, would need way to cycle lights	Valid, would need way to cycle lights	Partially
Check external ABS malfunction lamp	Valid—driver present	Valid—driver present	Valid, would need manual operation or self-check	Valid, would need manual operation or self-check	Valid, would need manual operation or self-check	Valid, would need manual operation or self-check	Valid, would need manual operation or self-check	Yes
Check cargo securement	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Step 22—Inspect Double, Triple and Full Trailers								
Check safety devices on full trailers/converter dollies	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check the safety devices (chains/wire rope) for improper repairs or missing components	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Inspect pintle hook, eye and drawbar for cracks, excessive movement and improper repairs	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Step 23—Inspect Right Rear Trailer Wheels								
Check as in Step 20				See Step 20 Comments				
Step 24—Inspect Right Side of Trailer								
Check as in Step 19				See Step 19 Comments				

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Step 25—Inspect Right Rear Tractor Area								
Check as in Step 18				See Step 18 Comments				
Step 26—Inspect Right Saddle Tank Area								
Check as in Step 16				See Step 16 Comments				
Step 27—Inspect Right Front Side of Tractor								
Check as in Step 15				See Step 15 Comments				
Step 28—Inspect Steering Axle(s)								
Note: Inform driver you are going under the vehicle. Enter the under carriage in view of the driver (at front of power unit, rear of power unit, and in front of trailer axle(s)).								
Check both sides of the steering system, front suspension, and front brake components	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check the front axle and frame components	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Mark pushrods on both sides (if applicable)	Valid—driver present	Valid—driver present	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Possibly
Step 29—Inspect Axles 2 and 3								
Check driveline/driveshaft	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Check frame components	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Check the suspension and brake components on both sides	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	No
Identify the size and type of the brake chambers and mark pushrods on both sides (if applicable)	Valid—driver present	Valid—driver present	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Possibly
Step 30—Inspect Axles 4 and/or 5								
Same as Step 29								
Step 31—Check Brake Adjustment								
Ensure air pressure is 90 to 100 psi (620 to 690 kPa)	Valid—driver present	Valid—driver present	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Possibly
Have driver fully apply brakes and hold	Valid—driver present	Valid—driver present	Invalid—no driver	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Invalid—no driver	Invalid—no driver	Possibly
Measure and record all pushrod travel and ensure brake lining to drum contact	Valid—driver present	Valid—driver present	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Valid, or Require Disk brakes?	Possibly
Listen for air leaks	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Yes
Step 32—Inspect Tractor Protection System								
Note: This procedure tests both the tractor protection system and the emergency brakes.								

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Ensure the emergency brakes are still released and have the driver disconnect both brake lines	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Possibly, automated system may be able to check this stop
Ensure the air stops leaking from the supply line	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	Possibly
Have driver give a full brake application	Valid—driver present	Valid—driver present	Valid, but need way to do it	Valid, but need way to do it	Valid, but need way to do it	Valid, but need way to do it	Valid, but need way to do it	
Listen for air leaks	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	
Have the driver reconnect the lines	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	
Step 33—Inspect Required Brake System Warning Devices								
Inspect the dash panel with key in the "on" position for the function of the ABS malfunction lamp(s) (if applicable)	Valid—driver present	Valid—driver present	Valid, need way to perform test	Valid, need way to perform test	Valid, need way to perform test	Valid, need way to perform test	Valid, need way to perform test	Yes
Ensure that the low air pressure warning device activates with the key "on" and the driver pumping the foot valve to exhaust air	Valid—driver present	Valid—driver present	Valid, could be automated (ECO Trac)	Valid, could be automated (ECO Trac)	Valid, could be automated (ECO Trac)	Valid, could be automated (ECO Trac)	Valid, could be automated (ECO Trac)	

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Step 34—Test Air Loss Rate								
With the engine running, the spring brakes released and the air pressure between 80 to 90 psi (551 to 620 kPa), have the driver apply the service brakes	Valid—driver present	Valid—driver present	Valid, could be automated to identify pressure loss	Valid, could be automated to identify pressure loss	Valid, could be automated to identify pressure loss	Valid, could be automated to identify pressure loss	Valid, could be automated to identify pressure loss	Possibly, automated system may be able to check this stop
Air pressure should maintain or build	Valid—driver present	Valid—driver present	Valid, could be automated to identify pressure loss	Valid, could be automated to identify pressure loss	Valid, could be automated to identify pressure loss	Valid, could be automated to identify pressure loss	Valid, could be automated to identify pressure loss	
Step 35—Check Steering Wheel Lash								
With the engine running, measure steering wheel lash while wheels are straight	Valid—driver present	Valid—driver present	Valid, automated with sensors	Valid, automated with sensors	Valid, automated with sensors	Valid, automated with sensors	Valid, automated with sensors	Possibly, automated system may be able to check this stop
Step 36—Check Fifth Wheel Movement								
Caution: If conducted improperly, this method of checking for fifth-wheel movement can result in serious damage to the vehicle. Use caution and instruct the driver carefully								
Remove the chock blocks and have the driver apply the spring brakes on the trailer	Valid—driver present	Valid—driver present	Valid, programmed into ADS operational system when in inspection mode	Valid, programmed into ADS operational system when in inspection mode	Valid, programmed into ADS operational system when in inspection mode	Valid, programmed into ADS operational system when in inspection mode	Valid, programmed into ADS operational system when in inspection mode	Possibly, depending if system allows manual inspection mode, could be programmed in

Task	Issue if Level 3 ADS	Issue if Level 4 ADS (Human Present, Driver)	Issue if Level 4 ADS (Human Present, Not Driver)	Issue if Level 4 ADS (No Human)	Issue if Level 5 ADS (Human Present, Driver)	Issue if Level 5 ADS (Human Present, Not Driver)	Issue if Level 5 ADS (No Human)	If Valid, Can this be Checked/ Communicated Electronically?
Check for excessive movement	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	
Ensure the spring brakes are operational on the trailer	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	
Step 37—Complete the Inspection								
Complete documentation	Valid—driver present	Valid—driver present	Valid	Valid	Valid	Valid	Valid	
Conclude with driver	Valid—driver present	Valid—driver present	Invalid—no driver	Invalid—no driver	Valid—driver present	Invalid—no driver	Invalid—no driver	
Follow correct and current out-of-service procedure (if applicable)	Valid	Valid	Valid	Valid	Valid	Valid	Valid	
Issue CVSA decal(s) (if applicable)	Valid	Valid	Valid	Valid	Valid	Valid	Valid	

Appendix B. Working Group Inspection Options Survey

B.1 Survey Form and Questions

Hello Working Group members:

Please find below the link to a brief, nonattributable survey of potential inspection options for automated driving system (ADS) equipped commercial motor vehicles (CMVs) developed through the work of this committee. For your convenience a survey synopsis is provided below and a copy of the eight (8) inspection options matrix worksheet is attached for reference.

Your input is invaluable as we determine inspection options to be provided to the Enforcement and Industry Modernization Committee in September 2019.

All individual responses will be anonymous to other Working Group members; only the technical team will have access to respondent name and organization. We encourage you to use the comment field provided in the survey for clarifications and/or follow-up discussion topics. Your responses will comprise the majority of our discussion during the August 8th Working Group Meeting.

We thank you, in advance, for your attention to this request!

SURVEY SYNOPSIS

Our Working Group identified eight options how inspections could take place with ADS equipped vehicles (with varying levels of automation); this matrix worksheet is attached for your reference. With the assistance of the Working Group, the executive team analyzed and narrowed the eight options to the following two recommended in the online survey:

- **Options #2** for SAE L1, L2, and L3* automation.
- **Option #7*** for SAE L4 and L5 automation vehicles.

Option #2 adds a new inspection step to the Level I inspection procedure (and other inspection levels, if applicable) instructing the inspector to conduct an **electronic inspection of the ADS overall system** (by indicator light, data readout or electronic message sent to an inspection tool or device, etc.; to be determined in future project phase). This approach is targeted toward vehicles with SAE L1, L2, and L3* *(see * below*) automation.

> *NOTE: One caveat to Option #2 is L1 and L2 trucks are currently sold today, with no indicators required (malfunction lamps other than ABS). Adopting this approach requires significant development of new standards for communicating ADS functional status (e.g., new FMVSS/FMCSR or industry established standard practice).*

Option #7* (*see * below*) **limits the inspection of ADS vehicles at the roadside**. Standard vehicle inspections could still apply, if necessary, but they should be limited.[65] Generally, this approach is suited for SAE L4 and L5 ADS functionality, such that even a vehicle with no human onboard, could be checked. Inspection would include origin/destination (or terminal) inspections including a holistic functional requirement check of the ADS system.

> * *L3 automation could potentially be accommodated in Option #7, provided the human driver's hours of service (HOS) compliance and enforcement can be accounted for in some manner.*

B.2 Survey Responses

CVSA surveyed members of its Automated Commercial Motor Vehicle (CMV) working group to inquire of whether they approved the inspection options identified by the group as the preferred inspection schemes for various levels of automation. Sixteen out of 20 voting working group representatives responded, including at least one response from each of five regions, local members, associates and Federal partners at FMCSA.

Question #4: Do you approve recommending Inspection Option #2 "Add new Step—electronic inspection of ADS overall system (by light, readout, electronic message to new inspection device, etc.)" for vehicles equipped with SAE L1, L2, and L3* automation capabilities? (Yes/No)

(16 of 17 approved.)

COMMENTS

- From associate members:
  - Suggest that the inspection time not take longer than conventional NAS inspections
  - Malfunction indicator lamps should be uniform
  - Does malfunction indication in the ADS result in a warning? Violation? OOS?
  - What if the driver turns off the ADS prior to inspection?
  - OOS needs to be defined for Levels 1, 2, and 3 automation to differentiate between a condition representing and imminent hazard and one in which a component of the ADAS has failed, but the vehicle is capable of being safely operated at a lower level of automation (including reversion to a Level 0 state).
  - OOS needs to be defined for when Levels 4 and 5 automation vehicles can be allowed to operate (safely) under remote control at or with a human operator sent to the scene at a lower level of

[65] Standard vehicle inspections would be limited to furtherance of an investigation, as the result of an incident, or some other special circumstance. Regular roadside inspections would not be conducted on these vehicles.

automation—example, when the ADS encounters a decision point that is not in its ODD and cannot resolve.

- From enforcement:
  - Should the malfunction or status lamp be checked for operational readiness if the driver was not using the technology at the time of the stop?
  - How can we impose a standard, and require it to work, when it is not being used on the vehicle?
  - From experience at roadside, drivers likely will not claim to have been using the technology at the time of an inspection.
  - The DOT 3.0 document discussed licensing of ADS equipped vehicles and a potential identifier. If there could be an identifier placed on the registration record, enforcement could use that to know when to check the operational readiness of the ADS system in L1 and L2, or any level of ADS system.
  - If the carrier is not going to use the ADS functionality of the vehicle, they could remove the identifier. The identifier would also then be available on an electronic inspection.

Question #5: Do you approve recommending Inspection Option #7 "Limit inspection of ADS vehicles roadside. Adopt an approach based on origin/destination (terminal) inspection model and have a functional requirement for an in-motion, or en-route, electronic inspection of an ADS equipped CMV, including the verification of its ADS status" for vehicles equipped with SAE L4 and L5 automation capabilities? (yes/no)

(15 of 17 approved.)

COMMENTS

- From associates:
  - We would support expanding terminal inspections today and into the future; however, fleets and drivers choose to equip their vehicles with ADS or non-ADS technologies to lead their roles in safety
  - The functional requirement for an in-motion e-inspection may not be an engineering design ADS suppliers and truck OEMs are looking at yet, if ever.
  - Regulation may be required before they invest more in these technologies and therefore how fleets and drivers pay for these systems IF looking to go down an ADS path.
  - Trailer condition will of necessity be a part of the "I'm OK" electronic inspection data package that is communicated. The Level 4 or 5 vehicle must be able to detect and react to trailer conditions (to be defined, including such as load shifting or other parameters than may constitute an imminent hazard).

- From enforcement:
  - I believe this inspection scheme will lead to a higher level of safety with ADS equipped vehicles than can be provided by random roadside inspections by enforcement personnel.
  - As far as enforcement manpower to conduct the occasional terminal inspection to verify quality of the safety program, the initially limited use of Level 4 and Level 5 automation vehicles is not going to overwhelm enforcement agencies.
  - As the technology expands, we can always revisit and adjust the requirements for enforcement. Down the road, I don't see the random checks happening all that often. The random checks were to help enforcement build their confidence in the ADS vehicles and the overall program since they cannot conduct their random roadside inspections.
  - Eventually, I envision occasional checks, just to keep everyone honest, and then targeted terminal inspections for those that had an incident or are demonstrating problems with their safety program.
  - I wouldn't include the requirement for electronic inspection while en-route at this point since the technology isn't available.
  - I would include it as an option as enforcements availability of electronic inspections becomes available.
  - If good pretrip inspections are done, by someone who is certified thru an enforcement accepted certification program, the en-routes are really not that important because if there are any issues within the technology used in the vehicle, which is the only thing that can be passed anyway, the vehicle would go into critical incident mode anyway. The main need of the pretrip is to visually inspect all the components that cannot be checked with technology.
  - Vehicle would be required to communicate (while in motion) that it has passed a “real-time” pass/fail check of electronically checked systems that are required in an “expanded NAS Level VIII.” This would be presented as a single malfunction indicator/message. Vehicle must be able to confirm it is operating within ODD while in motion. What are the requirements should the vehicle fail these automated checks? Return to operating base, pull off at safe location, etc.?