

Trucking Fleet Concept of Operations for Automated Driving System-equipped Commercial Motor Vehicles

Chapter 2: Demonstrations, Public Outreach, and Technology Refinement

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Abstract

Automated Driving Systems (ADS) are set to revolutionize the transportation system. In this project, the research team led by the Virginia Tech Transportation Institute developed and documented a concept of operations (CONOPS) that informs the trucking industry, government agencies, and non-government associations on the benefits of ADS and the best practices for implementing this technology into fleet operations.

To demonstrate the applications of ADS technology in day-to-day truck-driving tasks to fleet personnel and the general public, the research team provided audiences with first-hand experiences with ADS and showcased how this technology can improve truck driving safety, support drivers, reduce human errors, and optimize fleet operations at three major public events: the Intelligent Transportation Systems (ITS) America annual meeting (December 2021), the Technology Maintenance Council (TMC) annual meeting (March 2022), and the Commercial Vehicle Safety Alliance (CVSA) annual conference (September 2023). The research team also used opportunities at these conference events, attended by members of the trucking industry, to collect information on personnel expectations of ADS technology and what applications of the technology would be attractive to their operations.

Feedback on lessons learned from these events was also distributed on a rolling basis at various other academic conferences. The VTTI team attended over 20 conference sessions, sharing information about the project as it was obtained.

This report may be useful to fleets and drivers, policy- and decision-makers, ADS developers and original equipment manufacturers (OEMs), law enforcement, and the general public who will share the road with ADS vehicles in the future.

The following chapter has been extracted from the final report. For access to the full report, see this link: https://www.vtti.vt.edu/PDFs/conops/VTTI_ADS-Trucking_CONOPS_Final-Report.pdf

2. DEMONSTRATIONS, PUBLIC OUTREACH, AND TECHNOLOGY REFINEMENT

To support the CONOPS documentation and provide the trucking industry with clear information on how to implement ADS-equipped trucks among mixed fleets, VTTI hosted a series of roadshows and public outreach with support and participation from ADS partners. Pronto.ai partnered with VTTI during a live demonstration event and a ride-and-drive event. Kodiak Robotics, Inc., partnered at another event with VTTI to record and demonstrate an enhanced inspection for ADS-equipped CMVs. These were critical to enlightening stakeholders and users on the functionality, benefits, and limitations of ADS, as well as providing guidance to government, insurance, and inspection agencies and the public who are likely to shape policy in this area. The roadshows demonstrated how ADS can be implemented in trucking fleets in a manner that is (1) safe, (2) repeatable, and (3) commercially viable. Since ADS are new and most fleets have yet to encounter or operate an ADS, the outreach and roadshows provided opportunity for direct interaction with different technology solutions under development. Using existing contacts, three conferences and meetings, including the Intelligent Transportation Society of America (ITS America) Annual Conference, the Technology Maintenance Council (TMC) Annual Meeting, and the Commercial Vehicle Safety Alliance (CVSA) Annual Conference and Exhibition, were selected for the outreach and roadshow events. These events focused on providing the public with a focus on commercial fleet operators, with the opportunity to meet ADS technology developers and original equipment manufacturers (OEMs). The events also provided the attendees with opportunities to participate in hands-on technology demonstrations, such as in-vehicle demonstrations and closed-course roads. Feedback was also collected from attendees to understand their perception and acceptance of the technology and obtain insights on the potential use cases for different automation technologies and document their concerns that might be addressed in the CONOPS. The following sections provide extensive information on the three roadshows, including the participating technology vendor/OEM, exhibition booth experience, technical sessions, closed-course demonstration setup, and survey data collection on perception of the technology.

2.1 ROADSHOW – ITS AMERICA ANNUAL MEETING

The first of the three roadshows was held at the ITS America Annual Conference in Charlotte, North Carolina. This roadshow highlighted two testing demonstrations of ADS, including an interactive and behind-the-scenes look at ADS-equipped truck cross-country corridor operations (<https://www.vtti.vt.edu/PDFs/conops/Cross-Country.pdf>), as well as a port queuing demonstration highlighting the safe deployment of ADS technologies in port operations (<https://www.vtti.vt.edu/PDFs/conops/Port-Queuing-Brief.pdf>). Technical sessions were also held to provide information and answer questions related to the CONOPS project. A research brief was created to summarize the event and roadshow activities (<https://www.vtti.vt.edu/PDFs/conops/ITS-Roadshow.pdf>).

2.1.1 ADS Truck On-road Testing Demonstration

An interactive visualization of a prototype truck ADS database and map created from data being collected during the ADS cross-country operations was shown to the attendees. The visualization

allowed participants to experience the ADS truck driving a wide variety of Interstate highways and rating the highways based on the availability, quality, and strength of required supporting infrastructure. The behind-the-scenes presentations highlighted the ADS cross-country operations, including preparation, planning, training, data inputs, and real-world applications. Activities on the fleet instrumentation, setup, and measurement of metrics were presented to the attendees. Real-time data streams and performance metrics collected from the ADS-equipped trucks during the cross-country operations were also displayed at the demonstration. Attendees had the opportunity to ask questions and have a chat with a Pronto engineer who was monitoring the cross-country data collection from the ADS truck cab in real time. Lastly, a slideshow on the ongoing port queueing deployment was provided to attendees to illustrate how ADS-equipped trucks can relieve major congestion points in daily port operations (<https://youtu.be/DCs8uGJAuks>).

2.1.2 Highlights from the Technical Session

The technical session was given as an information session by a Pronto engineer. The session provided an overview on the existing knowledge gaps in ADS technology development, including the absence of a public dataset on the metrics required to measure the deployability of ADS-equipped trucks and how policy makers and ADS developers are presently relying on secondary data when developing automated vehicles (AVs). Following this, the presenter provided the CONOPS project objectives and how the project intended to fill some of these knowledge gaps by developing a first-of-its-kind national dataset of infrastructure readiness, developing ADS performance metrics required for autonomous operations, and demonstrating an automated truck safely traversing the United States, coast to coast, without a driver. The approach to ADS data collection, including driving automated trucks across routes under a variety of road conditions (traffic, weather, time of day) to measure infrastructure quality, and sharing this data, was presented to the attendees. Insights on the key infrastructure metrics (connectivity, lane marking quality, road bumpiness, and GPS satellite coverage) needed to support ADS integration on the various routes and how they were measured and rated were also presented. The session wrapped up with questions and answers, and attendees were directed to follow the project progress on the project website.

2.2 ROADSHOW – TMC ANNUAL MEETING

The second roadshow was conducted at the TMC annual meeting in Orlando, Florida. A research brief (<https://www.vtti.vt.edu/PDFs/conops/TMC-Roadshow.pdf>) and video (https://youtu.be/eBnlxkS7i_4) were created to summarize the event and roadshow activities. This featured an ADS-equipped truck running closed-course demonstrations, an exhibitor booth, and a technical session. The closed-course demonstrations involved a ride-and-drive to allow end users, stakeholders, and the public to experience ADS technology on closed test tracks and share information about their functionality, benefits, and limitations. The exhibitor booth showcased the ongoing overall CONOPS project and active deployments, including ADS Port Queueing and ADS Cross-Country Road Testing. VTTI personnel networked and interacted with attendees who visited the booth in the exhibit hall to further market the CONOPS project and disseminate information (<https://www.vtti.vt.edu/PDFs/conops/Tech-Brief.pdf>). Additionally, a video of the outdoor ride-and-drive was displayed at the booth to garner additional attention for the dynamic demonstration (<https://youtu.be/djWIsFFWw08>). On the other hand, the technical session



Figure 2. Photo. Work zone setup as part of the closed-course testing at the TMC Annual Meeting.



Figure 3. Photo. Unexpected crossing scenario at work zone.

Early signups for the ride-and-drive were available beginning one month prior to the event, and TMC organizers helped to disseminate the information by sending daily email blasts to the registrants. Over the course of the two-and-a-half-day conference, VTTI and Pronto conducted 54 ride-and-drive trips with a total of 161 attendees. Among the participants, 29.7% had a commercial driver's license (CDL), 17.8% worked as a CMV driver, and 70.3% had not previously experienced a commercial truck ADS. Figure 4 shows the distribution of the ride-and-drive participants based on their profession. To collect information from the attendees about their opinions, perceptions, and attitudes towards ADS applications in fleet operations, the VTTI team collected questionnaires both before and after attendee participation in the ride-and-drive. This allowed researchers to observe any changes in opinions and perception that could be attributed to their experience during the demonstration. A total of 101 paired pre- and post-roadshow

questionnaires were collected from the attendees who participated in the ride-and-drive. The questions obtained insights on their perception of the technology, such as the effectiveness, safety, desirability, cost-effectiveness, acceptability, performance, readiness for deployment, commercial viability, and integration into fleet operations.

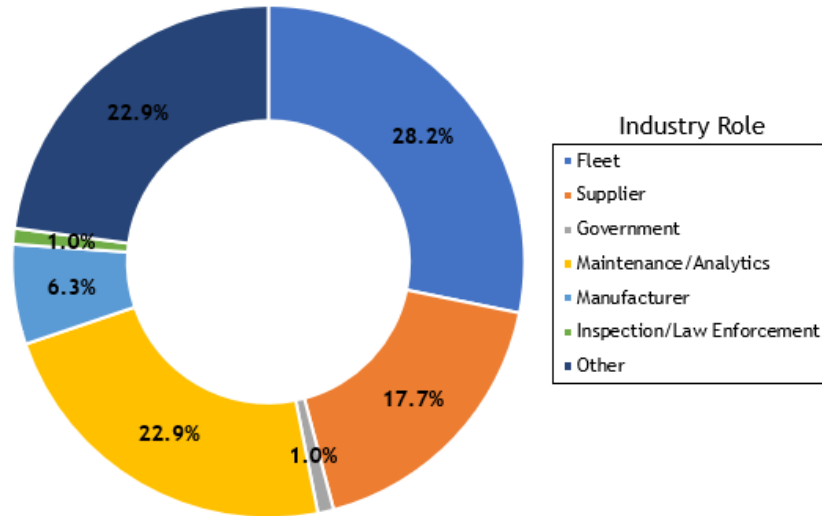


Figure 4. Chart. Ride-and-drive participant distribution based on industry role.

Figure 5 shows the responses to the survey questions, which were framed as pairs of polar opposites. Participants were asked to respond using a scale of 1 to 5, where “1” represented the first pole and “5” represented the second pole. Careful attention should also be paid to the questions, as the positive and negative valences of the responses were alternated between left and right in the pairings. In general, feedback from participants on ADS opinions and acceptance was positive and did not change drastically before and after demonstration participation. Specifically, questions on whether the technology was effective/superfluous, raising alertness/sleep inducing, unsafe/safe, cost-effective/too expensive, acceptable/unacceptable, performs well/performs poorly, and if training was difficult/easy received more positive responses after the demonstration. Questions on whether the technology was useful/useless, bad/good, irritating/likeable, assisting/worthless, or undesirable/desirable received a slightly less positive response. This could mean that more demonstration or exposure to use cases is required to have a much better judgment of the technology. Further, no changes were observed in the other survey responses. However, in all cases, all the responses were positive. Lastly, participants also requested future use case demonstrations, as shown in Figure 6. Participants were able to select multiple options for future demonstrations.

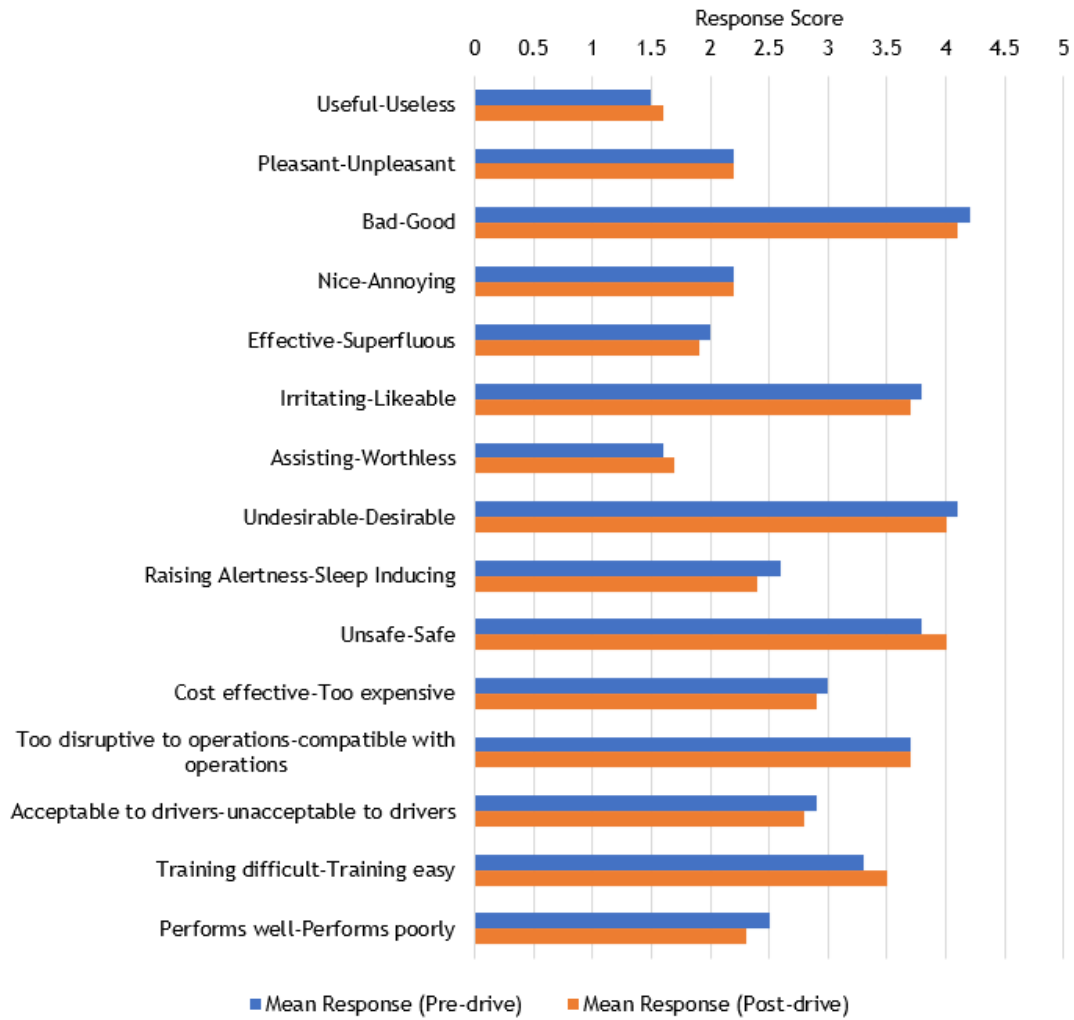


Figure 5. Chart. Participant responses to survey questions pre- and post-drive.

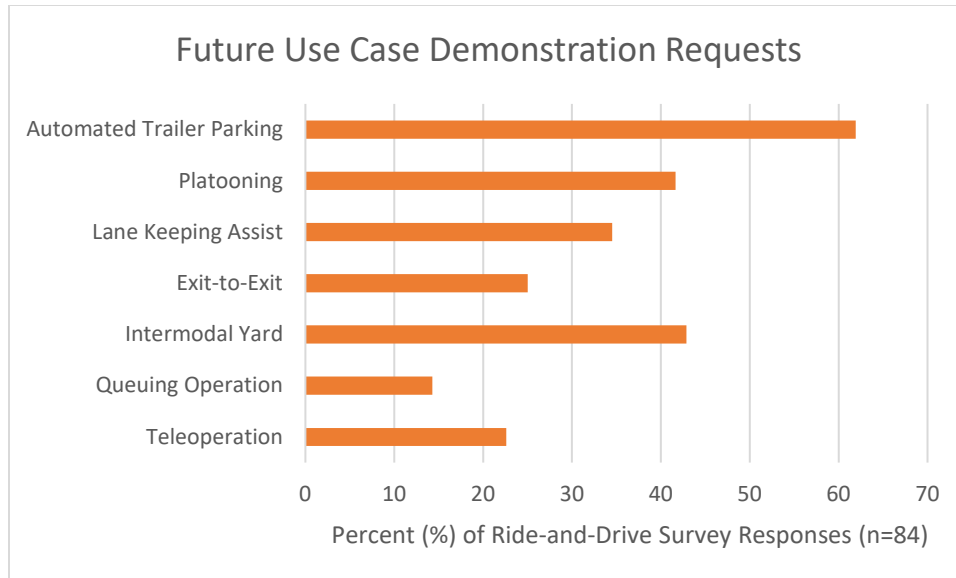


Figure 6. Chart. Future use case demonstration request.

2.2.2 Highlights from the Technical Session

The technical session was presented by a panel of experts involved in the CONOPS project and moderated by Tom Keane, Associate Administrator of the Office of Research and Registration at the Federal Motor Carrier Safety Administration (FMCSA). The assembled panel included experts in the automated commercial trucking industry to address important issues that fleets, shippers, brokers, State governments, and service/maintenance providers need to understand to plan for ADS deployment. Dr. Rich Hanowski, Division Director of Freight, Transit, and Heavy Vehicle Safety at VTTI, provided an overview of the active research project and pointed to some operating environments where automation might help drivers perform consistently and safely. Next, Jeff Loftus, Division Chief at the FMCSA Technology Division, shared information about the role that FMCSA is playing in supporting and guiding ADS trucking deployment. Jessica Kearney, Assistant Vice President at Travelers Institute, spoke about what the future of insuring ADS-equipped trucks may look like. Assuring that ADS-equipped trucks are well maintained through the right level of electronic and manual interactions was discussed by Will Schaefer, Director of Safety Programs at CVSA. Additionally, the fleet perspective was covered by Vice President of Maintenance at Bison Transport, Mike Gomes, who discussed his fleet’s experience with automation that supports drivers on the road. Finally, an expert who has watched the development of ADS vehicles for years, Ognen Stojanovski, Chief Operating Officer and Co-founder of Pronto.ai, discussed the beginnings of automation and where it can do the greatest good to support the safety and efficiency goals of every fleet.

2.3 ROADSHOW – CVSA ANNUAL CONFERENCE

The final roadshow was held at the CVSA Annual Conference and Exhibition in Grapevine, Texas, in September 2023. This roadshow focused on the CVSA Enhanced CMV Inspection Program. To capture early marketing footage and generate discussion prior to the roadshow activities, the research team conducted a site visit near Dallas, Texas, with Kodiak Robotics to

film, photograph, and document their protocols and the procedures surrounding their pilot of the Enhanced CMV Inspection Program. Technical sessions were also held at the conference with representatives from ADS developers and OEMs to discuss their experiences with the enhanced inspections and facilitate discussion about other important related ADS inspection topics. A research brief summarizing ADS-equipped trucks' inspection procedures (<https://www.vtti.vt.edu/PDFs/conops/ADS-CVSA-Brief.pdf>) and video (https://youtu.be/rcgJYd_gDnA) were created to summarize the site visit and roadshow activities.

2.3.1 Site Visit Activities

On Day 1 of the site visit, the research team (VTTI and FMCSA) worked with Kodiak and partners, the Texas Department of Public Safety (DPS) and Drivewyze, to film demonstrations of the electronic roadside verification communication procedures to highlight real-world applications and operational integration of the enhanced inspection standard. The demonstrations and filming took place along Interstate 45 and the weigh station in Wilmer, Texas. The team documented staged runs of the Kodiak ADS-truck driving on the interstate past the Wilmer weigh station to capture the truck wirelessly communicating the enhanced CMV inspection status, via the Drivewyze platform, to the DPS trooper monitoring the weigh station. The VTTI team set up multiple video cameras to capture different angles inside the truck cab (Figure 7). The team also captured the Drivewyze interface inside the weigh station to document the information communicated from the truck to the DPS trooper and how this messaging was received and displayed. During the demonstration, the Drivewyze team collected real-time data from their back-end interface and provided this to the VTTI team to help with data documentation and creation of the demonstration videos.



Figure 7. Photo. Internal view of truck cab.

To accompany the demonstrations, brief interviews were conducted with members of the Texas DPS and the Drivewyze team to gain their opinions and insights into the purpose, value, and next steps for the ADS enhanced inspection and electronic roadside verification communication

activities. The interviews provided an overview of Drivewyze's approach to the roadside screening of ADS-equipped trucks as they approach a stationary weigh station, including the development of software (Inspection Client) congruent with CVSA's enhanced pre-trip inspection procedures. The Inspection Client is the enhanced inspection that the CVSA-trained ADS developer goes through, certifying a defect-free inspection, before the truck is dispatched. The approach also includes inspection forms and public application programming interfaces (APIs) for data transfer from ADS developers to the Drivewyze AV database, which are then used for a pass/fail screen decision. Expectations on the potential benefits of the ADS enhanced inspection technology include reducing crashes stemming from human factors such as fatigued or aggressive drivers and improving overall highway safety.

On Day 2 of the site visit, the research team visited Kodiak's office and garage facilities in Lancaster, Texas, to demonstrate and document Kodiak's internal enhanced inspection procedures as an example implementation of the CVSA Enhanced CMV Inspection Program on their trucks. With CVSA's enhanced inspection certification program, other ADS personnel (not just law enforcement officers) are now able to complete training and certification to become certified inspectors. The industry is looking to developers, like Kodiak, to learn about the internal inspection processes and procedures in place at garage facilities and how these are being done thoroughly and efficiently prior to an ADS truck being dispatched. To document this, the VTTI team recorded a CVSA-certified inspector with Kodiak as he conducted a full enhanced inspection on a Kodiak truck. To highlight key elements of the enhanced inspection, CVSA recommended five areas to capture and reinforce the process. The following elements of the inspection were documented in detail with accompanying narrative from the Kodiak inspector: (1) interior checks including air loss/build up testing; (2) inspection of undercarriage and measurement of brakes under the CMV; (3) inspection of rear tractor and trailer lighting; (4) checking the securement and movement of the 5th wheel; and (5) checks of the ADS and components (i.e., cameras, lidar, radar, etc.).

Brief interviews were also conducted with the VTTI and the FMCSA teams to gain information on how these demonstrations support the research objectives of the CONOPS project as well as the future of ADS trucking. Team members from Kodiak were interviewed to discuss Kodiak's involvement in the ADS Enhanced CMV Inspection Program and how these programs support and advance ADS trucking initiatives. A comprehensive video documentation of the enhanced inspection process and interviews can be found on the project website (https://youtu.be/rcgJYd_gDnA).

2.3.2 Roadshow Activities

2.3.2.1 CONOPS Booth

VTTI sponsored a CONOPS booth in the exhibit hall that was staffed by project personnel for the duration of the conference to support the Enhanced CMV Inspection Demonstration. Project personnel spoke to attendees who visited the booth about the CONOPS project and how the CVSA Enhanced CMV Inspection Program and Electronic Roadside Communication activities supported the CONOPS goals. The video summarizing the site visit and roadshow activities was shown on a loop at the booth (https://youtu.be/rcgJYd_gDnA). Demonstration handouts (<https://www.vtti.vt.edu/PDFs/conops/ADS-CVSA-Brief.pdf>) and VTTI giveaway items were

distributed to attendees, and VTTI staff verbally advertised the Enhanced CMV Inspection Demonstration, which was held during the CVSA reception.

2.3.2.2 Enhance CMV Inspection Program Demonstration

The primary Roadshow activity demonstrated how ADS developers and OEMs are implementing the CVSA Enhanced CMV Inspection Standard within their operational policies and procedures. VTTI drove their newly refurbished Peterbilt truck and CONOPS trailer to Texas and showcased it in the CVSA exhibit hall for the demonstration. VTTI partnered with Kodiak Robotics and their Head of Service and Support and Hardware Manager, Matthew Cearnal, to demonstrate their procedures for implementing the Enhanced CMV Inspection within their fleet and daily operations. In addition to advising on the development of the CVSA Enhanced CMV Inspection training and certification program, Mr. Cearnal completed the training and is a certified inspector himself. The presentation and demonstration by Mr. Cearnal allowed attendees to consider questions they may want to address to better understand the program. Now that personnel are completing training and certification on enhanced inspections, what are the processes and procedures in place at shops? What does this business model look like? What do the in-transit versus dispatch inspections look like? How are certified inspectors completing these inspections efficiently? The demonstration was available during the opening reception, exhibit hall hours, and during lunch and midday breaks for the duration of the conference.

2.3.2.3 Enhanced CMV Inspection Program Presentation

The second element of the CONOPS roadshow demonstration at CVSA included a joint partner presentation at the Enforcement and Industry Modernization Committee Meeting to give ADS developers, OEMs, and fleets an opportunity to share their experiences with the Enhanced CMV Inspection Program and certification and training process. Presenters included Tom Kelly (FMCSA), Andrew Krum (VTTI), Kodiak (Brett Fabbri and Matt Cearnal), and Drivewyze (Miranda Leadbeater and Todd James). Mr. Kelly provided an overview of research of interest to the committee being conducted by FMCSA, including the CONOPS project. Mr. Krum presented an overview of the CONOPS project and showed the full video that was created during the June site visit to showcase the Enhanced CMV Inspection Program and electronic roadside communication activities and pilot program. Kodiak and Drivewyze closed the presentation with a discussion of their roles, perspectives, results and takeaways, and next steps from their pilot program. Topics of discussion during the presentations extended into other ADS inspection topics: What are the internal policies for checking the function of the ADS sensors and perception processors? How can the status of the vehicle's inspection be communicated electronically and securely? How will ADS-equipped trucks interact with roadside enforcement agents in emergencies? The presentation was well received by the committee and generated thoughtful discussions during and after the meeting.

2.4 CONFERENCES AND OUTREACH

Including these major outreach events and demonstrations, the research team spoke at and or attended 20 conference sessions to share information about the grant, collect new information, and provide feedback on lessons learned. These conferences covered topics such as automated

truck operations, maintenance, roadway metrics, ADS safety metrics, CMV inspections, sensors, insurance of CMVs, and global trucking automation research.