Federal Highway Administration

National Dialogue on Highway Automation: November 14-15, 2018 Infrastructure Design and Safety Workshop Summary

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16. Abstract The Federal Highway Administration (FHWA) initiated the National Dialogue on Highway Automation (National Dialogue) workshop series. The National Dialogue was a series of meetings held across the country to facilitate information sharing and to engage the transportation community in a conversation focused on how to integrate automated vehicles into the road network safely and efficiently. This document summarizes the key themes discussed among participants from the November 2018 National Dialogue workshop held in Dallas, Texas.		
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Acronyms and Abbreviations

ADS	Automated driving systems
AI	Artificial intelligence
AV	Automated vehicle
CADS	Cooperative automated driving systems
CARMA	Cooperative Automation Research Mobility Applications
DOT	Department of Transportation
EMS	Emergency medical services
FHWA	Federal Highway Administration
IOO	Infrastructure owner or operator
MPO	Metropolitan planning organization
MUTCD	Manual on Uniform Traffic Control Devices
OEM	Original equipment manufacturer
R&D	Research and development
SAE	Society of Automotive Engineers
SPaT	Signal phase and timing
USDOT	United States Department of Transportation

Overview

Automated vehicles (AVs) have the potential to transform the Nation's roadways. They could increase vehicle safety, improve transportation system efficiency, and enhance mobility for many people who may be unable to drive today. Although they offer a wide range of benefits, they may also introduce uncertainty for the agencies responsible for the planning, design, construction, operation, and maintenance of the Nation's roadway infrastructure.

In June 2018, the Federal Highway Administration (FHWA) initiated the National Dialogue on Highway Automation (National Dialogue), a series of meetings held across the country to facilitate information sharing and engage the transportation community in a conversation on how to safely and efficiently integrate automated vehicles into the road network. A diverse group of stakeholders provided input on key issues regarding automation. This input will help inform future and existing FHWA research, policies, and programs.

The National Dialogue series consisted of six national workshops each held in a different location and focused on a unique topic: policy and planning, data and digital infrastructure, freight, operations, and infrastructure design and safety. The workshop series kicked off with an introductory webinar in May 2018. More information about the webinar and meetings is available on the FHWA National Dialogue on Highway Automation website.[1]

Workshop Objectives

The FHWA identified several objectives for the workshop series, as follows.

- Gain an understanding of potential impacts of automated vehicles on national highway infrastructure, safety, policy, operations, and planning.
- Prioritize actions to inform the integration of automation into existing FHWA programs and policies.
- Create models for sustained information sharing among public agencies and the private sector. Support newly developed partnerships among these organizations and define a clear path of communication among FHWA and automation stakeholders.
- Gather insights from infrastructure owners and operators (IOOs) and inform the development of possible technical guidance actions at the Federal level.
- Validate or provide direction into highway research priorities and roles among FHWA, national partner organizations, industry, and State and local governments.

[1] https://ops.fhwa.dot.gov/automationdialogue/index.htm.

- Develop an engaged national community or coalition on integrating automated vehicles into the roadway system, using inputs from States, local governments, industry, and associations, alongside FHWA and other Federal agencies.

Infrastructure Design and Safety Workshop

The FHWA conducted a National Dialogue workshop on November 14-15, 2018, in Dallas, Texas. This workshop focused on the implications of AVs for the design and management of the roadway infrastructure and safety. Over 140 transportation stakeholders from industry, government, academia, and associations participated.

This document summarizes key themes that participants raised throughout the breakout sessions. The views in this document reflect participants' inputs and do not represent official positions, policies, or statements on behalf of FHWA or the U.S. Department of Transportation (USDOT).

Key Takeaways

Infrastructure Standards May Need Updates to Accommodate AV Technology

Existing infrastructure standards do not necessarily reflect the introduction of automated vehicles. As a result, they may require updates to accommodate new infrastructure requirements needed for AVs to operate safely and efficiently on public roads. Workshop participants emphasized the importance of reviewing infrastructure standards, such as the Manual on Uniform Traffic Control Devices (MUTCD) to assess needed updates. In addition, they discussed exploring a more flexible and nimble approach to updating and developing standards. Given the rapid pace of AV technology development, the standards development process may need to accelerate to keep pace with AV technology.

Infrastructure Changes and Funding Needs Remain Unclear

The specific infrastructure requirements for enabling AVs remain unclear. Some developers of AV technology have suggested that changes in the roadway design, condition, and level of maintenance can enable operations of AVs. Yet, other AV technology developers suggest that infrastructure changes are not needed because they are designing AVs to operate on the roadway infrastructure as it exists today. Participants discussed how IOOs seek greater clarity, not only on the infrastructure requirements and conditions needed to enable AV technology, but also the funding implications that may result from any infrastructure improvements. New funding mechanisms may need to be explored as AV infrastructure requirements become better understood.

Interactions Between AVs and Non-AVs Need to Be Better Understood to Ensure Safe Roadways

Automated vehicles will need to be able to interact safely with human drivers, bicyclists, pedestrians, and all road users. Participants noted how the vehicle fleet will likely remain diverse, including automated and non-automated vehicles, in the near future. As a result, AVs should have the capability to interpret the intent and movements of human drivers and other road users. In particular, human drivers and vulnerable road users often use nonverbal cues to communicate (e.g., hand signals). These types of interactions may require further exploration and should be considered in AV technology design.

Automated Vehicle Data Can Inform Safety and Infrastructure Management

Automated vehicles could generate large quantities of data that may benefit State and local agencies and the transportation community. Workshop participants discussed how AV-related data might allow them to identify the locations of traffic incidents, infrastructure in disrepair, and other roadway conditions that are otherwise not captured by conventional data collection methods. Infrastructure owners and operators, in particular, expressed an interest in having access to data generated by AVs, as the data could lead to improvements in infrastructure maintenance and traffic safety.

Communication Among Stakeholders and with the Public Will Be Critical for Safe and Successful Deployment of AVs

Workshop participants expressed an interest in facilitating more communication between IOOs and industry, especially those entities involved in developing AV technology. This could help inform what (if any) changes to infrastructure are helpful for supporting AV operations. Additionally, clear and consistent terminology is necessary to support open conversations between stakeholders and to better inform the general public. The general public may not always have access to understandable information on the nature of AVs and their capabilities.

Public Education, Engagement, and Training Are Critical for the Successful Implementation of AVs

Public acceptance of AVs should be a priority and can be addressed through education, engagement, and training. Various types of information could be useful for the public such as information on AV technology and its capabilities. Workshop participants suggested that creating a coherent messaging strategy about AVs, especially the safety benefits of AV technology, is important for adoption. Suggested methods to share information with the public included informational materials shared through State and local DOT and MPO channels, community workshops and demonstrations, and open communication about pilot testing. Multiple entities were suggested as potential leaders in this space, including the federal government, State and local governments, MPOs, educational or community institutions, associations, law enforcement, and industry.

Workshop Design

The workshop began with an overview presentation describing the National Dialogue and USDOT activities in automation. The overview presentation is available on the FHWA National Dialogue website.[2]

The workshop was divided into four different sessions designed to gather input from stakeholders:

- *Breakout Session 1*: Small group discussions focused on data needs and challenges for integration of AVs.
- *Breakout Session 2:* Small group discussions focused on digital infrastructure definitions and needs.
- *Collaboration Corner:* Informal interactive session where participants provided input at multiple stations, each focused on a distinct topic.
- *Breakout Session 3:* Group discussion focused on developing an action plan for the transportation community on automation.

USDOT representatives facilitated breakout session discussions at individual tables. Participants had 10-15 minutes to read and think about the discussion questions on their own, followed by group discussion. Information regarding the agenda, breakout session questions, and participants is included in the appendices of this document.

Breakout Session I: Safe Integration of Automated Vehicles

This section summarizes stakeholder discussion from the first breakout session. The following questions were asked:

- What can stakeholders do to assess and support safety as a priority when incorporating AVs into the roadway and highway systems?
- What safety challenges could be encountered by vulnerable road users, pedestrians, bicyclists, roadway workers, and emergency responders when sharing the road with AVs?
- How could existing roadway safety evaluation and safety planning tools be changed to address AVs? For example, how could crash modification factors be affected by the introduction of AVs?

[2] https://ops.fhwa.dot.gov/automationdialogue/index.htm.

Safety Is and Must Remain a Priority

Safety must remain a primary factor as AVs are widely introduced onto public roads. Yet, there was discussion among workshop participants regarding the right approach to ensuring the safety of AVs as they move through testing and deployment. Safety guidelines or standards for AVs could be developed and may provide guidance to State and local agencies wanting to ensure the safety of their roadways. Workshop participants stressed the safety mission of State and local transportation agencies and the need to balance potential safety benefits offered by AVs with any potential risks.

Safe Interaction with All Human Road Users Is a Key Challenge

The ability of AVs to interact safely with all road users is critical for public safety and acceptance. Yet, there was significant discussion around whether an AV can effectively and consistently recognize the intent of human drivers, cyclists, and pedestrians. Workshop participants asked for more information about the capability of AVs to safely detect and respond to other road users and to abnormalities in the roadway environment (e.g., damaged traffic signs, potholes). Other suggestions included possibly creating standards for the interactions between AVs and other road users, saying that such standards would help enable AVs and humans to abide by an agreed-upon set of rules.

AVs May Not Be Able to Navigate Complex Roadway Conditions

Certain complex infrastructure designs, road conditions, and operational environments may be challenging for AVs to navigate safely and efficiently. Several participants cited inclement weather, work zones, and railroad crossings as probable challenges to AVs and their object detection and navigation capabilities. Rail representatives specifically discussed the need for AVs to be able to recognize at-grade crossings, because these are complicated roadway environments that are challenging to navigate. During the discussion, examples of suggestions to address these challenges included equipping work zone personnel with sensor vests detectable by AVs and providing access to standardized, accurate, and real-time data regarding roadway conditions.

Data Is Critical for Evaluating the Safety of AVs and Its Implications for the Roadway

Data is an important component in the safety evaluation of AVs. Workshop participants discussed a range of data that could help identify the safety benefits and performance of AVs. Some noted how this information could help support improved infrastructure planning and assess investments in existing or planned safety countermeasures. In addition, some suggested that AVs also represent an opportunity for broader data collection, and AVs can be a significant source of safety and road quality data for IOOs. For example, AVs could identify through their driving patterns where unreported crashes have occurred and where potential hazards in the road are located.

Existing Roadway Safety Evaluation and Safety Planning Tools May Need Updates for AVs

Current safety models and tools may need updates to incorporate the safety benefits of AVs. Updated models and tools can help IOOs better understand the safety impacts of AVs and plan for future infrastructure improvements. Several participants mentioned the need to develop new crash modification factors, particularly in areas with high levels of AV fleet penetration. A crash modification factor is used to estimate the expected number of crashes after implementing a countermeasure on a road or intersection.

Safe Incident Management Practices and Protocols for AVs are Needed

Automated vehicles should have the ability to conduct safe interactions with emergency response vehicles and other incident management personnel as they operate on public roads. For example, an AV should be able to recognize an oncoming emergency response vehicle and move safely to the side of the road. To address these types of scenarios, workshop participants suggested that emergency responders have clear protocols and incident management practices for interacting with an AV at the incident site.

Workshop participants also noted how an AV without a human operator present should be able to navigate potential failures safely on public roads. There was significant discussion regarding the ability of AVs to transition to a 'fail safe' mode that does not disrupt traffic flow or create a safety hazard. For example, an AV should know to pull over to the side of the road or shoulder rather than stopping in the middle of the road. Key questions asked by participants included:

- Can AVs identify an upcoming or current maintenance concern? Can AVs tell the difference between critical and non-critical system failures?
- In the event of a critical failure, how will AVs navigate away from the road? Where can malfunctioning AVs safely stand by for assistance?
- To whom does the AV communicate this failure? Who is responsible for responding to AV failures?

Breakout Session II: Infrastructure and Automated Vehicles

This section summarizes the stakeholder discussion from the first breakout session. The following questions were asked:

- What are the long- and short-term impacts of AVs on roadways and structural infrastructure? For example, what are impacts of truck platooning on bridges, pavement rutting, etc.?
- What are possible changes in structural and operational infrastructure design and asset management practices to address AVs and how could they be implemented?
- How will these changes impact existing standards, manuals, and other national guidance for highway design, highway maintenance, and traffic control?

Infrastructure Standards Development and Updates Should Become More Nimble and Flexible to Keep Pace with AV Technology

Existing infrastructure standards may need to be modified to meet the needs of rapidly changing technology, but the development of (or update to) a standard can take years to complete. As more automated vehicles enter the fleet, participants were concerned that standards such as the Manual of Uniform Traffic Control Devices (MUTCD) may have difficulty meeting the needs of the rapidly changing technologies in automated vehicles. As a result, several suggested pursuing a more flexible and nimble standards approach to adapt to AVs and other emerging transportation technologies. This could include shorter periods between standards updates, for example. Finally, as standards and guidebooks are revised, State DOTs may also need to update their asset management plans more often.

Consistency in Infrastructure Standards Can Support Seamless AV Operation Across Geographic Boundaries

Although national standards exist, such as the MUTCD, they allow for flexibility and options. Infrastructure owners and operators implement their own versions of these standards, which can include slight variations. Workshop participants expressed that greater consistency in standards and the adherence to them can support AVs to efficiently operate between geographic boundaries. For example, certain roadway elements, such as signage and line striping could be more consistent (the MUTCD includes standards for four-inch and six-inch line striping).

Built Environment Must Support Changes in Traffic Composition and Roadway Use

As AVs are more widely integrated onto the roadway infrastructure, the design of roads, bridges, and pavements may need to change. Several examples suggested by participants included: development of AV-only lanes added to limited-access roadways, different bridge designs to accommodate vehicle platoons, and variations in curb design to allow for less parking and more

pick-ups and drop-offs. Others identified pavement rutting as a potential concern if there is no wheel path variation among AVs. Although these infrastructure design changes may not be necessary in the near future, participants generally agreed that road infrastructure design guides may require revisions to reflect changes in the use of the roadways.

Infrastructure Considerations for Truck Platooning Applications Require Further Research

The nature of automated truck platooning applications may introduce different challenges for pavement maintenance, bridge design, and ramps. Truck platoons were identified as potentially causing load issues for bridges, as they were not initially designed with automated platoons in mind. Some participants noted that truck platoons could also affect the harmonics of a bridge, which could ultimately lead to a collapse. Traveling through ramps, at-grade railroad crossings, and congested roadways were also identified as specific scenarios where truck platoons could interrupt traffic flows, causing queues and crashes. Overall, workshop participants stated the need for more research and testing in this area to better understand how automated truck platooning applications could be integrated safely into the existing roadway infrastructure.

Actively Engaging with and Having Transparency in Asset Management Plans Can Also Support AVs

Workshop participants discussed the importance of actively engaging with asset management plans, including comprehensive asset inventories. Several expressed that IOOs could have more frequent inventory and condition assessments to enable their asset management systems to better reflect real-world conditions and to support improved decision making. Some noted that, as AV technology advances, data collected by AVs could support the inventory and conditions assessments. To provide the conditions that AVs may need, IOOs may need more proactive asset management. Additionally, participants noted that IOOs need to be more transparent about their asset management plans and communicate with stakeholders about the decision-making process. Participants suggested that many stakeholders, including OEMs and the public, often do not understand why one infrastructure project is occurring instead of another. In addition, AV industry stakeholders could benefit from seeing DOT guidelines for asset management, as some may not necessarily understand how asset management is performed.

OEMs and IOOs Should Communicate to Provide Consistent Digital Representations of Infrastructure

In addition to the importance of physical infrastructure, the digital environment could be equally important in the success of AVs. Workshop participants suggested that IOOs and industry should work together to develop a consistent base map and representation of the built environment used for AVs. Yet, the discussion revealed significant uncertainty around such a development and how it would be funded. Overall, a knowledgeable workforce is required to develop and maintain the digital infrastructure, which participants suggested should be a consideration for public agencies as they explore their future workforce needs.

Understanding the Necessary Infrastructure Condition for AVs and Available Funding Remains a Gap

It remains unclear how much of the existing infrastructure should be improved to facilitate the widespread integration of AVs, if at all. Entities developing AV technology are designing the systems to be able to function fully on the current roadway infrastructure as it exists today. Most participants sought more research to determine whether infrastructure minimum conditions should be considered. Yet, there was significant concern about funding constraints and the ability of IOOs to fund any necessary infrastructure improvements for AVs. Participants pointed to how fiscal uncertainty poses a challenge for planning investments in the long term.

Collaboration Corner

Format

The Collaboration Corner consisted of a career-fair-style setup with seven stations for collecting different types of information from stakeholders. This setup encouraged a highly interactive session, with participants on their feet and moving from station to station. USDOT staff members were located at each station to encourage participation, clarify the exercise, engage in discussion, and ask follow-up questions. Participants were allowed to move at their own pace but were provided with informal prompts to move to a new station every 15 minutes. Information was collected at each station through two methods:

- **Sticky note exercise**—Attendees used sticky notes to respond to a specific prompt, which was presented on posters at each station. This was a public form of communication that allowed attendees to view and engage with their colleagues' suggestions.
- **Suggestion box**—Participants wrote their questions, suggestions, or other input on an index card and placed it into a suggestion box. This was a more private form of communication that allowed attendees to provide information that they may not have been comfortable sharing in a public forum.

Modernizing Infrastructure for AVs

At the *Modernizing Infrastructure for AVs* station, participants discussed the following three questions:

1. How do physical infrastructure and AVs support and challenge one another?
2. How do digital infrastructure and AVs support and challenge one another?
3. How can existing manuals and standards be updated to address AVs?

Table 1 summarizes their responses.

Table 1. Participant Input: Modernizing Infrastructure

Physical Infrastructure	
Connectivity dependencies	Connectivity will depend on power supply and the smooth operation of specific technologies such as 5G.
Data collection using vehicles	AVs can potentially support infrastructure maintenance and the overall system by collecting and communicating specific data (e.g., sending real time data on roadway conditions to IOOs).
Design goals	Various stakeholders need clarification on the expectations of the transportation system they are designing.
Funding concerns	Concerns spanned a range of topics, such as: • Who pays for vehicles to communicate to infrastructure? • How will the future system be financed? Most States and communities currently struggle to maintain existing assets to the desired standard.
Helpfulness of infrastructure	Physical infrastructure can be helpful to AVs by providing visual landmarks for navigation and real time communications about the state of the system (e.g., work zones, signals, incidents, etc.).
Lack of stakeholder guidance	IOOs and OEMs were identified as stakeholder groups that need further guidance about standards, installation, and cost recovery plans specific to AV infrastructure.
Lack of uniformity	The patchwork of infrastructure conditions poses problems as vehicles move from one jurisdiction to the next.
Digital Infrastructure	
Limitations of digital infrastructure	Need to address the accuracy and consistency of digital maps and the coverage and reliability with respect to communication systems.
Mapping methods	Thoughts and questions about how maps might be generated and implemented, included: • Should there be one true digital map all companies use, or should there be redundancy? • Private sector does all the heavy lifting on digital mapping (private sector easily adapts) • Crowdsource mapping system may be possible.
Purpose	Is the purpose of digital infrastructure to be a redundant failsafe?
Manuals and Standards	
Acknowledge both the human and the machine	Develop manuals and standards that clarify the similarities and differences between the machine driver and the human driver (e.g., machine vision versus human) and support infrastructure systems that meet the needs of both.
Crashworthiness	Protocol are needed to establish the crashworthiness of AVs and their components.
Intermodal and multimodal	Address the interfaces that enable a system that is both intermodal and multimodal (e.g., connectivity of automated driving systems with vulnerable road users).

Minimum requirements	Provide the minimum requirements for AVs to operate in a variety of different conditions (e.g., minimum visibility requirements for road markings in rain).
More frequent updates	The update cycles for manuals should be shorter.

FHWA AV Research Showcase

At the *FHWA AV Research Showcase*, a team of directors from the FHWA Office of Operations Research and Development (R&D) presented videos and fact sheets about their current research initiatives. The showcase focused on their Cooperative Automation research, which investigates platooning, speed harmonization, lane changing, and other capabilities of vehicles that can communicate with other vehicles and infrastructure. Special emphasis was placed on CARMA: the Cooperative Automation Research Mobility Applications[3] technology. CARMA is an open-source software platform that has enabled the testing of use cases for cooperative automated driving systems (CADS). The platform is an example of an innovative and collaborative project built using an agile software development approach within a diverse community of stakeholders. CARMA is available for download on the software development platform GitHub. FHWA anticipates that this open-access tool will continue to support industry collaboration and CADS testing to improve the safety and efficiency of transportation systems.

Participants provided feedback on FHWA's existing research portfolio as well as suggestions for future research. A summary of their input is in Table 2.

Table 2. Participant Input: Research Suggestions

Participant Input on Research Suggestions
• How automation will change land use patterns and community development. • How to best educate various stakeholders about AVs (e.g., drivers, all other road users, IOOs, regulators, elected officials, etc.). • How to establish tools that enable peer exchange (e.g., universal code for digital platform, clearly defined terminology). • How automation and platooning potentially impact human factors (e.g., level of exhaustion of a human driver whose truck is part of platoon). • How to test AV detection of and interaction with motorcycles. • How AVs might interact with rail.

[3] https://highways.dot.gov/research/research-programs/operations/CARMA

Roadway Safety Challenges for AVs

At the *Roadway Safety Challenges for AVs* station, participants discussed the following two questions:

1. What are safety challenges with AVs?
2. What tools, strategies, analysis should be explored to address safety challenges?

Table 3 summarizes their responses.

Table 3. Participant Input: Roadway Safety Challenges

Safety Challenges	
Communicating roadway changes	How are updates made to an area that has already been mapped for AVs (e.g., day-to-day changes such as work zones or new turn restrictions)?
Difference between human and machine driver	• Relative rigidity of the machine • The behavior of humans in traditional vehicles has influenced safety countermeasures up until this point; how will machine driving behavior differ, and what will this mean for safety countermeasures?
Health and safety related to AVs	What are the health and safety risks that accompany: • Regular, everyday exposure of passengers to AVs? • Exposure of fire/emergency medical service (EMS) personnel to AVs that have been involved in an incident?
Incidents and special situations	• Interaction with first response • Communication networks during power loss • Weather and other special events • Work zones • Dark intersections
Mixed fleet composition	How to ensure that AVs safely interact with a diverse and changing composition of other vehicles; developers might work with traffic compositions that vary by the percentage of AVs.
Safety Benefits	What's good enough? Questions were posed regarding what improvement in safety is good enough to allow AVs on the road. Is it simply a reduction in total vehicle crashes?
Tools & Strategies	
Backup power	Provide backup power systems to mitigate the risk of power loss.
Incident data	• Real-time and robust incident data • Work zone data • Incident data captured by an AV's "black box" (obtained post-incident)

Researching safety countermeasures	These countermeasures can be further researched through new safety data and potentially through a cost/benefit analysis.
Standardization	As a strategy to improve several areas, including: • Performance metrics • Submission of infrastructure changes to cloud • Physical infrastructure requirements • Road readiness of AV system
V2I	Connectivity as a tool to improve system safety

Workforce and Organizational Development

At the *Workforce and Organizational Development* station, participants discussed the following questions:

1. What are your workforce development needs?
2. What kind of technical assistance is needed to address AVs?
3. What guidance would be useful to address AVs?

Table 4 summarizes their responses.

Table 4. Participant Input: Workforce and Organizational Development

Workforce Development	
Preparing workforce for change	Train the employees enabling the current transportation system about the new capabilities required to enable the future system.
Cultivate expertise	• Human factors in context of AI (artificial intelligence) • Data management and analysis • Virtual simulation • Sensors • Communication of science and technology • Internet of things
Technical Assistance	
Computer vision/ programming transparency	Transportation officials want to understand how computers see and make decisions so they can design and manage infrastructure better.
Training for emergency responders	• What to do and not to do responding to AVs • Health and safety risks (e.g., potential exposures) • Necessary personal protective equipment
Guidance	
Customized for various organizational levels	Requests that guidance be customized for specific audiences (e.g., National strategy, metropolitan planning organizations (MPOs)/local planning, State infrastructure, EMS training).

Knowledge exchange	Need help seeking perspectives from a variety of groups and cultivating relationships between various groups (e.g., State/MPOs/local officials and AV developers).
Planning and design	Help design roadways to accommodate AV requirements and behavior.

Terminology

Participants shared the most common terminology that they hear when discussing AVs and indicated which terms are helpful and which are confusing. They placed these terms along two axes to show how these terms are used. The vertical axis represented the frequency with which these terms are used, and the horizontal axis represented the level of confusion surrounding the use of these terms. Table 5 illustrates the terms placed into each quadrant.

Table 5. Participant Input: Terminology

More Confusing	
5G (fifth-generation network for cellular mobile communications)	Connected vehicle
ADAS (advanced driver assistance systems)	Disengagements
AI (artificial intelligence)	Fallback conditions
Alphabet soup of agencies	Machine vision
Automated	Robots
Autonomous	RSM (roadside safety message)
Autonomous is wrong	SPaT (signal phase and timing)
BSM (basic safety message)	SAE (Society of Automotive Engineers) levels
Chaperone	Operational design domain
Connected	
Clear	
ADS (automated driving systems)	SAE levels
C-V2X (cellular vehicle to everything)	Safety driver
DSRC (Digital short-range communications)	SCMS (smart city management system)
I2V (infrastructure to vehicle)	Simulation
J2735 (SAE standard for dedicated short-range communications)	SPaT and Map Data (MAP)
Mapping	TOSCo (traffic optimization for signalized corridors)
MUTCD (Manual on Uniform Traffic Control Devices)	V2I (vehicle to infrastructure)
OEM (original equipment manufacturer)	V2V (vehicle to vehicle)
OBU (onboard unit)	V2X (vehicle to everything)
RSU (roadside unit)	

Parking Lot

Any remaining questions and comments that did not cleanly fit into the other topic areas were included in this topic area. Topics included:

- How legal and insurance industries should collaborate.
- Collaboration between agencies of the USDOT to provide optimal solutions.
- How the airline industry can guide planning and deployment for AVs.
- Need for an FHWA-led vision for planning near-term implementation.
- Need for considering train detection at passive crossings.
- Consideration of whether AVs may need to be marked or identified in a way that is obvious to other human drivers.
- Assessing how to keep the driver engaged at appropriate levels of automation.

Breakout Session III: Action Planning Discussion

This section summarizes feedback from stakeholders who participated in the final breakout session focused on developing an action plan around safety and infrastructure design for AVs. Key suggestions from this discussion included the following:

- Demonstrate safety benefits of technology using specific use cases to increase public acceptance.
- Update the MUTCD to clearly communicate safety parameters and priorities.
- Facilitate collaboration and conversation across private industry and government agency boundaries. Lead an overarching stakeholder coordination committee to develop standards and guidance.
- Host a conference for early adopters of AV pilots.
- In collaboration with private industry and other government agencies, develop guidance to support both digital and physical infrastructure needs (e.g., define common operating platform for data exchange, define baseline infrastructure parameters and minimum standards).
- Develop an education strategy that achieves the following objectives: education of the general public, capacity building for the future workforce, and training for current workforce of key stakeholders.
- Create a clearinghouse to serve as a resource and to share best practices.
- Convene OEMs, IOOs, and other stakeholders to determine funding mechanisms for new infrastructure needs.
- Develop a framework for incremental implementation of AVs that clarifies various areas of readiness (e.g., scorecard to validate roadway readiness for AV deployment).

- Conduct a pooled fund study on infrastructure including University Transportation Centers, States, and OEMs.
- State and local DOTs take inventory of infrastructure assets both to update asset management plans and to create 10-year plans to improve infrastructure to support AVs.
- Build a comprehensive, centralized warehouse of information on automation.

Conclusion

The National Dialogue on Highway Automation Workshop provided FHWA with diverse input about various issues and opportunities surrounding the integration of automated vehicles into the roadway system. Input provided from participants will inform FHWA policies, research, and programs. Infrastructure design and safety issues were also discussed in the other National Dialogue workshops and will continue to be important in the national conversation to advance roadway automation readiness. Additional information regarding the workshop series and related initiatives is available on the FHWA National Dialogue website.[4]

[4] https://ops.fhwa.dot.gov/automationdialogue/

Appendix A: Participants

Nearly 140 participants from 97 organizations attended the workshop.

3M	Houston-Galveston Area Council	Road Infrastructure Inc.
AASHTO	Iteris, Inc.	Sam Schwartz Consulting
AIA Engineers	Jacobs	Stantec
American Motorcyclist Association	JM Engineering, LLC	State of Texas
ARA	KCS	Surface Preparation Technologies, LLC
Arcadis	Kimley-Horn and Associates	Texarkana MPO
ADOT	Lee Engineering	TTI
ATSSA	Louisiana DOTD	Texas DOT
Barnes & Thornburg LLP	Maricopa Association of Governments	The Dow Chemical Company
Blyncsy	MCC	Town of Flower Mound
BNSF Railway	MDTA	Toyota
Bowman Engineering & Consulting	Mercer Strategic Alliance	TransCore
CAMPO	Merriweather Advisors	Transpo Group
Center for Transportation Research, UT	Michael Baker International	Transport Canada
Center on Disability and Development	Minnehaha County, SD	Transurban
Citel US	Minnesota DOT	TranSystems
City of Arlington	MRF	Trevilon, LLC
City of Bellevue	NACFE	TTI
City of Frisco	National Asphalt Pavement Association	University of Hawaii
Colo. Dept. of Transportation	NCTCOG	University of North Texas
Columbia	NHTSA	University of Texas
County of Travis	Nissan North America	University of Virginia
CSX	Noblis	UPRR
CTC, Inc.	Nokia	USDOT/Volpe Center
DART	Old Dominion University	UT Austin
Drive.ai	Olsson	VHB
ECIA	PEMCCO Inc.	Virginia DOT
FHWA	PTV Group	Virginia Tech Transportation Institute
Ford	Purdue University	Voxel51
General Motors	R. C. Ice and Associates	WA DOT
HDR, Inc.	REACH of Plano	WSP, USA
HNTB	RK Deering & Assoc.	ZincFive Inc.

Appendix B: Workshop Agenda

Day 1: Wednesday, October 24, 2018

Time (CT)	Agenda Item	Name
12:30 PM	**Registration & Sign-In**	
1:00 PM	**Welcome & Introduction**	Al Alonzi - Division Administrator, FHWA - Texas Division
1:05 PM	**Opening Remarks**	Darran Anderson - Director of Strategy and Innovation, Texas Department of Transportation
1:15 PM	**National Dialogue Overview**	Michael Griffith - Director, Office of Safety Technologies, FHWA
1:30 PM	**Small Group Session 1:** *Safe Integration of Automated Vehicles*	1. What can stakeholders do to assess and support safety as a priority when incorporating Automated Vehicles (AV) into the roadway and highway systems? 2. What safety challenges could be encountered by vulnerable road users, pedestrians, bicyclists, roadway workers, and emergency responders when sharing the road with AVs? 3. How could existing roadway safety evaluation and safety planning tools be changed to address AVs? For example, how could crash modification factors be affected by the introduction of AVs?
2:50 PM	**Small Group Session 1 Report Out**	All Participants
3:30 PM	**Break**	
3:45 PM	**Collaboration Corner**	1. **Modernizing Infrastructure for AVs:** Updating standards and manuals 2. **FHWA AV Research Showcase:** Highlighting FHWA research activities 3. **Roadway Safety Challenges for AVs:** Interacting safely with the roadway infrastructure 4. **Workforce and Organizational Development:** Preparing State and local agencies 5. **Terminology:** Building our lexicon around highway automation 6. **Parking Lot:** Questions and comments that do not cleanly fit at any of the other posts
5:00 PM	**Wrap Up**	John Corbin - Office of Transportation Management (HOTM), Connected/Automated Vehicles and Emerging Technologies Team, FHWA
5:30 PM	**End of Day 1**	

Day 2: Thursday, October 25, 2018

Time (CT)	Agenda Item	Name
7:30 AM	**Registration & Sign-In**	
8:00 AM	**Kick-Off Day 2**	Brian Fouch - Director, Office of Preconstruction, Construction and Pavements, FHWA
8:20 AM	**Small Group Session 2:** *Infrastructure and Automated Vehicles*	4. What are the long and short-term impacts of AVs on roadways and structural infrastructure? For example, what are impacts of truck platooning on bridges, pavement rutting, etc.? 5. What are possible changes in structural and operational infrastructure design, and asset management practices to address AVs and how could they be implemented? 6. How will these changes impact existing standards, manuals, and other national guidance for highway design, highway maintenance, and traffic control?
9:30 AM	**Small Group Session 2 Report Out**	All Participants
10:00 AM	**Break**	
10:20 AM	**Preparing for Automated Vehicles:** *A Panel Discussion*	*Moderated by James Pol - Technical Director of Safety R&D Office of Safety R&D, FHWA* • Darran Anderson - Director of Strategy and Innovation, Texas Department of Transportation • Ken Smith - Corporate Scientist, 3M Transportation Safety Division • Bill Duguay - Executive Vice President, J.D. Abrams; ARTBA Representative • Michael Morris - Director of Transportation, Department of Transportation, North Central Texas Council of Governments
11:30 AM	**Lunch (not included)**	
1:00 PM	**Small Group Session 3:** *What's Next?*	a) Developing the Moonshot b) Near-Term vs. Long-Term Actions c) Federal, State, Local Roles
2:30 PM	**Wrap Up**	John Corbin - Office of Transportation Management (HOTM), Connected/Automated Vehicles and Emerging Technologies Team, FHWA
3:00 PM	**End of Day 2**	

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