Connected and Autonomous Vehicles

Workshop Summary Report

"What Agencies Need to Do for the Connected and Autonomous Vehicles of Tomorrow"

12/11/2017 – 12/12/2017

 I-95 Corridor Coalition

Contents

Introduction

The I-95 Corridor Coalition organized a workshop at the end of 2017 to bring together representatives from the 17 state departments of transportation (DOTs) that comprise the I-95 Corridor Coalition to discuss, "*What Agencies Need to do for the Connected and Autonomous Vehicles of Tomorrow*." In the midst of fast-paced advances in technology, agencies are interested in charting a coherent path that supports the needs of the agency, the public at large, and connected and autonomous vehicles (CAV) industry players. In the interest of peer learning to support development of such approaches, the I-95 Corridor Coalition organized this workshop. Agency representatives were encouraged to:
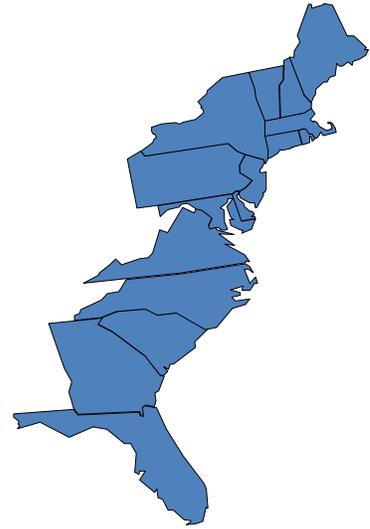
- Share CAV-related activities,
- Identify challenges and potential solutions, and
- Define a set of implementation steps for agencies and the region/Coalition.

By bringing together Coalition members exclusively, the workshop was an opportunity for participants to share experiences honestly. In doing so, the larger discussion around the potential of CAVs was distilled into a coherent discussion that led to a set of implementation steps grounded in real-world needs.

The workshop and other activities like it are important forums for building upon what states are already doing related to CAVs. Understanding lessons from others streamlines agency activities and can inform the FHWA approach as well. There is potential for the Coalition to be the leading voice because it represents diverse areas that produce 40 percent of the nation's gross domestic product. By providing clear direction, the Coalition can impact CAV deployment approaches in a transformative time.

Participants came from the 17 member DOTs. They included staff from a various levels and disciplines within each agency to bring a diverse set of perspectives into the discussions. Most of the 17 DOTs were represented along with representatives from other agencies such as the Maryland Transportation Authority (MdTA) and the Baltimore Metropolitan Council (BMC). The full list of participants is listed in Appendix A.

The workshop spanned two days, beginning on Monday, December 11. A welcome was provided by Dr. Patricia Hendren, Executive Director of the I-95 Corridor Coalition, as well as by Secretary Cohan of the Delaware DOT and Roger Cohen, Policy Director of the Pennsylvania DOT. Secretary Cohan emphasized how important the east coast region is for CAV testing; characteristics such as the variation in weather, the large amount of vehicle miles traveled, and existing toll interoperability provide an opportunity for robust testing. Having the I-95 Corridor Coalition is important as well, because a range of perspectives will allow agencies to proceed in the right direction regarding CAV developments and regulations. Mr. Cohen highlighted the potential benefits of CAVs, including improved safety, reduced pollution, economic development, and improved mobility for the elderly, disabled, and other groups. There is also a benefit to

the increased data that CAVs may produce that will improve agency performance overall. However, he cautioned that negative impacts should not be overlooked, such as benefits accruing inequitably and impacts on employment.

"We need to figure out our role"

Session One focused on information exchange across member agencies. Representatives from four DOTs presented and time was given for questions and discussion after each presentation. Later in the afternoon, Session Two focused on proposed CAV definitions of terms and initial thoughts regarding challenges and solutions. Discussion around terms referenced the American Association of State Highway Transportation Officials (AASHTO) Pooled Fund.

On Tuesday, December 12, breakout groups discussed four topics individually:

- Infrastructure and Asset Management
- Systems, Data, Communications/Networks
- Education/Outreach and Key Stakeholders
- Policies, Legislation, and Planning

Highlights from these discussions were shared with the larger group before discussion shifted to challenges and potential ways to overcome them. The workshop concluded with a prioritization exercise for next steps related to CAVs for agencies and the region/the I-95 Corridor Coalition.

CAV Along the Corridor: Pre-Workshop Survey

Participants were asked to take a survey prior to attending the workshop; some summary results were presented prior to the first session. Some highlights are discussed here.

Survey respondents considered safety to the top reason for engaging in CAV-related activities, with the second and third reasons respectively being to provide mobility options and to expand capacity (Figure 1). There is a wide range of engagement along the east coast, with states just beginning to engage with CAVs (less than a year of active involvement) and others with over three years of engagement. Likewise, some states identified themselves as leaders while others are looking to lessons learned from these leaders to inform their own approach. States have taken various approaches to CAV engagement, demonstrating that each agency must determine what works best for its particular context.

In the majority of states, the DOT is taking the lead. About a third of respondents indicated that the DOT operations division is leading within the DOT, with other responses equally distributed over the Division of Motor Vehicles (DMV), DOT policy office, DOT planning office, and no lead/lead to be determined. One response indicated that the Governor is taking the lead. This range demonstrates that CAV deployment and implementation can be appropriately situated in a variety of offices within the DOT.

Figure 1. Survey respondents' stated reasons for engaging in CAV-related activities.
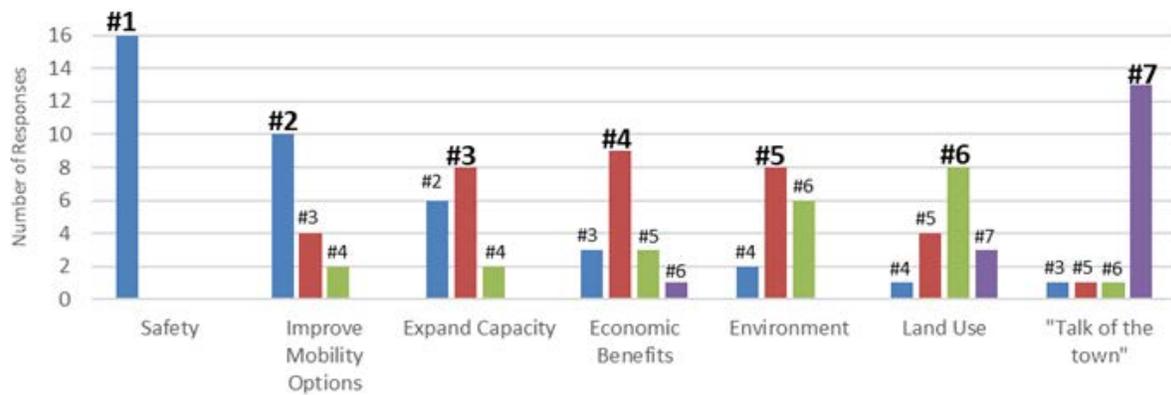
In response to the question of whether a champion had been identified, responses were almost evenly divided between states that had identified a champion and those that had not. However, emerging from the course of the workshop was a recommendation that states identify a champion as a first step in CAV implementation.

From Figure 2, it becomes clear that a wide range of stakeholders needs to be included in conversations surrounding CAV activities. DOT operations and planning are the two most consistently included groups, while a department of aging was a unique stakeholder. However, participants agreed that the inclusion of a Department of Aging highlights the potential ability for CAVs to improve mobility for elderly populations.

Figure 2. Stakeholders included in CAV conversations among Coalition states. Bars indicate the count of responses indicating that stakeholder.
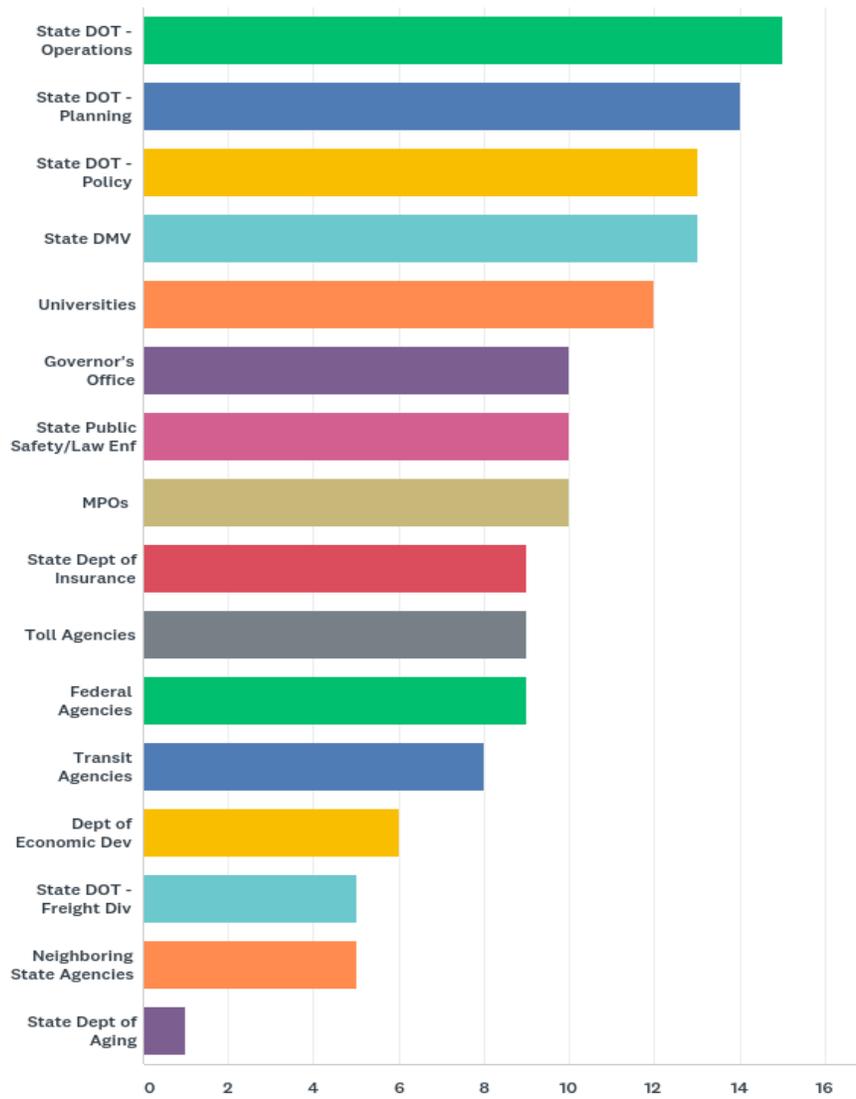
Update on State Activities

Representatives from four states presented on activities their respective DOT has undertaken related to a particular topic:

- Infrastructure and Asset Management
- Systems, Data, Communications/Networks
- Education/Outreach and Key Stakeholders
- Policies, Legislation, and Planning

Each presenter was asked to discuss CAV activities undertaken at the agency, what groups and individuals were involved in these activities, challenges faced and potential solutions, and key lessons learned. This served as a way for Coalition members to share experiences and lessons with each other.

Key takeaways include the fact that state DOTs find themselves in a challenging position regarding CAV implementation for a number of reasons. The potential for economic development related to CAV OEMs and testing lead states to provide a supportive regulatory environment, though this must be balanced with the need to promote the highest levels of safety for the public as tests are completed on public roadways. By requiring higher minimum levels of insurance, some safety risk can be mitigated. However, state agencies are also interested in promoting competition among industry players and higher minimum insurance requirements may disadvantage smaller companies.

CAV technology brings a series of data-related challenges for agencies. A vast wealth of data can potentially be gathered from both testing and fully operational fleets of CAVs in the future; however, the need and desire for data must be coupled with an agency's ability to manage it. A strategic focus on data that can be used will be critical. Agencies must also determine their scope of responsibility; many agencies have chosen to leave app development to third parties and simply provide data to these entities. Data latency was also a key issue highlighted through the presentations. Agencies discussed some innovative data sharing approaches, such as Virginia DOT's SmarterRoads.org data portal and Florida DOT's Data Integration and Video Aggregation System (DIVAS).

The industry is rapidly evolving, making it extremely difficult for states and DOTs to write legislation and regulations that balance the needs of all stakeholders. The government interest in safety and ensuring data is available for planning purposes must be considered against the industry's desire for flexibility. Looking to federal and other state approaches will be useful, but may prove to be too slow a process for developing appropriate regulation. In Maryland, the decision not to enact legislation provided much-needed flexibility and efficiency in the DOT's approach and their use of the Expression of Interest form allows all stakeholders a single point of entry.

There is a need for collaboration within DOTs, across other government agencies, and with external entities such as freight and technology advocacy groups. Pre-workshop survey results clearly show a wide range of stakeholders already included in the conversation in many states, and examples such as Maryland's Connected and Autonomous Vehicles Working Group demonstrate this. Connecticut had

stakeholders ranging from American Insurance Association to Uber testify regarding their CAV legislation, showing the diversity in groups interested and impacted by CAVs.

A few lessons learned were highlighted by multiple presenters:

- CAVs must be factored into long-range planning, even with large amounts of uncertainty.
- The technology is developing quickly and will impact agency work.
- Figuring out the CAV path forward will require continual engagement across multiple stakeholders and robust collaboration mechanisms.
- Do not let uncertainty prevent agencies from engaging with CAV development.

Virginia (Infrastructure and Asset Management)

Rob Cary, Chief of Innovation and Technology, presented about recent activities in Virginia including the Virginia Automated Corridors (VAC)—an initiative to create an automation-friendly environment that government agencies, original equipment manufacturers, and suppliers can use to test and certify their systems, providing a system migration path from test-track to real-world operating environments. The VAC will leverage extensive experience in on-road safety research to provide efficient solutions to automated-vehicle testing.   The VAC was developed in answer to Virginia Governor Terry McAuliffe's 2015 Governor's Proclamation declaring Virginia "open for business" in the realm of automated vehicles. The proclamation allows the testing of any automated vehicle on Virginia roads.

The Virginia Connected Corridors (VCC) is an initiative developed as a partnership between the Virginia Department of Transportation (VDOT) and the Virginia Tech Transportation Institute (VTTI). The VCC encompasses both the Virginia Smart Road and the Northern Virginia Connected-vehicle Test Bed, which is located along one of the most congested corridors in the United States. The VCC is facilitating the real-world development and deployment of connected-vehicle technology using more than 60 roadside equipment units. VTTI, VDOT, and researchers from across Virginia are already implementing connected applications using the VCC, including traveler information, enhanced transit operations, lane closure alerts, and work zone and incident management.

The agency has a long history of collaboration with Turner Fairbank Highway Research Center. In 2017, the agency signed a memorandum of understanding with Transurban and FHWA to facilitate CAV development and testing, resulting in a truck platooning test, where a lead driver regulates speed and distance for a series of following vehicles that only control steering of their own vehicle. Partners for this test included FHWA, FMCSA, CalTrans, and California PATH (which developed the platooning technology) as well as the Virginia State Police and the Fairfax County Government. A test was completed on I-66 and State Route 28 with a reasonably large volume of traffic. In this situation, any distance longer than 0.06 of a mile resulted in other vehicles interloping between the platooned trucks. In addition, platoon staging required law enforcement to clear traffic long enough to allow the platoon onto the roadway in combination, highlighting a first/last mile issue. This application of CAV technology has potential for

efficiency gains, but combinations of trucks will need to be considered carefully. If a lead truck is carrying very light material, while a follower is carrying heavier items, issues can develop when driving on grades.

The DOT has Innovation and Technology Transportation Funding (ITTF), around $25 million annually, that is specifically set aside for pilot programs to demonstrate high-tech infrastructure improvements. Virginia DOT is also exploring the possibility of using high occupancy tolling (HOT) lane pricing to fund some portion of costs related to CAV infrastructure. ITTF has supported additional signal phasing and timing (SPaT) and map data as the agency moves to evaluate latency in messages within a 65 Dedicated Short Range Communications (DSRC) system. The goal is to use a tablet-based definition within work zones that will work with a CAV deployment. The agency is also using a portal to make data available in raw form for third party usage in developing apps, with data including pavement, bridge, and travel time.

> "I plan to advocate for an innovation and technology fund in my state"

Florida (Systems, Data, Communications/Networks)

Raj Ponnaluri, State Arterial Management Systems Engineer, presented about Systems, Data, and Communications/Networks. Data infrastructure is a critical mechanism for attracting testing activity because companies prefer to test in places with a highly developed communication network, preferably with cloud-based data capabilities that allows them to understand the full realm of multimodality (pedestrian, transit, freight, etc.). For Florida, this is particularly important as the agency's focus is on improving safety and mobility.

Agencies should be considering wireless and cellular communication capabilities as well as DSRC, taking into account the Federal Communications Commission (FCC) DSRC Final Rule for 5.9 GHz spectrum sharing to be finalized later in 2018. The National Highway Transportation Safety Administration (NHTSA) vehicle-to-vehicle (V2V) final rule is also likely to be final in late 2018 which will impact state activities.

One of the most important elements surrounding CAVs is the incredible volume of data that could become available. Managing this data becomes a major issue and it will be beneficial for agencies to determine what data they actually need based on specific use cases, especially as many agencies are overwhelmed with data currently. Working backwards from these needs will help to reduce the amount of data being stored unnecessarily. Ensuring all of these elements are written into a data management plan will be critical. Latency also plays a major role in determining what data is useful. Other discussions around data include standards and interoperability, which is critical for a functioning CAV system across jurisdictions. The agency's goal is to develop standards aligned with national standards from, among others, the Society of Automotive Engineers (SAE), the Institute of Electronics and Electrical Engineers, and National Transportation Communications for Intelligent Transportation System Protocol.

The agency plans to use their DIVAS that integrates and manages actionable, real-time traffic and travel information to provide data to third parties including local agencies. Florida has agreements with WAZE, Google, and HERE which provide a wealth of information. Using lessons learned from TSMO, it becomes clear that each aspect of CAV systems must be interconnected and all projects must have before and after evaluations. Using lessons learned from signal systems and pilot projects, the Florida DOT seeks to

establish an understanding of needs regarding standards. However, developing interoperability through data standards is easier said than done.

On the human side, CAV technology highlights the need for more computer knowledge, data analytics, and data skillsets among employees. There are jobs that fall outside typical job expertise and to avoid losing these individuals to the private sector agencies need to allow for variations in salary.

Maryland (Education/Outreach and Key Stakeholders)

Chrissy Nizer, Motor Vehicle Administration Administrator, presented about Education/Outreach and Key Stakeholders. The DOT established a cross-agency Connected and Autonomous Vehicles Working Group in 2015 led by the Maryland Motor Vehicle Administration. The MVA was deemed the appropriate lead agency because its mission is focused on safety and its key statutory responsibilities include driver education and driver and vehicle licensing. In addition, the highway safety office is housed within the MVA further supporting Maryland's focus on the safety benefits associated with CAV. Other organizations involved in the working group include the Automobile Association of America (AAA), State Motor Truck Association, the Intelligent Transportation Society of Maryland, universities, and governments at the local and metropolitan planning organization (MPO) levels. The working group is responsible for strategic planning surrounding CAV technology.

The DOT has developed an online portal for entities to apply for approval of permits for CAV technology testing, which begins with an expression of interest followed by an interagency review group that includes law enforcement. The goal behind the portal is to build a system that works for all stakeholders. Permits for testing have been approved through the existing channel and these tests are underway. However, situations vary (small-scale test of automated parking feature v. larger road-based test),

> I want to "establish a process for testing that involves an expression of interest form" similar to Maryland.

requiring some adjustment to permit conditions and requirements in a collaborative manner with industry. None of the issued permits required changes to state legislation, and it was decided that no further legislation would be passed in the short term. Generally companies found this collaborative, though sometimes slow, process to be acceptable compared to dealing with legislative changes.

The DOT does not set aside funding specifically for CAV activity, but has completed research including testing on several non-interstate locations. In addition, an application was submitted to the United States Department of Transportation (USDOT) to use the I-95 corridor as a Maryland Proving Ground. USDOT chose US Army facility of Aberdeen Proving Ground instead, which means that Maryland still has a major CAV presence.

Connecticut (Policies, Legislation, and Planning)

Peter Calcaterra, Strategic Planning and Projects, presented about Policies, Legislation, and Planning. The Connecticut legislature passed Public Law 17-69 in June of 2017. The law defines terms related to CAVs (many of which are based on SAE standards), establishes a pilot program for testing, and creates a state legislative task force to study CAVs. The task force consists of 6 legislative appointees, 3 legislative transportation committee appointees, 2 governor appointees (one with insurance expertise), and four state agency executives from the DOT, DMV, state police, and the Office of Policy and Management. The task force is responsible for studying and recommending new laws and regulations.

Stakeholders provided input as the law was being drafted. Key takeaways include the desire for Connecticut to have a planned and appropriate approach to CAVs that will allow for careful deployment. Deployment should come after studies and testing have proven the technology. Stakeholders are excited by potential benefits and want to be part of the conversation around CAVs and are interested in working with other states and within federal guidelines.

The pilot program established in the law allows municipalities to apply to the state for testing approval, which is reviewed by a CAV working group. To keep testing manageable and safe, only four municipalities are selected (two of which must be cities) and agreements are signed with testers. Agreements, along with the law, outline requirements for testing and are based on a state template. Local interest in CAV testing arose when a locality wanted to provide a first/last mile connection to a transit center. Other localities are also interested in this potential, as well as the opportunity for economic development by attracting an original equipment manufacturer (OEM). To entice OEMs to the state, they are not required to share data.

The legislation states that testing requires a human driver to be in the driver's seat monitoring operation and capable of immediately taking over full control of the vehicle. This requires testers to have proper driver licensing and to be fully capable of operating the vehicle. Insurance is required and some consideration is being made towards increasing minimum insurance amounts, though there is concern that higher minimums will be an undue burden on smaller companies. Connecticut law additionally requires compliance with NHTSA rules once they are finalized. The legislature is also analyzing laws and regulations in other states to determine the appropriate approach to take; a report will provide recommendations for regulations but also regarding evaluation of the testing program. Vehicle testers are also required to submit data from testing that will assist in evaluation of the pilot program.

> "We need to figure out how to promote technology while addressing traveler concerns"

Level 3 CAVs were deemed a high risk because of the concern that a driver would not be able to take control of operation quickly enough, while level 4 and 5 CAVs were deemed safer and more likely to attract more OEMs and larger entities to the state. Therefore, only level 4 and 5 vehicles are allowed to be tested and only on designated roads which cannot include limited access highways.

Lessons learned include the need to review NHTSA Model State Guidelines and to borrow ideas and approaches from other states as a starting point. Conference and workshop participation is a great way to learn what others are doing. It is important to have local and legislative champions and to have robust collaboration through internal and inter-agency working groups that allow a wide range of perspectives to be included in the conversation.

Pre-Workshop Survey Results

The pre-workshop survey responses surrounding policy and legislation are relevant to the Connecticut DOT presentation. Responses showed that seven states and DC have passed CAV legislation, with two states in the process of passing legislation. This differs to the National Conference on State Legislatures (NCSL) tracking that shows a majority of east coast states have enacted legislation. More information can be found at this NCSL link. This suggests that practitioners should be cautious when drawing conclusions regarding the status of CAV legislation. Among Coalition members, the two most common reasons for legislation included the authorization to test/deploy either automated or autonomous vehicles on public infrastructure. The reasons to not enact legislation was to reduce the burden and attract CAV testing and deployment. In summary, CAV legislation is not a requirement per se but an evaluation of legislative restrictions (e.g., a vehicle operator must have hands on the steering wheel) is advised.

Figure 3. Status of CAV legislation among Coalition members.

CAV Legislation Passed
CAV Legislation In-Process

Figure 4. Status of CAV legislation nationwide. Blue states are those with enacted legislation, while green states used Executive Orders. Source: National Conference of State Legislatures.
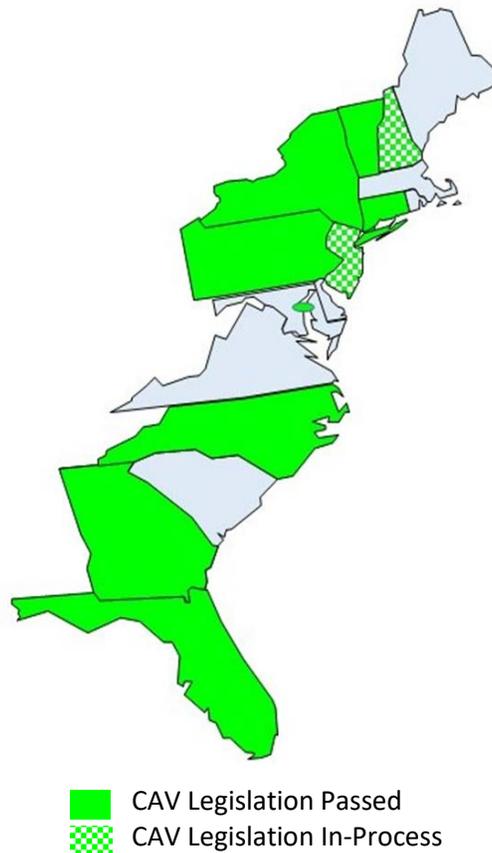
Addressing Barriers to Implementation

The pre-workshop survey results helped start the conversation about barriers to CAV implementation. Figure 5 indicates the count of responses for each of the barriers listed in the survey. These challenges were further discussed during the workshop sessions and the breakout groups. The main barriers raised during the workshop are summarized below along with potential solutions.

> "We need to make administrators aware of the need for data analysts for CAV technology"

Figure 5. Obstacles encountered by states in CAV efforts.

Human Factors	• A general misunderstanding and mistrust of CAV exists among policy makers, staff, and the public.
	• Getting CAV understanding to permeate through the entire agency.
	• General confusion about the levels of autonomy, the types of functions an AV provides, and what is required of a driver in particular driving modes.
	• People will get into a car with someone they do not know when using ride-hailing services but, may be warier of an autonomous vehicle.
	• Level of safety will likely need to reach that of commercial air travel for people to be comfortable.
	• Lack of trust in infrastructure owners and operators (IOOs) to test CAVs safely.

Solutions:

- Conduct education and outreach activities.
- "Translate" CAV terminology into easy to understand terms
- Partner with MPOs to share information and address misunderstanding and mistrust.
- Highlight rural examples of CAV testing (AVs perceived as only for wealthy and urban areas):
  - Wyoming DOT pilot.
  - VDOT rural testing (Smart Road Test Bed in Blacksburg, VA).
- Bring law enforcement into the conversation (alleviate concern that CAV data will be used to issue moving violations).
- Address the "hype" by identifying difficult scenarios and how agencies are prepared for them.
- Take lessons learned from the use of "auto-pilot" in the airline industry to inform approaches for regulation and transitioning from current state (e.g., the use of check-lists, requirement to have a pilot in the cockpit).
- Hold a "data-thon" or other similar technology oriented events to engage with public.
- Develop a single point of contact in a state to become the "face" of CAV.

> I was surprised by "the level of public opposition to automated vehicles"

Institutional Factors	- Technology is changing so rapidly it is difficult to keep up. - There is resistance to sharing data due to security concerns and that others will misuse the data and potentially expose the agency. - Key skills are lacking among current staff, such as data scientist, data journalist, etc. - There is significant uncertainty in a rapidly changing field. - Need for a closer working relationship between the DOT and DMV. - Lack of clarity in federal and state policies. - The procurement process can be long and rigid. - There can be a lack of consistency at the executive level. - Differing definitions, terminology and complex concepts can be confusing. - The effect of CAV on mass transit is unclear.

> "We need to make administrators aware of the need for data analysts for CAV technology"

Solutions:

- Develop an I-95 Corridor Coalition working group to hold webinars to highlight activities along the east coast.
- Gather open data portal information from VA, FL, DE, and DC to inform efforts by other states.
- Consider partnering with universities and other educational institutions to fill agency skill needs.
- Develop common terminology through things like the AASHTO Pooled Fund research project (SAE levels can be hard to understand)
- Create a centralized repository for research finding that can be put into "action."

> "There is a lack of IT depth in the workforce"

- Adjust procurement processes to be less rigid and lengthy.
- Consider MDOT's Expression of Interest form and criteria that promotes a conversation.
- Establishing an evaluation framework while also encouraging innovation.
- Overall, stay nimble to adjust to changes.

Funding	• Because of constrained budgets, funding CAVs will likely reduce funding in other areas especially if P3 opportunities cannot be leveraged. • Keeping infrastructure in a state of good repair is difficult. Investment needs outstrip funding, making it difficult to guarantee acceptable conditions to OEMs.

Solutions:

- Use CAVs as justification for state of good repair investments.
- Shift the conversation from state of good repair to the need to modernize infrastructure to support new and beneficial technology.
- Consider FHWA grant funding through Accelerated Innovation Deployment (AID), State Transportation Innovation Council (STIC), Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) programs.
- To make the case for funding:
  - Focus on the benefits of CAVs.
  - Show that CAVs have a positive benefit-cost ratio.
  - Use before and after studies.
- Agencies should work on and share cost benefit ratios for CAV projects.
- Ensure CAV projects and actions are included in planning documents (e.g., LRTP, STIP).
- Federal funds are eligible for CAV activities, so states should make use of them when needed.

> "Yes, we are expecting CAV; however, to what extent it will affect traffic volumes, routing, etc. this is a dangerous area due to risks. We are investigating how to incorporate this more into our LRPs, but not ready to make changes just yet."

Law Enforcement	• Lack of standardization of vehicle capabilities and characteristics make it difficult to have consistent law enforcement and first responder protocols. • No standard for vehicle licensing across state lines. • Documentation / proof needed that officers will be kept safe in roadways during an incident.

Solutions:

- Regular collaboration needed between developers, law enforcement and first responders (e.g., identify training scenarios, establish procedures on how to extricate victims from crashes).

- Discussion should include definitions of motor vehicle operational laws.
- Fund law enforcement technology to enable agenies to commuicate with vehicles.
- Need standardization of vehicle shut-off (e.g., how to stop an AV when there is crimial activity).

Operator and Vehicle Licensing	- The definition of the driver is changing. Currently, the "driver" is responsible for performance of the vehicle, but this likely will not be true when a vehicle is in autonomous mode. - As the definition of the driver changes, the roles of the federal vs. state government oversight becomes more unclear. - The cohabitation of CAV and non-CAV fleet will continue for a long time. - Unclear how vehicle safety inspections will be completed given this will require examination of operating systems which will likely be proprietary. - Given all the unknowns, establishing insurance will be very difficult.

Solutions:

- Must define who the operator is (e.g. a person sitting in the vehicle or controlling remotely?).
- Driver education and examination will need to be adjusted to levels of automation.
- Federal and state authorities need to agree on vehicle inspection responsibilities.
- NHTSA recommends that entities provide bonds with a minimum of $5 million and proof of insurance or self-insurance. Determine if the minimum should be increased to $10 million.
- Explore if driver regulation should move away from the DMV to more of a public utility commission, particularly if a CAV is being used to provide a service.
- Assessment of specific use cases are needed (e.g., minors, school buses, visibly handicapped).

> "It is hard to legislate/regulate something which you do not understand well. Trying to educate stakeholders and form a common understanding of CAVs, the testing, deployment, technologies, etc. is the most critical need."

Near Term Steps to Moving Forward

Participants formed breakout groups according to the four topics:

- Infrastructure and Asset Management
- Systems, Data, Communications/Networks
- Education/Outreach and Key Stakeholders
- Policies, Legislation, and Planning

Each group then reported the key elements of discussion to the larger group to ensure all information was shared across all participants. The purpose of this session was to share experiences and consider future actions on a more detailed level in small groups, resulting in a list of implementation actions participants feel are important to accomplish in the next one to three years.

One of the main conclusions that can be drawn from the discussion is the wide-ranging impacts CAVs are likely to have on the transportation system. New infrastructure will be required, such as fiber optic networks that enable communication between and to/from vehicles. However, the impacts are greater than this; even simple infrastructure like signs will need to retrofitted, which has particular implications for work zones that use temporary roadway alignments and signage. The cost of making these seemingly small pieces of the network CAV-compatible may be large.

In order to make smart investments, agencies will need to carefully consider competing priorities. Preparing for CAVs is important, but many other important needs already exist. Using a transportation performance management (TPM) approach, agencies will be better able to prioritize the most critical investments. Related to CAV investments in particular, before and after evaluations will enable agencies to continually adjust and improve investment decisions based on what does and does not work.

TPM relies on data; with the advent of CAV technology, agencies will have to contend with large amounts of data. Managing and sharing this data with key stakeholders (including the industry/private sector) will be critical tasks. Data will need to be efficiently managed to allow timely usage, but also protect the privacy of the general public. To some degree, agencies are already grappling with these issues in other areas of the transportation network; research and experience to date can provide lessons for challenges related specifically to CAV deployment.

> I want to "establish a community engagement and education strategy with more external partners"

In addition to data management, agencies must undertake robust collaboration and coordination. CAV deployment will be streamlined if consistency can be developed through interoperable communication networks, data formats, vehicle licensing, and interfacing with first responders. The private sector should be included in these discussions along with a multitude of others. At the same time, agencies should carefully consider how much the industry's needs should define public investment. While coordination was often discussed, coordination around transit and non-motorized transportation was a minor topic. It will be important to consider the impact of CAVs on complete streets and other elements of the local environment.

Planning will be key to accomplishing agency goals and investing appropriately to support CAVs. This will likely require increased coordination across agencies to bring TSMO, infrastructure development and retrofitting, and other related areas together to form cohesive strategies. However, the process of creating the plans may be just as valuable as the resulting product as it enables stakeholders to be in regular contact and to adjust plans on an iterative basis. Ideally, this will avoid the issue of plans becoming obsolete in a quickly changing industry.

> "I'm glad to see the support of officials on such a far-off concept"

Infrastructure and Asset Management

This discussion applied to physical infrastructure such as roads, bridges, maintenance equipment, pavement markings, and ITS equipment. Questions centered on what infrastructure will need to be enhanced, eliminated, or added to support CAV deployment both in the short term and over the long term, especially considering the many unknowns surrounding CAVs. Discussion also covered various aspects of deployment preparation such as what other modes should be included in the conversation, what steps will be needed for regional deployment of CAVs, and what new stakeholders are now relevant to transportation agencies because of CAV technology.

Infrastructure and Asset Management	Signage and Striping • Many unknowns still exist regarding what sign structure retrofitting or revised standards (if any) are needed to support CAV. Manufacturers are working with existing signage, but have communicated the need for more consistency across states. • There are line striping challenges for DOTs, especially in winter weather states. • Work zones need to be equipped with traffic control devices compliant with the Manual on Uniform Traffic Control Devices (MUTCD). Signaling • ITS uptime infrastructure and software needs to be included in planning and implementation. • Signal Operations and Timings and Signal Maintenance Agreements need to be considered. • States are taking back signal system ownership and costs for system management. Communication and Management • ITS Infrastructure is being used as a means for notifying the public. It is difficult to predict in 25 years how will technology have changed – will there be a need for dynamic message signs (DMS)? • Identify what changes are necessary in a "CAV World" for Advanced Traffic Management Systems (ATMSs) and integrations into TMCs. • Determine if there is potential for CAV technology to collect toll payments. • Establish pro / con for using dedicated lanes for testing and use of CAV.

Funding	• Federal money is eligible for use on CAV work. • Consider FHWA grant funding through AID, STIC, ATCMTD. • However, funding for CAV projects will likely require reduced funding for other priorities especially if P3 opportunities cannot be leveraged. • Agencies should work on and share cost benefit ratios for CAV. • Before / after evaluations will be key to making the case for CAV investments. • Ensure that CAV projects and actions are included in planning documents (e.g., LRTP, STIP). • Agencies can identify projects for CAV deployments even without having dedicated funding.
Multi-modal Inclusion (freight, non-motorized transportation, transit)	• Freight should be included in the CAV conversation from the beginning and on an ongoing basis. • Given the tight profit margins in the trucking industry, some suggest that freight will be the first industry to decidedly shift towards CAV technology. • Smaller businesses may be at a disadvantage with a shift towards CAV technology. • For urban areas where there are large amounts of movement by pedestrians and bicyclists, these modes need to be explored regarding how they would interact with CAV. • Identify where CAV technology may have the largest safety effect (e.g., accidents between larger vehicles and vulnerable road users in urban areas). • Transit agency vehicles, airport shuttles, and other transit could be outfitted with the appropriate communication technology like DSRC. • Continue assessment of technology deployment to determine what effect CAV will have on mass transit.

Systems, Data, Communications/Networks

This breakout group discussed issues surrounding the systems that support data collection, storage, analytics, and dissemination such as probe data, cellular communication, and DSRC. Questions related to what CAV data agencies should and should not be able to access based on the need for planning capabilities, consideration of privacy, and other issues as well as what DOT data might be valuable to the private sector. Discussion also covered issues of data management and methods for sharing across many stakeholders. Related to communications, discussion focused on critical conditions to be addressed to support CAVs in general, but also specifically related to ensuring interjurisdictional interoperability. Finally, participants discussed key elements of the transportation system that could be short term priorities for improved connectivity.

Communication Infrastructure	• Contingency plans need to exist for when communication infrastructure fails • Communication systems need to be agnostic and interoperable. • Agencies need to develop a policy that guides decisions about 5G vs. DSRC technology usage in the absence of federal guidelines. • Capital plans are needed for fiber/backhauls, DSRC, and/or cell data for network coverage • Share best practices / approach with constructing fiber network • While fiber may be attractive, it is very expensive and may be out of reach for some DOTs so, other communication networks (e.g., satellite with cellar capabilities) need to be considered.
Data Exchange	What data should transportation agencies have access to from CAV? • Vehicle classification • Vehicle identification number and make/model • Braking • Lights and wipers usage • Stability control • Traction • Pedestrian detection • Wrong-way driving • Temperature • Aggregated occupancy and speed • Aggregated origin-destination data What data should agencies **not** have access to from CAV? • Personal data • Vehicle-specific data • Enforcement data • Red light running data • Non-aggregated occupancy and speed data What data do DOTs have that would be of value to the CAV private sector? *(Note: the private sector may also produce these data so a two-way data exchange may be beneficial)* • Signal phasing and timing data • Variable speed limit placements and speed limit sectors • Signing and pavement marking conditions • Work zone conditions in real time at the lane usage level • Special event information and incident data • Mapping data • Routing information • Roadway restrictions • Overweight/over height data along with weight restrictions • Truck parking and weigh station facilities • Toll information/high occupancy vehicle (HOV)/HOT facilities • Transit/automatic vehicle location data

Data Management and Validation	• The data will be sophisticated and real time.
	• Data standards need to be in place to enable interoperability between a range of manufacturers and agencies
	• Data needs to be made available in the same format from all DOTs and manufacturers.
	• Workforce development will be needed and there will likely be consultant support alongside in-house staff.
	• Private data will need to be aggregated.
	• Networks will need to be reviewed for security and possibly even be rebuilt.
	• Mapping and geographic information system utilities would need to be updated so that DOTS can provide data in a timely and consistent manner.
	• There is the need to discuss latency in mapping (updates for design changes, construction activities, etc. lagging).

Education/Outreach and Key Stakeholders

The third breakout group focused on efforts to enhance understanding of CAVs across key stakeholders, including the general public, senior managers, elected officials, and the private sector. Questions related to determining potential benefits from working with particular stakeholders as well as their appropriate

"I would not have thought to work with the Department of Aging"

roles. Discussion also included barriers to promoting CAV understanding, how to address law enforcement concerns, and how to build strong partnerships with the private sector and universities while ensuring the agency's voice remains strong.

Public Outreach	How can the public's understanding of CAV be increased?
	• Show that existing vehicle features (such as lane departure warnings) are building blocks toward higher levels of automation.
	• Avoid the dominance of hypothetical questions as these situations are often very unlikely to occur and are difficult to address. Stay grounded in reality as much as possible.
	• Do not reinvent the wheel; use material, ideas and best practices that already exist. (e.g., Boston, MA "Robot Block Party" that introduced and excited the public about new technologies).
	• Conduct outreach in rural areas as CAVs are often seen as an urban issue. Wyoming DOT conducted a rural pilot that can be used as an example/template.

Stakeholders	Who are the most important stakeholders? (Note: these are not in order of importance). • The general public • Universities that develop CAV-related curricula • Vocational and technical schools • Technology developers • Investors • Planners • Infrastructure and asset management staff • Public officials, including executive and legislative branches • Law Enforcement and First Responders
Partnerships	With the private sector • Continue to invite industry representatives to working groups- this is essential. • Establish regular communication between DOTs and the private sector/OEMs so both parties understand what each other's needs. • Both sides (private and public) are indicating more engagement with each other is necessary. With other state DOTs • Work together as a group of states because a collective power is greater than a fragmented and varying message. • Work with other state agency staff within state administrations. • Take advantage of existing forums such as auto shows or other city or state forums. • Identify those aspects of data, program, and projects that can be shared.

Policies, Legislation, and Planning

Discussion focused on efforts to establish appropriate testing environments for CAVs in addition to issues of interoperability and coordination. Topics included possible changes to operator and vehicle licensing, insurance regulations, and other laws to remove barriers to CAV deployment. Planning issues were also discussed, including the incorporation of CAV impacts into long range planning, how a state policy/strategic plan might be developed, and how these documents relate to existing planning documents. Discussion touched on inter-jurisdictional issues as well such as recognition of operator and vehicles across state lines.

> "I assumed the answer to the question, 'do we need legislation to CAVs?' was 'yes'" but that is not the case.

Overall Approaches	• States need to identify a leader. • Start with small steps. • States need to include CAV in TSMO planning. • There needs to be master plan for ITS and communications that includes CAV for both freeways and arterials. • Should there be an engineering directive for projects to include CAV/ITS infrastructure or to develop master plans for DOTs?
CAV Policy/ Strategic Plan	• The process of developing the plan is truly valuable in itself. • As much as possible, policy development should attempt to keep pace with technology and be iterative. • Maintain regular contact with the industry. • Beneficial to merge ITS, CAV, and AV into a single category • Research needs and partnerships with academia need to be highlighted • New Jersey has modeled what current trip patterns would look like if provided by taxis as a way to begin understanding the impact of CAVs. • Map accuracy is critically important; when DOTs change roadways, reality does not align with the map. Manufacturers will be unwilling to deal with each state separately for updated information.
Long Range Planning	• Use a travel demand model that can reflect CAV scenarios. This can help define what trips / demand they serve, what could they serve and fleet penetration. • Land use: conversion of parking facilities once CAV are more prevalent (however, some parking will likely be necessary when AVs are not in use) • Plans need to consider operational ideas and determine what the agency of the future needs to think about. "Our DOT is working assess and analyze CAV scenarios to include on our statewide travel demand model (e.g., technology development, market penetration" • Address how to bring CAV benefits to BOTH urban and rural areas. • Most states have no option, but to focus on the state of good repair (SOGR) when planning investment strategies. Use CAV as an argument for SOGR. • Model future mass transit demand / behavior to better understand relationship to CAV. State experiences • South Carolina increased the gas tax and is already being questioned about whether corridor investments are still necessary. • Pennsylvania is starting to look at restructuring existing plans considering technology changes. There is cultural resistance to making changes. • The Virginia DOT is working on education outreach to MPOs to develop some agreement as to future impacts.

Session 5: The Way Forward

At the conclusion of the workshop, participants were asked to prioritize next steps for both individual agencies as well as for the region/the I-95 Corridor Coalition. The result of this concluding session was an indication of the highest priorities for agencies to consider and for the region to work on collaboratively. The initial list of actions were generated from across the workshop discussions. When participants prioritized actions, they were asked to pay particular attention to barriers and ideas on how to overcome those barriers.

> "I want to look at getting other agencies involved"

For Agencies

What are the highest priority actions for DOTs?

High priority	- Identify a leader - Create a strategic vision focused on the "why": safety, congestion relief, emergency response, economic development - Start a stakeholder group to understand agency culture, work with WAZE/Google/others in the private sector, and consider how to include CV systems in procurement/construction projects - Link SOGR investments to CAV and the need to modernize infrastructure
Medium priority	- Foster leadership buy-in across multiple stakeholders - Conduct regulatory/legislative review of vehicle codes for CAV and consider how FCC rules may affect them. - Engage in testing and pilot projects that can produce basic information needed for future work. Use the SPaT challenge as part of the regional approach to develop consolidated operations and data standards. - Decide if there is a want/need for legislation
Low priority	- Develop communication strategy and outreach/educational material (e.g., webpage) - Identify potential projects even if no funding is available - Work with FHWA Division Offices to voice state DOT needs
Overall	Remember to start small

For the Region / I-95 Coalition

What are the highest priority actions for the region/Coalition?

High priority	- Create a working group to keep Coalition member informed about actions to take "today" - Develop a CAV Academy in a similar manner as the Operations Academy and the Freight Academy) - Compile lessons learned from pilots - Identify key insights applicable today coming from research - Work on regional funding opportunities (e.g., grant applications to ATCMTD, AID, STIC and or National Cooperative Highway Research Program proposal. A potential topic is the broader impacts of CAVs on safety, mobility, and the economy (such as job displacement because of automation). - Develop data and CAV formats and standards to promote consistency and interoperability across states (benefits for both states and the industry) - Develop a library of member documents - Gather examples of open data portals (starting with information from VA, FL, DE, DC)
Medium priority	- Endorse common terminology - Generate educational/outreach material, toolkits, etc. to maintain a consistent message for full-corridor connectivity, among others - Get diverse stakeholders together (freight, rail, law enforcement, etc.) - Create a forum for information exchange, such as a listserv - Multi-state truck platooning pilot or demo - Investigate what is happening at ports - Explore rural highway examples
Low priority	- Develop guidance on commercial value of the right of way - Coordinate comments to USDOT

Appendix A: Workshop Participants

Agency	Participant	Title
Connecticut DOT	Peter Calcaterra	Strategic Planning and Projects
	Kevin Danh	Transportation Engineer
Delaware DOT	Jennifer Cohan	Secretary
	Shante Hastings	Deputy Director, Transportation Solutions
District of Columbia DOT	Soumya Dey	Director of Research and Technology Transfer
	Suzette Robinson	Chief Operating Officer
Florida DOT	Raj Ponnaluri	State Arterial Management Systems Engineer
Georgia DOT	Andrew Heath	Administrator, Office of Traffic Operations
	Matt Glasser	Assistant State ITS Engineer
Maine DOT	Luke Lorrimer	Assistant Engineer
	Herb Thomson	Director, Bureau of Transportation Systems Planning
Maryland MVA	Chrissy Nizer	Administrator, Maryland Motor Vehicle Administration
MD State Highway Administration	Carole Delion	Team Leader, Travel Forecasting & Analysis
	Joey Sagal	Director, Coordinated Highways Action Response Team
MD Transportation Authority	Roan Bennett	Manager, Business Planning, Policy & Performance
	Sushmita Mitra	Deputy Director of Engineering
	Roxane Mukai	Manager, Traffic Engineering
	Jason Pulliam	MdTA Police Lt., Bay Bridge Detachment Commander
Massachusetts DOT	Daniel Sullivan	Policy Analyst
	Neil Boudreau	State Traffic Engineer
New Hampshire DOT	Susan Klasen	Assistant Administrator
	Mike Servetas	Assistant Director of Operations
New Jersey DOT	Sue Catlett	Project Manager, TSM Engineering, Operations & Planning
	Bill Kingsland	Assistant Commissioner, TSMO
	Andy Swords	Director, Statewide Planning
North Carolina DOT	Dennis Jernigan	Turnpike Authority, Director of Highway Operations
	Torre Jessup	Commissioner, Department of Motor Vehicles
	Kevin Lacy	Director, State Traffic Engineer
	Beau Memory	Turnpike Authority, Executive Director
Pennsylvania DOT	Roger Cohen	Policy Director
	Mark Kopko	Manager, Travel Information and Advanced Vehicle Tech
Port Authority of NY and NJ	Daniel Jacobs	General Manager – Transportation & Revenue
	Jennifer Bates	Principal Engineer, Traffic Engineering – Transportation Technologies
South Carolina DOT	Rob Perry	State Traffic Management Engineer
	Mark Pleasant	Director of Planning
Vermont DOT	Emily Parkany	Research Manager
	Joe Segale	Director, Policy, Planning and Research Bureau
Virginia DOT	Ronique Day	Assistant Secretary of Transportation
	Rob Cary	Chief of Innovation and Technology
	Cathy McGhee	Director, Transportation Research Council
Baltimore Metropolitan Council	Eileen Singleton	Senior Transportation Engineer

Appendix B: Recommended CAV Resources

This section provides suggested resources for further learning around CAVs. Resources were identified by the workshop planning committee.

CAV Legislation and Guidance

Public Act 17-69: An Act Concerning Autonomous Vehicles	State of Connecticut	6/27/2017	https://www.cga.ct.gov/2017/act/pa/pdf/2017PA-00069-R00SB-00260-PA.pdf
Draft Autonomous Vehicles Testing Guidance	MassDOT	5/17/2017	
Application to Test Autonomous Vehicles (AVs) on Public Ways in Massachusetts	MassDOT	10/2017	https://www.mass.gov/files/documents/2017/10/13/ApplicationToTestHAVsInMassachusetts.pdf

Research

Connected and Automated Technologies and Transportation Infrastructure Readiness (White Paper – World Congress Version)	CAVita, LLC for NCHRP 20-24(111)	9/15/2017	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24(111)_CEOLeadershipForumWhitePaper-WorldCongressVersion.pdf
Connected and Autonomous Vehicles: NCHRP Support for Transportation Agency Leaders	NCHRP	5/2017	http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_cavbrochure.pdf
Planning Snapshot 11: Connected and Autonomous Vehicles	NCHRP 8-36 Research Series	7/2017	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-36(120)_Snapshot2017-011CAV.pdf

Others

Strategies to Advance Automated and Connected Vehicles: Briefing Document	NCHRP Report 845: Advancing CAV		https://connectedautomateddriving.eu/wp-content/uploads/2017/09/2017-08_National-Academy-of-Science_Strategies-to-advance-CAD.pdf
What the Car Did – And What it Might Do	The New York Times Magazine	11/7/2017	https://www.nytimes.com/interactive/2017/11/07/magazine/tech-design-future-autonomous-cars-american-interstate-highway-roads-suburbs.html